ELECTRICIAN

NSQF LEVEL - 4

1st Year

TRADE PRACTICAL

SECTOR: POWER

(As per revised syllabus July 2022 - 1200 hrs)

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Directorate General of Training

DIRECTORATE GENERAL OF TRAINING
MINISTRY OF SKILL DEVELOPMENT & ENTREPRENEURSHIP
GOVERNMENT OF INDIA

NATIONAL INSTRUCTIONAL MEDIA INSTITUTE, CHENNAI

Post Box No. 3142, CTI Campus, Guindy, Chennai - 600 032

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FOREWORD

The Government of India has set an ambitious target of imparting skills to 30 crores people, one out of every four Indians, by 2020 to help them secure jobs as part of the National Skills Development Policy. Industrial Training Institutes (ITIs) play a vital role in this process especially in terms of providing skilled manpower. Keeping this in mind, and for providing the current industry relevant skill training to Trainees, ITI syllabus has been recently updated with the help of Mentor Councils comprising various stakeholder's viz. Industries, Entrepreneurs, Academicians and representatives from ITIs.

The National Instructional Media Institute (NIMI), Chennai, an autonomous body under Ministry of Skill Development & Entrepreneurship is entrusted with developing producing and disseminating Instructional Media Packages (IMPs) required for ITIs and other related institutions.

The institute has now come up with instructional material to suit the revised curriculum for **Electrician 1st Year Trade Practical NSQF Level - 4 (Revised 2022) in Power Sector under Annual Pattern.** The NSQF Level - 4 (Revised 2022) Trade Practical will help the trainees to get an international equivalency standard where their skill proficiency and competency will be duly recognized across the globe and this will also increase the scope of recognition of prior learning. NSQF Level - 4 (Revised 2022) trainees will also get the opportunities to promote life long learning and skill development. I have no doubt that with NSQF Level - 4 (Revised 2022) the trainers and trainees of ITIs, and all stakeholders will derive maximum benefits from these IMPs and that NIMI's effort will go a long way in improving the quality of Vocational training in the country.

The Executive Director & Staff of NIMI and members of Media Development Committee deserve appreciation for their contribution in bringing out this publication.

Jai Hind

SHRI. ATUL KUMAR TIWARI., I.A.S.,
Secretary
Ministry of Skill Development & Entrepreneurship,
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New Delhi - 110 001

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PREFACE

The National Instructional Media Institute (NIMI) was established in 1986 at Chennai by then Directorate General of Employment and Training (D.G.E & T), Ministry of Labour and Employment, (now under Ministry of Skill Development and Entrepreneurship) Government of India, with technical assistance from the Govt. of the Federal Republic of Germany. The prime objective of this institute is to develop and provide instructional materials for various trades as per the prescribed syllabi (NSQF) under the Craftsman and Apprenticeship Training Schemes.

The instructional materials are created keeping in mind, the main objective of Vocational Training under NCVT/NAC in India, which is to help an individual to master skills to do a job. The instructional materials are generated in the form of Instructional Media Packages (IMPs). An IMP consists of Theory book, Practical book, Test and Assignment book, Instructor Guide, Audio Visual Aid (Wall charts and Transparencies) and other support materials.

The trade practical book consists of series of exercises to be completed by the trainees in the workshop. These exercises are designed to ensure that all the skills in the prescribed syllabus are covered. The trade theory book provides related theoretical knowledge required to enable the trainee to do a job. The test and assignments will enable the instructor to give assignments for the evaluation of the performance of a trainee. The wall charts and transparencies are unique, as they not only help the instructor to effectively present a topic but also help him to assess the trainee's understanding. The instructor guide enables the instructor to plan his schedule of instruction, plan the raw material requirements, day to day lessons and demonstrations.

In order to perform the skills in a productive manner instructional videos are embedded in QR code of the exercise in this instructional material so as to integrate the skill learning with the procedural practical steps given in the exercise. The instructional videos will improve the quality of standard on practical training and will motivate the trainees to focus and perform the skill seamlessly.

IMPs also deals with the complex skills required to be developed for effective team work. Necessary care has also been taken to include important skill areas of allied trades as prescribed in the syllabus.

The availability of a complete Instructional Media Package in an institute helps both the trainer and management to impart effective training.

The IMPs are the outcome of collective efforts of the staff members of NIMI and the members of the Media Development Committees specially drawn from Public and Private sector industries, various training institutes under the Directorate General of Training (DGT), Government and Private ITIs.

NIMI would like to take this opportunity to convey sincere thanks to the Directors of Employment & Training of various State Governments, Training Departments of Industries both in the Public and Private sectors, Officers of DGT and DGT field institutes, proof readers, individual media developers and coordinators, but for whose active support NIMI would not have been able to bring out this materials.

Chennai - 600 032 **EXECUTIVE DIRECTOR**

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ACKNOWLEDGEMENT

National Instructional Media Institute (NIMI) sincerely acknowledges with thanks for the co-operation and contribution extended by the following Media Developers and their sponsoring organisations to bring out this Instructional Material **(Trade Practical)** for the trade of **Electrician NSQF Level - 4 (Revised 2022)** under **Power** Sector for ITIs.

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NIMI records its appreciation for the Data Entry, CAD, DTP operators for their excellent and devoted services in the process of development of this Instructional Material.

NIMI also acknowledges with thanks the invaluable efforts rendered by all other NIMI staff who have contributed towards the development of this Instructional Material.

NIMI is also grateful to everyone who has directly or indirectly helped in developing this Instructional Material.

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INTRODUCTION

This manual for trade practical is intended for use in the ITI workshop. It consists of a series of practical exercises that are to be completed by the trainees during the first year of course is the **Electrician trade under Power Sector. It is National Skills Qualifications Framework NSQF Level - 4 (Revised 2022),** supplemented and supported by instructions/information to assist the trainees in performing the exercise. The exercises are designed to ensure that all the skills prescribed in the syllabus are covered including the allied trades.The syllabus for the 1st Year **Electrician** Trade under **Power Sector** Trade Practical is divided into Twelve Modules.The allocation of time for the various modules is given below:

Module 1 - Safety Practice and Hand Tools	40 Hrs
Module 2 - Wires, Joints - Soldering - U.G. Cables	95 Hrs
Module 3 - Basic Electrical Practice	51 Hrs
Module 4 - Magnetism and Capacitors	32 Hrs
Module 5 - AC Circuits	77 Hrs
Module 6 - Magnetism and Capacitors	50 Hrs
Module 7 - Basic Wiring Practice	110 Hrs
Module 8 - Wiring Installation and earthing	115 Hrs
Module 9 - Illumination	45 Hrs
Module 10 - Measuring Instruments	75 Hrs
Module 11 - Domestic Appliances	75 Hrs
Module 12 - Transformers	75 Hrs
Total Hrs	840 Hrs

The syllabus and the content in the modules are interlinked. As the number of workstations available in the electrical section is limited by the machinery and equipment, it is necessary to interpolate the exercises in the modules to form a proper teaching and learning sequence. The sequence of instruction is given in the schedule of instruction which is incorporated in the Instructor's Guide. With 25 practical hours a week of 5 working days 100 hours of practical per month is available.

Contents of Trade Practical

The procedure for working through the 106 exercises for the 1st Year with the specific objectives as the learning out comes at the end of each exercise is given is this book.

The skill objectives and tools/instruments, equipment/machines and materials required to perform the exercise are given in the beginning of each exercise.Skill training in the shop floor is planned through a series of practical exercises/experiments to support the related theory to make the trainees get hands on trainning in the Electrician trade along with the relevant cognitive skills appropriate for the level. A minimum number of projects have been included to make the training more effective and develop attitude to work in a team. Pictorial, schematic, wiring and circuit diagrams have been included in the exercises, wherever necessary, to assist the trainees broaden their views. The symbols used in the diagrams comply with the Bureau of Indian Standards (BIS) specifications.

Illustrations in this manual, help trainess visual perspective of the ideas and concepts.The procedures to be followed for completing the exercises is also given. Different forms of intermediate test questions have been included in the exercises, to enhance the trainee to trainee and trainee to instructor interactions.

Skill Information

Skill areas which are repetitive in nature are given as separate skill information sheets. Skills which are to be developed in specific areas are included in the exercises itself. Some subexercises are developed to fulfill the sequence of exercises in keeping with the syllabus.

This manual on trade practical forms part of the Written Instructional Material (WIM). Which includes manual on trade theory and assignment/test.

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LEARNING / ASSESSABLE OUTCOME

On completion of this book you shall be able to

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1	Prepare profile with an appropriate accuracy as per drawing following safety precautions. **(NOS: PSS/N2001)**	1.1.01 - 1.1.16
2	Prepare electrical wire joints, carry out soldering, crimping and measure insulation resistance of underground cable. **(NOS: PSS/N0108)**	1.2.17 - 1.2.26
3	Verify characteristics of electrical and magnetic circuits. **(NOS: PSS/N6001, PSS/N6003)**	1.3.27 - 1.5.56
4	Install, test and maintenance of batteries and solar cell.**(NOS: PSS/N6001)**	1.6.57 - 1.6.61
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NOTE :

- **ITI students can obtain certificate of competency (Trade license) from respective Labour/ Industries department under State/ UT Govt.**
- **Refer to notification available in public domain for concern states/ UT. Principal & Trade Instructors to facilitate trainees**.

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SYLLABUS

Duration	Reference Learning Outcome	Professional Skills (Trade Practical) With Indicative Hours	Professional Knowledge (Trade Theory)
Professional Skill 40 Hrs.; Professional Knowledge 10 Hrs.	Prepare profile with an appropriate accuracy as per drawing following safety precautions. **(NOS: PSS/N2001)**	1. Visit various sections of the institutes and location of electrical installations. (01hrs.) 2. Identify safety symbols and hazards. (02Hrs.) 3. Preventive measures for electrical accidents and practice steps to be taken in such accidents. (03hrs.) 4. Practice safe methods of fire fighting in case of electrical fire. (02hrs.) 5. Use of fire extinguishers. (03Hrs.)	Scope of the electrician trade. Safety rules and safety signs. Types and working of fire extinguishers. (03 hrs.)
		6. Practice elementary first aid. (02hrs.) 7. Rescue a person and practice artificial respiration. (01Hrs.) 8. Disposal procedure of waste materials. (01Hrs.) 9. Use of personal protective equipment. (01hrs.) 10. Practice on cleanliness and procedure to maintain it. (02 hrs.)	First aid safety practice. Hazard identification and prevention. Personal safety and factory safety. Response to emergencies e.g. power failure, system failure and fire etc. (03 hrs.)
		11. Identify trade tools and machineries. (03Hrs.) 12. Practice safe methods of lifting and handling of tools & equipment. (03Hrs.) 13. Select proper tools for operation and precautions in operation. (03Hrs.) 14. Care & maintenance of trade tools. (03Hrs.)	Concept of Standards and advantages of BIS/ISI. Trade tools specifications. Introduction to National Electrical Code-2011. (02 hrs.)
		15. Operations of allied trade tools. (05 Hrs.) 16. Workshop practice on filing and hacksawing. (05Hrs.)	Allied trades: Introduction to fitting tools, safety precautions. Description of files, hammers, chisels hacksaw frames, blades, their specification and grades. Types of drills, description & drilling machines. (02 hrs.)
Professional Skill 95 Hrs.; Professional Knowledge 20 Hrs.	Prepare electrical wire joints, carry out soldering, crimping and measure insulation resistance of underground cable. **(NOS: PSS/N0108)**	17. Prepare terminations of cable ends (03 hrs.) 18. Practice on skinning, twisting and crimping. (08 Hrs.) 19. Identify various types of cables and measure conductor size using SWG and micrometer. (06Hrs.)	Fundamentals of electricity, definitions, units & effects of electric current. Conductors and insulators. Conducting materials and their comparison. (06 hrs.)
		20. Make simple twist, married, Tee and western union joints. (15 Hrs.)	Joints in electrical conductors. Techniques of soldering.

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		21. Make britannia straight, britannia Tee and rat tail joints. (15Hrs.) 22. Practice in Soldering of joints / lugs. (12 Hrs.)	Types of solders and flux. (07 hrs.)
		23. Identify various parts, skinning and dressing of underground cable. (10Hrs.) 24. Make straight joint of different types of underground cable. (10Hrs.) 25. Test insulation resistance of underground cable using megger. (06 hrs.) 26. Test underground cables for faults and remove the fault. (10Hrs.)	Underground cables: Description, types, various joints and testing procedure. Cable insulation & voltage grades Precautions in using various types of cables. (07 hrs.)
Professional Skill 160 Hrs.; Professional Knowledge 36 Hrs.	Verify characteristics of electrical and magnetic circuits. **(NOS: PSS/N6001, PSS/N6003)**	27. Practice on measurement of parameters in combinational electrical circuit by applying Ohm's Law for different resistor values and voltage sources and analyse by drawing graphs. (08 Hrs.) 28. Measure current and voltage in electrical circuits to verify Kirchhoff's Law (08Hrs.) 29. Verify laws of series and parallel circuits with voltage source in different combinations. (05Hrs.) 30. Measure voltage and current against individual resistance in electrical circuit (05hrs.) 31. Measure current and voltage and analyse the effects of shorts and opens in series circuit. (05 Hrs.) 32. Measure current and voltage and analyse the effects of shorts and opens in parallel circuit. (05 Hrs.)	Ohm's Law; Simple electrical circuits and problems. Kirchoff's Laws and applications. Series and parallel circuits. Open and short circuits in series and parallel networks.(04 hrs.)
		33. Measure resistance using voltage drop method. (03Hrs.) 34. Measure resistance using wheatstone bridge. (02 Hrs.) 35. Determine the thermal effect of electric current. (03Hrs.) 36. Determine the change in resistance due to temperature. (02Hrs.) 37. Verify the characteristics of series parallel combination of resistors. (03Hrs.)	Laws of Resistance and various types of resistors. Wheatstone bridge; principle and its applications. Effect of variation of temperature on resistance. Different methods of measuring the values of resistance. Series and parallel combinations of resistors. (04 hrs.)
		38. Determine the poles and plot the field of a magnet bar. (05Hrs.) 39. Wind a solenoid and determine the magnetic effect of electric current. (05Hrs.)	Magnetic terms, magnetic materials and properties of magnet. Principles and laws of electro-magnetism. Self and mutually induced EMFs.

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		40. Determine direction of induced emf and current. (03hrs.) 41. Practice on generation of mutually induced emf. (03hrs.) 42. Measure the resistance, impedance and determine inductance of choke coils in different combinations. (05Hrs.) 43. Identify various types of capacitors, charging / discharging and testing. (05 Hrs.) 44. Group the given capacitors to get the required capacity and voltage rating. (05 Hrs.)	Electrostatics: Capacitor- Different types, functions, grouping and uses. (08 hrs.)
		45. Measure current, voltage and PF and determine the characteristics of RL, RC and RLC in AC series circuits. (06Hrs.) 46. Measure the resonance frequency in AC series circuit and determine its effect on the circuit. (05hrs.) 47. Measure current, voltage and PF and determine the characteristics of RL, RC and RLC in AC parallel circuits. (06Hrs.) 48. Measure the resonance frequency in AC parallel circuit and determine its effects on the circuit. (05hrs.) 49. Measure power, energy for lagging and leading power factors in single phase circuits and compare characteristic graphically. (06Hrs.) 50. Measure Current, voltage, power, energy and power factor in three phase circuits. (05hrs.) 51. Practice improvement of PF by use of capacitor in three phase circuit.(03Hrs.)	Inductive and capacitive reactance, their effect on AC circuit and related vector concepts. Comparison and Advantages of DC and AC systems. Related terms frequency, Instantaneous value, R.M.S. value Average value, Peak factor, form factor, power factor and Impedance etc. Sine wave, phase and phase difference. Active and Reactive power. Single Phase and three-phase system. Problems on A.C. circuits. (10 hrs.)
		52. Ascertain use of neutral by identifying wires of a 3-phase 4 wire system and find the phase sequence using phase sequence meter. (07Hrs.) 53. Determine effect of broken neutral wire in three phase four wire system.(04hrs.) 54. Determine the relationship between Line and Phase values for star and delta connections. (07Hrs.) 55. Measure the Power of three phase circuit for balanced and unbalanced loads. (10Hrs.) 56. Measure current and voltage of two phases in case of one phase is short-circuited in three phase four wire system and compare with healthy system. (07hrs.)	Advantages of AC poly-phase system. Concept of three-phase Star and Delta connection. Line and phase voltage, current and power in a 3 phase circuits with balanced and unbalanced load. Phase sequence meter. (10 hrs.)

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Professional Skill 50 Hrs.; Professional Knowledge 10 Hrs.	Install, test and maintenance of batteries and solar cell. **(NOS: PSS/N6001)**	57. Use of various types of cells. (08 Hrs.) 58. Practice on grouping of cells for specified voltage and current under different conditions and care. (12 Hrs.) 59. Prepare and practice on battery charging and details of charging circuit. (12 Hrs.) 60. Practice on routine, care/ maintenance and testing of batteries. (08 Hrs.) 61. Determine the number of solar cells in series / parallel for given power requirement. (10 Hrs.)	Chemical effect of electric current and Laws of electrolysis. Explanation of Anodes and cathodes. Types of cells, advantages / disadvantages and their applications. Lead acid cell; Principle of operation and components. Types of battery charging, Safety precautions, test equipment and maintenance. Basic principles of Electro-plating and cathodic protection Grouping of cells for specified voltage and current. Principle and operation of solar cell. (10 Hrs.)
Professional Skill 200 Hrs.; Professional Knowledge 42 Hrs.	Estimate, Assemble, install and test wiring system. **(NOS: PSS/N6001)**	62. Identify various conduits and different electrical accessories. (8 Hrs.) 63. Practice cutting, threading of different sizes & laying Installations. (17 Hrs.) 64. Prepare test boards / extension boards and mount accessories like lamp holders, various switches, sockets, fuses, relays, MCB, ELCB, MCCB etc. (25 Hrs.)	I.E. rules on electrical wiring. Types of domestic and industrial wirings. Study of wiring accessories e.g. switches, fuses, relays, MCB, ELCB, MCCB etc. Grading of cables and current ratings. Principle of laying out of domestic wiring. Voltage drop concept. (14 Hrs.)
		65. Draw layouts and practice in PVC Casing-capping, Conduit wiring with minimum to more number of points of minimum 15 mtr length. (15 Hrs.) 66. Wire up PVC conduit wiring to control one lamp from two different places. (15 Hrs.) 67. Wire up PVC conduit wiring to control one lamp from three different places. (15 Hrs.) 68. Wire up PVC conduit wiring and practice control of sockets and lamps in different combinations using switching concepts. (15 Hrs.)	PVC conduit and Casing-capping wiring system. Different types of wiring - Power, control, Communication and entertainment wiring. Wiring circuits planning, permissible load in sub-circuit and main circuit. (14 Hrs.)
		69. Wire up the consumers main board with MCB & DB's switch and distribution fuse box. (15 Hrs.) 70. Prepare and mount the energy meter board. (15 Hrs.) 71. Estimate the cost/bill of material for wiring of hostel/ residential building and workshop. (15 Hrs.)	Estimation of load, cable size, bill of material and cost. Inspection and testing of wiring installations. Special wiring circuit e.g. godown, tunnel and workshop etc. (14 Hrs.)

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		72. Practice wiring of hostel and residential building as per IE rules. (15 Hrs.) 73. Practice wiring of institute and workshop as per IE rules. (15 Hrs.) 74. Practice testing / fault detection of domestic and industrial wiring installation and repair. (15Hrs.)	
Professional Skill 25 Hrs.; Professional Knowledge 07 Hrs.	Plan and prepare Earthing installation. **(NOS: PSS/N6002)**	75. Prepare pipe earthing and measure earth resistance by earth tester / megger. (10 Hrs.) 76. Prepare plate earthing and measure earth resistance by earth tester / megger. (10 Hrs.) 77. Test earth leakage by ELCB and relay. (5 Hrs.)	Importance of Earthing. Plate earthing and pipe earthing methods and IEE regulations. Earth resistance and earth leakage circuit breaker. (5 Hrs.)
Professional Skill 45Hrs.; Professional Knowledge 10Hrs.	Plan and execute electrical illumination system and test. **(NOS: N/A)**	78. Install light fitting with reflectors for direct and indirect lighting. (10 Hrs.) 79. Group different wattage of lamps in series for specified voltage. (5 Hrs.) 80. Practice installation of various lamps e.g. fluorescent tube, HP mercury vapour, LP mercury vapour, HP sodium vapour, LP sodium vapour, metal halide etc. (18 Hrs.) 81. Prepare decorative lamp circuit to produce rotating light effect/running light effect. (6 Hrs.) 82. Install light fitting for show case lighting. (6 Hrs.)	Laws of Illuminations. Types of illumination system. Illumination factors, intensity of light. Type of lamps, advantages/ disadvantages and their applications. Calculations of lumens and efficiency. (10 hrs.)
Professional Skill 50 Hrs.; Professional Knowledge 08 Hrs.	Select and perform measurements using analog / digital instruments and install/ diagnose smart meters. **(NOS: PSS/N1707)**	83. Practice on various analog and digital measuring Instruments. (5 Hrs.) 84. Practice on measuring instruments in single and three phase circuits e.g. multi-meter, Wattmeter, Energy meter, Phase sequence meter and Frequency meter etc. (12Hrs.) 85. Measure power in three phase circuit using two wattmeter methods. (8 Hrs.) 86. Measure power factor in three phase circuit by using power factor meter and verify the same with voltmeter, ammeter and wattmeter readings. (10Hrs.) 87. Measure electrical parameters using tong tester in three phase circuits. (08Hrs.) 88. Demonstrate Smart Meter, its physical components and Communication components. (03 Hrs.) 89. Perform meter readings, install and diagnose smart meters. (04 Hrs.)	Classification of electrical instruments and essential forces required in indicating instruments. PMMC and Moving iron instruments. Measurement of various electrical parameters using different analog and digital instruments. Measurement of energy in three phase circuit. Automatic meter reading infrastructures and Smart meter. Concept of Prosumer and distributed generation. Electrical supply requirements of smart meter, Detecting/clearing the tamper notifications of meter. (08 hrs.)

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Professional Skill 25 Hrs.; Professional Knowledge 05Hrs.	Perform testing, verify errors and calibrate instruments. **(NOS: N/A)**	90. Practice for range extension and calibration of various measuring instruments. (10 Hrs.) 91. Determine errors in resistance measurement by voltage drop method. (8 hrs) 92. Test single phase energy meter for its errors. (7 Hrs.)	Errors and corrections in measurement. Loading effect of voltmeter and voltage drop effect of ammeter in circuits. Extension of range and calibration of measuring instruments. (05 hrs.)
Professional Skill 75 Hrs.; Professional Knowledge 10 Hrs.	Plan and carry out installation, fault detection and repairing of domestic appliances. **(NOS: PSS/N6003)**	93. Dismantle and assemble electrical parts of various electrical appliances e.g. cooking range, geyser, washing machine and pump set. (25 Hrs.) 94. Service and repair of electric iron, electric kettle, cooking range and geyser. (12 Hrs.) 95. Service and repair of induction heater and oven. (10 Hrs.) 96. Service and repair of mixer and grinder. (10 Hrs.) 97. Service and repair of washing machine. (13Hrs.)	Working principles and circuits of common domestic equipment and appliances. Concept of Neutral and Earth. (10 hrs.)
Professional Skill 75 Hrs.; Professional Knowledge 12 Hrs.	Execute testing, evaluate performance and maintenance of transformer. **(NOS: PSS/N2406, PSS/N2407)**	98. Verify terminals, identify components and calculate transformation ratio of single-phase transformers. (8 Hrs.) 99. Perform OC and SC test to determine and efficiency of single-phase transformer. (12Hrs.) 100 Determine voltage regulation of single-phase transformer at different loads and power factors. (12 Hrs.) 101 Perform series and parallel operation of two single phase transformers. (12 Hrs.) 102 Verify the terminals and accessories of three phase transformer HT and LT side. (6Hrs.)	Working principle, construction and classification of transformer. Single phase and three phase transformers. Turn ratio and e.m.f. equation. Series and parallel operation of transformer. Voltage Regulation and efficiency. Auto Transformer and instrument transformers (CT & PT). (12 Hrs.)
		103Perform 3 phase operation (i) delta-delta, (ii) delta-star, (iii) star-star, (iv) star-delta by use of three single phase transformers. (6 Hrs.) 104Perform testing of transformer oil. (6 Hrs.) 105Practice on winding of small transformer. (8 Hrs.) 106Practice of general maintenance of transformer. (5 Hrs.)	Method of connecting three single phase transformers for three phase operation. Types of Cooling, protective devices, bushings and termination etc. Testing of transformer oil. Materials used for winding and winding wires in small transformer. (06 Hrs.)

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Visit various sections of the institute and location of electrical installations

Objectives: At the end of this exercise you shall be able to
- **visit the various sections/trade in your ITI and draw the layout of your ITI**
- **record the telephone numbers of the ITI office, hospitals, police station and fire station**
- **draw the layout of your section**
- **identify the locations that have electrical installations.**

PROCEDURE

TASK 1: **Visit various sections of the ITI and draw the layout of your ITI**

Instructor will lead the new trainees to various sections of the ITI.

1 Visit the various sections in your ITI and identify the sections of the ITI. List the trades and record it in your note book.

2 Collect the information about the staff members in each trade.

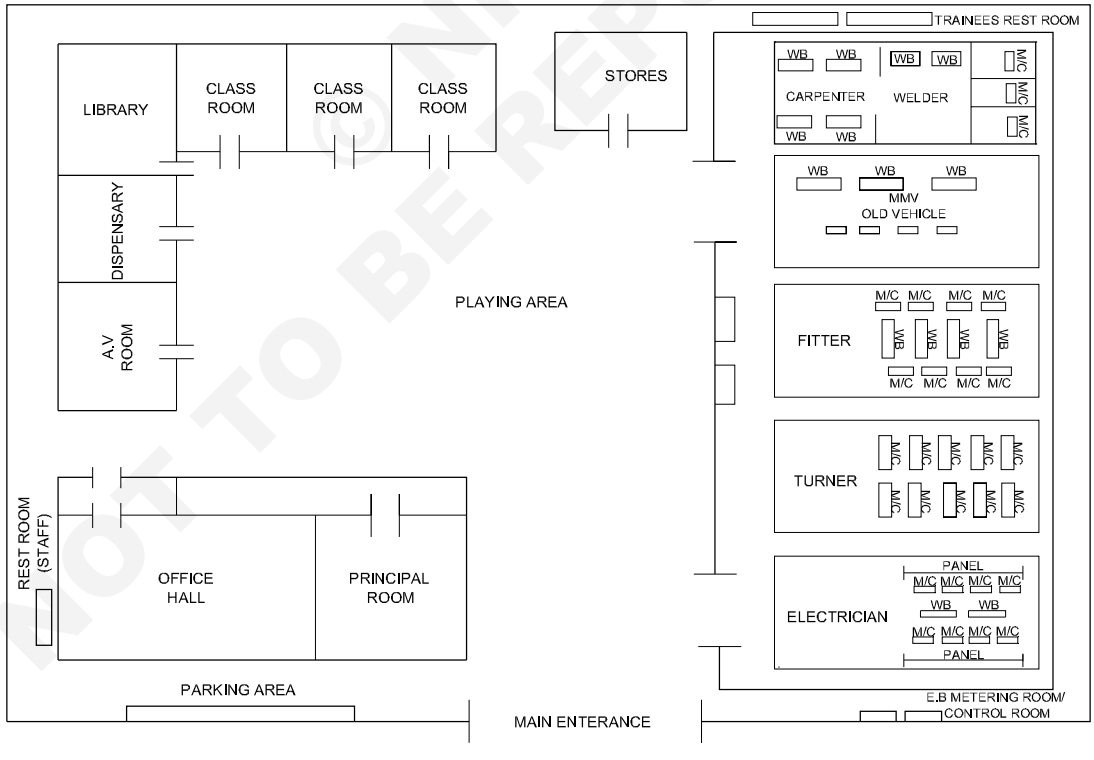
3 Identify the location of the ITI with details about the railway and bus stations in the locality and note down the list of bus route numbers which ply near the ITI.

4 Collect the telephone numbers of the ITI office, nearest hospitals, nearest police station and the nearest fire station and record.

5 Draw the layout of your ITI showing various trades.

Note :A Sample layout of the ITI (Fig 1) is given for your reference. Now draw the new layout of your ITI, with the trades/sections.

Fig 1



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TASK 2: **Draw the layout of your section in the ITI**

1 Draw the plan of your section to a suitable scale in a separate sheet of paper (A4 size).

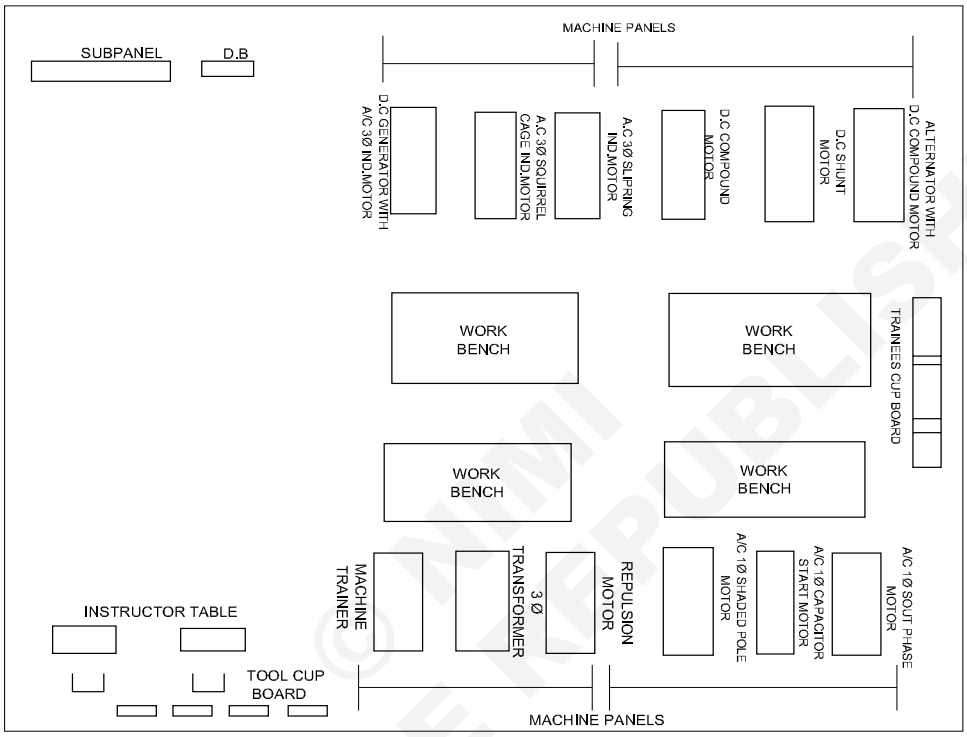
2 Take the length and the breadth measurements of machine foundations, work benches, panels, wiring cubicles, doors, windows, furniture, etc.

3 Draw the layout of the machines, work benches, panels and furniture.

The section plan should be in the same scale as in step 1 as per the actual placement of the machine foundations, panels, furniture, work benches etc.

Note : The sample layout of a typical electrician trade section is given for your reference (Fig 2). You have to draw your section's is layout using the sample as reference.

Fig 2



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TASK 3: **Identify the locations of Power installations**

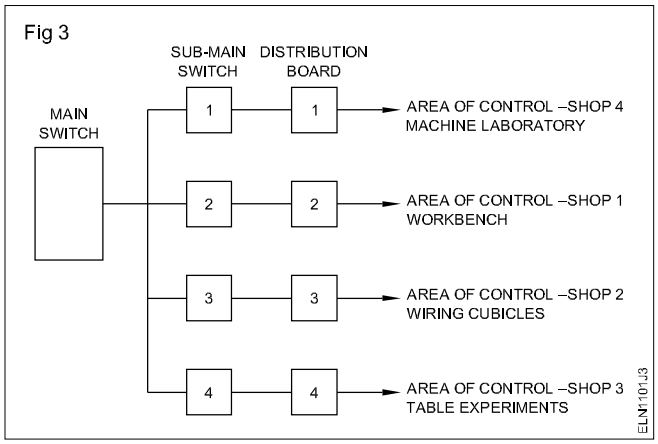
1 Identify the main switch and mark its position in the layout. (Fig 3)

2 Identify each of the sub-main switches, the area of control in the section and mark them on the layout.

3 Identify 3 or 4 spots in various locations of the electrician sections layout and identify the respective sub-main switches.

4 Practice switching 'off' the control switches, depending upon the area of control,imagining that victim are etectrocuted in a specific location/spot.

Fig 3



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Identify safety symbols and hazards

Scan the QR Code to view the video for this exercise

Objectives: At the end of this exercise you shall be able to
- **identify the safety symbols from the chart and their basic categories**
- **write their meaning and description mentioning where they are used**
- **read and interpret different types of occupational hazards from the chart.**

Requirements

Materials

- Basic safety signs chart - 1 No.
- Road safety signs and traffic signal chart - 1 No.
- Occupational hazards chart - 1 No.

PROCEDURE

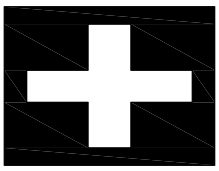
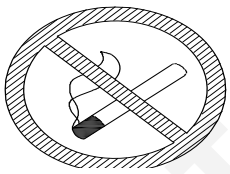
TASK 1: **Identify safety symbols and interpret what they mean with the help of their colour and shape**

Instructor may provide charts with various safety signs for the road safety signs in traffic signals. Then, explain the categories meaning and colour. Ask the trainees to identify the signs and record it in Table 1.

1 Identify the signs and their categories from the chart.

2 Write the name, categories, meaning and description of each sign and its place of use in Table 1.

Table 1

No.	Safety signs	Name of the sign and category	Place of use
1			
2			
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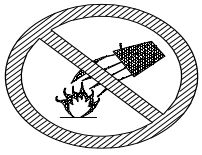
5			

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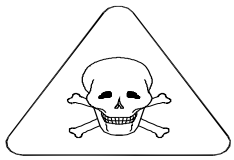
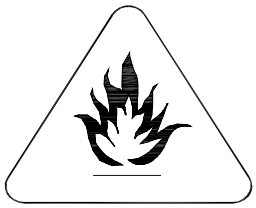
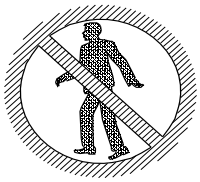
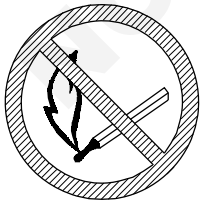
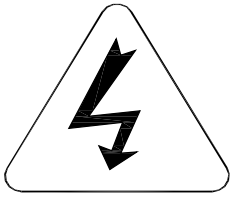
No.	Safety signs	Name of the sign and category	Place of use
6			
7			
8			
9			
10			
11			
12			
13			

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TASK 2 : **Read and interpret the different types of personal protective equipment (PPE) from the chart**

Instructor may brief the various types of occupational hazards and their causes.

1 Identify the occupational hazard matching it to the corresponding situation with the given potential in Table 2.

2 Complete the details and get it checked by your instructor.

Table 2

Sl.No.	Source or potential harm	Type of occupational hazard
1	Noise	
2	Explosive	
3	Virus	
4	Sickness	
5	Smoking	
6	Non-control device	
7	No earthing	
8	Poor housekeeping	

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Preventive measures for electrical accidents and practice steps to be taken in such accidents

Scan the QR Code to view the video for this exercise

Objectives: At the end of this exercise, you shall be able to
- **practice and follow preventive safety rules to avoid electrical accidents**
- **rescue the electric shock victim.**

Requirements

Materials

- Heavy insulated screwdriver 200 mm - 1 No.
- Electrical safety chart (or) display - 1 No.
- Gloves - 1 No.
- Rubber mat - 1 No.
- Wooden stool - 1 No.
- Ladder - 1 No.
- Safety belt - 1 No.

PROCEDURE

TASK 1: **Practice and follow preventive safety rules to avoid electrical accidents**

1 Do not work on live circuits. If unavoidable use rubber gloves or rubber mats.

2 Do not touch bare conductors.

3 Stand on a wooden stool or an insulated ladder while repairing live Power circuits/appliances or replacing fused bulbs.

4 Stand on rubber mats while working, operating switch panels, control gears, etc.

5 Always use safety belts while working on poles or high-rise points.

6 Use screwdrivers with wooden or PVC insulated handle when working on electrical circuits.

7 Replace (or) remove fuses only after switching off the circuit switches.

8 Do not stretch your hands towards any moving part of the rotating machine and around moving shafts.

9 Do not connect earthing to the water supply Power lines.

10 Discharge static voltage in HV lines/equipment and capacitors before working on them.

11 Keep the workshop floor clean and tools in good condition.

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TASK 2 : **Rescue the electic shock victim**

1 Switch OFF the power or remove the plug or wrench the cable free.

2 Move the victim from contact with the live conductor by using dry non-conducting materials like wooden bars. (Fig 1 & 2)

Avoid direct contact with the victim. Wrap your hands with dry material if rubber gloves are not available. If you are uninsulated, do not touch the victim with your bare hands.

3 Keep the patient warm and at mental rest.

Ensure that there is good air circulation. Seek help to shift the patient to a safer place. If the victim is aloft, take steps to prevent him from falling.

4 Loosen the clothing near the neck, chest and waist and place the victim in a relaxed position, if the victim is unconscious.

5 Keep the victim warm and comfortable. (Fig 3)

6 Send someone to call the doctor, in case of electric burns.

If the victim has Power burns due to shock, it may be very painful and is dangerous. If a large area of the body is burnt do not give treatment. Give first-aid as given in step 8

7 Cover the burnt area with pure running water.

8 Clean the burnt area using a clean cloth/cotton.

In case of severe bleeding

9 Lay the patient flat.

10 Raise the injured part above the body level. (If possible)

11 Apply pressure on the wound, as long as necessary, to stop the bleeding. (Fig 4)

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Fig 1

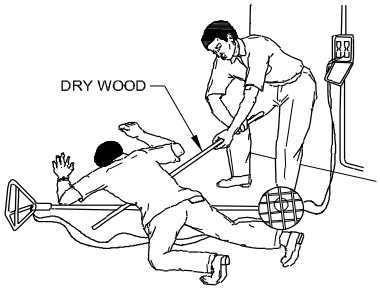

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Fig 2

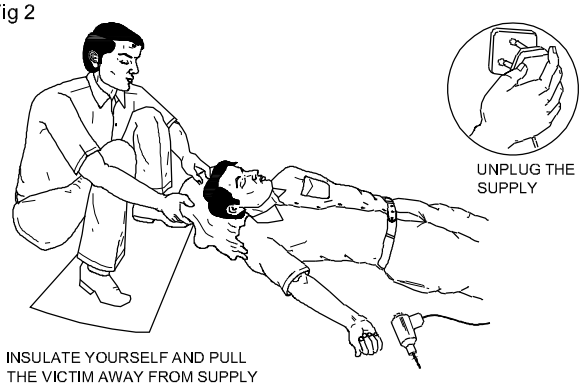

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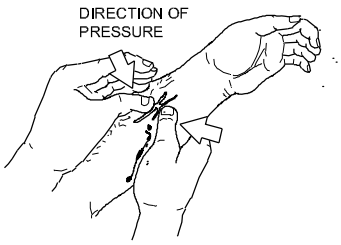
Fig 3

ELN1103H3

Fig 4



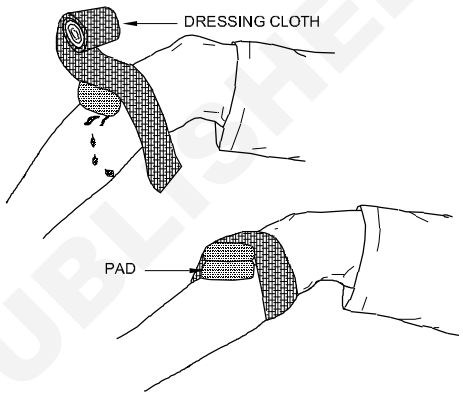
ELN1103H4

12 cover the injured area with a clean pad and bandage firmly, if it is a large wound. (Fig 5)

If bleeding is severe, use more than one dressing.

13 initiate right methods of artificial respiration, if the person is unconscious

Fig 5



ELN1103H5

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Practice safe methods of fire fighting in case of electrical fire

Scan the QR Code to view the video for this exercise

Objectives: At the end of this exercise you shall be able to
- **demonstrate the ability of fire-fighting during electrical fire**
- **as a member of the fire-fighting team**
- **as a leader of the group.**

Requirements

Equipment/Machines

- Fire extinguishers- CO_2 - 1 No.

PROCEDURE

General procedure to be adopted during electrical fire

1 Raise an alarm. Follow the methods given below to raise an alarm signals when the fire breakes out.
   - – Raise your voice and shout Fire! Fire! to draw attention.
   - – Run towards fire alarm/bell to activate
   - – Sswitch off the mains (if possible)

2 When you hear the alarm signal:
   - – Stop working
   - – Turn off all machinery and power
   - – Switch off fans/air circulators/exhaust fans. (it's good to switch off the sub-main)

3 If you are not involved in the fire fighting:
   - – Leave the place using the emergency exit.
   - – Evacuate the premises
   - – Assemble at a safe place along with others
   - – Check, if anyone has called the fire services
   - – Close the doors and windows, but do not lock or bolt

As a member of the fire-fighting team

4 If you are involved in fire fighting:
   - – Take instructions to extinguish fire in an organised way.

If taking instructions:
   - – Follow the instructions, and obey. Be safe and do not get trapped.
   - – Do not use your own ideas.

As a leader of the group

If you are giving instructions:
   - – Locate and use co_2 fire extinguisher
   - – Seek for sufficient assistance and inform the fire brigade
   - – Locate locally available suitable means to put out the fire
   - – Judge the magnitude of the fire, Ensure that emergency exit paths are clear with no obstructions and then attempt to evacuate the place. (Remove explosive materials, substances that would easly catch fire.
   - – Put off the fire with assistance identifying people with assigned responsibility for each activity.

5 Report the measures taken to put out the fire, to the authorities concerned.

Detailed reports on the fire accidents, even if they are small accidents, shall help in identification of the causes of the fire. The identified causes shall help in taking preventive measures to avoid similar occurences in the future

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Use of fire extinguishers

Objectives: At the end of this exercise you shall be able to
- **select fire extinguishers according to the type of the fire**
- **operate the fire extinguisher**
- **extinguish the fire.**

Scan the QR Code to view the video for this exercise

Requirements

Equipment/Machines

- Fire extinguishers-CO_2 - 1 No.
- Scissors 100mm - 1 No.
- Cell phone - 1 No.

PROCEDURE

1 Alert people in the surrounding area by shouting fire, fire, fire when you see fire (Fig 1a & b).

2 Inform fire service or arrange to inform them immediately (Fig 1c).

3 Open the emergency exit and ask the people inside the area to go away (Fig 1d).

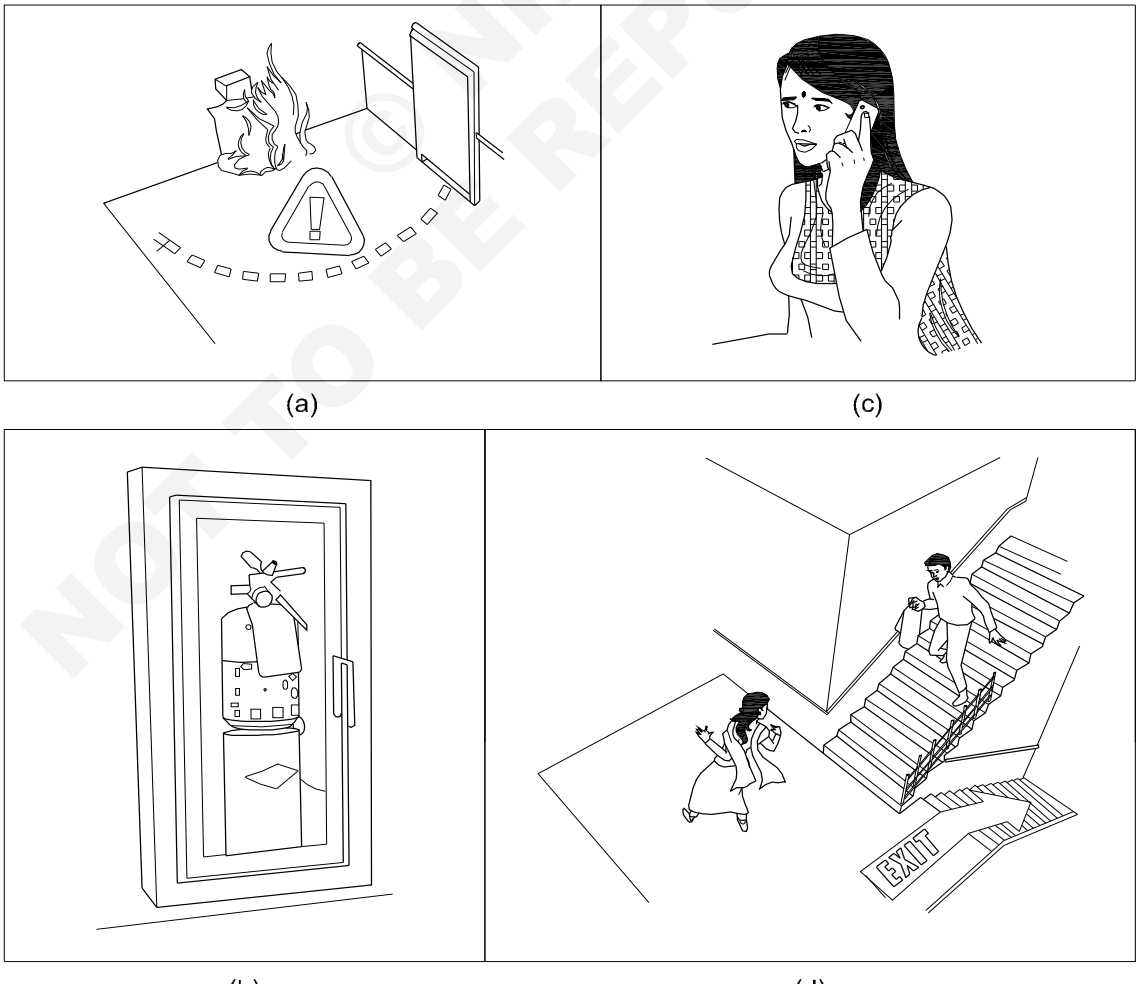
4 Switch "OFF" all electrical supply.

Do not allow people to go near the fire.

5 Analyze to identify the type of fire.

6 Assume that is type D fire (electrical fire).

Fig 1



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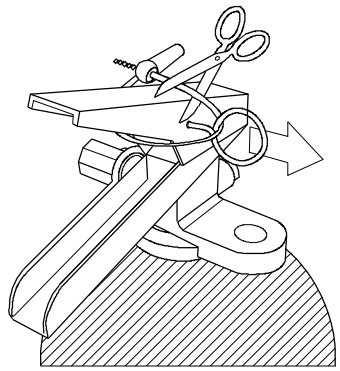
7 Select CO_2 (carbon dioxide) fire extinguisher.

8 Locate and take the CO_2 fire extinguisher. Check for its expiry date.

9 Break the seal. (Fig 2)

Fig 2

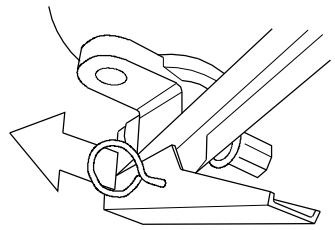


BREACKING OF SEAL

ELI1105-H6

10 Pull the safety pin from the handle. (Fig 3) (the Pin is located at the top of the fire extinguisher.) (Fig 3)

Fig 3



PULLING THE SAFETY PIN

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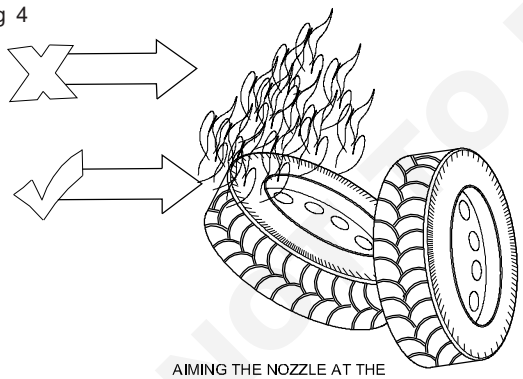
11 Aim the extinguisher nozzle or hose at the base of the fire. (This will remove the source of the fuel fire.) (Fig 4)

Keep your self low.

Fig 4



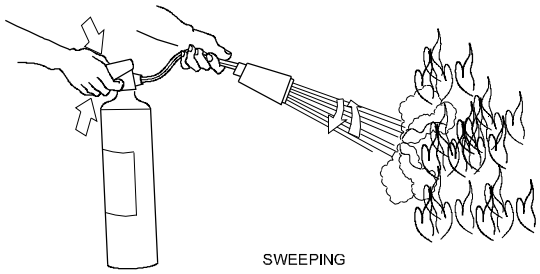
AIMING THE NOZZLE AT THE BASE OF THE FIRE

ELN1105-H8

12 Slowly squeeze the handle lever to discharge the agent.

13 Sweep from side to side approximately 15 cm over the fuel fire until the fire is put off. (Fig 5)

Fig 5



SWEEPING

ELN1105-H9

Fire extinguishers are manufactured for use from a distance.

Caution

- While putting off fire, the fire may flare up.
- Do not panic so long as it is being put off promptly
- If the fire does not respond well even after you have used the fire extinguisher, move away from the fire point.
- Do not attempt to put out a fire when it emits toxic smoke. Leave it to the professionals.
- Remember that your life is more important than the property. So do not take risks.

In order to remember the simple operation of fire extinguisher, remember P.A.S.S.

This will help to use the fire extinguisher.

P for pull

A for aim

S for squeeze

S for sweep

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Practice elementary first aid

Objective : At the end of this exercise you shall be able to
- **prepare the victim for elementary first aid.**

Scan the QR Code to view the video for this exercise

Requirements

Equipment/Materials

- Number of Persons (Instructor can divide the trainees into suitable Number of groups.) - 20 Nos.

PROCEDURE

Assumption: For easy manageability, Instructor may divide the trainees into groups and ask each group to perform one method of resuscitation.

TASK 1: **Prepare the victim before giving first-aid treatment**

1 Loosen the tight clothing as it may interfere with the victim's breathing. (Fig 1)

Fig 1

LOOSENING TIGHT CLOTHING

ELN1106J1

2 Remove any foreign material or false teeth from the victim's mouth and keep the victim's mouth open. (Fig 2)

3 safely bring the victim to the level ground, taking the necessary safety measures. (Fig 3)

Do not waste too much time in loosening the clothes or trying to open the tightly closed mouth.

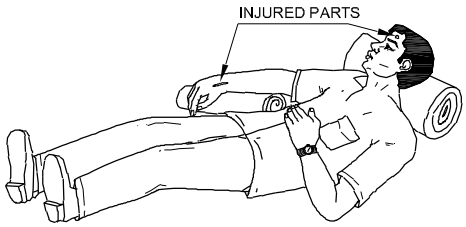
4 Avoid violent operations to prevent injury of the victim's internal parts.

Fig 2

KEEP THE MOUTH OPEN

ELN1106J2

Fig 3



SAFETY ON THE LEVEL GROUND

ELN1106J3

— — — — — —

TASK 2: **Prepare the victim for artifical respiration**

If breathing has stopped, try to provide artifical respiration

1 Send word for professional assistance. (If no other person is available, you stay with the victim and help as best as you can.)

2 Look for visible injury in the body and decide on the suitable method of artificial respiration.

- In the case of injury/burns on the chest and/or belly follow the mouth to mouth method.
- In the case of burn and injury in the back, follow Nelson's method.

3 Place the victim in the correct position before giving artificial respiration.

All actions should be taken immediately.

Delay by even a few seconds may be dangerous.

4 Cover the victim with coat, sacks or improvise with your own method. Help to keep the victim's body warm.

5 Proceed to perform the suitable artifical respiration method.

— — — — — —

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Rescue a person and practice artificial respiration

Objective : At the end of this exercise you shall be able to
- **rescue a victim from electric shock**
- **apply respiratory methods**
  - **Nelson's arm - Lift back method**
  - **Schafer's method**
  - **mouth to mouth method**
  - **mouth to nose method**
  - **revive breathing during cardiac arrest.**

Scan the QR Code to view the video for this exercise

Requirements

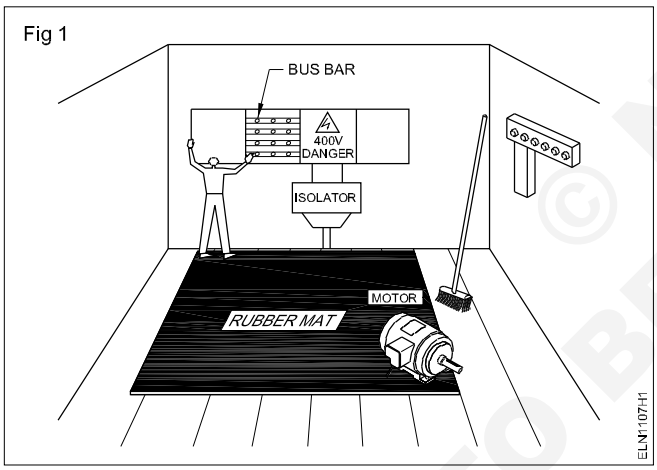
Equipment/Materials

- Control panel arrangement - 1 No.
- Motor - 1 No.
- Rubber mat - 1 No.
- Wooden stick - 1 No.
- 2 persons for demonstration purpose

PROCEDURE

TASK 1**: Rescue a person (mock victim) from live supply (simulated)**

Fig 1



1 Observe the person (mock victim) receiving an electric shock. Interpret the situation quickly.

2 Safely move the victim away from the `live` equipment by disconnecting the supply or using any insulating material. (Fig 1)

Do not run to switch off the supply that is far away.

Do not touch the victim with bare hands until the circuit is made dead or the victim is moved away from the equipment.

Push or pull the victim away from the point of contact of the live equipment, without causing serious injury to the victim.

3 Physically move the victim to a nearby place.

4 Take steps to revive breathing if the victim is unconscious and not breathing.

— — — — — —

TASK 2 : **Revive breathing in the victim by Nelson's arm-Lift back pressure method**

Nelson's arm-lift back pressure method must not be used when there are injuries to the chest and belly.

1 Place the victim with his arms folded with the palms one over the other and the head resting facing the ground with his cheek over the palms.

2 Kneel on one or both knees near the victim's hand.

3 Place your hands on the victim's back beyond the line of the armpits, with your fingers spread outwards and downwards, thumbs just touching as in Fig 2.

4 Gently rock forward keeping your arms straight until they are nearly vertical, and steadily keep pressing the victim's back as shown in Fig 3 to force the air out of the victim's lungs.

5 Synchronise the above movement of rocking back wards with your hands sliding downwards along the victim's arms, and grasp his upper arm just above the elbows as shown in Fig 4. Continue to rock backwards.

6 As you rock back, gently raise and pull the victim's arms towards you as shown in Fig 5 until you feel the tension in his shoulders. To complete the cycle, lower the victim's arms and move your hands up to the initial position.

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Fig 2

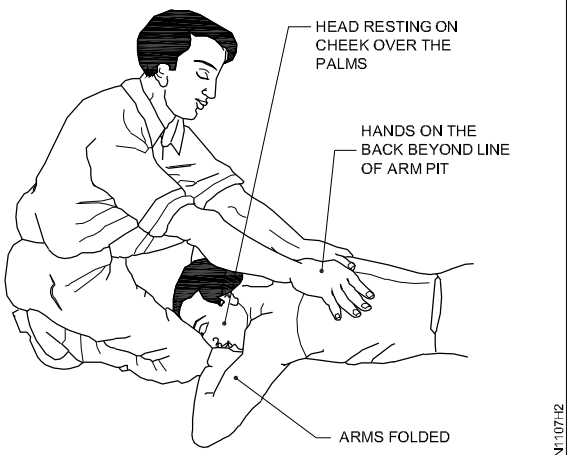


Fig 4

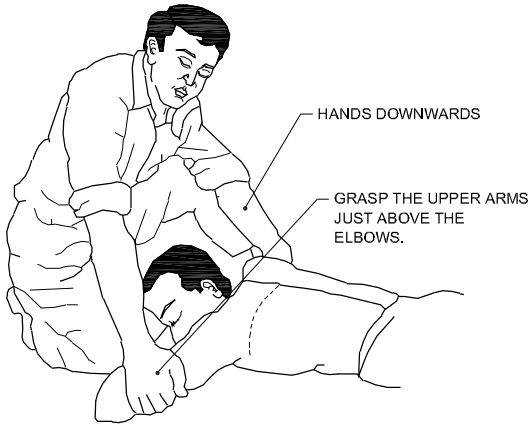


Fig 3

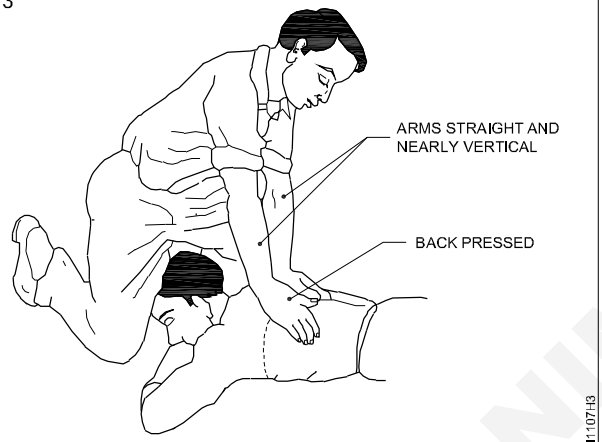
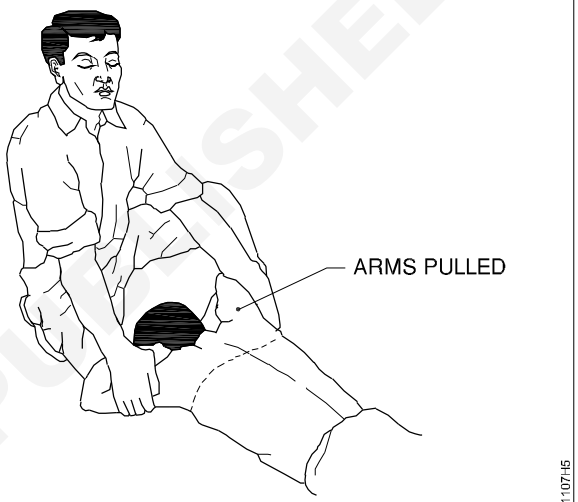


Fig 5



7 Continue artificial respiration till the victim starts to breathe naturally. Please note, in some cases, it may take hours.

8 When the victim revives, keep the victim warm with a blanket, wrapped around him or with hot water bottles or warm bricks. Stimulate blood circulation towards the heart by stroking the insides of the arms and legs.

9 Keep him in the lying position and do not let him exert himself.

Do not give him any stimulant, until he is fully conscious.

— — — — — —

TASK 3 : **Revive breathing in the victim by Schafer's method**

Do not use this method when the victim has injuries on the chest and belly.

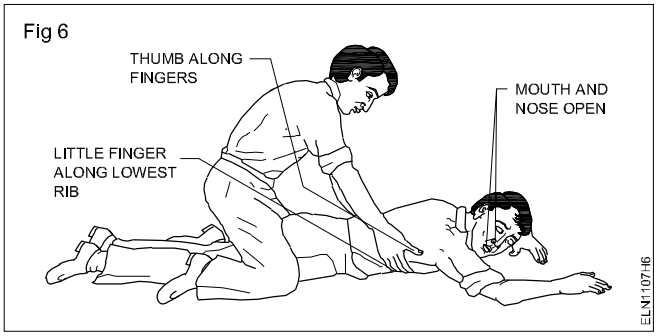
1 Lay the victim on his belly, one arm extended direct forward, the other arm bent at the elbow and with the face turned sideward and resting on the hand or forearm as shown in Fig 6.

2 Kneel when the victim is astride, so that his thighs are between your knees with your fingers and thumbs positioned as in Fig 6.

3 With the arms held straight, slowly swing forward so that the weight of your body is gradually brought to bear upon the lower ribs of the victim to force the air out of the victim's lungs as shown in Fig 7.

4 Now immediately swing backwards removing all the pressure from the victim's body as shown in Fig 8, to allow the lungs to fill with air.

Fig 6



5 After two seconds, swing again forward and repeat the cycle twelve to fifteen times per minute.

6 Continue it till the victim begins to breathe naturally.

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Fig 7

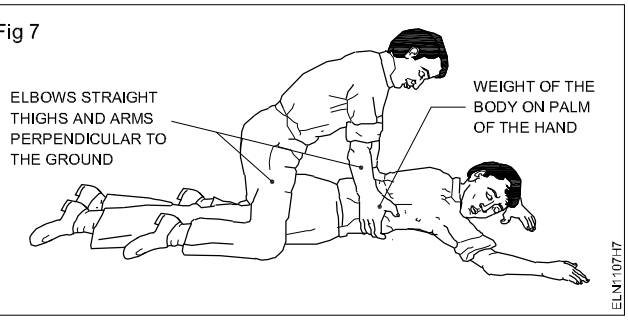
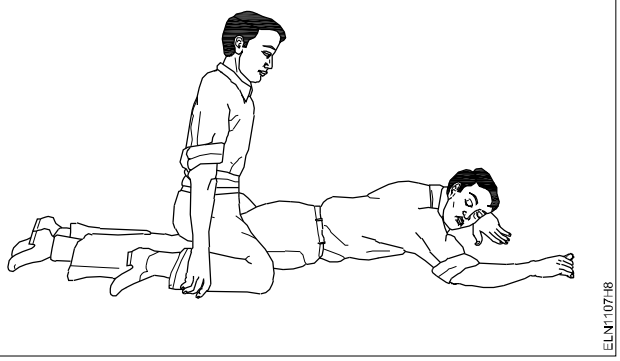


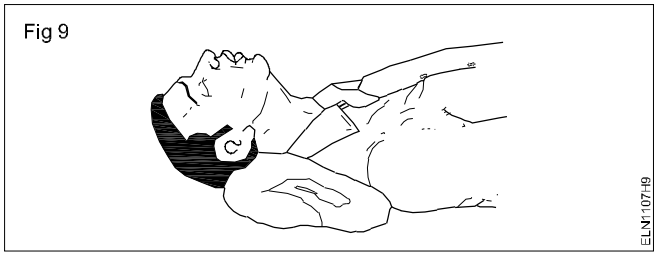
Fig 8



TASK 4: **Revive breathing in the victim by mouth-to-mouth method**

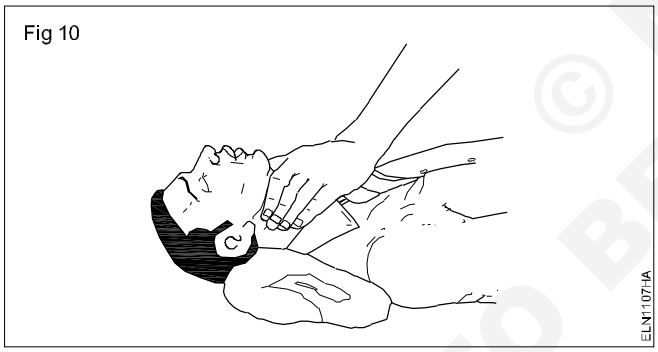
1 Lay the victim flat on his back and place a cloth roll under his shoulders to ensure that his head is thrown well back. (Fig 9)

Fig 9



2 Tilt the victim's head back so that the chin points straight upwards. (Fig 10)

Fig 10



3 Grasp the victim's jaw as shown in Fig 11, and raise it upwards until the lower teeth are higher than the upper teeth you may also place your fingers on both sides of the jaw near the victim's ear lobes and pull upward. Maintain this jaw position throughout the duration to revive respiration to prevent the tongue from blocking the air passage.

4 Take a deep breath and place your mouth over the victim's mouth as shown in Fig 12 making airtight contact. Pinch the victim's nose shut with the thumb and forefinger. If you dislike direct contact, place a porous cloth between your mouth and that of the victim's. For an infant, place your mouth over the infant's mouth and nose. (Fig 12)

Fig 11

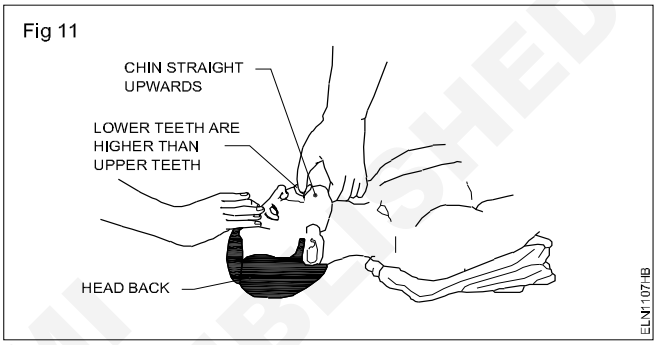
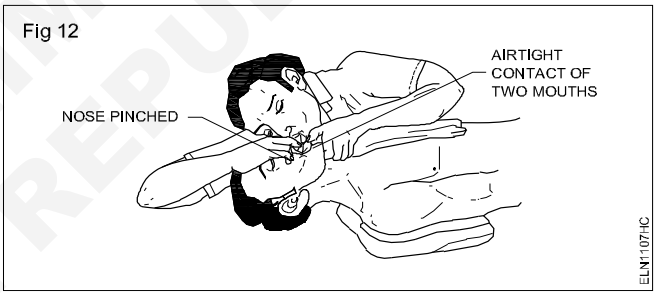


Fig 12



5 Blow into the victim's mouth (gently in the case of an infant) until his chest rises. Remove your mouth and release the hold on the nose, to let him exhale, turning your head to hear gushing the out of air. The first 8 to 10 breathings should be as rapid as the victim responds. Thereafter the rate should be slowed down to about 12 times per victim's minute (20 times for an infant).

If air cannot be blown in, check the position of the victim's head and jaw and recheck the mouth for obstructions. Then, try again more forcefully. If the chest still does not rise, turn the victim's face down and strike his back sharply to dislodge obstructions.

Sometimes air enters the victim's stomach as evidenced is the swelling of the stomach. Expel the air by gently pressing the stomach during the exhalation period.

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Disposal procedure of waste materials

Scan the QR Code to view the video for this exercise

Objectives: At the end of this exercise you shall be able to
- **identify the different type of waste material**
- **segregate the waste materials in the respective bins**
- **sort non-saleable and saleable materials separately and maintain record.**

Requirements

Materials

• Shovel	- 1 No.	• Trolly with wheels	- 3 Nos.
• Plastic/Metal bins	- 4 Nos.	• Brush and gloves	- 1 Pair

PROCEDURE

1 Collect all the waste materials in the workshop.

2 Identify and segregate them like cotton waste, metal chips, chemical waste and electrical waste (Fig 1) separately and label them.

3 Sort waste materials as saleable, non saleable, organic and inorganic materials.

4 Record the sorted waste material and fill Table-1.

Fig 1

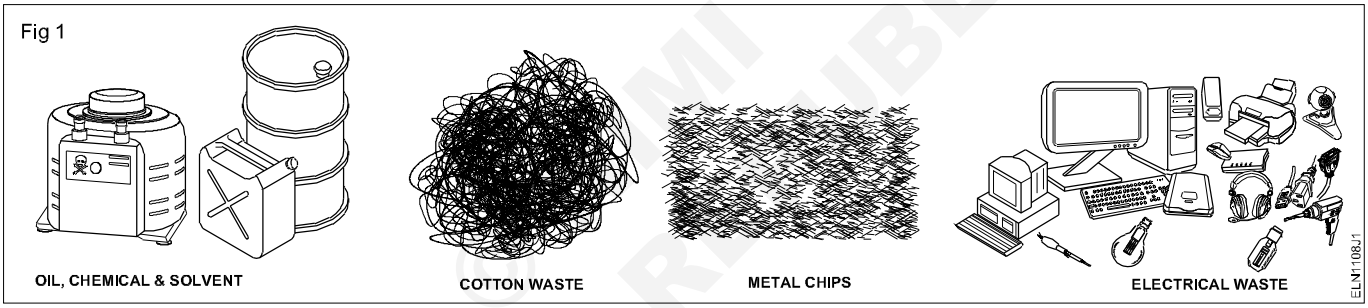

Table-1

Sl.No.	Name of the waste material	Quantity	Saleable or non Saleable
1			
2			
3			
4			
5			
6			

5 Arrange at least 3 trolleys with wheels for disposal. Stick label on each trolly as "Cotton Waste", "Metal Chips" and "others". (Fig 2)

6 Put the cotton waste in the cotton trolly and similarly put the metal chips waste and others in the respective trolleys.

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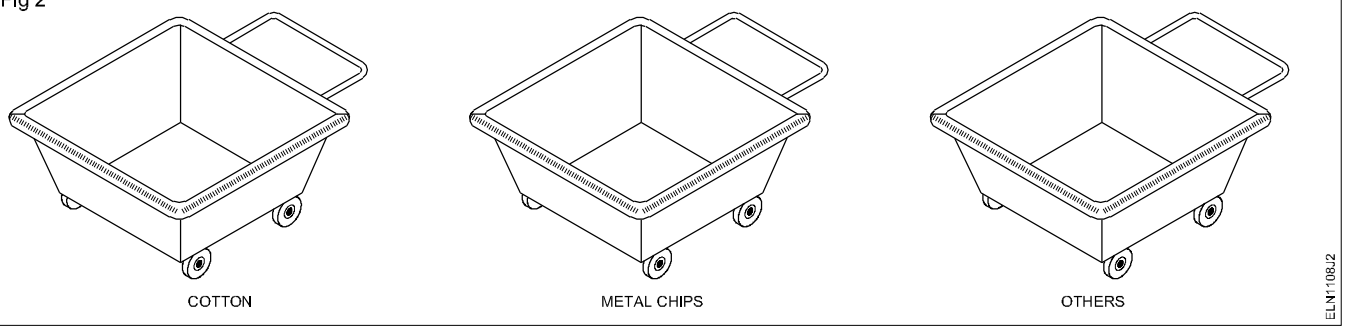
Fig 2



7 Keep 4 more bins to collect saleable scrap, non saleable scrap, organic waste and Inorganic waste and label them. (Fig 3)

Fig 3

— — — — — —

Skill Sequence

Separate the cotton waste and dispose it

Objectives: This shall help you to
- **separate and dispose cotton waste.**

1 Collect the chips by hand shavel with the help of a brush.

2 Clean the floor if oil has been spilt.

Do not handle the chip with bare hand. Separate the chip according to the metal.

3 Separate the cotton waste and store it in the bin provided for the purpose.

4 Store the each category in the assigned bins.

Each bin has respective label.

5 Collect all the saleable material and non salable one seperately and put them in the respective bins.

6 Collect all the non-saleable materials like cotton waste, paper waste, wooden pieces, etc., and keep them in the respective bin as in Fig 3.

7 Check the non-saleable material (organic) and send it for disposal by burning after getting approval.

8 Check the saleable material and segregate like Aluminium, Copper, Iron, Screws, nuts and other items separately and send it to the stores for disposal by auction (or) as per recommended procedure.

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Use of personal protective equipment

Objectives: At the end of this exercise you shall be able to
- **read and interpret different types of Personal Protective Equipment (PPE) from the chart (or) real PPE**
- **identify and name the PPEs corresponding to the type of protection and write their uses.**

Requirements

Tools / Equipment

- Chart showing different types of PPEs - 1 No.
- Real PPEs(available in section) - as required.

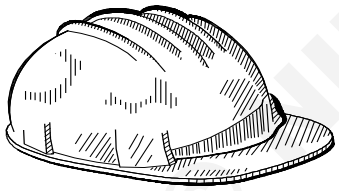
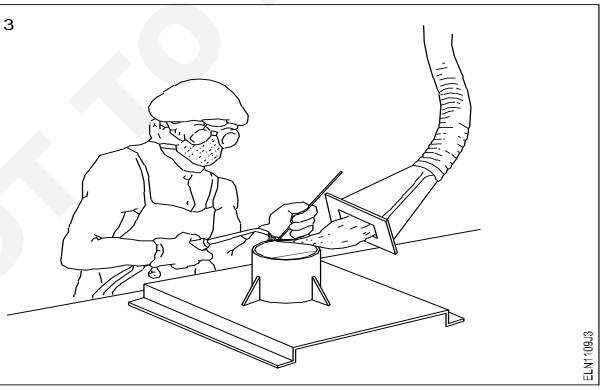
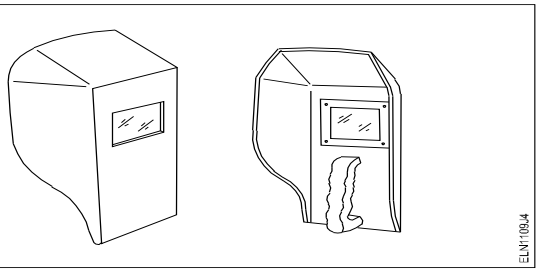
PROCEDURE

Instructor may arrange the available different types of PPEs in the table or provide the chart showing the PPEs. Instrcutor may also explain the types of PPEs and their uses, and the hazards for which each type is used.

1 Identify the different types of PPEs and write their names with the help of the chart and write in Table 1.

2 Write the type of protection and uses in the space provided against each PPE in Table 1.

Table 1

Sl. No.	Sketches	Name of PPE	Type of protection	Uses
1	Fig 1 			
2	Fig 2 			
3	Flg 3 			
4	Flg 4 			

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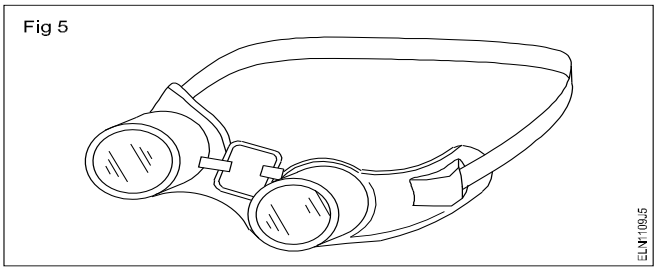
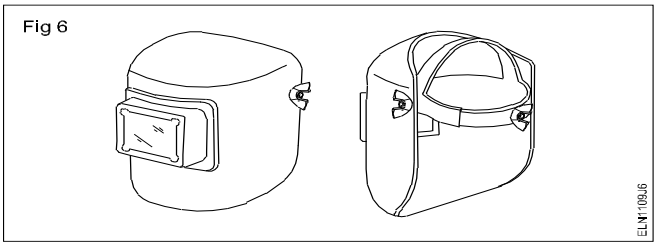
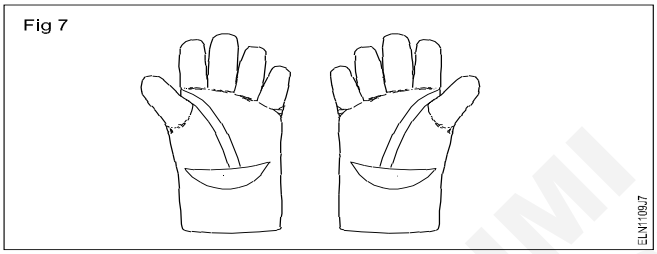
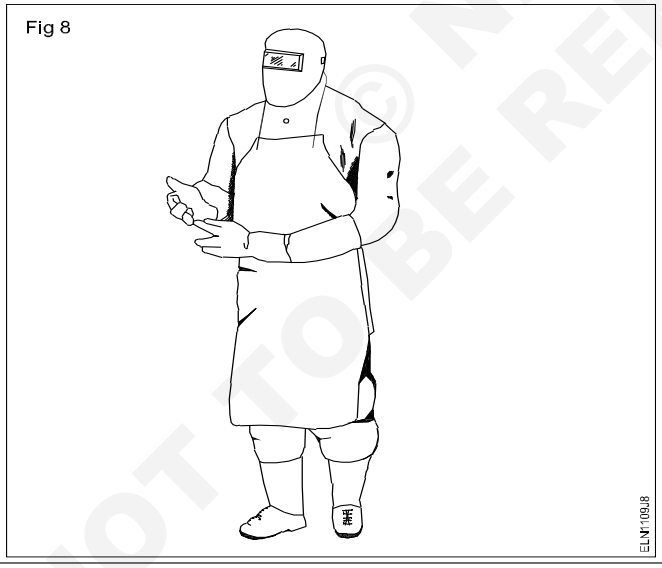
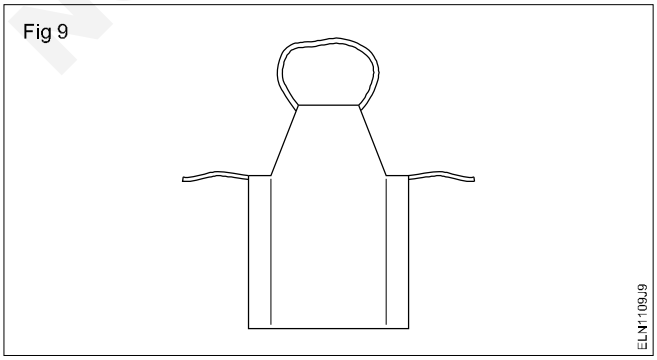
Sl. No.	Sketches	Name of PPE	Type of protection	Uses
5	Fig 5  ELN1109J5			
6	Fig 6  ELN1109J6			
7	Fig 7  ELN1109J7			
8	Fig 8  ELN1109J8			
9	Fig 9  ELN1109J9			

3 Get it checked by your instructor.

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Practice on cleanliness and procedure to maintain it

Objectives: At the end of this exercise you shall be able to
- **identify the places/machinery/equipment that are to be cleaned**
- **collect the cleaning materials/devices required for cleaning**
- **clean the machines/equipment and devices installed in your section.**

Scan the QR Code to view the video for this exercise

Requirements

Tools / Equipment

- Portable vacuum cleaner/blower - 1 No.

Materials

- Emery sheet-'O' grade - 1 No.
- Dusting cloth - as required.
- Dust bin - 3 Nos . (labelled)

PROCEDURE

Switch OFF all the machinery and equipment before starting the cleaning process. Use a mask or cover the mouth and nose.

Instructor has to brief the Japanese 5S concept to the trainees before starting the work.

Sort
Set in order
Shine
Standardise
Sustain

5s - concept

1 Identify the areas/equipment/machine that need to be cleaned.

2 Keep the movable items in one place and group them.

3 Clean the dust carefully, without damaging any part/ connection in the machine / equipment, using a cloth.

4 Use wet dusting cloth on areas that are wired.

5 Remove rust on parts of the equipment (or) devices using an emery sheet.

Do not remove lubricants in the machine while wiping/cleaning.

6 Use vacuum cleaners to suck dust from areas where a brush or cloth cannot help.

7 Collect the waste materials found in the lab and put it in the specified dustbin, as shown in Fig 1.

Dusting and cleaning can be arranged by dividing the trainees into groups under the supervision of the instructor.

8 Clean places where water or oil has been spilt on the floor

Note down abnormal things that you noticed while cleaning and report it to the instructor to take corrective action.

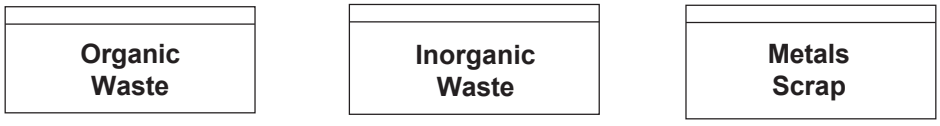
9 Put all the materials and equipment used for cleaning in their respective places.

10 Inspect and ensure that all machines are working after cleaning in the presence of the instructor.

11 Discuss abnormal things that you came across while cleaning with the instructor. Prepare a report if the instructor asks for it

Instructor may assign trainees the responsibilty of cleaning in batches. Disposal of waste may be organised as a routine actvity by coordinating with the stores.

Fig 1



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Identify trade tools and machineries

Objectives : At the end of this exercise you shall be able to
- **identify tools and draw their sketches**
- **identify the machineries in the lab and note down their names.**

Requirements

Tools/Instruments

- Combination plier (150 mm) - 1 No.
- Long nose plier (200 mm) - 1 No.
- Screwdriver (150 mm) - 1 No.
- Firmer chisel (12 mm) - 1 No.
- Ball pein hammer 125gm - 1 No.
- Flat file bastard (250 mm) - 1 No.
- Flat cold chisel15mm X 150mm - 1 No.
- Gimlet (4 mm x 150 mm) - 1 No.
- Centre punch - 1 No.
- Rawl jumper holder with bit No. 8 - 1 No.

Equipment/Machines

- Electric bench grinder - 1 No.

Materials

- Lubricating oil - 100 ml
- Cotton waste - as required.
- Cotton cloth - 0.50 m
- Grease - as required.
- Emery sheet - 1 sheet.

The instructor shall arrange for the necessary tool/equipment from other sections and also arrange for the required materials from scrap for practising the use of tools.

PROCEDURE

TASK 1 : **Identify tools with specification**

Assumption - A set of trainees tool kit and specified tools as given in this exercise are displayed on the workbench. Trainees are required to identify the tools from the specifications given and draw the sketch of the tools in the space allotted for the purpose.

1 Identify the tools from the specification given.
2 Draw a neat sketch against each item.

In case the specifications are different write the correct specification of the items given to you.

3 Get your sketches checked by your instructor.

Table 1

Sl. No.	Name of tool with specification	Sketch of tools
i	Combination plier with pipe grip, side cutter and insulated handle - size 150 mm,	
ii	Long nose pliers 200 mm,	
iii	Screwdriver 150 mm	
iv	Firmer chisel 12 mm	
v	Ball pein hammer 125 gms	
vi	Flat file bastard 250 mm	
vii	Flat cold chisel 15mm X 150mm	
viii	Gimlet 4 mm x 150 mm	
ix	Centre punch	
x	Rawl jumper holder with bit No.8	

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TASK 2: **Identify the machineries installed in the electrician section**

Instructor shall explain the names of the machineries installed in the electrician section and their locations. Then ask the trainees to write the name,and other details of each machine in the section.

1 Write the name and other details of each machine against their names in Table 2.

2 Get it checked by your instructor.

Table-2

Sl. No.	Name of the machine	Name and other details
1	Motor Generator set (A.C. motor with D.C generator)	
2	D.C. Series motor	
3	D.C. Shunt motor	
4	D.C. Compound motor	
5	Motor generator set (D.C. motor with A.C generator)	
6	A.C.Squirrel cage induction motor	
7	A.C Slip ring induction motor	
8	Universal motor	
9	Synchronous motor	
10	Diesel generator set	

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Practice safe methods of lifting and handling of tools and equipment

Objectives: At the end of this exercise you shall be able to
- **demonstrate how to lift and handle heavy equipment during working conditions while**
- **lifting from floor**
- **during lift**
- **carrying**
- **lowering to bench**
- **lifting from bench**
- **lowering to floor.**

Scan the QR Code to view the video for this exercise

Requirements

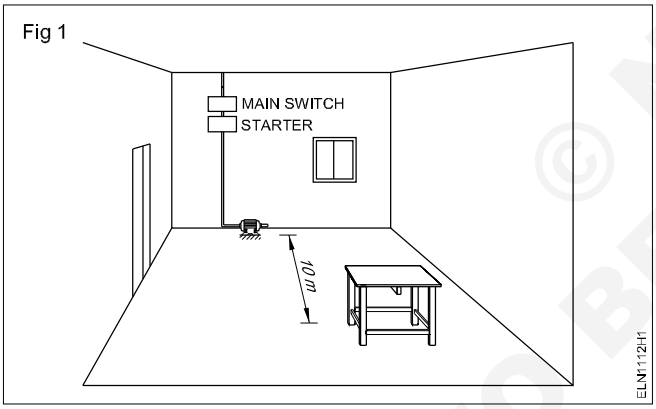
Tools and equipment

- Single phase one HP 240V/50Hz capacitor start induction motor - 1 No.
- D.E. Spanner set 5 mm to 20 mm - set of 8 - 1 No.
- Work bench or table - 1 No.

PROCEDURE

Instructor has to demonstrate, how to lift and handle heavy equipment and then ask the trainees to practice.

Fig 1



Assume one single phase motor has to be lifted and lowered to be placed on the floor. (Fig 1)

1 Switch OFF the motor and remove the fuse carriers.

Ensure that the equipment is disconnected from power supply and that the base plate nuts of the motor have been removed.

2 Ensure that you know the position where the equipment is to be placed.

3 Assess whether you need any assistance to carry the equipment.

4 Check for clear route to the location where the motor is to be placed. Remove obstacles, if any.

5 Position yourself close to the equipment to be lifted.

6 Lift the equipment from the floor using the correct posture.

7 Carry the equipment to the work bench safely, keeping the equipment close to your body.

8 place the equipment carefully on the bench, and adjust it to the correct position.

Assume that the overhauling work is over and the motor is to be placed in its orginal place.

9 Lift the equipment correctly with a firm grip.

10 Carry the equipment to its original place.

11 Safely lower the equipment with your feet apart, knees bent, back straight and arms close to your body.

12 Safely place the equipment on the floor.

If you feel the equipment is too heavy, take help from others.

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Scan the QR Code to view the video for this exercise

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Select proper tools for operation and precautions in operation

Scan the QR Code to view the video for this exercise

Objectives : At the end of this exercise you shall be able to
- **select proper tools for specific uses.**
- **follow care and maintenance and procedures with precaution for each tool.**

Requirements

Tools

- Combination plier - 150 mm - 1 No.
- Flat nose plier 150 mm - 1 No.
- Diagonal cutting plier 150 mm - 1 No.
- Round nose plier 150 mm - 1 No.
- Screw driver 150 mm - 1 No.
- Star-headed screw driver 100 mm - 1 No.
- Neon tester - 1 No.
- Electrician's knife 100 mm - 1 No.
- Try square 150 mm - 1 No.
- Firmer chisel 12 mm - 1 No.
- Tenon saw 300 mm - 1 No.
- Plumb bob - 1 No.
- Centre punch 50 mm - 1 No.
- Cold chisel - 1 No.
- Hacksaw frame with blade - 1 No.
- Portable electric drilling machine - 1 No.

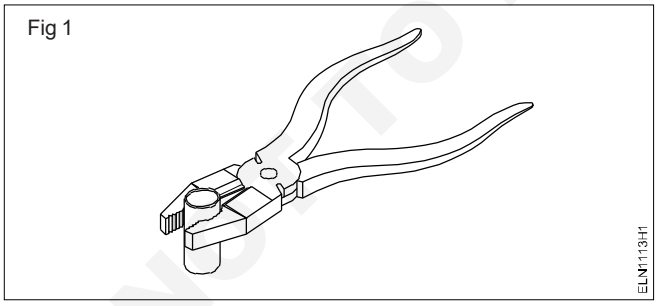
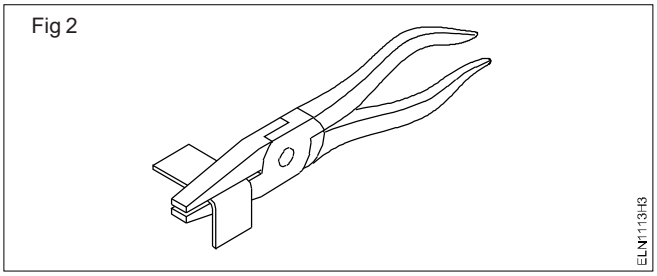
PROCEDURE

TASK 1: **Select the proper tools for specific uses**

1 Identify proper tools for specific uses from Fig 1 to 16 ,

2 Write the uses of each selected tool and the precautions to be followed while handling in Table 1.

Table 1

Tool	Uses/Operation/ used for	Care, Maintenance and Precautions in operation
1 Combination pliers (Fig 1)		
Fig 1 		
2 Pliers - flat nose		
Fig 2 		

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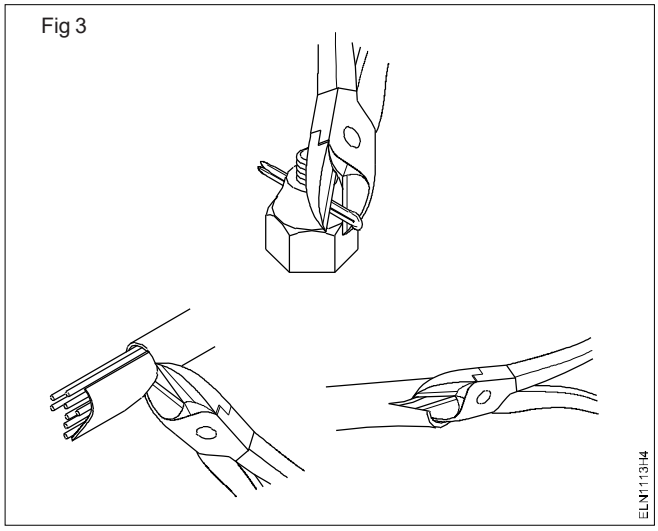
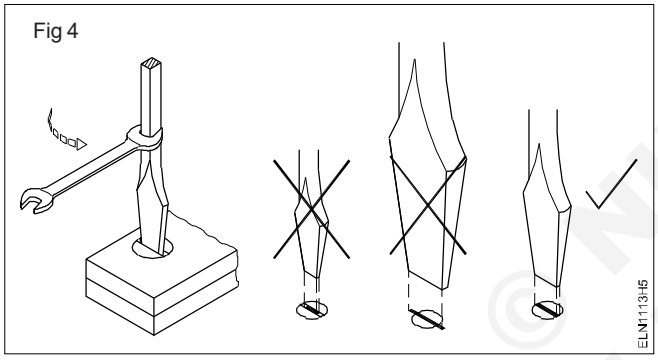
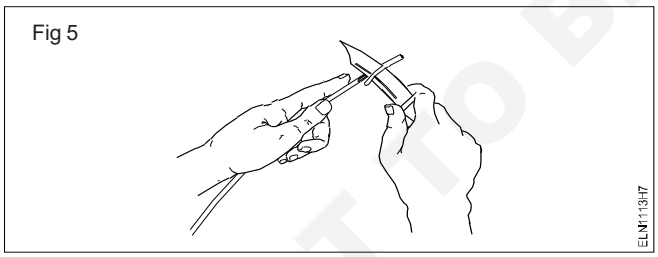
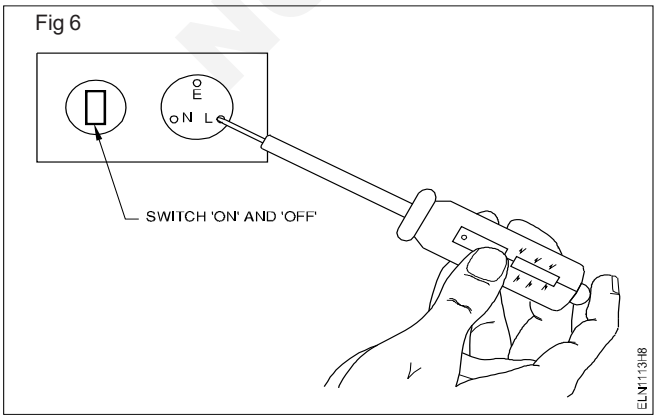
Tool	Uses/Operation used for	Care, Maintenance and Precautions in operation
3 Pliers - diagonal cutting Fig 3  		
4 Screwdriver Fig 4  		
5 Electrician's knife Fig 5  		
6 Neon tester Fig 6  		

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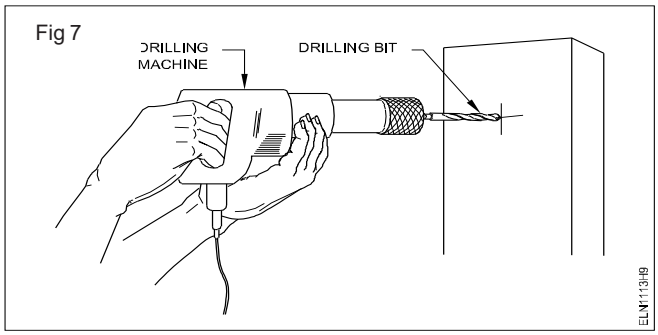
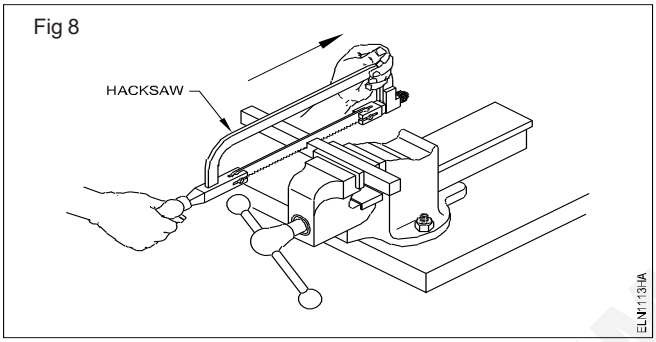
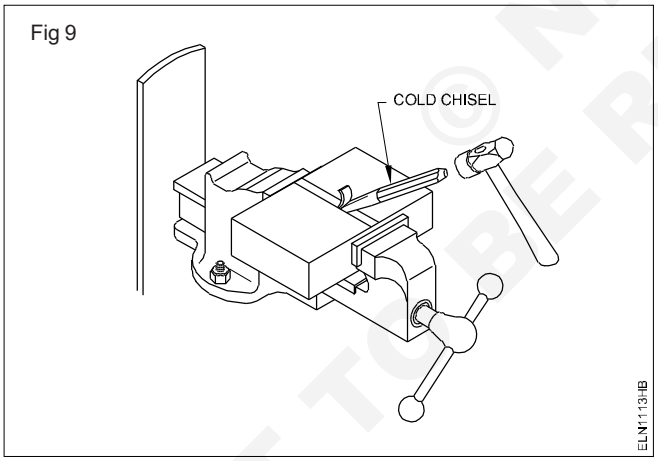
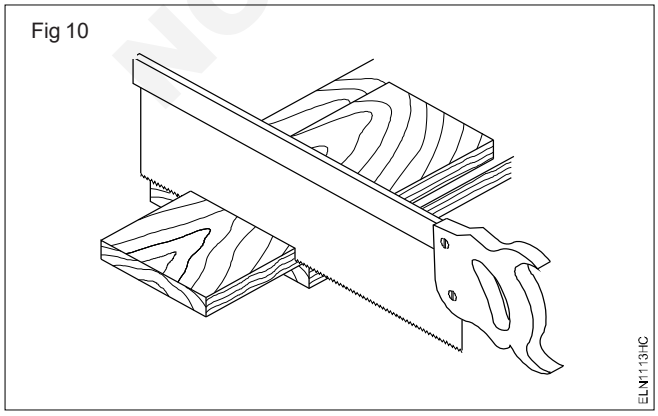
Tool	Uses/Operation used for	Care, Maintenance and Precautions in operation
7 Portable electric drilling machine Fig 7 		
8 Hacksaw Fig 8 		
9 Cold chisel Fig 9 		
10 Tenon saw Fig 10 		

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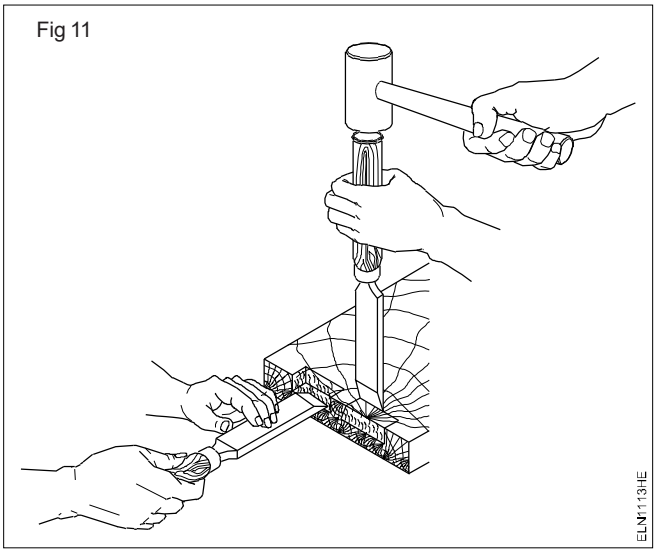
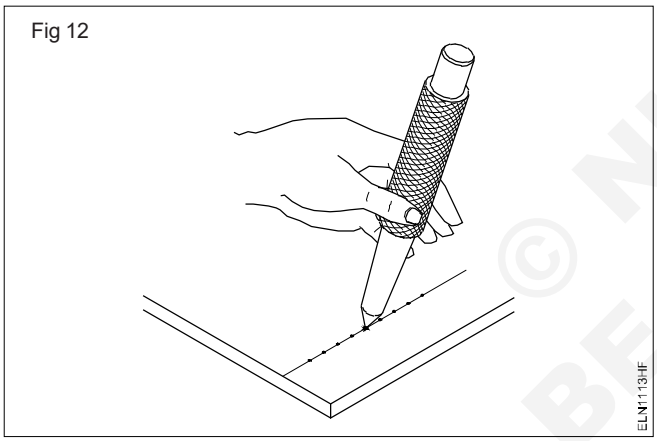
Tool	Uses/Operation	Care, Maintenance and
11 Firmer chisel Fig 11  		
12 Centre punch Fig 12  4 Get it checked by your instructor.		

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Care and maintenance of trade tools

Objective : At the end of this exercise you shall be able to
- **perform care and maintenance of tools.**

Requirements

Tools/Instruments

- Combination plier (150 mm) - 1 Set.
- Long round nose plier (200 mm) - 1 No.
- Screwdriver (150 mm) - 1 No.
- Firmer chisel (12 mm) - 1 No.
- Wood rasp file (250 mm) - 1 No.
- Flat file bastard (250 mm) - 1 No.
- Bradawl (6mm x 150 mm) - 1 No.
- Gimlet (4 mm x 150 mm) - 1 No.
- Ratchet brace (6 mm) - 1 No.
- Rawl jumper holder with bit No. 8 - 1 No.
- Triangular file bastard (150mm) - 1 No.
- Saw tooth setter - 1 No.

Equipment/Machines

- Electric bench grinder - 1 No.

Materials

- Lubricating oil - 100 ml
- Cotton waste - as reqd.
- Cotton cloth - 0.50 m
- Grease - as reqd.
- Emery sheet '00' - 1 sheet.

PROCEDURE

TASK 1: **Perform care and maintenance of tools**

Prevent rust formation

1 Inspect all the tools. If the tools are rusted, use fine emery paper to remove the rust.

While removing rust keep your hands safe from sharp edges. Do not use emery paper on steel rule or tape.

2 Apply a thin coat of oil over the surface of the rusted tool and clean with a cotton cloth.

A hammer should not have any trace of oil on its striking surface.

3 Check and lubricate tools for easy movement of the jaws of the pliers, blades of knives, jaws of wrench, pincers, gears of the hand drilling machine.

4 Apply a drop of oil on the hinged/geared surface, if the movement is hard.

5 Activate the jaws and gears till the muck/grim in the surfaces are cleaned

6 Apply a drop of oil again and clean the tools with a cotton cloth.

Remove the mushroom

7 Check the cold chisel and the hammer's striking face for mushrooms. If you find mushrooms report to your instructor to enable him to remove the mushroom through grinding.

Reshaping the screwdriver tip

8 Check the tips of the flat tipped screwdrivers. If the tip is blunt or disfigured report to the instructor.

Observe how the screwdriver tip is ground to form a perfect cornered tip for effective use.

Sharpen and set the saw-teeth

9 Check the teeth of the Tenon saw.

10 If the saw-teeth are blunt, report to your instructor.

Observe how the saw-teeth is filed to make the saw-teeth sharp.

11 Check the saw-teeth setting.

The teeth of the Tenon saw should be set to be able to alternately remove dust while sawing.

12 If the setting is not proper report to the instructor.

13 Check how the teeth are set by a saw-setter.

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Operations of allied trade tools

Objectives : At the end of this exercise you shall be able to
- **identify fitting, carpenter and sheetmetal tools**
- **write the names, specifications and operations of each tool.**

Requirements

Tools

- Fitter, carpenter and sheetmetal tools - 1 set.

PROCEDURE

Instructor may display the fitter, carpenter and sheetmetal tools (allied trade) on the workbench in the section and demonstrate how to identify the tools, their operation with specifications. Then ask the trainees to record it in Table 1.

TASK 1: **Identify fitter, carpenter and sheetmetal tools and mention their operation/uses**

1 Identify fitter, carpenter and sheetmetal tools provided on the workbench and recognise them with their names.

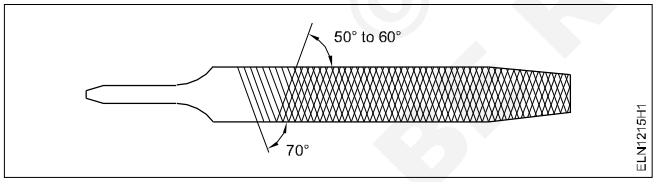
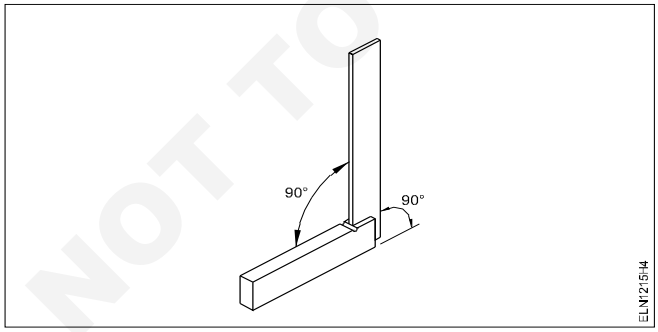
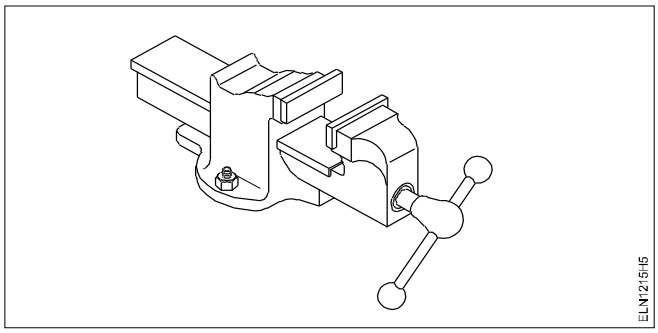
2 Write the name of the tool against the visual shown in Table 1 and mention the specifications.

3 Write the operations / uses of each trade tool.

Fitter	-	Fig 1 to 9
Carpenter	-	Fig 1 to 9
Sheet metal Worker	-	Fig 1 to 4

Table 1

Fitter Tools

Sl. No.	Visual of tool	Name of the tool with specifications	Operation/ uses
1			
2			
3			

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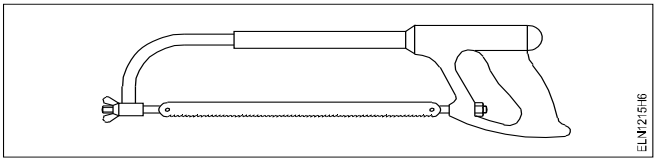
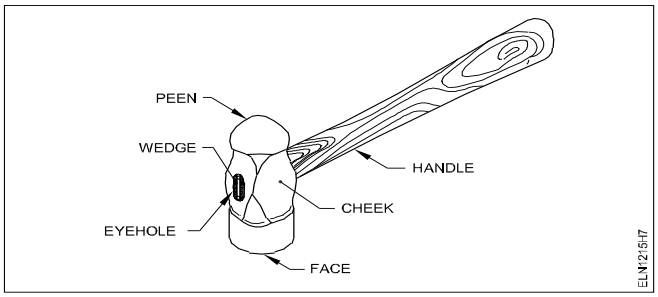
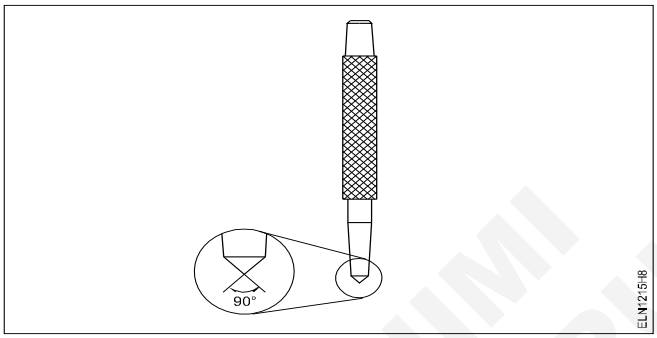
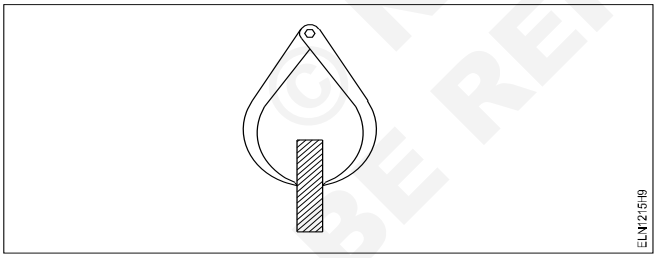
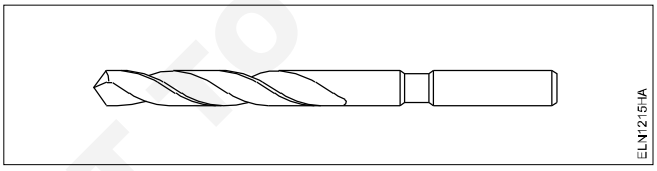
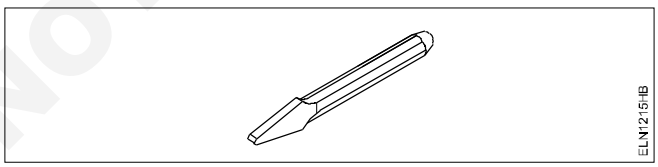
Sl. No.	Visual of tool	Name of the tool with specifications	Operation/ uses
4			
5			
6			
7			
8			
9			

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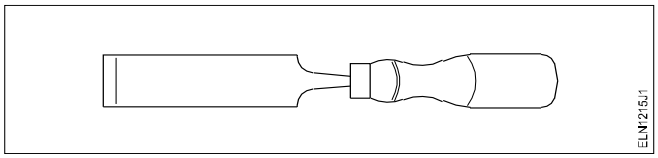
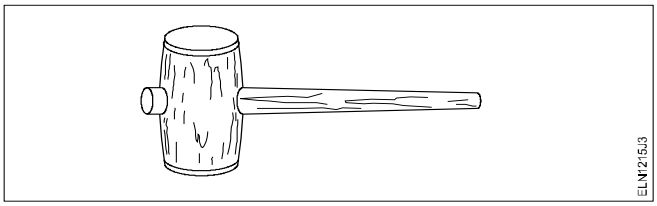
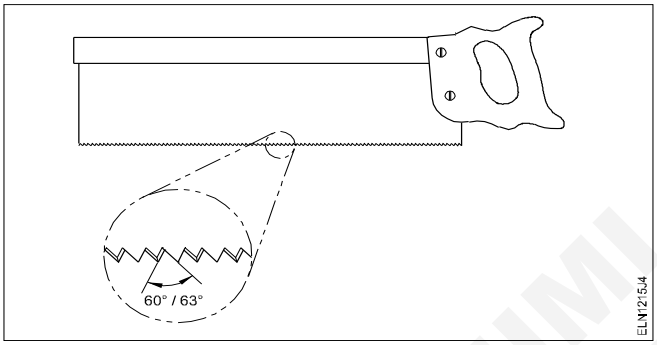
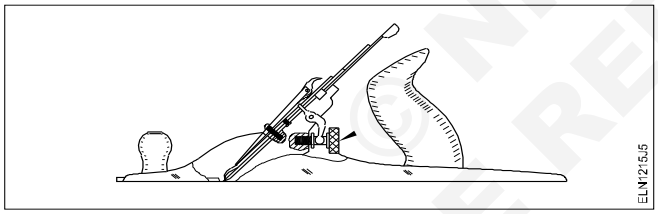
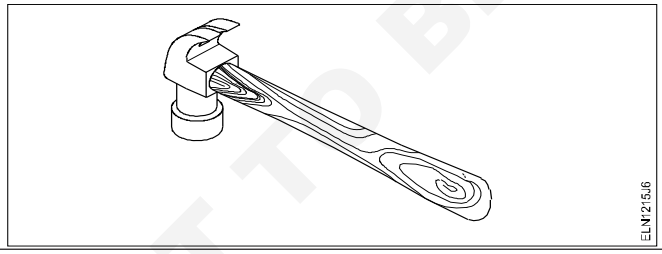
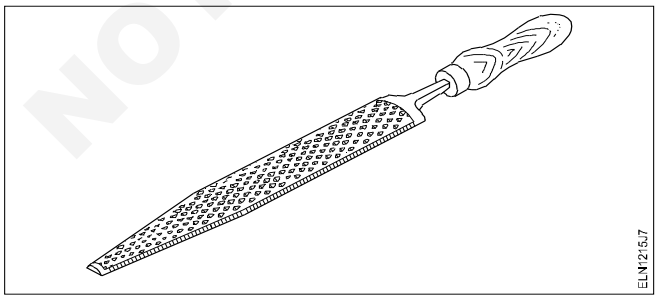
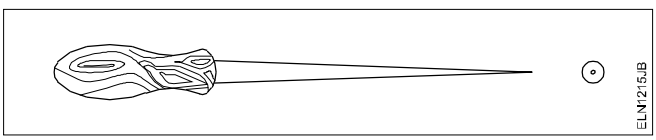
Table 2

Carpentary tools

Sl. No.	Visual of tools	Name of the tool with specifications	Operation/ uses
1			
2			
3			
4			
5			
6			
7			

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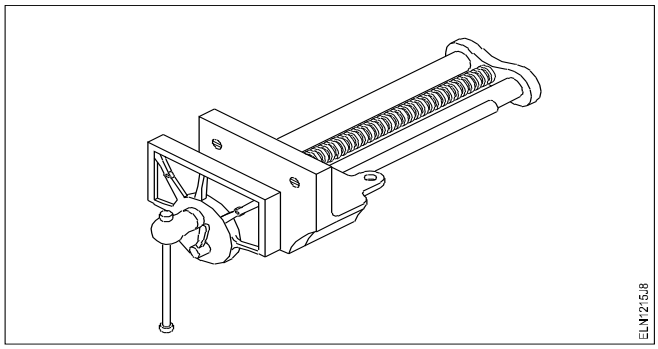
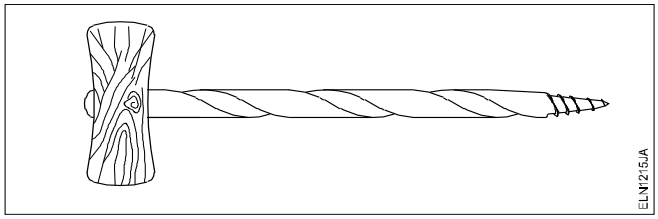
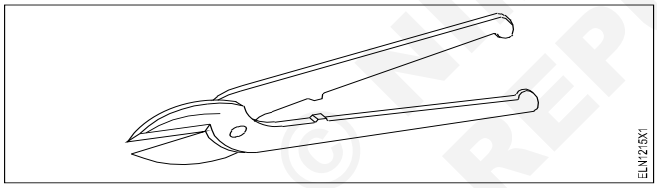
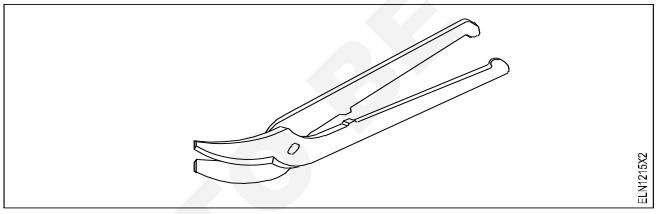
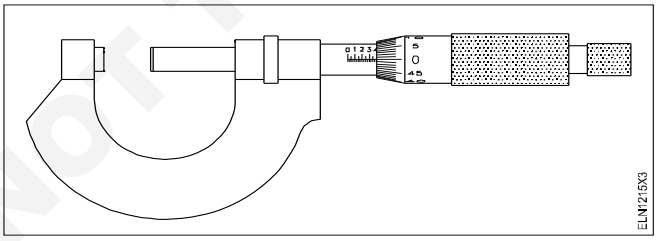
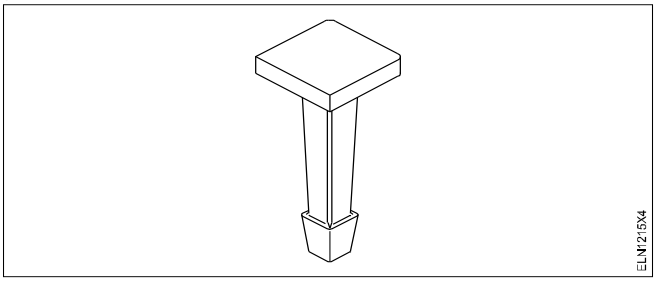
Sl. No.	Visual of tool	Name of the tool with specifications	Operation/ uses
8			
9			

Table 3

Sheetmetal tools

Sl. No.	Visual of tools	Name of the tool with specifications	Operation/ uses
1			
2			
3			
4			

4 Get it checked by the instructor.

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Workshop practice on filing and hacksawing

Scan the QR Code to view the video for this exercise

Objectives: At the end of this exercise you shall be able to
- **file a surface flat and check it with straight edge and light gap**
- **file two adjacent sides to 90° and check it with Try square**
- **perform operations of marking a straight line**
- **file and finish surfaces to an accuracy of 0.5mm.**

Requirements

Tools/Instruments

- File, flat bastard, double cut - 300 mm - 1 No.
- File, flat second cut, double cut 300 mm - 1 No.
- Try square - 150 mm - 1 No.
- Jenny caliper - 150 mm - 1 No.
- Ball peen hammer - 200 gm - 1 No.
- Hacksaw frame (200 mm) with blade (24 TPI) - 1 No.
- Mild steel square bar 25x25mx50mm - 1 No.

Equipment/Machines

- Bench vice - 50 mm Jaw size - 1 No.

Materials

- ISA 5555 Thickness - 8 mm
  Length -150 mm.

PROCEDURE

TASK 1: **Practice on filing**

1 Check the length and size of the given M.S.angle iron as per the sketch using a steel ruler.

2 Fix at right angle with one side (surface 'A') at least 15 mm above the jaws of the bench vice.

3 File the reference side (surface 'A' indicated in Fig 1) with the bastard file.

4 Test the flatness with the blade of the Try square.

Do not touch the surface of the job while filing.

Use a vice clamp for protecting the finished surfaces.

5 File the adjacent surface `B' with a bastard file.

6 Test the flatness and also check the right angle with the Try square.

7 File the side 'C' at right angle to surfaces 'A', 'B'.

8 Evenly apply marking media (lump chalk) on the surfaces 'A' and 'B'.

9 Place surface 'B' on the levelling plate and scribe a line parallel to 'B' on surface A at a distance of 53 mm as shown in Fig 1. Similarly on surface 'A' mark a line parallel to 'B' at a distance of 53 mm.

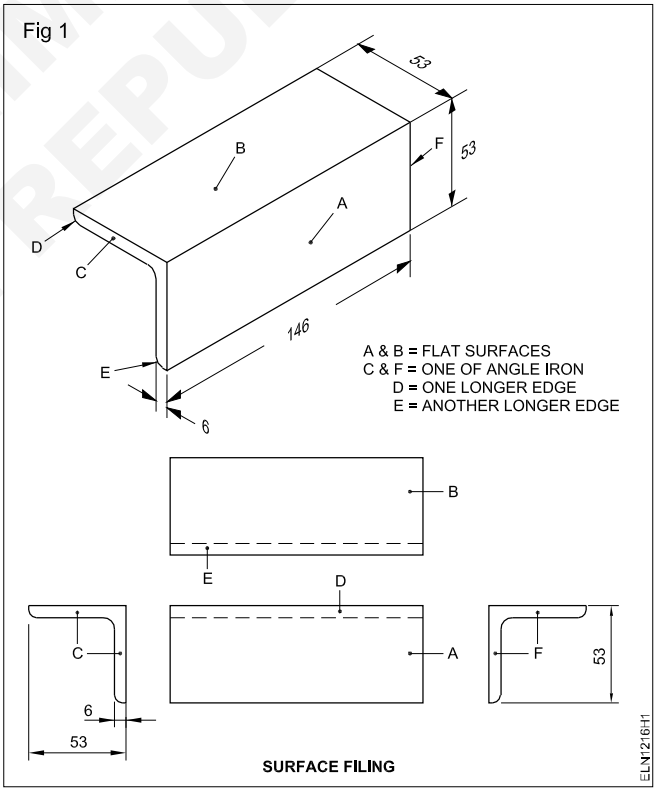
10 Place surface 'C' on the levelling plate and scribe a line parallel to 'C' on surfaces 'A' & 'B' at a distance of 146mm from surface 'C'.

11 Punch all the scribed lines.

12 File the sides 'D', 'E' and 'F' with a bastard file.

13 Finish the job with a second cut file. File within ± 0.5mm and check the right angles with reference to surfaces 'A' and 'B'.

Fig 1



15 Deburr all sharp edges.

Do not overtighten the vice.

Do not allow any pining of the file handle. Use a file card for removing pining of the file.

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Skill sequence

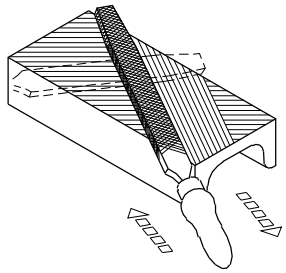
Types of filing

Objective: This shall help you to
- **file a flat surface.**

Filing method : The method of filing adopted depends on the type of surface profile to be filed, the type of surface texture required and the amount of materials to be removed.

Diagonal filing: This type of filing is done when heavy reduction of material is required. The strokes are at an angle of 45°. Because the stroke directions cross, the surface texture formed clearly indicates the high and low spots. Frequent checking of the level is not necessary, particularly, after one has developed a steady movement of the file. (Fig 1)

Fig 1

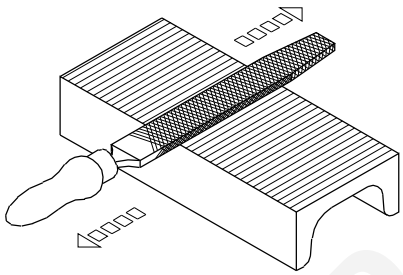


DIAGONAL FILING

ELN1216J1

Transverse filing: In this method the file strokes are at right angles to the longer side of the work. This is commonly used to reduce material from the edges. Using this method, the size of the workpiece is brought close to the finishing size, and then final finishing is done by longitudinal filing. (Fig 2)

Fig 2

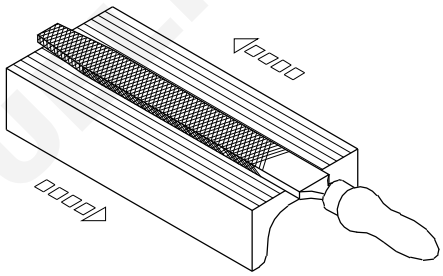


TRANSVERSE FILLING

ELN1216J2

Longitudinal filing: The file is moved parallel to the longer side of the work. Usually all surfaces are smooth–finished by this method. The filed surface texture will show uniform and parallel lines. (Fig 3)

Fig 3



LONGITUDINAL FILING

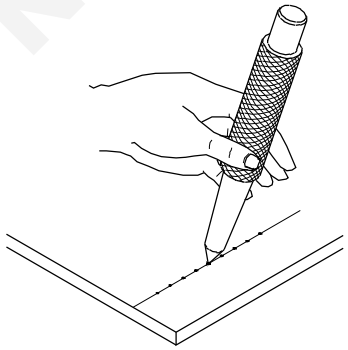
ELN1216J3

Method of using Centre Punch

Objectives: This shall help you to
- **hold a centre punch over a scribed line**
- **punch by dot/centre punch.**

Hold the punch in a relaxed manner between your thumb and your fingers. For centre/dot punching, place the workpiece on a steel support plate. Place the punch in position. Rest your hand on the workpiece while doing so. (Fig 1)

Fig 1

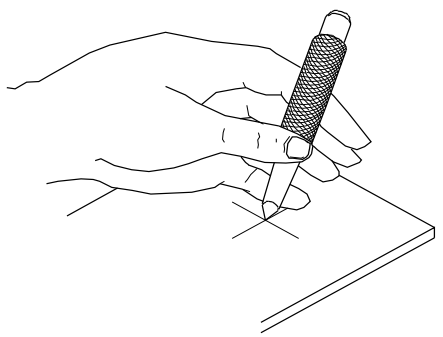


CENTRE PUNCH OVER SCRIBED LINES

ELN1216J1

Place the point of the centre punch on the line of intersection. (Fig 2)

Fig 2



CENTRE PUNCH ON INTERSECTION

ELN1216J2

Bring the punch in perpendicular position to the surface of the workpiece. (Fig 3)

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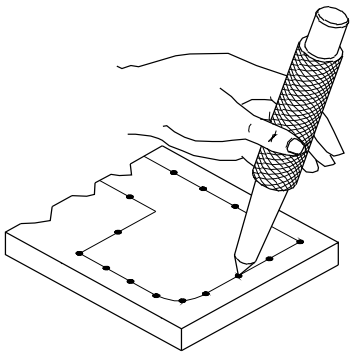
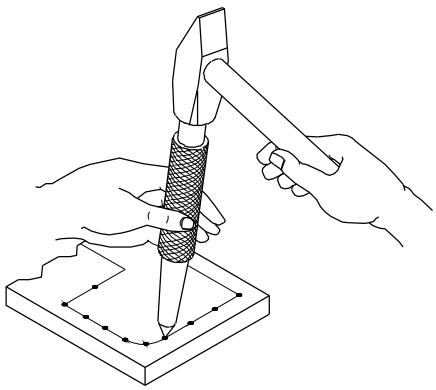
Fig 3



CENTRE PUNCH IN PERPENDICULAR

ELN1216Z3

Fig 4



LIGHT BLOW BY HAMMER

ELN1216Z4

Tap the head of the punch with a light blow by a hammer. A heavier blow is required for marking the position of drilling a hole. (Fig 4)

Sub Exercise (S. Ex.) 1.1.16 - 1

Practice in hacksawing

Objectives: At the end of this exercise you shall be able to

- **file one face flat and check by straight edge and light gap**
- **file angle to 90° within Try square accuracy**
- **mark straight lines**
- **mark parallel lines using a surface gauge**
- **mark parallel lines using a Try square**
- **file and finish surfaces flat and parallel within ± 0.5mm**
- **file and finish radius**
- **saw M.S.flat along a straight line.**

Requirements

Tools/Instrumentss

- File, flat bastard, double cut 300 mm - 1 No.
- File, flat, second cut, double cut 300 mm - 1 No.
- Try square - engineer's rule 150 mm - 1 No.
- Jenny caliper 150 mm - 1 No.
- Engineer ball peen hammer 200 gm - 1 No.
- Centre punch 100 mm - 1 No.
- Dot punch - 1 No.
- Steel rule 300 mm - 1 No.
- Hacksaw blade 300 mm - 1 No.
- Surface gauge - 1 No.
- Radius gauge - 1 set.
- File card - 1 No.
- Vice clamp - 1 pair.
- Divider - 1 No.
- Straight edge - 1 No.

Equipment/Machines

- Bench vice 50 mm jaw - 1 No.
- Surface plate - 1 No.
- Angle plate - 1 No.

Materials

- 60 ISF 8 (Length - 350 mm.) - 2 Nos.

PROCEDURE

1 Check the raw material size with the sketch using the steel ruler.

2 Securely fix the job in the bench vice.

3 File the reference face A (Fig 1) with a bastard file.

4 Check the flatness with the straight edge.

5 File adjacent edge or datum edge B (Fig 1) with a bastard file.

6 Check the right angle with a Try square.

7 File adjacent edge or datum edge C (Fig 1) with a bastard file.

8 Check the right angles to the datum edge B and reference surface A.

9 Evenly apply chalk on the surface A.

10 Place the job on the levelling plate and scribe the lines by the surface gauge, parallel to the datum edge B (size 58 mm) and on datum edge C (size 350 mm).

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11 Scribe the saw, cut parallel lines a, b, c & d as per the sketch. (Fig 1)

12 Scribe two arcs of radius 10 mm with the divider at the datum edge C as in the Fig 1.

13 Punch all the scribed lines and also the arcs by a dot punch.

14 File the edges D and E with a file.

15 Check for the right angle between edges D and E and also with the surface A.

16 Check the finished piece for length 350 mm and breadth 58 mm with an outside caliper.

17 Saw the depth a, b, c, and finally saw part at 'd' in Fig 1.

18 File and finish the saw - Cut surface of part 1 for a length of 300 mm.

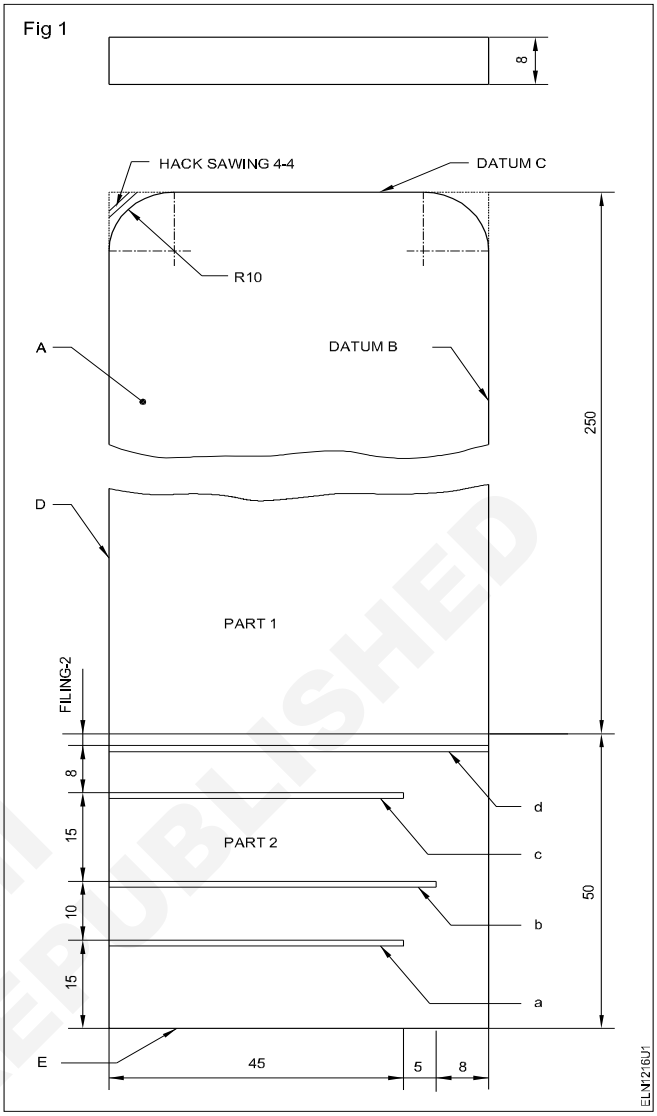
19 Saw the corners for removing the unwanted metal for filing the radius.

20 File and finish two corners by radius filing on part 1.

21 Check the radius with a radius gauge.

22 File and finish the job with a second cut file within a tolerance of ± 0.5 mm (use outside calipers for checking).

Fig 1



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Skill sequence

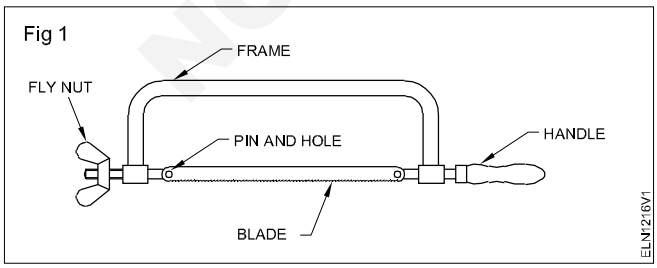
Fixing of hacksaw blade on the frame and sawing

Objectives: This shall help you to
- **fix the hacksaw blade on the frame**
- **practice sawing with dimensions.**

The teeth of the blade should point from the handle.

1 Fix the blade to the frame in good tension. (Fig 1)

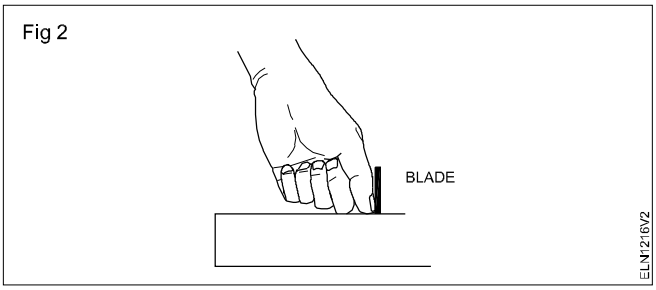
Fig 1



2 Set your thumb nail vertically to the location of the cut, and this location should be at least 10 mm from the vice. (Fig 2)

3 Hold and press the hacksaw straight. (Fig 3)

Fig 2

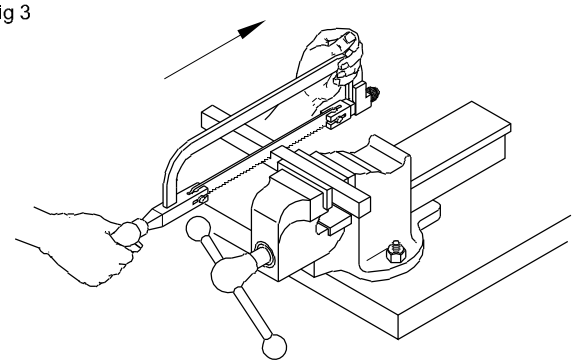


Do not use force when pulling back. Occationally apply cutting compound while cutting .

Use the full length of the hacksaw blade.

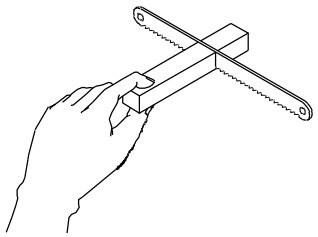
4 Make the last few cuts holding the piece to be cut in your left hand. (Fig 4)

Fig 3



ELN1216V3

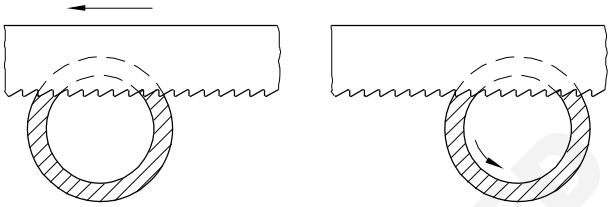
Fig 4



ELN1216V4

For this section use a fine grade blade. A minimum of two to three teeth should be in contact with the work. (Fig 5)

Fig 5



ELN1216V5

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Prepare terminations of cable ends

Objectives : At the end of this exercise you shall be able to
- **prepare a loop termination**
- **prepare the cable end of fine multistranded wire**
- **identify the connecting parts of the socket of an appliance and connect it to cable with earth contact**
- **connect the appliance to the cable with earth contact**
- **identify the connecting parts of a 3-pole (plug) pin and connect the cable.**

Scan the QR Code to view the video for this exercise

Requirements

Tools/Instruments

- Steel rule 300 mm - 1 No.
- Electrician's knife 100 mm - 1 No.
- Wire stripper (manual) 150 mm - 1 No.
- Combination pliers 200 mm - 1 No.
- Screwdriver 100/150 mm x 4 mm - 1 No.
- Screwdriver 100 mm x 2 mm - 1 No.
- Long round nose pliers 150 mm - 1 No.
- Side cutting pliers 150 mm - 1 No.

Materials

- Pieces of 250 to 300 mm long aluminium and copper - as reqd.
- Single conductor cable 1.5 sq.mm - as reqd.
- Single conductor cable 2.5 sq. mm - as reqd.
- Bare copper wire No.10 SWG - small pieces 300 mm long or as available.
- Multistrand cable14/0.2 mm - small pieces 300 mm long or as available. - as reqd.
- Multistrand cable 23/0.2 mm - as reqd.
- Multistrand cable 48/0.2 mm - 2 Nos.
- Single pole plug (double banana plug) 4 mm screw type connection - 4 Nos.
- Crocodile clips insulated 2A and 6A, 250 V - 2 Nos.
- Test lamp with bulb 40 W, 240 V - 1 No.
- PVC cable 3-core copper 23/0.2 mm - 5 m
- Socket 2-pole with earthing contact 6A, 250 V grade - each of different rating and make - 4 pairs
- Plug 2-pole with earthing contact - 4 pairs
- Socket 2-pole with earthing contact 6A - 5 Nos.
- PVC Cable 3-core 48/0.2 mm - 3.5 m
- Plug 3-Pole 6A, 250 V different makes - 2 Nos.
- Plug 3-Pole 16 A, 250 V different makes - 2 Nos.
- Metal clad plug 2-pin with earth 20A - 2 Nos.

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PROCEDURE

TASK 1: **Preparation of loop termination (Solid conductor)**

1 Collect a single conductor cable of 1.5 sq.mm (copper) about 250 to 300 mm long from scrap.

2 Mark on the insulation the length 'L' from the cable end. The length 'L' is five times the diameter of the terminal screw. (Fig 1)

3 Skin the insulation over the length 'L'. (Fig 1)

4 Grip the bare conductor with the round nose pliers as shown in Fig 2.

The diameter of the jaw at the gripping point of the round nose pliers is little more than the terminal screw diameter.

5 Turn the firmly gripped nose pliers to form the required loop. (Fig 3)

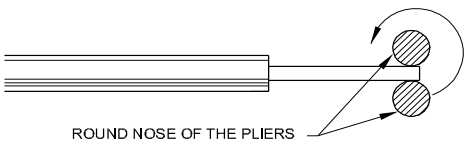
6 Finally set the loops with the nose pliers as shown in Fig 4.

Fig 1

MAKING A LOOP IN THE WIRE

ELN1324-I5

Fig 2



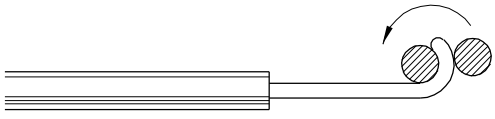
MAKING A LOOP IN THE WIRE

ELN1324-I6

The hook (loop) should go at least about three quarters of the way around the screw.

Check the inner diameter of the loop with the terminal screw.

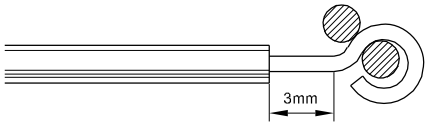
Fig 3



MAKING A LOOP IN THE WIRE

ELN1324H7

Fig 4



MAKING A LOOP IN THE WIRE

ELN1324H8

Never make the hook long as the conductor may overlap.

Keep the length of the exposed conductor to the minimum, not more than 3 mm, to prevent accidental contact with other wires. (Fig 4)

7 Repeat the task for 2.5 sq.mm copper single conductor cable.

8 Repeat the task for aluminium cable single conductor of 1.5 sq. mm and 2.5 sq. mm.

9 Repeat the task for bare copper wire of 10 SWG and other available sizes.

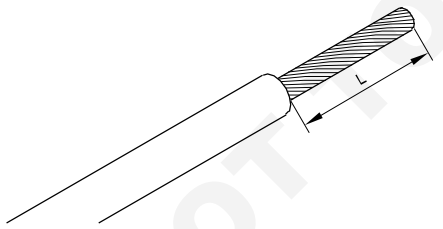
Preparing a fine multistrand cable end for termination to screw-on terminal of terminal blocks

10 Collect a piece of fine multistrand flexible copper cable, of size 14/0.2 mm.

11 Mark the length 'L' from the end of cable. Length 'L' is equal to five times the diameter of the terminal screw.

12 Remove the insulation to the length 'L' (Fig 5) using a pair of wire stripping pliers.

Fig 5

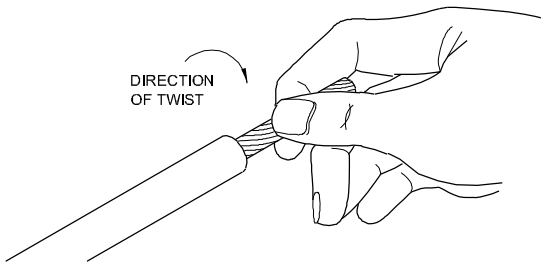


MULTI STRAND CABLE

ELN1324H9

13 Retwist the bared strands in the same direction with your fingers. (Fig 6) Note, that the strands are twisted in the wire in a certain direction.

Fig 6

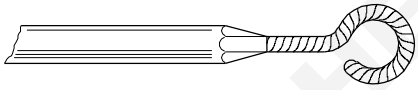


TWISTING THE MULTI-STRAND CABLE CORE

ELN1324HA

14 Loop in fine multistrand conductor. (Fig 7)

Fig 7

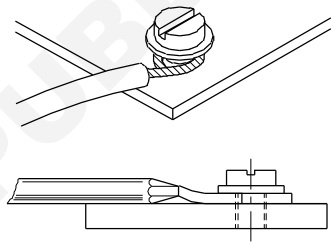


LOOP IN FINE MULTI-STRAND CONDUCTOR

ELN1324H2

15 Make termination in screw on terminal. (Fig 8)

Fig 8

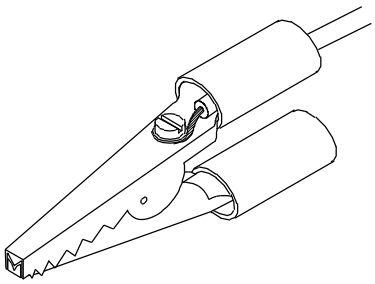


TERMINATION IN SCREW ON TERMINAL

ELN1324H3

16 Repeat the task for terminating flexible cable end on crocodile clips. (Fig 9)

Fig 9



ELN1324HB

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Practice on skinning, twisting and crimping

Scan the QR Code to view the video for this exercise

Objectives : At the end of this exercise you shall be able to
- **skin the cable insulation using the electrician's knife**
- **skin the cable insulation using manual stripper**
- **skin the cable insulation using auto-stripper**
- **practice on making a straight twist joint**
- **prepare termination of cable lugs using crimping tool.**

Requirements

Tools/Instruments

- Electrician tool kit - 1 No.
- Electrician's knife 100 mm blade - 1 No.
- Wire stripper, manual 200 mm - 1 No.
- Wire stripper auto–eject 150 mm - 1 No.
- Combination pliers 150 or 200 mm - 1 No.
- Steel rule 300 mm - 1 No.
- Diagonal cutter or side cutting pliers 150 mm - 1 No.

Materials

Aluminium cables of the following sizes:
- PVC single strand cable 1/1.4, 1.5 sq. mm - 3 m
- PVC single strand aluminium cable 1/1.8, 2.5sq. mm - 3 m

Flexible cables with copper conductor of size:
- PVC cable 14/0.2 mm - 3 m
- PVC cable 23/0.2 mm - 3 m
- PVC cable 48/0.2 mm - 3 m
- PVC cable 80/0.2 mm - 3 m
- PVC cable 128/0.2 mm - 3 m
- PVC cable,PVC sheathed cable – assorted small pieces -as reqd

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PROCEDURE

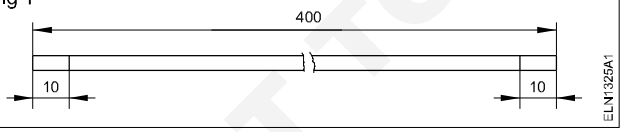
TASK 1 **: Skinning cable insulation using the electrician's knife**

1 Mark the length of the 1.5 sq. mm cable at 400 mm from its end.

2 Cut the cable using combination pliers on the mark.

3 Mark the length of insulation to be skinned from either end. (Fig 1)

Fig 1



4 Check the sharpness of the knife blade and re-sharpen, if necessary.

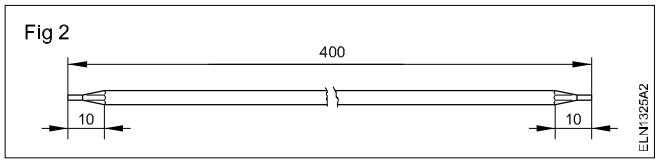
Use an oilstone to sharpen the knife's blade.

Visible thickness at the cutting edge of the knife blade indicates a blunt edge. In the case of a sharp edge, the thickness or end will not be visible.

5 Remove the insulation of the cable for about 10 mm at the ends using a knife. (Fig 2) Keep the knife blade at an angle less than 20° to the cable.

6 Check for nicking over the conductor. Also check if the cable is not shaved.

Fig 2



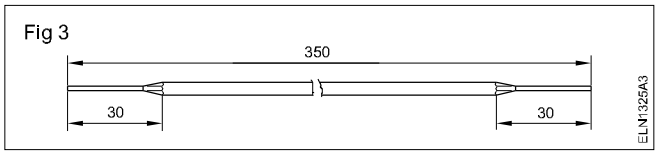
7 Clean the surface of the bare conductor and show it to the instructor.

8 Cut the cable at 12 mm from either end using a combination plier.

9 Repeat steps No.5 to No.8, until the cable is of 350 mm length

10 Mark the insulation that is to be removed as in Fig 3 and repeat steps 5 and 6.

Fig 3



11 Repeat the skinning of cable insulation of 2.5 sq. mm, 14/0.2 mm, 23/0.2 mm, 48/0.2 mm, 80/0.2 mm and 128/0.2 mm flexible cables.

The length of the cable after skinning both the ends shall be suitable for termination using crimping and screw.

12 The length of the finished skinned cable should be 300, 500, 600, 800, 1000 mm.

These cable pieces are to be used for later exercises.

In the case of flexible stranded cables to ensure that the strands are not cut is essental.

— — — — — —

TASK 2**: Skinning cable insulation using a manual stripper**

1 Mark the length of the cable to be trimmed off.

2 Trim the cable at the mark using a combination plier diagonal cutter.

3 Straighten the ends where the insulation is to be skinned.

4 Mark the point where the insulation is to be skinned.

5 Adjust the jaws of the manual stripper and set them to suit the cable conductor.

6 Set the jaws at the mark, press the handle of the stripper and turn to cut the insulation.

Do not nick the conductor. For better practice try on a small waste piece.

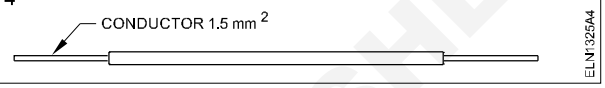
7 Pull the stripper to remove the insulation.

Partially cut insulation can be removed only with more force. Excessive force, indicates improper cutting of insulation.

8 Repeat the skinning of insulation for 10 mm to develop skill in the use of the wire stripper.

9 Remove insulation to the required extent at the ends as per Fig 4.

Fig 4



10 Be careful with flexible cables to ensure that you do not nick even a single strand.

— — — — — —

TASK 3**: Skinning cable insulations using auto-stripper**

1 Mark the length of the insulation to be removed from the ends.

2 Straighten the cable ends.

3 Select a proper set of stripper.

4 Locate the jaws of the stripper exactly on the mark.

5 Press the stripper.

Further pressing may damage the insulation from the cable end, that is also to be removed.

6 Check that the cable conductor is not nicked.

7 Repeat steps No 1 to 7 for different sizes of cables.

— — — — — —

Skill sequence

Hand tools for skinning - knife

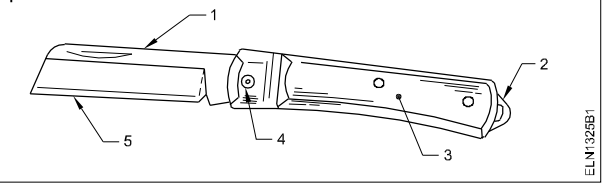
Objectives : This shall help you to
- **identify the parts of the knife used for skinning**
- **perform care and maintenance in using the knife.**

The most frequently used tool for skinning is the knife

A knife may have a single or double blade. A single blade knife is the most commonly used one. (Fig 1)

- back of the blade
- hanger
- haft
- hinge pin
- blade

Fig 1



Be careful while using the knife.

Always cut keeping the object to be cut away from your body.

Slice the insulation at an angle of approximately 15° to avoid cutting into the conductor. (Fig 2)

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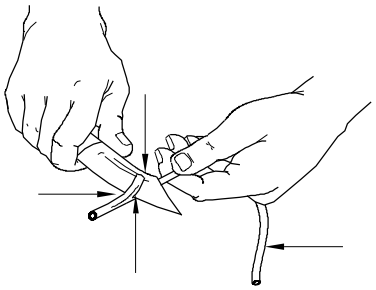
Fig 2



ELN1325B2

Knives should not be used to remove insulation on very fine single or stranded conductors.

Knives should not be used to cut conductors.

Hand tools for skinning - manual wire stripper

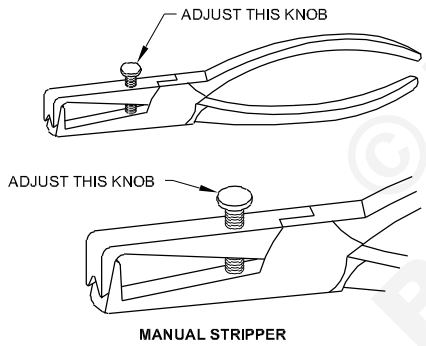
Objectives: This shall help you to
- **identify the parts of the manual wire stripper**
- **perform care and maintenance of manual wire stripper.**

Hand operated wire stripping tools can be used to remove P.V.C. or rubber insulation from a single core cable without damaging the conductor. They are of two types manual and auto-eject.

Manual wire stripper: The jaws have V shaped notches to cut the insulation.

The adjuster screw allows to cut a wide range of wire diameters. (Figs 1 and 2).

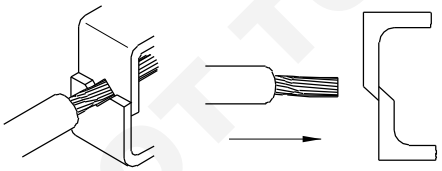
Fig 1



MANUAL STRIPPER

ELN1325C1

Fig 2



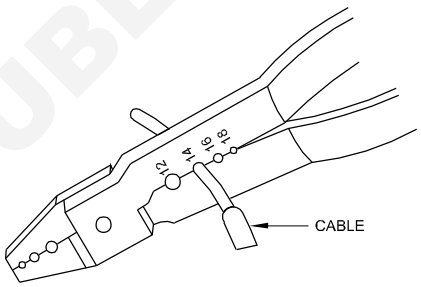
MANUAL STRIPPER

ELN1325C2

Often one cutter becomes sharper than the other, and cuts more than halfway through the wires, damaging the conductors. In such an event, the blunt cutter should be sharpened.

Fig 3 shows manual wire stripper.

Fig 3



MANUAL WIRE STRIPPER

ELN1325C3

This tool has a series of sharp openings in its scissor blade to allow stripping of wire in gauge of different sizes or diameters. The gauge size of the wire must match with the opening in the wire stripper to prevent cutting into the wire and weakening it.

Precautions:

- **When using this tool, make sure that it is correctly adjusted before trying to strip the insulation from the cable so that it does not damage the conductor.**
- **Do not use this tool to cut metallic conductors.**

Hand tools for skinning - auto-eject stripper

Objectives: This shall help you to
- **identify an auto-eject stripper**
- **take care while using an auto-eject stripper.**

Auto-eject strippers are used to cut the insulation from electrical wire without damaging the wire strands. They remove the insulation automatically. (Fig 1)

This stripper has two sets of jaws: one set grips the insulation while the other set has cutting edges.

When the handles are apart, both sets of jaws are open. (Fig 2)

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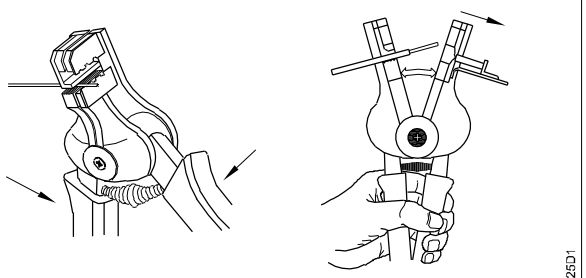
Fig 1



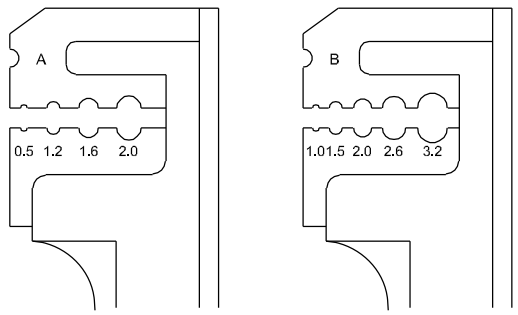
AUTO - STRIPPER

ELN1325D1

This stripper operates automatically when the correct position on the blade matching the diameter of conductor in mm is selected, and the handles are compressed together.

In an auto-eject stripper, we can select different blade sizes to match different sizes of conductors.

Fig 2



JAWS OF AN AUTO STRIPPER

ELN1325D2

Precautions: While using this stripper the cable insulation should be put in the proper slot to avoid damage to the conductor.

Sub Exercise (S.Ex.) 1.2.18 - 1

Prepare termination of cable lugs by using crimping tool

Objectives: At the end of this exercise you shall be able to

- **skin the cable end**
- **select the pressure terminal (compression connector) that suits the size of the wire and that of the terminal**
- **select the pressure pliers that match the size of the pressure terminal**
- **use the crimping tool to crimp the lugs at the cable end.**
- **use an eyelet crimping plier for eyelet termination.**

Requirements

Tools/ Instruments

- Pressure pliers 200 mm - 1 No.
- Electrician's knife 100 mm - 1 No.
- Wire stripper (manual) 200 mm - 1 No.
- Combination pliers 200 mm - 1 No.
- Crimping pliers 150/200 mm - 1 No.
- Wire stripper auto-eject 200 mm - 1 No.
- Steel rule 300 mm - 1 No.
- Side cutting pliers 150 mm - 1 No.
- Eyelet closing pliers 200 mm with eyelets having inner diameter of 3,4,5,6,7 mm. - 1 No.

Materials

- Crimping eyelet, eye hole dia. 6 mm - 12 Nos.
- Crimping ferrule 4 mm,10 mm long - 6 Nos.
- Crimping spade lug 6A - 6 Nos.
- Crimping spade lug 10A - 6 Nos.
- Crimping spade lug 16A - 2 Nos.
- Conducting paste - 1 tube

PROCEDURE

TASK 1 **: Crimping of lug connector**

1 Collect the cable (fine multistrand copper conductor).

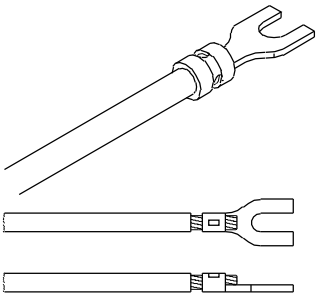
2 Collect the spade connector suitable for the wire thickness and terminal size of 6 mm diameter (Fig 1).

3 Select the wire stripper blade size to match the wires thickness (auto-eject) or adjust the jaws of the stripper. (Fig 2)

4 Strip a length of insulation that suits the terminal size (spade connector) (Fig 3)

Be sure not to cut or damage the wire core.

Fig 1



CRIMPED ON SPADE CONNECTOR

ELN1325G1

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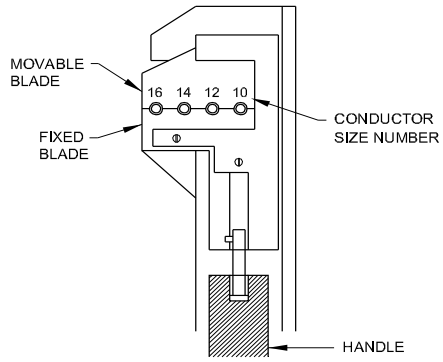
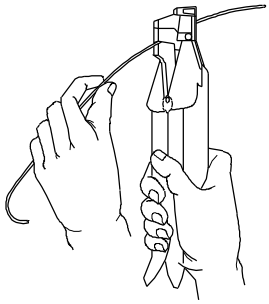
Fig 2



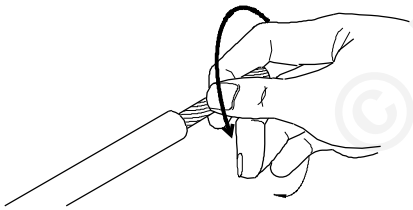
AUTO - WIRE STRIPPER

Fig 3



5 Twist the strands of the wire lightly in the direction of strands. (Fig 4)

Fig 4

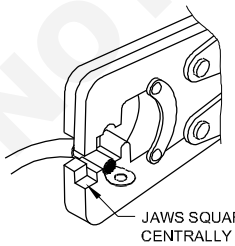


6 Select the crimping pliers that matches the terminal size.

7 Clamp the spade connector with the crimping pliers with the matching position of jaws.

8 Insert the wire far enough in the compression connector. (Fig 5)

Fig 5



Do not clamp the insulation in the terminal. (Fig 6)

Strands must not stick out of the connector. (Fig 7)

Fig 6

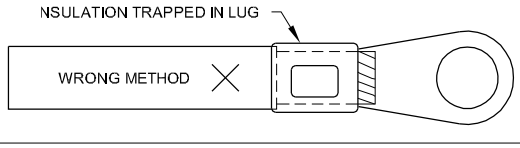
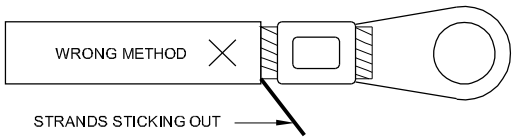


Fig 7



Do not strip too much insulation. (Fig 8)

Adjust the length of the wire so that it does not interfere with the terminal hole. (Fig 9)

Fig 8

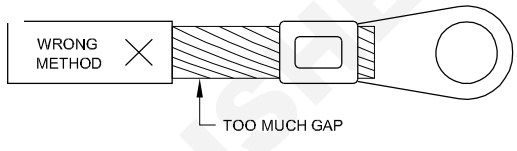
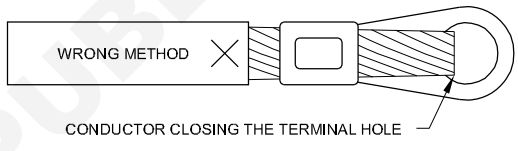


Fig 9

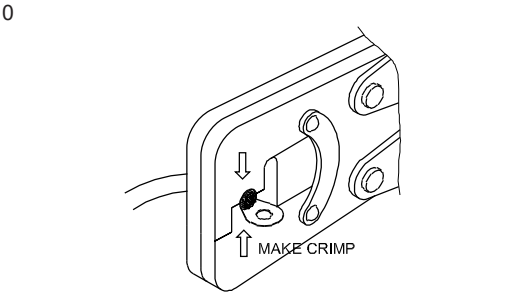


9 Apply light pressure to create a light impression on the compression connector.

10 Check whether the press is located in the middle of the band of compression connector and, if necessary, make final adjustment.

11 Apply sufficient pressure in the handle to press the compression connector fully, as shown in Fig 10.

Fig 10



12 Check whether the prepared compression/crimping joint is firm by pulling the cable and compression connector.

13 Repeat the crimping of compression in the connectors of various sizes of copper and aluminium conductors of different lengths.

Trim the appropriate length of the skinned cable ends to suit the compression connectors.

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TASK 2: **Crimping an eyelet**

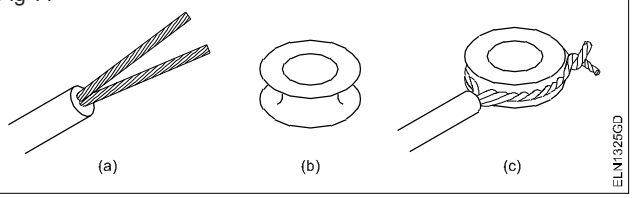
1 Collect the multistrand cable.

2 Split the number of strands into two equal parts and twist them. (Fig 11a)

3 Collect the eyelet. (Fig 11b)

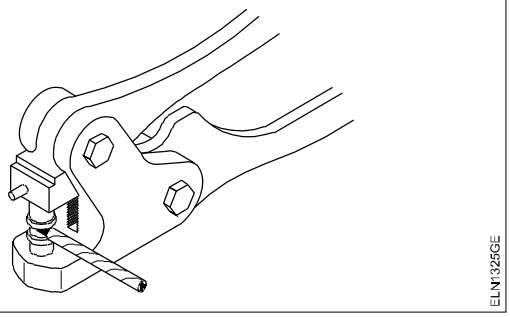
4 Fix the eyelet by placing the eyelet between the grouped strands close to the insulation and twist the free ends of the strands as shown in Fig 11c.

Fig 11



The eyelet is then pressed on to the wire end by the two formers of the eyelet closing pliers. (Fig 12)

Fig 12



5 Trim the excess length of the multi-strand wire after closing the eyelet using side-cutting pliers.

6 Repeat the exercise with different sizes of eyelets for cable end termination.

7 Get it checked by your instructor.

TASK 3**: Practice on twisting of single strand wires**

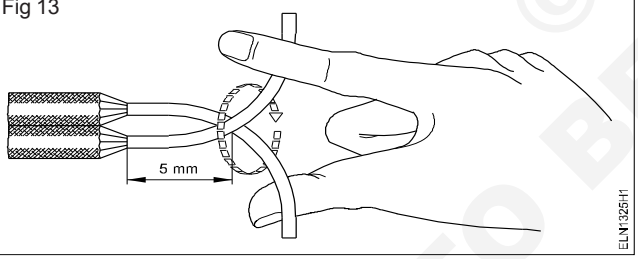
1 Take 300 mm of 1/1.5 mm^2 aluminium wire, or 1/1.2 mm P.V.C copper cable.

2 Cut it into two pieces of 150 mm each.

3 Remove the insulation of 50 mm in each piece by using stripper and clean it with cotton cloth.

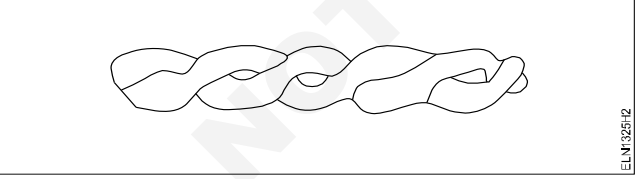
4 Cross the bare wires at 45º and at a distance of 45 mm from the cable end. (Fig 13)

Fig 13



5 Twist the ends tightly at least 6-8 twists. (Fig 14)

Fig 14



While twisting 2 wires together avoid gaps between the twists. If it twisted with gap, it will trigger sparks and overheat as shown in Fig 14.

6 Finish twisting the wires as shown in figure 15 & 16.

7 Get it checked by your instructor.

Fig 15

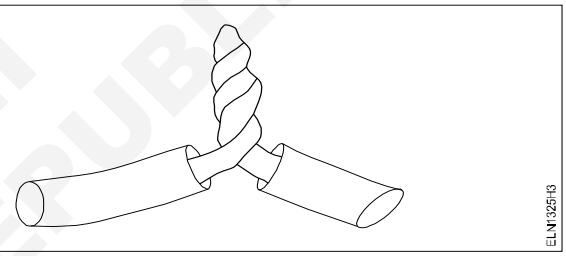
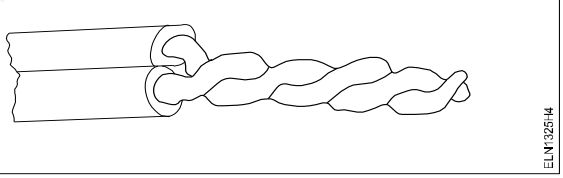


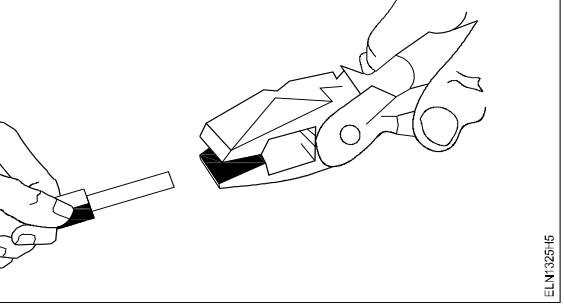
Fig 16



Joining of wires by twisting using plier

8 Hold wires together near the plier. (Fig 17)

Fig 17



9 Grab both the copper ends with pliers.

10 Rotate your wrist while using pressure on pliers.

When joining three large wires, strip the insulation more.

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Identify various types of cables and measure conductor size using SWG and micrometer

Objectives: At the end of this exercise you shall be able to
- **identify types of wires and cables**
- **verify their specifications referring to the data book**
- **measure wire sizes using SWG**
- **measure wire size using micrometers.**

Requirements

Tools / Instruments

- Standard Wire Gauge (SWG 0-36) - 1 No.
- Micrometer (0-25) - 1 No.
- Electrician's knife - 1 No.
- Manual wire stripper 150 mm - 1 No.
- Combination pliers 150 mm - 1 No.

Materials

- Wires (assorted size) - as required.
- Cables (underground armoured and unarmoured cable) - as required.
- Wire/ cable specification data book - 1 No.

PROCEDURE

TASK 1: **Identify types of wires and cables**

The instructor will arrange and provide the various types of cable and wire pieces (assorted sizes) on the table and label them with alphabets and explain them to trainees on, how to identify the types of insulation, conductors, size of wires. Demonstrate how to measure the size of wires using SWG and micrometer.

1 Take any one wire from the table, note down its aplhabet in Table 1.

2 Identify the type of insulation, type of conductor material and size of wires. Note it down in Table 1.

3 Take at least five different types of wires and repeat steps 1 and 2 Note down the details in Table 1.

4 Verify the specifications of the wires by referring with the data book.

5 Take any one cable from the table, note down its alphabet.

6 Identify the type of cable (unarmoured and armoured cable) and note down in Table 1.

7 Identify the type of insulation, core and record in Table 1.

8 Verify the specifications of the cable by referring with the data book.

9 Repeat steps 1 to 8 for various wires and note the data in Table 1.

Table 1

Sl. No.	Alphabet	Type of insulation	Type of conductor material	Type of cable		Type of core single/3/3½	Core size in mm
				Armoured	Unarmoured		
1	A						
2	B						
3	C						
4	D						
5	E						

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TASK 2: **Measuring the wire sizes by SWG in gauge number**

1 Skin the insulation of the cable.

Exercise care to prevent from nicking.

2 Clean the surface of the wire with a cotton cloth. Remove insulation particles and any adhesive coating from the surface of the conductor.

Do not use abrasives to clean the conductor. Use of abrasive material, reduces the size of the conductor.

3 Straighten the end of the conductor to be measured.

Do not straighten conductors by directly using hand tools on them.

4 Insert the conductor in the slot of the wire gauge and determine its close fit. (Fig 1)

5 Read the marking at the slot, Fig 2. It gives the wire size in SWG. The other side will give you the diameter. of the wire in mm.

6 Record the measured size in the notebook.

Fig 1

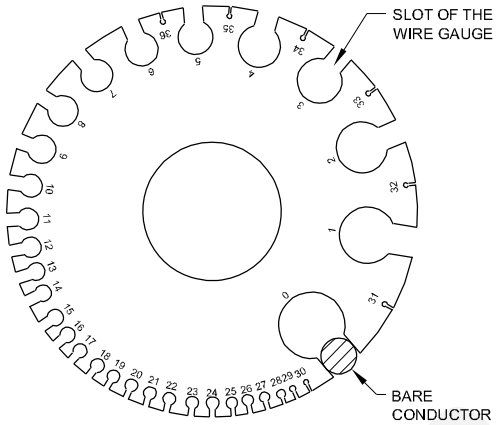
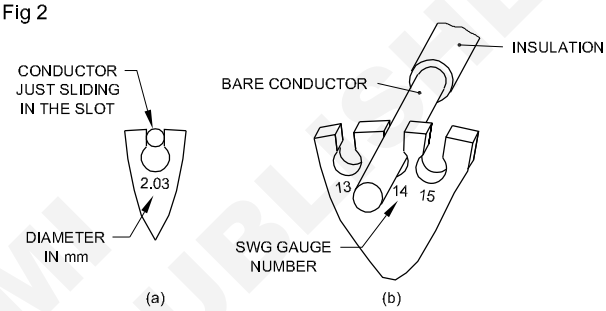


Fig 2



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TASK 3: **Measuring the wire size, using micrometer**

1 Repeat steps 1-3 of TASK 2.

2 Check the micrometer for zero error by operating the spindle.

3 Record the error value with the sign- +ve or –ve.

4 Place the cleaned, straight portion of the conductor between the jaws (anvil and spindle) of the micrometer. (Fig 3)

5 Close the spindle of the micrometer by turning the thimble.

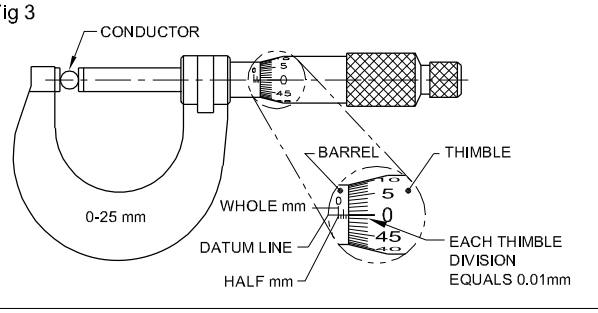
Use the ratchet drive to avoid overtightening.

6 Read and record the diameter in the notebook after computing zero error.

7 Refer to the conversion table which is available with the instructor to get the size of the conductor in the standard wire gauge.

8 Repeat the steps to find the measurement for the given cables.

Fig 3



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Make simple twist, married, Tee and western union joints

Objectives : At the end of this exercise you shall be able to
- **mark the length of the insulation to be removed**
- **skin the insulation**
- **prepare simple twist joint**
- **prepare married joint in stranded conductor**
- **prepare 'T' joint in multistranded conductor**
- **prepare western union joint in bare conductor.**

Scan the QR Code to view the video for this exercise

Requirements

Tools/Instruments

- Electrician's knife with two folding steel blades of 75 mm and 100 mm - 1 No.
- stainless steel rule 300 mm, with graduations on either edge cm/mm and inches - 1 No.
- Diagonal cutting pliers 150 mm with 660 volts grade insulated handle suitable for cutting hard wires - 1 No.
- Combination pliers 200 mm with 660 volts grade insulated handles with pipe grip, side cutter and two joint cutters - 1 No.
- Wooden mallet 75 mm - 1 No.
- Flat file - bastard 250 mm - 1 No.
- Hard vice 58 mm - 1 No.

Materials

- PVC insulated copper cable 1/1.12 - 2 m.
- PVC insulated aluminium cable 1/1.40 - 2 m.
- Cotton cloth 30 cm square - 1 No.
- Sandpaper `OO' (smooth) - 1 sheet
- PVC insulated copper cable 7/0.914/600V - 1 m.
- PVC insulated copper cable 3/0.914/250V - 1 m.
- Bare copper wire 4 mm 30 cm - 2 Nos.
- GI wire 4 mm 30 cm - 2 Nos.
- Sand Paper 'O' grade - 1 sheet

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PROCEDURE

TASK 1: **Make simple (straight) twist joint as shown in Fig 1**

Fig 1

STRAIGHT TWIST JOINT

ELN1327H1

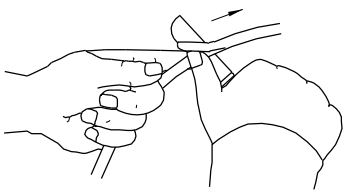
1 Collect 2 pieces of 1/1.12 PVC copper cable of 0.5 m length.

2 Straighten the cables.

3 Mark 80 mm length on one end of each piece of the cable.

4 Use the knife at 20° as shown in Fig 2.

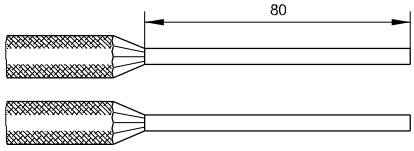
Fig 2



ELN1327H2

5 Remove the insulation from each conductor for a length of 80 mm. (Fig 3)

Fig 3



ELN1327H3

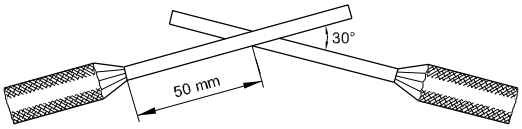
Avoid nicks in the conductor.

6 Clean the ends with the help of a cotton cloth.

Use smooth sandpaper, if necessary, to clean the conductor.

7 Place the conductors together, about 50 mm from the ends. (Fig 4)

Fig 4



ELN1327H4

8 Twist them tightly around each other in the opposite directions. (Fig 1)

Pliers can be used to just grip the crossed conductors.

Each side should contain about 6 turns.

Each turn of the conductor should closely fit to the adjacent turn.

9 Cut the excess length of the conductor using side cutters.

10 Press the sharp edge of the conductor end and smoothen it.

Soldering the joint and insulating it with tape should be completed before putting the jointed cable in use.

11 Show the joint to your instructor.

12 Cut the joint after leaving 30 mm cable from the joint. (Fig 5)

Fig 5

13 Repeat steps 3 to 9 and make at least 4 more joints for practice, using the remaining cable.

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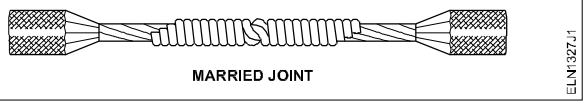
TASK 2: **Prepare married joint in 7/0.914 stranded conductors as shown in Fig 1**

Fig 1



1 Collect 2 pieces of PVC sheathed copper cable 7/0.914 0.5 metre in leagth.

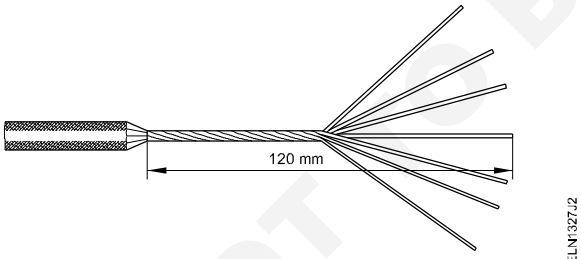
2 Mark both the the cables at 120 mm from the cable ends.

3 Remove the insulation for 120 mm on both the cables.

Carefully remove the insulation. Do not nick or shave the conductor.

4 Open the strands, clean the wires, and re-twist the strands in the original direction up to 50 mm from the cable insulation. (Fig 2)

Fig 2



5 Cut the centre strand of both the cables close to the twist (about 70 mm from the free end).

6 Bind on the twisted part of one cable end as shown in Fig 3.

7 Interlace the strands keeping the centres butt. (Fig 4)

Fig 3

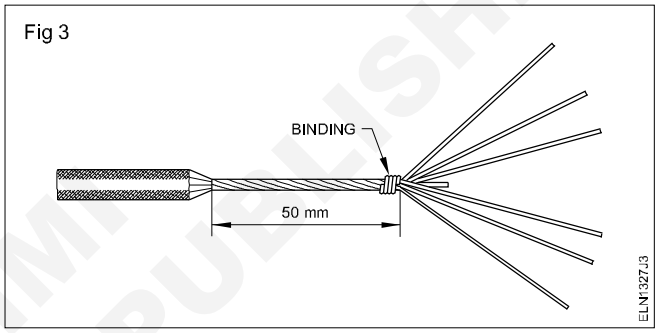
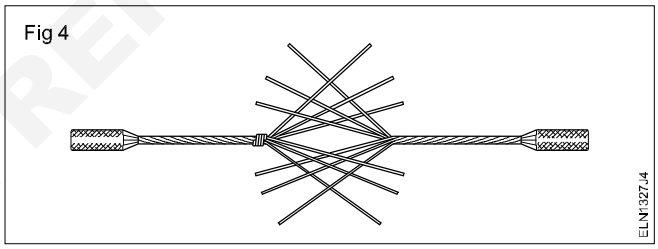


Fig 4



8 Hold the cable end (that is without the binding) in one hand and twist the strands of the other cable end over it, one by one, closely and tightly. Each strand has to be twisted half a turn at a time.

The direction of twist to form the shoulder should be the same as that of the cable twist .

9 Remove the binding made in step 6.

10 Repeat the operation as in step 8 on the other side with the 2nd cable end.

11 Complete the joint as shown in Fig 1 by rounding off the twisted strands with a mallet or pliers, and cut the excess wires.

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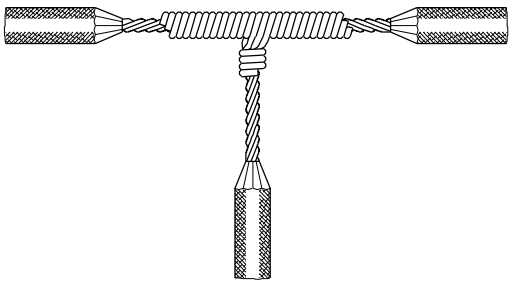
TASK 3: **Prepare 'T' joint in multi-stranded conductor**

Fig 1 shows a completed Tee joint in strandard conductors.

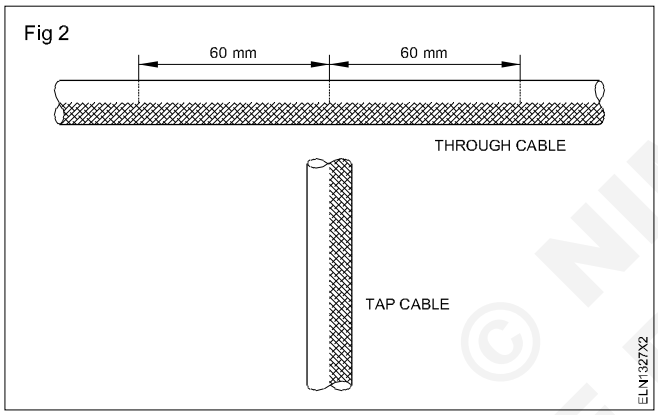
Fig 1



1 Collect two pieces of PVC insulated stranded copper cable 7/0.91. Indicate one piece as `through cable' and the other one as `tap cable'.

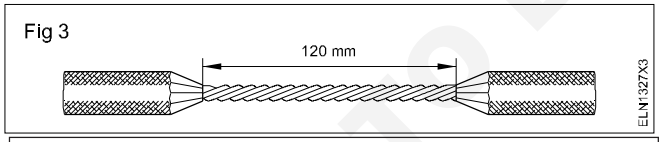
2 Mark the point of tap in the `through cable' and mark 60 mm on either side of the tap point for the insulation to be removed as shown in Fig 2.

Fig 2



3 Remove 60 mm insulation on either side of the `through cable' from the point of tap. (Fig 3)

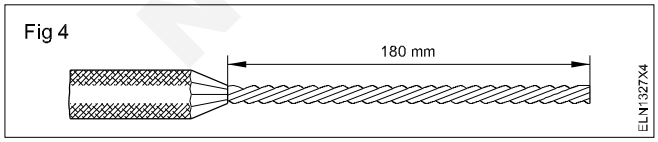
Fig 3



Do not nick or shave the conductor while removing insulation.

4 Remove the insulation for 180 mm at the end of the `tap cable'. (Fig 4)

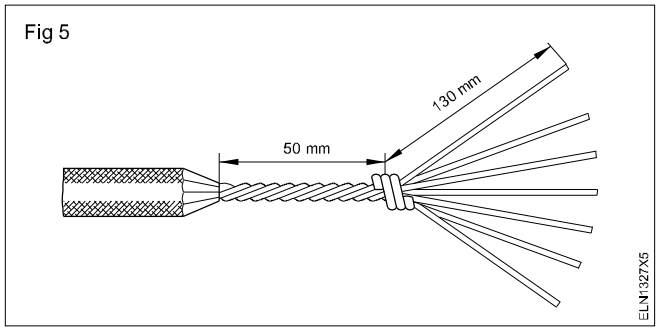
Fig 4



5 Open the strands of the `tap cable' and clean it. Use smooth `00' sandpaper, if necessary.

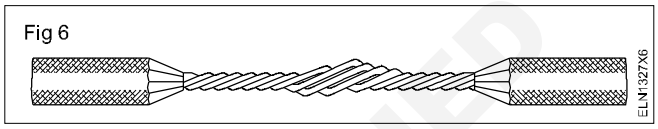
6 Re-twist the strands in the original direction up to 50 mm from insulation, and make a binding on the twisted part of the `tap cable' as shown in Fig 5.

Fig 5



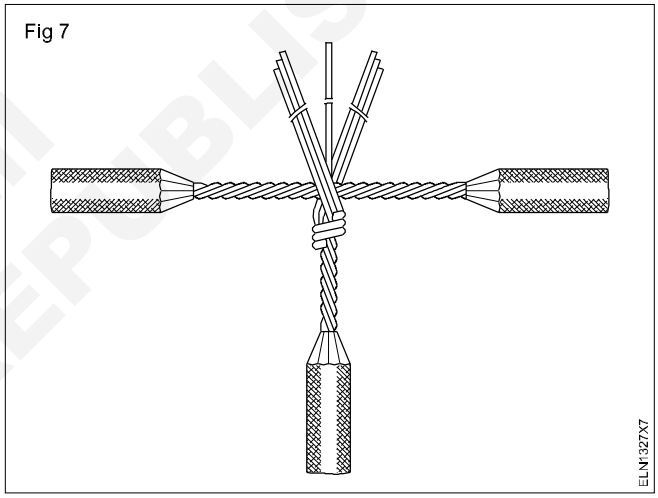
7 Untwist the `through cable' to provide opening at the point of tap. (Fig 6)

Fig 6



8 Insert the centre (middle) strand of the `tap cable' in the opening of the 'through cable' as shown in Fig 7.

Fig 7



9 Wrap 3 strands of the `tap cable' around the `through cable' on either side of the tap point to form shoulder on `through cable'.

10 Wrap the strands up to 50 mm to leave a 10 mm gap between insulation and shoulders (Fig 1) and trim the excess length of strands.

11 Remove the binding from the `tap cable', wrap the centre strand of the `tap cable' around the `through cable' and wrap it in the place of the binding. (Fig 1)

12 Round the ends with the combination pliers or mallet to avoid sharp edges of the strands.

13 Collect two pieces of PVC stranded aluminium cable 19/1.12, or 19/1.63, 500 mm long and repeat working steps 2 to 12.

With 19/1.2, 19/1.63 mm cable, 9 strands of the `tap cable' are to be wrapped on either side of the `through cable'. Insulation that has to be removed is 170 mm on the `through cable' and 250 mm on the `tap cable'.

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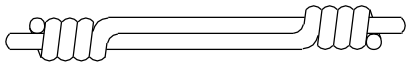
TASK 4: **Prepare western union joint in bare conductor**

(A completed western union joint is shown in Fig 1)

Fig 1



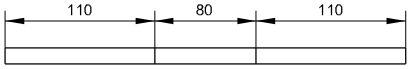
ELN132721

1 Collect two pieces of bare copper conductor of 4 mm diameter. and 30 cm long.

2 Straighten the conductor with a mallet.

3 Mark the conductor as shown in Fig 2.

Fig 2

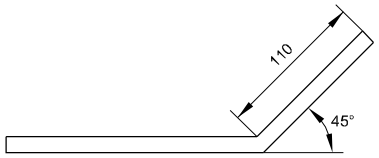


ELN132722

4 Clean both the conductors with `00' grade sandpaper to a length of 250 mm from one end.

5 Bend both the pieces of conductors at a distance of 110 mm from one end to 45° as shown in Fig 3.

Fig 3

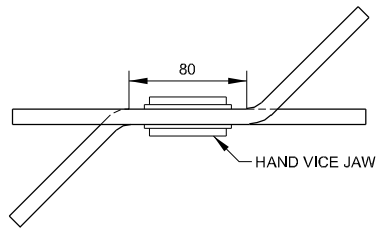


ELN132723

6 Hold the conductors in the hand vice as shown in Fig 4.

To avoid nicks on the conductors while gripping in a hand vice, always use soft materials like aluminium sheets between the jaws.

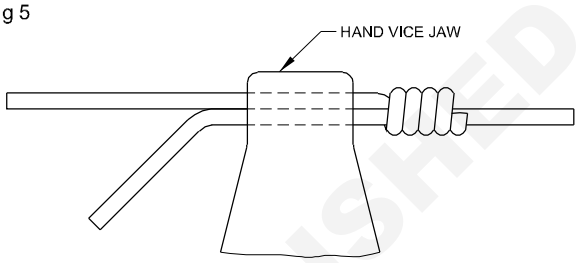
Fig 4



ELN132724

7 Wrap one conductor over the other conductor using combination pliers. Make at least 5 to 6 turns as shown in Fig 5.

Fig 5



ELN132725

8 Repeat the same procedure in the other end of the conductor, but wrap the conductor in the opposite direction.

9 Cut the surplus conductor ends with a diagonal cutter.

10 Use a mallet to mesh the ends with the straight conductor.

11 Smoothen the ends of the conductors with a flat file to avoid sharp edges.

12 Repeat the Western union joint with G.I. wire of diameter 4 mm.

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Make britannia straight, britannia 'T' (Tee) and rat tail joints

Objectives : At the end of this exercise you shall be able to
- **make britannia straight joint in solid copper conductor**
- **make britannia 'T' (Tee) joint in solid copper conductor**
- **make rat tail joint.**

Requirements

Tools/Instruments

• Steel rule 300 mm	- 1 No.
• Diagonal cutting plier 150 mm	- 1 No.
• Combination plier 200 mm	- 1 No.
• Hand vice 50 mm jaw	- 1 No.
• Flat file bastard 200 mm	- 1 No.
• Wooden mallet 75 mm diameter.	- 1 No.

Materials

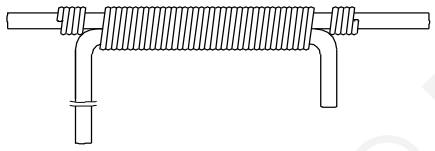
• Hard drawn bare copper wire 4 mm diameter 0.2 metre	- 4 Nos.
• Tinned copper wire of dia. 0.91 mm	- 4 m.
• Sandpaper `0 0'	- 1 sheet
• Cotton cloth 300 x 300 mm	- 1 No.
• PVC copper cable 1/1.2 mm 8.5 m	- 2 Nos.

PROCEDURE

TASK 1: **Make britannia straight joint**

(A completed brittannia 'T' joint is shown in Fig 1).

Fig 1



BRITANNIA TEE JOINT

ELN1328H1

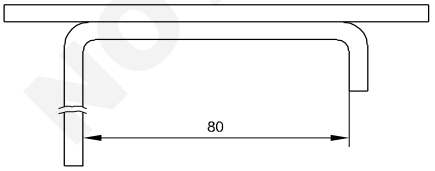
1 Collect two pieces of 4 mm diameter Hard Drawn Bare Copper (H.D.B.C) . wire, 0.2 m long.

2 Straighten the conductors using a mallet and clean it using fine sandpaper and cotton cloth.

Use the mallet to make the wires straight. The two pieces should be free from twists over the entire length of the joint.

3 Bend each piece at one end for about 20 mm length at 90° as shown in Fig 2.

Fig 2



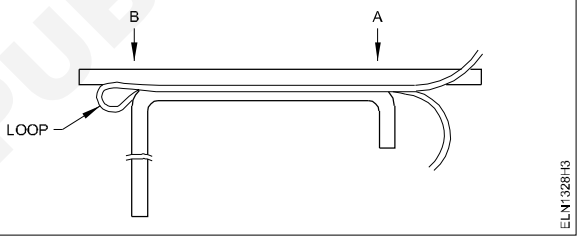
ELN1328H2

4 Collect the binding wire and straighten it without any kink.

5 Hold the two ends of the bare copper wire to be joined in the hand vice as shown in Fig 2.

6 Form a loop of binding wire leaving one end about 250 mm at the right side of the joint. Place the binding wire in the groove formed in between the main conductors as shown in Fig 3.

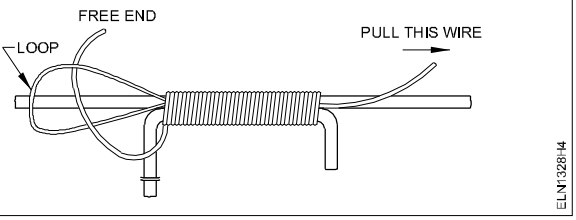
Fig 3



ELN1328H3

7 Start binding the wire tightly over the joint from position `A' and continue till position `B'. (Fig 4)

Fig 4



ELN1328H4

8 Insert the free end of the wire inside the loop as shown in Fig 4.

9 Grip the 250 mm loose end of the wire with a pair of pliers, and carefully pull it so that the loop and the free end of the wire go inside the joint.

10 Wrap the free end and the loose end over the conductors as shown in Fig 1.

11 Press the ends of the binding wire to the conductors with pliers .

12 Smooth the sharp edges of the protruding wire ends with a flat file.

13 Repeat the above steps and make two or more joints to get more practice.

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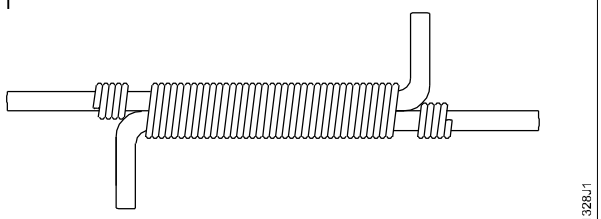
After completion the joint must be soldered before putting it to use.

TASK 2: **Make britannia straight joint**

(A completed britannia `Tee' joint is shown in Fig 1.)

Fig 1

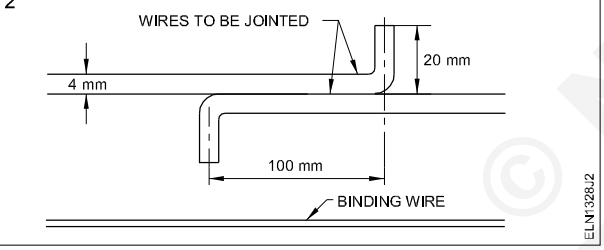


1 Collect two pieces of 4 mm diameter Hard Drawn Bare copper (H.D.B.C) 0.2 m long.

2 Straighten the conductors using a mallet and clean it with fine sandpaper and cotton cloth.

3 Bend and shape of one of the conductors according to the size shown in Fig 2, with the help of combination pliers.

Fig 2



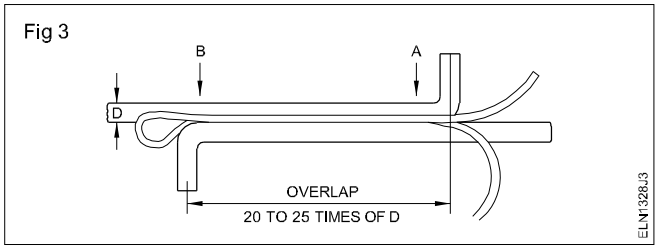
4 Straighten the (0.914 mm diameter.) binding wire.

5 Hold the two copper conductors to be joined with the help of a hand vice as shown in Fig 2 .

6 Form a loop of binding wire leaving one end about 250 mm at the right side of the joint. Place the binding wire in the groove formed between the conductors as shown in Fig 3.

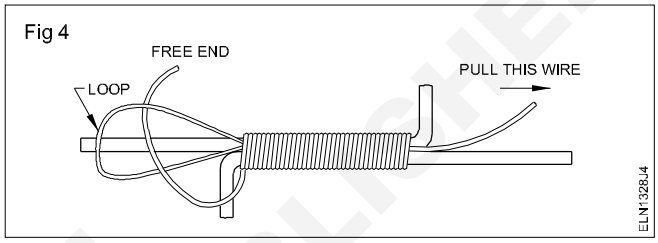
7 Start binding the wire tightly over the joint from position `A' and continue till the position `B'. (Fig 3)

Fig 3



8 Insert the free end of the wire inside the loop as shown in Fig 4.

Fig 4



9 Grip the 250 mm loose end of the wire with a plier, and carefully pull it so that the loop and the free end of the wire go inside the joint.

10 Wrap the free end and the loose end over the conductors as shown in Fig 1.

11 Press the ends of the binding wire to the conductors with plier.

12 Smooth the sharp edges of the binding wire ends with a flat file.

13 Repeat the above procedure to make two or more joints to get more practice.

The joints need to be soldered before putting them into use.

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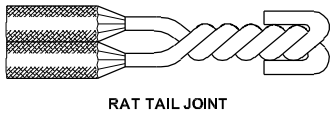
TASK 3: **Make rat-tail joint** (Fig 1)

Fig 1



RAT TAIL JOINT

ELN1328X1

1 Collect 2 pieces of 1/1.2 mm PVC copper cable of 0.5 m length.

2 Straighten the cables.

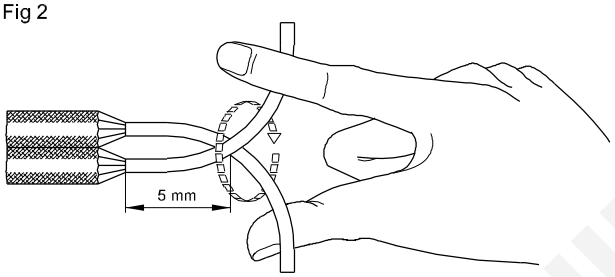
3 Skin both the cable ends for 50 mm.

4 Clean the conductor ends with the help of cotton cloth.

5 Cross the bare wires at of 45° and at a distance of 45 mm from the cable end.

6 Tightly twist the ends as shown in Fig 2.

Fig 2

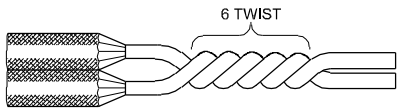


ELN1328X2

The twist on the wire should be uniform and close.

7 Make at least 6 twists. (Fig 3)

Fig 3



ELN1328X3

8 Fold the remaining wire back on the twists. (Fig 1)

9 Press the ends of the wire with the help of combination pliers (Fig 1) to avoid sharp ends, and cut the excess wire.

10 Repeat the steps.3 to 8 of TASK 3 for at least 4 more joints for practice, using the remaining cable.

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Exercise 1.2.22

Practice in Soldering of joints/lugs

Scan the QR Code to view the video for this exercise

Objectives : At the end of this exercise you shall be able to
- **solder the copper conductor joints using a soldering iron and rosin solder**
- **solder the lugs in copper conductor with the help of a blow lamp.**

Requirements

Tools/Instruments

- Electrician tool kit - 1 No.
- Combination piler 200 mm - 1 No.
- Electric soldering iron 125W, 250V, 50Hz - 1 No.
- Flat file bastard 250 mm - 1 No.
- Electrician's knife 100 mm - 1 No.
- Steel rule 300 mm - 1 No.
- Diagonal cutting plier 150 mm - 1 No.
- Blowlamp 1 litre capacity - 1 No.
- Tongs 300 mm - 1 No.
- Sheet steel tray 150 x 150 x 20 mm - 1 No.

Materials

- Finished simple twist joint - 1 No.
- Sandpaper 'OO' grade - 9 Sq.cm
- Resin-cored solder - 25 gms
- VIR or PVC copper cable 7/1.06 mm or 7/0.914 - 250 mm long - 2 pieces
- Lug 30 amperes - 1 No.
- Resin flux - 10 gms.
- Solder stick 60/40 - 100 gms.
- Matchbox - 1 No.
- Cotton tape or cloth - as required.
- Sandpaper `O' grade - 9 sq. cm.
- Blowlamp pin - 1 No.
- Kerosene - 1 litr.

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PROCEDURE

TASK 1: **Solder the copper joints**

(A finished soldered joint will look like Fig 1)

Fig 1

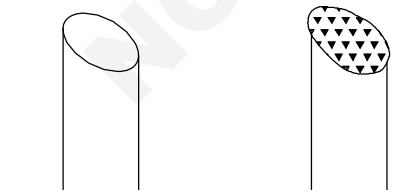
SOLDERED JOINT

ELN1329H1

1 Select a 60W, 240V AC 50 Hz. soldering iron and check that the iron has no physical damage, the body is well insulated from the element and is of the correct voltage and power rating.

2 Check the bit (Fig 2) to see whether the surface is smooth and clean.

Fig 2



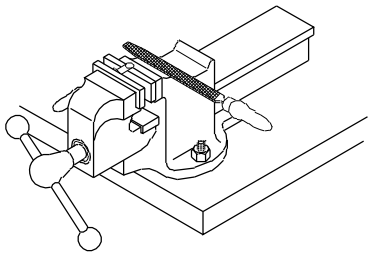
SOLDERING BITS

ELN1329H3

3 If found corroded, file the tip with a flat file, so that the surface is smooth and clean. (Fig 3)

4 Connect the soldering iron to the supply and switch it `ON'.

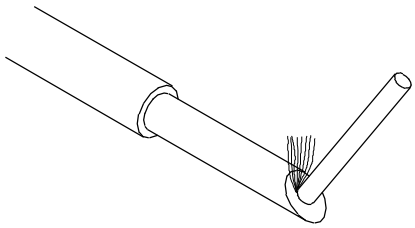
Fig 3



ELN1329H4

5 When the bit becomes sufficiently hot, apply a small quantity of rosin-cored solder, and tin the bit. (Fig 4)

Fig 4



TINNING THE SOLDERING BIT

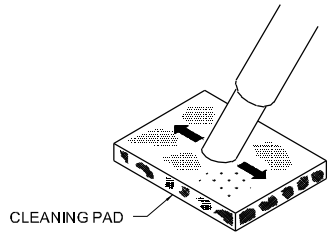
ELN1329H5

If the bit is not completely and evenly covered with solder, clean and tin it again.

Never flick excess solder off the bit. The hot solder may cause burns to someone or fall on the work and cause a short circuit.

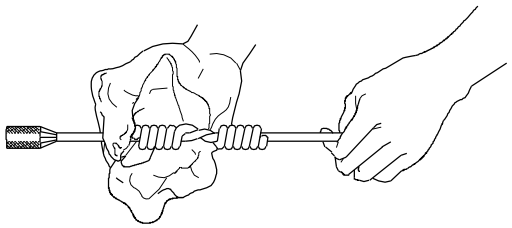
6 Wipe the bit gently on the cleaning pad to remove excess solder as shown in Fig 5.

Fig 5



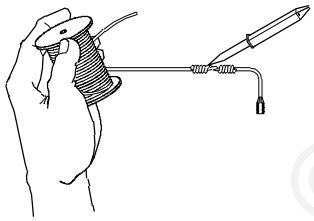
7 Clean the joint to be soldered with the help of sandpaper `0 0', grade as shown in Fig 6, and wipe the dust with a wire brush.

Fig 6



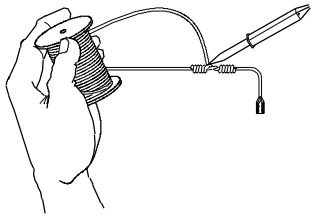
8 Keep the soldering iron bit on the joint and heat it for soldering as shown in Fig 7.

Fig 7



9 Keep the rosin-cored solder on the wire joint and allow it to melt as shown in Fig 8.

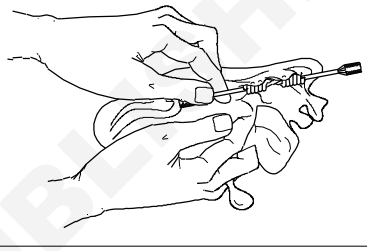
Fig 8



10 Melt the solder with the heat of the bit and make sure that the solder flows freely and evenly on the joint.

11 Remove the soldering iron. use cotton cloth to wipe off the excess solder from the surface of the joint when it is still hot as shown in Fig 9.

Fig 9



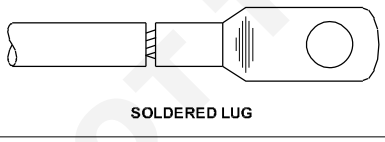
12 Allow the joint to cool naturally. Do not blow air for cooling.

A shining solder surface indicates good soldering. Do not move the joint until the solder solidifies.

TASK 2: **Solder lug to a copper conductor**

(A soldered lug should look as shown in Fig 1.)

Fig 1



1 Collect a 30 amps cable lug, copper cable 7/1.06 or 7/0.914(6 sq.mm) of 250 mm length, blowlamp, match-box, cotton cloth, solder stick, tray and flux.

2 Clean the inner and outer surfaces of the 30 amps cable lug using `00' grade sandpaper.

3 Put the cable lug to one end of the cable and mark the cable according to the depth of the cable lug, as shown in Fig 2.

4 Add about 2 mm to the marking, remove the insulation from the cable (Fig 3) and clean the strands.

Fig 2

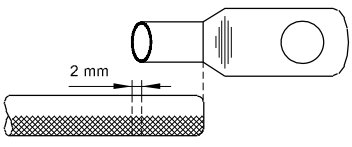
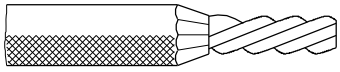


Fig 3



Avoid damage to the strands of the cable while skinning. Clean the tray thoroughly. The tray should be free from dirt and water.

5 Wrap a cloth/cotton tape on the insulation of the cable to a length of 30 mm as shown in Fig 4, and wet it with water.

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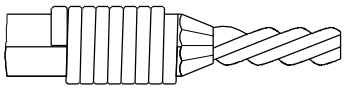
Fig 4



WRAPPED WITH WET CLOTH

ELN1329J4

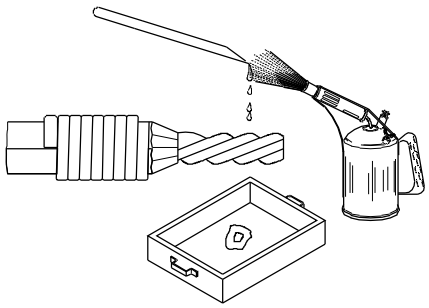
Use minimum water to wet the cloth/tape. Do not allow water to drip.

6 Light the blowlamp and let it emit a blue flame.

7 Apply a thin coat of flux to the cable end.

8 Tin the cable end by monitoring the blowlamp on the solder stick and allowing the molten solder to fall on the bare stranded cable end as shown in Fig 5.

Fig 5



TINNING CABLE END

ELN1329J5

A thin coating of tin should be on the stranded cable end.

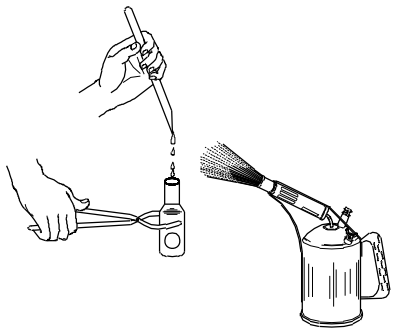
9 Apply a small quantity of flux inside the lug socket. Tin the lug by melting the solder stick to fill the socket and pour the molten solder in the tray.

Pouring out the molten solder from the lug socket a couple of times will make the tinning perfect.

10 Apply some flux to the cable end and the interior of the socket.

11 Fill the socket of the lug with molten solder. (Fig 6)

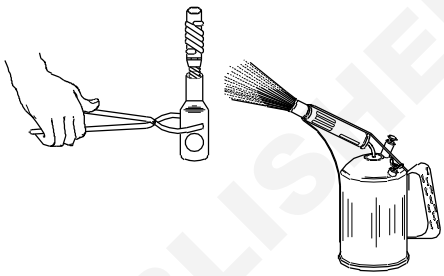
Fig 6



ELN1329J6

12 Monitor the blowlamp flame on the socket, insert the cable in the socket and hold the cable vertically as shown in Fig 7.

Fig 7



ELN1329J7

13 Remove the blowlamp and firmliy hold the cable and socket without shaking.

14 Remove the extra solder from the lug and cable by wiping it with a piece of cotton cloth while the solder is still hot.

15 Keep on holding the cable and lug as in Fig 7 and allow the solder to solidify.

Do not use water to cool the lug. This will crystallize the solder and make it weak.

— — — — — —

Scan the QR Code to view the video for this exercise

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Identify various parts, skinning and dressing of underground cable

Objectives: At the end of this exercise you shall be able to
- **identify the voltage grade of the cable**
- **skin the UG cable**
- **dress the UG cable.**

Requirements

Tools/Instruments

- Insulated combination piler 200 mm - 1 No.
- DE Electrician's knife 100 mm - 1 No.
- Hacksaw adjustable 300 mm with blade - 1 No.
- Handvice 50 mm jaw - 1 No.

Materials

- UG cable multicore eu/Al. 30 cm - 1 piece
- Binding wire 16 SWG - as required.

PROCEDURE

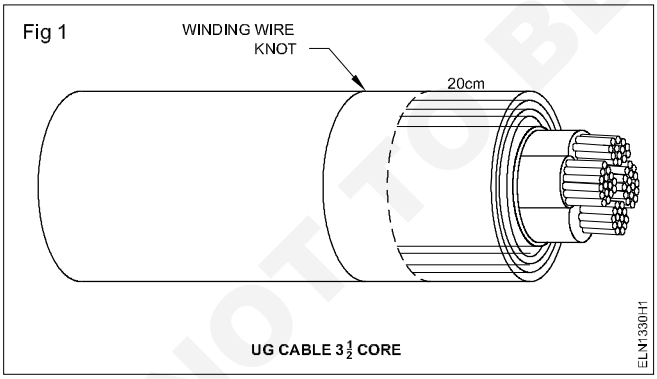
Paper insulated 3, 31/2 core cable may be taken. This instructor has to demonstrate the steps for skinning and dressing of cables in this exetcise.

1 Collect the UG cable piece and examine it for physical damage.

2 Bind the winding wire at 20 cm (20 cm at one side) of the UG cable.

3 Mark 18 cm at one end near the binding wire knot from the end where skinning is to be done, as shown in Fig 1.

Fig 1



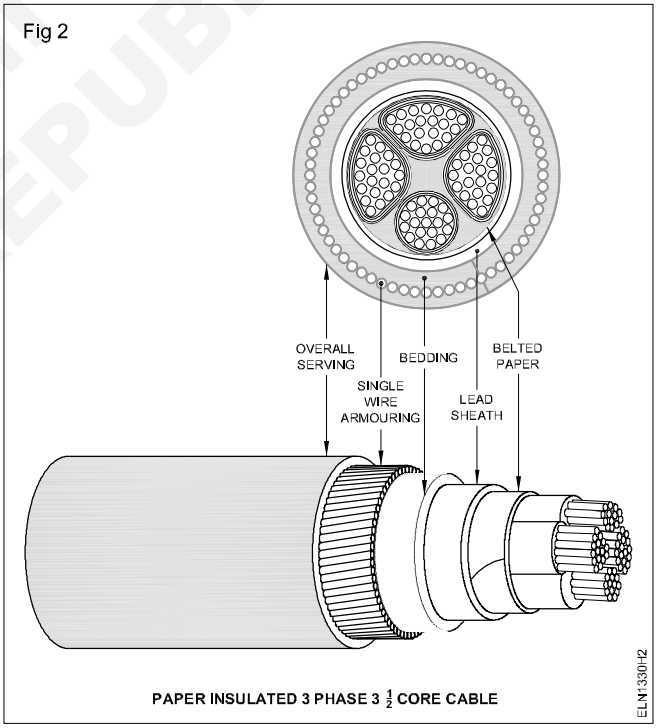
4 Cut the overall serving using the knife and remove the overall serving.

5 Mark 3 cm from the cutting edge and cut the single wire armouring using hacksaw.

6 Mark 3 cm from cutting edge and cut the bedding using knife/hacksaw.

7 Repeat steps 2-6 to skin all other layers till it is visible as shown in Fig 2.

Fig 2



Carefully examine the skinned portion for any damage/excess cutting.

8 Dress the protruding parts of the cable using a knife for a better finish.

9 Get your work approved by your instructor.

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Make straight joint of different types of underground cable

Objectives: At the end of this exercise, you shall be able to
- **cut the cable according to requirement**
- **prepare the cable as per measurement**
- **join the cables using split sleeves or ferrules and epoxy compound**
- **insulate the wires, cable joints.**

Requirements

Tools/Instruments

- Insulated combination plier 200 m - 1 No.
- Screwdriver 200 mm - 1 No.
- D.E. Spanner 6mm to 25 mm - 1 set
- DE Electrician's knife 100 cm - 1 No.
- Melting pot with 1 set of ladles - 1 No.
- Blow lamp 1/2 litre capacity - 1 No.
- Tongs 300 mm - 1 No.
- Triangular file smooth 200 mm - 1 No.
- Hacksaw adjustable 300 mm with 32 TPI blade
- Hammer ball pein 250 g - 1 No.
- Plier round nose 150 mm - 1 No.
- Hand vice 50 mm - 1 No.

Materials

- UG cable multi-core copper/ aluminium - as required.
- Binding wire 16 SWG - 200 g
- Lead and tin alloy 60/40 - asrequired
- Kerosene oil - 2 litre.
- Cotton tape 25 mm10mm long - 1 roll
- Bitumen compound ('epoxy'compound) - as required
- Jute thread 3 mm - 100 g.
- Impregnated cotton tape - as required.
- Porcelain barrier - as required.
- Coupling sleeve of suitable size - as required.
- Metal connectors of suitable size - as required.
- Slit sleeve of suitable size - as required.
- Insulating paste board or yarn tape - as required.
- Match box - 1 No.
- Asbestos thread - 50 g.
- Alca 'P' solder - 1/2 kg.
- Soldering flux - 100 g.
- Bricks - as required.
- Cotton cloth - as required.
- Eyre flux - 100 g.

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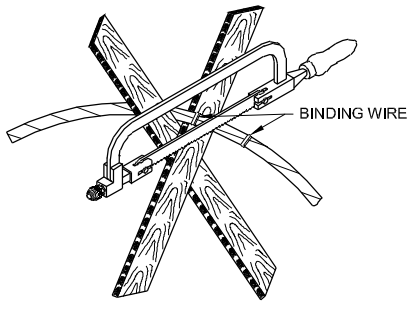
PROCEDURE

TASK 1 : **Make straight joint using sleeves in U.G cable**

1 Cut the given cable into two pieces as in Fig 1.

Fig 2 is given here for your guidance. Actual measurement for the cable insulation removal depends upon the type of cable joint box and cable sealing compound. Conventional method of cable jointing is done with bitumen compound for sealing the joint , brass glands at the ends of the joint box for sealing the joint entry and plumbing to finish the job. Modern joints with epoxy compounds are done by sealing the joint entry either with special tapes or with special compounds. According to the method chosen, the measurement has to be made and the insulation has to be removed at specified points. For procedural convenience in this sheet, L_1 is taken as 200 mm and so on.

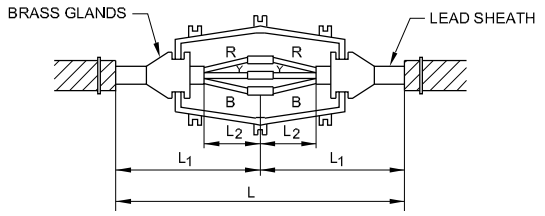
Fig 1



2 Bind 16 SWG GI binding wire on the serving (PILC cable) of the cables at a distance of 210 mm from one end as shown in Fig 3 to avoid loosening of the serving and damaging of the armour.

3 Remove the armour and serving of the cables to a length of 200 mm from the end of each cable as shown in Fig 4.

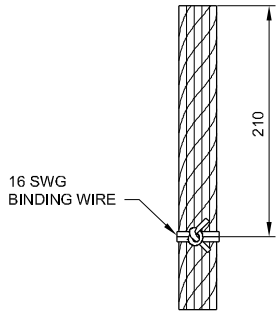
Fig 2



CONVENTIONAL JOINT USING FERRULE SLEEVE
BRASS GLAND FOR SEALING

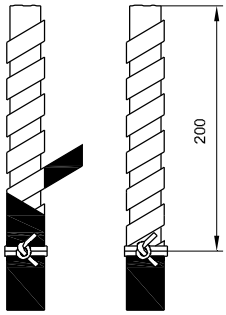
ELN1331J2

Fig 3



ELN1331J3

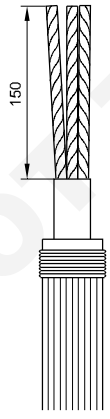
Fig 4



ELN1331J4

4 Remove the lead sheath to a length of 150 mm from the end of each cable as shown in Fig 5 and also remove the impregnated paper.

Fig 5



ELN1331J5

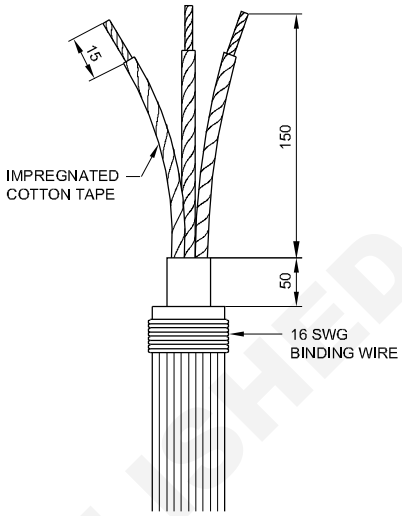
Avoid nicks or cuts on the core. Do not remove the paper insulation of individual cables.

5 Remove the paper insulation from both the cables to a length of 15 mm from the end.

Some prefer staggering of the joint position to have maximum efficiency of the joint. In such cases, the cable insulation should be removed accordingly. Fig 8 shows such a joint.

6 Twist the bare conductors tightly and tin the conductors. (Fig 6)

Fig 6



ELN1331J6

Wrap the end of the paper insulation near the bare conductor with lightly wetted cotton tape or asbestos tape to protect against excess heat.

7 Wrap the portion of the paper insulated cable with impregnated cotton tape to protect it from moisture and hot solder. (Fig 6)

Provide colour coding marks on cables at this stage.

8 Clean the split copper sleeves and the brass glands thoroughly and tin them.

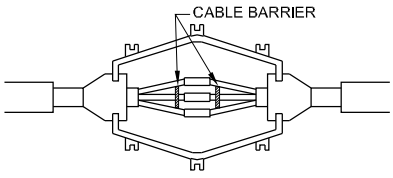
9 Clean the joint box and keep the bottom cover on the floor.

10 Insert the brass glands in the cables and position the bare end of the cable and gland inside the joint box as shown in Fig 2.

11 Insert the tinned portion of the cable ends into the split sleeve with the help of the colour code of the cables. (Fig 2)

12 Insert barriers (separators) between the three individual cables at both sides of the cable as shown in Fig 7.

Fig 7



ELN1331J7

13 Turn the split portion of the sleevves in the upward position to facilitate pouring of the solder.

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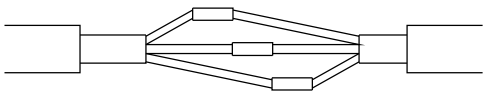
14 Remove the bottom cover of the joint box and push the brass glands apart and keep it in staggered position as in Fig 8.

Fig 8



STAGGERED POSITION OF JOINT

ELN1331J8

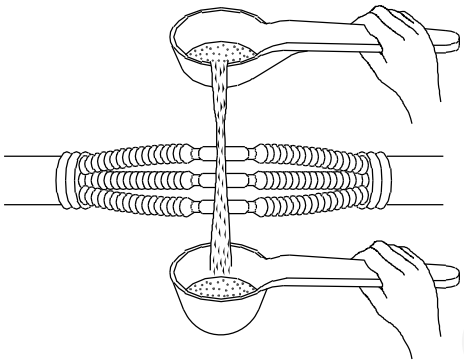
15 Apply soldering flux to the split sleeves and the bare portion of the conductor.

16 See that the ladles are dry and then start alternately scooping the molten solder with the ladles till the ladles are sufficiently hot.

17 Keep one of the empty ladles underneath the split sleeve that has to be soldered.

18 Pour the molten solder on the sleeve such that the solder enters the joint through the split as shown in Fig 9.

Fig 9



A THROUGH - TYPE JOINT ON PAPER INSULATED CABLES USING POT AND LADLE

ELN1331J9

After the joint is sufficiently heated, increase the time between the pourings to allow the solder to solidify inside the joint.

19 Stop pouring the solder when the sleeve is filled up, and the colour of the solder is bright.

20 Repeat this procedure to other joints one after another.

Do not shake or disturb the position of the cables during the soldering process as it will result in dry joints.

21 After the joint is cold, wrap with at least 2 layers of impregnated PVC tape over the joints.

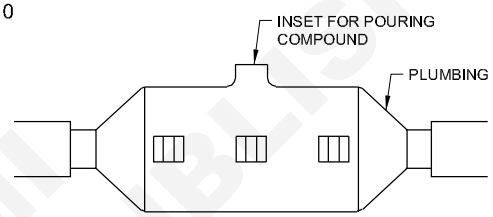
22 Preheat the joint box before filling the preheated sealing compound.

23 Close the top and bottom parts of the joint box together and, position the brass glands.

24 Use the solder lead to make proper plumbing joints between the lead sheath and the brass gland.

25 Pour molten sealing compound through the cover inlet as shown in Fig 10.

Fig 10



ELN1331JA

When the compound is filled up to the mouth of the inlet, stop pouring and allow it to cool.

After sufficient cooling, the compound will shrink, and now fill the available space with more molten compound.

26 Fix the cover inlet of the joint box after the joint is sufficiently cooled.

27 Cheek for cracks, melting due to heat or any other mechanical damage.

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Test insulation resistance of underground cable using Megger

Objectives : At the end of this exercise, you shall be able to
- **measure the insulation resistance between conductors of an armoured cable using Megger**
- **measure the insulation resistance between earth and conductors of an armoured cable.**

Requirements

Tools/Instruments

- Insulation resistance tester (Megger) 500 V - 1 No.

Materials

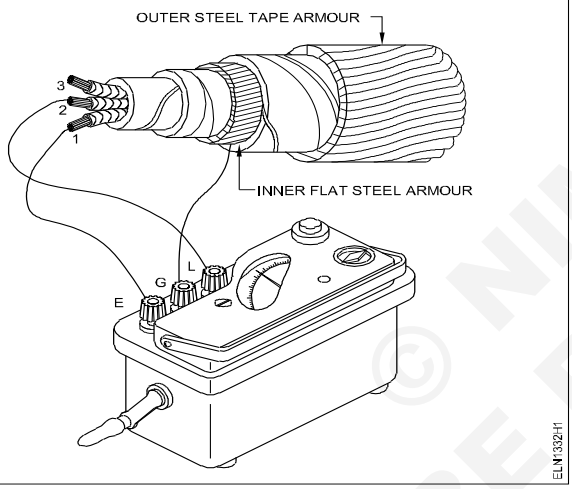
- Testing prods - 3 Nos.
- Armoured cables of different sizes and length - 2 Nos.

PROCEDURE

TASK 1: **Measure the insulation resistance between conductors of an armoured cable**

1 Connect the armoured cable as shown in Fig 1.

Fig 1



Connect the guard terminal of the meter with the armour (metal sheath) of the cable.

2 Measure the insulation resistance between the conductors and record the readings in Table 1.

Table 1

Measurement	Insulation resistance in megohms
Between conductors	
Conductor 1 and conductor 2	
Conductor 2 and conductor 3	
Conductor 1 and conductor 3	
Between earth and conductors	
Conductor 1 and earth	
Conductor 2 and earth	
Conductor 3 and earth	
Conductor 1, 2, 3 shorted and earth	

Steadily rotate the insulation tester's handle at a constant speed (160 r.p.m) at least for one minute duration before recording the meter reading.

— — — — — —

TASK 2: **Measure the insulation resistance between earth and conductors of an armoured cable**

1 Connect the armoured cable as shown in Fig 2.

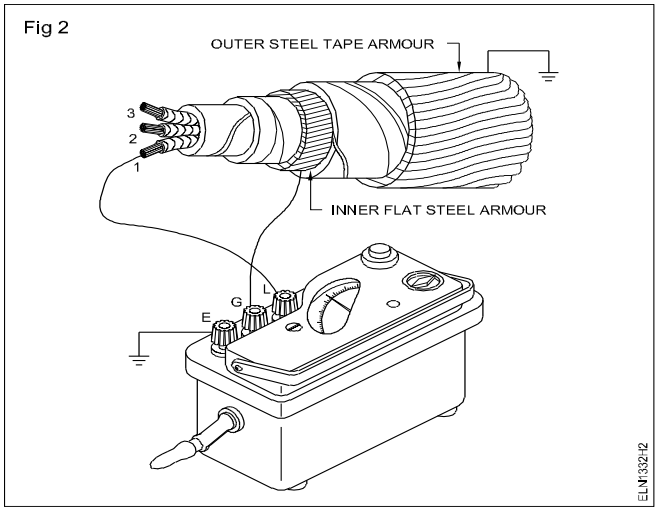
If the armoured cable is buried in the ground, connect the Megger as shown in Fig 2.

2 Measure the insulation resistance between earth and each conductor and record the readings in Table 1.

3 Measure the insulation resistance between earth and all the three conductors by shorting them together and record the reading in Table 1.

Discuss the required insulation resistance value of the cable with your instructor

Fig 2



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Test underground cables for faults, and remove the fault

Objectives: At the end of this exercise you shall be able to
- **locate open circuit faults in the cable**
- **locate short circuit faults in the cable**
- **locate the ground fault in the cable and rectify the fault.**

Requirements

Tools/Instruments

- Combination plier 200 mm - 1 No.
- Connector Screw driver 100 mm - 1 No.
- Screw driver 200 mm with blade of 4 mm width - 1 No.
- D.E electrician's knife 100 mm - 1 No.
- Megger 500V - 1 No.

Equipments/Machine

- Wheatstone bridge - 1 No.

Materials

- Connecting Prod for Megger - 1 set
- Connecting Prod for Wheatstone bridge - 1 set
- Connecting Cables (flexible, uniform, cross sectional area) - as reqd.

PROCEDURE

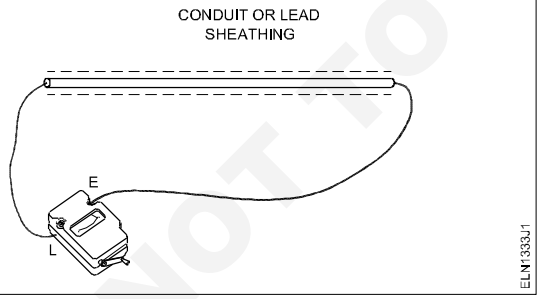
TASK 1: **Locate open circuit faults in underground cable**

This test is made to check whether the cable insulation is in open condition and to identify the exact location of the open circuit.

1 Switch 'OFF' the mains. Remove the fuse and the neutral links in the main switch and keep them in safe custody.

2 Select 500 V Megger and connect one terminal of the Megger, say L, to the one end of cable as shown in Fig 1.

Fig 1



3 Connect the other terminal of the Megger say 'E' to the other end of the cable.

4 Rotate the megger at 160 r.p.m.

5 Observe the megger reading. If the megger shows infinity, there is open circuit in the cable.

Open circuit may be due to open in the cable.

If the megger shows '0' reading, it indicates no open in the cable.

6 Connect the 'E' terminal near the middle of the cable and repeat the above procedure for open circuit.

If it shows '0' reading, there is no open in between 'L' and the middle of the cable.

7 Repeat the above procedure, connecting the 'E' terminal to beyond the middle point of the cable at varied distances.

When the megger shows infinity in a parhcilar place, that is the point of open.

8 Locate the faulty portion and make fresh straight joint to the UG cable.

— — — — — —

TASK 2: **Locate the short circuit fault in U.G cable**

This test is made to locate the short circuit in the cable by Murray loop test.

1 Switch 'OFF' the main switch. Remove the fuse of the main switch and keep it in safe custody.

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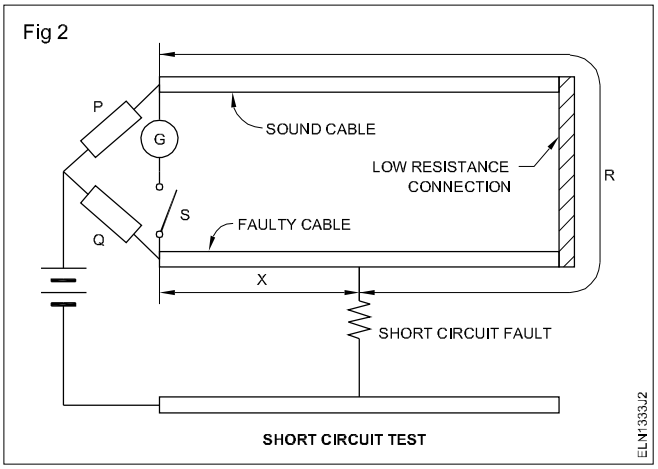
2 Select a Wheatstone bridge and connect one end of the cable to the meeting point of P and Galvanometer and another cable end to the meeting point of Q and Galvanometer as shown in Fig 2.

Fig 2



SHORT CIRCUIT TEST

3 Measure the length of each cable.

4 Connect the other two ends of both the cables by means of low resistance wire.

5 Take the battery terminal (negative) wire and place it at any point of the cable and observe the deflection in the Galvano meter.

The area of the cable where the Galvanometer shows '0' reading is the exact location of the short circuit. It can be calculated with the formula given below.

$$(i.e)\ \frac{x}{p} = \frac{Q}{P} \text{ or } \frac{X}{R+X} = \frac{Q}{P+Q}$$

where X is the length of the fault from the test end.

L is length of each cable.

6 Locate the fault while measuring the length of the cable and clear the short circuit in the UG cable.

— — — — — —

TASK 3: **Locate the ground fault in U.G cable**

This test is also done to locate ground fault in the cable by Murray Loop test.

1 Connect the cables as shown in the Fig 3 and repeat the steps explained in the short circuit test (TASK 2).

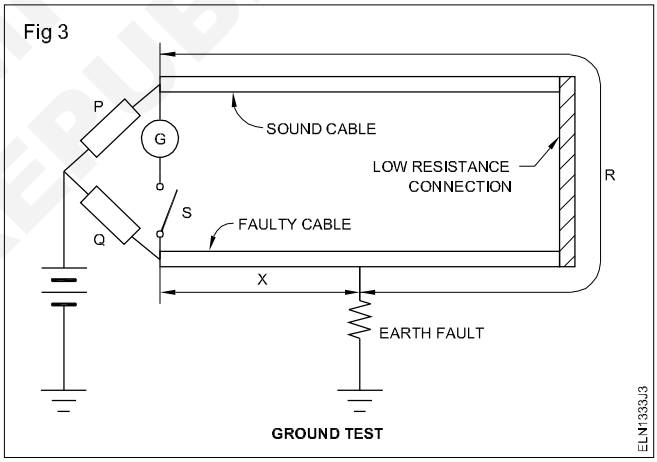
The area of the cable where the Galvanometer shows '0' reading is the exact location of the ground fault.

2 Calculate and locate the place of the ground fault as given below.

$$X = \frac{Q}{P+Q} \times 2L$$

Where 'X' is the length of the fault from the test end.

Fig 3



GROUND TEST

3 Locate the place where the ground fault is by measuring the length from the test end and repair the fault.

— — — — — —

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Practice on measurement of parameters in combinational Power circuit by applying Ohm's Law for different resistor values and voltage sources and analyse by drawing graphs

Objectives: At the end of this exercise you shall be able to
- **verify the relation between voltage and current when resistance is constant**
- **verify the relation between current and resistance when keeping voltage is constant**
- **plot the graph in both conditions illustrating the behaviour of current with respect to resistor.**

Requirements

Tools/Instruments

- Screwdriver 150 mm - 1 No.
- MC Ammeter 0 to 500 mA - 1 No.
- MI Ammeter 0 to 1A - 1 No.
- MC Voltmeter 0 15 V - 1 No.

Equipment/Machines

- 12 Volts battery 60 AH capacity OR - 1 No.
- DC variable power supply 0 - 30 V 2 amperes - 1 No.
- Rheostat 20 ohms - 3.7A - 1 No.

Materials

- S.P.Switch, 6A, 250V - 1 No.
- Resistors 10, 20, 50 Ohms 5 watts - 1 each.
- Resistor 20 ohms,2W - 1 No.
- Connecting leads 14/0.2 mm - 1 No.
- P.V.C. insulated copper wires of assorted length - 8 Nos.
- Graph sheet - 1 No.

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PROCEDURE

TASK 1: **Verify the relation between current and voltage when resistance is constant**

1 Check the voltmeter from the dial marking 'V'.

2 Check the ammeter from the dial marking 'A'.

3 Identify the fixed and variable terminals of the rheostat.

4 Connect the circuit elements as shown in Fig 1.

Fig 1

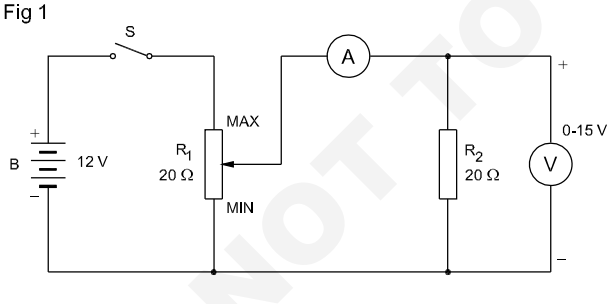


TABLE 1

No.	VOLTAGE (VOLTS)	CURRENT (AMPS)	RELATION BETWEEN I AND V

ELN1434-H1

5 Check the value of each major division and minor division of the scales of the meters.

6 Close the switch keeping the variable rheostat at the minimum value of output.

7 Apply different voltages by varying the rheostat arm of the potential divider in succession across the resistance.

8 Measure the voltage and the corresponding current from the instruments.

9 Record the measured values in Table 1.

To avoid parallax error:

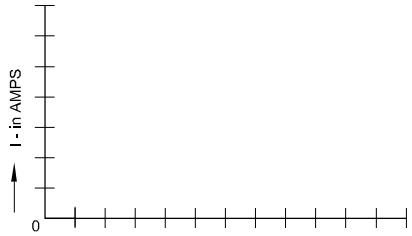
Position your eye in line with the pointer and also in front level of the instrument

Position your eye to coincide with the mirror image of the pointer in instruments having anti-parallax mirror.

10 Refer the recorded value and plot a graph. Write your conclusion considering the calculated R values.

V in Y Axis; I in X axis as shown in Fig 2.

Fig 2



Conclusion

Write your findings and conclusion by interpreting the current and voltage

_____

_____

— — — — — — — — —

TASK 2**: Verify the relation between current and resistance: Voltage is constant and resistance is variable**

1 Connect the circuit elements as shown in Fig 3 with 0 -1A ammeter. Adjust V at 10 volts keep it constant.

Fig 3

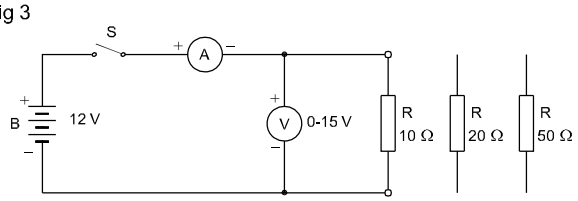


TABLE 2

No.	VOLTAGE (VOLTS)	RESISTANCE (OHMS)	CURRENT (AMPS)	RELATION--BETWEEN I AND R

ELN-4341-13

2 Close the switch 'S' and measure the current and voltage.

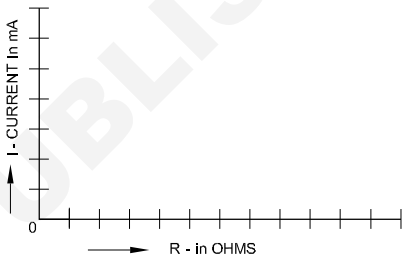
3 Read and record values in the given Table 2.

4 Open the switch (OFF). Change the ammeter to 0-500 mA and repeat steps 2 and 3 by replacing 10 - ohm resistance by 20 and 50 ohms.

5 Refer the recorded value and plot the graph. Write your conclusion considering the calculated I values.

R in Y Axis; V in X Axis as shown in Fig 4.

Fig 4



Write your findings and conclusion by interpreting the current and resistance.

Conclusion

_____

_____

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Measure current and voltage in Power circuits to verify Kirchhoff's Law

Objectives: At the end of this exercise you shall be able to
- **verify Kirchhoff's current Law in two and three branch currents**
- **verify Kirchoff's voltage Law with one voltage and two voltage source.**

Requirements

Tools/Instruments/Equipment

- Trainees kit - 1 No.
- Variable DC power supply unit 0-30V/1A - 2 Nos.
- Milliammeters 0 - 500 mA - 3 Nos.
- Milliammeters 0 - 30 mA - 1 No.
- Power supply unit 0 - 30 V - 1 No.

Materials

- Resistors 1K - 4 Nos.
- Resistors 2.2K - 1 No.
- Resistors 3.3K - 1 No.
- Resistors 4.7K - 1 No.
- Lug board - 1 No.
- Toggle switch, SPST, 1amp. - 2 Nos.
- Patch cords - as required.
- SPST switch 6A, 250V - as required.

PROCEDURE

TASK 1: **Verify the Kirchhoff's current law with two branch currents**

1 Connect the PSU, milliammeters, SPST switch and resistors as illustrated in the schematic circuit and the layout diagram as shown in Fig 1.

Keep the SPST and PSU in the OFF position while making circuit connections.

2 Switch 'ON' PSU and set output to 12 volts.

3 Simplify the circuit in Fig 1 and calculate the theoretical total circuit current and branch currents of the circuit for a set DC supply of 12 volts. Record values in Table 1.

Check if the connected ammeters can measure the calculated current. Change the meter, if necessary.

4 Get the circuit connections checked by your instructor.

5 Switch ON SPST.

6 Measure and record the total circuit current (I_T) and branch currents I_{S1} and I_{S2} in Table 1.

7 Switch OFF the SPST.

8 Set the output of the RPSU to 9 volts.

9 Calculate the theoretical circuit currents for the set supply voltage of 9V.

10 Record values in Table 1.

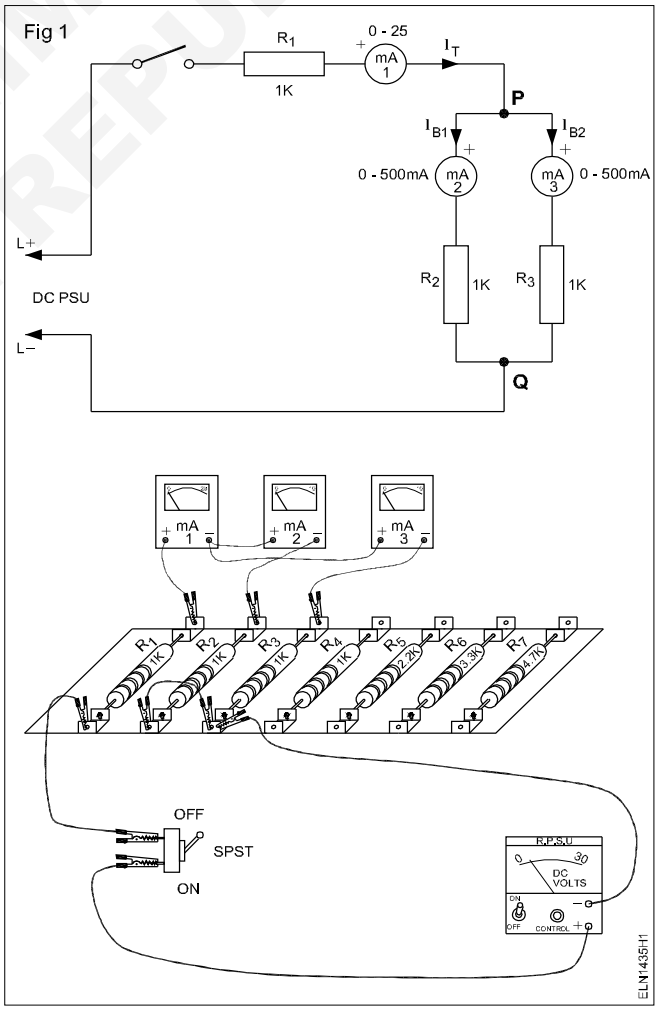
11 Repeat steps 4 and 6.

12 Switch OFF SPST and PSU.

13 Write Kirchhoff's current equations for the nodes P and Q.

14 Verify the equation substituting the measured current values.

Fig 1



15 Get the readings and equations checked by your instructor.

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Table 1

Set circuit voltage	Calculated values of circuit current			Measured values of circuit currents		
	Total circuit current (I_T) $I_T = I_{B1} + I_{B2}$	I_{B1}	I_{B2}	Total circuit current (I_T) $I_T = I_{B1} + I_{B2}$	I_{B1}	I_{B2}
12V						
9V						

— — — — — — — — —

TASK 2: **Verify the Kirchhoff's voltage Law with one voltage source**

1 Measure and record in Table 2, values of resistors R_4, R_5 and R_6 soldered on the lug board.

2 Make the circuit connections as shown in Fig 2.

3 Mark the polarity of the voltage drops across resistors R_4, R_5 and R_6 in the copy of Fig 2.

4 Get the circuit connections and polarities marked and checked by your instructor.

5 Switch ON PSU and set output to 12V. Switch ON SPST. Following the voltage polarities marked across the resistors, measure and record the drop in voltage across resistors R_4, R_5 & R_6 in Table 2.

6 Switch OFF SPST and PSU.

7 Write Kirchhoff's loop equations for the closed paths a-c-d-b-a, a-e-f-b-a and c-e-f-d-c. Substitute the voltage readings recorded in Table 2 in the equations for verification.

8 Get your readings and equations checked by your instructor.

Fig 2

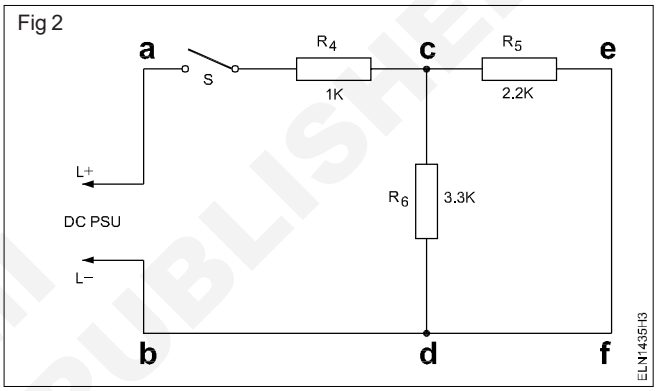

Table 2

Set circuit voltage	Measured values of			Voltage measured across		
	R_4	R_5	R_6	V_{R4}	V_{R5}	V_{R6}

— — — — — — — — —

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Verify law's of series and parallel circuits with voltage source in different combinations

Objectives: At the end of this exercise you shall be able to
- **verify the laws of series circuits**
- **verify the laws of parallel circuits.**

Requirements

Tools/ Instruments

- Electrician tool kit - 1 Set
- Ammeter MC 0-500 mA - 3 Nos.
- Rheostat - 100 ohms, 1A - 1 No.
- Voltmeter MC 0-15V - 1 No.
- Multimeter - 1 No.
- Rheostat 0 - 25 ohm, 2A - 2 Nos.
- Potentiometer 60 ohm, 1A - 1 No.
- Rheostat 0 - 300 ohm, 2A - 2 Nos.
- Rheostat 0 - 10 ohm,5A - 2 Nos.

Equipment/ Machines

- DC source, 0 - 6V/30AH (battery), Battery 12V, 90AH - 1 No. OR DC 0-30V variable voltage supply source with current limiting facility 0-1 ampere - 1 No.

Materials

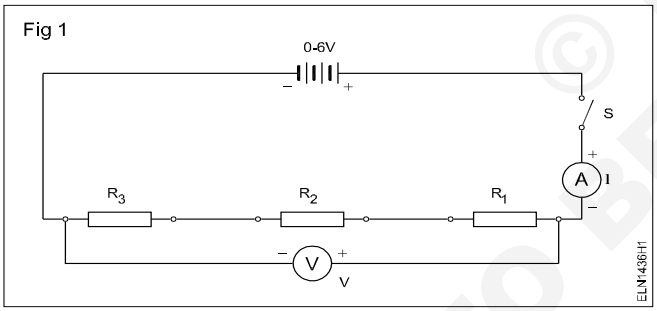
- Switch SPT 6A 250V - 1 No.
- Resistor 10 ohm 1 W - 2 Nos.
- Resistor 20, 30, 40 & 60 ohm 1 W - 1 No. each
- Connecting cables - as required.

PROCEDURE

TASK 1: **Verify the characteristics of series circuits**

1 Construct/ assemble the circuit as shown in Fig 1. (R_1 = 10 Ω, R_2 = 20 Ω , R_3 = 10 Ω)

Fig 1

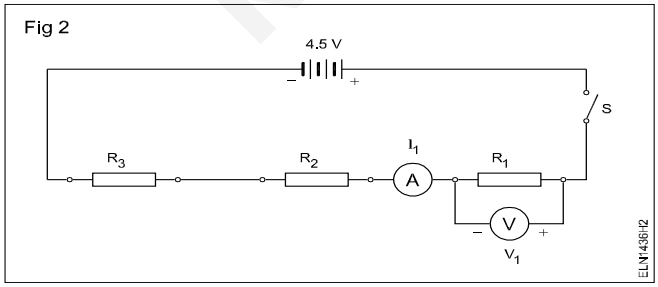


2 Close the switch 'S', measure the current (I) and voltage (V).

3 Enter the measured value in Table 1.

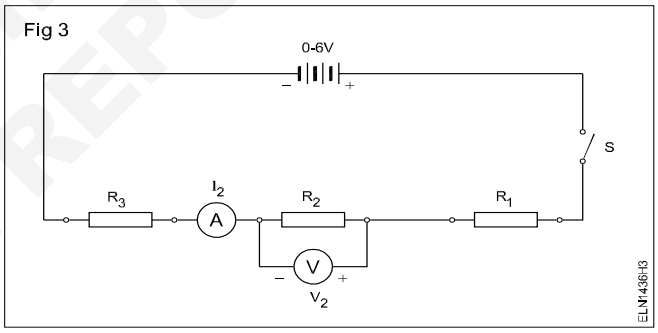
4 Switch OFF the supply. Reconnect the ammeter and voltmeter as shown in Fig 2 and measure voltage (V_1) and current I_1 through R_1.

Fig 2



5 Switch OFF the supply. Reconnect the voltmeter and ammeter as shown in Fig 3 and measure the voltage (V_2) and current (I_2) in R_2.

Fig 3



6 Also measure the current (I_3) and voltage (V_3) across R_3.

7 Enter the measured values in Table 1.

8 Record the relationship between I_1, I_2, I_3 and I.

_____

9 Write down the mathematical form of current law of a series circuit.

_____

_____

10 Record the relationship between V_1, V_2, V_3 and V.

_____

_____

11 Write down the mathematical form of voltage law of a series circuit.

V =

12 Calculate resistance from the measured values, record the results with the values indicated on the resistors.

13 Record the relationship between R and R_1, R_2, R_3.

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_____

_____

14 Write down the mathematical form of resistance law of a series circuit.

R =

15 Get it checked by the instructor

Table 1

Values	Total	R_1=10	R_2=20	R_3=10
Current	I =	I_1 =	I_2 =	I_3 =
Voltage	V=	V_1 =	V_2 =	V_3 =
Resistance	R = _____ =	R_1=_____ =	R_2=_____ =	R_3=_____ =

TASK 2 : **Verify the characteristics of parallel circuits**

1 Use an Ohm meter to set the values of a rheostat or resistor R_1 = 40 ohms, R_2 = 60 ohms and R_3 = 30 ohms.

2 Connect the resistors (Rheostats) in parallel with the switch S, ammeter A, voltmeter V and battery B as in Fig 4 and measure the current I_s and V_s. Record the valuesin Table 2.

3 Measure the voltages V_S, V_1 , V_2 & V_3 and record them in Table 3.

Fig 4

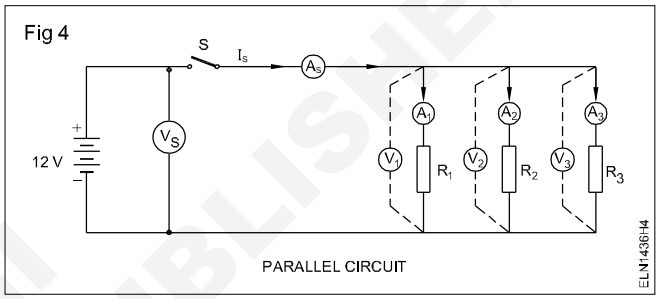

Table 2 Measured Value of R_T = ----------Ohms

Sl.No.	R_1	R_2	R_3	Calculated $R_T = \frac{1}{\frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_3}}$	I_s	V_s	$R_T = \frac{V_S}{I_S}$

4 Calculate the current through each resistor taking into consideration V_S, applying Ohm's law and enter the values in Table 3.

5 Measure the currents I_S, I_1, I_2 & I_3 and record them in Table 3.

6 Compare the calculated values with the measured values. Record your observation. _____

_____

7 Calculate the value of total resistance R_T, from the above measured values.

8 Compare the measured and calculated values of total resistance R_T.

Conclusion

Current Characteristics $I_S = I_1 + I_2 + I_3$

Voltage Characteristics $V_S = V_1 = V_2 = V_3$

Total Resistance $R_T = \frac{1}{\frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_3}}$

Table 3

V_s	V_1 Measured	V_2 Measured	V_3 Measured	Calculated				Measured			
				I_S	I_1	I_2	I_3	I_S	I_1	I_2	I_3

Conclusion

_____

_____

9 Get the work checked by the instructor.

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Measure the voltage and current against individual resistance in electrical circuit

Objectives: At the end of this exercise you shall be able to
- **connect individual resistor in series and measure current and voltage**
- **connect individual resistor in parallel and measure current and voltage**
- **compare the theoretical values with actuals in the circuit.**

Requirements

Tools/ Equipments

• Cutting plier 150 mm	- 1 No.
• Screw driver 150 mm	- 1 No.
• Voltmeter MI 0-300V	- 1 No.
• Ammeter MI 0 - 1A	- 1 No.
• Multimeter	- 1 No.
• AC source 240V/6A	- as required.

Materials

• Connecting leads	- as required.
• Lamp 250V/ 40W	- 2 Nos.
• Lamp 250V/ 60W	- 2 Nos.
• Switch 240V/6A	- 2 Nos.

PROCEDURE

TASK 1: **Measure the voltage and current of resistors in series**

1 Construct the circuit as shown in Fig 1.

2 Record the cold resistor value of lamps in Table 1.

3 Connect two 40W lamps in series and switch 'ON" AC 240V/6A. Measure and record the current and voltage V_1 and V_2 in Table 1 as per Fig 1A.

4 Switch 'OFF' and replace One 40W lamp and connect 60W lamps in series and repeat the step 3 process after switch 'ON' (Fig 1B).

5 Switch OFF and connect 2 lamps of 60W in series and repeat step 4. (Fig 1C).

6 Get the work checked by the instructor

Fig 1

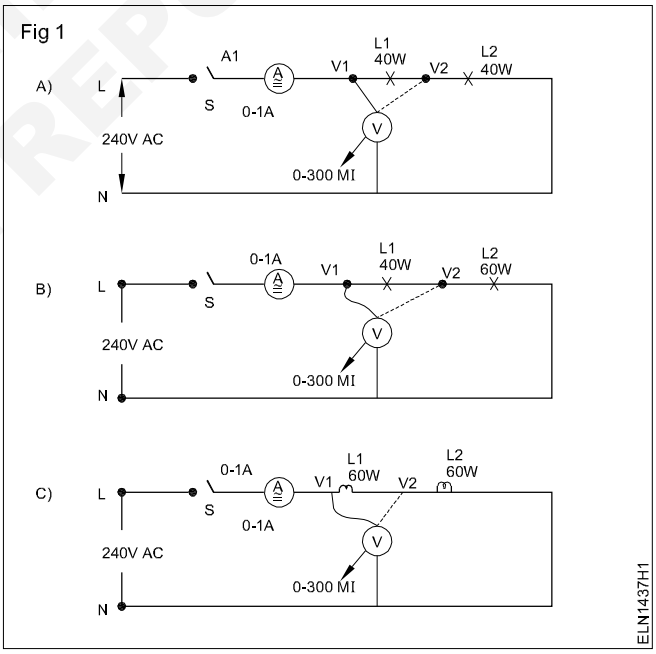

Table 1

Cold resistor		40W - 40W In series			40W - 60W In series			60W - 60W In series		
40W	60W									
		A	V1	V2	A	V1	V2	A	V1	V2
Value Measured										
Value Calculated										

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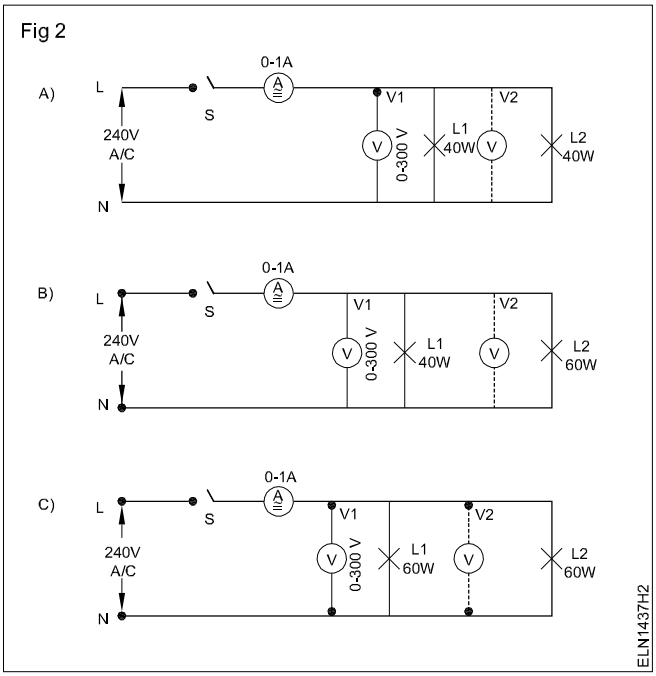
TASK 2: **Measure the voltage and current of resistors in parallel**

1 Connect the circuit as shown in Fig 2.

Fig 2



2 Connect two 40W lamps in parallel and switch 'ON' AC 240V/6A. Record the current, voltage V_1 and V_2 in Table 2 as per Fig 2A.

3 Switch 'OFF' and replace one 40W Lamp with 60W Lamp. Switch 'ON'and repeat the step 2 (Fig 2B).

4 Switch OFF and use two 60W Lamps and repeat step 3 (Fig 2C).

5 Record the reading in Table - 2 and write the conclusion.

6 Get the work checked by the instructor.

Table 2

Cold resistor		40W - 40W			40W - 60W			60W - 60W		
40W	60W	In parallel			In Parallel			In Parallel		
		A	V1	V2	A	V1	V2	A	V1	V2
Value measured										
Value calculated										

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Measure current and voltage and analyse the effects of shorts and opens in series circuits

Objectives: At the end of this exercise you shall be able to
- **examine the effects of short circuited resistors in series circuits**
- **analyse the effects of open circuited resistors in series circuits.**

Requirements

Tools/ Instruments

- Screwdriver 150 mm - 1 No.
- Voltmeter MC 0-15V (Sensitivity 20K Ω/V) - 1 No.
- Voltmeter 0 - 15V MC - 1 No.
- Ammeter 0 - 500mA - 1 No.
- Multimeter - 1 No.
- Rheostat 100/120 Ω, 300 Ω,1A - 1 No.
- DC voltage source variable 0-15V, 1 amp or Battery lead acid 12V, 60AH - 1 No.

Materials

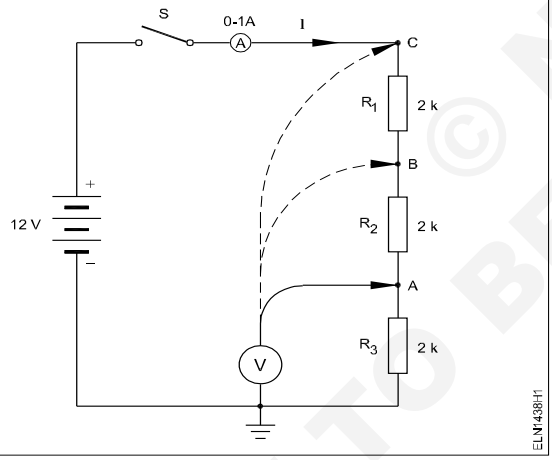
- Resistors 2K, 1 Watt - 3 Nos.
- Connecting leads - as required
- Switch 6A 250V - 2 Nos.

PROCEDURE

TASK 1: **Examine the effects of short and open circuited resistors in series circuits**

1 For the circuit in Fig 1, calculate the nominal values for the voltages V_A, V_B and V_C and record them in Table 1.

Fig 1



Note: All voltages are with respect to ground.

2 Considering resistor R_1 as shorted, calculate and record the resulting voltages at A, B and C, if this were to occur.

3 Enter the calculated values in the first column of Table 1 under the heading `Fault conditions'.

4 Repeat steps 2 and 3 for each resistor in turn.

5 Consider now removing R_1, calculate and record the resulting voltages at A, B and C.

6 Enter the calculated values in the fourth column of Table 1 under the heading `Fault conditions'.

7 Repeat this for each resistor in turn.

Note: Only one fault is simulated.

8 Verify your calculations in steps 3 and 6 by connecting a piece of wire across each resistor in turn, simulating a short circuit across that resistor, and then removing each resistor, simulating an open at the location.

10 Measure voltage for each fault condition and be sure to check consistency with the calculated values.

11 Record all measured data in the corresponding columns of Table 1.

12 Analyse the readings in healthy condition (normal condition) and faulty (OC and SC) condition and record the findings.

13 Get the work checked by your instructor.

Table 1

Voltages	Nominal Value	Fault conditions											
		R_1 Cal	S/C Meas	R_2 Cal	S/C Meas	R_3 Cal	S/C Meas	R_1 Cal	O/C Meas	R_2 Cal	O/C Meas	R_3 Cal	O/C Meas
V_A													
V_B													
V_C													

Cal - Calculated S/C - Short circuited
Meas - Measured O/C - Open circuited

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Measure the current and voltage and analyse the effects of shorts and open in parallel circuits

Scan the QR Code to view the video for this exercise

Objectives: At the end of this exercise you shall be able to
- **examine the effects of short and open circuited resistors in parallel circuits**
- **analyse the effects of short and open circuited resistor in parallel circuits.**

Requirements

Tools/ Instruments

- Screw driver 150 mm - 1 No.
- MC Voltmeter 0-15V (Sensitivity 20K Ω/V) - 1 No.
- MC Voltmeter 0 - 15V - 1 No.
- MC Ammeter 0 - 500mA - 1 No.
- Multimeter - 1 No.
- Rheostat 0 - 300 Ω, 2A - 1 No.
- DC voltage source variable 0-15V, 1 amp or Battery lead acid 12V, 80AH - 1 No.

Materials

- Connecting leads - as required
- Switch 6A 250V - 2 Nos
- Resistors, carbon composition 62KΩ 1/4 W, ± 5% - 1 No.
  - 33KΩ - 1 No.
  - 22KΩ - 1 No.
- Resistors, carbon composition
  - 220Ω - 1 No.
  - 1/2 W, ± 5%
  - 330 Ω - 1 No.
  - 470 Ω - 1 No.

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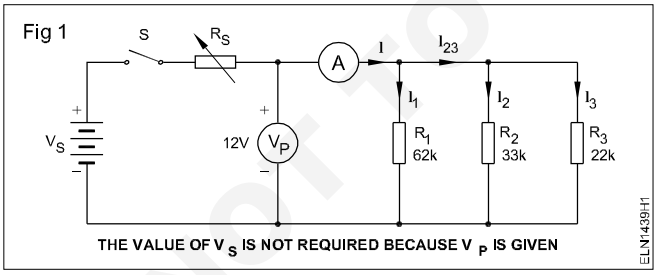
PROCEDURE

TASK 1: **Analyse the effect of short and open circuited resistors in parallel circuits**

1 Calculate the nominal values for the currents I, I_1 and I_{23}, I_2 and I_3 for the circuit in Fig 1 and record them in Table 1.

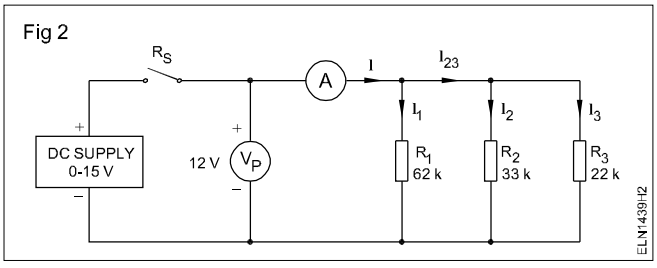
2 Construct the circuit (shown in Fig 1) and adjust R_S, source voltage series resistor, to a value that produces 12 volts across the parallel set of resistors.

Fig 1



3 Set the current limit to 100mA, if the DC power supply with current limiting feature is used as V_s. Omit the series resistor R_S. (Fig 2)

Fig 2



4 Measure and record the values of currents (I, I_1, I_{23}, I_2, and I_3). (Use Multimeter DC milliamperes range). Record them in the 'nominal' column in Table 2.

5 Now consider a shorted R_1. Estimate and record the resulting currents if this were to occur. Enter the calculated values in the first column in Table 1 under the heading `Short resistor'.

6 Repeat step 5 for each resistor in turn.

7 Now consider removing R_1. Calculate and record the resulting currents if this were to occur. Enter the calculated values in the last column in Table 1 under the heading `Open resistor'.

8 Repeat step 7 for each resistor in turn.

Only one fault is simulated.

9 Verify the calculations in steps 5 and 6 by connecting a piece of wire across each resistor in turn to simulate a short circuit across that resistor. Measure and record the current for each fault condition in Table 2.

10 Check the measured value of current consistency with the calculated values in Table 1.

11 Verify the calculation in steps 7 and 8 by removing each resistor in turn to simulate an open circuit at that location.

12 Measure and record the current for each fault condition in Table 2 .

13 Check for the measured value of currents consistency with the calculated values in Table 2.

14 Analyse the readings in healthy condition (normal) and faulty (OC & SC) condition and record the findings.

15 Get it checked and approved by the instructor.

Table 1

Currents	Nominal	Calculated value of current					
		Short resistor			Open resistor		
		R_1	R_2	R_3	R_1	R_2	R_3
I							
I_1							
I_{23}							
I_2							
I_3							

Table 2

Currents	Nominal	Measured value of current					
		Short resistor			Open resistor		
		R_1	R_2	R_3	R_1	R_2	R_3
I							
I_1							
I_{23}							
I_2							
I_3							

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Measure resistance using voltage drop method

Objectives: At the end of this exercise you shall be able to
- **determine unknown high resistance by voltage drop method**
- **test unknown low resistance by voltage drop method.**

Requirements

Tools/Equipments

- Cutting plier 150 mm - 1 No.
- Screwdriver 100 mm - 1 No.
- Ammeter MC 0-500 mA - 1 No.
- Multimeter - 1 No.
- DC power supply unit 0-30V (RPS) - 1 No.

Materials

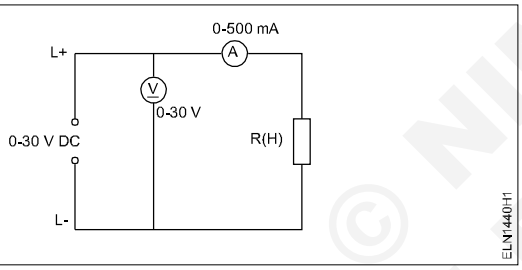
- Resistor high value - 2 Nos.
- Resistor low value - 2 Nos.

PROCEDURE

TASK 1: **Measure the high value resistance by voltage drop method.**

1 Construct the circuit as diagram. shown in Fig 1 and connect the high value resistor.

Fig 1



2 Switch ON power supply and adjust the DC volt to 30V.

3 Note the current and record it in Table 1.

4 Replace with another high value resistor and repeat step 3.

The true value and the measured value of R will be equal if we provide "0Ω resistance" ammeter and infinite voltmeter resistance.

Table 1

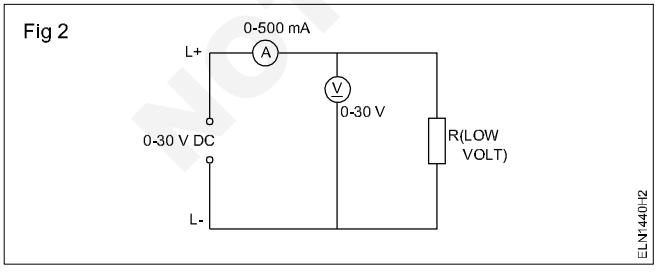
Sl.No.	V	I	$R_m = \frac{\text{V reading}}{\text{A reading}}$
1			
2			

— — — — — — — — —

TASK 2: **Measure low value resistance by voltage drop method**

1 Costruct the circuit as per shown in Fig 2 and connect the low value resistor.

Fig 2



2 Repeat step 2 in TASK 1.

3 Record the current and voltage in Table 2.

Table 2

Sl.No.	V	I	$R_m = \frac{\text{V reading}}{\text{A reading}}$
1			
2			

The true value and measured value of R will be equal if we provide "0Ω resistance" ammeter and infinite voltmeter resistance.

4 Write your conclusion _____.

5 Get the work approved by the instructor.

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Measure resistance using wheatstone bridge

Objectives: At the end of this exercise you, shall be able to
- **identify the terminals of a Wheatstone bridge**
- **complete the bridge with resistors**
- **operate a wheatstone bridge to get 'Null' deflection**
- **calculate the value of unknown resistance using the wheatstone bridge.**

Requirements

Equipment/Machines

- Wheatstone bridge - 1 No.

Materials

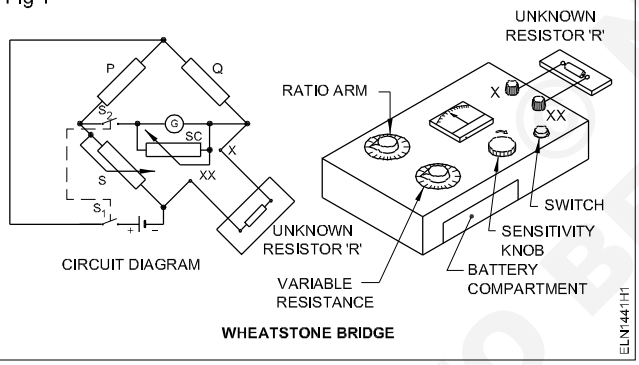
- Resistor 2 ohms 5 W - 1 No.
- Resistor 50 ohms 5W - 1 No.
- Resistor 10 ohms 5W - 1 No.
- Resistor 1K ohms 2W - 1 No.
- Resistor 330K ohms 2W - 1 No.
- Torch cells/battery for Wheatstone bridge - as reqd.

PROCEDURE

TASK 1: **Measuring an unknown resistance using Wheatstone bridge**

1 Identify the ratio arm (PQ), variable resistance (S), sensitivity control (SC), switch (S1), galvanometer (G), connecting terminal (x, xx) and battery compartment of the Wheatstone bridge and correlate it with the schematic diagram in Fig 1.

Fig 1



2 Check the battery for its condition.

3 Check the values of the ratio arm.

4 Check the minimum and maximum values of the variable resistance.

5 Connect the unknown resistor across terminals x and xx.

6 Set the ratio arm to the approximate value of the unknown resistor.

7 Set the variable resistor knob in the middle.

8 Set the sensitivity control to `Low'.

9 Close the switch and watch the deflection of the galvanometer.

10 Adjust the variable arm by closing the switch, to get a minimum deflection in the galvanometer. (In case the galvanometer needle overshoots, reset the ratio arm.)

11 Increase the sensitivity and repeat step 10.

12 When `Null' deflection is achieved in the galvanometer, note the value of the ratio arm and position of the variable resistance. Enter the values in Table 1.

13 Apply the formula given below and calculate the resistance.

Unknown resistance in ohms = _____

Reading of ratio arm setting X value of variable resistance

$$\frac{P}{Q} = \frac{S}{R}$$

$$R = \frac{S}{P} \times Q$$

14 Enter the values in Table 1.

15 Repeat the procedure for measuring at least four unknown resistors and enter their respective values in Table 1.

16 Get the work approved by the instructor.

Table 1

Sl.No.	Type of resistor	Setting of ratio arm	Value of variable resistance	Resistor value in ohms = Ratio arm x value of variable resistance

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Determine the thermal effect of electric current

Objectives: At the end of this exercise you shall be able to
- **connect the ammeter in circuit**
- **read the ammeter**
- **connect the circuit element in series**
- **test the Power continuity**
- **analyse the effects of electric current - thermal effect.**

Requirements

Tools/Instruments

- Ammeter 0-15A MC - 1 No.
- Battery lead acid 90 AH 12 V - 1 No.
- Rheostat 10 ohms, 2A - 1 No.

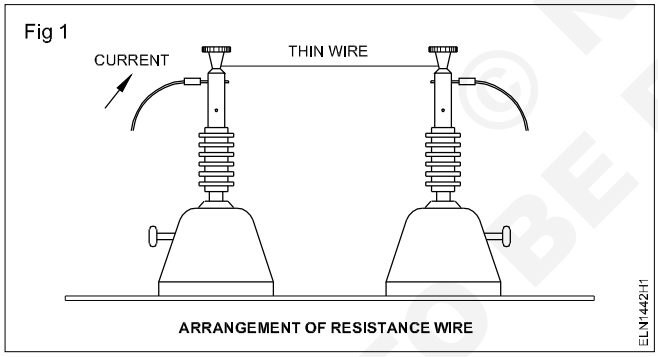
Materials

- Connecting leads
  48/0.2mm 1m - 8 Nos.
  80/0.2mm 1m - 8 Nos.
  128/0.2mm 1m - 8 Nos.
- Resistance wire Nichrome/constantine diameter. 0.2 to 0.3mm 250 to 500 mm.
- S.P.T.Switch 16A 250V - 1 No.
- Connecting terminal post 16A - 2 Nos.

PROCEDURE

1 Connect the resistance wire to the connecting terminal post. (Fig 1)

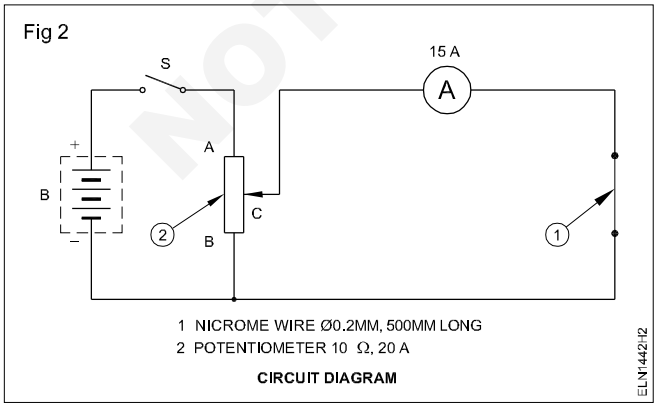
Fig 1



ARRANGEMENT OF RESISTANCE WIRE

2 Form the circuit with the resistance wire, ammeter, switch potential divider and battery. (Fig 2)

Fig 2



1 NICROME WIRE Ø0.2MM, 500MM LONG
2 POTENTIOMETER 10 Ω, 20 A

CIRCUIT DIAGRAM

3 Keep the potential divider point C at B.

4 Close the switch and adjust the potential divider for current. (Approximately.1 ampere.)

5 Observe the ammeter reading.

6 Touch the resistance wire and feel.

7 **Conclusion**

When the current flows in a resistive wire _____ is generated.

8 Gradually increase the current by varying the potential divider.

Note: For every change in current value - switch OFF and allow the wire to cool down to the room temperature.

For every change of current, the time duration to feel the heat must be the same, say 5 minutes.

9 Observe the value of the current through the resistance wire.

Note: Feel the heat at a distance without touching the wire. Be cautious not to burn your fingers.

10 **Conclusion**

When current increases _____ increases in the resistive wire.

11 When current is too high the resistance wire becomes _____.

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Determine the change in resistance due to temperature

Objectives: At the end of this exercise you shall be able to
- **measure cold resistance of the incandescent lamp using ohmmeter**
- **measure hot resistance of the incandescent lamp with supply by voltmeter and ammeter**
- **identify the colour of the filament with respect to the voltage variation**
- **determine the relation between resistance and changes in temperature.**

Requirements

Tools/Instruments

- Connector screwdriver 100 mm - 1 No
- MI Voltmeter 0-300V - 1 No.
- MC Ammeter 0-1A - 1 No.
- Ohmmeter (shunt type) - 1 No.
- MC Voltmeter - 5 volts or multimeter (digital) - 1 No.

Materials

- Double-pole switch 250V,6A - 1 No.
- Lamp 15W, 250V - 1 No.
- Lamp-holder B.C.batten - 1 No.
- Candle - 1 No.
- Potentiometer 500 ohms, 0.5A - 1 No.
- Iron wire 0.2 mm diameter. - 2.5m.
- Connecting leads -11 Nos.
- Terminal post 16A - 2 Nos.
- Lamp 40W, 250V - 1 No.

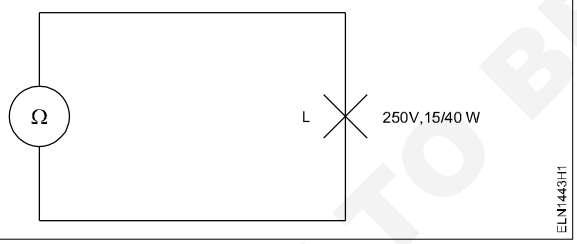
PROCEDURE

TASK 1: **Measuring of cold and hot resistance of the incandescent lamp by using ohmmeter**

1 Set the ohmmeter to 'zero' and touch the two leads on the pins of the lamp.

2 Measure the resistance of the given incandescent lamp using ohmmeter (Fig 1).

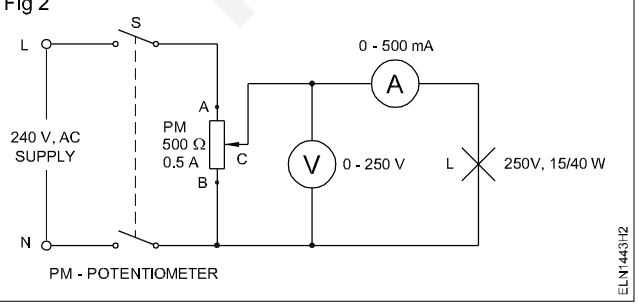
Fig 1



3 Record the value in Table 1.

4 Form the circuit with the lamp-holder, voltmeter, ammeter, potentiometer, D.P.S.T. switch and supply as per the circuit diagram. (Fig 2)

Fig 2



5 Get the circuit checked by the instructor. Keep the potential divider point C at B.

6 Fix the incandescent lamp in the lamp-holder and close the switch.

Note: Switch off the supply before fixing the lamp.

7 Adjust the potentiometer at 50 volts.

8 Close the switch and read the voltmeter and ammeter.

9 Record the values in Table 1.

10 Observe the colour of the filament and feel the temperature on the lamp's glass.

Table 1

Measurement			R in Ω	Colour of filament
1	Cold resistance of bulb measured by ohmmeter			
	V in volts	I in mA		
2	50 V			
3	100 V			
4	150 V			
5	240 V			

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10 Repeat steps 6 to 8 for 100V, 150V and 240V.

11 Calculate the resistance using the formula $R = \frac{E}{I}$ for every set of reading.

12 Record the calculated values of resistance in the Table.

Conclusion

_____

_____

_____

_____

— — — — — — — — —

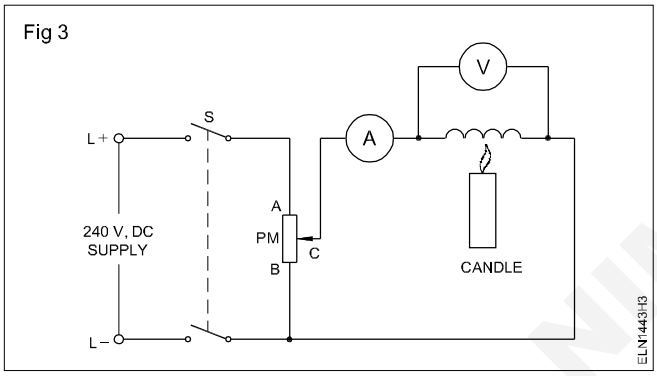
TASK 2: **Determine the relation between resistance and changes in temperature using a candle**

1 Make a coil of iron wire of length 0.5 m and diameter 0.2 mm.

2 Fix the coil between the two terminal posts mounted on a piece of insulating board.

3 Build the circuit according to Fig 3.

Fig 3



4 Increase the supply voltage to the iron coil by adjusting the potentiometer so that the current (I) reaches a value of 450mA.

5 Measure the voltage drop V_D across the coiled wire.

6 From both the values (I and V_D) calculate the resistance of the coil.

7 The result is: I = ____ A

V_D = ____ V.

Therefore, $R_D = \frac{V_D}{I}$

8 Now, warm the coil by heating it in candle flame record and the measurement for calculation of resistance. Do not change the potential divider movable arm position.

9 This now results in : I _____ A

V_D _____ V.

Therefore, $R_D = \frac{V_D}{I}$ = ... ohms

The result may vary considerably due to different temperatures of the wire.

Conclusion

What is the relationship between resistance and temperature?

_____

_____

_____

— — — — — — — — —

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Verify the characteristics of series parallel combination of resistors

Objectives: At the end of this exercise you shall be able to
- **form series parallel combination circuits**
- **verify characteristics of series and parallel circuits.**

Requirements

Tools/ Instruments

- Electrician tool kit - 1 Set
- MC Ammeter 0-500 mA - 3 Nos.
- Rheostat - 100 ohms, 1A - 1 No.
- MC Voltmeter 0-15V - 1 No.
- Multimeter - 1 No.
- Potentiometer 60 ohm 2A - 1 No.
- Rheostat 25 ohms 2A - 1 No.
- Rheostat - 40 ohms,2A - 2 Nos.
- Rheostat - 300 ohms, 2A - 1 No.

Equipment/ Machines

- DC source,Battery 12V,80AH or DC 0-60V variable voltage supply source with current limiting facility 0-1 ampere - 1 No.

Materials

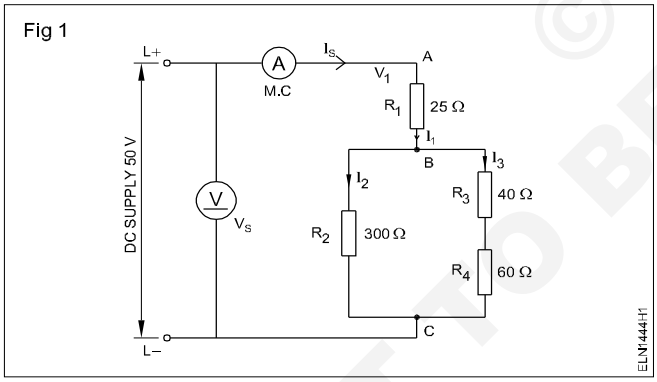
- Switch SPT 6A 250V - 1 No.
- Resistor 22 ohms 1 W - 1 No.
- Resistor 10 ohms 1 W - 1 No.
- Connecting cables - as reqd.

PROCEDURE

TASK 1: **Verify the characteristics of series parallel combination of resistors**

1 Draw the circuit diagram and calculate the voltage and currents for the series parallel circuit shown in Fig 1. Enter the values in Table 1.

Fig 1



2 Calculate the total resistance R_T and total current I_S for V_S = 50V and enter in Table 2.

3 Set the value of the rheostat resistances equal to the values given in Fig 1 (i.e. R_1 = 25 ohms, R_2 = 300 ohms, R_3 = 40 ohms and R_4 = 60 ohms) by measuring the resistance value between one end and the variable point of the rheostat.

4 Form the circuit and measure the voltages and current. Record them in Table 1.

5 Calculate the value of R_T from V_s and I_s and enter in Table 2. Compare with the value obtained in step 2.

Verification

$I_S = I_2 + I_3$; $V = V_R + V_R$; $R_T = R_1 + (R_2/(R_3 + R_4)$.

Table 1

		V_{RI}	I_S	I_2	V_{R2}	I_3	V_{R3}	R_3+R_4	$R_2 \| (R_3+R_4)$
V_S = 50V R_1 = 25Ω R_2 = 300Ω R_3 = 40Ω R_4 = 60Ω	Calculated Values								
	Measured Values								

Table 2

Calculated Values	$R_T = R_1 + \{R_2 \parallel (R_3 + R_4)\}$ =
Measured Values	$R_T = \frac{V_S}{I_S}$ =

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Determine the poles and plot the field of a magnet bar

Objectives: At the end of this exercise, you shall be able to
- **determine the polarity of a permanent magnet**
- **trace the magnetic field of the given magnetic bar**
- **trace the magnetic lines with the aid of a compass needle and iron filings.**

Requirements

Tools/Instruments

- Bar magnet 12 x 6 x 100 mm - 2 Nos.
- Compass needle 10 mm diameter. - 1 No.

Materials

- M.S.bar 12 x 6 x 100 m or (make a M.S. bar to the size of the bar magnet available) - 1 No.
- Thread (tensionless) - 1 m
- Iron filings - 25 gms
- Iron nails - 25 gms.
- Aluminium wire - a few pieces
- Copper wire - a few pieces
- Cotton thread sleeve - a few pieces
- Wood chips - a small quantity.
- Paper pins - as required.

PROCEDURE

TASK 1: **Determine the pole of a permanent bar magnet**

1 Suspend the magnet as shown in Fig 1 with a tensionless thread.

2 Observe the direction of the poles of the suspended magnet.

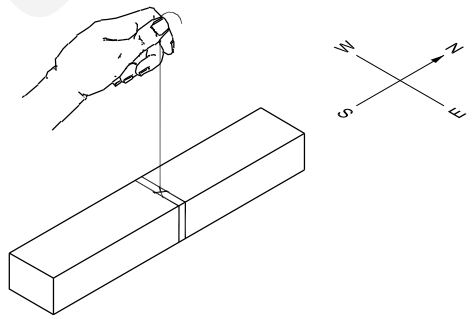
3 Mark the polarity N on the free end of the suspended magnet that points (seeks) at the north direction of the earth.

4 Reorient the position of the suspended magnet to cofirm the polarity.

5 Check the identified pole with a magnetic compass.

The compass needle must not be taken near the poles of the bar magnet.

Fig 1



ELN1545H2

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TASK 2: **Trace the magnetic path of the given magnetic bar**

1 Place the bar magnet's north pole underneath the paper as shown in Fig 2. Sprinkle some iron filings on the paper.

2 Tap the paper gently on all the corners. Observe the random filings getting oriented into a definite pattern.

3 Gently draw lines along the orientation of the iron filings with a pencil. Repeat the expriment for the other pole as shown in Fig 3.

4 Place the bar magnet underneath a thin cardboard as shown in Fig 4. Sprinkle some iron filings. Gently tap the paper to orient the iron filings and trace the magnetic path with a pencil.

Fig 2

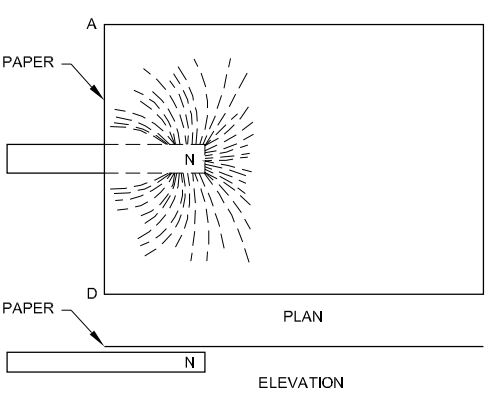

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Fig 3

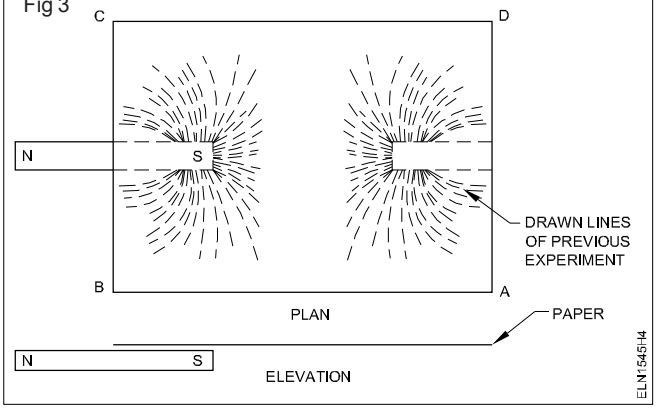
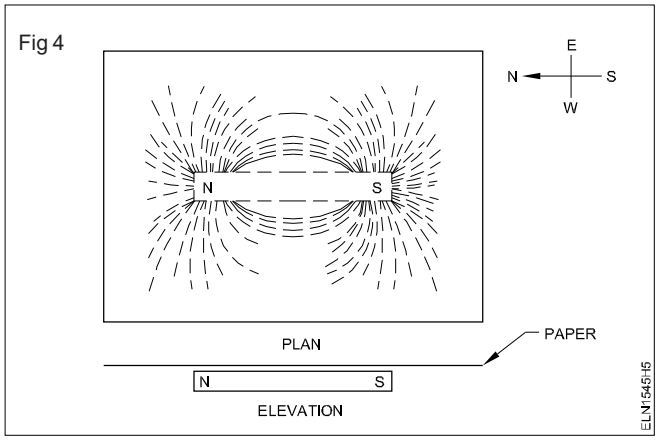


Fig 4

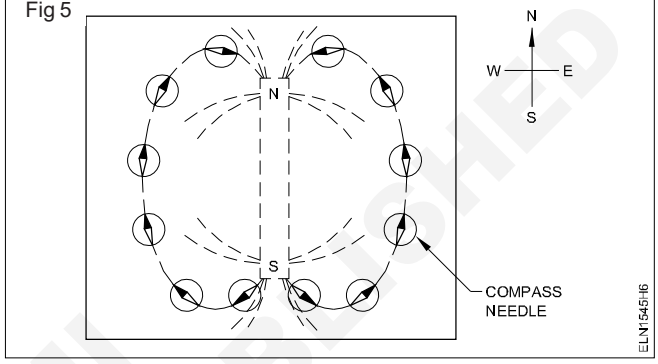


5 Place another thin card over the bar magnet as shown in Fig 5. Trace the magnetic lines using a compass needle by positioning the needle in the required areas..

For steps 4 and 5, the bar magnet should be oriented in the geometrical north-south direction.

Do not use a strong bar magnet for mapping the field with a compass.

Fig 5



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Wind a solenoid and determine the magnetic effect of electric current

Objectives: At the end of this exercise you shall be able to
- **prepare a bobbin**
- **select the suitable wire and make the winding for solenoid**
- **determine the pulling strength of a solenoid.**

Requirements

Tools/Instruments

- Combination pliers 150 mm - 1 No.
- Screwdriver 100 mm - 1 No.
- Screwdriver 150 mm with 3 mm blade - 1 No.
- Magnetic compass 12 mm diameter - 8 Nos.
- Rheostat 10 Ohms, 20A - 1 No.
- MC Ammeter 0-10A - 1 No.
- MC Ammeter 0-30A - 1 No.
- MC Voltmeter 0-15/0-25V - 1 No.

Equipment/Machines

- Battery 12V, 80 or 100AH or variable voltage source DC 0-25V, 30A - 1 No.

Materials

- Iron filings - 50 gms
- Connecting leads - as reqd.
- DPST knife switch 16A/ 250V - 1 No.
- Enamelled copper wire 16SWG - 50 cm
- Paper pins - a few
- Terminal post 16A - 2 Nos
- SPST knife switch 16A / 250V - 1 No.
- PVC insulated cable 4 sq.mm 250V grade - 4 m.
- Barrator resistor 0.48 ohms 250W - 1 No.
- Cardboard A4 (R 48) size - 1 No.
- Bare copper wire 4 sq.mm - 1 m.
- Porcelain connectors 2-way 32A - 2 Nos.
- Transparent sheet of plastic, A4 size, 3 mm thick - 1 No.
- PVC saddles 50mm - 2 Nos.
- PVC pipe 25 mm 100 mm long - 1 piece.
- PVC washer 25mm inner diameter. 50 mm outside dia. - 2 Nos.
- PVC adhesive tape - as reqd.
- Super-enamelled copper wire 22 SWG - 50m.
- 4–way terminal pad - 1 No.
- T W plank 150 mm x 300 mm - 1 No.
- Soft iron piece 22 mm dia 75 mm long with hook on one end - 1 No.
- SPST Knife switch 16A - 1 No.
- Adhesive paste for fixing washers - as reqd.
- PVC/Empire sleeve 2 mm - as reqd.

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PROCEDURE

TASK 1: **Make the solenoid and determine its polarity for the given direction of current**

1 Fix the PVC washers at both ends of the PVC pipe to make the bobbin. (Fig 1)

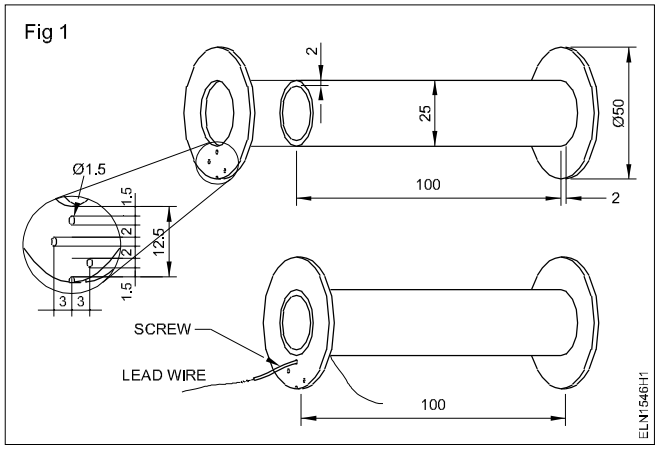
2 Fix the bobbin suitably in a hand drilling machine.

3 Secure the lead-out wire to the bobbin by means of an adhesive tape after inserting the lead wire with sleeve through the hole in the side wall of the bobbin.

4 Find the number of turns wound over the bobbin for one rotation of the drilling machine handle.

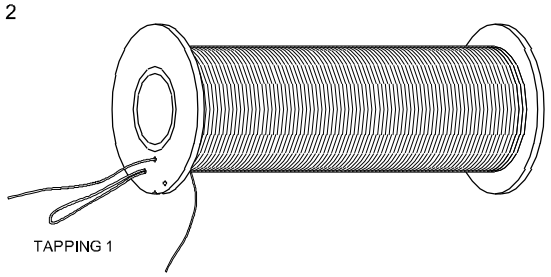
5 Calculate the number of handle rotations required for winding 200, 400 and 600 turns.

Fig 1



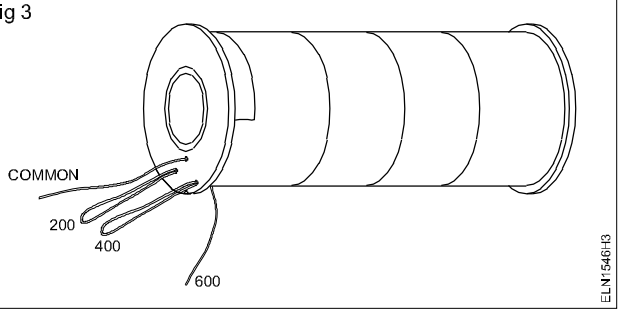
6 Complete the windings by taking tapping at an interval of every 200 turns (200, 400 and 600) such that the common and three terminals are taken out through the holes provided in the side wall (PVC washer). (Fig 2)

Fig 2



7 Insulate the top layer with an adhesive insulation tape. (Fig 3)

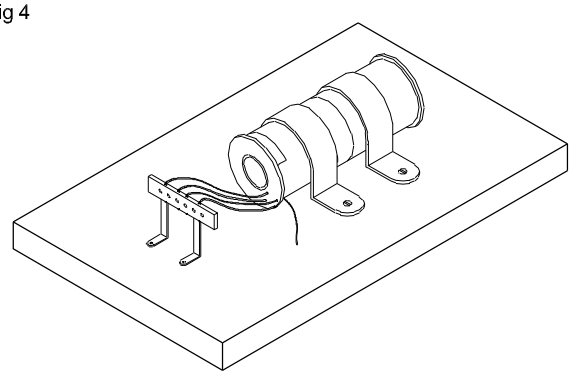
Fig 3



8 Fix the solenoid on a 150 mm x 300 mm wooden board using a plastic saddle. (Fig 4)

9 Connect the drawn out ends with sleeves to the 4-way terminal pad, fixed on the board. (Fig 4)

Fig 4

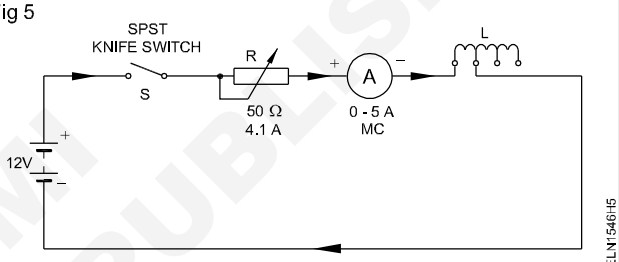


Carefully remove the enamel insulation without damaging the conductor.

10 Check the continuity with an Ohmmeter.

11 Connect the ends of the solenoid to the 12V battery through switch S, variable rheostat and ammeter 0 - 10A. (Fig 5)

Fig 5



12 Close the switch S and test the solenoid with a bar.

TASK 2: **Determine the magnetic effect of electric current**

1 Vertically mount the coil on a stand.

2 Suspend the spring balance from the stand and hook it vertically to the (plunger) soft iron piece. (Fig 6)

Check for the free movement of the plunger inside the solenoid.

3 Take the initial reading of the spring balance.

4 Connect the solenoid to the first tapping, say 200 turns, through an ammeter, knife switch and rheostat as shown in Fig 5. Get the circuit checked by the instructor.

5 Close the switch and adjust the current to 5 amperes.

6 Note the reading of the ammeter and spring balance and record in Table 1.

7 Open the switch.

8 Repeat operations 4 to 7 for tappings 400 and 600 by keeping the current constant at 5A, adjusting the rheostat.

9 Calculate the pulling power for strength in all the 3 cases.

10 Ascertain the relationship between the number of turns and magnetic strength when the solenoid carries the same current, and record the conclusion accordingly.

11 Connect the coil to 600 turns tappings.

12 Close the switch.

13 Keep the current at 1 ampere by adjusting the rheostat. (Fig 6)

14 Note and record the spring balance readings in Table 2.

15 Repeat step 14 for different current values (in steps of 1 ampere up to 5 amperes).

16 Calculate the pulling power for strength in all the 5 cases.

17 Ascertain the relationship between the current and the magnetic strength when the number of turns of the solenoid is constant. Record the conclusion accordingly.

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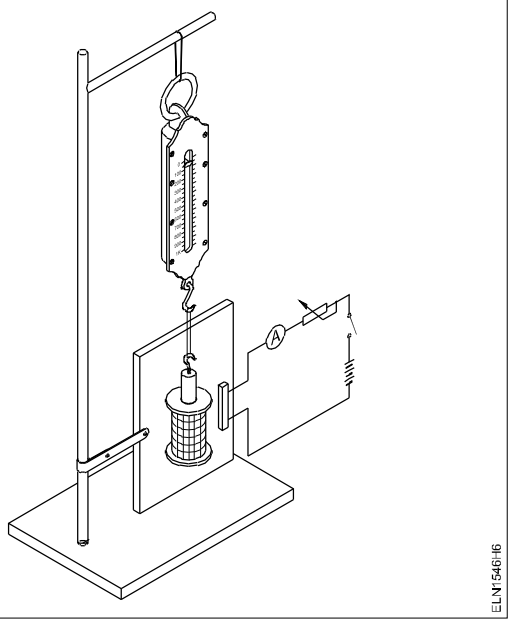
Fig 6



18 Get it checked by the instructor.

Conclusion

Table 1

Magnetic strength with respect to the number of turns (Current kept constant)

Sl.No.	No.of turns	Current	Initial reading of balance W1	Spring balance reading W2	Strength of pulling power (W3 = W2 - W1)
1	200	5 amps			
2	400	5 amps			
3	600	5 amps			

Table 2

Magnetic strength with respect to the current
(Turns kept constant = 600 turns)

Sl.No.	Current	Initial reading of the balance W1	Spring balance reading W2	Strength of pulling power (W3 = W2 - W1)
1	1 amp			
2	2 amps			
3	3 amps			
4	4 amps			
5	5 amps			

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Determine direction of induced E.M.F and current

Objectives: At the end of this exercise you shall be able to
- **determine the direction of e.m.f induced in the circuit**
- **determine the direction of the current by the induced e.m.f.**

Requirements

Tools/Equipment

- Voltmeter (100 mv - 0 - 100 mv) - 1 No.
- Bar magnet 4” - 1 No.
- Solenoid (Assembled) fitted on board (prepared in previous exercise) - 1 No.
- Multimeter - 1 No.
- Magnetic compass - 1 No.

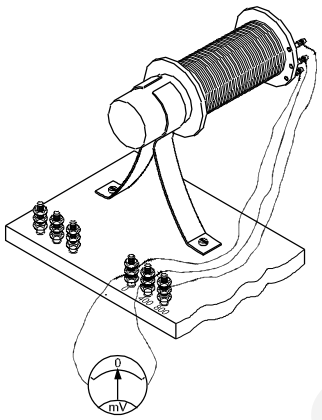
Materials

- Connecting leads - as required.
- PVC transparent sheet with drilled holes (4” x 3”) - 1 No.

PROCEDURE

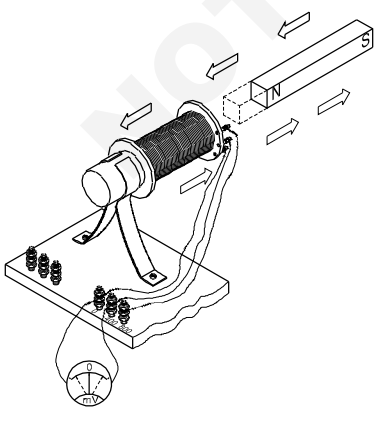
1 Connect the centre zero voltmeter to the solenoid and test the continuity of the coil as shown in Fig 1.

Fig 1



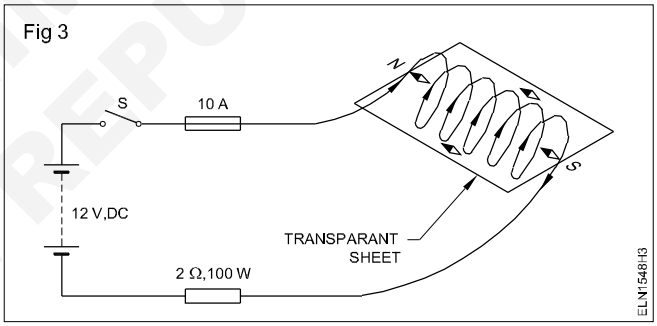
2 Check whether the induced voltage is present in the coil by mounting bar magnet as shown in Fig 2.

Fig 2



3 Extend one end of the coil wire and make 10 turns at equal distance in a drilled hole made on a transparent sheet on it as shown in Fig 3.

Fig 3



4 Place the compass at one entry point of the conductor by pointing ‘N’ to the entry of the coil as shown in Fig 3. Record your findings in Table 1.

5 Insert the magnet into the coil and move the magnet to and fro as in the earlier exercise. Note the deflection in the compass needle.

6 Change the polarity of the magnet and repeat step 4. Note the deflection in the compass needle.

The current direction shown in Fig 4 is for your reference.

The direction of the current in a conductor’s cross-section is shown by the (+) plus symbol inside a conductor or a (.) dot symbol outside a conductor. (Fig 4)

7 Interpret your findings and record the conclusion in Table 2. (A sample result is given for reference)

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Fig 4

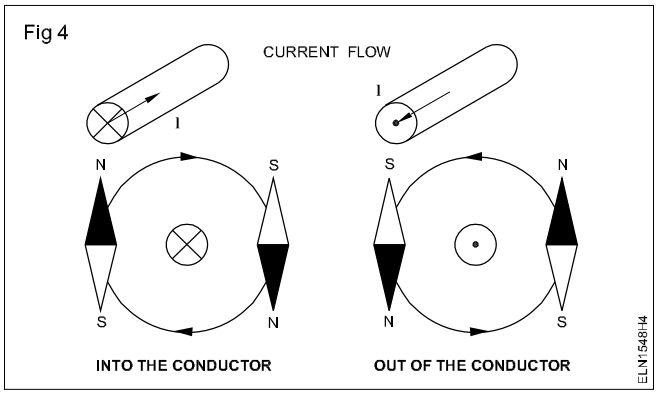
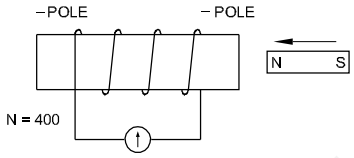
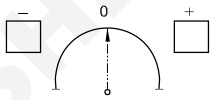
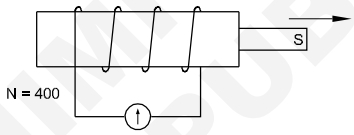
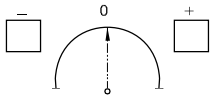
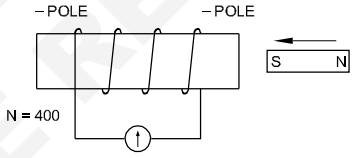
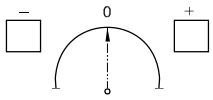
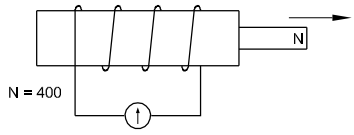
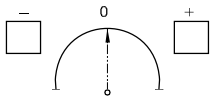


Table 1

Sl. No.	Compass N towards entry	Compass S towards entry
1		
2		
3		

Table 2

(POLARITY OF INDUCED EMF)

Case	Operation	Figure	Polarity of induced voltage
1.	Magnet is moved inside the coil		
2.	Magnet is moving away from the coil		
3.	Magnet with changed polarity is moved inside the coil		
4.	Magnet with changed polarity is moving away from the coil		

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Practice on generation of mutually induced E.M.F

Objectives: At the end of this exercise, you shall be able to
- **prepare a solenoid having two sets of winding**
- **wind the solenoid with both primary and secondary windings**
- **measure the induced voltage in the secondary wrinding.**

Requirement

Tools/Equipments

- Voltmeter (100 MV - 0 - 100 MV) - 1 No.
- Bar magnet 100 mm - 1 No.
- Solenoid (Assembled) fitted on board (prepared in previous exercise) - 1 No.
- Multimeter - 1 No.
- Magnetic compass - 1 No.

Materials

- Connecting wires - as reqd.
- PVC transparent sheet with drilled holes 100 x75 mm - 1 No.
- Super Enamelled copper wire 22 SWG - 25 m
- Supporting stand - 1 Pair.

PROCEDURE

Use the solenoid, used in exercise 1.4.39 and 1.4.40.

1 Take the two ends of the coil, solenoid and check its continuity.
2 Wrap the tape over the solenoid.
3 Wind the copper wire (22 SWG) over the solenoid from one end to the half the length of the coil and wrap it with the tape.
4 Take the two terminals of the copper wire and check its continuity.
5 Fix the solenoid, which already has two windings in the board using clamps and screws as shown in Fig 1.
6 Connect 0 -10V MI voltmeter between two ends of copper wire.
7 Apply AC 10V to the solenoid (primary) and measure voltage between two ends of copper wire as shown in Fig 1.
8 Note down the reading of the voltmeter in table 1.
9 Insert the soft iron core into the solenoid. Now the voltage will increase. Note down the voltage in Table 1.
10 Switch OFF and insert a non-magnetic cylindrical core inside the coil. Switch ON the 10V supply. Note down the voltage in Table 1.
11 Switch OFF and tabulate all the readings.
12 Get the work approved by the instructor.
13 Note down the result and conclusions.

Fig 1

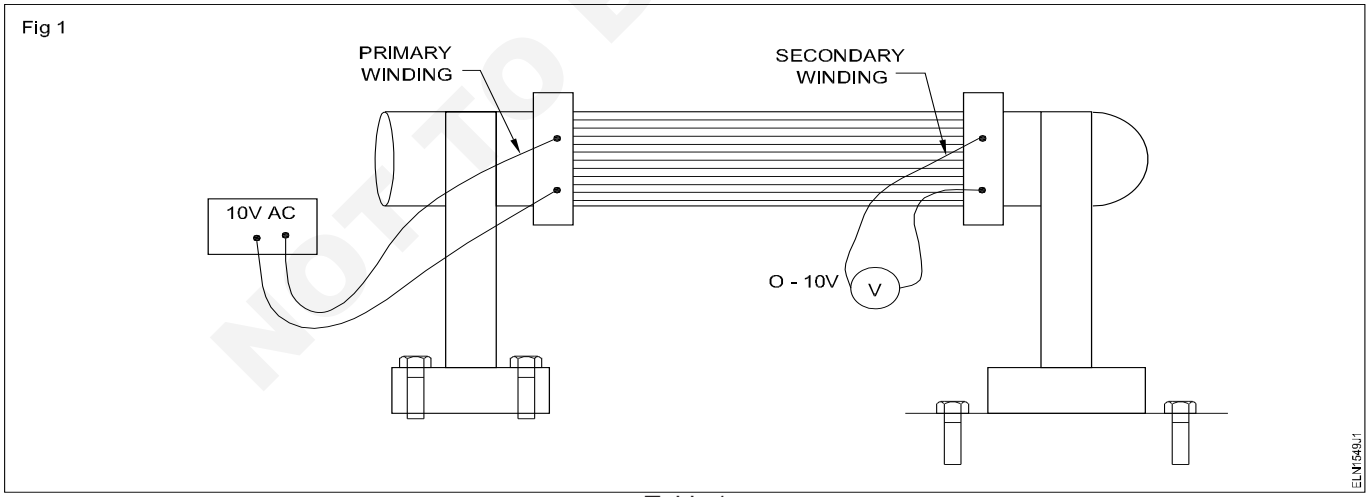

Table 1

Primary Turn (Solenoid)	Secondary Turn (Copper wire)	Without soft iron core		With soft iron core		Any other core	
		Primary Voltage	Secondary Voltage	Primary Voltage	Secondary Voltage	Primary	Secondary
		10		10		10	

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Measure the resistance, impedance and determine the inductance of choke coils in different combinations

Objectives: At the end of this exercise, you shall be able to
- **measure the resistance of the coil**
- **measure the impedance in AC circuit using the voltmeter and ammeter**
- **determine the inductance of the coil.**

Requirements

Tools/Instruments

- MC Voltmeter 0-15V - 1 No.
- MI Voltmeter 0-300V - 1 No.
- MC Ammeter 0-500mA - 1 No.
- MI Ammeter 0 500mA - 1 No.
- Ohmmeter 0 - 2 K ohms - 1 No.

Equipment/Machines

- Potential divider 480 ohms 1A - 1 No.
- 12 volts DC source (RPS)
- 240 volts AC source

Materials

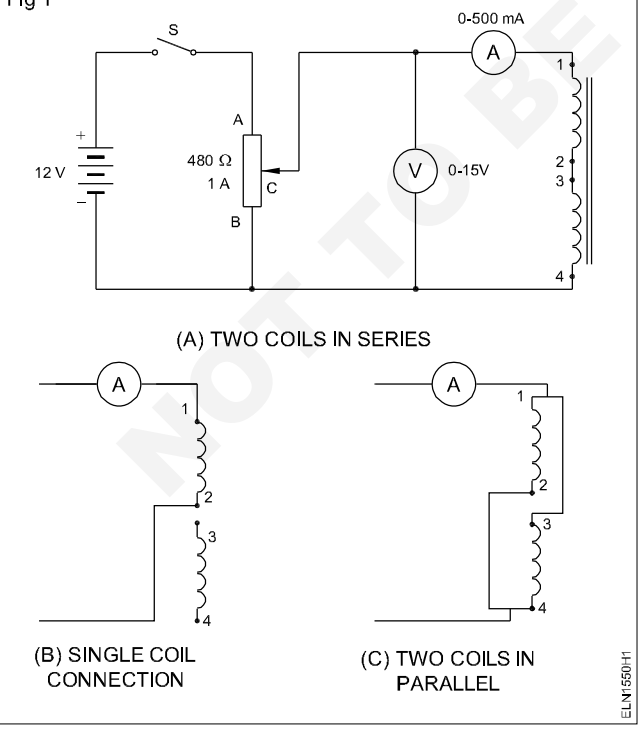
- SPT switch 6A 250V - 1 No.
- Connecting leads - 7 Nos.
- Wound choke (Solenoid coil) - 2 Nos.
- Tube light choke 40W, 240V - 2 Nos.

PROCEDURE

TASK 1: **Measure the resistance of the coil**

1 Connect the elements and form a circuit as shown in Fig 1.

Fig 1



Keep terminal `C' at `B' in the potentiometer/ voltage divider for minimum output voltage

2 Show the connections to the instructor and get it approved.

3 Close the switch `S' and adjust the potentiometer for 100mA current. Record the value of I and V in Table 1.

4 Adjust the potentiometer to obtain the current, 200 and 300mA. Record I and the corresponding voltages.

5 Calculate the resistance of the coil applying Ohm's Law. Record the result in Table 1. Find the average value of resistance in ohms ie. R = V/I

6 Disconnect one coil i.e. terminals 3 and 4. Repeat the experiment to get the resistance measured for single coil with terminals 1 and 2. (Fig 1b)

7 Connect terminal 3 at 1 and 4 at 2. Read and record the V and I in Table 1. (Fig 1c)

8 **Result:** Resistance of the 2 choke coils in series = ... ohm

Resistance of one choke coil = ... ohm

Resistance of two coils chokes in parallel = ... ohm

.....

9 Verify the above results with the help of an ohmmeter.

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Table 1

Sl.No.	DC voltatge across coils	current in mA	Resistance R = V/I	Coils connected
1				Two in series
2				One coil only
3				Two in parallel

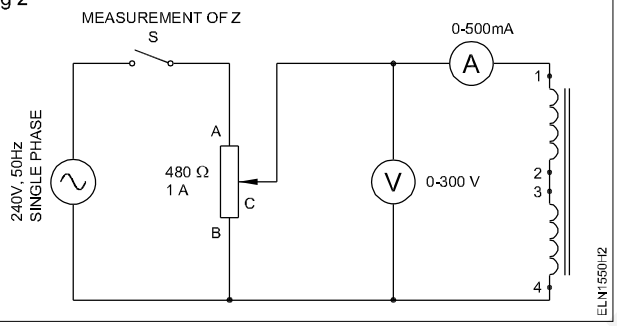
Average resistance of both coils = _____ ohms
Average resistance of the single coil = _____ ohms
Average resistance of the parallel coils = _____ ohms

— — — — — —

TASK 2: **Measure the impedance of the coil in AC supply**

1 Replace the voltmeter and ammeter with MI of type 0-300V and 0.5 ampere respectively. Connect the circuit to AC 240V 50 Hz supply source as shown in Fig 2.

Fig 2



Keep the terminal of the potentiometer `C' at `B' for the minimum output voltage.

2 Show the connections to the instructor and get his approval.

3 Close the switch `S' and adjust the potentiometer to obtain a current of 100mA. Record the I and V in Table 2.

4 Adjust the potentiometer for a current of 200mA. Record the corresponding voltage. Repeat it for 300mA.

5 Calculate the value of R = V/I for each case. Record the value under the column ` impedance ' and find the average value of impedance _____ ohm

6 Disconnect one coil (i.e. terminals 3 and 4). Repeat steps 2 to 4 to determine impedance of one coil.

Conclusion

i) When both coils are in series the impedance is _____

_____

ii) Impedance of one coil is _____ ohms.

— — — — — —

TASK 3: **Determine the inductance of the choke**

Calculate the inductance (L) in the method shown below:

Average value of resistance (R) of the choke from Table 1 = _____ ohms.

Average value of impedance (Z) of the choke from Table 2 = _____ ohms.

$X_L = 2\pi fL$

$L = \frac{X_L}{2\pi f}$

where π = 3.142 (22/7)

f = Frequency of supply in Hz

L = Inductance in Henry

Inductance of the choke coil is $L = \frac{X_L}{2\pi f}$ Henry (H)

L = _____ Henry

— — — — — —

Table 2

Sl.No.	AC voltage across coils	AC current in mA	Impedance Z = V/I	Coils connected
1				Two in series
2				
3				One coil only
4				

Average value of impedance of both coils = _____ ohms
Average value of impedance of single coil = _____ ohms

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Identify various types of capacitors, charging/discharging and testing

Objectives: At the end of this exercise, you shall be able to
- **identify the type of capacitor by visual inspection**
- **identify the capacitor's value and rating from the marking**
- **test the capacitor with DC supply for insulation and leakage**
- **test the capacitor for charge and discharge.**

Requirements

Tools/Instruments

- Ohmmeter (multimeter - ohms range) - 1 No.
- MC Voltmeter (0 - 15V) - 1 No.
- MC Ammeter (100mA - 0 - 100mA) - 1 No.

Equipment/Machines

- DC source 12 V or 0-30V variable (R.P.S) - 1 No.

Materials

- Capacitors - paper, mica, electrolytic, mylar, tantalum, variable air core and mica – assorted values and different voltage ratings - as required.
- Potentrometer 100 k ohm - 1 No.
- Single pole, double throw switch 16A 250V - 1 No.

PROCEDURE

TASK 1: **Identification of capacitors**

1 Look at Figs 1(a) to 1(t). Identify the capacitors and read the value of capacitance and working voltage from the markings, if indicated, and record in Table 1.

2 From the capacitor provided by the instructor read the value of the capacitor and identify its type.

Fig 1

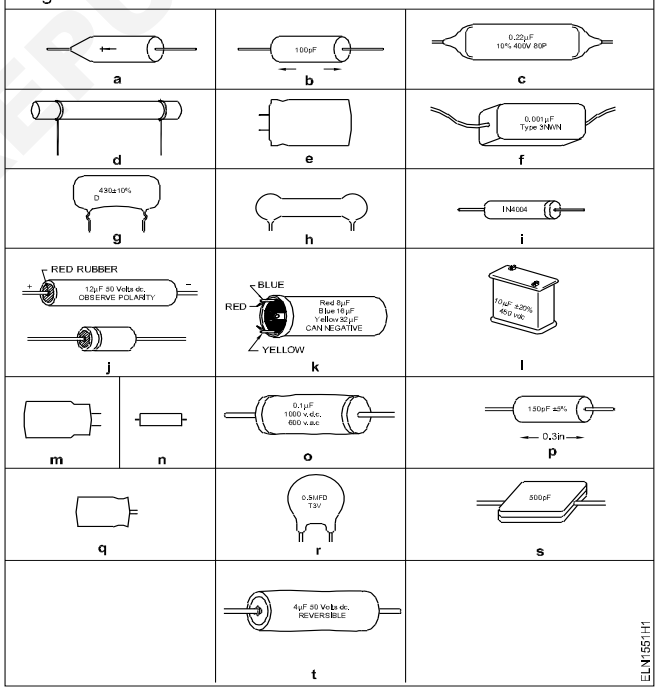

Table 1

Fig.No.	Name of component	Symbol	Type	Capacitance value	Voltage rating

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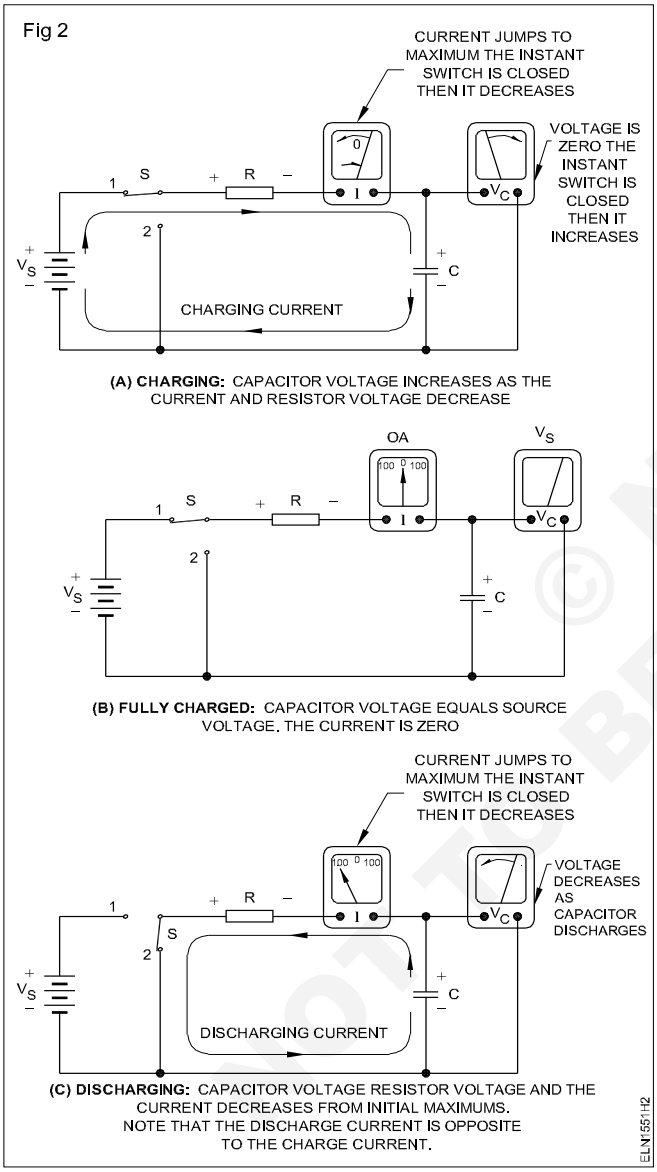
TASK 2: **Test the capacitor for charging and discharging**

1 Initially touch both leads of the capacitor with the voltmeter (suitable range).

> **If there is any deflection, contact both leads through a resistance for sufficiently a long time.**
>
> **Do not touch the capacitor leads by hand. High voltage retained by a charged capacitor will give a severe shock.**

2 Form the 12V circuit for testing the capacitor circuit elements as shown in Fig 2. Keep the switches open.

Fig 2



3 Keep the switch S connected to the battery. Observe the deflection in the ammeter and voltmeter.

4 Record the deflection in the ammeter when the switch S is closed to position 1.

5 Observe the voltmeter reading at equal intervals of time. (At least 4 readings from zero to the maximum deflection.)

6 Record the time and voltage in Table 2.

7 Repeat steps 1 to 5 by changing the value of the series resistor 'R' (increasing the value of R increases the time).

8 Open the switch 'S' and observe the voltmeter reading for 5 minutes.

9 Result

The voltage across the capacitor remains _____ because of _____ condition of the capacitor.

10 Close the switch S to position 2 and observe the voltmeter and ammeter readings.

11 Observe the deflection of the voltmeter:

(a) The voltage of the capacitor gradually decreases.

(b The current shoots to maximum at the instant switch S is closed to position 2, then it decreases gradually, indicating that the capacitor is losing charge.

12 Repeat the test for different values of capacitance rated for different voltages.

> **The testing voltage should be close to the voltage rating of the capacitor.**

Table 2

Sl. No.	Value of		Time in seconds	Voltage volts
	Capacitor µF	Resistor kW		
1	470	500		
2				
3				
4				
5	4370			
6				
7				
8				
9	470			
10				
11				
12				

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TASK 3: **Testing of capacitor with ohmmeter**

1 Discharge the given capacitor.

2 Connect the ohmmeter to test the capacitor (Fig 3) and observe the deflection in the meter.

Set the ohmmeter selector switch at a higher range.

While testing with a polarised capacitor, the positive terminal of the capacitor is to be connected to the positive terminal of the ohmmeter and the negative terminal to the negative terminal of the ohmmeter.

While testing with non-polarised capacitor (mica, ceramic, etc) the low values in fractions of micro-farad will not show any deflection in the ohmmeter.

Table 3

Sl. No.	Value of Capacitor	Meter reading	Result
1			
2			
3			
4			
5			

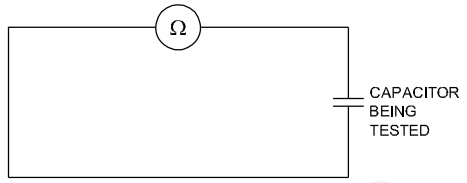
For electrolytic capacitor only.

3 Assess the condition of the capacitor under test, using the information available in Fig 3 and record the findings in Table 3.

4 Discharge the capacitor.

5 Perform the test in different capacitors.

Fig 3



INDICATION OF TEST INSTRUMENT	CONDITION OF CAPACITOR UNDER TEST
METER INDICATES SOME RESISTANCE	LEAKAGE
NO DEFLECTION	OPEN
DEFLECTS AND RETURN BACK SLOWLY	GOOD CONDITION
CONTINUOUSLY SHOWS ZERO READING	SHORT

TESTING OF CAPACITOR WITH OHMMETER

ELN1551H3

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Group the given capacitors to get the required capacity and voltage rating

Objectives: At the end of this exercise you shall be able to
- **determine the capacitive reactance**
- **select capacitors and connect in series**
- **select capacitors and connect in parallel**
- **test combinations of capacitors.**

Requirements

Tools/Instruments

- MI Voltmeter 0 to 300V - 1 No.
- MI Ammeter 0 to 500mA - 1 No.
- Rheostat, about 300 ohms 2A - 1 No.

Equipment/Machines

- 240V AC source.

Materials

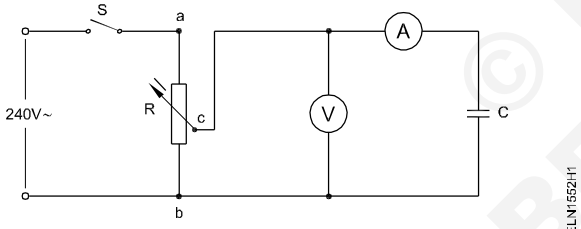
- Switch SPT 6A 250V - 1 No.
- 2 MFD 240V/400V - 2 Nos.
- 4 MFD 240V/400V - 1 No.
- 8 MFD 240V/400V 50 Hz. - 1 No.
- Connecting leads - as required.

PROCEDURE

TASK 1: **Measure capacitive reactance (Xc)**

1 Form the circuit as shown in Fig 1 with a 2 - µF capacitor. (Fig 1)

Fig 1



Discharge the capacitor before handling.

2 Close the switch S and adjust the potential divider for the rated voltage of the capacitor (240 V).

3 Note the voltmeter and ammeter readings and record in Table 1.

4 Calculate the reactance $X_C = \frac{V}{I}$ and record the result in Table 1

Table 1

Sl.No.	Value of Capacitor	Voltage	Current	$X_C = \frac{V}{I}$

5 Compare the calculated value using the formula

$$X_C = \frac{1}{2\pi fC}$$

6 Find the capacitive reactance value for 4 µF repeating steps 1 to 5.

7 **Conclusion**

i When capacitance increases the capacitive reactance _____

ii Increased reactance means _____ capacitance.

— — — — — —

TASK 2: **Connect capacitors in series**

1 Form the circuit with two capacitors in series as shown in Fig 2. (2 MFD, 2 MFD)

2 Determine the X_C value for the series combination performing steps 2 to 5 of TASK 1. Fill X_C values in Table 2 under the appropriate columns.

3 Calculate the total capacitance C_{total} as

$$\frac{1}{C_{total}} = \frac{1}{C_1} + \frac{1}{C_2}$$

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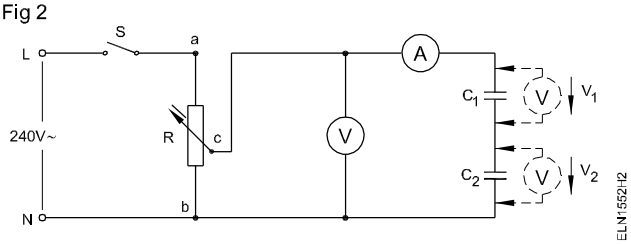
Fig 2



4 Calculate the C_{total} from the X_c. Check for its confirmity.

Result

When capacitors are connected in series

i the total reactance _____

ii the net capacitance value _____

5 Measure the voltage across each capacitor and record it in Table 2 under column 3.

6 Repeat steps 1 to 5 for series grouping of capacitors.

a) 2 & 4 MFD b) 4 & 8 MFD

7 Get it checked by the instructor.

Conclusion

The voltage across the capacitor and the value of capacitor in series.

_____

_____

Table 2

Sl. No.	Value of Capacitor C_1 in µfd	Value of Capacitor C_2 in µfd	Voltage across C_1 V_1	Voltage across C_2 V_2	Current in mA	Voltage V	Total $\frac{1}{C}=\frac{1}{C_1}+\frac{1}{C_2}$	Capacitive reactance $XC=\frac{1}{2\Pi fc}$
1	2	2						
2	2	4						
3	4	8						

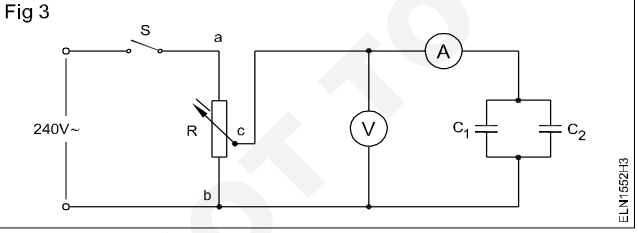
— — — — — —

TASK 3: **Connect capacitors in parallel**

1 Form the circuit with two capacitors in parallel as shown in Fig 3 (2 MFD, 2 MFD).

2 Determine the reactance X_C of the parallel combination performing steps 2 to 5 of TASK 1. Fill up X_C in Table 3.

Fig 3



3 Calculate the total capacitance $C_{total} = C_1 + C_2$. Record C_{total} in Table 3.

4 Calculate the C_{total} from X_C. Check for its confirmity.

Result

In parallel combination of capacitance

i the total reactance _____.

ii the total capacitance _____.

Discharge the capacitors at the end of each experiment / test

5 Repeat steps 1 to 5 for parallel grouping of capacitors.

Table 3

Sl. No.	Value of Capacitor C_1 in mfd	Value of Capacitor C_2 in mfd	Voltage across C_1 V_1	Voltage across C_2 V_2	Current in mA	Voltage V	Total $C_{total}=C_1+C_2$	Total reactance $XC=\frac{1}{2\Pi fc}$
1	2	2						
2	2	4						
3	4	8						

— — — — — —

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Measure current, voltage and PF and determine the characteristics of the RL, R-C, R-L-C in AC series circuits

Objectives: At the end of this exercise, you shall be able to
- **measure the current, voltage, power and P.F in R-L series circuits**
- **measure the current voltage, power and P.F in R-C, series circuits**
- **measure the current voltage, P.F in R-L-C series circuits**
- **measure the power and P.F. in R-L-C series circuits.**

Requirements

Tools/Instruments

• MI voltmeter 0 - 300 V	- 3 Nos.
• MI ammeter 0 - 1.5 A	- 1 No.
• Wattmeter 250 V, 2.5 amps	- 1 No.
• Power factor meter (0.5 lag to 0.5 lead) 250 volts, 2.5 amps	- 1 No.

Equipment/Machines

• Auto transformer 0-270V/8A	- 1 No.

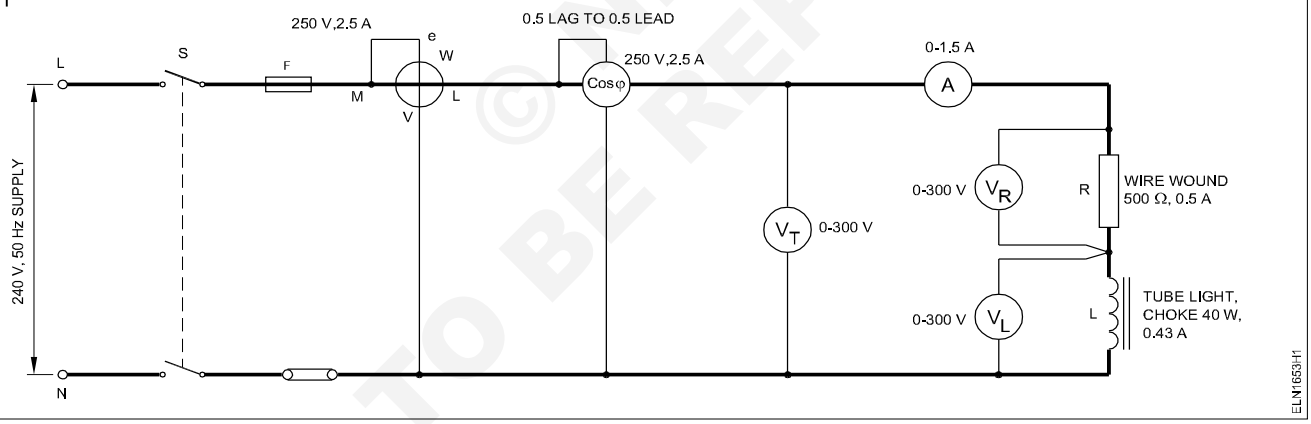
Materials

• Connecting cables	- as reqd.
• Choke (tube light) 40 W, 0.43 A, 250 V	- 1 No.
• I.C.D.P. switch - 16 amps, 250 volts	- 1 No.
• Wire wound resistor 500Ω/0.5A	- 1 No.
• Wire wound resistor 100Ω/1.5A	- 1 No.
• Electrolytic capacitor 8μFd/400V	- 1 No.
• Electrolytic 1μFd, 2μFd, 4μFd/400V	- 1 No.each

PROCEDURE

TASK 1: **Measure the current, voltage, power and P.F in R-L series circuit**

Fig 1



1 Assemble the circuit by connecting instruments, resistor R, inductor L as in Fig 1. Switch ON the supply.

2 Measure the voltage V_R, V_L, supply voltage V_T and the circuit current and record in Table 1.

3 Read power (W_1) and power factor ($\cos\phi$) and record it in Table 1.

4 Calculate the apparent and the true power consumed in the circuit and compare them.

5 Calculate the power factor and compare it with the measured power factor.

6 Draw the vector diagram to add the voltage drops across R and L.

- Keep current as the reference vector.
- Select a suitable scale for the voltage.
- Draw the voltage vector (V_R) in-phase with current (I).
- Draw the voltage vector V_L leading-current I by 90°.
- Add vector V_R and V_L to get V_{T1}

7 Compare the above with the measured supply voltage.

8 Calculate the power factor from the true power and apparent power.

9 Compare the calculated power factor with the measured power factor.

10 Repeat the steps changing two values for the resistor and inductor and record them in Table 1 in columns 2 and 3.

11 Get it checked by the instructor.

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Table 1

Measured value							Calculated value			
Sl. No.	Circuit current	Supply voltage	Power consumed (Wattmeter reading)	Voltage across resis-tance	Voltage across induc-tance	Power factor (reading of P.F. meter)	Vector addition of VR and VL	Difference in VT_1 and VT_2	Power consumed in circuit	Difference between measured & calculated power factor
	I	V_{T1}	W_1	V_R	V_L	Cos ϕ_1	V_{T1}	$V_T - V_{T1}$	W2= V_T X I X Cos ϕ_1	Cos ϕ_1– Cos ϕ_2

Conclusion

The difference between vector addition of V_R and V_L with respect to V_T is due to _____

_____

TASK 2: **Measure the current voltage, power and P.F in R-C series circuit**

1 Test the capacitor with an ohmmeter for its condition.

Discharge the capacitor before testing.

2 Check the value of the given resistance with a digital multimeter for its value.

Check the suitability of the selected wattmeter and P.F. meter with respect to the circuit specifications.

3 Construct the circuit as per diagram. (Fig 2) Keep the switch 'S' open.

Set the auto-transformer output to zero voltage.

4 Close switch 'S' and adjust the auto-transformer output voltage to 100V.

5 Measure the circuit current, voltage power consumed and power factor and note the readings in Table 2.

6 Calculate cosϕ and impedance.

7 Compare the calculated P.F with measured P.F.

8 Measure the voltages across R and C and note in Table 3.

9 Compare the arithmetical sum of V_R and V_C with the supply voltage and observe that this is a wrong procedure.

10 Add V_R and V_C by the vector method (graphically) selecting a suitable scale and compare with the measured supply voltage.

11 Adjust the output voltage to 200 V and repeat steps 5 to 10.

12 Get it checked by the instructor.

Fig 2

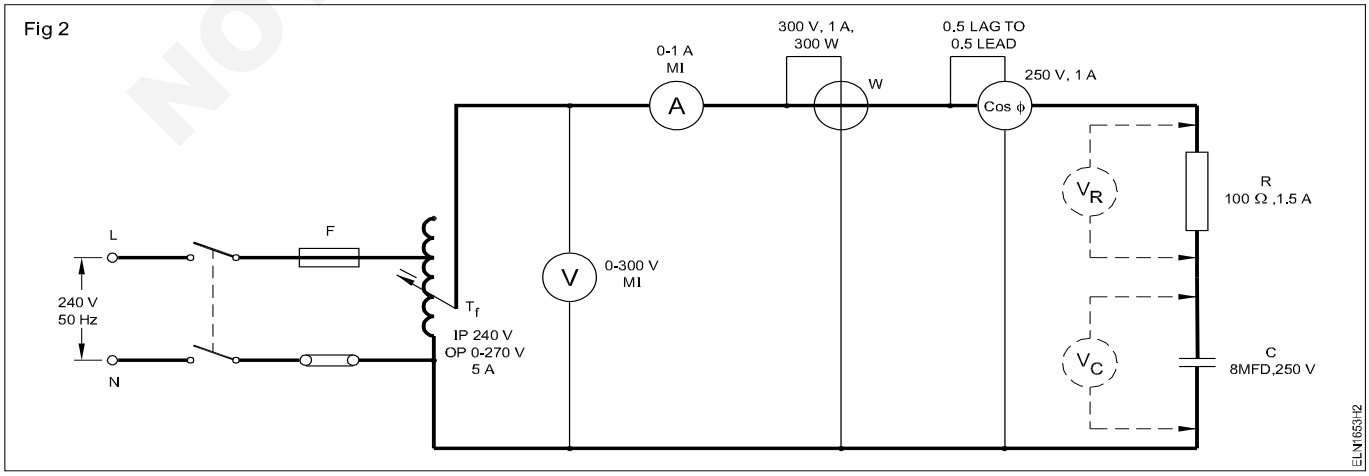

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Table 2

Measured				Calculated	
V supply	I	W	PF	$PF = \frac{W}{VI}$	$Z = \frac{V}{I}$
100 V					
200 V					

Conclusion

Table 3

V supply	V_R	V_C	$V_R + V_C$ (Arithmetic)	$V_R + V_C$ (Vector)
100 V				
200 V				

TASK 3: **Measure the current voltage, P.F, in R-L-C series circuit**

1 Assemble the circuit as per circuit diagram (Fig 3) with the instruments and components collected.

Before forming the circuit, confirm that the capacitor is discharged.

2 Switch 'ON' the supply and adjust the auto-transformer until the voltmeter indicates 240 volts.

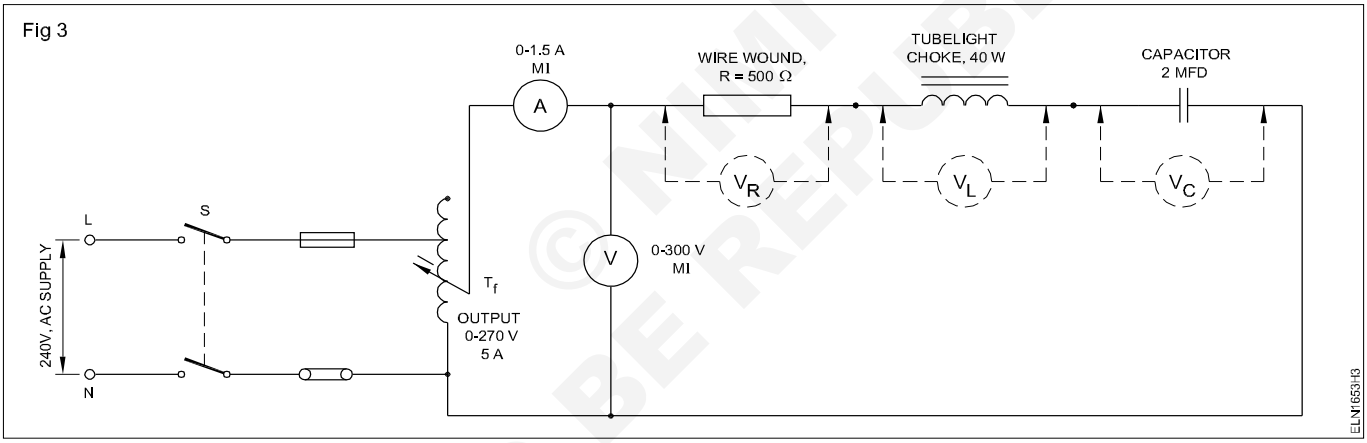
3 Measure the voltage across each element and note it in the Table 4.

Table 4

Supply	V_R	V_L	V_C	I
240 v				

4 Measure the current and note the same in Table 4. Switch off the circuit.

Fig 3



5 Draw the vector diagram (say 1cm = 50 V and 1cm = 0.1A) taking the current as the reference vector.

6 Determine the supply voltage from the vector diagram.

Supply voltage (vector sum) =.....V

Assumption: The resistance of the choke is negligible in this case.

7 Compare the value of the resultant vector voltage with reading of the voltmeter across the mains.

If the vector sum of voltages V_R V_C V_L is not exactly equal to the measured supply voltage, it may be due to---

- **observation error**
- **drawing of the vector diagram incorrectly**
- **assumptions made.**

8 Replace the capacitor with another value, say 8.0 MFD and repeat the steps 2 to 7.

9 Replace the capacitor with another value, say 1.0 MFD and repeat the steps 2 to 7.

10 **Result:** Total measured voltage is_____

_____

11 Get it checked by the instructor.

Conclusion

A The voltage across individual component and total supply voltage_____

_____

B The circuit current_____

_____

C The phase angle of current with supply voltage (from voltage vector) _____

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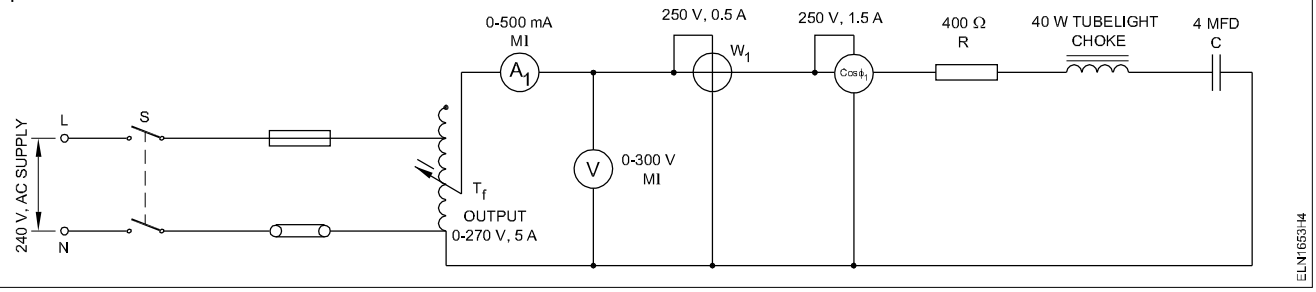
TASK 4: **Measure the power and P.F. in R-L-C series circuit**

1 Form the circuit as shown in Fig 4.

Fig 4



Discharge the capacitor. With an ohmmeter check the resistance for its value, the inductor for its continuity and the capacitor for leakage.

2 Set the auto-transformer to have zero output. Switch 'ON' the supply.

3 Gradually increase the output voltage until it is 100V.

4 Measure the corresponding current. Note down the readings in Table 5. Also read the Wattmeter and the power factor meter and record it in Table 5.

5 Calculate the apparent power from voltmeter and ammeter reading.

Apparent power = V x I in volt amp (VA)

6 Determine the power factor by using the formula and record it in Table 5.

$$\text{Cos}\ \phi = \frac{\text{True power}}{\text{Apparent power}}$$

7 Verify the measured power factor with the calculated power factor.

8 Increase the voltage to 200 volts and repeat steps 4 to 7.

Do not increase the voltage beyond 200V for this circuit.

9 Reduce the output voltage back to zero and switch off the supply.

10 Repeat the experiment (steps 2 to 9) with

i) the capacitor removed

ii) a 2 micro-farad capacitor connected

iii) a 8 micro-farad capacitor connected keeping the voltage at 200 V.

11 Compare the readings of the power factor in all the four cases. Record your observation.

12 **Result**

The change of the capacitor in the R-L-C series circuit for given R-L (value)

_____

_____

_____

13 Get it checked by the instructor.

TABLE 5

Sl. No.	**V Volt**	**I Amp.**	**W True power**	**AP = V xI in VA Apparent power**	**cos ϕ = W/AP**	**P.F. Meter reading**	**Capacitor value in MFD**
1	100 V						8
2	200 V						4
3	200 V						0
4	200 V						2

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Measure the resonance frequency in AC series circuit and determine its effect on the circuit

Objectives: At the end of this exercise you shall be able to
- **determine the resonance frequency of a given LC series circuit and circuit current**
- **plot a graph of frequency versus circuit current**
- **test the working of a series LC as a wave trap**
- **determine the effect of the resonance on the circuit.**

Requirements

Materials/Components

- General purpose Lug board - 1 No.
- Capacitor 0.1 µF - 1 No.
- Inductor coil, around 40mH (Use the solenoid coil made in Ex. 1.5.46) - 1 No.
- LED with holder - 1 No.
- Hook-up wires - as reqd.

Tools/Equipments/Instruments

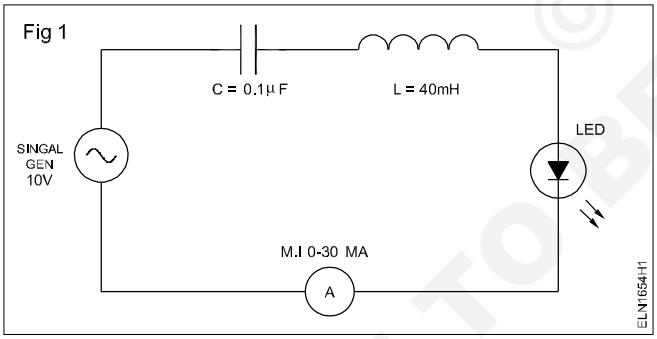
- Trainees kit - 1 No.
- CRO, 20 MHz - 1 No./batch
- Function generator - 1 No./batch
- MI Ammeter 0 - 30 mA - 1 No.

PROCEDURE

TASK 1: **Finding Resonance frequency and circuit current**

1 Solder the components as shown Fig 1 to obtain a simple series resonance circuit. Connect instruments as shown in Fig 1.

Fig 1



The LED in the circuit is to get a visual indication of the current through the circuit at different frequencies.

3 Calculate and record the resonance frequency of the series resonance circuit with known values of L and C

4 Set the output of the signal generator to $10V_{rms}$ and frequency to 1KHz. Record the current, I through the circuit in Table 1.

LED may not be glow or may be very dim, because the set frequency of 1 KHz may not be the resonance frequency of the circuit.

5 Gradually increase the frequency and record the resonance frequency f_r at which the circuit current becomes maximum (LED glows brightly).

This is the resonance frequency of the series resonance circuit because at series resonance, current I through the LC circuit will be maximum.

6 Compare and record the difference in the resonance frequency calculated in step 3 and that measured in step 5.

7 Vary the input frequency in steps of 500 Hz around the resonance frequency and in each step record the value of circuit current in Table 1.

8 From the recorded readings of current in step 6, plot a graph of frequency versus current and mark the resonance frequency of the LC series circuit. (Fig 2)

9 It may appear as in Fig 2 working of the circuit, Record readings and plot the graph and get it checked by the instructor.

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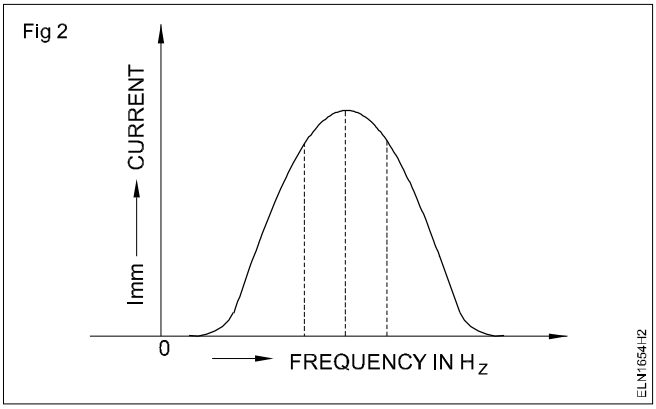
Table 1

Frequency	+500HZ	+1KHZ	+1.5KHZ	+2KHZ
Current				

Fig 2



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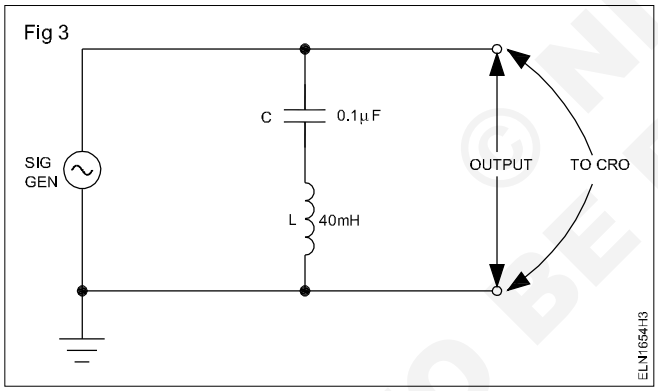
TASK 2: **To use series LC circuit as wave-trap to determine the effect on the circuit**

1 Using known values of L and C, make the circuit connections as in Fig 3.

Fig 3



2 Set the output of the signal generator to 3 volts, 50KHz, sine wave.

3 Increase the frequency till the output of the trap circuit is minimum. Record this frequency as the trap frequency and its the effect on the circuit.

At trap frequency, which is the resonance frequency of the Shunt connected LC circuit, the impedance of the circuit will be minimum and hence the voltage across the circuit will be minimum. Ideally, this should be zero. But, because of the internal resistance of the coil, the output voltage will not be zero but, will be minimum.

4 Get your work checked by the instructor.

LAB ASSIGNMENT: Change the value of the capacitor used in the LC circuit to 0.01µF and redo TASK 2 to find the new wave-trap frequency.

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Measure current, voltage and PF and determine the charactertics of R-L, R-C and R-L-C in AC parallel circuits

Objectives: At the end of this exercise you shall be able to
- **measure the current, voltage in R-L parallel circuit**
- **measure the current and voltage in each branch circuit of R-C parallel circuits**
- **determine the characteristics of R-L-C in parallel circuits.**

Requirements

Tools/Instruments

- Digital multimeter - 1 No.
- MI Ammeter 0 to 2 ampere (0-5A) - 2 Nos.
- MI Ammeter 0 to 3 amperes (0-5A) - 1 No.
- MI Voltmeter 0-250 V - 1 No.
- Frequency meter 50Hz/±5 - 1 No.

Equipment/Machines

- Auto-transformer - input 240 V - output 0 to 270 V, 8 amps - 1 No.
- Rheostar 400Ω/1A - 1 No.

Materials

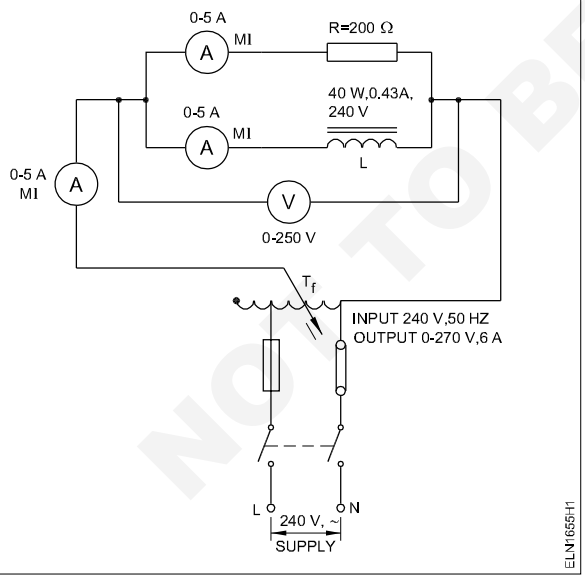
- Connecting cables - as reqd.
- I.C.D.P switch 250V, 16 A - 1 No.
- Wire wound resistor - 200 ohms - 1 No.
- Choke coil of 40 watts, 240V 50 Hz. tube light - 1 No.
- E.capacitor 8μFd/4μFd/400V - 1 each.
- E.capacitor 2μFd/400V - 1 each.

PROCEDURE

TASK 1: **Measure the current, voltage in R-L parallel circuit**

1 Assemble the circuit with the instruments, inductance coil and resistance. (Fig 1)

Fig 1



2 Set the auto-transformer output at zero position.

3 Switch 'ON' the supply and gradually increase the output voltage to 50V.

4 Measure the branch and total currents and record in Table 1. Repeat this step for different voltages say 100V, 125V, 150V, and 175V.

Table 1

Sl.No.	Measured V	Measured I_R	Measured I_L	Measured I_T	Graphical I_T Value
1	50				
2	100				
3	125				
4	150				
5	175				

5 Draw the vector diagram with suitable scale for currents taking voltage as reference vector in your practical record.

6 Determine the total current graphically.

The calculated values of total current and the actual measured value of current may vary due to instrument error, observational error and non-availability of pure inductance. Hence, about 5% error is permissible.

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7 Compare the total current measured with the calculated value entered in table 2.

TABLE 2

Sl.No.	Measured value		Calculated value	
	V	I_T	$I_T = \sqrt{(I^2_R + I^2_L)}$	$Z = \frac{V}{I_T}$
1	50			
2	100			
3	125			
4	150			
5	175			

8 Find the Impedance of the circuit from the supply voltage and measured current. Calculate $Z = \frac{V}{I_T}$

Conclusion

Total current in an AC parallel circuit is the vector _____ of I_R and I_L and not _____ addition.

— — — — — — —

TASK 2: **Measure the current and voltage in each branch circuits of R-C parallel circuits**

1 Test the capacitor with an ohmmeter for its condition.

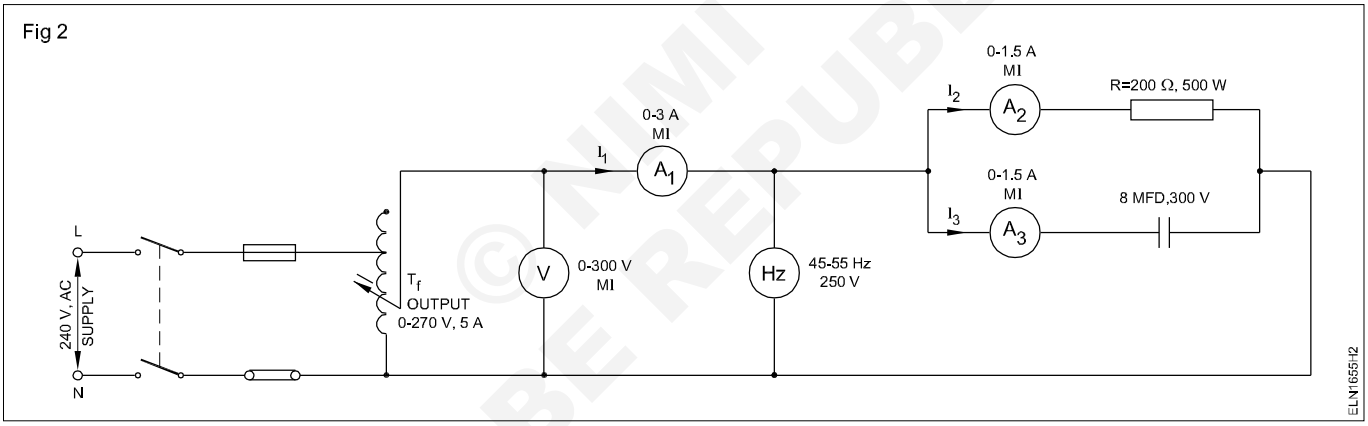
Discharge the capacitor before testing.

2 Test the resistor with an ohmmeter for its value.

6 Calculate the impedance 'Z' and record in Table 3.

7 Calculate the capacitive reactance ($X_c = V/I_3$) and record your result in Table 3.

Fig 2



3 Build the circuit as per diagram. (Fig 2) Keep the switch open. Set the auto-transformer to the minimum output voltage.

4 Switch ON the supply. Adjust the auto-transformer for an output voltage of 200V.

5 Record the frequency, voltage and the three ammeter readings in Table 3.

8 Calculate the capacitance from the values recorded in Table 3.

9 Establish that the arithmetical sum of the branch current is not equal to the main circuit current.

10 Graphically add the currents I_2 and I_3 and determine the value of I_1. Compare this value with the measured value.

Table 3

Sl.No.	V	f	I_1	I_2	I_3	$Z = \frac{V}{I_1}$	$X_C = \frac{V}{I_3}$	$C = \frac{1}{2\pi f X_C}$

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11 Adjust the supply voltage to about 100 V and repeat steps 5 to 10.

Discharge the capacitor after the experiment.

12 Repeat the exercise for changed values of R and C in the circuit.

Conclusions

i The calculated value and the indicated value of the capacitor

ii The arithmetic sum of the branch current and the measured value of total current.

iii The vectorial sum of the branch currents and the measured value of the total current.

iv The determination of PF from the vector diagram

— — — — — — — —

TASK 3 : **Determine the characteristics of R-L-C in parallel circuits**

1 Form the circuit as shown in Fig 3.

2 Repeat steps 2 to 12 of TASK 2 and record the readings in Table 4.

3 Compare the readings of the power factor in all the cases. Record your observations.

Conclusion

i Effect of change of supply voltage in R-L-C parallel circuit as regards power factor of circuit

ii Effect of change in capacitance in RLC parallel circuit.

Fig 3

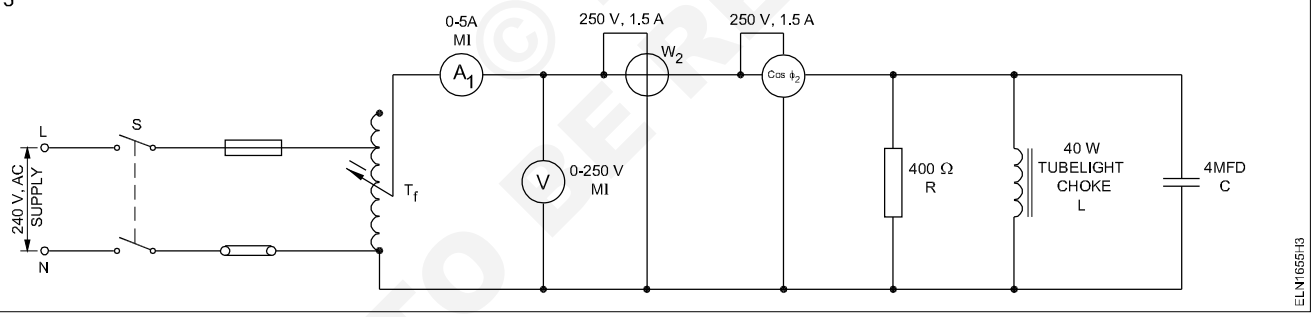

Table 4

Sl. No.	V Volt	I Amp.	W True power in Watt	AP = V xI Apparent power in VA	$\cos\phi = \frac{W}{AP}$	P.F. Meter reading	Capacitor value in μFD
1	100 V						4
2	200 V						4
3	200 V						0
4	200 V						2
5	200 V						3

— — — — — — — —

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Measure the resonance frequency in AC parallel circuit and determine its effects on the circuit

Objectives : At the end of this exercise you shall be able to
- **determine the resonance frequency of a given LC parallel circuit**
- **determine the circuit current for different frequencies**
- **plot a graph of frequency versus circuit current**
- **calculate the value of unknown C using LC parallel resonance**
- **determine the effect of LC parallel circuit on the circuit.**

Requirements

Tools/Equipment/Instruments

- Trainees kit
- CRO, 20 MHz - 1 No./batch
- Function generator - 1 No./batch
- MI Ammeter 0-50mA - 1 No.

Materials/Components

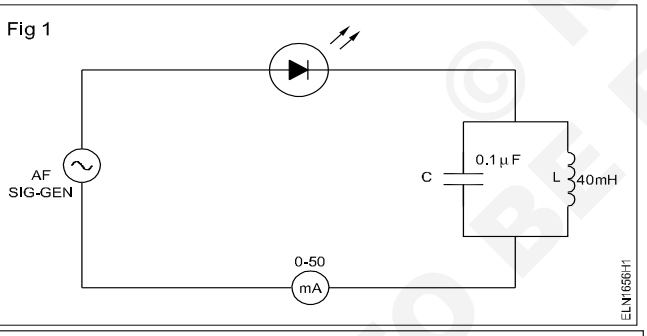
- General purpose Lug board - 1 No.
- Capacitor 0.1 µF - 1 No.
- Inductor coil, around 40mH - 1 No.
  (Use the solenoid coil made in unit 5) - 1 No.
- LED with holder - 1 No.
- Hook-up wires - as reqd.

PROCEDURE

TASK 1: **Determine parallel resonance frequency and circuit current**

1 Solder the components as shown Fig 1 to obtain a simple parallel resonance circuit. Connect the instruments as shown in Fig 1.

Fig 1



The LED in the circuit is to get a visual indication of the current through the circuit for different frequencies.

2 Calculate and record the resonance frequency of the parallel resonance circuit from the value of L and C.

3 Set the output of the signal generator to $4V_{rms}$ and frequency to 1KHz in Table 1. Record the current, I through the circuit.

Ensure that the current through the circuit is around 10 to 12 mA and not more. If current flowing is more, reduce the output level of the signal generator. LED will glow at all frequencies except at the resonant frequency.

4 Gradually increase the frequency and record the resonance frequency f_r at which the circuit current becomes minimum (LED does not glow or glows very dimeter).

Table 1

Frequency	+500HZ	+1KHZ	+1.5KHZ	+2KHZ
Current				

This is the resonance frequency of the parallel resonance circuit because at parallel resonance, current I through the parallel LC circuit will be minimum.

5 Compare and record the difference in the resonance frequency calculated in step 2 and that measured in step 4.

6 Vary the input frequency in steps of 500 Hz around the resonance frequency and in each step record the value of circuit current in Table 1.

7 From the recorded readings of current in step 6, plot a graph of frequency versus current and mark the resonance frequency of the LC parallel circuit.

8 Get the working of the circuit, recorded readings and the graph checked by the instructor.

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Measure power, energy for lagging and leading power factors in single phase circuits and compare the characteristics graphically

Objectives: At the end of this exercise you shall be able to
- **measure power and energy for lagging P.F.**
- **measure power and energy for leading P.F.**
- **draw a graph to compare lagging and leading P.F.**

Requirements

Tools and Instruments

- M.I Ammeter 0-5A/10A - 1 No.
- M.I Voltmeter 0-300V - 1 No.
- Wattmeter 250V/5A - 1 No.
- P.F. meter 250V/ 2A - 1 No.
- Variac 0-270/5A - 1 No.
- AC source 0-240V/5A - 1 No.
- Energy meter 5A 250 V - 1 No.
- Stop watch - 1 No.
- Lamp load 240 V/5A - 1KW - 1 No.

Materials

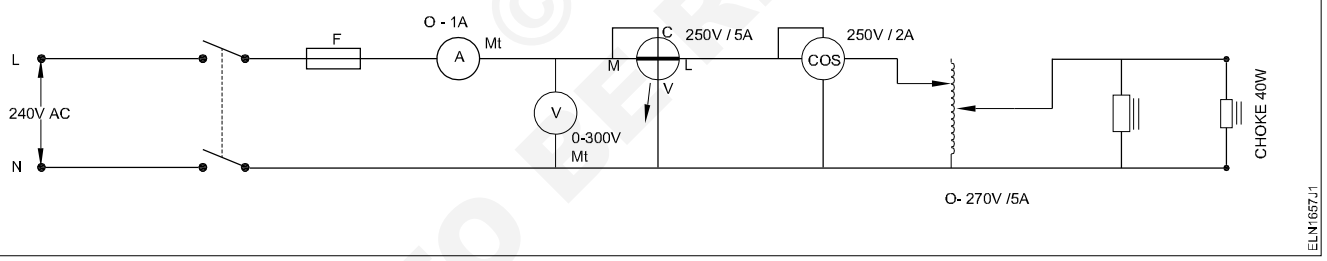
- Choke (T.L) 40W/250V - 2 Nos.
- Electrolytic capacitor, 2.5µFd/415V - 2 Nos.
- Connecting leads - as reqd.

PROCEDURE

TASK 1: **Measure the power for lagging P.F**

1 Assemble the circuit as shown in Fig 1.

Fig 1



2 Before giving supply disconnect one end of both the chokes and set the variac ouput voltage at 250V.

3 Switch 'ON' and note down the wattmeter and P.F. meter readings in Table 1.

4 Switch 'OFF' and connect one choke and record the readings (W and P.F.).

5 Switch 'OFF' and connect the second choke, record the readings in Table 1.

Table 1

S.No.	Voltage (V)	Current (I)	W (w)	PF +/- Lag/Lead	No. of Chokes
1					With one choke
2					With two chokes

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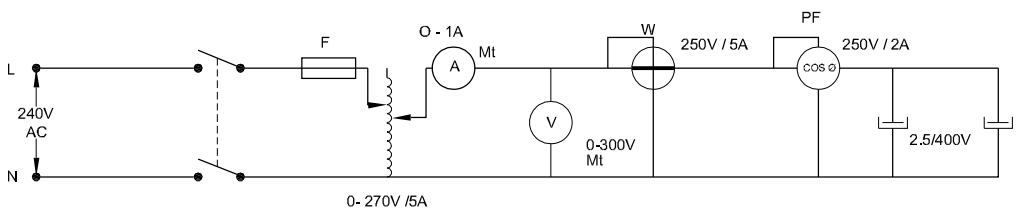
TASK 2: **Measure the power for leading P.F.**

1 Switch 'OFF' and modify the circuit as shown in Fig 2.

Fig 2



2 Disconnect one end of both the capacitor and switch 'ON'. Record the W and P.F. reading in the Table 2.

3 Switch OFF and connect one capacitor and switch 'ON'. Record the W and P.F. reading in the Table 2.

4 Switch 'OFF' and connect second capacitor and switch 'ON'.

5 Record the W and P.F. reading in the Table 2.

Table 2

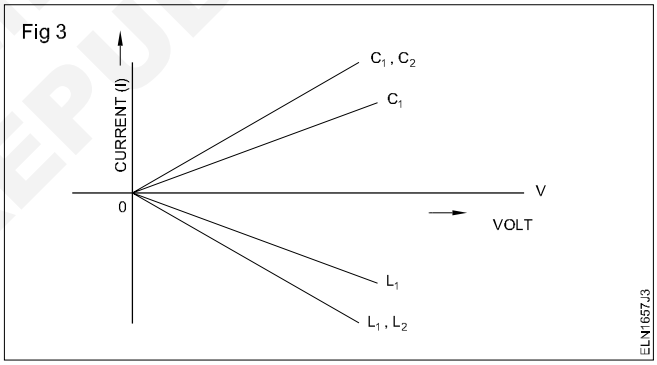
S.No.	Voltage V	Current I	W w	PF +/- lead/lag	Condition
1					With one capacitor
2					With two capacitor

6 Compile all the readings and plot a graph with volt to current for both leading and lagging PF.

Note: A sample graph is shown for reference. in Fig 3.

7 Get your work approved by the instructor.

Fig 3



TASK 3: **Measurement of energy with lagging and leading P.F.**

1 Identify the energy meter terminals - line and load, after removing the terminal cover.

Always mount the meter vertically.

2 Associate the circuit diagram (inside) with the terminal markings of the instrument.

3 Connect the energy meter terminals (line and load) in the circuit as shown in Fig 4.

4 Note the meter constant from the nameplate of the energy meter. (Fig 5)

5 Record the initial meter readings.

6 Switch ON the circuit with load.

7 Record the reading after 30 minutes in Table 3.

Fig 4

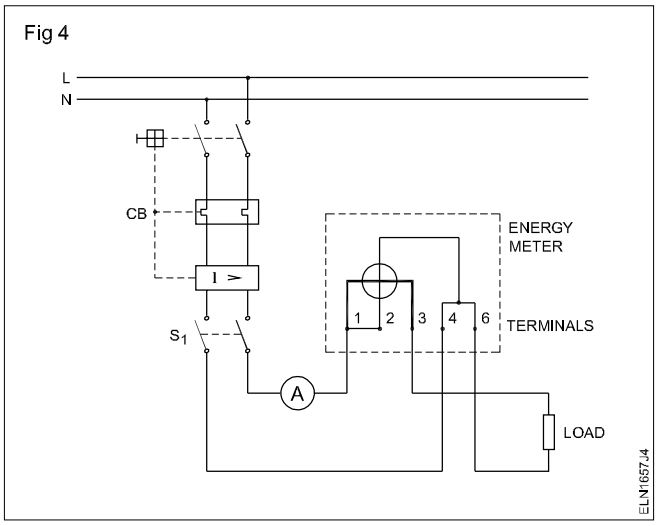


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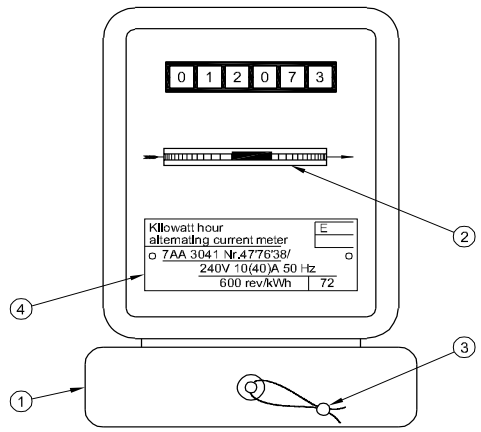
Fig 5



1 TERMINAL COVER 3 METAL SEAL
2 DISC 4 NAME-PLATE

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Table 3

Sl. No.	Volt (V)	Current (I)	Meter constant	Time (Secs)	Energy	
					Wh (Measured)	Wh (Calculated)

8 Connect the inductive load (Lagging power factor) and record the reading (Fig 6) in Table 4

9 Calculate the energy for lagging PF.

Fig 6

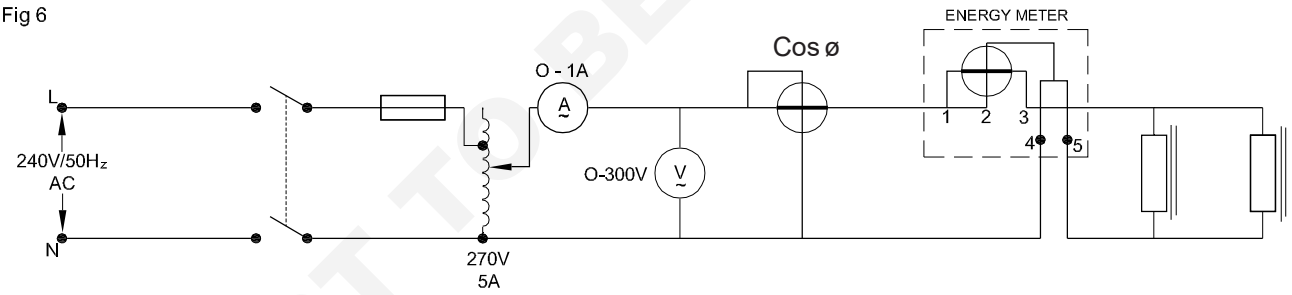

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Table 4

Sl. No.	Volt (V)	Current (I)	W	Meter constant	Time (Secs)	Energy	
						Wh (Calculated)	Wh (Measured)

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9 Switch Off the power and remove the inductive load.

10 Connect the capacitive, reactance (Fig 7) load and record the reading in Table 5.

Fig 7

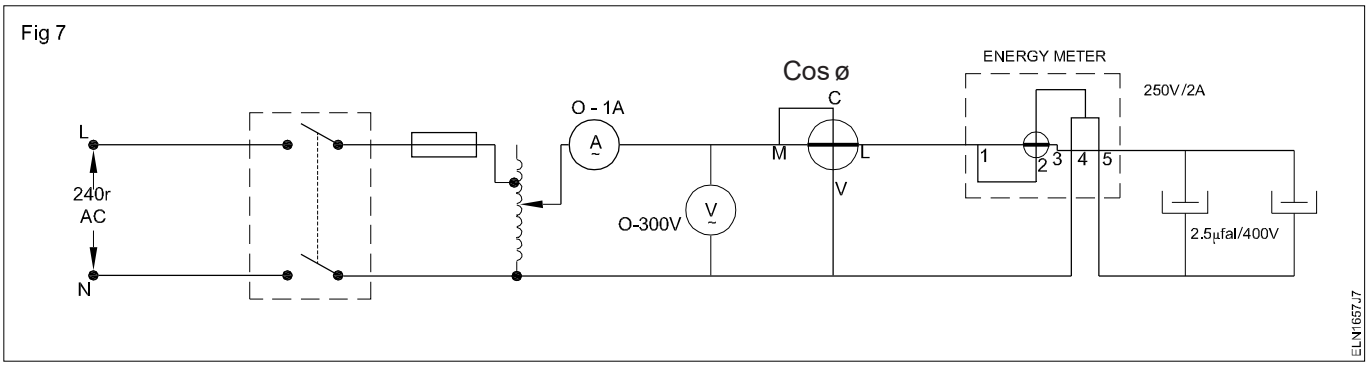

Table 5

Sl. No.	Volt (V)	Current (I)	W	Meter constant	Time (Secs)	Energy	
						Wh (Calculated)	Wh (Measured)

11 Calculate the energy for leading P.F. compile all the values and record the findings.

12 Plot the graph for lagging and leading P.F. for energy with respect to load current in the space provided

13 Get it checked by the instructor.

Result :

Space for Graph

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Measure current, voltage, power, energy and power factor in 3 phase circuits

Objectives: At the end of this exercise, you shall be able to

- **connect voltmeter, ammeter, wattmeter and power factor meter and 3 phase energy meter in 3 phase circuits**
- **measure the voltage, current, power and power factor and 3 energy in 3 phase circuits with lamp load**
- **measure the voltage, current, power and P.F and energy in 3 phase circuits with inductive lead (Induction motor).**

Requirements

Tools and Instruments

- Insulated screw driver 200 mm - 1 No.
- Insulated cutting plier 150 mm - 1 No.
- M.I Voltmeter 0-300V/600V - 1 No.
- M.I Ammeter 0-5A/10A - 1 No.
- Wattmeter 250V/500V, 5A/10A - 1 No.
- Power Factor meter 415V/20A - 1 No.
- 3 phase 4 wire energy meter 415V/20A - 1 No.

Equipment/Machines

- 3-phase induction motor 415V, 50 Hz, 5 HP (3.75 KW) - 1 No.
- 3-phase lamp load 100 W - 6 Nos.

Materials

- PVC insulated copper cable 2.5 mm^2 650V grade TPIC 16A/500V - 20 m.
- 200 Watt/250V, lamps - 6 hrs.

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PROCEDURE

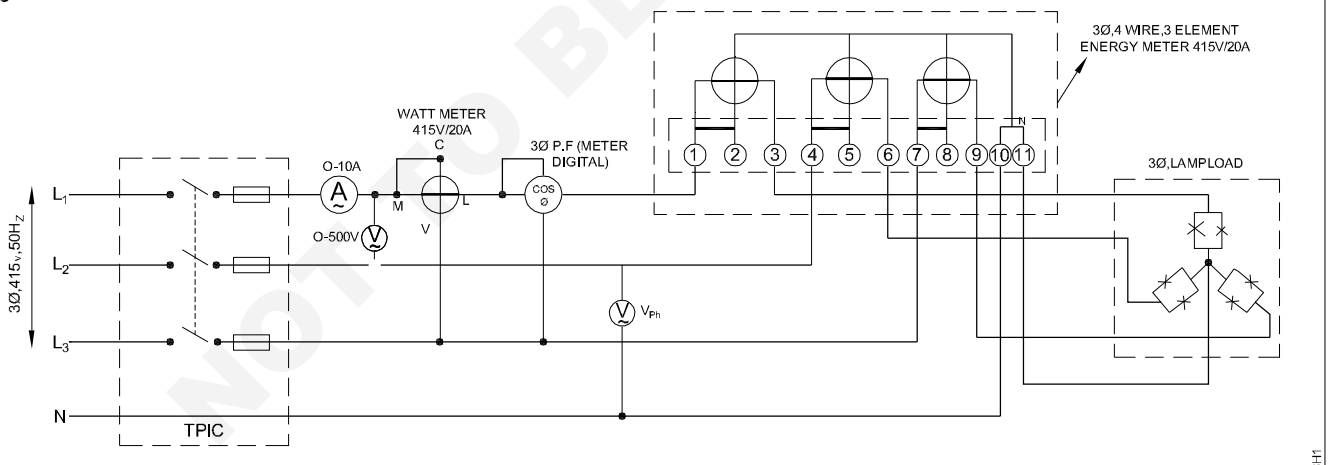
TASK 1: **Measure three phase current, voltage, power and power factor in 3 phase circuit with lamp load**

1 Select and collect the proper range of meters and lamp load for 3 phase circuit.

The lamp load should have equal wattage in all three phases

3 Switch 'ON' the power supply momentarily after getting the approval of the instructor and observe all themeter deflections. Keep the switch closed if nothing is abnormal.

Fig 1



CIRCUIT DIAGRAM FOR MEASURING OF VOLTAGE, CURRENT,POWER,ENERGY AND P.F IN 3 PHASE CIRCUIT

2 Make the connections of the meters and load as per the circuit diagram (Fig 1).

Connect the current coils of wattmeter, energy meter and P.F meter in series with the load.

4 Note down the initial reading of the energy meter.

5 Note down the meter readings and enter in Table 1.

6 Keep the load in 'ON' position for at least 10 minutes and then note and record the final reading and calculate the energy consumption (i.e) F.R - I.R.

Table 1

Load	Line Voltage V_L	Phase Voltage V_{ph}	Line Current I_L	Phase Current I_{PH}	Power in Watt	Power factor	Initial reading in energy meter	Final reading after 10 min in energy meter F.R	Energy consumption F.R - I.R in KWh
Lamp load for 100W									
Lamp load for 200W									
3ϕ Ind. meter load									

7 Swtich 'OFF' the power supply.

8 Replace the 100 Watt lamp with 200W lamp load.

9 Repeat steps 3 to 6 and record the readings in Table 1.

10 Switch 'OFF' power supply and disconnect the lamp load and connect 3 phase induction motor 3.75 KW/ 4.5V/50 Hz to the circuit.

11 Repeat steps 3 to 6 and record the readings in Table 1.

12 Get it checked by the instructor.

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Practice improvement of PF by use of capacitor in three phase circuit

Objectives: At the end of this exercise you shall be able to
- **connect 3 phase balanced inductive load and measure the P.F.**
- **connect 3 phase capacitor bank to inductive load and measure the P.F.**
- **calculate and record the improvement of P.F, after connecting the capacitor bank.**

Requirements

Tools and Instruments

- Insulated combination pliers 200 mm - 1 No.
- Insulated screwdriver 200 mm - 1 No.
- 3 ϕ P.F. meter 240V/440V ; - 1 No.
- Wattmeter 250/500 V, 5A/10A - 2 Nos.
- M.I Ammeter 0-5A/10A - 1 No.
- M.I Voltmeter 0-300V/600V - 1 No.
- Power factor improving capacitor bank 3 phase 415V, 1.5 KVAR - 1 No.

Equipment/Machines

- 3-phase induction motor 415V, 2.25 KW (with loading arrangement) - 1 No.
- 3-phase lamp load 0-3KW - 1 No.

Materials

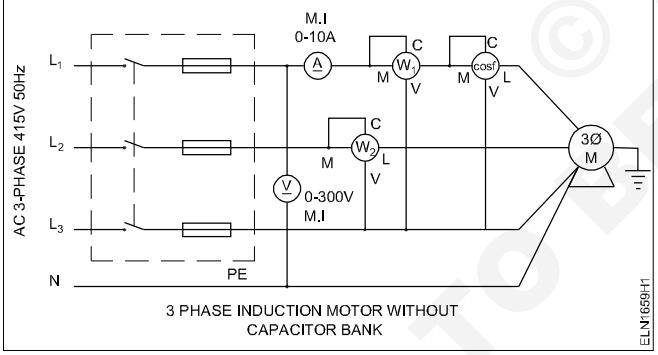
- PVC insulated copper cable 2.5 Sq, MM, 650V grade - 20 m.
- T.P.I.C.Switch 16A, 500V - 2 Nos.

PROCEDURE

TASK 1: **Connect 3 phase unbalanced inductive load and measure the P.F.**

1 Connect two Wattmeters P.F. meter, voltmeter and ammeter to 3 phase motor as shown in Fig 1.

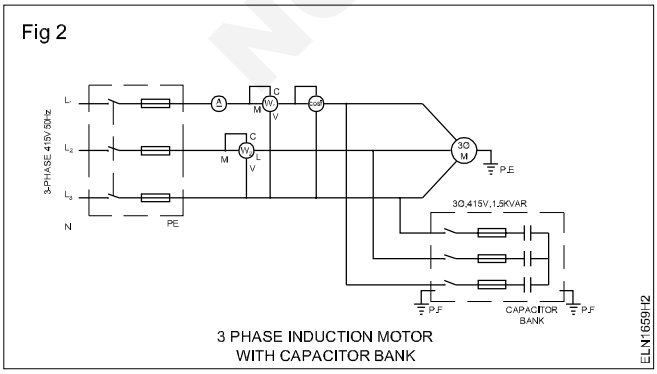
Fig 1



2 Get the connection checked by the instructor.

3 Switch 'ON' and load the motor to 60% of its load capacity and note the readings in Table 1.

Fig 2



4 Switch OFF and connect the capacitor bank as shown in Fig 2.

5 Switch ON and adjust 60% of the load and verify the readings as in step 3. The readings will be same.

6 Switch ON the capacitor bank and record the readings in Table 1 for the load conditions.

7 Calculate the P.F. in each case using the following formula.

a) P.F. calculated 1 = $\cos \varphi = = \dfrac{W_1 + W_2}{3E_{PH}\, I_{PH}}$

b) P.F. calculated 2 = Cos θ where the angle θ is derived from the formula $\text{Tan}\ \theta = \sqrt{3}\,\dfrac{W_1 - W_2}{W_1 + W_2}$

8 Enter the values in Table 1. Determine the percentage of error.

$$\%\ \text{error} = \frac{(\text{Calculated P.F.} - \text{Measured P.F.}) \times 100}{\text{Calculated P.F}}$$

Write your conclusion and reasons for if any.

9 Get it checked by your instructor.

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Table 1

Condition	Ammeter reading I_{PH}	Voltmeter reading E_{PH}	3-phase apparent power in volt amperes $3 \times E_{PH} \times I_{PH}$	Wattmeter reading W_1 watts	Wattmeter reading W_2 watts	3-phase true power $W_1 + W_2$	P.F. Calculated 1 $\text{Cos}\,\varphi\,(\text{P.F}) = \frac{W_1 + W_2}{3E_{PH} I_{PH}}$	P.F. Calculated 2	P.F. measured	Percentage of error
Motor with load										
Motor with load and capacitor bank										

Conclusion:

After connecting the capacitor bank, the effect in value of P.F. is _____

— — — — — — — —

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Ascertain use of neutral by identifying wires of a 3-phase 4 wire system and find the phase sequence using phase sequence meter

Objectives: At the end of this exercise, you shall be able to
- **test the phase wire and identify neutral with the use of test lamp**
- **identify, check and confirm the neutral wire with a meter**
- **connect and verify the phase sequence with 3-phase sequence meter.**

Requirements

Tools and Equipment

- Connector/Screw driver 100 mm - 1 No.
- Combination plier 150 mm - 1 No.
- Test lamp (40W/250V) - 2 Nos.
- Voltmeter 0-600V M.I. - 1 No.
- Phase sequence meter - 1 No.

Materials

- Connecting wires - as reqd.

PROCEDURE

TASK 1: **Test the phase line and identify the neutral with the use of test lamp**

1 Prepare a test lamp by connecting two lamps in series.

2 Mark the terminals as 1, 2, 3 and 4 and connect one lead of lamp to the marked 1 and other lead to the earth point provided in the frame as shown in Fig 1 and record the condition of lamp in Table 1.

Fig 1

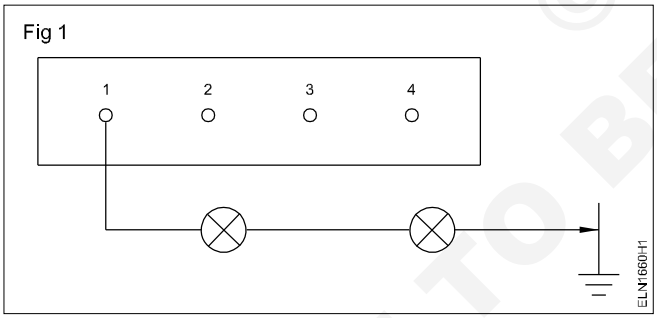

Table 1

Terminals	Glowing	Not glowing
1 to E		
2 to E		
3 to E		
4 to E		

3 Repeat the above step for other terminals 2, 3 and 4 and record the conditions in Table 1.

4 Mark the terminal where the lamp is not glowing as neutral. (N)

The three terminals at which the test lamp glows are the phase leads.

5 Connect one lead, No:4 (Identified as N) and connect the other lead of test lamp to 1, 2, 3. (Fig 2). Record the glow condition of the lamp in Table 2.

Fig 2

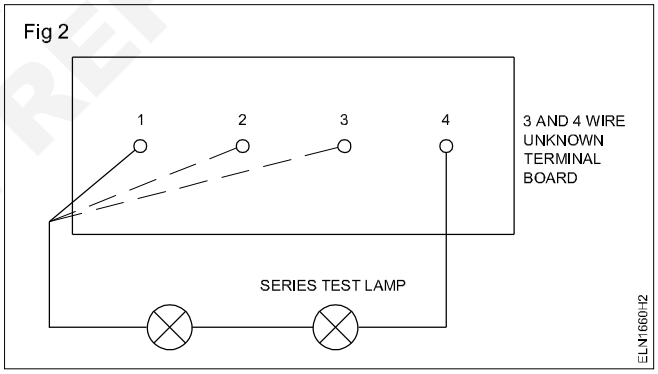

Table 2

Sl.No.	Terminals	Lamp condition	
		Glowing	Not glowing
1	4 - 1		
2	4 - 2		
3	4 - 3		
	1 - 2		
	1 - 3		
	2 - 3		

6 Refer to Table 2, mark the terminals where the lamp is glowing dim as neutral. If the lamp glows bright in the other three terminals i.e. 1-2, 1-3, 2-3 are phase terminal

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7 Repeat steps 1 to 5 by replacing lamps in series by connecting the voltmeter (0-600v) and record the readings in Table 3 as shown in Fig 3.

Fig 3

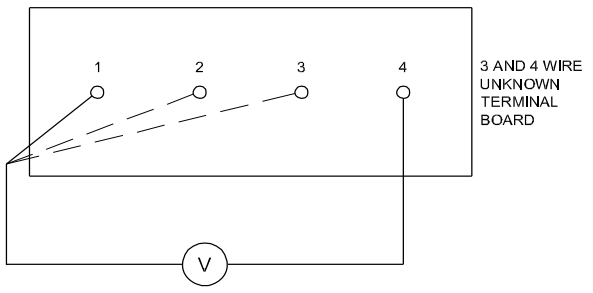


Table 3

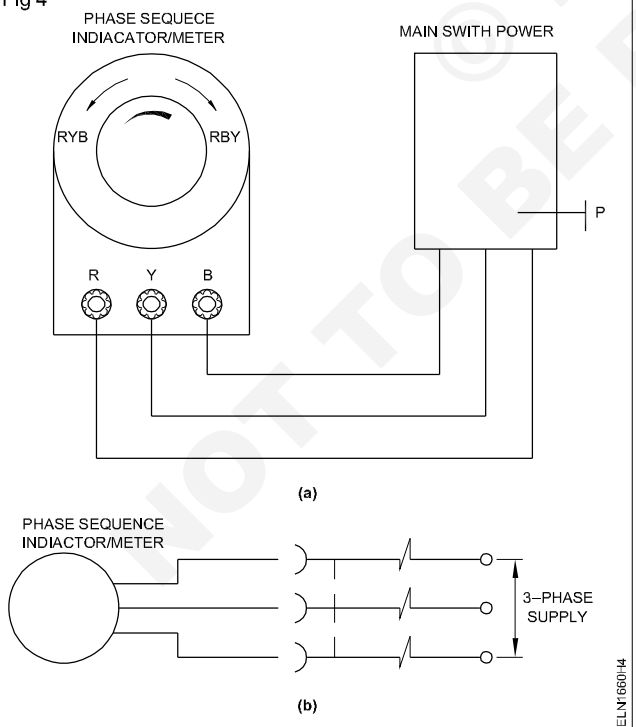
Sl.No.	Test terminals	Voltage	
		High	Low
1	4 -1		
2	4 - 2		
3	4 - 3		
4	1 - 2		
5	1 - 3		
6	2 - 3		

— — — — — — — —

TASK 2: **Identify the phase sequence in 3-phase 4 wire system by using phase sequence meter**

1 Read and record the marking of the phase sequence indicator direction: (Fig 4)

Fig 4



Rotation	Remarks
Same as arrow of the disc	
Opposite to the arrow of disc	

RYB Sequence
RBY Sequence
} Arrow marking to be indicated

Arrow in clockwise - ↱

Arrow in anti-clockwise - ↰

2 Switch 'OFF' the supply and connect the corresponding terminals (R, Y & B) to the phase sequence Indicator .

3 Mark leads as I, II, III. Connect them, such that I is connected to R, II to Y, III to B,

You can connect any lead (phase) to any terminal in the sequence indicator.

4 Switch 'ON' and observe the rotation of the disc and record the direction of rotation.

5 If the direction is anticlockwise switch 'OFF' the supply and interchange the terminals 1 and 2. Switch 'ON' and see that the rotation is reversed.

6 Mark the leads corresponding to the letters on the Phase Sequence Meter. (PSM)

If you connect any wire to any terminal, the disc will rotate anticlockwise if the RYB sequence is reversed, and it will be in the clockwise direction when RYB is connected in sequence.

7 Get it checked by your instructor.

— — — — — — —

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Determine effect of broken neutral wire in three phase four wire system

Objectives: At the end of this exercise you shall be able to
- **check the effect of broken neutral wire in 3-phase 4 wire system.**

Requirements

Tools and Instruments

- Combination plier 150 mm - 1 No.
- Connector screw driver 150 mm - 3 Nos.
- Three phase test board with netural link - 1 No.
- Lamp 40/240 V - 3 Nos.
- M.I Voltmeter 0-600V - 1 No.
- M.I Ammeter 0-5A - 3 Nos.
- Line tester 500V/5A - 1 No.

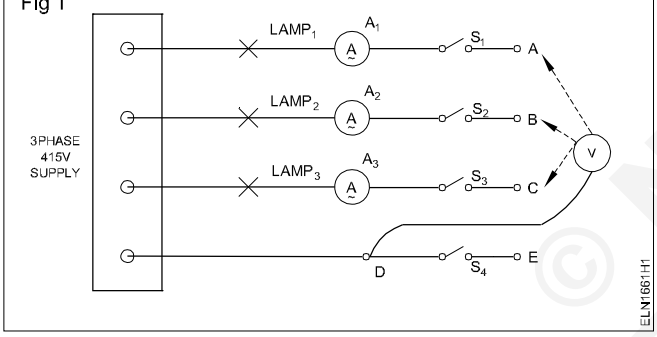
Materials

- Connecting wires - as reqd.
- ON-OFF switch - 4 Nos.

PROCEDURE

1 Connect the circuit as shown in Fig 1.

Fig 1



2 Switch 'OFF' all the switches S_1, S_2,S_3,S_4 and switch ON the 3-phase supply.

3 Check whether the lamps are glowing. Lamps do not glow

4 Switch 'OFF' 3-phase supply. Connect the terminal 'B to D', 'C to D' and 'A to E'

5 Switch 'ON' 3-phase supply. Switch 'ON' S_1, S_2, S_3. Switch 'OFF' S_4. Check if the lamps are glowing. Record all the readings in the Table 1. (L_1 will not glow L_2 and L_3 will glow - Step 2)

6. Switch 'OFF' 3-phase supply. Link 'B-E'. Follow the step 3 in Table - 1. Record the readings

7. Repeat the above step while linking 'C-E' (step 4 in Table 1). Record all the readings

It is evident that when neutral is broken the current does not flow So lamp will not glow, even though supply is available.

Table 1

S. No.	Switch position	A_1	A_2	A_3	V_1	V_2	V_3	Links	Links
1	**S_1,S_2, S_3, S_4 OFF**	0	0	0	0	0	0	–	–
2	**S_1,S_2, S_3 ON S_4 OFF**	0			0			A - E	B to D C to D
3	**S_1,S_2, S_3 ON S_4 OFF**		0			0		B - E	A to D C to D
4	**S_1,S_2, S_3 ON S_4 OFF**			0			0	C - E	A to D B to D

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Determine the relationship between Line and Phase values for star and delta connections

Objectives: At the end of this exercise you shall be able to
- **verify the relationship between Line and Phase values in star connection**
- **verify the relationship between Line and Phase values in delta connection.**

Requirements

Tools/Instruments

- Screw driver 150 mm - 1 No.
- Combination plier 150 mm - 1 No.
- M.I Ammeter type 0-1 amp - 2 Nos.
- M.I Voltmeter type 0-500V - 2 Nos.
- ICTPN switch 16A 500V - 1 No.

Materials

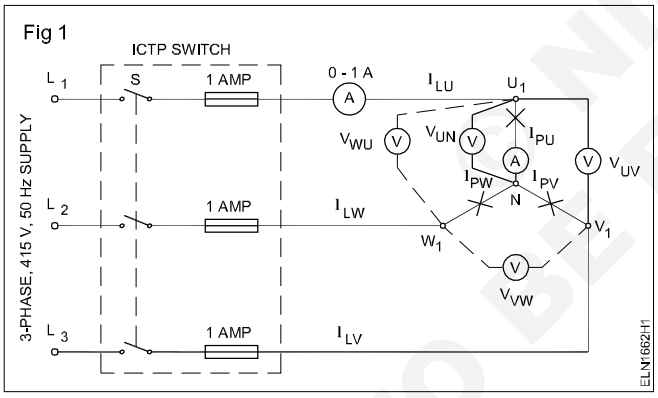
- Connecting leads - as reqd.
- Lamp BC - 40W 240V - 6 Nos.
- 100W 240V - 6 Nos.
- 200W 240V - 6 Nos.

PROCEDURE

TASK 1: **Verify the relationship between Line and Phase values in star connection of three phase system**

1 Form the circuit as per the given circuit diagram. (Fig 1) with one lamp each connected to all the 3 phases (40/100/200 W).

Fig 1



2 Identify the 3-phase (L_1, L_2, L_3) and neutral (N) of supply terminals.

3 Switch 'ON' the 3-phase supply.

4 Measure the line voltage V_{UV} by placing the voltmeter leads between the two lines and enter the reading in Table 1.

5 Repeat for the other line voltages V_{VW}, V_{WU}.

6 Measure the phase voltages by placing the voltmeter leads between one line and star point N, and enter the readings in Table 1.

7 Measure the Line and Phase current and enter the readings in Table 1.

Switch 'OFF' supply before effecting any change in load.

8 Repeat steps 3 to 7 for different loads.

9 Calculate the ratio between the Line voltage and Phase voltage.

$$\frac{V_{UV}}{V_{UN}} =$$

$$\frac{V_{VW}}{V_{VN}} =$$

$$\frac{V_{WU}}{V_{WN}} =$$

10 Verify the ratio between Line current and Phase current, i.e.

$$\frac{I_{LU}}{I_{PU}} = \frac{I_{LV}}{I_{PV}} = \frac{I_{LW}}{I_{PW}} =$$

11 Get it checked by the instructor.

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Table 1

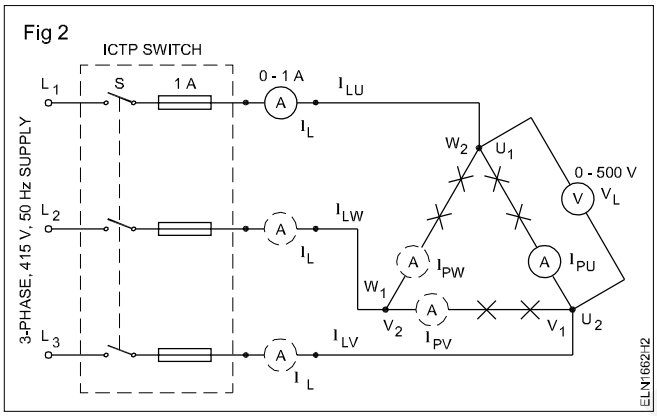
Sl. No.	Load in watts per phase	Line voltage			Phase voltage			Line current			Phase current		
		V_{UV}	V_{VW}	V_{WU}	V_{UN}	V_{VN}	V_{WN}	I_U	I_V	I_W	I_{UN}	I_{VN}	I_{WN}
1	40W												
2	100W												
3	200W												

— — — — — — — —

TASK 2: **Verify the relationship between Line and Phase values in delta connection in three phase system**

1 Form the circuit as per the given circuit diagram. (Fig 2) Two lamp in series to be connected between two phases of same voltage.

Fig 2



2 Switch ON the 3-phase supply. Measure the line voltages by connecting the voltmeter leads between two of the terminals U_1, V_1, W_1.

3 Measure the phase voltage by placing the voltmeter leads across the lamps, i.e. U_1, U_2 or V_1, V_2 or W_1, W_2.

4 Record the Line voltages and Phase voltages measured, under the appropriate column in Table 2.

5 Measure the Line and Phase currents and enter the readings in Table 2.

An ammeter connected between supply and load indicates Line current. An ammeter connected in series with single load (two lamps in series) indicates Phase current.

6 Repeat steps 2 to 5 for different loads.

Switch off the supply before effecting any change in the load.

7 Verify the relationship between Line and Phase value of current and voltage. Enter in Table 3.

Result

In star : Line current and Phase current are _____

whereas Line voltage =_____ x Phase voltage.

In delta :Line voltage and Phase voltages are _____

whereas Line current =_____ x Phase current.

8 Get it checked by the instructor..

Table 2

Sl. No.	Load in watts per phase	Line voltage			Phase voltage			Line current			Phase current		
		V_{U1V1}	V_{V1W1}	V_{W1U1}	V_{U1U2}	V_{V1V2}	V_{W1W2}	I_U	I_V	I_W	I_{U1U2}	I_{V1V2}	I_{W1W2}
1	40W												
2	100W												
3	200W												

Table 3

Load	$\frac{V_{U_1V_1}}{V_{U_1U_2}}$	$\frac{V_{V_1W_1}}{V_{V_1V_2}}$	$\frac{V_{W_1U_1}}{V_{W_1W_2}}$	$\frac{I_{LU}}{I_{PU}}$	$\frac{I_{LV}}{I_{PV}}$	$\frac{I_{LW}}{I_{PW}}$
40W						
100W						
200W						

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Measure the power of 3-phase circuit for balanced and unbalanced loads

Objectives: At the end of this exercise, you shall be able to
- **identify and connect the terminals of a single-phase Wattmeter**
- **connect single wattmeter in star, balanced load and measure the power**
- **connect two wattmeters in the circuit as per the given diagram**
- **connect two wattmeters in unbalanced, star-connected load and measure the power**
- **identify and connect 3-phase wattmeter and measure the power in star.**

Requirements

Tools/Instruments

- Single-phase wattmeter 250V/5A - 1 No.
- Wattmeter 500V/5A - 2 Nos.
- PF meter, single phase 250V,5A - 1 No.
- Voltmeter 0-500 V M.I. - 1 No.
- Ammeter 0-5A M.I. - 1 No.

Materials

- 200W, 250V lamps - 3 Nos.
- 100W, 250V lamps - 3 Nos.
- Capacitor 400V AC 4 MFD - 2 Nos.
- Connecting leads - as reqd.
- Pendent-holders 6A 250V - 6 Nos.

Equipment/Machines

- 3-phase, 415V AC induction motor 3 HP coupled with DC generator - 1 No.

PROCEDURE

TASK 1: **Connect balanced load in star and measure the power with one single element Wattmeter**

1 Form the circuit as per the given circuit diagram. (Fig 1)

Connect proper voltage and current ranges of Wattmeters suitable to the given load.

2 Switch ON the 3-phase supply and read the wattmeter and record the wattmeter readings in Table 1.

3 Measure the power in the other two phases by connecting the wattmeter in turns and record the redings.

4 Total the readings of the wattmeters and check its confirmity with the calculated total power.

5 Repeat steps 1 to 4 for different load conditions.

Fig 1

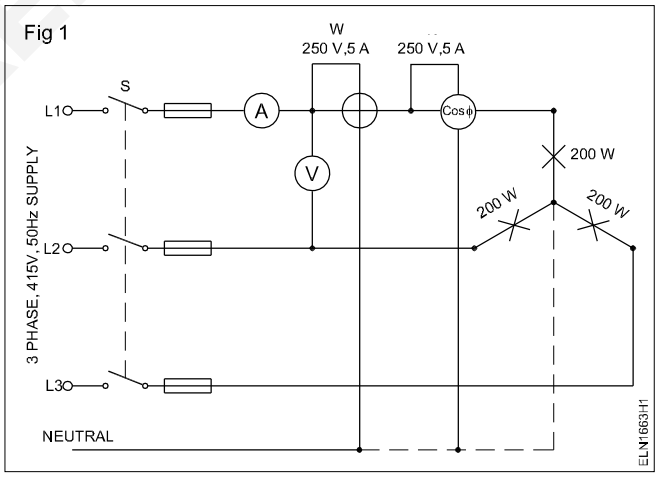

Table 1

Type of Load	Wattmeter connected in the line			V_L	I_L	P.F	Calculated Total power	Total power = Total of three wattmeter readings
	W_{L1}	W_{L2}	W_{L3}				$W=\sqrt{3}\ V_L I_L \cos\theta$	$W_{L1} + W_{L2} + W_{L3} = W$
1								
2								
3								
4								

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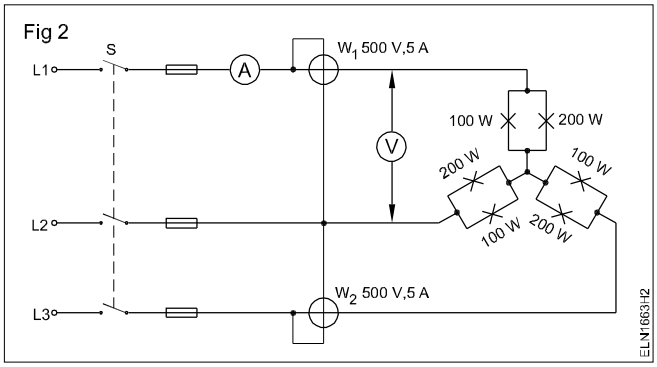
TASk 2: **Power measurement by two-wattmeter method in 3-phase unbalanced load**

1 Form the circuit as per the given circuit diagram. (Fig 2)

Connect proper ranges of meters suitable for the given load.

Fig 2



2 Switch 'ON' the 3-phase supply and check whether the deflection of wattmeter is correct. If both wattmeters deflect properly, go to step 4, otherwise continue from step 3.

3 Switch 'OFF' the supply, if any one wattmeter deflects in the reverse direction. Change the connection of the potential coil of the reverse deflection wattmeter. Go to step 5.

4 Read the wattmeters W_1 and W_2 and record in Table 2. Add the readings W_1 and W_2 and record the total power; Go to step 6.

5 Switch on the supply and read the wattmeters W_1 and W_2. Record the values in the Table. Record the readings of the wattmeter with the changed potential coil as negative quantity.

6 Measure the 3-phase power for different load conditions specified below:

a) L_1 = 500 W bulb

L_2 = 100 W bulb parallel 4 MFD capacitor

L_3 = 200 W bulb

b) Water load to take a current maximum of 3 amps.

c) Induction motor 3 HP on no load

d) Induction motor 3 HP with load

The instructor may connect the three-phase motor to ensure it is running properly.

7 Calculate the power factor in all the above cases and enter them in Table 2.

8 Get it checked by the instructor.

Table 2

Type of Load	**Wattmeter W_1**	**Wattmeter W_2**	**Total $W_1 + W_2$**	**Calculated Power factor Cos θ** $\text{Tan } \theta = \sqrt{3}\,\frac{W_1 - W_2}{W_1 + W_2}$ **Determine Cos θ**
1				
2				
3				
4				
5				

Conclusion : _____

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Measure current and voltage of two phases in case of one phase is short-circuited in three phase four wire system and compare with healthy system

Objectives: At the end of this exercise, you shall be able to
- **connect and test the circuit**
- **measure the current and voltage in healthy conditions**
- **check the condition of the two phase, when one phase is overloaded/short-circuited**
- **record the current and voltage in both conditions.**

Requirements

Tools/Instruments

- M.I Ammeter 0-10A - 2 Nos.
- M.I Ammeter 0-20A - 1No.
- M.I Voltmeter 0-300V - 3 Nos.
- Load 1500W/ 240V - 4 Nos.
- 3 Phase supply board 3φ, 4 wire - 1 No.

Materials

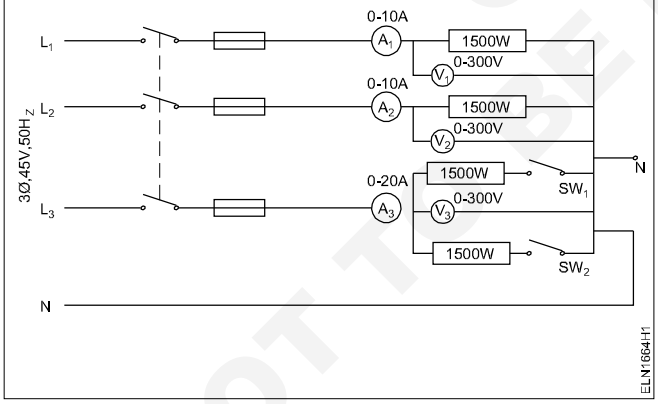
- S.P. switch 240V/16A - 2 Nos.
- Connecting wires - as reqd.
- TPIC - 415V/16A - 1 No.

PROCEDURE

We cannot manually make a short circuit in the phase line as it is dangerous and it may trip the circuit. In order to make a short circuit condition load current is doubled in one phase.

1 Connect the circuit as per the diagram shown in Fig 1.

Fig 1



2 Switch 'ON' the 3 Phase supply and ON the switch SW_1. Record the current and voltage the tabular column.

3 Switch 'OFF' the 3 Phase in supply and SW_2 switch 'ON'.

4 Switch 'ON' the 3 Phase supply and record the readings of the current and voltage in the tabular column.

5 Switch 'OFF' all the supply lines, and disconnect the wiring and return all the materials and equipment.

6 Get it checked by the instructor.

Conclusion : _____

Table 1

Sl.No.	SW_1 - ON		SW_1 - ON & SW_2 ON			
1	A_1	V_1	A_1		V_1	
2	A_2	V_2	A_2		V_2	
3	A_3	V_3	A_3		V_3	

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Use of various types of cell

Objectives: At the end of this exercise you shall be able to
- **read and interpret the different type of cells from the chart or physically available cells**
- **name the cells, parts and uses.**

Requirements

Equipments

- Different types of cells - 1 each

Materials

- Chart showing different types of cells - 1 No.

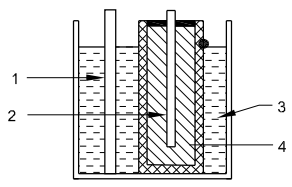
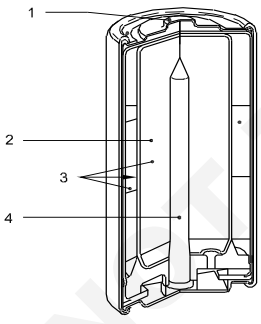
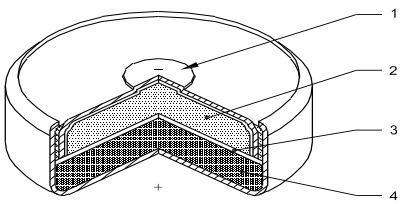
PROCEDURE

Instructor may arrange the available different types of cells on the table. Explain the types of cells and their uses

1 Identify the type of cell and write their names to corresponding cell placed on the table or by referring from chart as in Table1 (Fig 1 to Fig 6)

2 Write the name of the parts against the number and uses in the blank space provided against each cell in table 1.

Table 1

Sketches	Name of Cell	Parts of cell	Uses
Fig 1 		1 2 3 4	
Fig 2 		1 2 3 4	
Fig 3 		1 2 3 4	

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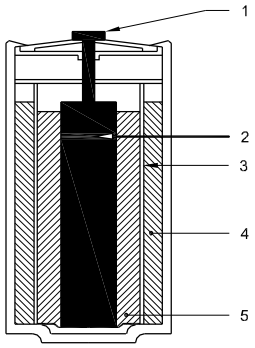
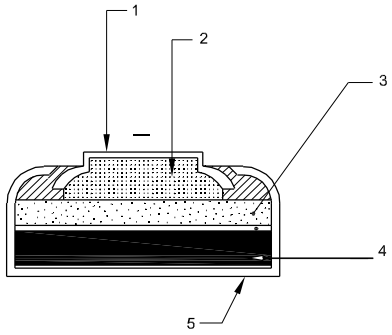
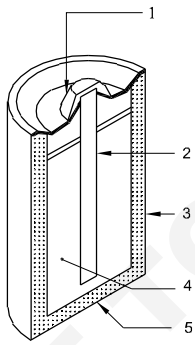
Sketches	Name of Cell	Parts of cell	Uses
Fig 4 		1 2 3 4 5	
Fig 5 		1 2 3 4 5	
Fig 6 		1 2 3 4 5	

3 Get it checked by your instructor.

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Practice on grouping of cells for specified voltage and current under different conditions and care

Objectives: At the end of this exercise you shall be able to
- **make grouping of cells in series connection**
- **make grouping of cells in parallel connection**
- **make grouping of cells in series and parallel connection.**

Requirements

Tools/Instruments

- MC Ammeter 0-1A - 1 No.
- MC Voltmeter 0-15V - 1 No.
- MC Ammeter 500 mA - 1 No.
- Multimeter - 1 No.
- Rheostat 20 ohms 3.7A - 1 No.

Materials

- Cells 1.5V - 8 Nos.
- SP Switch 6A, 250V - 4 Nos
- Connecting leads - as reqd.
- Resistor 5 Ω , 10W - 1 No.
- 4 Cell battery pack - 2 Nos.
- miniature lamp 6V / 9V, 300 mA - 1 No.
- Resistor 10 Ω , 10W - 1 No.

PROCEDURE

TASK 1 : **Grouping of cells in series connection**

1 Check the individual cells for their condition.
- Select 500 mA DC current range in mulimeter or 500 mA DC ammeter.
- Connect the cell across the meter in series with a 3 ohm resistor.
- Watch the deflection.

Full deflection shows good condition of cell. Low deflection shows disharged condition of the cell.

Cells having a higher internal resistance should not be used for series connection.

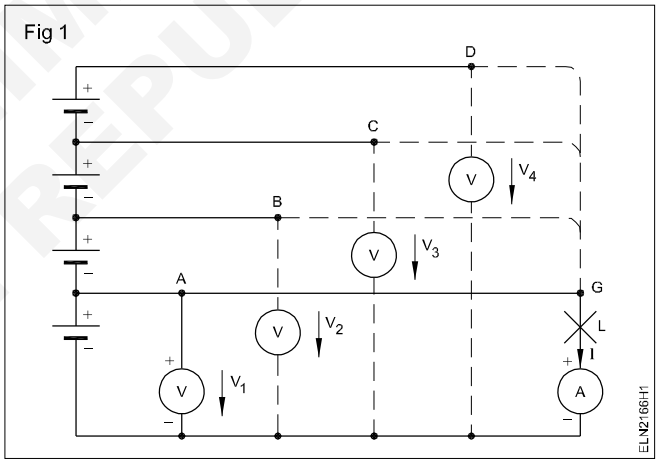
Care should be taken for the cells polarity.

2 Connect the cells as shown in Fig 1.

3 Measure the voltage of one cell V_1, two cells V_2, three cells V_3 and four cells V_4 connected in series.

4 Record your observations in the first and second columns of Table 1.

Fig 1



5 Connect the terminal 'G' to the terminal A and observe the ammeter reading and the glow condition of the lamp.

6 Change the contact of termnal ' G' terminals B,C and D in succession.

7 Record your observations under the columns 3 & 4 in Table 1

Table 1

Sl No.	No. of cells in series	Voltmeter reading	Ammeter reading	Glow
1				
2				
3				
4				

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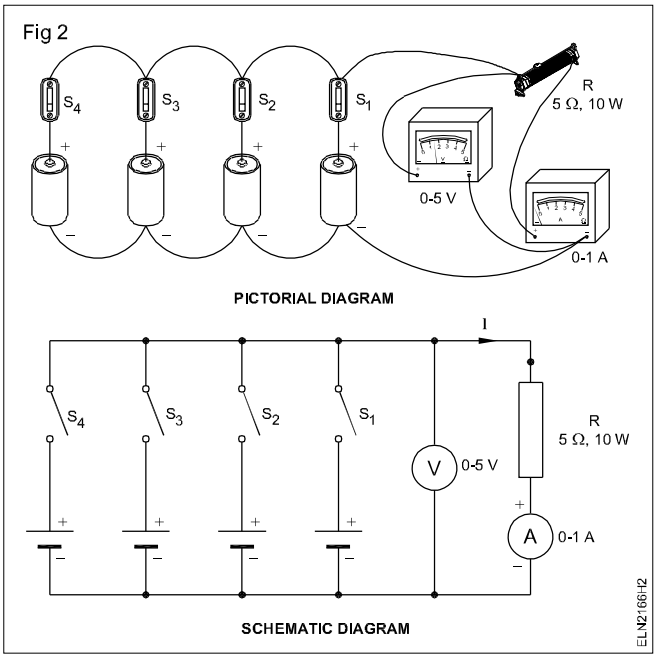
TASK 2: **Grouping of cells in parallel connection**

1 Check the voltage of each cell.

2 Form the circuit as shown in Fig 2.

Fig 2



3 Close the switch S_1 and measure voltage and current. Record the values in Table 2, under columns 2, 3 and 4.

Table 2

Sl. No.	No. of Cells in Parallel	V	I

4 Check and record the readings of V and I after closing switch S_2, then S_3, and S_4 in succession.

Unequal voltage cells cannot be connected in parallel.

Conclusion

When cells of equal voltage are connected in parallel the terminal voltage is equal to _____

As the load current is shared by the cells in parallel, the terminal voltage across the load is _____ when compared to a single cell supplying current to the same load.

The effect of a number of cells in parallel to a given load.

_____

_____

_____

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Prepare and practice on battery charging and details of charging circuit

Objectives: At the end of this exercise you shall be able to
- **connect and charge the battery by using a battery charger**
- **connect and charge the battery by the constant current method**
- **connect and charge the battery by the constant potential method**
- **prepare electrolyte.**

Requirements

Tools/ Instruments

- Cutting plier 150 mm - 1 No.
- Screw driver 150 mm - 1 No.
- MC Voltmeter 0-15V - 1 No.
- MC Ammeter 0-10A - 1 No.
- Hydrometer - 1 No.
- High rate discharge tester - 1 No.

Equipment/Machines

- Battery charger for 12V - 1 No.
- Low voltage DC power supply 0-30 volts 10A. - 1 No.
- Variable resistor 10 ohms, 5A capacity - 1 No.
- Battery 12V lead acid type - 1 No.

Materials

- Distilled water - 1 bottle (450ml)
- Petroleum jelly - as reqd.
- Sandpaper - as reqd.
- Test leads with crocodile clips - 1 pair
- Clips - 1 pair
- concentrated sulphuric acid - 100 ml
- Clean jar for mixing 1 litre capacity - 2 Nos.
- Cotton Waste - as reqd.
- Soda bi-carbonate - as reqd.

PROCEDURE

TASK 1 : **Charging a battery using a battery charger**

1 Clean the battery terminals, if corroded, with sandpaper : if sulphated, clean with wet cotton waste or with soda bicarbonate.

Do not damage the battery terminal by scraping with any metal strip.

2 Unscrew all the vent plugs and check the level of the electrolyte.

Do not clean the battery top surface keeping the vent plugs open. The accumulated dirt may fall inside the cells and form sediments.

3 Top up the electrolyte to the marked level in all the cells with distilled water.

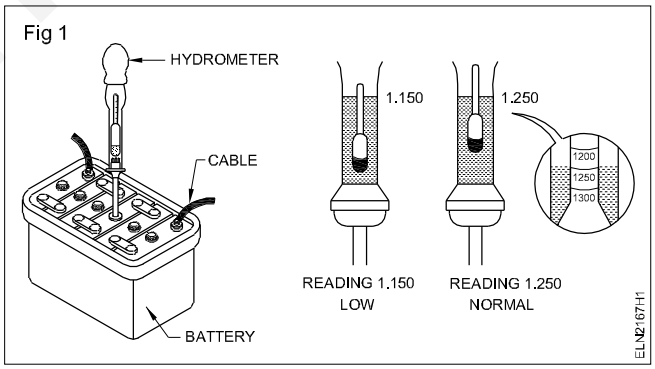
No electrolyte to be used to top up battery.

4 Check the initial specific gravity of the electrolyte of each cell using a hydrometer (Fig 1) and record in Table 1.

5 Measure the cell voltage and the battery voltage with a voltmeter and record in the Table 1.

Do not use a high rate discharge tester for measuring voltage.

Fig 1



6 Connect the battery charger's +ve lead to the +ve terminal of the battery and the -ve lead of the charger to the -ve terminal of the battery. (Fig 2)

7 Adjust the battery charger output voltage equal to or a little higher than the voltage of the battery to be charged.

8 Set the charger voltage to produce the determined value of initial charging current.

Follow the manufacturer's recommendation for current setting for charging as well as discharging.

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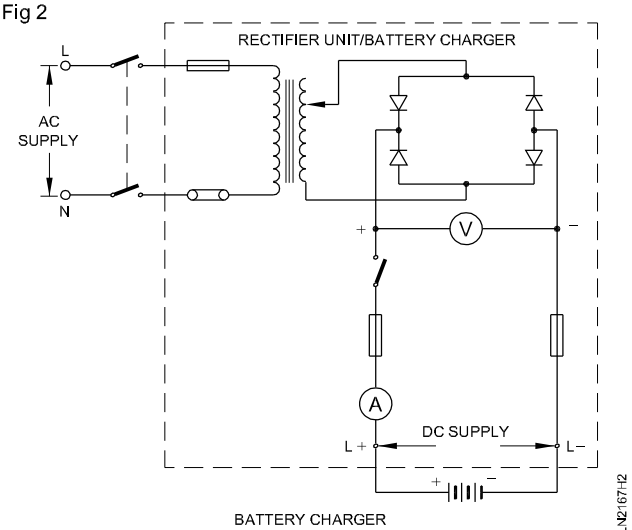
Fig 2



9 Check the voltage of each cell of the battery and specific gravity of the electrolyte at regular intervals (say ONE hour).

Remove the vent plug to enable the gas to escape.

10 Disconnect the battery when fully charged. Fit the vent plugs, clean the outer surface with wet cloth. Apply petroleum jelly to the terminals.

11 Check the battery for its working voltage under load using a high rate discharge tester for a short period. (Fig 3)

Do not keep a high rate discharge tester for along period, say more than five seconds.

Fig 3

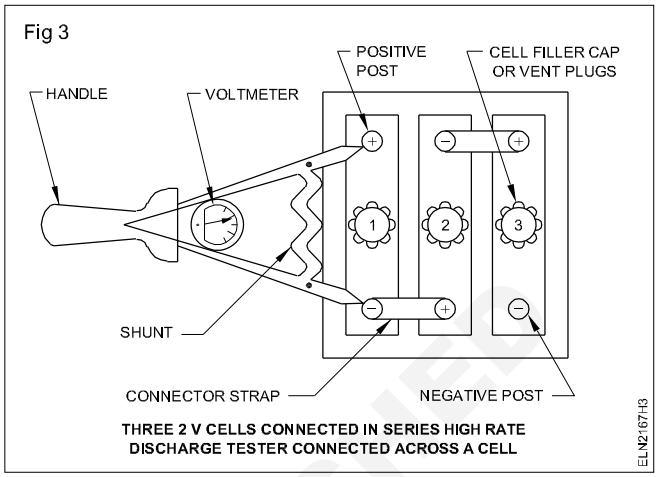


Table 1

Cell No.	Initial condition		Charged condition after									
	Specific gravity	Voltage	1 Hr		2 Hrs		3 Hrs		4 Hrs		5 Hrs	
			SP	V	SP	V	SP	V	SP	V	SP	V
1												
2												
3												
4												
5												
6												

— — — — — — — —

TASK 2 : **Charge a battery by constant current method**

1 Form the circuit as shown in Fig 4.

2 Clean the battery terminals and unscrew all the vent plugs.

3 Check the level of the electrolyte and top up.

4 Check the specific gravity and voltage of each cell and record and prepare a blank table (as shown in Table 1).

5 Connect the given batteries in series with the lamp bank as per Fig 4.

6 Adjust the current rating through the lamp bank.

7 Set the lamp bank to produce the determined value of the initial charging current.

Don't touch the battery terminals since the circuit is connected to 220V DC.

Proper protective devices should be provided in the circuit.

8 Read the voltage and specific gravity of each cell at regular intervals and record in Table 1.

9 Repeat the steps 10 and 11 of Task 1.

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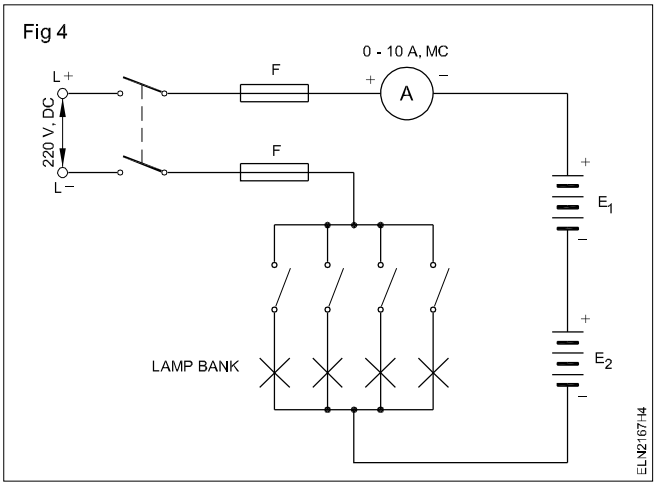
Fig 4



TASK 3 : **Charge a battery by constant potential method**

1 Form the circuit as shown in Fig 5.

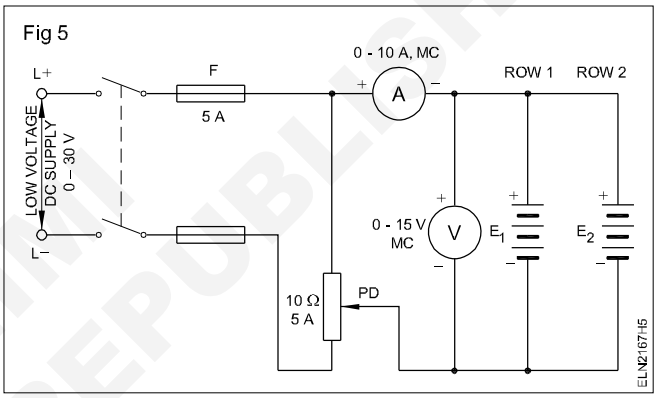
2 Repeat the steps 2 to 4 of Task 2.

3 Adjust the voltage by adjusting the rheostat to the required value.

4 Read and record the voltage, current and specific gravity at regular intervals in Table 3. (Prepare a blank table as shown in Table 1)

5 Repeat the steps 10 and 11 of Task 1.

Fig 5



TASK 4 : **Preparation of electrolyte**

1 Prepare the necessary materials for electrolyte preparation.

2 Fill distilled water of the required quantity in the glass jar.

3 Add concentrated sulphuric acid little by little to the water and stir with a glass rod simultaneously.

Don't pour excess acid at a time to the water to avoid excess generation of heat.

4 Allow the mixture to cool sufficiently to the ambient temperature.

5 Read the specific gravity (Fig 1). If the specific gravity is below 1250, add a little more acid to bring to the correct specific gravity.

Take care not to sprinkle the electrolyte.

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Practice on routine, care / maintenance and testing of batteries

Objectives: At the end of this exercise you shall be able to
- **prepare and follow the routine care/maintenance schedule chart for batteries**
- **carry out the general procedure and maintenance for batteries.**

Requirements

Tools/ Instruments

- Ring spanner (6 mm - 25 mm) - 1 Set
- Combination pliers 150mm - 1 No.
- Insulated screw driver 200mm - 1 No.
- Hydrometer - 1 No.
- High rate discharger tester - 1 No.

Equipment/Machines

- Lead acid battery 12V / 60 AH - 1 No.

Materials

- Banian cloth - as reqd.
- Distilled water - as reqd.
- Sodium bicarbonate solution - as reqd.

PROCEDURE

TASK 1: **Prepare and follow the routine care/maintenance schedule chart for batteries**

1 Collect the care/maintenance activities required for lead acid batteries.

2 Make a care/maintenance chart for daily, weekly, monthly, six monthly maintenance schedule as in chart - 1.

3 Perform the routine care/maintenance activities of battery by referring the following chart 1.

Routine Care/ Maintenance Schedule Chart-1

Sl.No.	Routine	Activities to be done	Remarks
1	Daily	• Inspect the batteries visually. • If it is found abnormal, report and do necessary action.	
2	Weekly	• Inspect all batteries visually • Clean surface, check tightness of connectors and vent plugs • Check supporting clamps	
3	Monthly	• Check level of electrolyte • Do charging of battery, if not been automatically charged • Clean terminals, reconnect, apply protection jelly. • Clean top surface by sodium bi carbonate solution in water. • Wipe surface for dryness. • Check that other materials surface should not have contact with batteries and top surface of battery	
4	Six Monthly	• Check level and specific gravity, charging rate, charging hours, voltage cell	

(Life of well maintained lead acid battery can be about five to six years)

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TASK 2 : **Carry out the general preventive maintenance of lead acid battery**

1 Perform the following steps for the preventive maintenance of battery.

Steps to be followed for preventive maintenance of battery

- Maintain the level of the electrolyte 10 to 15 mm above the plates (or) as per manufacturer's manual.
- Add the distilled water to the acid; and do not add acid to water.
- Connect the positive terminal of the battery to the positive terminal of the supply, and connect the negative terminal of the battery to the negative terminal of the supply while charging the battery.
- Keep the vent plug open for the liberation of gases during charging.
- Clean the vent plugs holes for proper discharging of gas.
- Keep the battery terminals always cleaned.
- Apply a thin layer of Vaseline (or) petroleum jelly over them to prevent corrosion.
- Do not charge or discharge the battery in higher rate continuously.
- Remove the lead sulphate which is formed due to over charge after four months.
- Maintain well-ventilated room for battery charging.
- Use high rate discharge tester only for charged battery not for discharged battery.
- Check the specific gravity of the electrolyte before charging and discharging.

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Determine the number of solar cells in series / Parallel for given power requirement

Objectives: At the end of this exercise you shall be able to
- **determine the number of solar cells required for a series group for a given voltage requirement**
- **determine the number of group of solar cells in parallel for a given ampere hour capacity**
- **calculate the total number of solar cells required for a given power requirement**
- **connect the given cells in series and parallel groups to charge the battery.**

Requirements

Tools/Instruments

- Cutting pliers 200 mm - 1 No.
- Screw driver 250 mm - 1 No.
- Connector screw driver 100 mm - 1 No.
- Voltmeter MC type 0 - 15V - 1 No.
- Ammeter 0-500 mA - MC - 1 No.
- Soldering Iron 35W 240V 50 Hz - 1 No.

Materials/Components

- Solar cells 125 mW/cm^2, 0.45 V, 57 mA - 87 cells
- Connecting wires 3/0.91mm PVC insulated cable - 20 m
- Insulation tape 30 cm long - 1 No.
- Miniature bulb B.C Type 3W 12 V with holder - 1 No.
- 'On' and 'Off' flush mounting switch 6A 240 Volts - 2 Nos.
- Resin core solder 60:40 - 2 Nos
- - as reqd.

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PROCEDURE

TASK 1 : **Determine the number of cells required for a series group**

A village panchayat office requires a light of 12V 3Watts for display purpose for four hours which has to be energized through a battery. The battery is to be charged through an array of solar cells having 125 mw/cm^2 capacity. The light from sun expected to be available for 8 hours a day. Calculate the number of solar cells in series group and the number of groups in parallel to charge the battery and wire up the solar cells accordingly.

1 Determine the number of solar cells in series group.

$$\text{No. of cells in series group} = \frac{\text{Total required voltage}}{\text{Volt per cell}}$$

Assuming charging voltage is
equal to battery voltage + 1 volt = 12 + 1 = 13 V

$$\text{No. of cells in series group} = \frac{13}{0.45} = 29 \text{ cells}$$

Calculate the ampere hour requirement

$$\text{The current required} = \frac{\text{Power}}{\text{Voltage}} = \frac{3 \text{ watts}}{12 \text{ volts}} = \frac{1}{4} \text{ amps}$$

say 250 mA

The charge taken from the batteries at the rate of 250 mA for 4 hours

$$\text{Hence ampere hour requirement} = \frac{250}{1000} \times 4$$

= 1 AH

$$\text{Charging current rating} = \frac{\text{ampere hour lost in actual usage}}{\text{No. of possible charging hours}}$$

$$= \frac{1\text{AH}}{8} = 0.125 \text{ amperes}$$

$$\text{Total No. of cells in parallel group} = \frac{\text{Output current}}{\text{Cell current}}$$

$$= \frac{0.125 \text{ amp}}{57 \text{ mA}}$$

$$= \frac{125}{57} = 2.2$$

= say 3 cells/group

Hence total number of cells required = 29 x 3

= 87 cells

— — — — — — — —

TASK 2 : **Connect the given 87 cells in series parallel groups to charge the 12 v battery**

1 Connect 29 cells in a series group and solder the points.

2 Make 3 groups of 29 cell series groups.

3 Connect the three series groups in parallel and solder the connections ends.

4 Connect the series parallel group of cells with a voltmeter, an ammeter, battery and a 6A Switch as shown in the Fig 1.

5 Measure the voltage across the groups with the help of 0-15 V M.C. voltmeter and enter the values in Table 1.

6 Close the switch and measure the charging current and enter the values in Table 1.

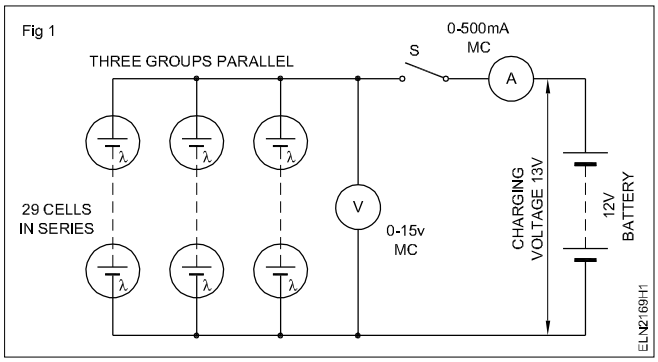

Table 1

Open circuit voltage of coils	Load voltage	Charging current

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Identify various conduits and different electrical accessories

Objectives: At the end of this exercise you shall be able to
- **identify and name the conduits and conduit accessories and write their specification and uses.**
- **identify and name the electrical accessories**
- **write the specification and uses of the electrical accessories**
- **draw the electrical accessories IE symbols.**

Requirements

Tools/Instruments

- Insulated screw driver 4mm x150mm - 1 No.
- Insulated connector screw driver 4 mm x100 mm - 1 No.
- Tray 60x30x4 cm - 1 No.
- I.S. books on graphic symbols (B.I.S 2032 all parts) - 1 No.

Materials

- PVC conduit pipe - 19 mm and 25 mm - 3M long - 1 No. each
- GI conduit pipe - 19 mm and 25mm - 3 m long - 1 No. each
- PVC Channel - 20mm and 25mm - 1M long - 1 No. each
- PVC pipe coupling - 19mm & 25mm - 1 No. each
- PVC junction box - 1,2,3 and 4 way -19mm & 25mm - 1 No. each
- PVC bend - 19 mm & 25mm - 1 No. each
- PVC Elbow - 19 mm & 25 mm - 1 No. each
- PVC Tee - 19mm & 25mm - 1 No. each
- GI conduit coupler & Inspection Coupler - 19mm & 25mm - 1 No. each
- GI Elbow & Inspection Elbow - 19mm & 25mm - 1 No. each
- Tees & Inspection Tee - 19mm & 25mm - 1 No. each
- GI junction box -1,2,3 & 4 way square type 19mm & 25mm - 1 No. each
- S.P. switch 6A 250V flush type, single way - 1 No.
- S.P. switch 6A 250V flush type two way - 1 No.
- S.P. switch 6A 250V mounting type single way - 1 No.
- S.P. switch 6A 250V mounting type two-way - 1 No.
- Tube light starter holder 6A - 1 No.
- Combined tube and starter holder 6A - 1 No.
- Tube light holder - 6A - 1 No.
- Brass batten-holder 6A 250V - 1 No.
- Bakelite batten-holder 6A 250V - 1 No.
- Brass pendent-holder 6A 250V - 1 No.
- Bakelite pendent-holder 6A 250V - 1 No.
- 3-pin 6A wall socket, mounting type - 1 No.
- 3-pin 16A wall socket, mounting type - 1 No.
- 3-pin 6A wall socket, flush type - 1 No.
- 3-pin 16A wall socket, flush type - 1 No.
- 2-pin 6A wall socket, flush type - 1 No.
- 2-pin 6A mounting type - 1 No.
- Ceiling rose 6A 250V 2 plate - 1 No.
- Ceiling rose 6A 250V 3 plate - 1 No.
- Fan regulator - 1 No.
- Kit-kat fuse 16A 250V - 1 No.
- Intermediate switch 6A 250V - 1 No.
- 3-pin 6A 250 V plug - 1 No.
- 3-pin 16A 250 V plug - 1 No.
- Terminal plate 16A 250 V 3- way - 1 No.
- I.C.D.P. switch 16A 250V - 1 No.
- I.C.T.P. switch 16A 400V - 1 No.
- Neutral link 16 amps - 1 No.
- I.C. cutouts 16A 250V - 1 No.
- Distribution box 4-way - 1 No.
- Bell-Push/switch 6A, 250V flush type - 1 No.
- Bell-Push/switch 6A, 250V mounting type - 1 No.
- HRC Fuse - 16A - 1 No.
- Iron connector - 5A - 1 No.
- Toggle switch 6A - 1 No.
- MCB 1,2 & 3 Pole - 1 No. each

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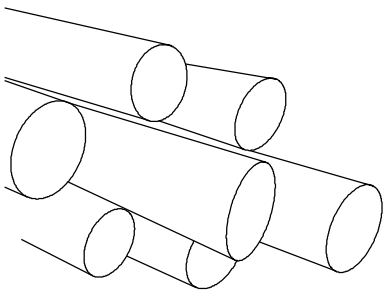
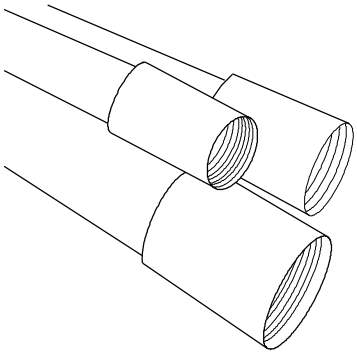
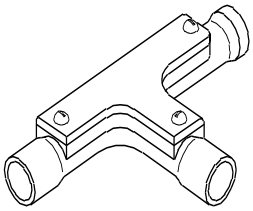
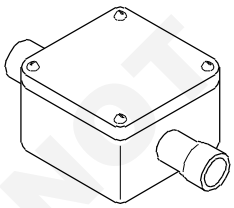
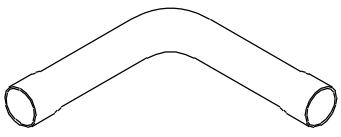
PROCEDURE

TASK 1 : **Identify various conduit and conduit accessories**

1 Identify each items and write the name in the table. (Fig 1 to Fig 10)

2 Write the specification and use of each conduit & conduit accessory in the column given.

Conduit Pipe & Conduit accessories

Sketch	Name	Specification	Use
Fig 1  ELN2270H1			
Fig 2  ELN2270H2			
Fig 3  ELN2270H3			
Fig 4  ELN2270H4			
Fig 5  ELN2270H5			

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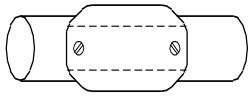
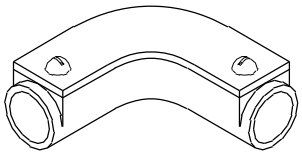
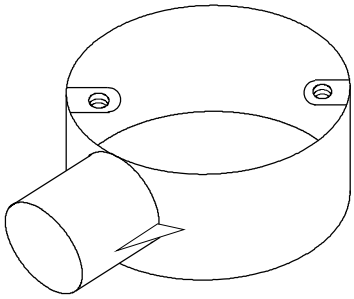
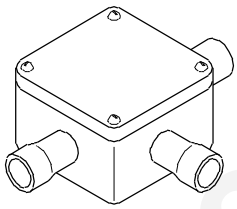
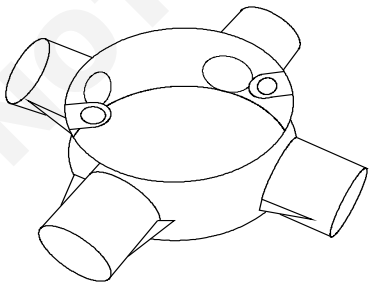
Sketch	Name	Specification	Use
Fig 6  ELN2270H6			
Fig 7  ELN2270H7			
Fig 8  ELN2270H8			
Fig 9  ELN2270HA			
Fig 10  ELN2270HB			

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TASK 2 : **Identify electrical accessories and write their names**

1 Identify each accessory and write the name in the table 2 (Fig 11 to 28)

Different manufacturers design the outline of accessories differently to suit various conditions. However, the Power contact positions of the accessories remain the same. As such there should not be much difficulty in identifying the accessories.

On the other hand, single way and two-way switches as well as two and three plate ceiling roses look alike. A careful look at the rear of the accessory will make the identifying process much easier.

2 Write the specification of each accessory in the column given by the side of each (accessory) figure.

Most of the specifications can be collected from the markings on the accessory itself. Otherwise try to get them from an approved catalogue or approach the instructor for guidance.

3 Identify the I.E symbols used for the accessory from the related theory or B.I.S.books and sketch the symbols in the columns/spaces provided.

4 Show the completed sheets of specifications, identification and symbols to the instructor and get his approval.

Table 2 **- Electrical accessories**

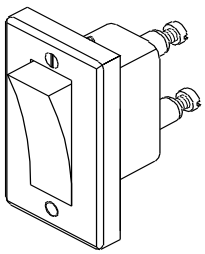
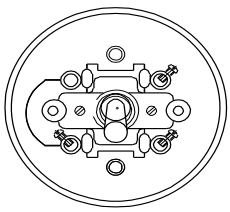
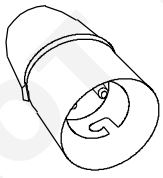
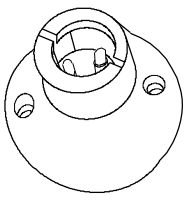
Sketch	Name	Specification	Use	IE Symbol
Fig 11  ELN2270HC				
Fig 12  ELN2270HD				
Fig 13 				
Fig 14 				

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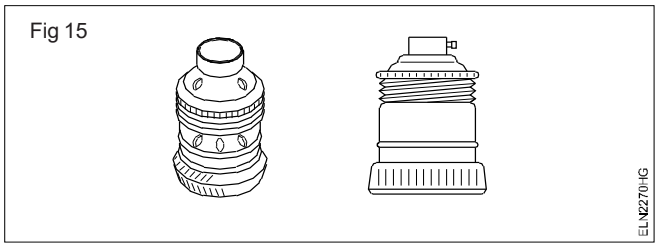
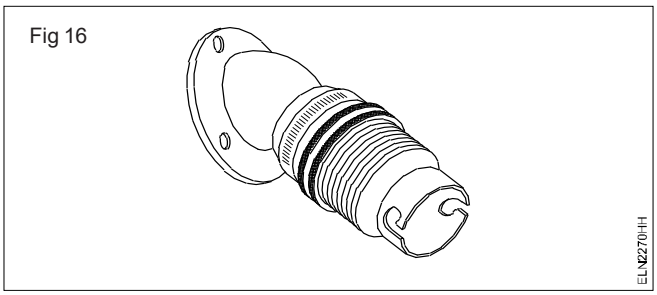
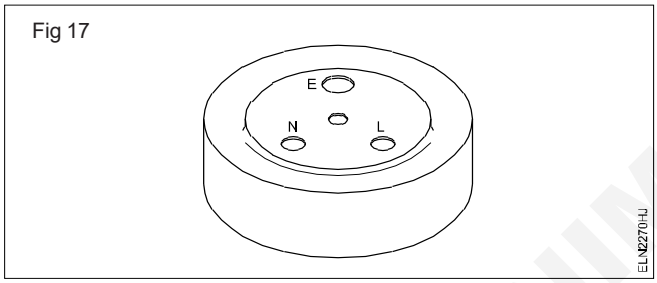
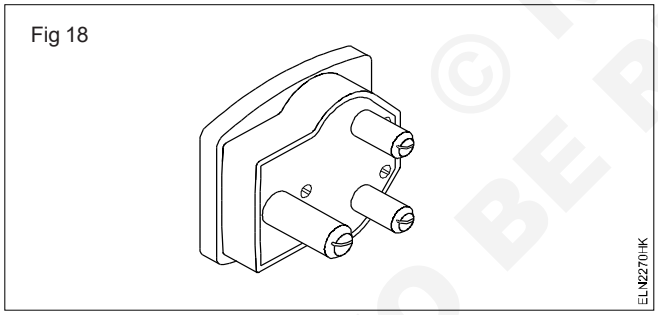
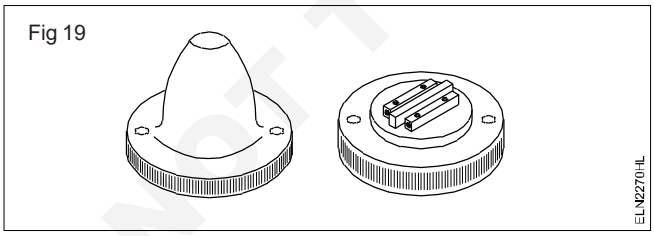
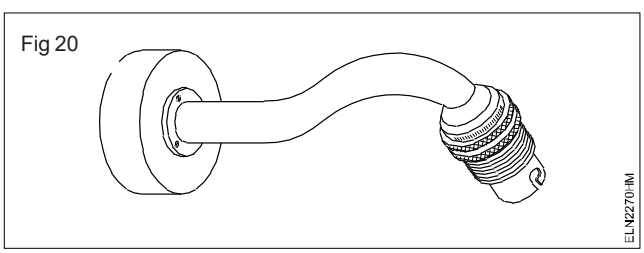
Fig 15 				
Fig 16 				
Fig 17 				
Fig 18 				
Fig 19 				
Fig 20 				

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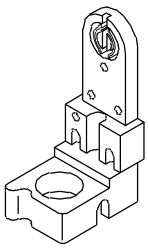
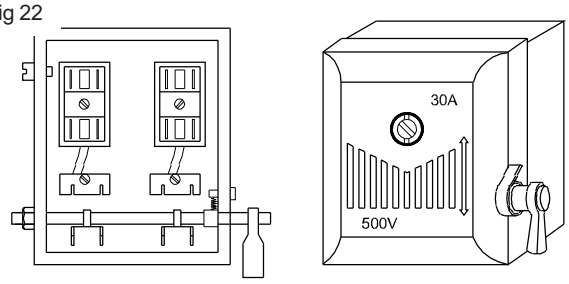
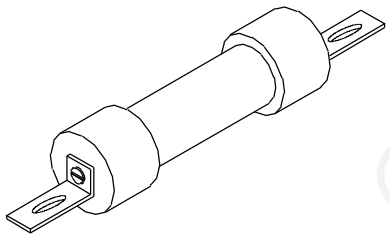
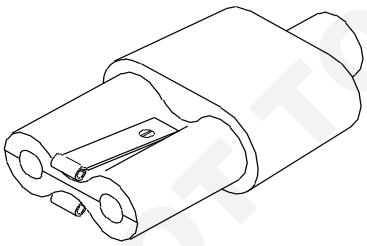
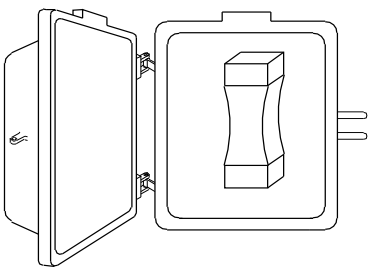
Sketch	Name	Specification	Use	IE Symbol
Fig 21  ELN2270HN				
Fig 22  ELN2270HO				
Fig 23  ELN2270HP				
Fig 24  ELN2270HQ				
Fig 25  ELN2270HR				

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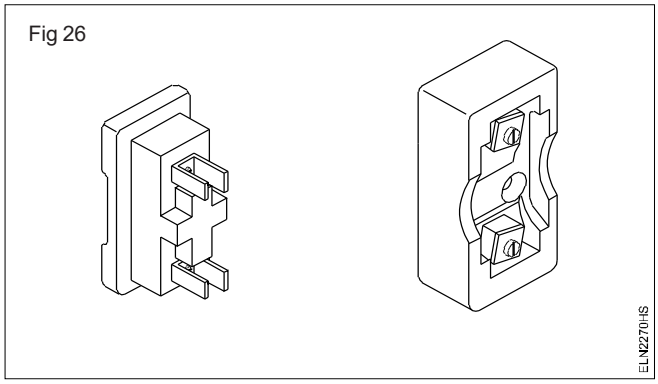
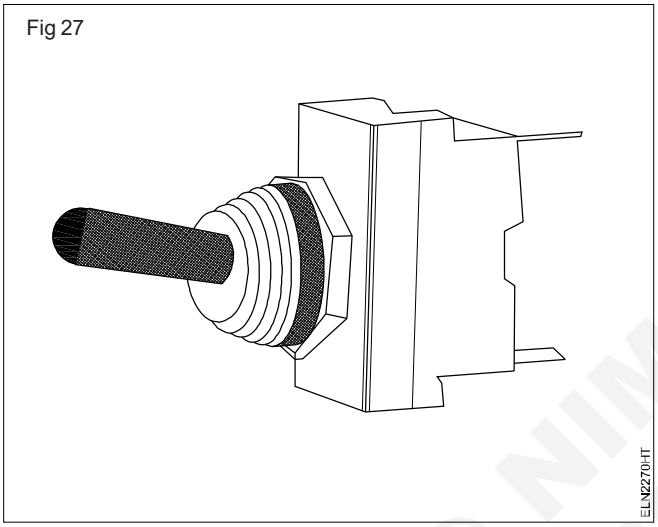
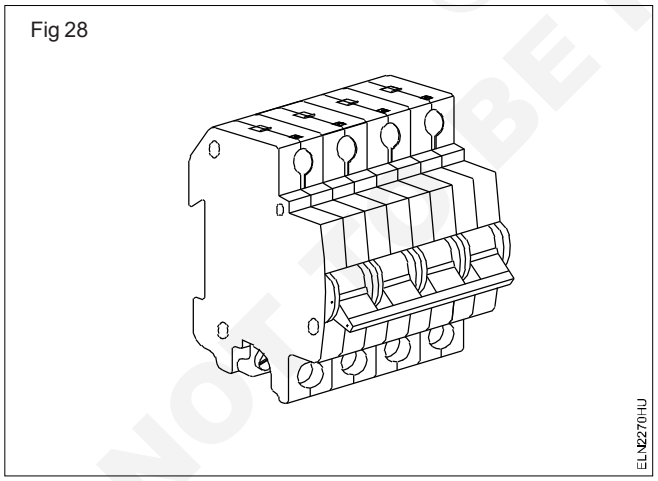
Fig 26 				
Fig 27 				
Fig 28 				

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Practice cutting, threading of different sizes of conduits and laying installations

Objectives: At the end of this exercise you shall be able to

- **cut metal conduit pipes of heavy gauge to the required dimensions**
- **fasten the conduit pipe in the pipe vice and prepare the conduit ends for threading**
- **cut the threads on heavy gauge metal conduit,according to requirements using a conduit die set**
- **fix the conduit accessories to the pipes according to the pipe size using the threaded method**
- **fix the conduit with the necessary clamps and spacers on surface installation in accordance with the B.I.S.recommendations**
- **draw cables in the metallic conduit pipes**
- **bond the conduit pipes at joints and junctions**
- **earth the conduit as per B.I.S. recommendations**
- **prepare metal boxes and fix Power accessories**
- **terminate the cable ends at the accessories according to the wiring diagrm**
- **test the wiring.**

Requirements

Tools/Instruments

- Screwdriver 200mm with 5mm blade - 1 No.
- Connector screwdriver 100mm with 3mm blade - 1 No.
- Pipe vice 50 mm - 1 No.
- Steel rule 300 mm - 1 No.
- Hacksaw with a blade of 24 teeth per 25 mm (25 TPI) - 1 No.
- Flat file bastard 250 mm - 1 No.
- Half round file 2nd cut 200 mm - 1 No.
- Reamer 16 mm - 1 No.
- Oil can 250ml - 1 No
- Conduit stock and dies for 19 mm & 25 mm conduit - 1 Set
- Wire brush 50 mm - 1 No.
- Plumb bob with thread - 1 No.
- Electrician's knife DB 100 mm - 1 No.
- Poker 200 mm - 1 No.
- Ball peen hammer 500 grams - 1 No.
- Hand drilling machine 6 mm capcity with 4 mm drill bit - 1 Set
- Scriber 200 mm - 1 No.
- Combination pliers 200 mm - 1 No.

Materials

- Conduit pipe, heavy gauge 19 mm dia. - 6 m
- Conduit pipe,heavy gauge 25 mm dia - 3 m
- Metal Box 90 mm Square of hexagonal type with top cover - 4 Nos.
- Conduit pipe inspection Tee 19 mm - 3 Nos.
- Conduit elbow 19 mm - 4 Nos.
- Conduit bend 19 mm - 1 No.
- Conduit junction box 3-way 19 mm - 4 Nos.
- T.W. spacers 60mm long 19 mm width and 12mm thick - 25 Nos.
- Tinned copper wire 14 SWG - 12 mts.
- Earth clamps, tinned copper suitable for 19 mm pipe with bolt, nut and washers - 3 doz.
- G.I. saddles 19 mm - 25 Nos.
- Wood screws and machine screws assorted - as reqd.
- P.V.C. aluminium cable 1.5 sqmm 250 V grade - 18 mts.
- S.P.T. switch 6A 250V - 1 No.
- Two-way Flush type switch 6A 250V - 3 Nos.
- Ceiling rose 2-way 6A 250V - 4 Nos.
- Pendent-holder, bakelite 6A 250V - 4 Nos.
- B.C. bulbs 40W, 230V - 4 Nos.
- Colour chalk - 1 piece
- Terminal plate 16 amps 3-way - 1 No.
- G.I. wire as fish wire 14 SWG - 6 mts.
- P.V.C. bushes suitable for 19 mm pipe - 40 Nos.
- Conduit check-nut 19 mm - 8 Nos.
- Lubricant coconut oil - 100 gm
- Cotton Waste - as reqd.

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PROCEDURE

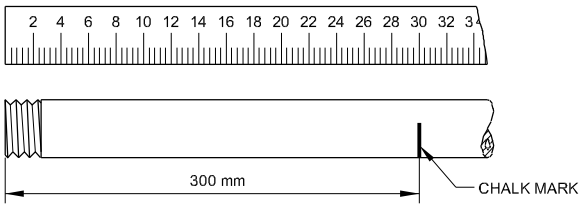
TASK 1: **Preparation of conduit pipe for cutting**

Assume the job needs a 300 mm long conduit drop but a standard length pipe of 3000 mm is only available. Normally both the ends of a standard length pipe will have threads. To make the required conduit drop, the standard length 3000 mm pipe is to be cut for a length of 300 mm and threaded again at one end.

Cutting could be done either by pipe cutters or with hacksaws. In practice, cutting with a hacksaw is popular, and the method is explained below.

1 Measure 300mm from the threaded end of the 19 mm pipe and mark it with chalk as shown in Fig 1.

Fig 1



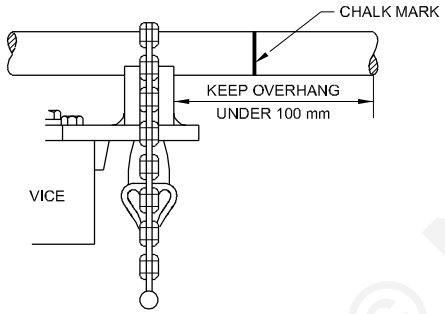
MEASURE THE PIPE LENGTH

ELN2271H1

2 Open the jaw of the vice and insert the pipe so that it is horizontal and parallel to the jaw serrations.

3 Keep the chalk mark of the pipe within 100 mm of the vice as shown in Fig 2.

Fig 2



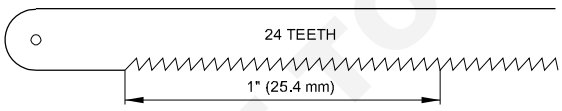
GRIP THE PIPE IN THE VICE FOR SAWING OPERATION

ELN2271H2

4 Close and tighten the vice jaw.

5 Select a hacksaw with a blade having 24 teeth per 25mm (25 TPI), as shown in Fig 3.

Fig 3



HACK SAW BLADE

ELN2271H3

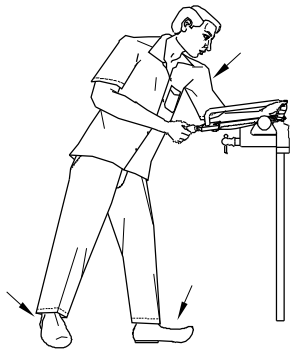
Ensure that the hacksaw blade is firmly tightened in the frame and that the teeth point in the forward direction.

6 Take up the hacksaw and position yourself, as shown in Fig 4, with your left shoulder pointing in the direction of the cut.

7 Grip the hacksaw handle with the right hand and position the hacksaw blade on top of the cutting line.

8 Prepare to cut by guiding the blade with the thumb of your left hand exactly on the cutting line against the saw blade as shown in Fig 5.

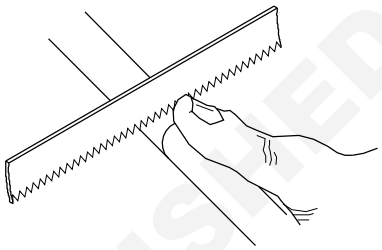
Fig 4



HACK SAWING - POSITION OF SAWING

ELN2271H4

Fig 5



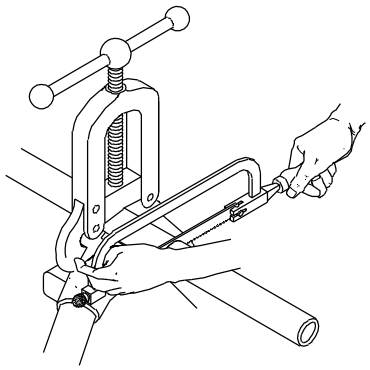
USE THUMB AS A GUIDE INITIALLY

ELN2271H5

9 When the initial cut has been made, move the left hand to the front end of the hacksaw frame and use both hands for the cutting operation as shown in Fig 6.

10 When sawing, use the full length of the blade, increasing gradually the pressure on the forward stroke, and releasing the pressure as the blade is drawn back. (Fig 6)

Fig 6

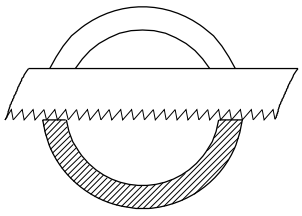


HOLDING SAW WHILE SAWING

ELN2271H6

11 Saw with steady, even strokes, keeping the blade upright and square to the cut as shown in Fig 7.

Fig 7



HOLD THE STRAIGHT

ELN2271H7

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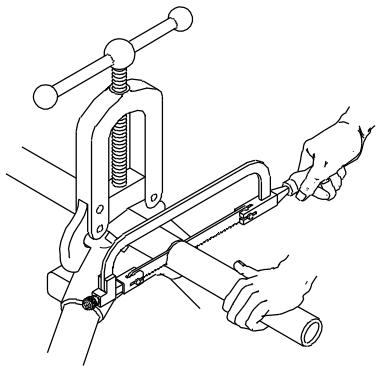
12 When getting near to the end of the cut, the conduit must be supported with your left hand as shown in Fig 8. Finish the cut.

Fig 8



END OF SAWING

ELN22711H8

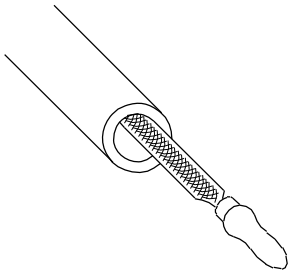
Support the free end of the conduit to prevent the blade of the hacksaw from being damaged.

13 Use a reamer or half round file to remove the inside burrs as shown in Fig 9.

14 Use the flat portion of the half round file to smoothen the sharp edges. (Fig 10)

15 Again follow the steps 2 to 14 for cut the 300 mm long from the threaded end of 25 mm dia. 3 m long pipe.

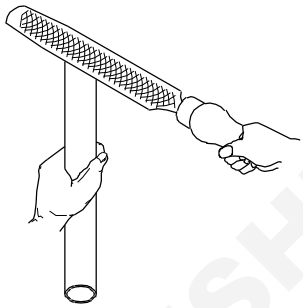
Fig 9



REMOVAL OF BURRS

ELN22711H9

Fig 10



REMOVAL OF SHARP EDGES

ELN22711HA

16 Clean the hacksaw and vice after the end of the work and keep them in their respective places.

— — — — — — — —

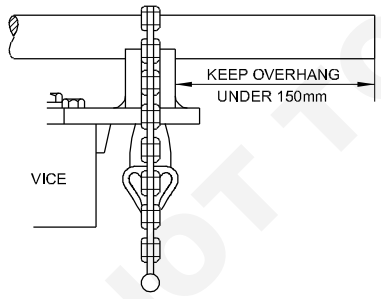
TASK 2 : **Preparation of conduit pipe for threading**

1 Open the jaw of the vice and insert the 19 mm dia pipe so that it is horizontal and parallel to the jaw serrations.

2 Keep the end of the tube within 150 mm of the vice.

3 Close and tighten the vice as shown in Fig 11.

Fig 11



HOLD THE PIPE IN THE PIPE VICE FOR THREADING OPERATION

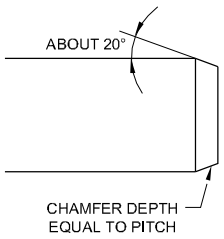
ELN22711HB

4 File the end of the tube flat and chamfer the outer edge to an angle of about 20° as shown in Fig 12.

Make the depth of the chamfer equal to the pitch of the thread (1.5 mm for conduit).

5 Choose the correct dies and stock suitable for the pipe to be threaded. (Fig 13 shows the conduit stock and dies set)

Fig 12



BEFORE THREADING, CHAMFER THE EDGE OF THE PIPE

ELN22711HC

Assembly drawing for the quick cut stock and dies is given in Fig 13. The die size is engraved on the die itself. Check the size with that of the pipe. The handle of the stock is not shown in the picture for clarity.

6 Insert each half of the die in the cap(stock) with the chamferred threads (leading faces) being adjacent to the guide.

7 Screw the guide into position.

8 Adjust each adjusting screw equally to make the die halves centralized to the pipe axis.

9 Slide the stock guide over the end of pipe, adjust the adjusting screws such that the dies just grip the pipe evenly on both sides.

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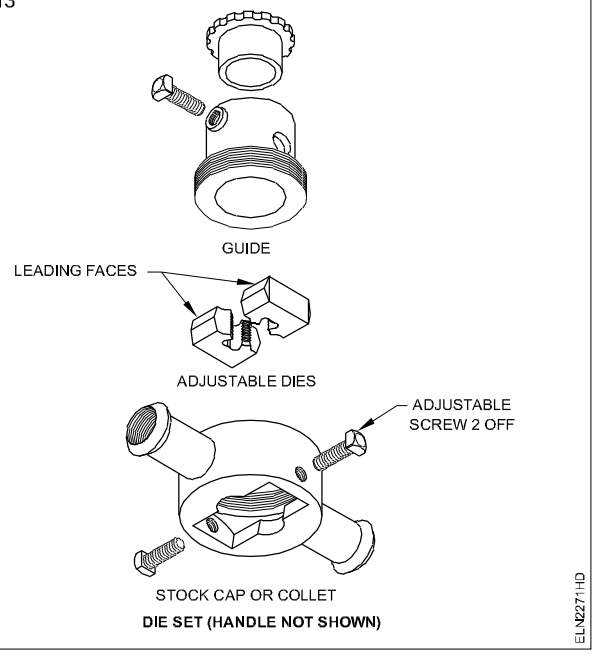
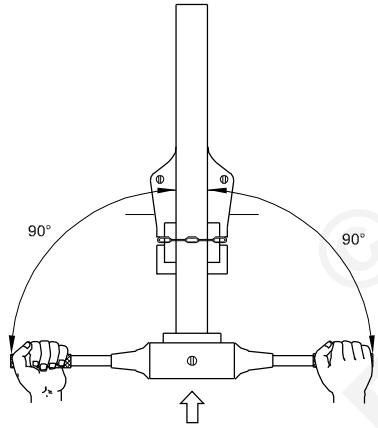
Fig 13



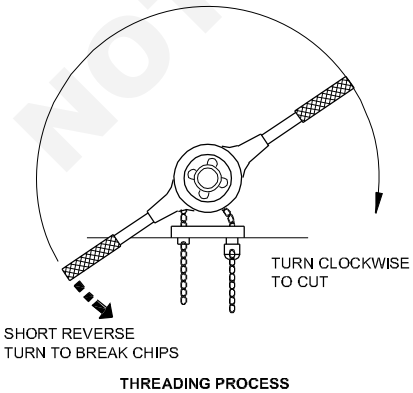
10 Apply pressure to the stock and keep the handles at right angles to the pipe as shown in Fig 14.

Fig 14



11 Rotate the handles clockwise in a plane at right angles to the pipe axis as shown in Fig 15.

Fig 15



12 Apply the lubricant to the part to be threaded after the thread has been started.

The lubricant allows the die to cool off the heat developed and thereby helps the edges to stay sharp and to produce a better thread finish.

13 Make one or two complete turns in a clockwise direction.

Check whether the stock is at right angle to the pipe axis.

14 As indicated by the increased resistance of rotation, ease the handle as frequently as necessary, back in an anticlockwise direction for half a turn.

Reverse turning is necessary to break off long cuttings and to clear the cutting edges of the die.

15 Apply the lubricant at frequent intervals.

Use a brush to remove the metal burrs from the die.

16 Remove the stock. Check the length and fit of the thread by screwing on the female fittings (coupling etc.).

The length of the thread should be sufficient to fit half way into the couplings and fully into the other fittings.

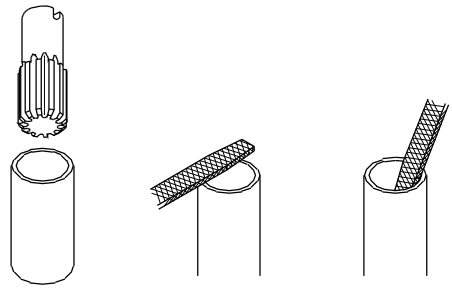
17 If the thread is not smooth (i.e.tight in the fittings) mount the stock and tighten the adjusting screws by half turn evenly and repeat working steps 10 to 16.

18 Remove any burrs or sharp edges from inside the end of the pipe with a reamer or half round file as shown in Fig 16, and file off the sharp edges, if any.

19 Again follow the steps from 2 to 18 in the task-2 for thread the 25 mm dia conduit pipe.

20 Clean the die stock and vice. Keep them in their respective places.

Fig 16



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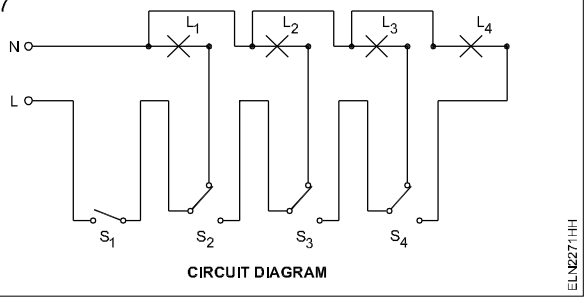
TASK 3 : **Install and wire up in metal conduit in the lighting circuit for godown**

1 Form the circuit with the required wiring accessories as per circuit diagram (Fig 17) on the workbench.

Fig 17

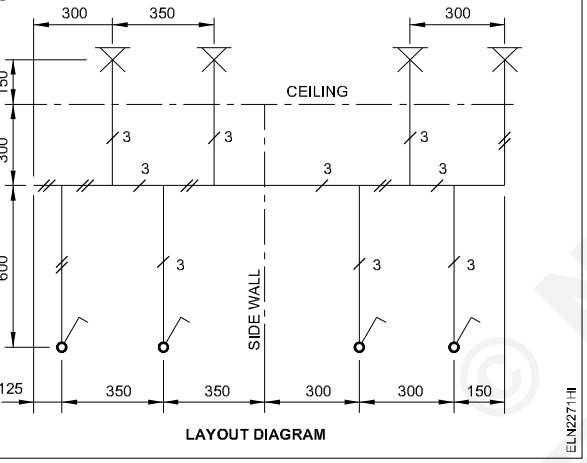


2 Get the circuit approved by the instructor.

If it is incorrect, trace the circuit and correct it.

3 Mark the layout on I.P.C. (Installation Practice Cubicle) as per the layout given in Fig 18

Fig 18



4 Select the required conduit fittings as per the layout.

5 Measure the length of the conduit pipes required for each run as per the layout.

Take into consideration the length of accessories to be used in various places along with the conduit threads while taking conduit measurements.

6 Cut the length of the conduit as per markings and remove the burrs.

While marking on the conduit pipe for cutting, consider the economical way to utilize the pipes without much wastage in the lengths.

7 Cut threads in the pipes and remove the burrs.

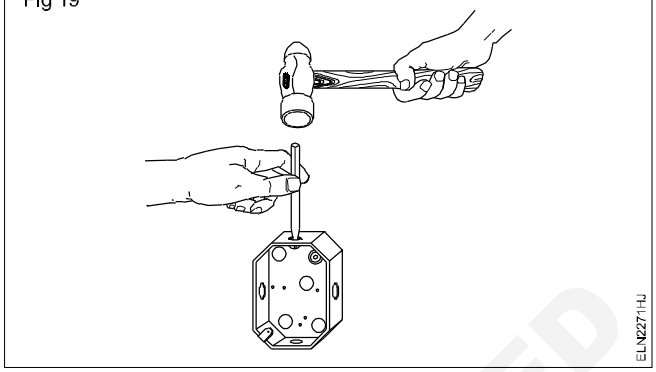
8 Prepare the T.W. spacers with through holes for fixing on the I.P.C. and pilot holes to fix the saddles.

9 Fix the T.W. spacers as per the layout.

10 Fix the conduit pipe and conduit accessories as per the layout by means of saddles.

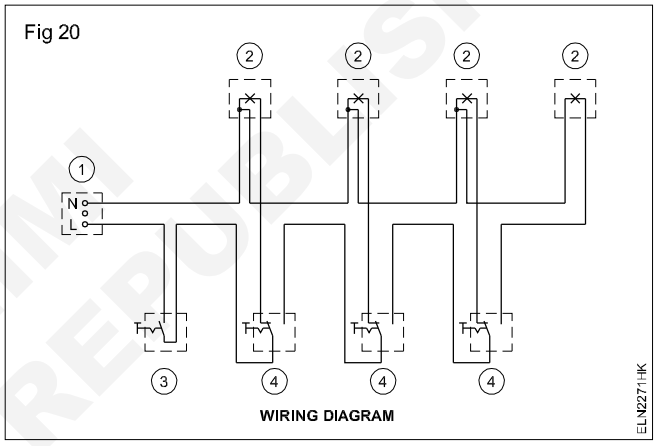
Knock out the holes in the square/hexagonal metal boxes for conduit pipe terminations as shown in Fig 19.

Fig 19



11 Measure and cut the cables as per the cable route given in the wiring diagram. (Fig 20)

Fig 20



Make an allowance in cable lengths for terminations.

12 Provide bushes in the conduit ends.

13 Insert the given fish wire in the pipe run for drawing cables.

Drawing of cables should be done stage by stage, taking each run one by one, and consolidating the number of cables in each run.

14 Skin the cables and mark each cable legibly at both ends.

15 Group the cables as per cable route and cable runs and fasten them to the fish wire as shown in Fig 21.

Check the continuity of cables before fastening the cables to the fish wire.

16 Pull the cables by means of the fish wire, and, at the same time push the cables from the other end as shown in Fig 22.

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Fig 21

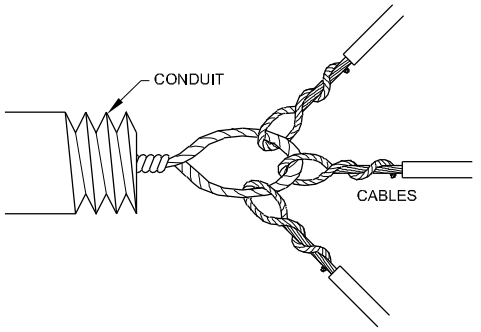
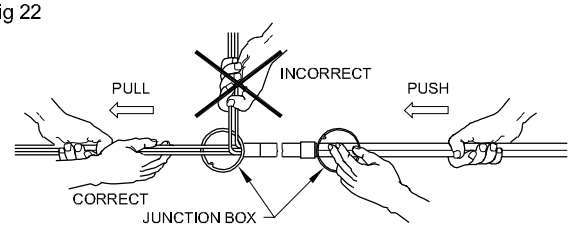


Fig 22



You may require a helper while drawing cables. There should not be any kink or twist in the cables while drawing the cables through the conduit pipe. For long conduit runs, it is better, the drawing of the cables is done in stages, firstly from one end to the inspection type accessory, and then from the inspection type accessory to the end of the conduit, and so on.

17 Prepare top covers of the square metal boxes for fixing the accessories by drilling through holes for cable entry and accessory fixing.

18 Fix the ceiling roses on the one-way junction boxes.

Ceiling roses can be fitted directly on the one-way junction boxes, using the machine screws provided for fixing the cover.

19 Prepare the cable ends and terminate them in the accessories as per Fig 17 and 20, and cable markings done as per step 14.

20 Fix the accessories with machine screws.

21 Close the top covers of the metal boxes.

22 Close the inspection windows of the inspection type accessories.

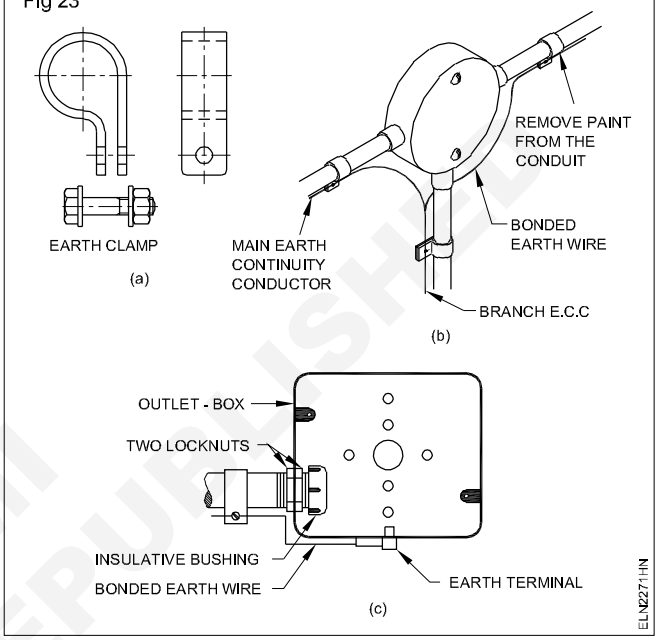
23 Run the given earth wire along the conduit pipe by means of earth clamps and terminate at the junction boxes and metal boxes. (Fig 24)

It is necessary to follow the looping system to avoid joints in the earth wire runs.

As an alternate to the looping method, the bonding system could be used. Wherever accessories are used, bonding by earth clamps and earth wire as shown in Fig 23 is recommended.

Remove the paint on the surface of the conduit, the copper wire and the clamps before fixing.

Fig 23



24 Prepare the pendent-holders and connect the cables to the ceiling roses.

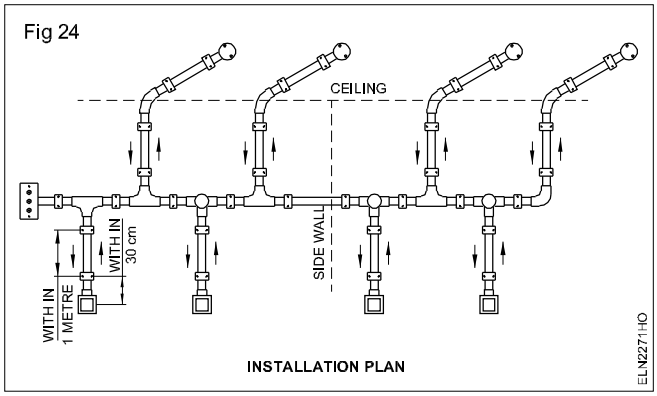
25 Fix the bulbs.

A completed installation looks as shown in Fig 24.

26 Get the wiring checked by the instructor.

27 Connect the supply and test the wiring.

Fig 24



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Prepare test boards/extension boards and mount accessories like lamp holders, various switches, sockets, fuses, relays, MCB, ELCB, MCCB Etc.

Objectives: At the end of this exercise you shall be able to
- **identify and use Power accessories like double-pole switch and indicating neon lamp**
- **select the correct size of board to mount specified accessories**
- **position the accessories and mount them on the T.W. board**
- **wire up and test the test board. / Extension Board.**

Requirements

Tools/Instruments

- Combination pliers 200 mm - 1 No.
- Screwdriver 200 mm with 5 mm blade - 1 No.
- Screwdriver 150 mm with 3 mm blade - 1 No.
- Poker 200 mm - 1 No.
- Firmer chisel 12 mm - 1 No.
- Try square 150 mm - 1 No.
- Tenon-saw 300 mm - 1 No.
- Gimlet 5 mm dia. 200 mm - 1 No.
- Ball peen hammer 250 gms - 1 No.
- 4 mm drill bit - 1 No.
- Connector screwdriver 100 mm - 1 No.
- Hand drilling machine 6 mm capacity - 1 No.
- Mallet 75mm dia. head with handle - 1 No.
- Steel Rule 30 cm - 1 No.
- Key hole saw 200 mm - 1 No.

Materials

- T.W. hinged box 375x250x80 mm - 1 No.
- B.C. batten lamp-holder 6A 250V - 2 Nos.
- Flush mounting 250V 6A 3-pin socket - 3 Nos.
- Flush mounting 250V 6A S.P.T. switch 250V, 6A - 2 Nos.
- PVC copper cable 3/20 - 2 m
- 14 SWG G.I. wire - 1 m
- 12 mm No.5 wood screws - as reqd.
- 20 mm No.6 wood screws - as reqd.
- 25 mm No.6 wood screws - as reqd.
- Neon lamp flush-mounting 250V with holder 6A - 1 No.
- BC bulb 60W, 250V - 1 No.
- Kit-kat fuse-carrier with base flush-type 16A 250V - 1 No.
- Insulated terminals non-detachable 4 mm plug entry - 3 Nos.
- Flush mounting type D.P. switch 250V 20A with neon indicator - 1 No.
- Twin twisted flexible wire 23 / 0.2mm - 5 metre

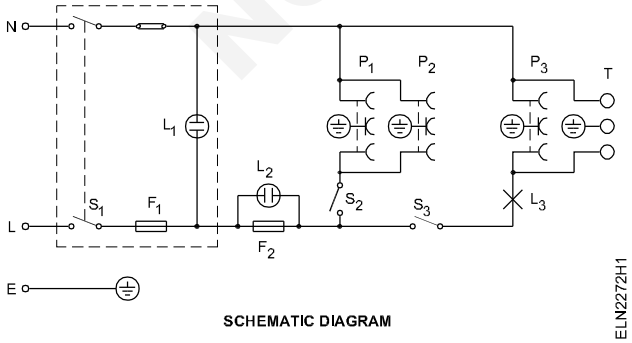
PROCEDURE

TASK 1 : **Prepare the test board / Extension board**

1 Identify the D.P. switch, its incoming/outgoing terminals and its operation. Identify a neon lamp and its connection.

2 Form the circuit as per the schematic diagram Fig 1, using a flexible wire for the testing circuit.

Fig 1



SCHEMATIC DIAGRAM

3 Get the formed circuit checked by the instructor.

If incorrect, make necessary changes.

4 Effect supply and test the circuit.

5 Place the accessories on a cardboard to suit the technical and aesthetic aspects and draw a layout. Select the size of the T.W. board accordingly.

6 Compare the layout drawn by you with the layout given in Fig 2 and discuss with your co-trainees about their merits and de-merits.

7 Mark the position of the double-pole switch and other accessories on the T.W. board as per the given layout (Fig 2) and the supplied drawing of the front panel. (Fig 3)

8 Cut profiles for fixing the accessories to the T.W. board and drill holes for cable entries, insulated terminals and fixing screws, and make pilot holes wherever necessary.

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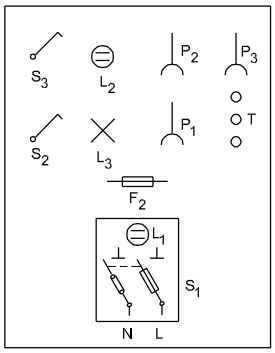
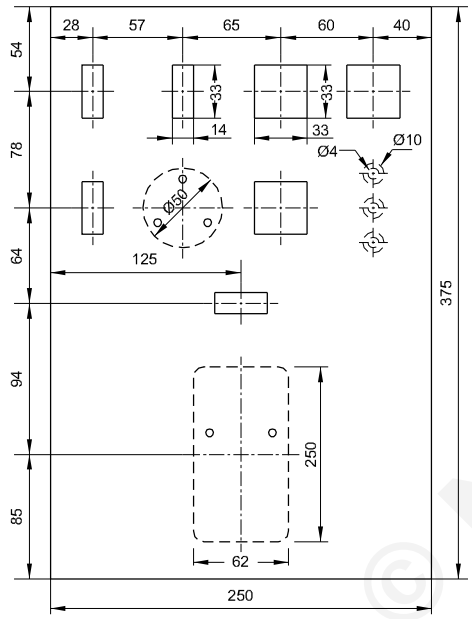
Fig 2



TEST BOARD-LAYOUT DIAGRAM

ELN2272H2

Fig 3



TEST BOARD FRONT PANEL DRAWING SHOWING THE PROFILE

ELN2272H3

9 Fix the Power accessories on the T.W. board.

10 Fix three numbers of insulated terminals.

11 Measure and cut cables for harnessing, according to the circuit diagram. (Fig 1)

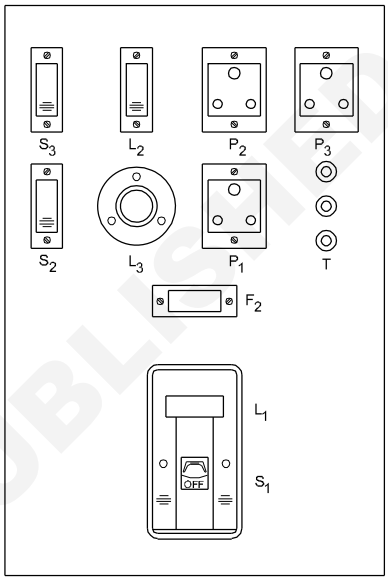
Use the B.I.S. recommended colour code for cable connections within the test board.

12 Route the connecting cables between accessories neatly, harness (strap - bunch) the cables.

13 Connect the accessories and the insulated terminals after identifying phase and neutral.

14 Connect the earth wire with earthing terminals of socket outlets, one of insulated terminals and the double pole switch. A completed test board will look as shown in Fig 4.

Fig 4



FRONT PANEL VIEW OF THE TEST BOARD

ELN2272H4

15 Provide bulbs in the lamp-holders.

16 Get the approval from your instructor and test the test board.

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Draw layouts and practice in PVC casing - capping, conduit wiring with minimum to more number of points of minimum 15 metre length

Objectives: At the end of this exercise you shall be able to
- **mark the layout on the work station/location**
- **prepare PVC channel as per the marked layout**
- **fix the PVC channel and other PVC accessories**
- **run the cable as per the circuit diagram**
- **fix the top cover on the casing**
- **prepare & fix the PVC boxes**
- **mount the switches, fan regulator, socket on the switch board**
- **connect the end terminals to load as per the circuit diagram & test it.**

Requirements

Tools and Instruments

- Electrician tool kit - 1 No.
- Hacksaw frame with blade - 1 No.
- Rawl jumper No.14 - 1 No.
- Screw driver 100mm - 1 No.
- Steel tape 5 m - 1 No.
- Steel Rule 300mm - 1 No.
- Electric/Hand drilling machine (capacity 6mm) - 1 No.
- Twist drill bit 5mm - 1 No.

Material required

- PVC casing and capping 25mm x 10 mm - 20mtrs
- PVC round block - 90 mm x 40 mm - 3 Nos.
- T.W. box 250 mm x 100 mm with Sunmica cover - 1 No.
- Terminal plate 16 Amps - 3 way - 1 No.
- Single pole one way switch-6A,230V Flush type - 4 Nos.
- Electronic fan regulator - socket type - 1 No.
- 3 Pin socket - 6A 250V Flush type - 1 No.
- Batten lamp holder - 6A, 250V - 2 Nos.
- Ceilling rose 6A, 250V - 1 No.
- PVC insulated aluminimum cable 1.5 sq. mm - 100 mtr.
- Wood Screw No. 6 X12 mm - 20 Nos.
- Wood Screw No.6 X 20 mm - 7 Nos.
- PVC Casing and capping Elbow -25 mm - 1 No.
- PVC casing and capping Tee (3 way) - 2 Nos.
- PVC Casing and capping internal coupler - 3 Nos.
- Colour chalk / pencil - 1 No.
- PVC insulation tape roll 20mm -1 Roll

PROCEDURE

1 Analyze the layout diagram Fig 1 showing the location of fittings, accessories and their distances.

2 Draw the wiring diagram for the given circuit as per layout plan. Check the correctness of the wiring diagram with the help of Fig 1 (supplied by the instructor).

3 List out the materials required for this wiring along with complete specifications and quantity required for this wiring .

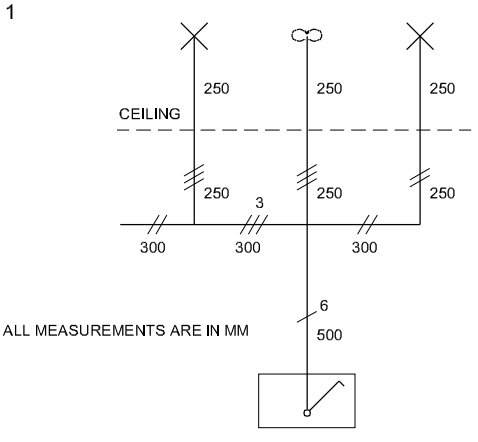
4 Check your material list with that of supplied list.

Hand over the list to the instructor for checking and get the approval.

5 Collect the materials as per the list.

6 Mark the layout as per the work station/location. Cut and prepare the casing as per the installation plan diagram.

Fig 1



LAYOUT DIAGRAM

7 Drill holes in the PVC channel for fixing with a gap of 60cm using drilling machine.

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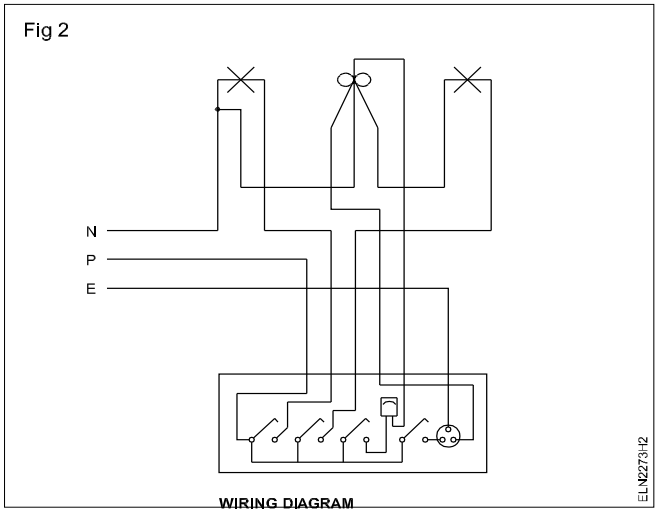
8 Place the PVC channel in the route mark coinciding with the jumper holes for fixing.

9 Prepare the joints on PVC channel (refer layout).

10 Fix the PVC channel on the work station as per the layout.

11 Run the cable into the PVC channel as per wiring diagrams (Fig 2)

Fig 2



WIRING DIAGRAM

12 Fix the cover on the channel.

13 Mark and cut the PVC boxes for the channel entries.

14 Drill holes for cable entry and take out cables as per installation plan.

15 Terminate the cable in accessories and mount the switches, regulator & socket over the switch box.

16 Test the circuit for insulation resistance, continuity test & polarity.

Only after obtaining satisfactory results of the above test, circuit to be energised.

17 Connect the circuit with supply and test it.

18 Repeat the wiring steps using PVC conduit pipe for a 15 meter length.

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Wire up PVC Conduit wiring to control one lamp from two different places

Objectives: At the end of this exercise you shall be able to
- **form the circuit using two-way switches to control one lamp from two different places**
- **cut the profiles in a wooden board according to marking for flush-type accessories**
- **wire up a circuit in PVC conduit pipe to control one lamp from two different places.**

Requirements

Tools/Instruments

- Cross Peen hammer 250 gms - 1 No.
- Insulated screwdriver 200 mm width 5 mm blade - 1 No.
- Insulated screwdriver 150 mm width 5 mm blade - 1 No.
- Electrician's knife (100 mm) - 1 No.
- Connector screwdriver 100 mm - 1 No.
- Mallet 5 cm dia. -500 gram - 1 No.
- Gimlet 5 mm dia. 200 mm long - 1 No.
- Hand drilling machine 6 mm capacity - 1 No.
- Drill bit 3 mm to 5 mm - 1 each
- Try square 150 mm - 1 No.
- Bradawl 150 mm - 1 No.
- Insulated combination pliers 200 mm - 1 No.
- Hacksaw frame with blade (24 TPI) - 1 No.
- Steel rule (300 mm) - 1 No.

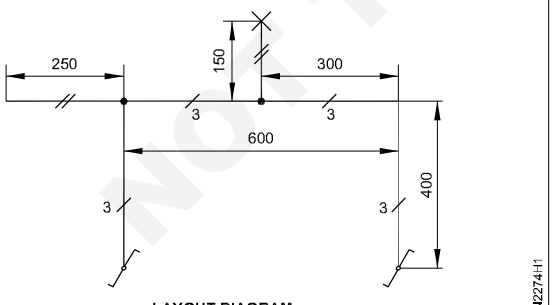
Materials

- PVC conduit pipe -19 mm dia. - 2 mtrs
- PVC terminal box - 1 No.
- Wood screws No.6x12 mm - 3 Nos.
- Wood screws No.6x20 mm - 4 Nos.
- PVC--Insulated aluminium cable 1.5 sq mm. 250V grade - 6 m
- Flush mounting two-way switch 6A, 250V - 2 Nos.
- Batten lamp-holder, 6A, 250V - 1 No.
- Terminal plate 3-way - 1 No.
- Bulb 40W, 250V, BC type - 1 No.
- PVC round block (90mm x 40 mm) - 1 No.
- PVC box 100 mm x 100 mm - 2 No.
- PVC 'Tee' 19 mm - 2 Nos.
- Marking Pen/Pencil/Chalk - as reqd.
- Marking thread - as reqd.
- PVC Insulation tape - 1 Roll
- Self tapping screw (20 mm) - as reqd.
- PVC bend 19mm - 2 mtrs

PROCEDURE

1 Estimate the tools and materials required for the job according to the layout (Fig 1) and the wiring diagram. (Fig 3) Compare the list with the given list. Discuss with your co-trainees/instructor about the variations between the two lists.

Fig 1



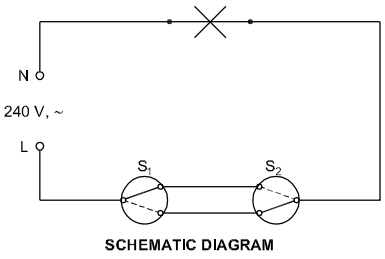
2 Collect materials as per the list.

3 Identify and confirm the switches received are two-way switches only.

4 Identify the terminal points, cable entry holes and fixing holes of the switches and batten lamp-holders.

5 Form the circuit as per the schematic diagram shown in Fig 2.

Fig 2



Get the approval of the instructor. If necessary, make alterations in the connections.

6 Connect the supply, check the function of the circuit and note the results in Table 1.

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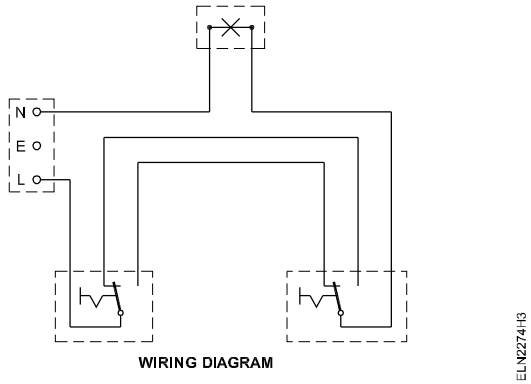
TABLE 1

S_1,S_2 position up	
S_1,S_2 position down	
S_1 up and S_2 down	
S_1 down and S_2 up	

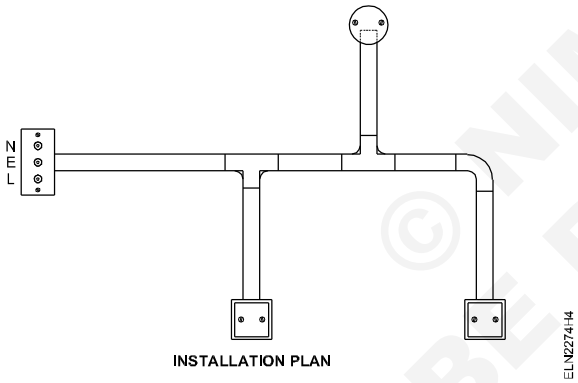
Fig 3



WIRING DIAGRAM

7 Mark the layout points on the building as per the installation plan (Fig 4)

Fig 4



INSTALLATION PLAN

8 Cut the required length of PVC pipes as per the layout marking.

Take into consideration the length of bends, tees and corners in appropriate places to reduce the measured length of the P V C conduits.

9 Mark the posistion of the saddles on the building and fix them loosely on one side only.

Observe the N.E. Code for the distance between saddles. In the case of brick/concrete walls, the wooden plugs (gutties) are to be fixed flush with the walls, cemented and cured.

10 Fix the PVC pipe and accessories in the saddle and tighten the saddle screws. Cut the cables according to the wiring diagram (Fig 2)

Keep an extra 200 to 300 mm for termination

11 Insert the cables in the pipes and fittings and push / draw the cables to the other end of the pipes according to the wiring diagram (Fig 3)

For longer lengths of PVC conduit runs, use fish wire/curtain spring to pull the cables through the conduits.

12 Mark the entry profile of the conduit in the round block and boxes. Based on the conduit entry position, position the accessories on the round block, mark the through holes for cable entry, and the pilot holes for fixing the accessories.

13 Prepare the conduit entry profile, drill/make through and pilot holes in the round block and boxes.

14 Insert the cables through the cable entry holes of the round blocks and boxes and fix the round block and boxes on the building.

15 C onnect the cable ends to the accessories according to the wiring diagram and fix the accessories on round blocks and boxes.

The completed installation should look as per the installation plan shown in Fig 4

16 Test the circuit after getting the approval of the instructor.

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Wire up PVC conduit wiring to control one lamp from 3 different places

Objectives: At the end of this exercise you shall be able to

- **verify and draw the intermediate switch connections in alternate positions of the knob**
- **draw a schematic diagram to show one lamp being controlled from 3 different places based on the I.M. switch connections**
- **form the given circuit with the intermediate switch**
- **cut and lay the PVC pipes as per dimensions with the required number of bends, elbows and different types of junction boxes in the ceiling and the wall**
- **draw the cables through pipe according to the wiring diagram**
- **fix the accessories on boards and terminate the cables in accessories**
- **test the circuit.**

Requirements

Tools/Instruments

- Hacksaw frame 300mm with 24 TPI blade - 1 No.
- Steel tape roll 5 Meter - 1 No.
- Insulated Screwdriver 250mm with 4mm blade width - 1 No.
- Insulated Screwdriver 150mm with 3mm blade width - 1 No.
- Insulated Connector screw driver 100mm with 3mm blade width - 1 No.
- Plumb bob with thread - 1 No.
- Try square 250mm - 1 No.
- Ball peen hammer 250 grams - 1 No.
- Poker 4mm dia. 200mm - 1 No.
- Gimlet 4 mm dia. 200mm - 1 No.
- Electrician's D.B knife 100 mm - 1 No.
- Cutting pliers, insulated 200mm - 1 No.
- Hand drilling machine, 6mm capacity - 1 No.
- S.S. drill bit 3mm and 4mm - 1 each
- Side cutting pliers 150mm - 1 No.
- Firmer chisel 12 mm - 1 No.

Materials

- PVC pipe 20mm dia. - 4 mtrs
- PVC bend 20mm dia. - 2 Nos.
- PVC elbow 20mm dia. - 1 No.
- PVC Tee 20mm dia. - 3 Nos.
- Saddles 20mm dia. heavy gauge - 10 Nos.
- Wood screws No.6 12mm - 40 Nos.
- Wood screws No.6 18mm - 8 Nos.
- PVC cable 1.5 sq.mm 250V grade - 15 m
- T.W. round blocks with box 90 x 40mm - 4 Nos.
- Terminal plate 3-way - 1 No.
- S.P.switch 2-way Flush type 6A 250V - 2 Nos.
- Intermediate switch 6A 250V - 1 No.
- Bakelite batten-holder of B.C. type 6A 250V - 1 No.
- B.C. lamp 40W 250V - 1 No.

PROCEDURE

TASK 1 : **Ascertain the connections of an intermediate switch**

1 Collect the accessories and materials for the exercise.

2 Identify the mode of connections to the terminals with respect to the position of the knob and draw the connection diagram in your record book.

3 Keeping the above connections as the base, draw a schematic diagram to control one lamp from three different places, in your record book.

4 Show the connections to your instructor and get his approval.

TASK 2 : **Form the circuit on the workbench/trainer board**

1 Form the circuit according to the approved diagram on the workbench/trainer board.

2 Show the circuit to the instructor and get his approval.

3 Operate the switches as given in Table and note down the results in Table.

Position of S_1 knob	Position of S_2 knob	Position of S_3 knob	Condition of lamp
↑	↑	↑	ON/OFF
↓	↑	↑	
↓	↓	↑	
↓	↓	↓	
↑	↓	↓	
↑	↑	↓	
↓	↑	↑	
↓	↑	↓	

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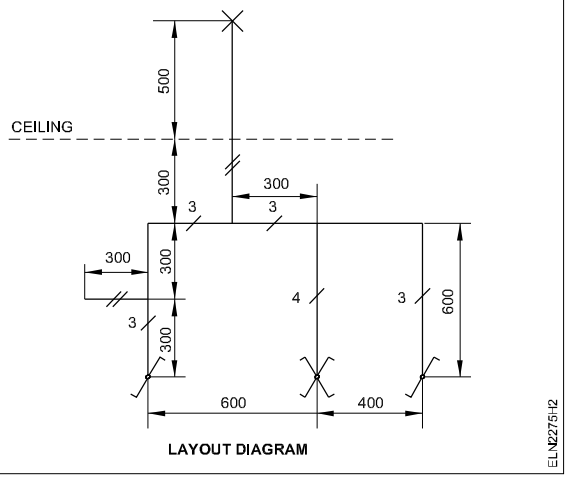
TASK 3 : **Execute PVC conduit wiring**

1 Mark the layout on the installation practice cubicle as per the layout given in Fig 1.

Fig 1



LAYOUT DIAGRAM

2 Cut the required length of P V C pipes as per the layout marking.

Take into consideration the length of bends, tees and corners in appropriate places to reduce the measured length of the P V C conduits.

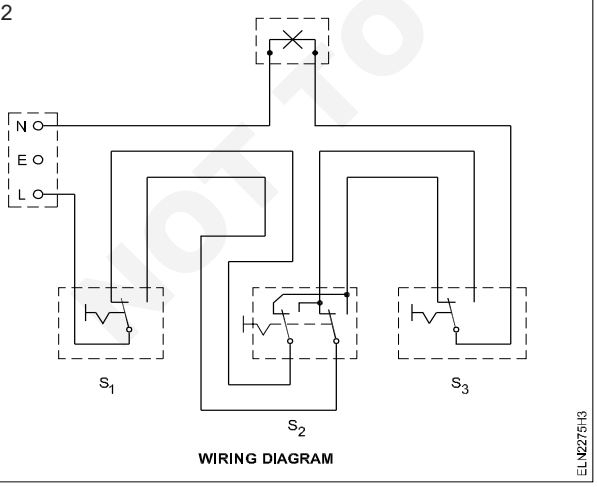
3 Mark the position of the saddles in the I.P.C. and fix them loosely on one side only.

Observe the N.E. Code for the distance between saddles. In the case of brick/concrete walls, the wooden plugs (gutties) are to be fixed flush with the walls, cemented and cured.

4 Fix the PVC pipe and accessories in the saddle and tighten the saddle screws.

5 Cut the cables according to the wiring diagram. (Fig 2)

Fig 2



WIRING DIAGRAM

Keep an extra 200 to 300mm for termination.

6 Insert the cables in the pipes and fittings and push/draw the cables to the other end of the pipes according to the wiring diagram. (Fig 2)

For longer lengths of P V C conduit runs, use fish wire/curtain spring to pull the cables through the conduits.

7 Mark the entry profile of the conduit in the round block.

8 Based on the conduit entry position, position the accessories on the round block, mark the through holes for cable entry, and the pilot holes for fixing the accessories.

9 Prepare the conduit entry profile, drill/make through and pilot holes in the round block.

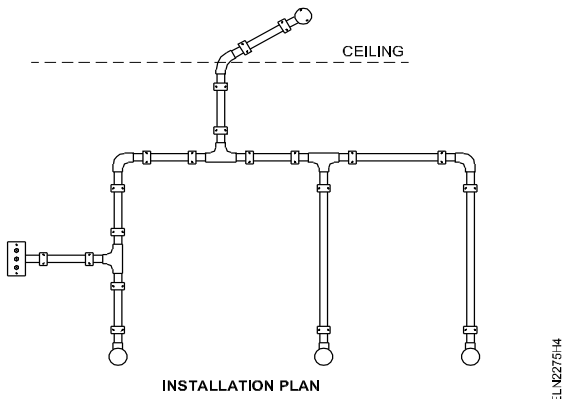
10 Insert the cables through the cable entry holes of the round blocks and fix the round block on boards.

11 Connect the cable ends to the accessories according to the wiring diagram and fix the accessories on the T.W. round blocks.

The completed installation should look as per the installation plan shown in Fig 3.

12 Test the circuit after getting the approval of the instructor.

Fig 3



INSTALLATION PLAN

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Wire up PVC Conduit wiring and practice control of sockets and lamps in different combinations using switching concepts

Objectives: At the end of this exercise you shall be able to
- **determine the size of the cable for power wiring**
- **cut non-metallic conduit pipes**
- **fix the accessories to the pipes according to the pipe size with the tight grip method**
- **fix conduit with the necessary clamps and spacers on surface installation in accordance with I.S. recommendations**
- **draw wires with non-metallic conduit pipes**
- **wire up the power circuits in P.V.C. conduit**
- **test the circuit.**

Requirements

Tools/Instruments

- Insulated combination pliers 200mm - 1 No.
- Insulated screwdriver 200mm width 4mm blade - 1 No.
- Insulated side cutting pliers 150mm - 1 No.
- Electrician's knife 100 mm - 1 No.
- Bradawl 150mm - 1 No.
- Ball peen hammer 250 grams - 1 No.
- Hacksaw with 24 TPI blade - 1 No.
- Firmer chisel 6mm x 200mm - 1 No.
- File rasp half round 200 mm basted with handle. - 1 No.
- Flat file rasp 200mm - 1 No.
- Neon tester 500V - 1 No.
- Drill bits 6mm, 3mm - 1 No. each
- Hand drilling machine 6mm capacity - 1 No.

Materials

- PVC pipe 20 mm dia. - 11 mts
- 3-way junction box 25 mm - 3 Nos.
- 20mm sadles - 19 Nos.
- TW Box 200 x 150 x 40mm - 4 Nos.
- PVC sheathed aluminium cable 4 sq mm. 250 V - 52 mts
- Copper wire 14 SWG - 13 mts
- SPT switch 16A 250V - 2 Nos.
- 3-pin socket 16A 250V - 2 Nos.
- 3-pin socket with switch 16A 250V - 2 Nos.
- T.W. wooden spacers - 20 Nos.
- Terminal plate 16 A 6-way - 1 No.
- Wood screws No. 6 x 25 mm - 20 Nos.
- Wood screws No. 6 x 12 mm - 40 Nos.
- PVC elbow 20 mm - 1 No.
- Surface-mounting type Kit-kat fuse 16A, 250V - 2 Nos.

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PROCEDURE

TASK 1: **Determine the size of cable for power wiring**

1 Ascertain the load particulars of each socket, assuming each socket is feeding one room air-conditioner of 1.5 ton capacity.

2 Determine the number of circuits, the size of cables for the circuit and branch circuits.

Refer to I.E. regulations, NE code and I.S. recommendations regarding socket connections, loading and maximum number of sockets per circuit.

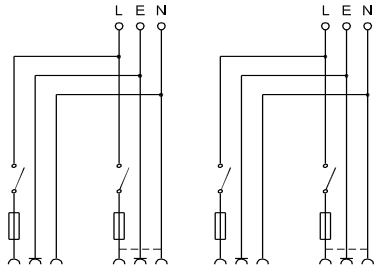
TASK 2 : **Form the circuit and test it**

1 Form the circuit on the workbench/trainer board with the required accessories as per schematic diagram. (Fig 1)

2 Get the approval from your instructor.

3 Effect supply and test the circuit.

Fig 1

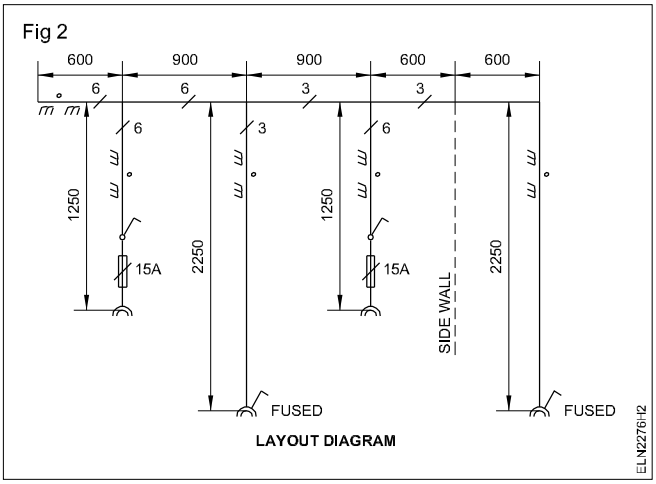


SCHEMATIC DIAGRAM

TASK 3 : **Wire the power circuit with P V C conduit**

1 Mark the layout on I.P.C. as per the layout diagram. (Fig 2)

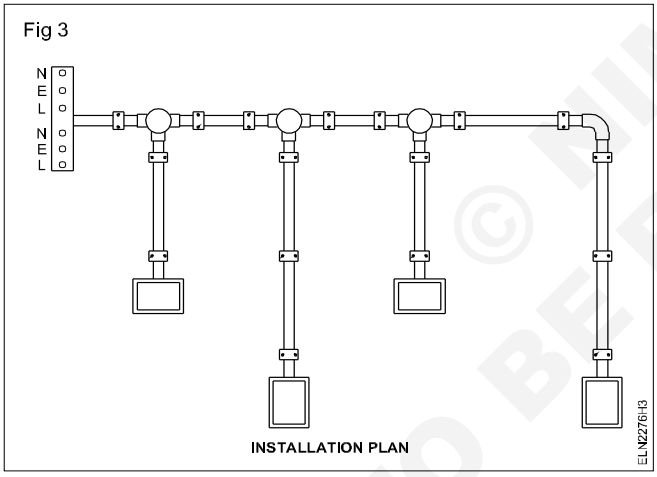
Fig 2



2 Cut the PVC conduit according to the layout by taking the length of the fittings into consideration.

3 Fix the wooden spacer on the layout marking as per installation plan shown in Fig 3, with the help of 25mm wood screws.

Fig 3

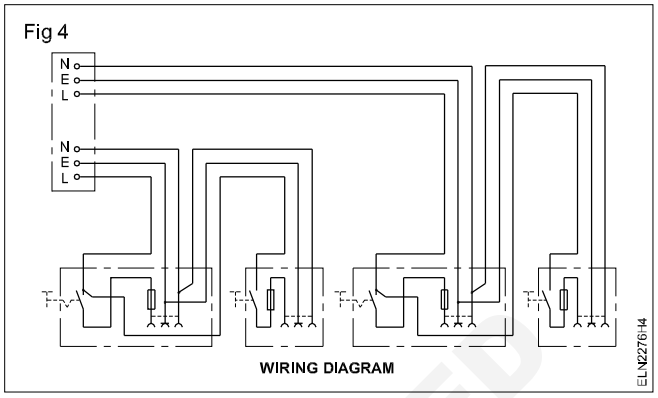


4 Fix the saddles on one side only on the wooden spacers.

5 Cut the cable length according to the route length taking into consideration the layout diagram, Fig 2 and the wiring diagram, Fig 4.

Keep an extra length of 200 to 300 mm in each cable run.

Fig 4



6 Fix the PVC conduits and accessories in the saddles and tighten the saddles by means of wood screws.

7 Insert the cables and the earth wire in the pipe and fittings, and push the wires to the other end of the pipe.

8 Prepare wooden boxes for conduit terminations, for fixing accessories and for taking cable terminations.

9 Fix the base of the boxes on the I.P.C. and fix the cover on the boxes after inserting the cables in the respective holes.

Expansion of the acronym I.P.C. is Installation Practice Cubicle/Wiring cabin/Wiring booth.

10 Connect the cable ends to the accessories and fix the accessories to the boxes with screws.

11 Connect the earth wire. (The completed installation should look as shown in Fig 3.)

The minimum size of earth wire, 14 SWG, tinned copper must be used.

12 Get the approval of the instructor.

13 Test the circuit.

— — — — — — — —

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Wire up the consumer's main board with MCB & DB'S and switch and distribution fuse box

Objectives: At the end of this exercise you shall be able to

- **place the MCB switch and distribution fuse box on the board as per the given layout observing the standard code of practice**
- **mark on the board to drill holes for the purpose of drawing wires and for fixing the accessories**
- **drill suitable holes to fix accessories and for cable entry**
- **fix the accessories**
- **identify and earth the metal parts**
- **identify the cable to be connected for phase and neutral according to the colour of insulation**
- **select and confirm the size of the cables according to the capacity of the main switch and D.B.**

Requirements

Tools/Instruments

- Steel rule 300mm - 1 No.
- Insulated Side cutter 150mm - 1 No.
- Combination pliers 200mm - 1 No.
- Hand drilling machine 6mm capacity with 3mm,6mm bits - 1 Set
- Poker 200mm - 1 No.
- Insulated Screwdriver 200mm with 4mm blade - 1 No.
- Insulated Screwdriver 150mm with 3mm blade - 1 No.
- Connector screwdriver 100mm - 1 No.
- Neon tester 500V - 1 No.
- Wooden mallet 7.5cm dia.500 g - 1 No.
- Electrician's knife DB 100 mm - 1 No.
- Tenon-saw 300mm - 1 No.
- Gimlet 200mm with 4mm dia. stem - 1 No.
- Firmer chisel 12mm - 1 No.
- Wood rasp file 200mm flat - 1 No.

Material

- 2 pole MCB 16A - 1 No.
- Distribution fuse box 4-way 16A 250V - 1 No.
- Wood screws No. 25 x 6 mm - 4 Nos.
- Wood screws No. 20 x 6 mm - 4 Nos.
- Wood screws No. 15 x 6 mm - 2 Nos.
- PVC aluminium cable 2.5 sq mm in red and black colour - 1.5 m each.
- Tinned copper wire 14 SWG - 3 m
- T.W. hinged box 300 x 250 x 80 mm - 1 No.
- 3mm dia. 25 mm long full-threaded G.I bolt, nut and washer - 10 Nos.
- PVC Cable clips 10 mm wide 2 mm thick - 300 mm

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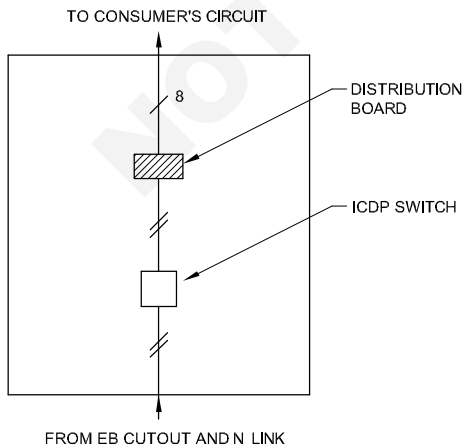
PROCEDURE

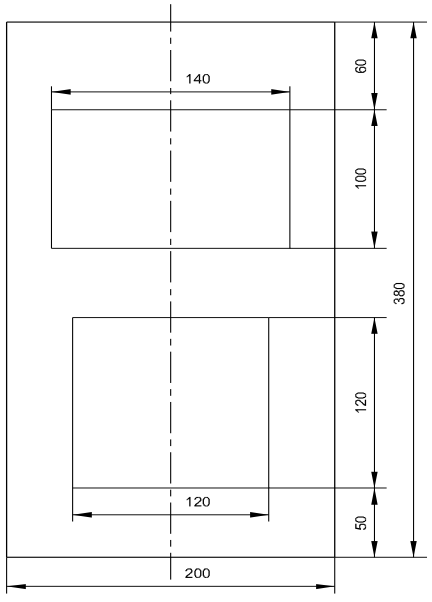
1 Mark the position of the given MCB and DB on the top surface of the T.W. board as shown in Figs 1 and 2.

Fig 1



LAYOUT DIAGRAM

Fig 2



INSTALLATION PLAN

2 Mark the position of through holes for cable runs and earth conductor.

3 Drill suitable holes (either pilot or through) in the T.W. board to fix MCB and DB.

4 Drill holes for cable entry.

5 Provide holes in the top and bottom of the base T.W. board for the supply and outgoing cables.

6 Fix MCB and DB using wood screws/other fasteners.

7 Select and confirm the size of the cables according to the ratings of the main switch and DB.

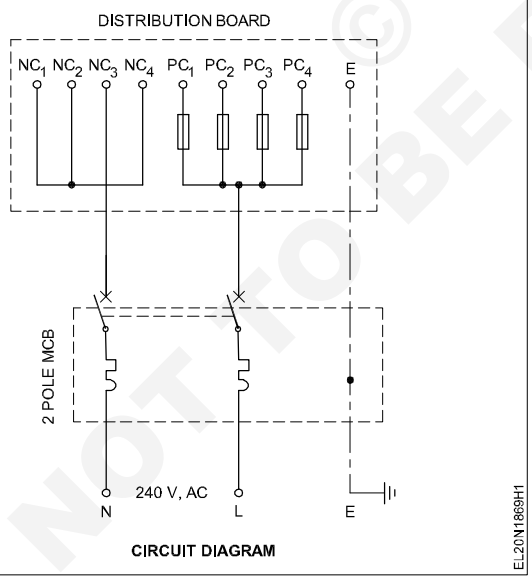
8 Connect the supply leads to the MCB through the T.W. board. Mark the end of the phase cable.

While connecting the incoming and outgoing cables to the MCB and D.B. they should pass through the holes in the top board and then through the holes provided in the top and bottom sides of the base board.

In both cases sufficient allowance of length should be given in the cables such that the hinged top board could be opened at an angle of 120° from the base board. Harnessing of the cables inside the board should be done with the P.V.C. cable clips, and the cables should pass in or out from the MCB and D.B. through the P.V.C. bushed holes.

9 Interconnect the MCB and DB as shown in Fig 4. Provide 4 pairs of outgoing cables from the D.B. for four branch circuits. Compare the wiring diagram (Fig 4) with the Circuit diagram (Fig 3).

Fig 3



While using connecting cables observe the colour code. Phase:red, Neutral:black.

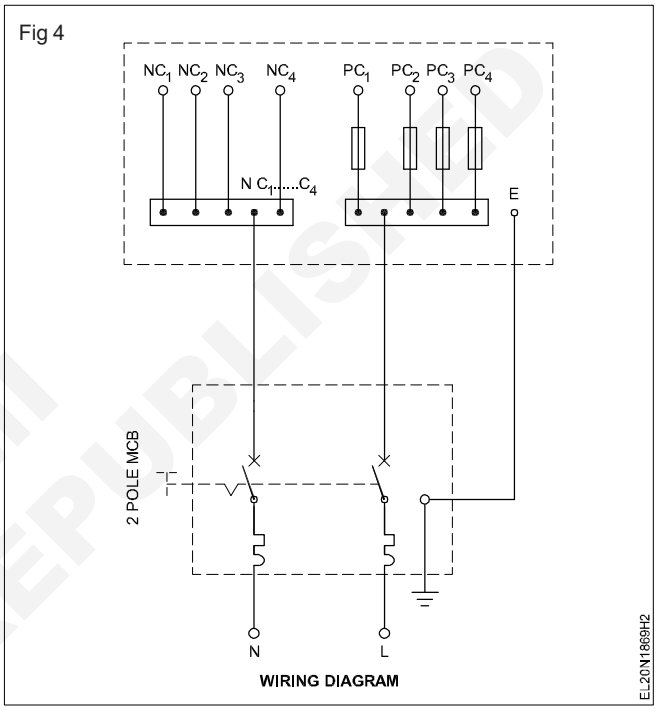
10 Locate the earth connecting points on the DB and drill suitable holes for the earthing leads in the T.W. board.

11 Connect the earth wire to the DB and then connect the E.C.C. to the meter board earth plate.

12 Fix the fuses in the DB and main switch according to the circuit/main loads.

Individual circuit loads have to be indicated in amperes by fixing labels on the D.B

Fig 4



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Prepare and mount the energy meter board

Objectives: At the end of this exercise you shall be able to
- **make holes on the wall according to requirement with a rawl jumper and hammer**
- **fill the holes with filling material**
- **make recess holes for fixing wooden gutties**
- **fix wooden gutties (wooden plugs) in the wall**
- **use a pipe jumper for making holes through the masonry wall**
- **mount the given energy meter, iron-clad cut out and the neutral links on the meter board**
- **connect the meter, iron-clad cut out and the neutral link as per regulations**
- **mount the meter board on the wall.**

Requirements

Tools/Instruments

- Insulated Steel rule 300mm - 1 No.
- Insulated Side cutter 150mm - 1 No.
- Combination pliers 200mm - 1 No.
- Hand drilling machine with 3mm and 6mm drills - 1 No.
- Insulated Screwdriver 200mm with 4mm blade - 1 No.
- Insulated Connector screwdriver 100mm - 1 No.
- Poker 200mm long with 4mm dia. stem - 1 No.
- Electrician's knife DB 100 mm - 1 No.
- Firmer chisel 12mm wooden handle - 1 No.
- Rawl jumper No.8 with holder and bit - 1 No.
- Cold chisel 200mm long with 12mm edge - 1 No.
- Ball peen hammer 500 gm. - 1 No.
- Tenon-saw 250mm - 1 No.
- Mallet with 7.5cm dia. head 500 gm - 1 No.
- Neon tester 500 V - 1 No.
- Scriber 200mm with 3mm dia. stem - 1 No.
- Mason's trowel - 1 No.
- Tray for cement mortar - 1 No.

Equipment Machines

- Single phase energy meter 10/15A 250V

Materials

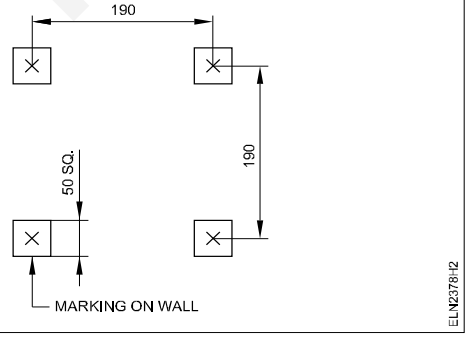
- PVC insulated copper cable 2.5 square mm - 3 m
- Tinned copper wire 14 SWG - 1 m
- Iron-clad cut out 16A - 1 No.
- Neutral link 16A - 1 No.
- T.W. board 250x250x40mm - 1 No.
- Porcelain spacers - 4 Nos.
- Teak wood gutties (wooden plugs) 40mm square x 60mm long x 30mm square - 4 Nos.
- Wood screws No.4 x 25 mm - 3 Nos.
- Cement - 1/2 kg.
- River sand - 2 kgs
- Rawl plug No.8 - 4 Nos
- Rawl plug Compound - 25 gms.
- Chalk piece (colour) - 1 No.
- G.I. pipe 20mm - 400 mm.
- Wood screws No. 50 x 8 mm - 4 Nos.

TASK 1 : **Prepare wall for mounting meter board**

If the wall is not too rigid, follow this method.

1 Mark 50mm square around the marking as shown in Fig 1.

Fig 1



2 Remove the plaster and the brick at the marked surfaces to a depth of 70 mm from the wall surface with the help of a cold chisel and hammer.

3 Prepare cement and sand mortar in the ratio of 1:4.

Let the mortar be in a semi-solid condition.

4 Sprinkle water in all the pits.

5 Insert a small quantity of cement mortar inside the pit with the help of a mason's trowel.

6 Insert the wooden gutties inside the hole pit such that the broad portion is inside and the narrow portion is outside and is just flush with the surface of the wall. (Fig 2)

7 Apply the cement on all sides of the gutty such that the gutty remains in the centre of the square hole.

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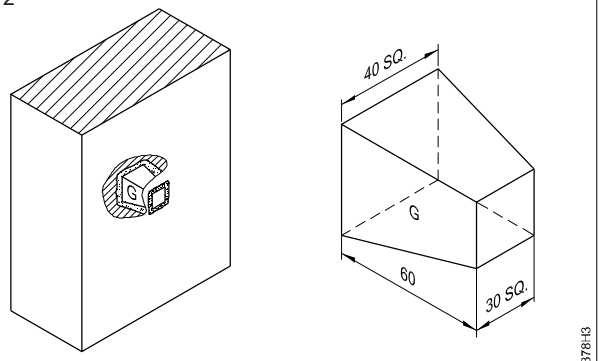
Fig 2



MOUNTING GUTTY IN THE RECESS GUTTY

8 Smoothen the surface of the wall with a mason's trowel.

Allow the cement to dry for 4 hours and sprinkle water on the cement every one hour so that the cement settles. The gutties become rigid after approximately 24 hours. Then only the boards could be fixed on to the gutties.

Now the wall is ready for fixing the T.W. board.

9 Fix the T.W. board with the help of 45mm long wood screws.

Trainees are required to identify the relationship between the stem thickness of 45mm long wood screws and the respective designation numbers.

— — — — — — — —

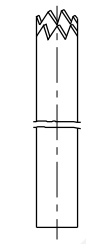
TASK 2: **Preparation of wall for drawing the service connection**

Sometimes the service connection wires need to be taken through the wall using a G.I. pipe. There is then the necessity of making a hole through the wall with the help of a pipe jumper. The method to do it is as explained below. The diameter of the pipe jumper depends on the diameter of the service connection pipe and the length of the pipe jumper depends upon the wall thickness.

1 Take a 20mm dia. G.I. pipe of 400mm length.

2 Make serrations by cutting at one end of the pipe as shown in Fig 3 using a hacksaw.

Fig 3



PIPE JUMPER

This type of pipe jumper is also called crown jumper, due to its very look.

3 Inspect the wall and mark a place on the wall considering the nearest point to the electric service pole.

The marking should be close to the meter terminals. It should not be on the R.C. . beam or granite stone embedded in the wall.

In the case of an old building check whether any concealed wiring is running through the wall at the place of marking. In such cases the marking should be done at a different place. However, in buildings, where wiring exists, switch `off' the mains, remove the fuse-carrier and keep it under your custody.

4 Keep the pipe jumper on the mark and hammer it lightly.

5 Rotate the pipe jumper for every stroke of hammer.

This process removes the broken masonory and allows free movement of the pipe jumper. Take care to keep the pipe jumper perpendicular to the wall surface.

6 Slow down the hammer strokes when the pipe jumper reaches near to the other end of the wall.

Hitting hard on the hammer at the end of a hole will make a larger sized plaster to fall out at the other end of wall.

7 Clear the hole.

8 Insert the G.I. pipe for the service cable in the hole and plaster around the pipe with cement.

Wiring up a meter board

1 Confirm the capacity of the energy meter.

2 Select and confirm the size of the cable as per the meter rating.

Follow the standard colour code for phase and neutral.

3 Position the meter, I.C. cut-out and earth-plate as per layout (Fig 4) and mark their position as per layout on the T.W. board.

4 Mark the cable entry positions and mounting screw positions.

5 Select the drill bit according to the cable size.

6 Drill through holes in the T.W. board for cable entry and pilot holes for fixing the meter, I.C. cut out and the earth plate.

7 Fix the meter, I.C. cut out and the earth plate.

8 Determine the length of the cables according to the layout and cut them with reference to Figs 4 and 5.

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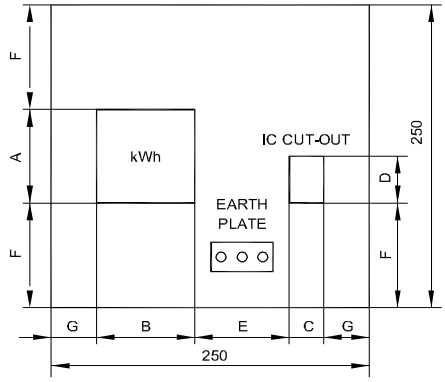
Fig 4



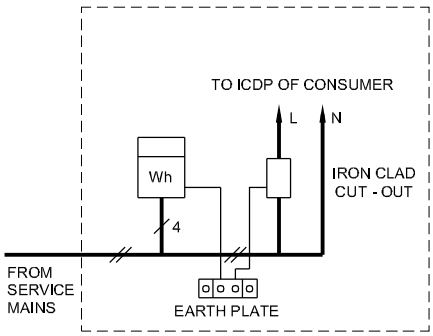
A-B OUTSIDE MEASUREMENTS OF ENERGY METER $F = \frac{250 - A}{2}$

C-D OUTSIDE MEASUREMENTS OF METAL CLAD (IRON CLAD) CUT - OUT
E = 50mm $G = \frac{250 - B - C - E}{2}$

INSTALLATION PLAN

ELN2378-H5

Fig 5



ENERGY METER SINGLE PHASE (6-16A-240V)

LAYOUT DIAGRAM

ELN2378-H6

9 Connect the supply leads and the outgoing phase wire to the I.C. cut–out. Pass the neutral directly as per the wiring diagram. (Figs 6 and 7)

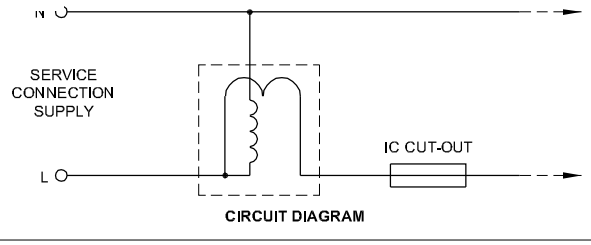
10 Earth the casing of the meter and the I.C. cut out body to the earth plate.

11 Keeping the meter board in a vertical position, test the circuit after getting the approval of the instructor.

12 Mount the meter board on the previously prepared wall with the help of 45mm wood screws.

The completed work should look as shown in Fig 8.

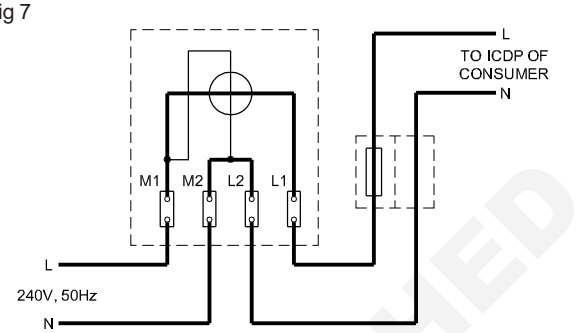
Fig 6



CIRCUIT DIAGRAM

ELN2378-H7

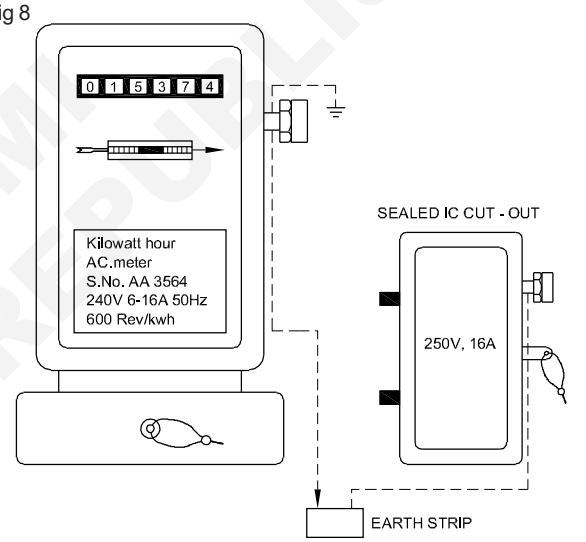
Fig 7



WIRING DIAGRAM

ELN2378-H8

Fig 8



METER BOARD WITH MOUNTED ACCESSORIES

ELN2378-H9

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Estimate the cost/bill of material for wiring of hostel/residential building and workshop

Objectives: At the end of this exercise you shall be able to
- **calculate the total load in sub-circuit**
- **select the size of cable in the sub circuits**
- **estimate the quantity of materials**
- **estimate the cost of wiring.**

Requirements

Tools/Instruments

• Measuring tape 0-25 m	- 1 No.
• SWG	- 1 No.
• Steel rule 300 mm	- 1 No.
• Micrometer 0-25 mm	- 1 No.

Materials

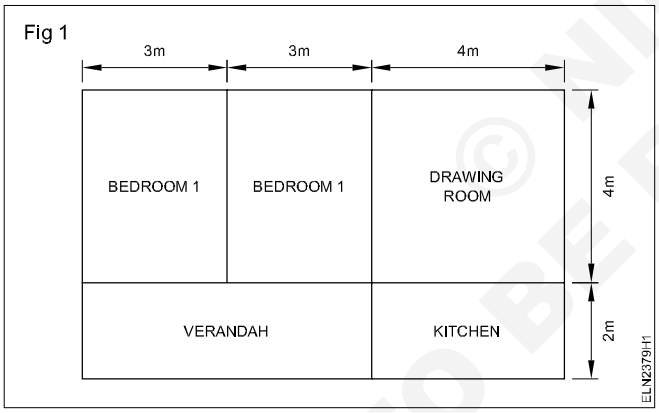
• A-4 Paper	- as reqd.
• Pencil/HP	- 1 No.
• Eraser	- 1 No.

PROCEDURE

TASK 1 : **Estimate the cost/bill of material for wiring of hostel / residential building**

1 Obtain the building plan as shown in Fig.1

Fig 1



2 Collect the requirements of lights, fans, lighting and power sockets etc.

3 Mark the location of switch board, Power loads and DB in the plan.

The type and quantity of loads depend upon the customer's requirement. Hence, complete data are to be collected before starting estimation. A sample requirements is given for the trainee's reference.

The wall thickness	- 40 cm
The height of roof from ground	- 3.5 m
Height of conduit run	- 3 m
Height of main board	- 2.5 m
Height of switch	- 1.5 m
Height of light brackets	- 3 m
Height of main board	- 3 m

The details of standard requirement of Power loads are given in Table - 1

Table - 1

Location	Light (60 W)	Fan (80 W)	6A Plug Point (80 W)	16A Power Plug (1000 W)
Verandah	1	1	1	1
Kitchen	1	1	Nil	1
Bedroom	2 +2	1 + 1	1 + 1	Nil
Drawing Room	2	1	1	Nil

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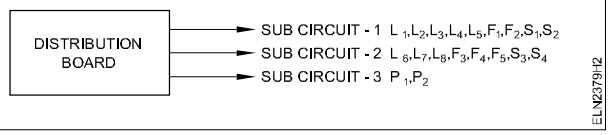
4 Calculate the number of sub circuits required for the above load as per IE rules.

Indian electricity rule states that there should be separate sub circuits for light/fan loads and power loads. Therefore 6A plug points (Sockets) are considered as light / fan load points as they are meant for connecting table fan /table lamp etc. 16A power plug are considered as power points as they are used for connecting heavy loads like heaters, kettles etc.

Total wattage of light points	= 8 x 60 = 480 W
Total wattage of fan points	= 5 x 80 = 400 W
Total wattage of (6A) sockets	= 4 x 80 = 320 W
Total 17 Nos	= 1200 W

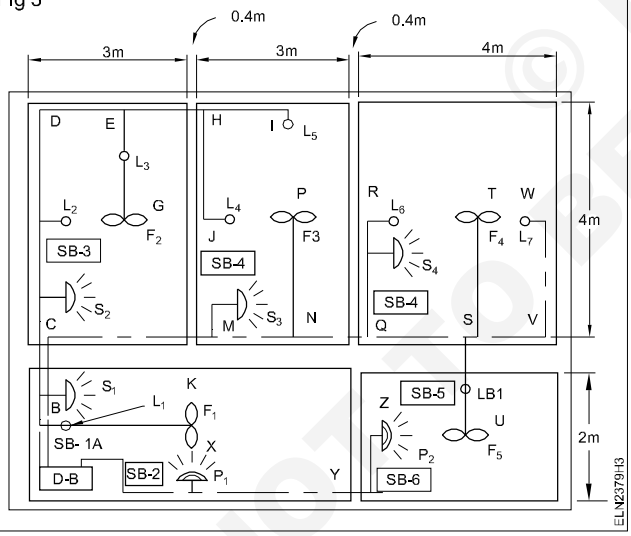
As there are 17 points, we need two sub - circuits. The division of outlets on each sub circuit is made more or less uniform, ie., 8 & 9. Refer Fig 2

Fig 2



5 Draw the layout of conduit, switch board, loads and DB as shown in Fig 3.

Fig 3



6 Calculate the size of each cable as shown below.

i current through subcircuit-1

$$= \frac{(5 \times 60) + (2 \times 80) + (2 \times 80)}{230} = 2.696 \text{ A}$$

ii Current through subcircuit -2

$$= \frac{(3 \times 60) + (3 \times 80) + (2 \times 80)}{230} = 2.522 \text{ A}$$

iii Current through sub circuit 3 $= \frac{2000}{230} = 8.696 \text{A}$

Total current = 2.696+2.522+8.696 = 13.9 A

16A, 250V flush type DP main switch is sufficient

7 Calculate the length of PVC conduit and cable as shown below.

19mm conduit can be used up to ABC length and for remaining length, 12mm conduit is sufficient.

Horizontal runs

19mm conduit for length ABC	= 2.4 m
19mm conduit for length at C (wall thickness)	= 0.4 m
Total	**= 2.8 m**

12 mm Conduit

Length CDEHI (4 + 3 + 1.5)	= 8.5 m
Length EG	= 2.0 m
Length HJ	= 2.0 m
Length CMNQSVW (3+3+4+2)	= 12.0 m
Length MS3	= 1.5 m
Length NP	= 2.0 m
Length QR	= 2.0 m
Length ST	= 2.0 m
Length SV	= 1.0m
Length BK	= 3.0 m
Length AXYZ (6+1)	= 7.0 m
Length (wall thickness) at C, H, M, Q, S & Y (6x0.4)	= 2.4 m
Total	**= 45.4 m**

Vertical down drops (horizontal run to SB's) :

19 mm conduit

Length B to roof	= 0.5 m
Length E to roof	= 0.5 m
Length N to roof	= 0.5 m
Length S to roof	= 0.5 m
Total	**= 2.0 M**

Total 19 mm conduit required = 2.8+1.5+0.5 = 4.8 m

Wastage 10%	= 0.48 m
Total	= 5.28 m (Take 6m)

Total 12mm conduit required 45.4+10.50 = 55.9 M

Wastage 10%	= 5.59 m
Total	= 61.49 m (Take 62m)

Cable for (power) sub circuit -3 (1/1.8m Al)
= 3 x (6+1+1.5+1.5) = 30 m

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Cable for subcircuit 1 & 2 (1.0 mm^2 copper)

= 3 x (6+62-10) = 174 m

Trainee shall select the cable size by refering the table given in related theory

8 Calculate the labour cost.

Meter board	= 2 Points
Distribution board	= 2 Points
Light / fan	= 17 Points
Power	= 2 Points
Total points	**= 23 Points**

Labour cost / point should be taken by referring the local rate list.

For example, take the labour cost is Rs.100/point

Then, total labour cost is 23 x 100 = Rs. 2300/-

9 Prepare a list of "material of schedule and cost" as shown in Table-2.

Table 2

Material of schedule and cost

Sl.No.	Material Specification	Rate Cost				
		Qty.	Rs. Ps.	Per	Rs. Ps.	Remarks
1	D.P Main switch 10A, 240V flush type	1 No	.....	each	.....	For M.B For power load
2	I.C cut out 16A, 240V	1 No	.....	each	.....	
3	Flush type fuse unit 16A	1 No	.....	each	.....	
4	Flush type fuse unit 6A	2 Nos	.....	each	.....	
5	PVC conduit 19 mm (heavy guage)	6 m	.....	length	.....	1 length = 3 m
6	PVC conduit 12 mm (heavy guage)	62 m	.....	length	.....	1 length = 3 m
7	1.0mm^2 multistrand copper, VIR cable	174 m	.....	100m	.....	
8	1/1.8 mm aluminium VIR cable	30 m	.....	100m	.....	
9	1/1.8m copper VIR cable	2 m	.....	100 m	.....	From M.B to D.B
10	Switches 6A, 240V one way flush type	17 Nos	.....	each	.....	
11	2-pin sockets 6A, 240V	4 Nos	.....	each	.....	
12	3 -pin sockets 16A, 240V with switch and neon	2 Nos	.....	each	.....	
13	Ceiling rose 2 - plate 6A 240V	5 Nos	.....	each	.....	
14	Lamp holders brass batten type	8 Nos	.....	each	.....	
15	PVC junction boxes 25 mm 4 - way	1 No	.....	each	.....	
	12 mm 3-way	7 Nos	.....	each	.....	
	12 mm 2-way	5 Nos	.....	each	.....	
16	PVC bends 12 mm	4 Nos	.....	each	.....	
17	PVC reducers (25 mm to 12 mm	1 No	.....	each	.....	
18	Saddles 25 mm	24Nos		Doz	.....	
	12 mm	144No		144 Nos	.....	
19	Wooden boards (a) 30 x 30 Cm	2 Nos	.....	each	.....	For M.B & D.B For S.D's
	(b) 18x10 Cm	7 Nos	.....	each	.....	
20	Round blocks	5 Nos	.....	each	.....	
21	Wooden gutties/plugs 9cm2 x 4 cm^2 x50 mm	3 doz		doz	.....	For boards
22	Nails 25 mm	1 kg		kg		Per conduit
23	Wooden screw 60 mm	25 Nos		100		For boards
	Wooden screw 12 mm	25 Nos		100	....	Forholders
24	Copper wire (16SWG) for earth	1 Kg		kg	.....	
	(GI WIRE 14 SWG)	1 Kg		kg		
25	Earth set (Pipe, salt, coal)	1 set		...	.....	
26	Cement	2 kg		kg		
27	Labour cost	2 kg			.....	For 4 gutties
	Total				.....	
	Contingency 10%				.....	
	Grand Total					

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The rate of each material shall be obtained from the price list of the branded items

— — — — — — — —

TASK 2 : **Estimate the cost / bill of materials for wiring of workshop**

1 Obtain the floor plan of the workshop.

2 Mark the positions of motors on the floor plan with the consultation of the customer.

A sample requirement is given below for trainee's reference

1 One 5HP, 415V 3 phase motor

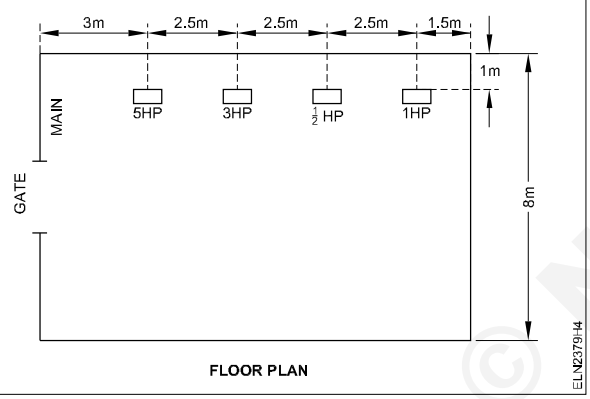
2 One 3HP, 415V 3 phase motor

3 One ½ HP, 240V 1 phase motor

4 One 1HP, 415V 3 phase motor

The motors are to be arranged as shown in Fig.4

Fig 4



The main switch, motor switch and starters are assumed to be mounted at a height of 1.5m from the ground level.

Height of horizontal run from ground level will be 2.5 m

The cost of motors and starters are not to be included in the estimate.

3 Calculate the size of cable

Assuming the motor efficiency to be 85% power factor to be 0.8 and supply voltage is 400 V for all the motors.

$$\text{FL current of 5HP motor} = \frac{5 \times 735.5}{\sqrt{3} \times 400 \times 0.85 \times 0.8} = 7.806\text{A}$$

$$\text{FL current of 3HP motor} = \frac{3 \times 735.5}{\sqrt{3} \times 400 \times 0.85 \times 0.8} = 4.68\ \text{A}$$

$$\text{FL current of ½ HP motor} = \frac{0.5 \times 735.5}{240 \times 0.85 \times 0.8} = 2.25\ \text{A}$$

$$\text{FL current of 1HP motor} = \frac{1 \times 735.5}{\sqrt{3} \times 400 \times 0.85 \times 0.8} = 1.56\ \text{A}$$

The main switch and the cable from meter to main switch should be capable of handling starting current of one motor of high rating plus full load current of the all other motors.

i.e, 15.6+4.68+2.25+1.56 = 24.9A

4 Prepare a table showing cable size of each motors to be installed as shown in Table 3.

Table 3

Sl. No.	Motor	FL current I_L (A)	Starting current $I_S = 2I_L$ (A)	Recommended cable size
1	5HP motor	7.5	15.0	2.0mm² copper conductor cable (17A) or 2.5mm² aluminium conductor cable (16A)
2	3HP motor	4.68	9.36	2.0mm² copper conductor cable (17A)
3	1/2 HP motor	2.25	4.5	1.0mm² copper conductor cable (11A) minimum recommended cable
4	1HP motor	1.56	3.12	1.0mm² copper conductor cable (11A) minimum recommended cable

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The type and gauge of cable shall be selected by referring the table given in related theory

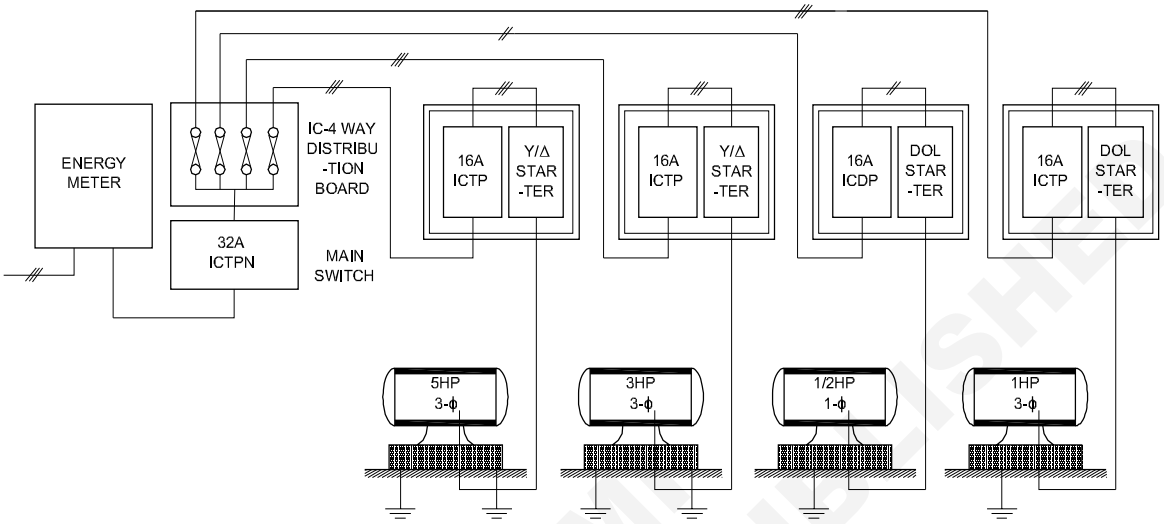
5 Select the suitable switches and distribution board

- 32A, 415V ICTP switch with fuses can be used as main switch.
- 16A, 415V, ICTP switches with fuses can be used for 5HP, 3HP, & 1HP motors.
- 16A, 240V, ICDP switch with fuses can be used for ½ HP motor.
- 415V, 4 way, 16A per way IC distribution board with neutral link can be used for power distribution.

6 Draw the single line diagram of power wirings as shown in Fig 5.

7 Calculate the size and length of conduit.

Fig 5



SINGLE LINE DIAGRAM OF POWER WIRING IN WORKSHOP

19mm heavy gauge conduit should be used for 3 cable runs and 25 mm heavy gauge conduits should be used for 6 cable runs.

- 19 mm heavy gauge conduit

Length from main board of 5HP motor starter

= 1+1+3+1 = 6.0m

Length from main board to 3HP motor starter

= 1+1+5.5+1 = 8.5m

Length from main board to ½ HP motor base

= 1+1+8+1+1.5+1.5 = 14.0m

Length from main board to 1HP motor base

= 1+1+10.5+1+1.5+1.5 = 16.5m

Total = 45.0 m

10% wastages = 4.5m

Total length = 49.5m, say 50.0m

- 25.4 mm heavy gauge conduit.

Length from meter to main switch = 0.75 m

Length from 5HP motor starter to 5HP motor base

(1.5 +1.5) 3.0 m

Length from 3HP motor starter to motor base = 3.0 m

Total = 6.75 m

10% wastage = 0.67 m

Total = 7.42m, Say 8.0m

- 25 mm flexible conduit for 5HP & 3 HP motor (0.75+0.75) = 1.5, Say 2.0m

8 Calcualte the length of cables.

2.0mm^2 copper conductor from main board to 5HP motor terminals = 3(1+1+3+1) + 6(1.5+1.5+0.75) = 40.5m

15% wastages & end connections = 7.2 m

Total = 55.2m , Say = 56.0m

1.0mm^2 copper conductor from main board to 1/2 HP motor terminals = 2(1+1+8+1+1.5+1.5+0.75) = 29.5 m

15% wastages & end connections = 7.76m

Total = 59.51m, Say 60.0m

9 Calculate the labour cost as per the local rate and rules for calcualting number of points.

10 Prepare "Schedule of material and cost as shown in Table 4.

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Table 4

Material of schedule and cost

Sl.No.	Specification of material	Qty.	Rate	Cost	Rs. Ps	Remarks
			Rs. Ps.	Per		
1	32A, 415V- Iron -clad triple - pole (ICTPN) switch with fuses	1 No.	.....	each	.....	
2	16A, 415V, Iron- clad triple -pole switch with fuses	3 Nos.	.....	each	.....	
3	16A, 240V, Iron -clad double - pole switch with fuses	1 No.	.....	each	.....	
4	4-Way distribution box, 415V, 16A	1 No.	.....	each	.....	
5	Conduit heavy gauge ..... 19 mm	50 m	.....	m	.....	
	25mm	8 m	.....	m	.....	
6	Flexible conduits ..... 19 mm	2 m	.....	m	.....	
	25 m	2 m	.....	m	.....	
7	2.0 mm^2 copper conductor single core (17A)	47 m	.....	100 m	.....	
8	1.0mm^2 copper conductor single core (11A)	56 m	.....	100 m	.....	
9	1.0mm^2 copper conductor single core (11A)	34 m	.....	100 m	.....	
10	1.0mm^2 copper conductor single core (11A)	60 m	.....	100 m	.....	
11	Angle iron frame 50 x 30 m	5 Nos.	.....	each	.....	For M.B & D.B
12	Conduit bends 19mm	10 Nos.	.....	each	.....	
	25 mm	2 No.	.....	each	.....	
13	Saddles ..... 19 mm	150 Nos.	.....	100	.....	
	25 mm	25 No.	.....	100	.....	
14	Conduit couples 19mm	6 No.	.....	each	.....	
	25 mm	1 No.	.....	each	.....	
15	Wooden gutties	120 No.	.....	doz	.....	
16	Earth wire, GI, 8 SWG	40 m	.....	kg.	.....	1kg. $\simeq$ 10 m
17	Lugs for connecting leads to motors	17 No.	.....	each	.....	(6+6+2+3)
18	Earthing pipe perforated 25.4mm dia	2.5 m	.....	m	.....	Two earths
19	Coal	40 kg.	.....	kg.	.....	
20	Salt	40 kg.	.....	kg.	.....	
21	Funnel with wire mesh	1 No.	.....	each	.....	
22	Labour charges for earthing (Civil work)	2 Nos.	.....	pit	.....	
23	Caution plate	1 No.	.....	each	.....	
24	Nails 25.4 mm	2	.....	kg.	.....	
25	Shock treatment chart	1	.....	each	.....	
26	Labour cost	-	.....	point	.....	
	Total	.....	.....	.....	.....	
	Contingency 10%	.....	.....	.....	.....	
	Grand total	.....	.....	.....	.....	
	Say	.....	.....	.....	.....	

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Practice wiring of hostel and residential building as per IE rules

Objectives: At the end of this exercise you shall be able to
- **read and interpret the circuit diagram of a bank/ hostel/ jail**
- **mark the layout of the wiring scheme**
- **prepare and install a conduit frame as per layout**
- **draw the cables through the conduit**
- **connect the accessories as per circuit**
- **test the circuits.**

Requirements

Tools /Instruments

- Combination pliers 200 mm - 1 No.
- Screw driver 200 mm with 4 mm blade - 1 No.
- Side cutting pliers 150 mm - 1 No.
- Electrician's knife 100 mm - 1 No.
- Bradawl 150 mm - 1 No.
- Ball peen hammer 250g - 1 No.
- Hacksaw with 24 TPI blade - 1 No.
- Firmer Chisel 6 mm - 1 No.
- Flat rasp file 200 mm - 1 No.
- Neon tester 500V - 1 No.
- Electirc drilling machine 6 mm capacity with 5mm drill bit. - 1 No.

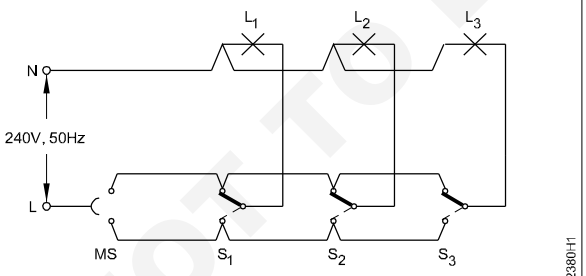
Materials

- 2 way switch 6A 250V - 4 Nos.
- Batten holder 6A 250V - 4 Nos.
- PVC switch box 100 X 100 X 40 mm - 4 Nos.
- PVC Cable 1.5 sq mm, 660 V - as reqd.
- Saddle 19 mm - 20 Nos.
- Wooden gutties - 20 Nos.
- Conduit bend 19mm - 20 Nos.
- Fish wire - as reqd.
- PVC Conduit 19 mm - 50 m
- Flexible conduit 19 mm - 2 m
- Conduit coupler 19 mm - 6 Nos.
- Earth wire G1, 8 SWG - 20 m
- Wood Screw 25 x 6 mm - 1 box
- Wood Screw 12 x 6 mm - 1 box

PROCEDURE

1 Read and interpret the schematic diagram (Fig 1) and the layout diagram (Fig 2).

Fig 1



SCHEMATIC DIAGRAM OF A HOSTEL WIRING

2 Draw the wiring diagram based on Figs 1 and 2 and compare with the given wiring diagram. (Fig 3).

3 Draw your own wiring diagram according to the layout.

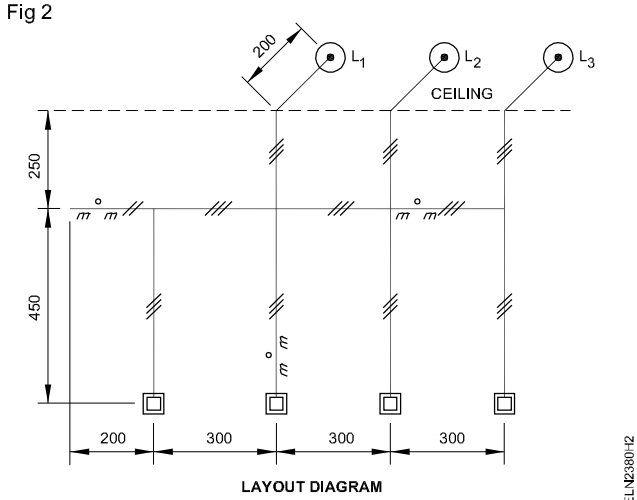
4 Estimate the material required for wiring installation referring to the layout as well as the wiring diagrams.

5 Mark the layout on the Installation Practice Cubicle (IPC).

6 Prepare the PVC conduit frame as per the layout plan.

7 Mark the saddles position and fix them loosely as per the layout plan.

Fig 2



LAYOUT DIAGRAM

8 Fix the conduit pipe on the IPC with the help of saddles.

9 Insert the fish wire into the conduit pipe.

10 Draw the cable as per the wiring diagram. (Fig 3)

Leave an excess length of 200 to 300mm in each cable for termination

11 Fix the batten holders as per the Fig 2 and terminate the cable ends.

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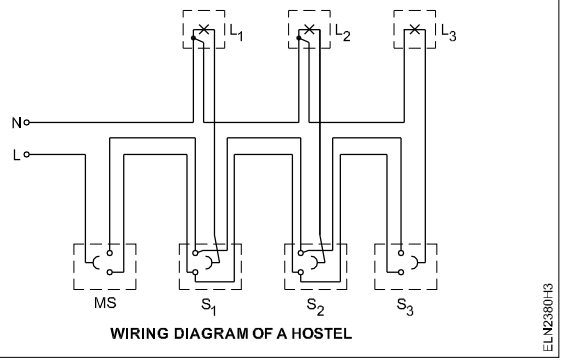
Fig 3



WIRING DIAGRAM OF A HOSTEL

12 Fix the switches on the PVC switch boxes.

13 Prepare the end termination of cables and connect the accessories as per the circuit.

14 Test the circuit after getting the approval of the instructor.

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Practice wiring of Institute and workshop as per IE rules

Objectives: At the end of this exercise you shall be able to
- **read and interpret the floor plan of a workshop**
- **mark the single line diagram of power wiring in workshop**
- **prepare and install a conduit frame as per line diagram**
- **draw the cables through the conduit**
- **connect the accessories as per circuit**
- **test the circuits.**

Requirements

Tools/Instruments

- Power drilling machine 6mm with 5 mm drill bit - 1 No.
- Combination pliers 200 mm - 1 No.
- Side cutting pliers 150 mm - 1 No.
- Electrician's knife - 1 No.
- Bradawl 150mm - 1 No.
- Ball peen Hammer 250 gm - 1 No.
- Hacksaw with 24 TPI blade - 1 No.
- Firmer Chisel 6 mm - 1 No.
- Neon Tester 500V - 1 No.
- 3ϕ Energy meter 30A, 440V - 1 No.

Equipment / Machines

- 5 HP 3ϕ 440V AC motor - 1 No.
- 3 HP 3ϕ 440V AC motor - 1 No.
- 1/2 HP 1ϕ 240V AC motor - 1 No.
- 1 HP 1ϕ 240V AC motor - 1 No.
- Star Delta starter 4, 5V 50 Hz - 2 Nos
- DOL starter 1ϕ, 10A, 250 V - 2 Nos.

Material

- Metal conduit pipe 20 mm - 10 m
- Conduit junction box - 20 Nos.
- TW box 200 X 150 X 40 mm - 3 Nos
- TW box 300 x 200 x 40 mm - 4 Nos.
- TPIC 16A - 415V - 2 Nos.
- DPIC 16A, 250V - 2 Nos.
- Saddles 19 mm - 50 Nos.
- Wooden gutties - 50 Nos.
- Conduit bend 19 mm - 10 Nos.
- Angle Iron frame 50 x 30mm - 5 Nos.
- Fish wire - as reqd.
- PVC sheathed aluminium cable 4 Sq mm 250 V - 60 m
- Copperwire 14 SWG - 15 meter
- Metal conduit Elbow 20 mm - 25 Nos.
- Distribution box 4 ways 200x150x40mm - 1 No.
- TW wooden spacer - 30 Nos.
- Wood screws 25 x 6 mm - 1 Box
- Wood screws 12 x 6 mm - 1 Box
- Surface mounted kit kat fuse 16A 250V - 4 No.

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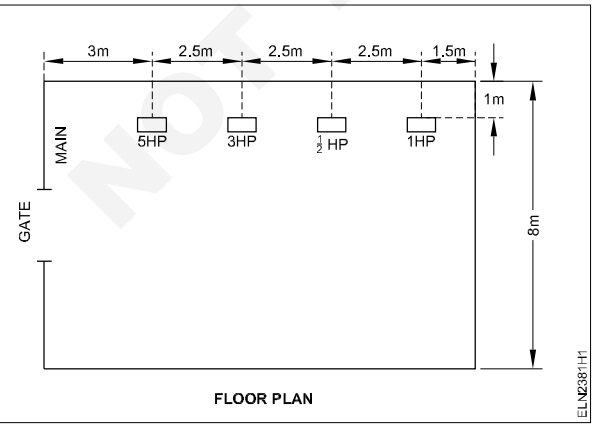
PROCEDURE

1 Obtain the floor plan of the work shop (Fig 1).

Fig 1



FLOOR PLAN

2 Mark the position of motors on the floor plan with the consultation of the customer.

A Sample requirement is given below for trainees reference.

1 One 5 HP, 415V 3 phase motor.

2 One 3 HP, 415V 3 phase motor.

3 One 1/2 HP; 240V, 1 Phase moor

4 One 1 HP, 240V, 1 Phase motor

The motors are to be arranged as shown in Fig 1.

The mainswitch, motor switch and starter are assumed to be mounted at a height of 1.5 m from the ground level.

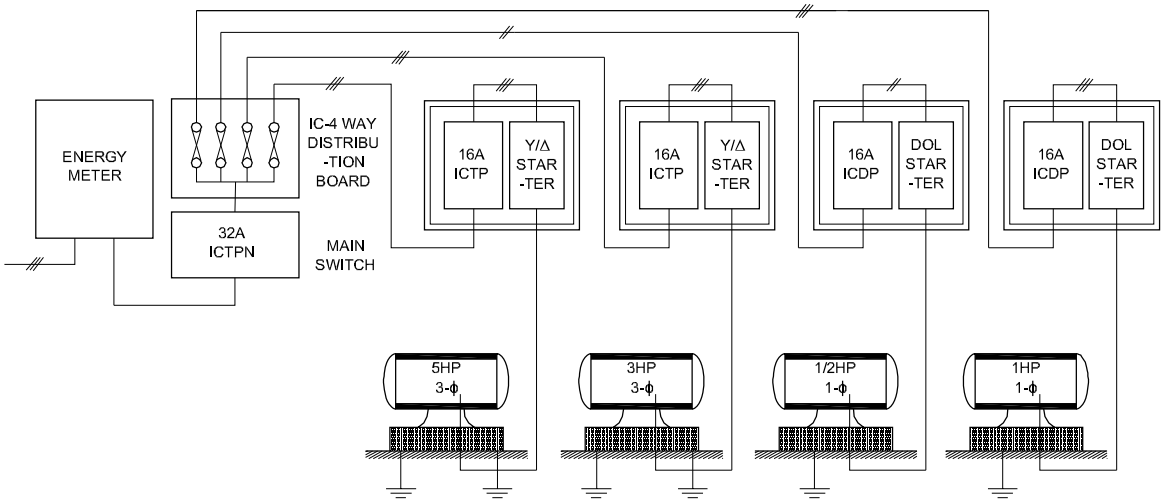
Height of horizotal run from ground level will be 2.5 m

3 Draw the wiring diagram based on Fig 1.

4 Mark the layout based on Fig 2.

5 Prepare the PVC coduit frame as per layout.

Fig 2



SINGLE LINE DIAGRAM OF POWER WIRING IN WORKSHOP

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Practice testing /fault detection of domestic and industrial wiring installation and repair

Objectives: At the end of this exercise you shall be able to
- **detect and repair open circuit fault in domestic and industrial wiring**
- **detect and repair shortcircuit fault in wiring**
- **detect and repair earth fault in wiring**
- **prepare the flow chart for location rectification of fault in domestic wiring installation.**

Requirements

Tools/Instruments

• Connecting screw driver 100 mm	- 1 No.
• Cutting plier 150 mm	- 1 No.
• Screw driver 200 mm	- 1 No.
• Neon tester 500 V	- 1 No.
• D.E. Electrician knife100 mm	- 1 No.
• Multimeter	- 1 No.
• Megger 500V	- 1 No.

Materials

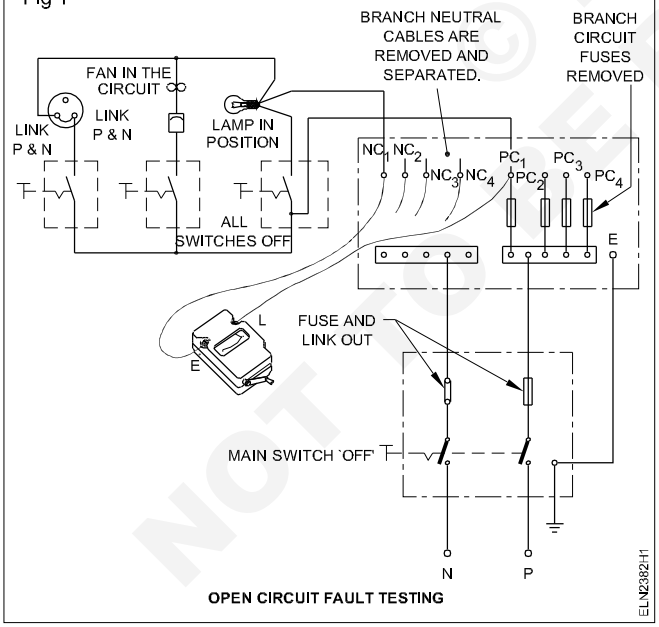
• Test lamp 100W, 240 V	- 1 No.
• Crocodile clip 15A	- 2 sets
• PVC flexible cable 1.5sq.mm, 660 V	- 10m

PROCEDURE

Open Circuit Fault

1 Consider the circuit as shown in Fig 1 in a domestic installation.

Fig 1



OPEN CIRCUIT FAULT TESTING

For open circuit fault removal of fuses, etc are to be done before doing the test by using megger.

2 Check whether the cables used in an installation have proper continuity or not using megger.

3 Check circuit fuses whether in order or not, if not, rewire the fuses.

4 Check one circuit at a time and then proceed step by step.

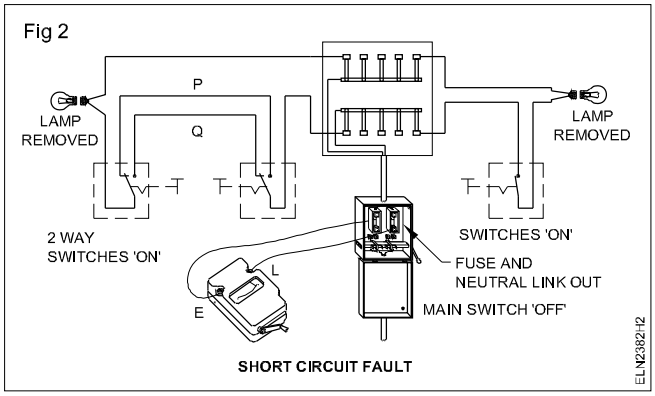
5 Check the circuits having 2 way switches, the concerned switches may be operated alternately to ensure the correct test result.

6 Check the defective fan, regulators or lamps by shorting the suspected appliance if necessary and then retest it.

Short circuit fault

1 Make the circuit as shown in Fig 2 and connect the megger, if it shows continuity in both ON and OFF positions of the switch, this indicates short in circuit.

Fig 2



SHORT CIRCUIT FAULT

2 Check insulation resistance between the cables of the installation and earth.

3 Connect the megger terminal 'E' to the live wire and L to the corresponding neutral wire, the megger will read zero or very low value of insulation resistance and confirms the short circuit.

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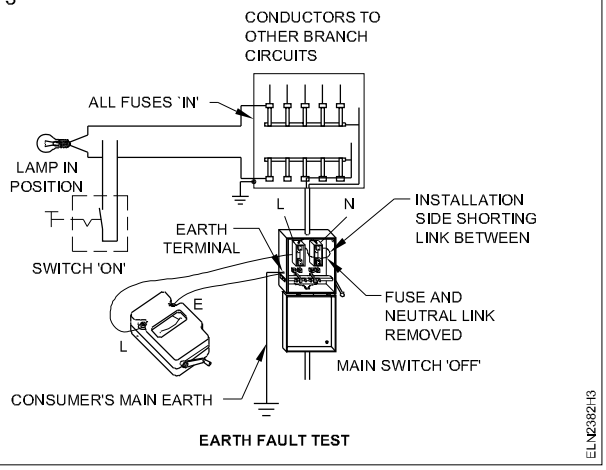
4 Repeat the test procedures in each and every circuit and locate the shorting point of the live and neutral wire by inspection and remove it by insulating the bare conductors.

Earth fault

1 As per the circuit as shown in Fig 3 keep all the fuses, switches bulbs etc in closed position as indicated in the figure.

Fig 3



EARTH FAULT TEST

Isolate the live conductor from neutral, remove all other lamps and other equipments connected with wiring.

2 Switch 'ON' all the switches.

3 Using Insulation resistance Tester, terminal 'E' of the megger connect to the earth point of the system provided at the Meter Board and Terminal 'L' of the megger with each conductor in turn at the main board cut-out terminal and rotate the handle of the megger to send current through closed circuit formed between conductor and earth.

4 Note down the reading of the meter which gives directly the insulation resistance between the conductor and earth.

5 Repeat the step 3 and 4 for other circuits, subcircuits, live conductors and main switch board etc.

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Electrician - Wiring Installation and earthing

Prepare pipe earthing and measure earth resistance by earth tester/megger

Scan the QR Code to view the video for this exercise

Objectives: At the end of this exercise you shall be able to
- **prepare the pipe for earthing**
- **dig the pit in the ground**
- **install the earth pipe and test it.**

Requirements

Tools/Instruments

- G.I. die stock with 12.7 mm, 19mm and 38mm dies - 1 Set
- D.E. spanners 5mm to 20mm of six. - 1 Set
- Blowlamp, 1 litre with kerosene - 1 No.
- Crowbar, hexagonal 1800mm long - 1 No.
- Powrah (spade) - 1 No.
- Pick axe - 1 No.
- Cement mortar tray - 2 Nos.
- Tongs 300mm - 1 No.
- Measuring tape 5m - 1 No.
- Ladle - 2 Nos.
- Combination pliers 200mm - 1 No.
- Pipe wrench 50mm - 1 No.
- Hacksaw with 32 T.P.I. blade - 1 No.
- Wooden box 150(l) x 150(b) x 300(h) mm - 1 No.
- Soldering pot (melting) - 1 No.
- Sledge Hammer 2 Kg. - 1 No.

Equipment/Machines

- Earth tester with connecting leads and spikes - 4 Nos. - 1 No.

Materials

- G.I. pipe 12.7mm dia. - 5 m
- G.I. bend 12.7mm dia. - 2 Nos.
- C.I.cover hinged to C.I. frame 300 mm square - 1 No.
- G.I. pipe 19mm dia. - 1 m
- G.I.pipe 38mm dia. having 12mm dia. holes - 2.5 m
- Reducer 38 x 19 mm - 1 No.
- Funnel with 19mm dia. sleeve & wire mesh - 1 No.
- G.I.nut for 19mm dia. sleeve & wire mesh - 1 No.
- G.I. check-nuts for 19mm dia. G.I.pipe - 4 Nos.
- G.I.washer 40mm with 19mm hole - 1 No.
- G.I. wire No.8 SWG - 10 m
- Copper lug 200 amps with 19 mm dia. hole - 1 No.
- Solder 60/40 - 100 gms.
- Matchbox - 1 No.
- Soldering paste - 10 gms.
- Cement - 10 kgs.
- Blue metal chips 6mm size - 40 kgs.
- River sand - 80 kgs
- Salt (common) - 3 bags
- Coke or charcoal - 3 bags

PROCEDURE

1 Collect G.I.pipes and the accessories.

2 Make a slant cut of 30° in the 38mm dia. G.I.pipe to have sharp edge as shown in Fig 1.

3 Make threads in the other end of 38mm dia. G.I.pipe to a length of 25mm.

4 Make threads in both ends of 19mm dia. G.I.pipe to a length of 25mm on one side and 75mm on the other side.

5 Fabricate the 38mm and 19mm dia. G.I. pipes as shown in Fig 1.

6 Select an earth pit site atleast 1.5 metres away from the building foundation.

An earth electrode should not be installed in proximity to a metal fence to avoid the possibility of the fence becoming live. If the metal fence is unavoidable, it should be earthed.

7 Dig an earth pit of dimensions 1 m width x 1 m breadth x 3.75 m depth.

8 Place the fabricated pipe in an upright position as shown in Fig 1 and position the pipe with the help of bamboo sticks.

9 Place the wooden box around the pipe and fill it to a height of about 15cm with charcoal, and fill the sorrounding outer space of the box with soil.

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It is difficult to dig a pit 150mm square. A pit of dimension 1 metre square is therefore suggested to be dug. The area sufficient to be filled with salt and charcoal is about 150mm square. Hence fill the surrounding extra area with the soil which was taken out earlier.

10 Lift and place the wooden box above the coke layer. Fill up with salt to a height of about 15cm and to an area of 150 x 150mm area around the pipe.

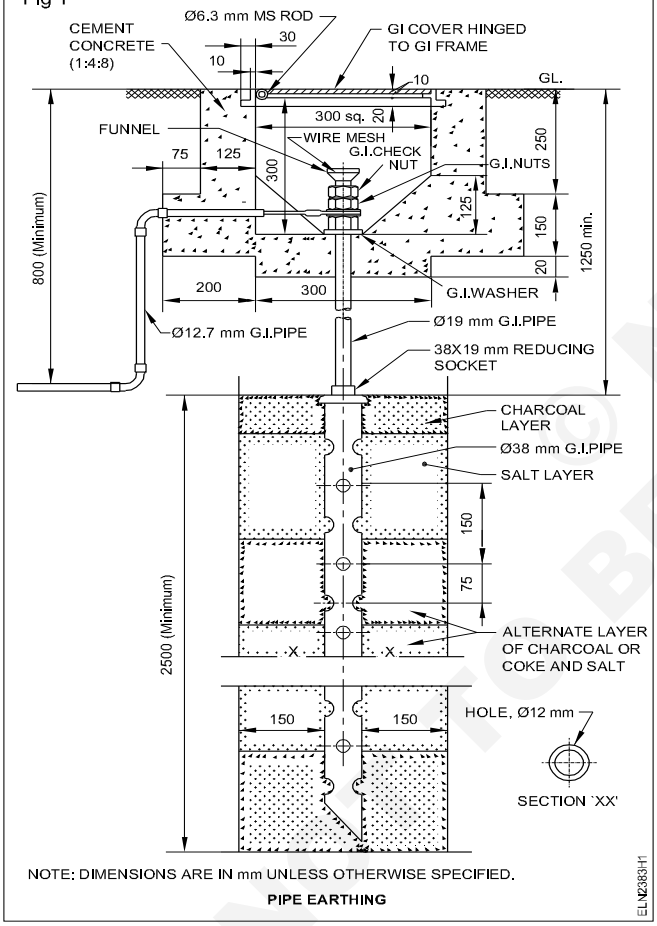
Fill up the surrounding area with soil.

11 Repeat the above steps 10 and 11 up to 2.5 metres as shown in Fig 1.

12 Place the G.I.pipe 12.7 mm dia. meter with G.I. bends in proper position for E.C.C. connection.

13 Prepare the concrete mixture and build the structure as shown in Fig 1.

Fig 1



14 Fix the G.I. cover also.

Atleast allow one day for curing the concrete structure. Pour water every 2 hours. (A wetted gunny sack will hold the moisture for several hours.)

15 Insert the G.I.wire No.8 SWG through the 12.7mm dia. G.I.pipe.

The size of the earth wire depends upon the incoming supply cable size.

16 Use the ladle and the blowlamp and melt the solder.

17 Solder the lug in the G.I. wire.

18 Insert the lug in the 19mm dia. G.I.pipe and tighten it with the G.I.nut and check-nut.

19 Pour three or four buckets of water through the funnel.

Allow an hour for the water to be absorbed in the earth.

20 Test the earth electrode resistance with an earth Megger.

The earth continuity conductor (E.C.C.) should not be connected to the earth electrode while measuring the earth electrode resistance.)

21 Enter the value of the earth electrode resistance in Column 5 of Table 1. Fill up the other particulars also. The acceptable value of the earth electrode resistance has been given earlier. Check the value if it.

22 Check the value of the earth resistance is found higher than the acceptable value, make one more pipe earth electrode at a distance of 8 metres from the earlier one and connect both of them in parallel.

23 Measure the earth electrode value and enter it in Column 6 of Table 1.

The second reading with two electrodes will be approximately half the first reading which was taken with one electrode. The measured value should be within the recommended value.

24 Get it checked with your instructor.

Table 1

Sl.No.	Date	Climate	Earth electrode Location	Earth resistance in ohms		Remarks
				Single	Double	
1	2	3	4	5	6	7

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Prepare plate earthing and measure earth resistance by earth tester / megger

Objectives: At the end of this exercise you shall be able to
- **prepare the plate for earthing according to ISI standard**
- **prepare the earthing pit in ground according to required standard**
- **install the plate in earthing pit**
- **test the earthing and measure the earth resistance using earth tester / Megger.**

Requirements

Tools/Instruments

- G.I. die stock with 12.7 mm, 19mm and 38mm die - 1 Set
- D.E. spanner set 6mm to 25mm - 1 Set
- Blowlamp, 1 Pint - 1 No.
- Crowbar38mmx 1800mm long - 1 No.
- Spade 300mm x150mm - 1 No.
- Cement mortar tray - 1 No.
- Tongs 300mm - 1 No.
- Hacksaw frame with 24 TPI blade - 1 No.
- Pipe wrench 50mm - 1 No.
- Soldering pot with ladle - 1 No.
- Combination pliers 200mm - 1 No.
- Measuring tape 5m - 1 No.
- Sledge Hammer 2 Kg. - 1 No.

Equipment/Machines

- Earth tester with spikes and connecting lead - 1 Set

Materials

- G.I. plate 600mmx600mmx63mm - 1 No.
- G.I. pipe 12.7mm dia. - 5 m.
- G.I. pipe 19mm dia. - 1 m.
- C.I.cover hinged to C.I. frame 300mm square - 1 No.
- Funnel with 19mm dia. sleeve & wire mesh - 1 No.
- G.I.nut for 19mm dia. sleeve & wire mesh - 2 Nos.
- G.I. check-nuts for 19mm dia. G.I.pipe - 2 Nos.
- G.I.washer 40mm with 19mm hole - 2 No.
- G.I. wire No.8 SWG - 10 m
- Copper lug 200 amps with 19mm dia. hole - 1 m
- Solder 60x40 - 100gms.
- Soldering paste - 10 gms.
- Matchbox - 1 No.
- Cement - 10 kgs.
- Blue metal chips 6mm size - 40 kgs.
- River sand - 80 kgs.
- Charcoal or coke - 5 kgs.
- CommonSalt - 5 kgs.

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PROCEDURE

TASK 1: **Prepare the plate for earthing according to ISI standard**

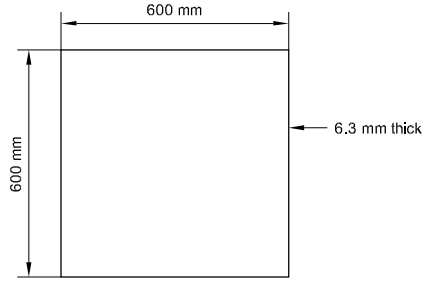
1 Collect G.I plate and accessories for earthing

2 Mark thread on one side of 19mm dia GI pipes to a length of 25mm

3 Fabricate GI plate as shown in Fig 1 600mmx600mm square plate with a thickness of 63mm

4 Fabricate 19mm dia G.I pipe as shown in Fig 2

Fig 1



TASK 2 : **Prepare the earthing pit in ground as per standard**

1 Select an earth pit site atleast 1.5meters away from the building foundation

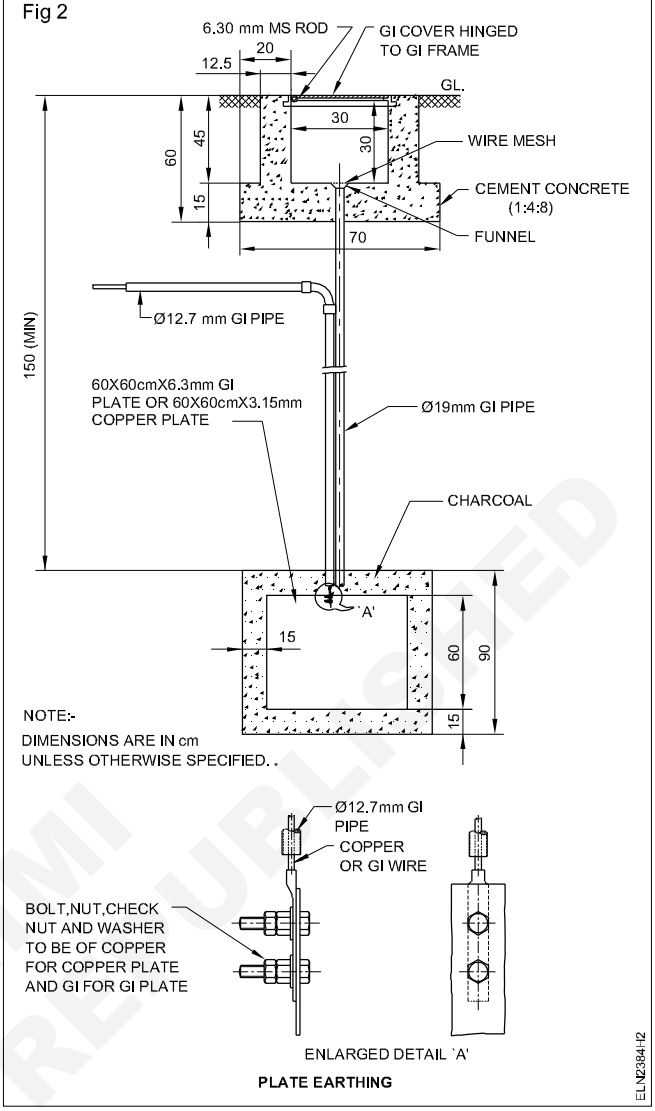
An earth electrode should not be installed is proximity to a metal fence to avoid the possibility of the fence becoming live.

2 Dig an earth pit of dimensions 1m width x 1m breadth x2.5m depth

The depth given here is the minimum recommended. However the depth may be increased till moist soil is reached

3 Fabricate G.I pipe 12.7mm diameter with GI bonds in proper position and insert the G.I wire missing through GI pipe by soldering lug at external and fix GI plate with bolt and nut as shown in (Fig 2)

Fig 2



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TASK 3 : **Install the plate in earthing pit already prepared**

1 Place the fabricated 19mm GI plate in an upright position as shown in fig 2 and position the pipe with the helps bamboo sticks

2 Place the wooden box around the plate and fill it to a height of about 15cm with charcoal and fill the surrounding outer space of the box with soil.

It is difficult to dig a pit 150mm square .A pit of dimension 1 meter square is therefore suggested to be dig. The area sufficient to be filled with salt and charcoal is about 150mm square. Hence fill the surrounding area with the soil which was taken out earlier

3 Lift and place the wooden box above the coke layer and fill up with salt to a height of about 15cm and to an area of 150x 150mm area around the pipe.

Fill up the surrounding area with soil.

4 Prepare the concrete mixture and build the strcuture as shown in figure 2.

5 Fix the GI core with the plates

At least allow one day for curing the concrete structure. Pour water every 2 hours (A wetted gunny is a act will hold the moisture for several times.

6 Pour three or four buckets of water through the funnel to the earth pit

Allow an hour for the water to be obsorbed in the earth.

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TASK 4 : **Test the earthing and measure the earth resistance using earth tester**

1 Test the earth electrode resistance with an earth tester.

2 Record the earth electrode resistance.

If the earth resistance is found higher than the acceptable value, make one more plate earth electrode at a distance of 8 meters from the earth in one and connect both of them in parallel

3 Measure the resistance of earth electrode value and record

The second reading with two electrodes will be approximately half the first reading which was taken with one electrode. The measured value should be with in the recommended value. If not have an another earth electrode may be distance of 8 meters from the other electrodes.

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Test earth leakage by ELCB and relay

Objectives: At the end of this exercise you shall be able to
- **identify the terminals of ELCB**
- **connect the ELCB in an Power circuit and test its functioning**
- **measure the leakage current at which ELCB trips off.**

Requirements

Tools/Instruments

- Cutting plier 150mm - 1 No.
- Screw driver 150mm - 1 No.
- Electrician's knife 100 mm - 1 No.
- Wire stripper 150 mm - 1 No.
- Ammeter MI (0 - 10A) - 1 No.
- Ammeter MI (0 - 100mA) - 1 No.
- Philips star screw driver 100 mm - 1 No.

Equipments

- ELCB 240V, 25A, 2 pole with Tripping leakage current 30mA - 1 No.
- MCB 240V, 10A, 2 pole - 1 No.

Materials

- 10KW 1W wire wound variable resistor - 1 No.
- 5KW 1W fixed resistor - 1 No.
- Pushbutton switch 250V, 6A - 1 No.
- Water rheostat - 1 No.

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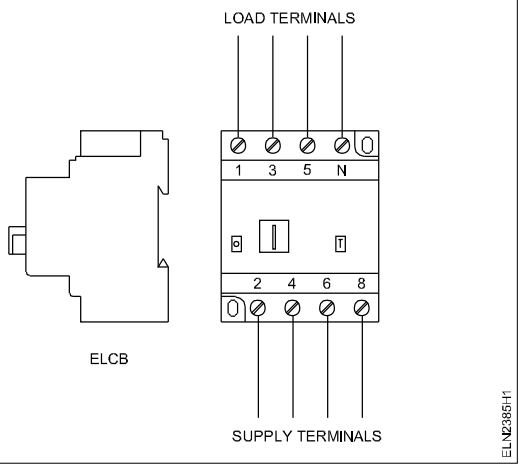
PROCEDURE

TASK 1 : **Identify the terminals of ELCB**

1 Collect the ELCB from your instructor and read the specification given on it.

Identify the supply terminals and load terminals referring the marking on the unit as given in Figure 1.

Fig 1



TASK 2 **: Connect and test the operation of ELCB**

1 Wire up the circuit as shown in the circuit diagram. (Fig 2)

2 Switch on the main supply keeping the MCB and ELCB in ON position.

3 Close switch S_1 and operate the water rheostat till the ammeter 'A' reads about 5 A current.

Keep variable resistance in full cut in position.

4 Press the test switch and vary the variable resistance and note the leakage current and record

_____

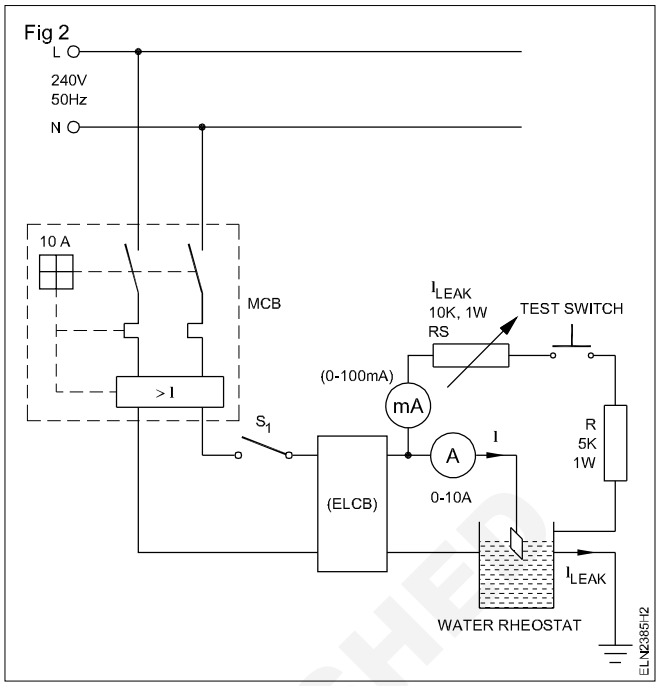
5 Record the leakage current at which the ELCB trips off

_____

6 Open the external test switch and reset the ELCB.

7 Test ELCB for ‘Trip function’ by operating the ‘Test button’. In this case the ELCB must trip off when the button is pressed.

Fig 2



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Install light fitting with reflectors for direct and indirect lightings

Objectives: At the end of this exercise you shall be able to
- **design the light reflectors to a given room according to working situation**
- **install and check the effect of light reflection.**

Requirements

Tools/Instruments

- Cutting plier 200mm - 1 No.
- Screw driver 150mm - 1 No.
- Drilling machine electric 6 mm capacity with drill bit - 5 mm - 1 No.

Materials

- Incandescent lamp 100W 240V with lamp shades of similar design - 2 No.
- Reflector lamp 100W 240V - 2 No.
- Silvered bowl lamp 100W 240 - 2 No.
- Wiring materials - as reqd.

PROCEDURE

1 Identify the loaction and working situation, for light reflectors.

2 Carry out the marking for fixing the two ceiling roses at close proximity.

3 Carry out the wiring as per the circuit.

4 Check the wiring with a series test board.

5 Hang one lamp shade to face down, and one lamp shade up side down as shown in Fig 1 with suitable strings.

6 Fix similar type (incandescent) bulbs in both the shades.

7 Keep some display articles just beneath the lamp shades on a table.

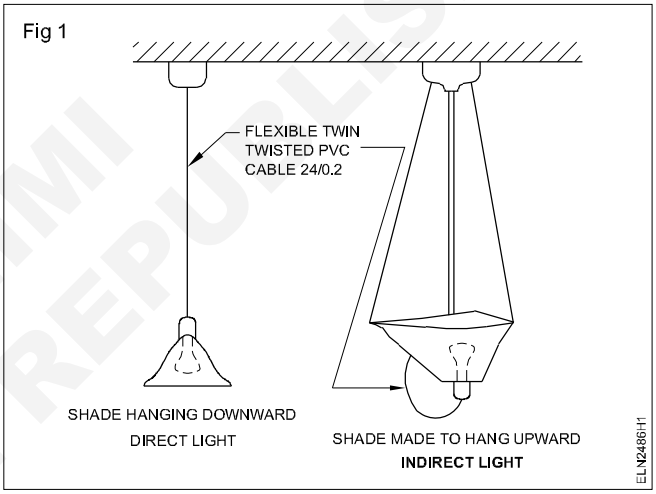
8 Give the supply and check the lighting emitted by direct and indirect lights one by one.

9 Check the illumination of the lighting emitted by direct and indirect lights one by one.

10 Change the bulbs of similar variety (say reflector type) of same wattage in the shades and repeat the steps 8 and 9.

11 Write the conclusion based on the illumination level and suitability of direct and indirect lighting of displaying mercantize.

Fig 1



Conclusion :

_____

_____

_____

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Group different wattage lamps in series for specified voltage

Objectives: At the end of this exercise you shall be able to
- **read and interpret the data stamped on a given lamp**
- **measure the voltage drop across the lamp when unequal wattage lamps are connected in series to the supply**
- **state the reasons for the behaviour/condition of glow of unequal wattage lamps in series.**

Requirements

Tools/Instruments

- Multimeter - 1 No.
- Voltmeter MC 0-15V - 3 Nos.
- Ammeter MC 0-500 mA - 1 No.

Equipment/Machines

- DC variable source 0-24 volts, 5 amps with output current & voltage indicator - 1 No.

Materials

- Bulbs screw cap - 6V 100 mA - 10 Nos.
- Bulbs screw cap - 6V 150 mA - 6 Nos.
- Bulbs screw cap - 6V 300 mA - 4 Nos.
- Bulb-holders - 20 Nos.
- Connecting leads - as reqd.
- Knife switch DPST 16A - 1 No.

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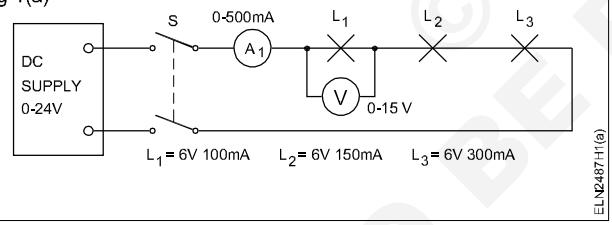
PROCEDURE

TASK 1 : **Connect 3 lamps of 6 volts in series across 18 volts supply (unequal wattage) and test it**

1 Connect the three lamps with ammeter A in series to the variable voltage DC supply source Fig 1a.

Fig 1(a)



Keep the output of DC source at minimum, say 0 volts.

2 Connect a MC voltmeter (0-15 V) across L_1 (i.e low current rating/low wattage bulb). Close the switch S.

3 Gradually increase the supply voltage from 0 volts, observing ammeter, voltmeter and lamp L_1.

4 Increase the voltage upto 18 volts. Record your observations.

_____

_____

_____

5 Does the lamp L_1 fuse? If yes, give your reasons, stating the observation made just before fusing.

_____

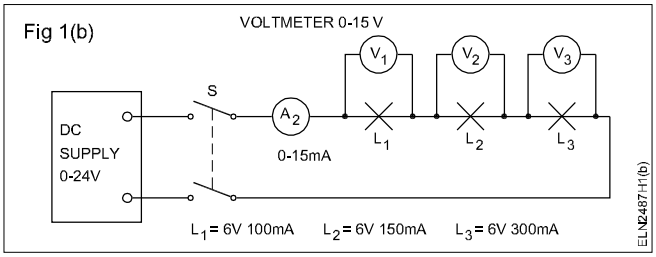
_____

_____

6 Open the switch S and reset the supply voltage to OV. Replace the bulb L_1.

7 Form the circuit Fig 1(b) with 3 voltmeters 0-15 volts connected across each lamp.

Fig 1(b)



8 Close the switch S and increase the supply voltage until the current reaches 100 mA., (i.e. rated current of low wattage bulb in the series circuit).

9 Read the voltages V_1, V_2 & V_3 and record in Table 1.

Table 1

Supply Voltage	V_1	V_2	V_3

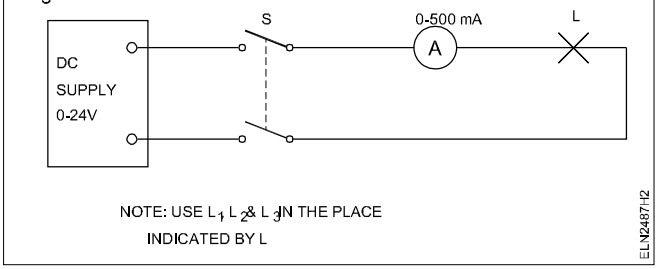
10 Give your reasons for the unequal distribution of supply voltage.

11 Connect each lamp L_1, L_2 & L_3 independently in the circuit Fig 2 and record the value of current and voltage when the supply voltage is 6 V in Table 2.

Table 2

Lamp in circuit	Supply voltage	V	I	V/I
L_1 6 V 100 mA	6 V			
L_2 6 V 150 mA	6 V			
L_3 6 V 300 mA	6 V			

Fig 2



Conclusion

The voltage across each of the lamps connected in series varied because of

_____

_____

_____

The stamped value of voltage and current on the lamp means that the specified _____ when applied will cause a _____ to flow.

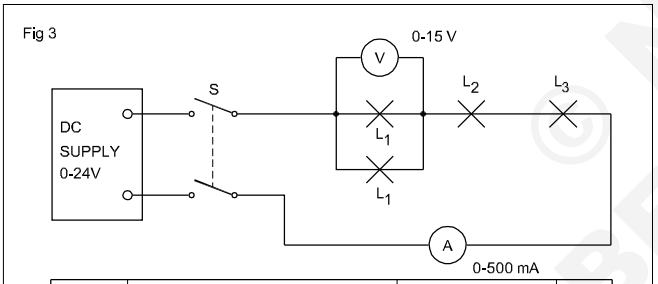
Resistance of lamp varies because of different _____ of lamp.

— — — — — — — —

TASK 2 : **Connect two low wattage L_1 lamps in parallel as in Task 1 and test it**

1 Form the circuit as per the diagram, Fig 3.

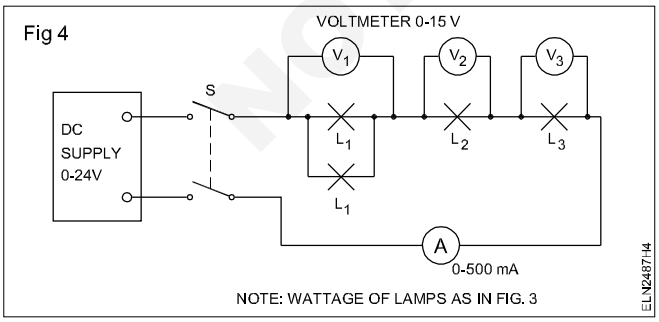
Fig 3



L_1	MINIATURE LAMP	6V,100mA	2
L_2	MINIATURE LAMP	6V,150mA	1
L_3	MINIATURE LAMP	6V,300mA	1

2 Observe the effect of increasing the supply voltage from 0 to a value that causes 6 volts across low wattage lamps L_1.

Fig 4



3 Does the lamp L_2 fuse? If yes, give your reasons stating observations made just at the time of L_2 fusing.

_____

_____

_____

4 Open the switch S, connect the 3 voltmeters as shown in Fig 4.

5 Replace the lamp L_2 and reset the DC source at OV. Close the switch S. Increase the supply voltage until a current of 150 mA flows in the circuit.

6 Read and record the voltages V_1, V_2 & V_3 in Table 3.

Table 3

Supply Voltage	V_1	V_2	V_3

Conclusion

The voltage is V_2 is greater than V_1. Also $V_2 > V_3$, because

_____

_____

_____

— — — — — — — —

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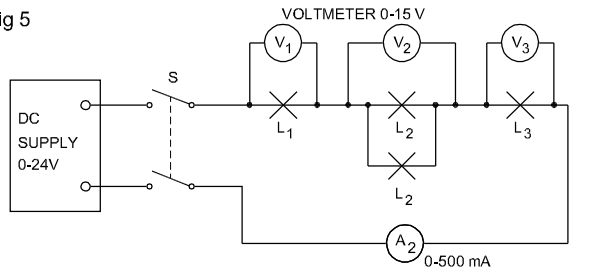
TASK 3 : **Connect two (L_2 lamps) in parallel as in task 1 and test it**

1 Form the circuit as shown in Fig 5.

Fig 5



L_1	MINIATURE LAMP	6V,100mA	1
L_2	MINIATURE LAMP	6V,150mA	2
L_3	MINIATURE LAMP	6V,300mA	1

ELN2487-H5

2 Gradually increase the supply voltage up to 18V after closing the switch S. Observe the voltage V_1, current and glow of lamp L_1.

3 Does the lamp L_1 fuse again? What are the conditions at the time of fusing?

_____ V_1
_____ DC supply voltage
_____ current

4 Is there any difference in the values as compared with the one in Task 1? Give your response.

5 Open the switch S. Replace the fused lamp L_1. Reset the supply voltage to 0V. Close the switch S and increase the current through the circuit to 100 mA. Record the voltages V_1, V_2 & V_3 in Table 4.

Table 4

Supply Voltage	V_1	V_2	V_3

Conclusion

_____

_____

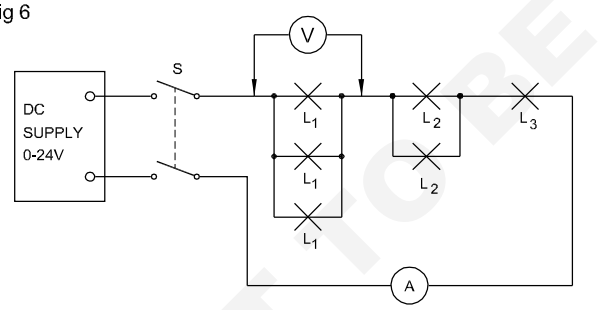
_____

— — — — — — —

TASK 4 : **Connect three L_1 lamps connected in parallel and the whole in series with one lamp L_3 two L_2 lamps in parallel as in task 1**

1 Form the circuit as shown in Fig 6.

Fig 6



L_1	MINIATURE LAMP	6V,100mA	3
L_2	MINIATURE LAMP	6V,150mA	2
L_3	MINIATURE LAMP	6V,300mA	1

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2 Close the switch S. Increase the supply voltage gradually to 18 V. Observe the lamps, ammeter and measure the voltage across the lamp group L_1, lamp group L_2 and L_3.

3 Now all the lamps glow with their normal brightness. No lamp fused. Why?

_____

_____

_____

Conclusion

In a serial set of lamps, while replacing a fused lamp the lamps voltage and also _____ or _____ should also _____ wattage lamp, replacement should be

— — — — — — — —

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Practice installation of various lamps eg. fluorescent tube, HP mercury vapour, LP mercury vapour, HP Sodium vapour, LP Sodium vapour, Metal halide etc.

Objectives: At the end of this exercise you shall be able to
- **connect a flourescent tube with accessories, install and test it**
- **connect a H.P. M.V lamp with acccessories, install and test it**
- **connect a H.P.S.V lamp with accessories install and test it**
- **connect a L.P.S.V lamp with accessories install and test it**
- **connect a metal halide lamp with accessories install and test it.**

Scan the QR Code to view the video for this exercise

Requirements

Tools/Instruments

- Insulated combination plier - 150 mm - 1 No.
- Insulated screwdriver - 200 mm x 4mm - 1 No.
- Insulated connector screw driver - 100 mm - 1 No.
- Long round nose plier - 150 mm - 1 No.
- D.B. Electrician's knife 100 mm - 1 No.
- Test lamp 100 W, 250 V - 1 No.

Materials

- Tube light fitting 1200 mm - single patti - 1 No.
- Choke 40w, 250V - 1 No.
- Tube light starter - 40W,250V - 1 No.
- Tube light holder plain - 2 Nos.
- Starter holder - 2 Nos.
- MV lamp holder suitable for 240W, 250 V lamp (Goliath screw type) single patti - 2 Nos.
- MV lamp choke - 240 Watts, 250 V - 1 No.
- Capacitor 4 MFD / 380 U - 1 No.
- L.P.M.V lamp 40 W, 250 V - 1 No.
- MV lamp 240W, 250V - 1 No.

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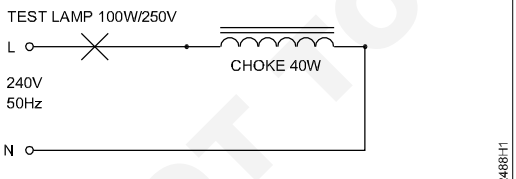
PROCEDURE

TASK 1: **Assembling of a fluorescent lamp (LPMV lamp) with its accessories**

1 Check the choke for its short and open with a test lamp as shown in Fig 1.

Fig 1



TEST CIRCUIT

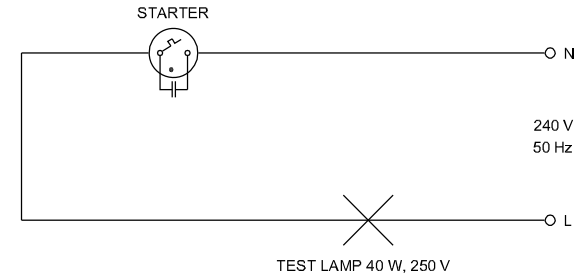
2 Check the starter with a series test lamp as shown in Fig 2. Observe the flickering of the lamp which indicates good condition of the starter.

3 Assemble the following fluorescent tube accessories in the fitting base. Refer to the sketch. (Fig 3)

1) Holders for tube 2) Starter-holder 3) Choke.

4 Connect the accessories as shown in Fig 4 (for a single tube light). Also install the tested starter.

Fig 2



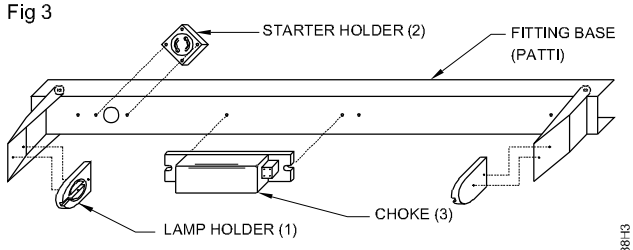
TESTING OF STARTER

5 Test the filament on both sides of the fluorescent tube for its continuity as shown in Fig 5. Discard the fluorescent tube with open or fused filament in either side.

6 Fix the bulb in the holder.

Firstly, you have to make sure that the slot in the inner parts of the holder is turned to the proper position.

Fig 3



ASSEMBLY OF ACCESSORIES

Fig 4

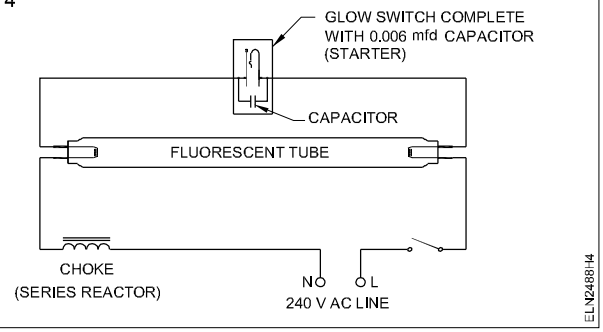
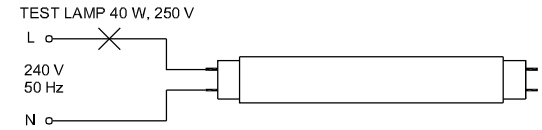


Fig 5



TESTING THE TUBE

7 Test the tube light assembly for its working.

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TASK 2 : **Installation of tube light fitting**

1 Follow the recommended method and procedure depending on the type of wiring.

The fixing of the tube to the wall, ceiling or tubular post should be strong enough to support the weight of the fitting.

The installed fitting must be below the level of the ceiling fan to avoid the flickering effect of the shadow.

2 Connect the tube light fitting to the ceiling rose.

Check the supply at the ceiling rose. Switch off the supply before making any connection.

3 Fix the fluorescent tube in the fitting.

Use a stable ladder and a helper to hold the ladder while you are working on the ladder.

4 Switch `ON' the supply and observe the glow of the tube. If the tube is not glowing, check for proper housing of starter and tube.

— — — — — — — —

TASK 3 : **Install and test the H.P.M.V (High Pressure Mercury Vapour) lamp with accessories**

1 Read the specification of the mercury vapour lamp and the choke from the markings. (Fig 6)

2 Connect the H.P.M.V. lamp in series with the 60W 240V bulb and test in 240V AC supply. Check whether the series test lamp glows.

3 Test the choke for its working condition.

4 Assemble the accessories (choke, holder and capacitor) in the fitting, following the manufacturer's instructions.

5 Connect the accessories as per circuit diagram, Fig 7 (Pictorial diagram Fig 8) using the recommended type of termination.

Choose the tapping of the choke suitable to the rated supply system voltage.

6 Fix the bulb in the holder and test the working of the lamp with the supply voltage.

Ensure the fitting is properly earthed at the earthing terminal provided, before testing.

7 A modern M.V. lamp with a built-in resistor needs no external accessories to be connected as discussed above. It can be connected as we do an incandescent lamp.

Installation of the M V lamp fitting

8 Assemble, connect and test the M.V. lamp fitting on a table, for its working. Then remove the cover and bulb.

Mount at the location

9 Observe the recommended method and procedure specified by the manufacturer in the installation leaflet.

Do not alter the specifications recommended by the manufacturer because it should be strong enough to support the weight of the fitting.

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Fig 6

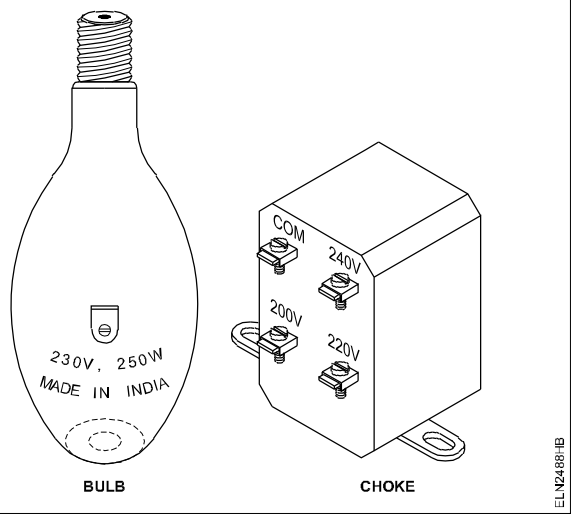
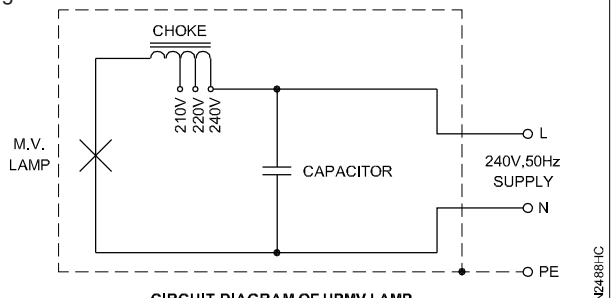


Fig 7



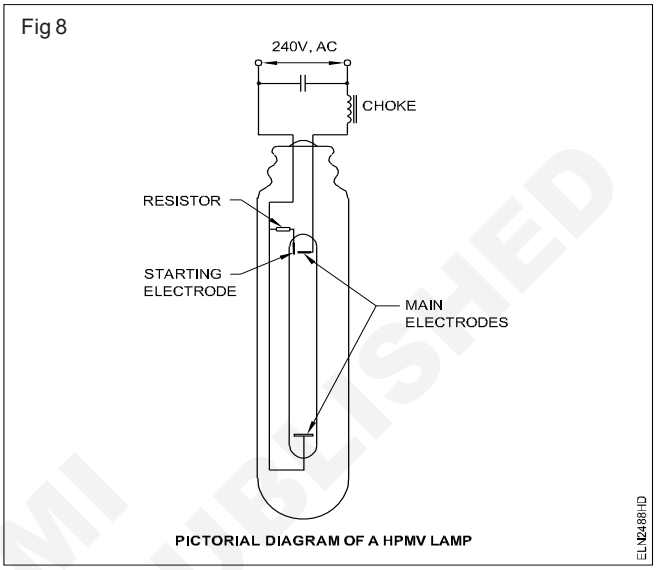
10 Connect the M.V. lamp fitting to the supply. The method depends on the system of wiring, location of fitting etc.

Ensure that the supply line is dead (not live), before making the connections.

11 Fix the bulb in the holder securely and refit the cover.

12 Switch on the supply and wait until the high pressure mercury vapour lamp glows with its full brightness. then switch off the supply.

Fig 8



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TASK 4 : I**nstall and test H.P.S.V. (High Pressure Sodium Vapour) and LPS lamp with accessories**

1 Read the specification from the markings on the leak transformer, choke and bulb.

2 Check the transformer and choke with a test lamp for shorts and open.

3 Assemble the accessories (choke, leak transformer and lamp-holder) in the fitting.

Follow strictly the manufacturer's instructions.

4 Give connections as per diagram shown in Fig 9.

Use the recommended type of termination only.

5 Choose the appropriate voltage tapping suitable to the supply voltage. (Fig 9)

6 Fix the bulb in the holder.

Ensure the fitting is properly earthed.

7 Test the working of the assembled fitting by connecting it to the mains.

8 Note the time taken for the bulb to give full illumination.

9 Repeat the above steps for a high pressure sodium vapour lamp. Connect as per the diagram shown in Fig 10.

Fig 9

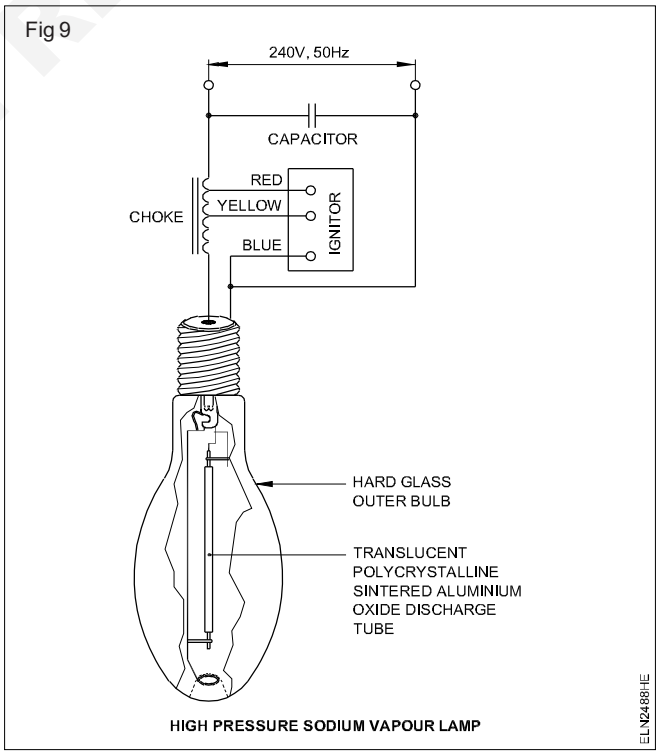
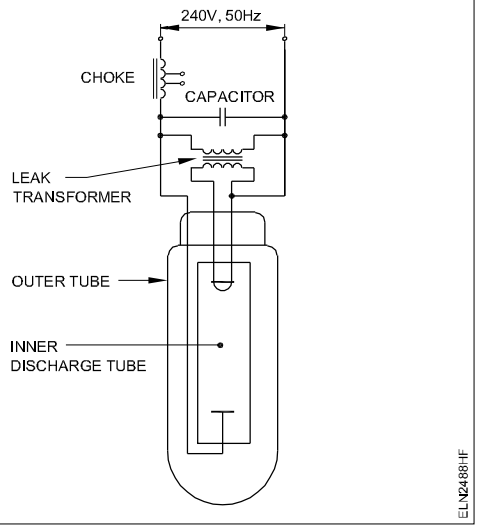


Fig 10



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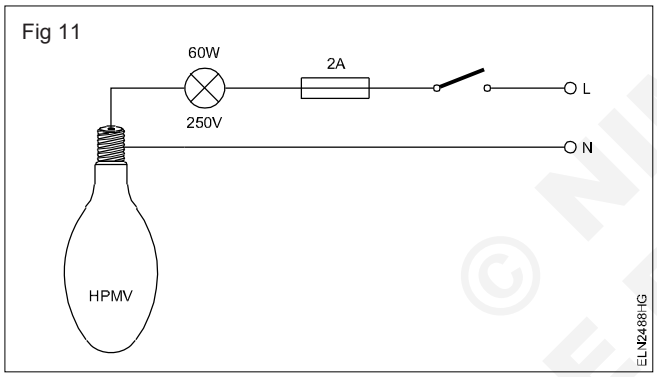
TASK 5 : **Testing of High prssure metal Halide**

1 Read the specifications of the given Halide lamp as Fig 11 collect the required accessories.

Fig 11



2 Connect the HPMH lamp in sries with a 60W. 250V incandescent amp as shown in fig. 11 and test with 240V AC supply. Check whether the series test lamp glows. If the test lamp flows it means that HPMV lamp in good codition.

3 Connect as the circuit diagram and test with 240V supply.

4 Measure the current and test with 240V supply.

Measure the current and voltage. Calculate the power and verify with the rated values.

Voltage :_____Volt

Current : _____Amp

Power : _____Watt

— — — — — — — —

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Prepare a decorative lamp circuit to produce rotating light effect/ running light effect

Objectives: At the end of this exercise you shall be able to
- **select lamps/sequential control for light decoration**
- **design lighting layout for running light**
- **design layout for rotating light**
- **connect the motor for 3-point running light (sequential control motor)**
- **connect lamp circuits in the electronic sequential controller.**

Requirements

Tools/Instruments

- Multimeter - 1 No.

Equipment/Machines

- Single phase motor FHP with reduction gear - 1 No.
- 240V operation output load 5 to 10 A with speed and intensity control - 2 Nos.

Materials

- Cams - 3 Nos.
- Brushes - 3 Nos.
- Connection leads flexible - as reqd.
- Cam drive arrangement with shaft - 1 No.
- Lamps 240V, 15W, BC - 54 Nos.
- Batten Lamp holder 6A, 250 V - 54 Nos.
- DPST knife switch 16A 250V - 2 Nos.
- Electronic sequential controller - 1 No.

PROCEDURE

TASK 1 : **Prepare a rotating**

1 Connect the lamps, switches and the flasher motor. (Fig 1).

2 Keep the D.P.S.T switches S_1 & S_2 Open.

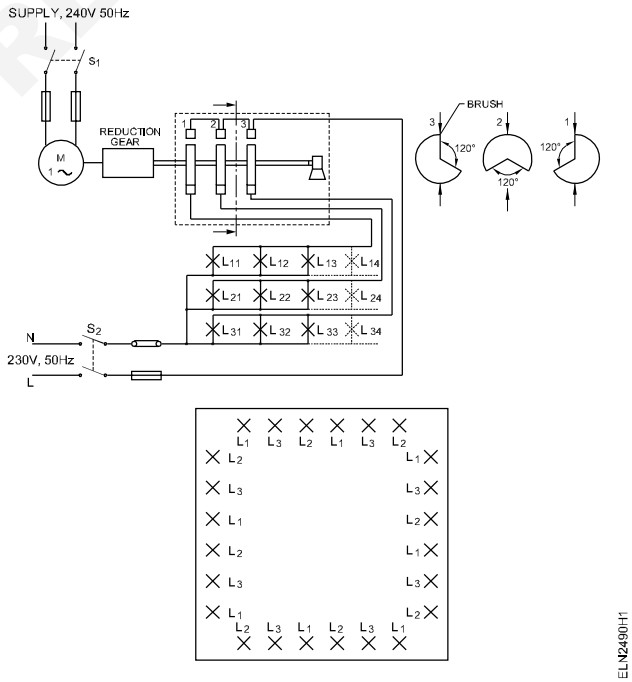
3 Close the D.P.S.T switch S_1 and start the flasher motor (sequential light controller.

4 Close the D.P.S.T Switch S_2 and observe the make and break contacts 1,2,3 and "ON" "OFF" operations of the 3 lamp banks.

Do not touch live wires

6 Open the D.P.S.T. switch S_1 and S_2

Fig 1



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TASK 2 : **Prepare a running light effect**

1 Prepare the lighting design as shown in Fig 2.

2 Close the D.P.S.T. switch S_1 and observe the lighting.

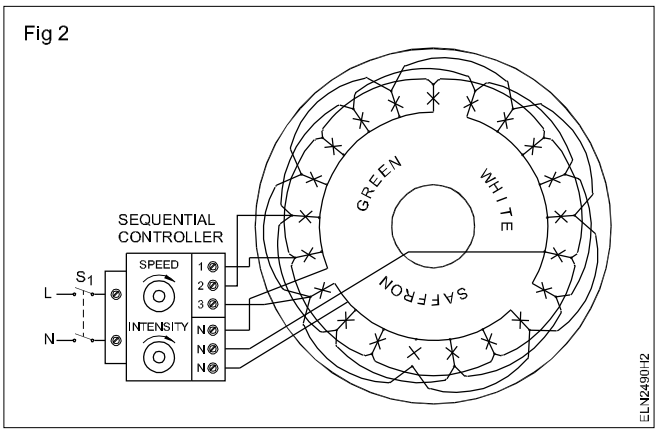
3 Increase the speed of operation by operating the speed control.

4 Adjust the intensity of light-adjusting the knob on the electric sequential controller.

5 Reduce the speed and intensity of the lighting system.

6 Open the D.P.S.T. switch S_1.

Fig 2



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Install light fitting for show case lighting

Objectives: At the end of this exercise you shall be able to
- **install and wire up the show case window lighting for tie rack**
- **wireup a show case window lighting to display clothes.**

Requirements

Tools and Instruments

- Insulated cutting pliers 150 mm - 1 No.
- Screw driver set of five - 1 Set
- Line tester 500V - 1 No.
- Electric hand drilling machine 6 mm capacity - 1 No.

Materials

- Complete set of circline tube light 30 cm 32 watts 250V 50 Hz with suitable shade and stand - 1 No.
- Complete set of 1200 mm fluorescent lamp fitting 40 watts 250V 50 Hz - 4 Nos.
- Wiring materials - as reqd.

PROCEDURE

TASK 1 : **Install and wire up the show case window lighting for tie rack**

1 Place a suitable sized plywood board in the base of the window with spacers.

2 Locate the circline tube fitting with its stand in proper position in the show case so that complete stand is visible from the window. Refer Fig.1.

3 Wire up in such a way that a 3 pin 5 amps socket is fitted in the inner side of the window.

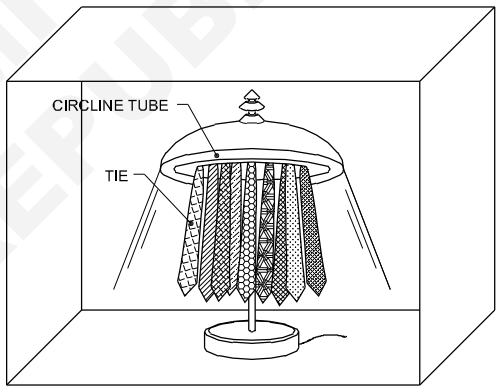
4 Mark the position of stand base and drill a hole in the marked centre to allow the circline tube cable to pass.

5 Draw the cable through the hole and connect a 3 pin plug at the cable ends.

6 Check the connections and connect the plug to the socket.

7 Give supply and check the lighting for the tie rack.

Fig 1



SHOWCASE WINDOW LIGHTING FOR TIE RACK

ELN2491H1

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TASK 2 : **Wire up the show case window lighting for a mannequin (dummy figure used for to display clothes)**

The show case needs four (400mm) tube light fittings to be wired in parallel and the tubes are hidden behind the frame. Refer Fig 2. Draw the connection diagram and wire up the fluorescent tubes in concealed wiring.

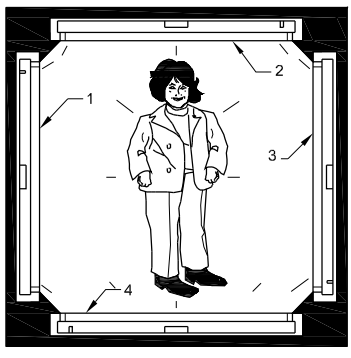
1 Prepare suitable frame for 4 tube light fittings which are to be hidden behind the frame (Fig 2)

2 Draw the connection diagram and wireup the 4 tube lghts in parallel.

3 Place the dummy figure at the centre used to display the clothes

4 Get the supply and check for its functioning.

Fig 2



1,2,3 AND 4 TUBELIGHTS
TUBES AND WIRING ARE CONCEALED IN THE FRAME

INDIRECT LIGHTING OF SHOWCASE WINDOW

ELN2491H2

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Practice on various analog and digital measuring instruments

Objectives: At the end of this exercise you shall be able to
- **connect various analog measuring instruments and measure electrical parameters**
- **connect various digital measuring instruments and measure electrical parameters.**

Requirement

Tools / Instruments

- MI voltmeter 0 - 500V (analog) - 1 No.
- Digital voltmeter 0 - 500V - 1 No.
- MI ammeter 0 - 30A (analog) - 1 No.
- Digital ammeter 0 - 30A - 1 No.
- Power factor meter 0.5 lag - 1 - 0.5 lead (Analog) - 1 No.
- Digital power factor meter - 1 No.
- Analog wattmeter 0-1500W - 1 No.
- Digital wattmeter 0-1500W - 1 No.
- Analog frequncy meter 45-55HZ - 1 No.
- Digital frequncy meter 45-55HZ - 1 No.

Equipment / Machines

- Squirrel cage Induction motor 3 phase, 440V, 5 HP - 1 No.

Materials

- Connecting leads - as reqd.
- TPIC switch 16A, 500V - 1 No.

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PROCEDURE

TASK 1: **Measure the value of current, voltage, power factor, power and frequency by connecting respective analog meters in the circuit**

1 Identify the analog type of voltmeter, ammeter , wattmeter power factor meter and frequency meter from the given Figure Nos. 3 to 13.

2 Verify the range of analog voltmeter, ammeter wattmeter, powerfactor meter and frequency meter.

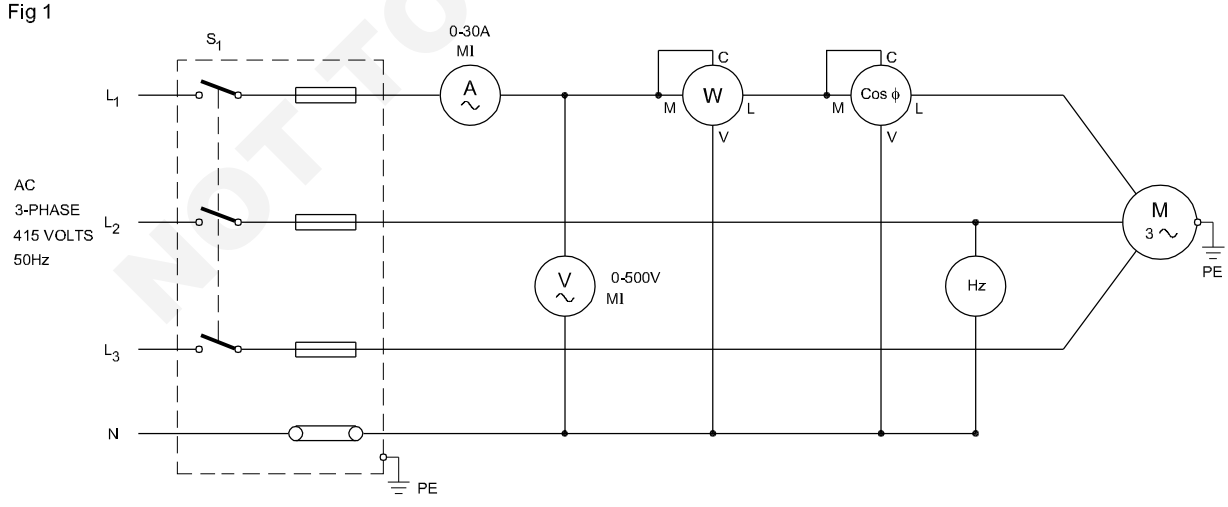
3 Connect the power supply with switch, fuse, analog meters and load as shown in Fig 1

4 Close the switch

5 Measure the corresponding values from the instruments and record the values in Table 1.

6 Switch off the Power Supply and disconnect the connection.

Fig 1



CIRCUIT DIAGRAM WITH ANALOG METERS

ELN2592-11

Table 1

Sl. No.	Meter	Reading
1	Voltmeter	
2	Ammeter	
3	Watt meter	
4	Power factor meter	
5	Frequency meter	

TASK 2 : **Measure the value of current, voltage, power factor, power and frequency by connecting respecitve digital meters in the circuit**

1 Identify the digital type of voltmeter, ammeter, wattmeter, power factor meter and frequency meter from the given figure nos. 3 to 13.

2 Verify the range of digital voltmeter, ammeter, wattmeter, power factor meter and frequency meter.

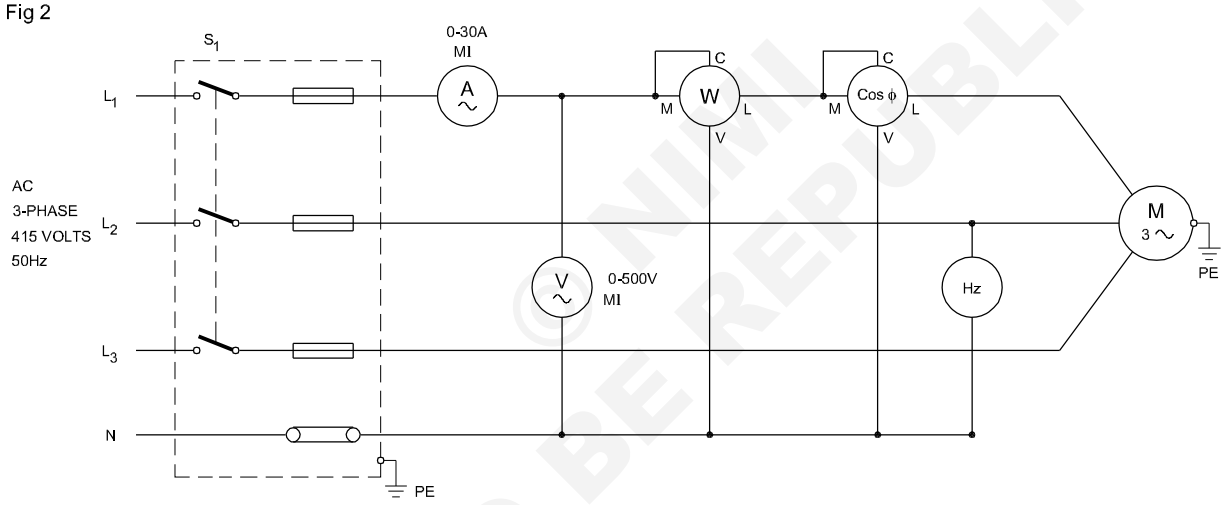
3 Connect the power supply with switch, fuse, digital meters and load as shown in Fig 2

4 Close the switch.

5 Measure the corresponding values from the instruments and record the values in Table - 2

6 Switch off the power supply and disconnect the connection.

Fig 2



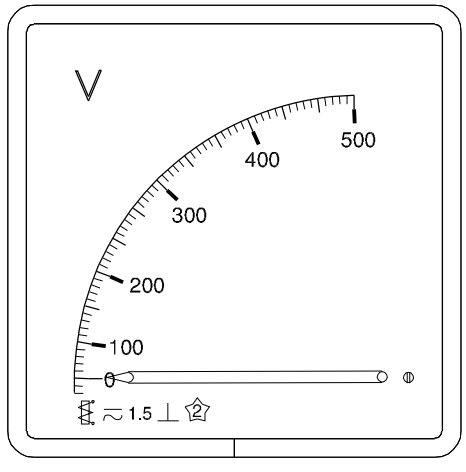
CIRCUIT DIAGRAM WITH DIGITAL METERS

ELN2592H2

Table 2

Sl. No.	Meter	Reading
1	Voltmeter	
2	Ammeter	
3	Watt meter	
4	Power factor meter	
5	Frequency meter	

Fig 3



ANALOG VOLT METER

ELN2592H3

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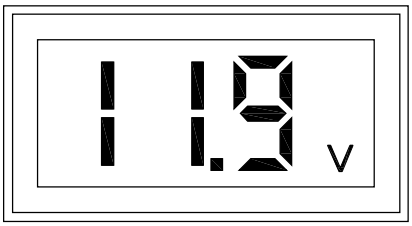
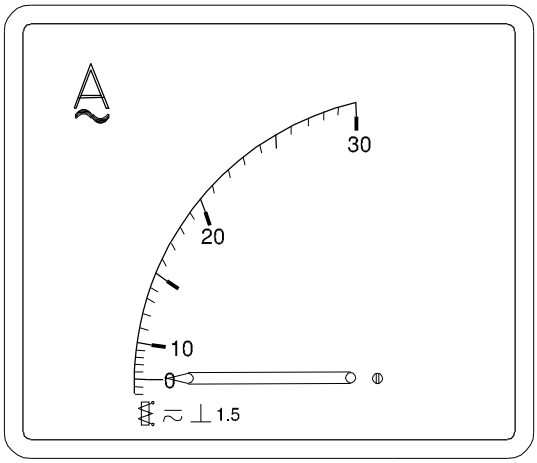
Fig 4



DIGITAL VOLT METER

ELN2592H4

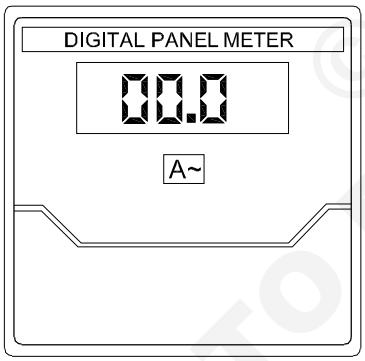
Fig 5



ANALOG AMMETER

ELN2592H5

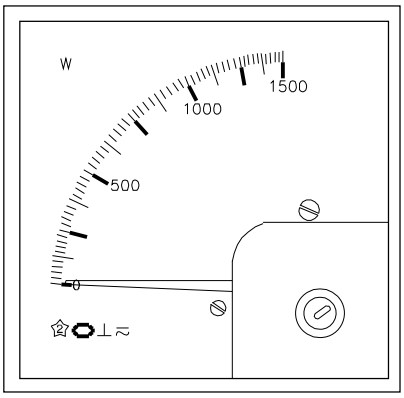
Fig 6



DIGITAL AMMETER

ELN2592H6

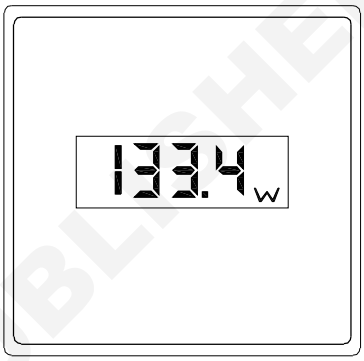
Fig 7



ANALOG WATT METER

ELN2592H7

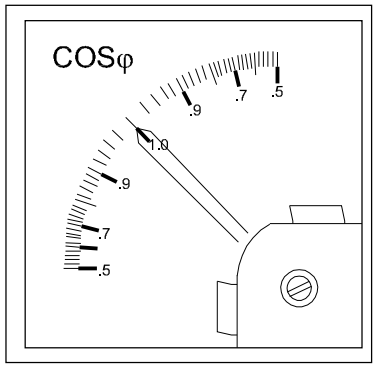
Fig 8



DIGITAL WATT METER

ELN2592H8

Fig 9



ANALOG POWER FACTOR METER

ELN2592H9

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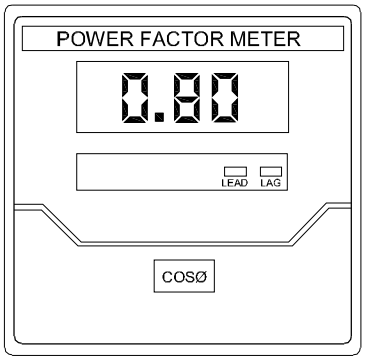
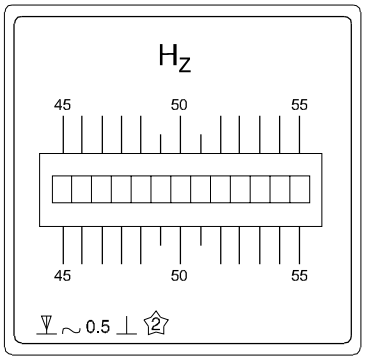
Fig 10



DIGITAL POWER FACTOR METER

ELN2592HA

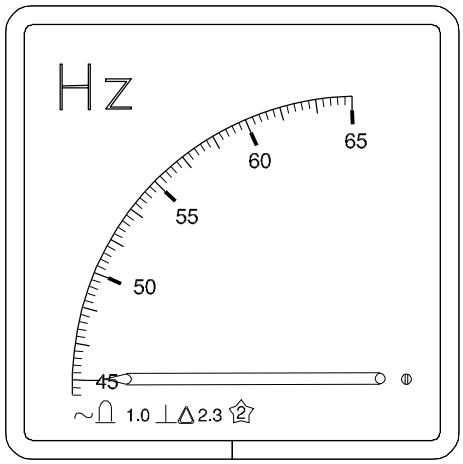
Fig 11



FREQUENCY METER

ELN2592HB

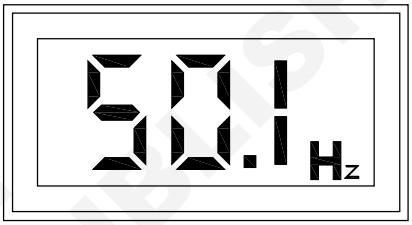
Fig 12



ANALOG FREQUENCY METER

ELN2592HC

Fig 13



DIGITAL FREQUENCY METER

ELN2592HD

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Practice on measuring instrument in single and three phase circuit eg. multimeter, wattmeter, energy meter, phase sequence and frequency meter etc.

Objectives : At the end of this exercise you shall be able to

- **connect voltmeter, ammeter, wattmeter, energy meter, frequency meter and power factor meter in single phase load**
- **connect voltmeter, ammeter, wattmeter, energy meter, frequency meter, power factor meter and phase sequence indicator in 3 phase balance load**
- **measure voltage, current, power, energy, frequency, power factor and record the values**
- **connect phase sequence meter to find the phase sequence.**

Requirement

Tools/Instruments

- Electrician Tool kit- 1 Set
- MI volmeter 0 - 300 v - 1 No.
- MI Ammeter 0 - 5 A - 1 No.
- wattmeter AC 0 - 1500 W - 1 No.
- Energy meter 3ϕ 4 15V - 1 No.
- power factor meter 0 -5 leg-1 - 1 No.
- Frequence of meter 0 - 50 Hz led - 1 No.

Equipment / Machines

- Lamp load 1000W - 1 No.

Materials

- Fuse carrier - 5A - 1 No.
- DPIC Switch 16A, 250v - 1 No.
- 14 SWG copper wire - 0.5 kg.
- Insulation tape 25 mm of 5 m - 1 roll
- 1.5 mm^2 pvc copper wire - 5 m
- TPIC switch 16A - 1 No.

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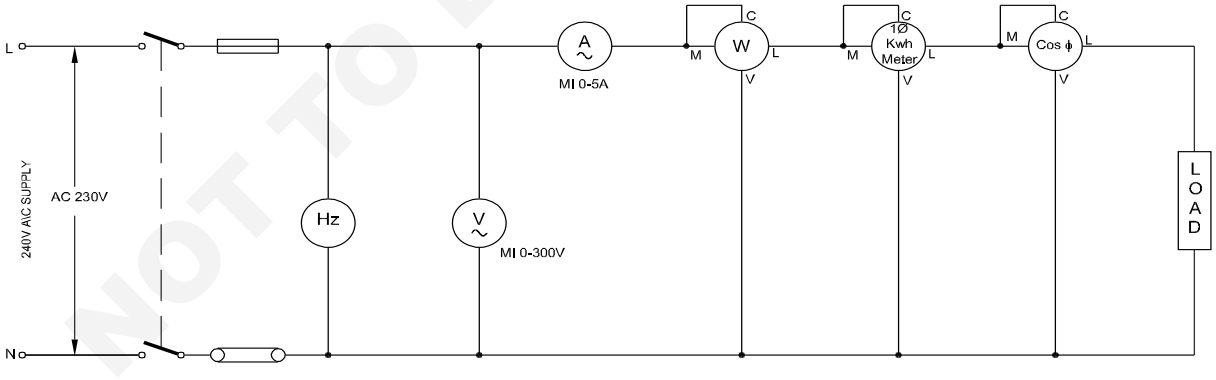
PROCEDURE

TASK 1 : **Connect voltmeter, ammeter, wattmeter single phase energy meter, power factor meter and frequence meter in single phase circuit**

1 Collect the required materials, meters and load.

2 Make necessary connections with meters and load as per circuit diagram (Fig 1)

Fig 1



The current coil of the wattmeter, energy meter and P.F meter must be connected in series with load. Provide 5 Amps fuse in the fuse carrier.

3 Get the circuit approved by the instructor.

4 Switch 'ON' the power supply and observe deflections of the meters.

If the wattmeter shows reverse direction interchange the connection of current coil

5 Note down the meter readings and enter in Table 1.

6 Switch "OFF" the power supply and disconnect the connection.

Table 1

Sl. No.	Ammeter reading (Amps)	Voltmeter reading (volts)	Wattmeter reading (watts)	Frequency meter (Hz)	Power factor meter (Cosϕ)	Energy meter (kwh)

— — — — — — — —

TASK 2 : **Connect voltmeter, ammeter, wattmeter, energy meter, frequency meter, power factor meter and phase sequence indicator in 3 phase circuit**

1 Collect the required materials, meters and load.

2. Make necessary connections with meters and load as per circuit diagram (Fig - 2)

The current coil of the wattnmeter, energy meter and P.F. meter must be connected in series with load. Provide 5 amps fuse in the fuse carrier.

3 Get the circuit approved by the instructor.

4 Switch 'ON" the power supply and observe deflections of the meters.

If the wattmeter shows reverse direction interchange the connection of current coil.

5 Find out the phase sequence of the 3 phase supply.

6 Note down the meter reading and enter in Table - 2.

7 Switch 'OFF' the power supply and disconnect the connection.

Fig 2

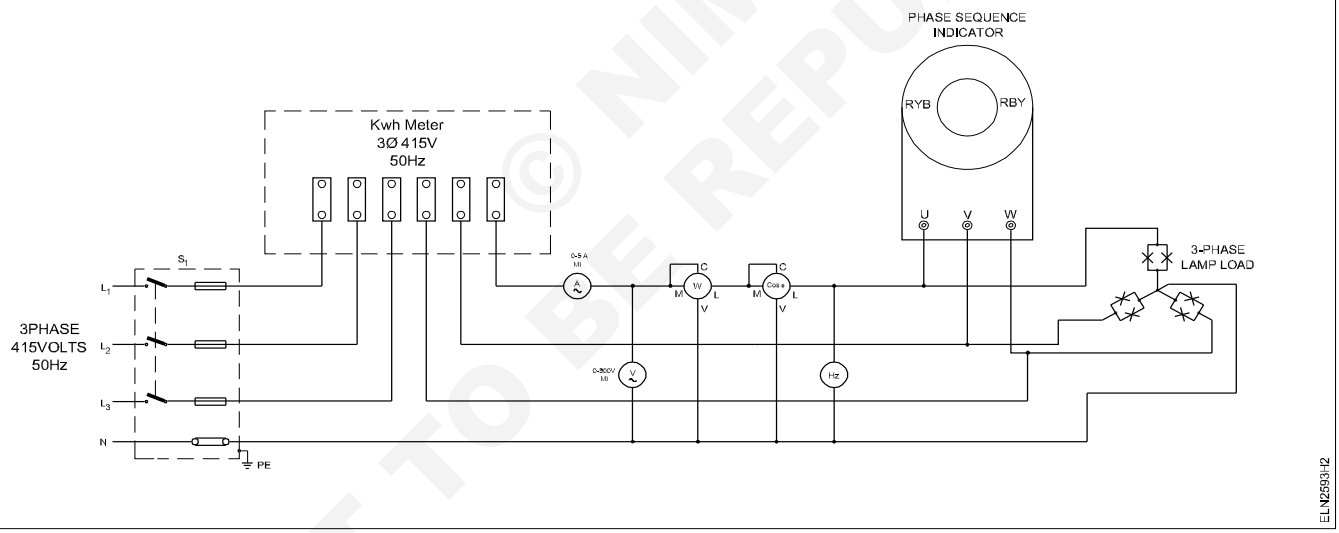


Table 2

Sl. No.	Ammeter reading (Amps)	Voltmeter reading (volts)	Wattmeter reading (watts)	Frequency meter (Hz)	Power factor meter (Cosϕ)	Energy meter (kwh)	Phase sequence RY B / R BY

— — — — — — — —

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Measure the power in 3-phase circuit using two wattmeter methods

Objectives : At the end of this exercise you shall be able to

- **connect two wattmeters in the circuit as per the given diagram**
- **measure the power and calculate the power factor.**

Requirements

Tools / Instruments

- Wattmeter 500V/5A, 3 KW - 2 Nos.
- M.I. Voltmeter 0-500 V - 1 No.
- M.I. Ammeter 0-5A - 1 No.

Equipment / Machines

- 3-phase, 415V AC induction motor 3 HP - 1 No.

Materials

- 200W, 250V lamps - 3 Nos.
- 100W, 250 lamps - 3 Nos.
- Connecting leads - as reqd.
- Pendent-holders 6A 250V - 6 Nos.

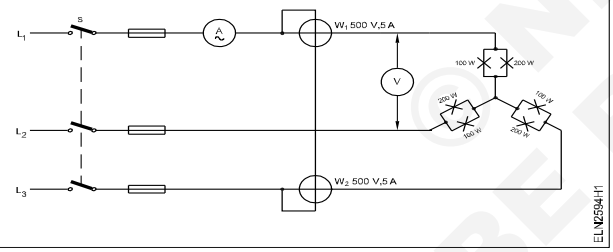
PROCEDURE

TASK 1 : **Measure the power in 3 phase circuit using two wattmeter method and calculate power factor**

1 Form the circuit as per the given circuit diagaram. (Fig 1)

Connect proper ranges of meters suitable for the given load.

Fig 1



2 Switch 'ON' the 3-phase supply and observe for the proper deflection of wattmeters. If both wattmeters deflect properly, go to step 4, otherwise continue from step3.

3 Switch 'OFF' the supply, if any one wattmeter deflects in the reverse direction. Change the connection of the potential coil of the reverse deflection wattmeter. Go to step 5.

4 Read wattmeters W_1 & W_2 and record in Table 1. Add the readings W_1 and W_2 and record the total power; go to setp 6.

5 Switch on the supply and read the wattmeters W_1 & W_2. Record the values in the Tables. Record the readings of the wattmeter with the changed potential coil as negative quantity.

6 Measure the 3-phase power for different load conditions specified below :

a L_1 = 500 W bulb
L_2 = 300 W bulb
L_3 = 200 W bulb

b L_1, L_2, L_3 water load to take a current of max. 3 amps

c Induction motor 3 HP on no load

d Induction motor 3-HP with load

The instructor personally to connect the three-phase motor for proper running.

7 Calculate the power factor in all the above cases and enter them in Table 1.

8 Get your work checked by Instructor.

Table 1

Type of Load	Wattmeter W_1	Wattmeter W_2	Total $W_1 + W_2$	Calculated Power factor Cos θ
				Cos θ
1				
2				
3				
4				
5				

Conclusion: _____

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Measure power factor in three phase circuit by using power factor meter and verify the same with voltmeter, ammeter and wattmeter readings

Objectives: At the end of this exercise you shall be able to
- **connect a single phase P.F. meter in 3-phase balanced load and read the P.F**
- **verify the P.F. by voltmeter, ammeter and wattmeter readings and determine the error**
- **connect the capacitor bank in the 3-phase circuit and measure the P.F.**

Requirements

Tools / Instruments

- Single phase P.F. meter 250V/ 500V; 5A/ 10A - 1 Set
- Wattmeter 250/500V, 5A/10A 1500W - 1 Nos.
- M.I Ammeter 0-5 A/ 10A - 1 No.
- M.I Voltmeter 0-300V/ 600V - 1 No.
- Insulated combination plier 200mm - 1 No.
- Insulated screwdriver 200mm - 1 No.

Equipment / Machines

- 3-phase induction motor 415V 2.25 KW (with loading arrangement) - 1 No.
- Power factor improving capacitor bank single phase 250V, 50 Hz 1kvar - 1 Set
- 3 Phase lamp load 3 KW 415 V 50 Hz - 1 No.

Materials

- PVC insulated copper cable 2.5 sq. mm 650 V - grade - 20 m
- T.P.I.C. switch 16A, 500V - 2 Nos.

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PROCEDURE

1 Collect the meters and the 3-phase lamp load.

The lamp load should have equal wattage in all the three phases.

2 Make necessary connections of the meters and load as per circuit diagram - Fig 1.

Connect the current coils of wattmeter and P.F. meter in series with load.

3 Get the circuit approved by the instructor.

4 Switch 'ON' the power supply momentarily observe deflections of all the meters. Keep the switch closed if nothing is abnormal.

5 Equally load all the three phases and note down the meter readings and enter in Table 1.

6 Switch 'OFF' the power supply.

Fig 1

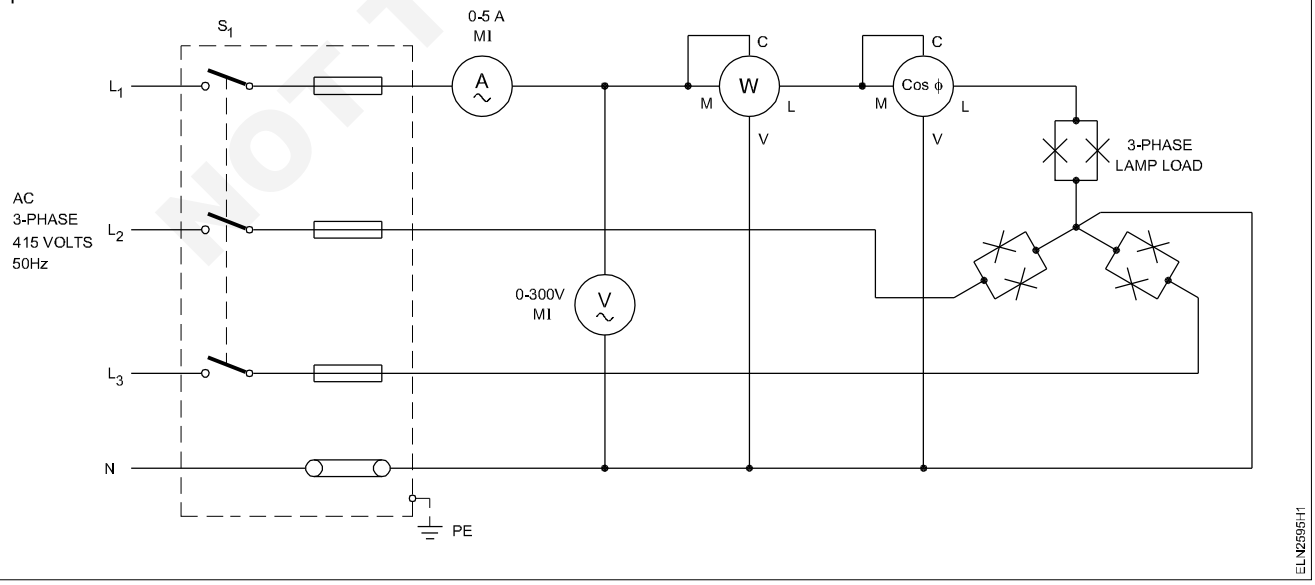


Table 1

Load condition	Ammeter reading in Amps. (I_{ph})	Volt-meter reading in Volts (E_{ph})	3-phase apparent power in watts $3xE_{ph}xI_{ph}$	Wattmeter reading in Watts W	3-phase power W x 3	Calculated value of P.F. $P.F.=\frac{W\times3}{3\times E_{Ph}\times I_{ph}}$	P.F. measured value	Remarks
Resistive load								
Motor without load								
Motor without load but with capacitor								
Motor with load								
Motor with load and with capactior								

If P.F. meter shows leading P.F. for inductive load, switch 'off' the supply and interchange current coil connections of the P.F. meter.

7 Determine the power factor by using the formula,

$$P.F.=\frac{W\times3}{3\times E_{Ph}\times I_{ph}}$$

Where W- Wattmeter reading (power in one phase)

E_{ph} - Phase voltage

I_{ph} - Phase current (Also equal to line current)

8 Compare the calculated power factor and power factor meter reading and write your observation.

Observation _____

_____

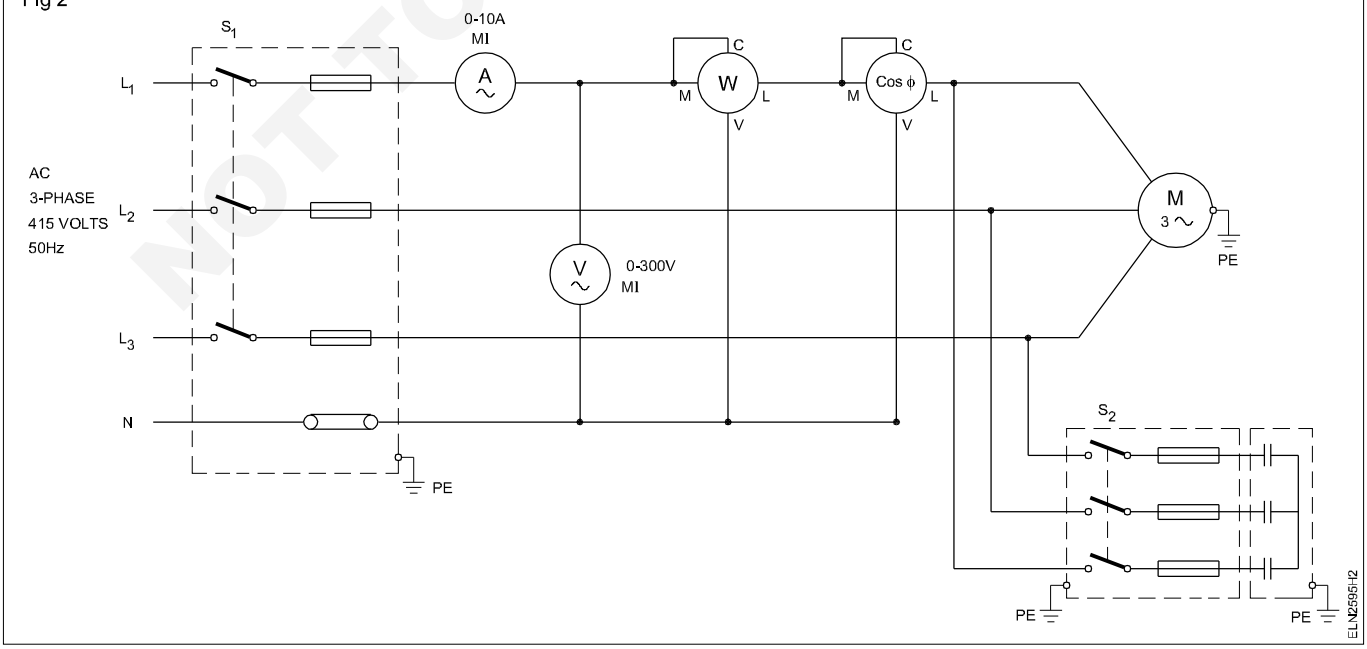
_____

9 Show the readings to your instructor for approval.

10 Disconnect the lamp load and connect the 3 phase induction motor with P.F. improving capacitor as shown in Fig 2.

11 Ensure that the range of current coil in wattmeter and P.F. meter are well higher than the load current of the connected load.

Fig 2



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12 Keep the capacitor switch in OFF condition. Switch ON the power supply and observe the deflection of the meters.

13 Record the meter readings in Table 1 for the load conditions shown in Table 1.

14 Switch 'OFF' the power supply and disconnect the connection.

15 Calculate the power factor in each case and compare with the measured P.F.

Consider the multiplying factor of the wattmeter which depends on the range of watt meter with respect to current and voltage ranges and C.C. and P.C. range selected. The reading of the wattmeter should be multiplied with the multiplying factor to get the actual power.

16 Observe the P.F. each load condition and write your observations.

Observation _____

_____

_____

17 Show the readings and observation to your instructor for approval.

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Measure electrical parameters using tong tester in three phase circuit

Objectives: At the end of this exercise you shall be able to
- **select a sutiable range in tong testers to measure the different electrical parameters**
- **measure the AC volt, DC volt and frequency**
- **measure the AC current**
- **measure kw, KVA, PF and phase angle in AC circuit**
- **measure resistance**
- **measure capacitance**
- **measure AC and DC micro ampere.**

Requirement

Tools / Instruments		Equipment / Machines	
• Tong - tester	- 1 No.	• Single phase lamp load	- 1 Set
		• Welding Transformer	- 1 No.
		• 3 phase Induction motor 3 HP 440V, with suitable load	- 1 Set

PROCEDURE

TASK 1 : **Measure the AC and DC voltage and frequency**

The operating instruction given below is for one particular tong Tester. Some other model Tong Testers are also be available in market. Follow the operating instructions accordingly

1 Set the rotary switch to the 'V' Position.

2 Insert the test leads into the input Jack (Black to COM and Red to V)

3 Connect the test leads in parallel to the measured circuit.

4 The meter will automatically switch to ACV or DCV display.

5 The meter will automatically select the appropriate range.

6 Read the voltage and frequency values displayed on the LCD and note down in Table (Fig 1)

— — — — — — — —

TASK 2 : **Measure current in AC circuit**

1 Set the rotary switch to the 'A' position.

2 Press the trigger to open the jaw and fully enclose the conductor to be measured.

No gap is allowed between the two half Jaws

3 The clamp will automatically select the appropriate range

4 Read the current values displayed on the LCD and note down in Table (Fig 1).

— — — — — — — —

TASK 3 : **Measure AC kW, KVA, PF and ∅ (phase angle)**

1 Set the rotary switch to the KW / KVA Position

2 Insert the test leads into the input Jack. (Black to COM and Red to V)

3 Connect the Black lead COM to the neutral line.

4 Connect the Red lead 'V' to power line and clamp the same connductor where V (red) terminal is connected.

5 The power clamp will automatically select the appropriate range.

6 Read the watt and HP values displayed on the LCD and note down in Table.

7 Press range button to display required parameters.

$$PF = \frac{KW}{KVA} = \text{Cos}\theta$$

8 For 3 phase 3 wire balanced load system, insert 3 plug in adapter in terminals " COM" and "V". Connect three crocodile clips to appropriate phase (R, Y and B) 3 phase power = 3 x meter indication (Fig 1).

— — — — — — — —

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TASK 4 : **Measurement of Resistance**

1 Before taking resistance measurement, make sure the circuit is not live and discharge any capacitor present in the circuit.

2 Set the rotory switch to the Ω or M Ω range.

3 Insert the test leads into the input jack. (Black to com and red to Ω)

4 Connect the test leads to the circuit being measured and read the displayed value.

5 Note down the reading in Table.

— — — — — — — —

TASK 5 : **Measurement of capacitance**

1 Insert the test leads into the input Jacks (Black to COM and Red to

2 Set the rotary switch to the "⊣⊢" Positon.

3 Connect the rotary test lead to the anode side and black test lead to the cathode side of the capacitor being tested

4 Read capacitance value on LCD and note it in Table.

— — — — — — — —

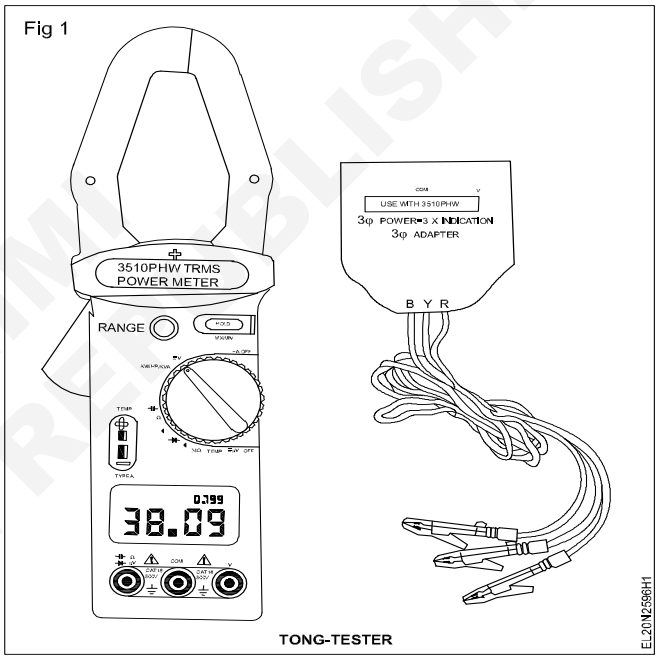
TASK 6 : **AC + DC Micro Ampere measurement**

1 Set the rotary switch is " ≂μA" position.

2 Insert the test leads into the input Jack (Black to COM and Red to/μA) (Fig 1)

3 Connect the meter in series the with the circuit being measured and read the displayed value and note down the reading in Table.

Fig 1



Table

Sl. No.	Measurement	Reading 1	Reading 2
1	AC voltage		
2	DC voltage		
3	Frequency		
4	KW		
5	KVA		
6	PF		
7	Phase angle		
8	Resistance		
9	Capacitance		
10	AC Micro Ampere		
11	DC mircro Ampere		

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Demonstrate smart meter, its physical components and communication components

Objectives: At the end of this exercise you shall be able to
- **read and interpret the name plate details of smart electrical meter**
- **identify physical components**
- **identify communication components.**

Requirements

Tools / Instruments

- Electrician tool kit - 1 Set
- Smart energy meter - 1 No.

Materials

- Connecting leads -1 No.
- Pencil - 1 No.
- Drawing sheet - 1 No.

PROCEDURE

1 Take one smart meter (Fig 1) and note down the name plate details in Table 1.

Fig 1

Table 1

Name	
Sl.No.	
Voltage	
Current	
Frequency	
Type	
Model	

2 Inspect physical compnents and study the application and note down.

Physical components		Application
Sl.No.	Name	
1		
2		
3		
4		
5		

3 Find out the communication components and read its application and note down.

Communication components		Application
Sl.No.	Name	
1		
2		
3		
4		
5		

4 Discuss your findings with your instructor and verify the doubts.

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Perform meter readings, install and diagnose smart meters

Objectives: At the end of this exercise you shall be able to
- **connect a smart energy meter in the supply**
- **take readings of smart energy meter**
- **operate communication components.**

Requirements

Tools / Instruments

- Electrician tool kit - 1 Set
- Smart energy meter with communication components - 1 No.
- Resistive load - 1 No.
- Volt meter 0-300v M.I - 1 No.
- Ammeter 0-5A - 1 No.
- Watt meter 5A 1500W - 1 No.

Materials

- Connecting leads - as reqd.
- ICDP main switch - 1 No.

PROCEDURE

1 Read and note down the name plate details of smart energy meter in Table 1.

Table 1

Name	
Sl.No.	
Voltage	
Current	
Frequency	
Type	
Model	

2 Connect the smart meter as for the circuit diagram. (Fig 1)

Fig 1

Terminals screws of energy meter should be tightened gently.

3 Switch on the power supply and resistive load.

4 Note down the initial readings in Table 2.

5 Wait for half-an-hour and note down the final reading in Table 2.

6 Use communication components and note down the readings for the same time with same load and enter in table 2.

7 Compare both readings.

8 Show the readings to your instructor and clarify your doubts.

Table 2

S. No.	Mode	Initial reading	Final reading	Consumption
1	Direct			
2	Through Communication Components			

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Practice for range extension and calibration of various measuring instruments

Objectives: At the end of this exercise you shall be able to
- **extend MC 0-15V voltmeter range to MC 0-30V voltmeter**
- **extend MC 500 milli ammeter range to MC 2.5 ampere**
- **extend MC 500 milli ammeter range to MC5 ampere**
- **extend MC 100 milli ammeter range to MC1 ampere**
- **calibrate MC 0-50V voltmeter**
- **calibrate MI 0-300V voltmeter**
- **calibrate MC 0-500 m.A. ammeter**
- **calibrate MI 0-1 A ammeter.**

Requirements

Tools / Instruments

• Electrician's Tool Kit	- 1 Set
• Combination pliers 150mm	- 1 No.
• Wire stripper 150 mm	- 1 No.
• Electric soldering iron 230V 35W	- 1 No.
• MC milli voltmeter 0-50mV	- 2 Nos.
• MC milli ammeter 0-10mA	- 1 No.
• M C Voltmeter 0-15V	- 1 No.
• MC Ammeter 0-500 m.A	- 1 No.
• MC Voltmeter 0-100 m V	- 1 No.
• MC Voltmeter 0-1V	- 1 No.
• Ohmmeter or multimeter	- 1 No.
• MC Voltmeter 0-50V	- 1 No.
• Digital Voltmeter	- 1 No.
• M.I. Voltmeter 0-300V	- 1 No.
• M I Ammeter 0-1A	- 1 No.
• Rheostat 100Ω/5W	- 1 No.

Equipment/Machines

• Variable D.C. power supply 0-50V	- 1 No.
• Standard resistors for multipliers (Decade reistance box in 5 decades 1, 10, 100, 1000, 10000) OR Variable tubular wire wounded resistors	- 3 Nos.
• Battery 12V 100 A H	- 1 No.
• Variac 0-300V/5A	- 1 No.

Materials

• Potentiometer 10k 2W	- 1 No.
• Resistor 1K 2W	- 1 No.
• Resin core solder	- as reqd.
• Connecting leads	- as reqd.
• Copper wire 18 SWG	- as reqd.
• Nichrome wire 18 SWG	- 1/2 m

PROCEDURE

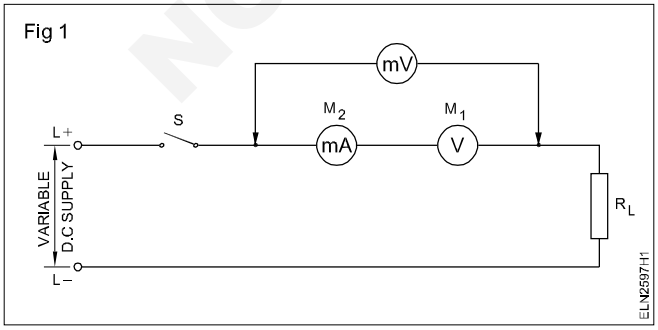
TASK 1 : **Extension MC 0-15V voltmeter range to MC 0-30V voltmeter**

1 Remove the cover of the MC 0-15V Voltmeter, examine and disconnect the series resistance, if any.

2 Connect the moving coil ends to the meter terminals and close the cover.

3 Form the circuit as shown in Fig 1.

Fig 1



Keep the switch open and the variable DC supply at minimum level.

4 Close the switch; gradually increase the DC voltage until full scale deflection is acheved in M_1 (voltmeter under test).

5 Record the reading of M_2 and then the voltage drop across M_1 at full scale deflection in Table 1.

6 Open the switch and disconnect the circuit.

7 Calculate the M C resistance of M_1 using Ohm's Law and record in Table 1.

Table 1

Reading of M_2 at f.s.d. of M_1	Voltage drops. across M_1 at f.s.d.	Resistance of MC of M_1
1	**2**	**3**

8 Calculate the resistance of the multiplier for the proposed range (say 0-30V) using the formula

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Multiplier resistance =

$$\frac{\text{Proposed range of voltage - Voltage drop across MC at FSD}}{\text{MC current at FSD}}$$

9 Calculate the multiplying factor (M.F.) by the formula

$$MF. = \frac{\text{Proposed voltmeter range}}{\text{Voltage drop across MC at FSD}}$$

10 Select the standard resistance suitable for the value of the multiplier reistance calculated in step 8 and connect them all in series with meter M_1.

11 Form the circuit as ahown in Fig 2, keeping the switch open.

Keep the variable D C Supply at minimum level.

12 Close the switch and increase the voltage gradually to get exact divisions in standard voltmeter M_3.

13 Record the readings of M_1 and M_3 in Table 2 for each setting (in M_3) until M_1 reaches the full scale deflection.

14 Open the switch and disconnect the circuit.

15 Calculate the actual voltage using 'M_1 reading' and the 'Multiplying factor' of the multiplier connected.

16 Calculated the error using the formula given below and record in Table 2.

Error = standard meter - calculated voltage from the reading of M_1

In case of non-availability of wire-wound resistors of different values of suitable wattage to form the multiplier resistance, you may make use of wire-wound tubular variable resistance for laboratory use and verify the working of the instrument in the extended range.

Set the value of variable wire-wound resistance exactly equal to the multiplier resistance using the Wheatstone bridge.

Fig 2

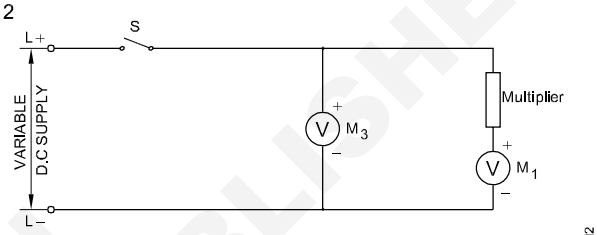


Table 2

Sl No	Reading of M_3	Reading of M_1	Multiplying factor M.F.	Voltage = M_1 x MF	Error (Col.2)-(Col.5)
1	2	3	4	5	6

TASK 2 : **Extension of M.C 500 milliammeter range to 2.5 amperes**

1 Connect the 0-500mA range milliammeter as shown in Fig 3 to the variable DC power supply. If a variable DC power supply is not available, make connections to a battery as shown in the circuit Fig 4.

2 Set the output voltage to the circuit at the minimum and close the switch S.

3 Gradually increase the voltage until the milliammeter reads full scale deflection.

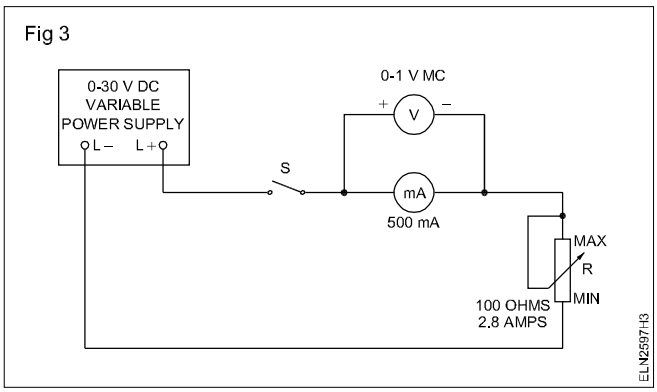
4 Observe and the record the reading of the voltmeter and ammeter in Table 3. The measuring element indicates full scale deflection at V_i = ____ **V**

I_i = ____ **A.**

5 Open the switch S and disconnect the circuit elements.

6 Calculate the shunt resistance R_{sh}.

Fig 3



$$R_{sh} = \frac{V_i}{I_{sh}}$$

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Fig 4

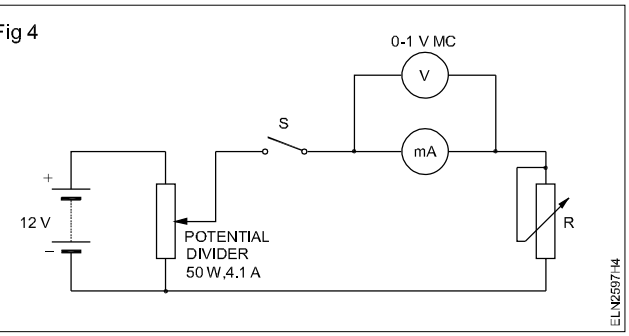


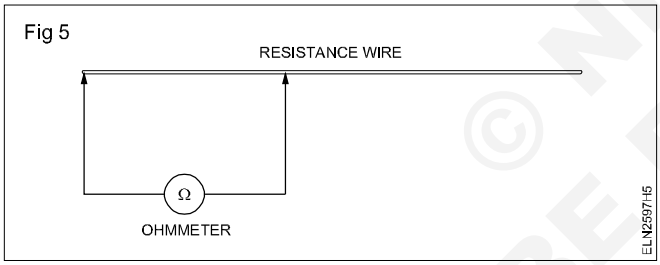
Table - 3

Voltmeter reading in Volts	Ammeter reading in Amps.

The voltage across the shunt resistance is then equal to V_i. The current I_{sh} in the shunt resistance is the difference between the end value of the measuring range I = 2.5A and the current in the measuring element I_i.
ie. $I_{sh} = I - I_i$.

7 Measure the exact length of the Manganin wire that has a resistance equal to R_{sh} as shown in Fig 5, using an ohmmeter and go to step 9.

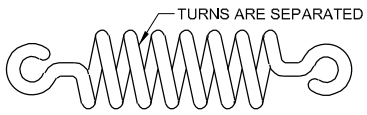
Fig 5



9 Cut the wire 1 cm greater in length than measured.

10 Coil the wire with eye formation at both ends. Exercise care to see the excess length of 1 cm is used for eye formation at the ends. (Fig 6)

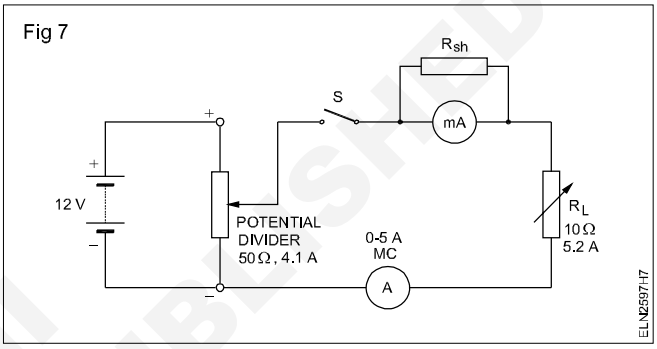
Fig 6



11 Connect the coiled wire as shunt across the terminals of the milliammeter.

12 Set up the circuit accroding to the circuit diagram. (Fig 7)

Fig 7



13 Adjust the variable load resistance R_L to 4 ohms.

14 Switch on the power and adjust the ouptut voltage to circuit, equal to 10V. Observe the ammeter deflection.

15 Read the value of current 'I'.

16 Verify that the readings shown are in in amperes by inserting a 5A ammeter in series.

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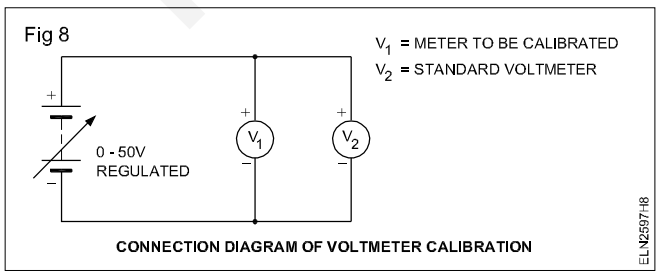
TASK 3 : **Calibrate a 0-50V MC type voltmeter**

1 Check and set the pointer of the meter under calibration to read zero (mechanical zero setting).

2 Connect the 0-50V meter to be calibrated and a standard digital voltmeter across a regulated DC power supply as shown in the Fig 8.

3 With the output of the adjustable DC PSU set to zero Volt, get the connections checked by your instructor.

Fig 8



4 Increase the output voltage of the DC PSU such that the standard meter (V_2) reads 5V (1/10th of the range of the meter under calibration.).

5 Record the corresponding voltage reading of the meter under calibration (V_1) in Table 4

6 From the readings of the standard meter and the reading shown by the meter under calibration, find the % of error in the meter under calibration as given in Table 4

7 Repeat steps 4,5 and 6 to find the % error at different readings of the meter under calibration as given in Table 4

8 From the % error found at different readings, calculate and record the average % error of the meter under calibration.

9 Get your work checked by the instructor.

Table 4

Type of meter :

Range :

Sl. No.	PSU output volts	Voltmeter readings in volts		error ($V_2 - V_1$)	% of error $\frac{V_2 - V_1}{V_2} \times 100$
		Standard V_2	undercalibration V		
1	5	5			
2	10	10			
3	20	20			
4	30	30			
5	40	40			
6	50	50			

$$\text{Average\% error} = \frac{\text{Total \% error}}{\text{No. of reading}}$$

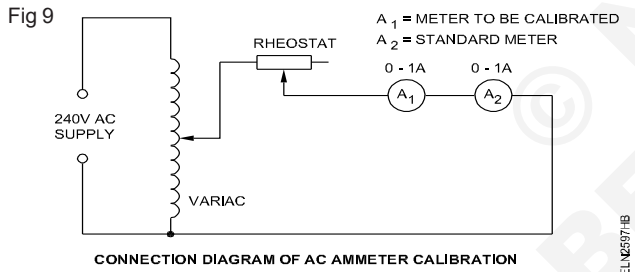
— — — — — — — —

TASK 4 : **Calibrate a 0-500mA MC type ammeter**

1 Check and set the pointer of the meter under calibration to read zero(mechanical zero setting).

2 Connect the given 0-500mA DC meter to be calibrated and a standard digital DC Ammeter for some range across the output of a regulated DC power supply via a rheostat as shown in the Fig 9.

Fig 9



CONNECTION DIAGRAM OF AC AMMETER CALIBRATION

3 Set the Rheostat to its half resistance position and set the output of DC PSU to zero volts. Get the wired circuit checked by your instructor.

4 Increase the output of the PSU slowly till the standard ammeter (A_2) read 500 mA (full scale value of the ammeter under calibration (A_1).

5 Adjust the rheostat such that the standard ammeter(A_2) reads 450mA (decrease in current equivalent to 1/10 of the full range of the meter under calibration).

6 Record the corresponding reading on the ammeter (A1) under calibration in Table 5.

7 From the readings of the standard meter and the reading shown by the meter under calibration, find the % of error in the meter under calibration using the formula given in Table 5.

8 Repeat step 5,6 and 7 for the values given in Table 3 to cover the complete range of the ammeter under calibration.

9 From the % error found at different readings, calculate and record the average % error of the meter under calibration.

10 Get your work checked by the instructor.

11 Paste a slip on the calibrated meter indicating date of calibration and average % error.

Table 5

Sl.No	Ammeter reading in mA		Error ($I_2 - I_1$)	% of error $\frac{(I_2 - I_1)}{I_2} \times 100$
	Standard I_2	Undercalibration I_1		
1	50			
2	150			
3	250			
4	350			
5	450			
6	500			

$$\text{Average\% error} = \frac{\text{Total \% error}}{\text{No. of reading}}$$

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Determine errors in resistance measurement by voltage drop method

Objectives: At the end of this exercise you shall be able to
- **determine errors in resistance measurement by voltage drop method**
- **connect suitably the voltmeter and ammeter to minimize measurement errors.**

Requirement

Tools/Instruments

- Insulated cutting pliers 150 mm - 1 No.
- Screwdriver 150 mm - 1 No.
- Connector screwdriver 100 mm - 1 No.
- 0-30V mC panel type voltmeter - 1 No.
- Multimeter - 1 No.
- 0-5 amps ammeter, P.M.M.C type - 1 No.
- Ohmmeter, Shunt type 0-100 ohms - 1 No.

Equipment / Machines

- 24V DC power supply unit - 1 No.
- Rheostat 10 ohms, 20 ohms and 50 ohms 4A capacity each - 1 No.

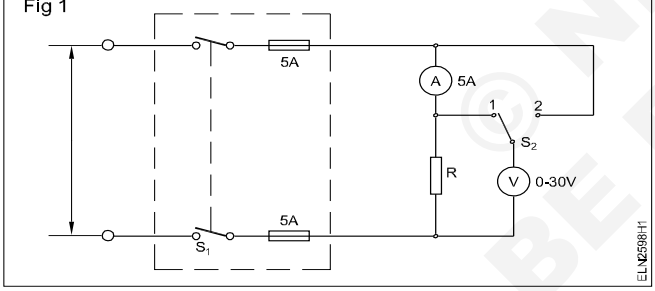
Materials

- DPST knife switch 16 A - 1 No.
- SPDT knife switch 16A - 1 No.
- 5A fuse wire - 1 No.
- P.V.C. cable 48/0.2mm - 10 m
- Glass catridge fuse with holder 100 mA - as reqd.

PROCEDURE

1 Form the circuit as shown in Fig 1. (Use only high sensitivity voltmeter.)

Fig 1



2 Measure the value of resistor R and enter the measured value in Table1.

3 Switch on the supply keeping switch S_2 at position1, across the resistor only. Read the voltmeter and ammeter and record the readings in Table 1 switch off the circuit.

4 Calculate the resistance value from the measured quantities using the formula R = V/I, and enter the values in Table 1.

5 Change switch S_2 to position 2, across the resistor and ammeter. Read and record the voltage and the current.

6 Repeat step 4 for these values.

7 Calculate and enter the error occurred in the measurement of resistance by using the formula

$$\% \text{ error} = \frac{(R_{2cal} - R_{2mes}) \times 100}{R_{2mes}}$$

8 Repeat the same proceduce for different values of R as given in Table 1.

Table 1

Resistance value			Voltmeter connected across	Voltage	Current	Calculated value of resistance R = V/I	% error = $\frac{(R_{2cal} - R_{2mes}) \times 100}{R_{2mes}}$
Sl No.	Marked R_{Mar}	Measured R_{Mes} ohms					
1	10		R only				
			R & A				
2	20		R only				
			R & A				
3	50		R only				
			R & A				

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Test single phase energy meter for its errors

Objectives : At the end of this exercise you shall be able to
- **identify the creeping in energy meter**
- **test the energy meter for starting current error**
- **select suitable loading arrangements for determining errors in energy meters**
- **determine the percentage error in an energy meter.**

Requirements

Tools/Instruments

- Electrician's Tool Kit - 1 No.
- Single phase energy meter 5A 250 V 50HZ - 1 No.
- Voltmeter MI 0 - 300V - 1 No.
- Ammeter MI 0 - 5 A - 1 No.
- Power factor meter 240 V 5 A 50 Hz - 1 No.
- Ammeter MI 0 - 50mA - 1 No.

Equipment/Machines

- Single phase capacitor motor with brake load 240V 50 Hz AC 1/2 kW - 1 No.
- Lamp load single phase 250 V 50 Hz 1.25 kW - 1 No.
- Auto-transformer 0 to 270V 8A 50 Hz - 1 No.

Materials

- Electric bulb 5 W 240 V with holder - 1 No.
- PVC insulated cable 1.5 sq. mm 250 V grade - 10 m

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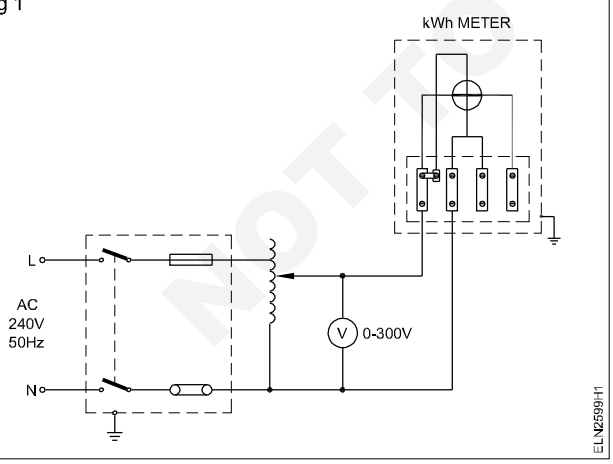
PROCEDURE

Adjustment of errors inside the energy meter is beyond the scope of this course as it requires costly equipment like rotating sub-standard meter etc. Hence the simplified method of finding errors only is included here.

TASK 1 : **Check the energy meter at no load (to find the creeping error)**

1 Connect the energy meter through an auto-transformer as shown in Fig 1.

Fig 1



2 Vary the input voltage to the energy meter between 80% and 110% of the rated voltage of the energy meter.

For an energy meter rating of 240 Volts the input voltage is between 192 V to 264 V. Observe, if the meter disc is rotating or not. The load should not be connected or the load switch should be 'off' during the observation period.

3 Write your observations correlating your findings from the above experiments with the recommendation given in IS 722.

OBSERVATION

As per IS 722 (Part I) 1977 the meter shall not make a complete revolution at any voltage between 80% and 110% of the reference voltage.

— — — — — — — —

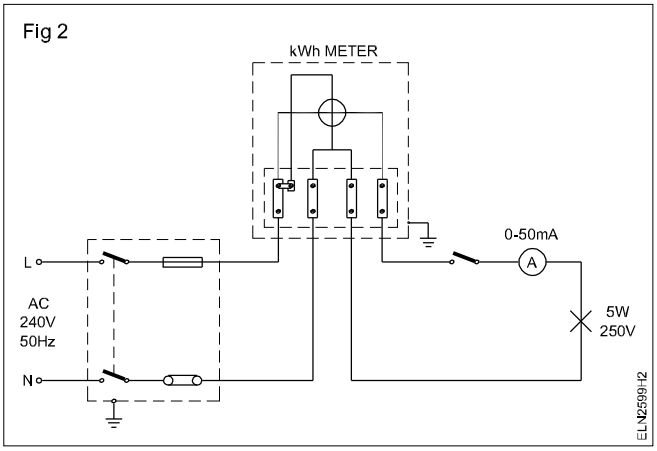
TASK 2: **Task for starting current error in energy meter**

1 Connect low load (5 W lamp) as shown in Fig 2.

2 Switch on the load and observe the meter rotation.

3 Write your observations, correlating your finding from the above experiment with the recommendation given in IS 722 (Part III).

Fig 2



OBSERVATION

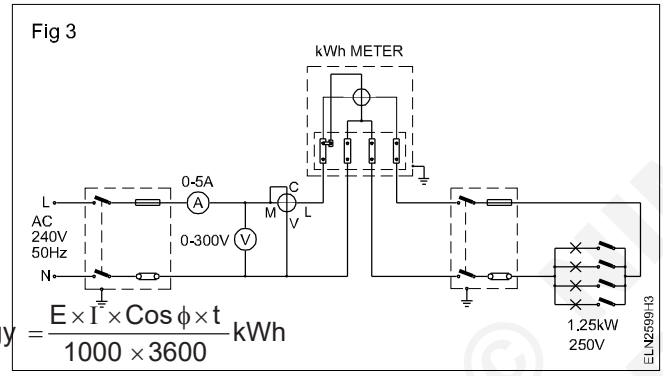
As per IS 722 (Part II) 1977 the starting current shall be 0.5% of the rated basic current across = 1 for dial and pointer type register whereas for drum type register it will be 0.75%. For meters provided with reverse stop the values will be 1% and 1.5% respectively.

— — — — — — — —

TASK 3 : **Task for percentage error in single phase energy meter**

1 Make the connections as shown in Fig 3 with the lamp load.

Fig 3



2 Switch 'ON' the lamps so that 25% of the rated current of energy meter flows in the circuit.

3 Tabulate the voltmeter, ammeter and P.F. meter readings in Table 1.

4 Keeping the load constant, count the number of revolutions of the energy meter disc for 2 minutes (120 seconds) and record the same in Table 1.

5 Calculate the true energy by using the formula

$$\text{True energy} = \frac{E \times I \times \text{Cos}\,\phi \times t}{1000 \times 3600}\ \text{kWh}$$

where 't' is the time in seconds.

6 Calculate the energy registered (recorded) by the meter using the formula

$$\text{Recorded energy} = \frac{\text{No.of revolutions}}{\text{Meter constant}}\ \text{kWh} = \frac{N}{K} = \text{kWh}$$

7 Find the error using the formula

Error = Recorded energy - True energy.

8 Calculate the percentage error, using the formula

$$\text{Percentage error} = \frac{R - A}{A} \times 100$$

where R = Energy registered by the meter

A = True energy.

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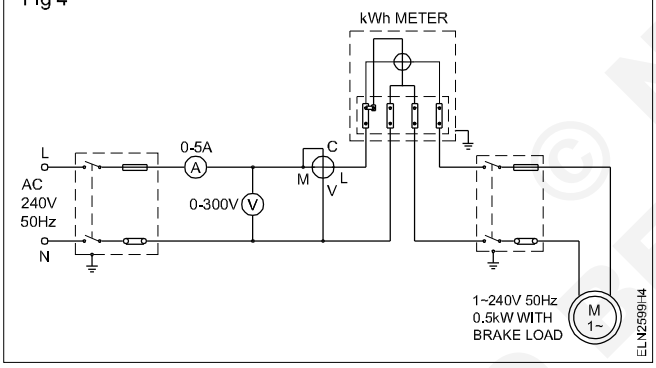
Table 1

Sl. No.	Load reading	Voltmeter reading	Ammeter reading	P.F. meter reading	Time in Sec	True energy	Revolution counted N	Meter constant K	Recorded energy	% error
	Resistive									
1	25%									
2	50%									
3	75%									
4	100%									
	Inductive									
1	25%									
2	50%									
3	75%									
4	100%									

Repeat the working steps from 2 to 8 for 50%, 75%, 100% resistive and inductive loads and enter in Table 1.

For inductive load, make the connection as shown in Fig 4.

Fig 4



For checking the proper registraion of energy, verify the readings through initial and final reading differences recorded in the energy meter. As per I.S. 722 (Part III) 1977, the percentage error shall not exceed ±2%, both at unity power factor and at 0.5 lagging.

If the above errors are beyond the limitation prescribed in I.S., take action for calibration of the energy meter at the meter testing department attached to the electricity board.

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Dismantle and assemble electrical parts of various electrical appliance e.g cooking range, geyser, washing machine and pump set

Objectives: At the end of this exercise you shall be able to
- **dismantle the cooking range, geyser, washing machine and pump set**
- **assemble the dismantled electical appliances**
- **test them for their working**
- **replace the faulty parts with good ones where ever necessary.**

Requirements

Tools / Instruments

- Electrician Tool Kit - 1 Set
- Spanner set 6 to 22 mm (6 Nos) - 1 Set
- Megger 500 V - 1 No.
- Multimeter - 1 No.
- Test lamp 60 w / 240 V - 1 No.
- Pulley puller 3 leg 150 mm - 1 No.

Equipment / Machines

- Cooking range 1500 W / 240 V - 1 No.
- Geyser 1500W/240 V - 15 liters - 1 No.
- Washing machine ordinary or semi automatic types 240 V / 50 Hz - 1 No.
- Pump set coupled with single phase motor 240V /50Hz - 1 No.

Materials

- Service manual - 1 No.
- Cleaning brush - 2.5 cm dia - 1 No.
- Cotton waste - as reqd.
- Kerosine - as reqd.
- Grease - 200 gms

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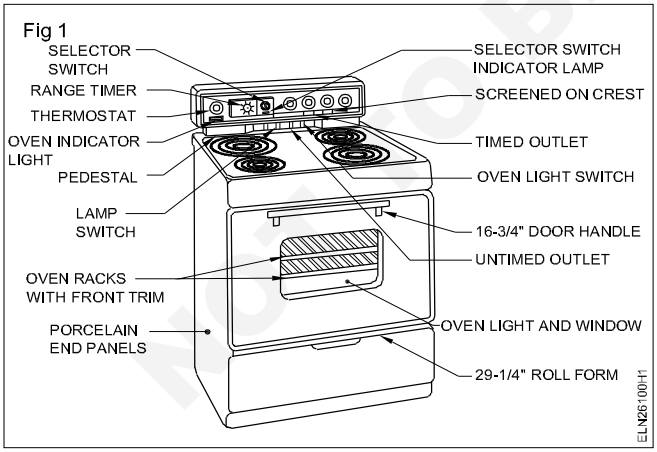
PROCEDURE

TASK 1 : **Dismantle and assemble the cooking range**

1 Note the name plate details of the electric cooking range in Table 1.

2 Disconnect the power supply from the cooking range

3 Open the terminal connection box (Refer Fig 1)

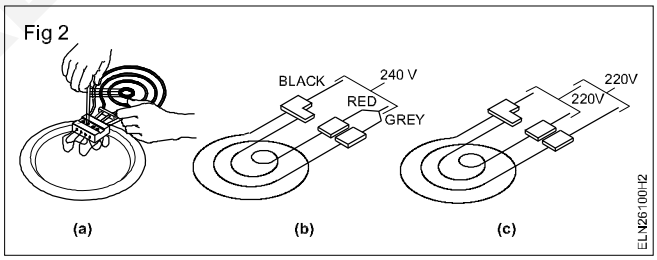


4 Check the proper tightness of the screw at selector switch, indicator lamp, range timmer and thermostat.

5 Remove the cooking range and check the continuity of the surface heating unit element one by one.

6 Check the correct shape, wattage and voltage of the element (Refer Fig 2)

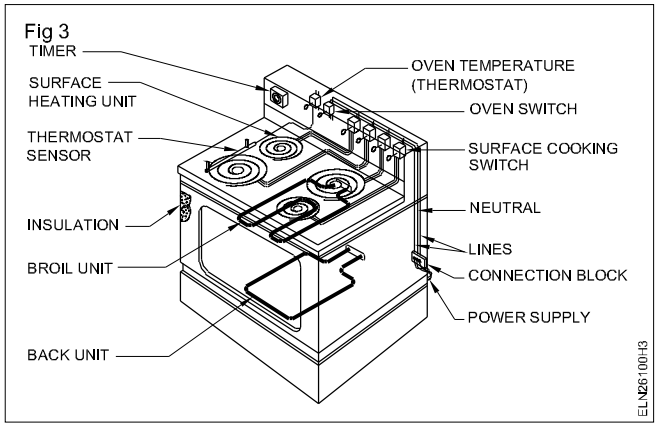
7 Open the porcelein end panel which is at bottom of the cooking range.



8 Check the condition of the oven racks (Fig 1)

9 Measure the insulation value between the all terminals to body of the cooking range.

10 Assemble and connect the electric cooking range to the supply (Fig 3)



TASK 2 : **Dismantle and assemble the geyser**

1 Note down the name plate details of the geyser in a separate Table simlar to table 1

2 Disconnect the power supply from the geyser

3 Open the inspection cover for Power terminals connection and thermostat installation. (Refer Fig 4)

4 Check proper tightness of the screw at thermostat, pilot lamp, and heating element

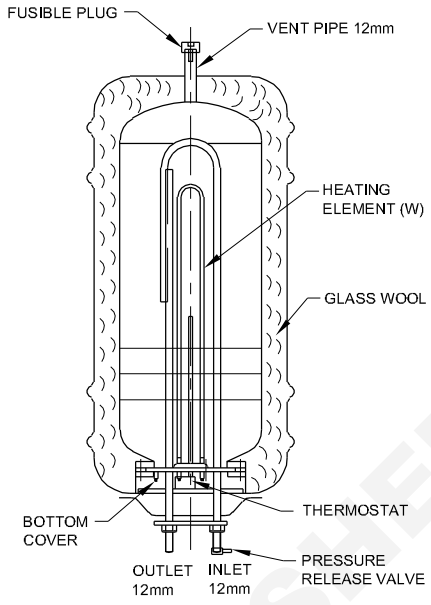
5 Conduct visual examination of the power cord pin terminals and termination of applicance.

6 Conduct insulation test between the leads, lead and earth and record in a separate Table

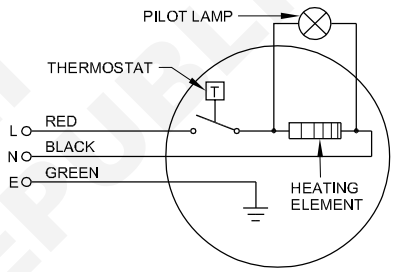
7 Measure the insulation resistance between element and body and record in a separate Table

8 Assemble and connect the geyser to the supply.

Fig 4



(a) GEYSER



(b) SCHEMATIC DIAGRAM OF A GEYSER

ELN26100H4

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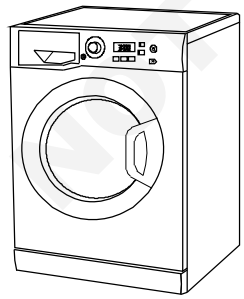
TASK 3 : **Dismantle and assemble washing machine**

1 Note the name plate details of the washing machine in a separate Table (Fig 5)

Fig 5



WASHING MACHINE

ELN26100H5

2 Disconnect the power supply from the washing machine.

3 Open the terminal connection panel and check the proper tightness of the screws

4 Remove the washing drum from the washing machine.

5 Check the inlet pipe and out let pipe

6 Check the outgoing valve

7 Check the tightness of shaft pulley / drum belt

8 Check the rubber bushings that are used is the machine for absorbing mechanical vibration

9 Conduct insulation test to the motor by using a megger.

10 If every thing is ok, place the drum and close the inspection hatch/cover.

11 Connect the machine to the supply for its working

— — — — — — — —

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TASK 4 : **Dismantle and assemble pumpset**

1 Note the name plate details of the pumpset in separate Table.

2 Disconnect the supply from the pumpset

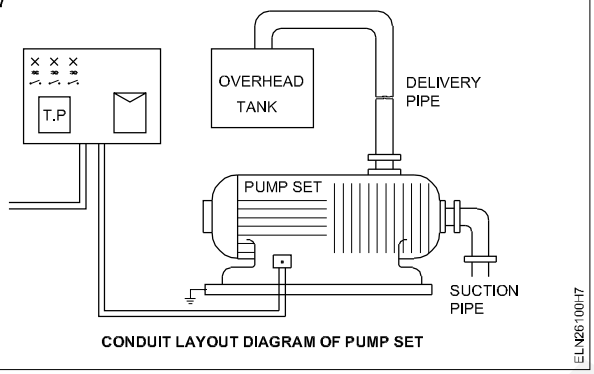
3 Dismantle the pumpset (Fig 6)

4 Check the shaft for smooth running, carbon seal, motor adaptor, Drive collar, impeller, casing gasket, bearings (refer Fig 6)

5 It every thing is satisfactory, assemble the pumpset

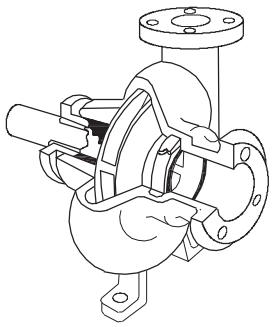
6 Connect the pumpset to the supply for its working . (Fig 7)

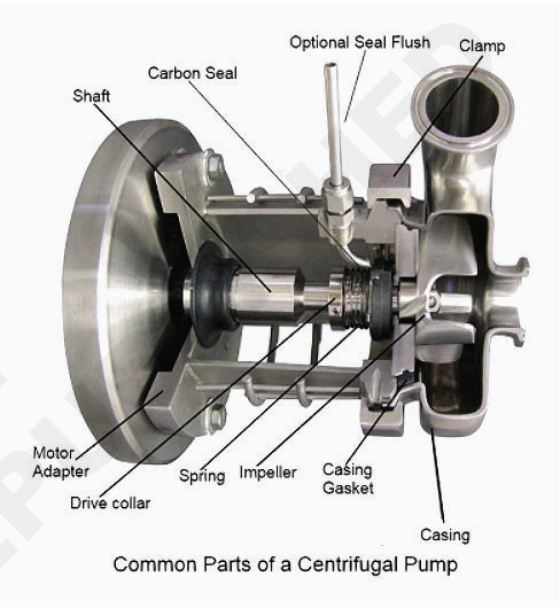
Fig 7



CONDUIT LAYOUT DIAGRAM OF PUMP SET

Fig 6





Common Parts of a Centrifugal Pump

Table 1

Name of the appliance : ..... Voltage : ..... Supply : ..... Capacity :		Serial No : ..... Current : ..... Wattage : ..... Make :	
Cord Insulation	Between line ..... Megohm	Between line/body ..... Megohm	Date of servicing
Element insulation	Between terminal and body / thermostat		Recommended Repair Replacement if any
	Cold		
	Hot		

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Service and repair of electric iron, electric kettle, cooking range and geyser

Objectives: At the end of this exercise you shall be able to

- **connect and test the given automatic iron for its working**
- **dismantle the automatic iron and reassemble it**
- **trace and identify (or) locate the faults in an automatic iron**
- **replace the faulty parts with good one**
- **test the electric kettle element and identify the defect**
- **replace the old element with a new one**
- **assemble the kettle and test for its working**
- **dismantle the suspected parts of the cooking range**
- **test the continuity of heating element**
- **replace the burn out heating element and worn out selector switch**
- **reassemble, connect and test the cooking range**
- **test the line cord for continuity**
- **dismantle a geyser**
- **trace identify and locate faults in a geyser**
- **replace faulty parts with good ones**
- **assemble the geyser and test for its working.**

Scan the QR Code to view the video for this exercise

Requirements

Tools/Instruments

- Screwdriver 150mm - 1 No.
- Spanner set 6 to 22mm (6 Nos) - 1 Set
- Megger 500 V - 1 No.
- Multimeter - 1 No.
- Electircian tool kit - 1 Set
- Cutting plier 150mm - 1 No.
- Tester 500 V - 1 No.
- Nose piler 150 mm - 1 No.

Equipment/Machines

- Automatic electric iron box 750W 250 V - 1 No.
- kettle (sauce pan type) 500W/ 250V - 1 No.
- Electric cooking range1500W/250 V - 1 No.
- Geyser 1500W 250V 25 liters - 1 No.
- Megger 500 V - 1 No.

Materials

- Kettle Element 500W/250V - 1 No.
- Asbestos sheet and fibre washers - as reqd.
- Test lamp 100W/240V - 1 No.
- Element suitable for available Cooking range 1500W, 250V - 1 No.
- Geyser heating element 1500W, 240V - 1 No.
- Geyser thermostat - 1 No.
- 3- core flexible cord (48/0.2 with 15A, 3 pin plug) - 1 No.
- Insulating material such as asbestos and mica sheets Suitable for electric Iron - as reqd.

PROCEDURE

TASK 1 : **Service and repair of electric iron**

1 Conduct a visual examination of the power cord and plug, after interpreting the name plate details

2 Conduct preliminary test for
- short circuit, continuity & insulation
- earth fault
- defective element circuit

3 Replace the cord, if necessary

4 Check for the insulation resistance between line terminal of the iron and the body of the iron (Fig 1) and record in Table 1.

Disconnect the indicator bulb if any before the short, open and IR test.

Always disconnect the iron from supply while testing with insulation tester / Megger.

5 Check for insulation resistance between the neutral terminal and earth.

6 Connect the electric iron to the mains and check for its working

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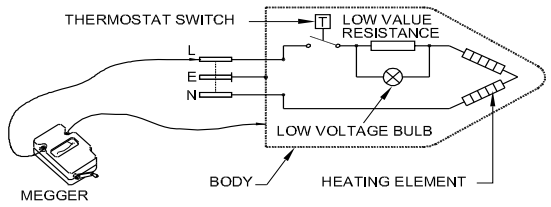
Fig 1



MEASUREMENT OF INSULATION RESISTANCE BETWEEN THE BODY AND THE TERMINALS

ELN26102H1

Table - 1

Terminals	Value in Megohms
L & Body	
N & Body	
E & Body	
Plug pin L & Body	
Plug pin N & Body	
Plug pin E & Body	

7 Check the presence of dangerous voltage existing between the body and earth of the supply with a neon tester or voltmeter.

In case of earth fault

8 Disconnect the electric iron from the supply, dismantle it. Visually inspect and test with a multi-meter/megger for any contact of live wire with the body
- insulation failure
- broken parts
- damaged thermostat/actuating leaf porcelain
- switch actuator.
- Check for continuity of thermostat and heating element.

9 Rectify the fault by replacing the defective part (element, thermostat etc.) Fig 2 (A & B).

In case of open in element circuit

10 Remove the cover to check the thermostat, indicator bulb circuit and element
- Connect the series test lamp to the element circuit shorting the contacts of the thermostat indicated by 1 in Fig 3. If the test lamp glows the thermostat is defective.
- Connect the terminals of the indicating bulb by a piece of insulating wire, shown by 2 in Fig 3. If the test lamp glows the trouble is in this section.
- Short the terminals of the element shown by 3 in Fig 3. If the lamp glows the element is open. Replace the element.

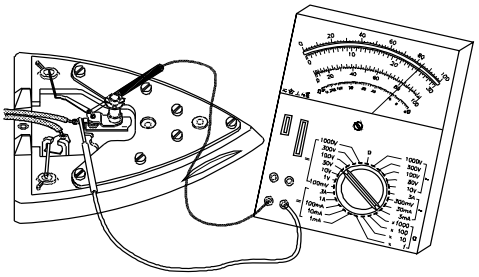
Failure of temperature setting controller

11 Check the adjusting knob for proper fixing and actuation of shaft. (Fig 4)

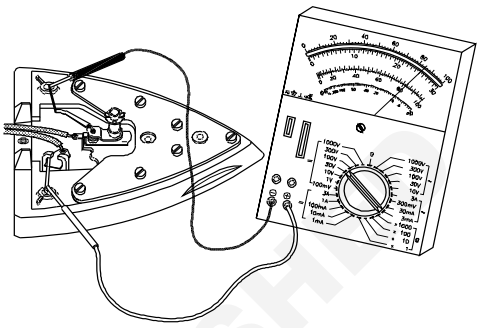
12 Open the contacts of the thermostat and inspect them visually.

13 Clean the pitted or burnt out contacts.

Fig 2



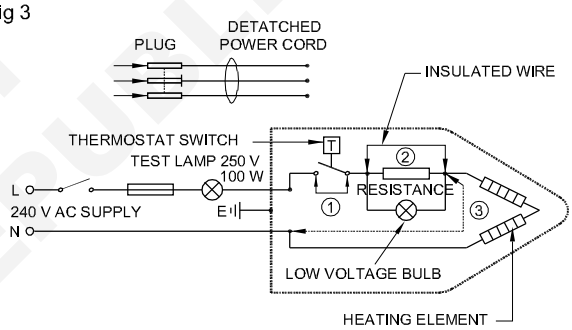
(A) TESTING THE THERMOSTAT FOR CONTINUITY



(B) TESTING THE HEATING ELEMENT FOR CONTINUITY

ELN26102H2

Fig 3

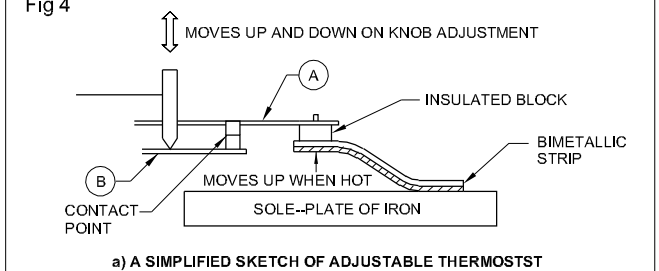


ELN26102H3

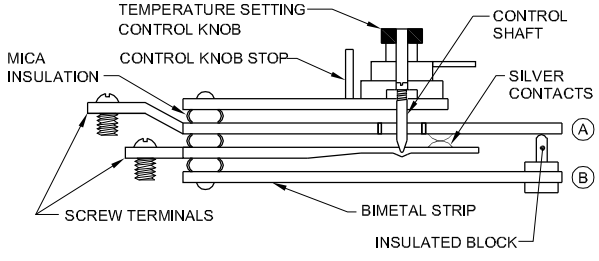
14 Check for the actuating mechanism. (Heat the thermostat by a suitable external heating device.)

15 Assemble the iron and test for good working.

Fig 4



a) A SIMPLIFIED SKETCH OF ADJUSTABLE THERMOSTST



b) OPEN FRAME BIMETALLIC ADJUSTABLE THERMOSTAT

ELN26102H4

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TASK 2 : **Service and repair of a Kettle**

1 Record the name-plate details of the appliance.

Name-plate Details

2 Disconnect the power cord and check the power cord for continuity of the cable, soundness of the terminal connection and insulation resistance between the line, neutral and earth terminals.

If found defective, either repair or replace the power cord.

3 Check the continuity of the kettle heating element either by using a test lamp or a Megger without opening the kettle.

If there is no continuity, the element is as sumed to be open and it has to be replaced

4 Check the insulation resistance between the appliance socket terminals and the body of the kettle.

If the insulation resistance is less than one Megohm, the kettle element needs to be replaced.

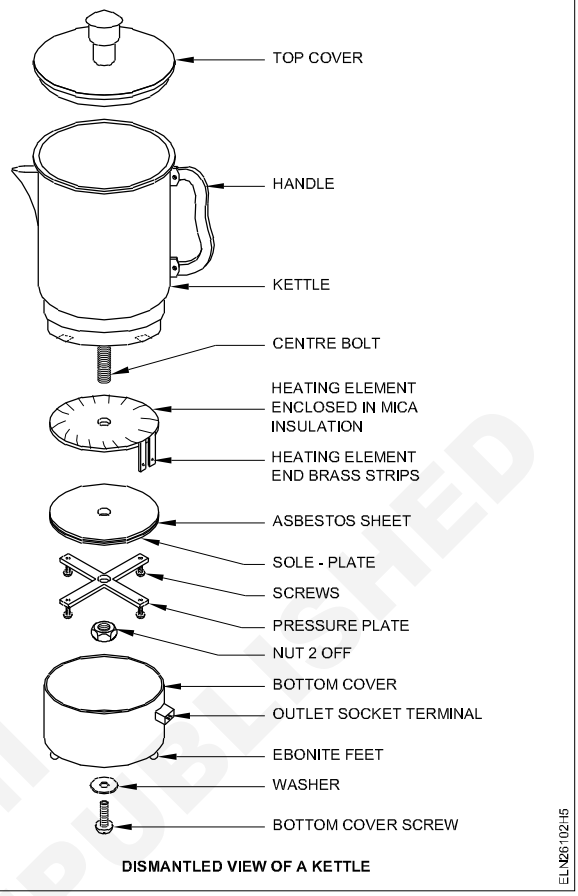
5 Read the assembly diagram in the instruction book of the kettle and dismantle the parts in the sequence recommended by the manufacturer.

6 In the absence of the manufacturer's recommended sequence diagram of the assembly, the following parts may be removed observing the correct procedure as shown in the exploded Fig 5.

- Bottom cover
- Pressure plate
- Sole-plate with asbestos insulation
- Element

7 Obtain a suitable element of the right shape, wattage and voltage and necessary mica and asbestos sheets of the same type and quality.

Fig 5



DISMANTLED VIEW OF A KETTLE

8 Check the element for its continuity and ohmic value.

9 Replace the new element in position.

10 Assemble the parts in proper order and connect the appliance.

Take care to fit the asbestos sheet and the sole plate at the sole plate housing in the correct order.

11 Measure the insulation resistance between the body of the appliance and its terminals before and after connecting the power cord.

Switch 'ON' the kettle only after filling water in it.

12 Test the appliance with supply for its working.

— — — — — — — —

TASK 3 : **Service and repair of a cooking range**

1 Note the name plate details of the electric cooking range.

2 Disconnect the power supply from the appliance.

3 Study the connection diagram, given by the manufacturer or trace the connections of the cooking range (Fig 6).

4 Check the continuity of the surface unit element one by one.

5 Replace the burnt out surface unit element as shown in Fig 7.

Before replace the coil check the correct shape, wattage and voltage of the element. Do not attempt to open parts whcih are not notified as defective.

6 Assemble and connect the electric cooking range.

7 Measure the insulation value between the terminal to body of the appliance at various positions of all the switches.

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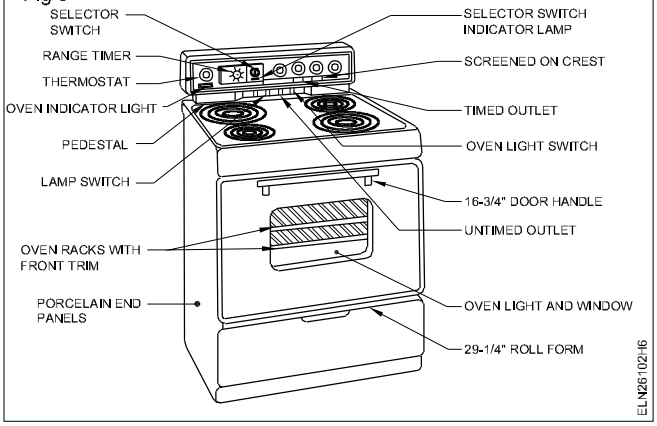
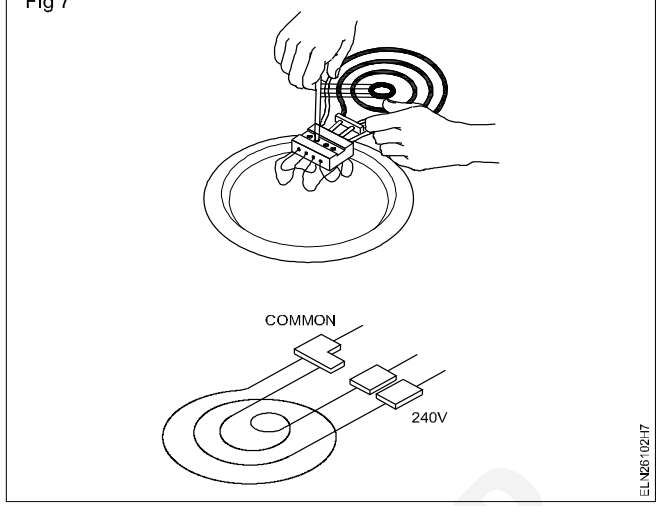
Fig 6



Insulation resistance value should be more than one Megohm.

8 Check the appliance with the supply for its working condition.

Fig 7



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TASK 4 : **Replace the wornout selector switch of cooking range**

1 Open the cover of the defective switch, trace the connections and note down the position and column of cables.

2 Open the connections of the switch from the terminals.

3 Check the continuity of input and output of the selector switch.

4 Confirm the condition of the contacts. If found wornout, then remove the switch from the appliance. (as shown in Fig 8).

Take care to fix the screws, washers at the complete housing of the selector switch.

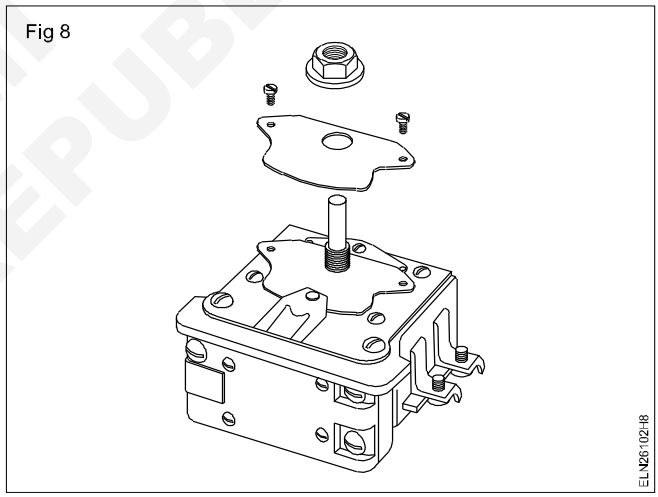
5 Replace the new selector switch in position.

6 Connect the cables as per made in step 1.

7 Measure the insulation resistance between line terminals and the body of the cooking range at various positions of all the switches. Measured insulation resistance should be above one megohms.

8 Test the assembled switch with the supply for its working.

Fig 8



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TASK 5 : **Service and repair of a geyser**

1 Record the details of the appliances in Table 2

2 Open the inspection cover for Power terrminals connection and thermostat installation in the geyser after removing the power plug. (Fig 9)

Check and ensure that the switch is off before removing the power plug.

3 Connect a visual examination of the i) power cord ii) plug pin termination and iii) termination at appliance.

4 Check for proper tightness and good Power contact at terminations. Replace the plug pin if found pitted.

5 Conduct the insulation test on the cord - between the leads, lead and earth. Enter in Table 1

6 Measure the insulation resistance between the element and the earth/body and record in Table 1. The minimum value of the insulation resistance should be one megohm. If it is less than one megohm, send the geyser for repair and rectification.

7 Connect the geyser to the supply and switch on the appliance, keeping the inspection/bottom cover of the Power connections open.

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The geyser should be switched on only with water in the container.

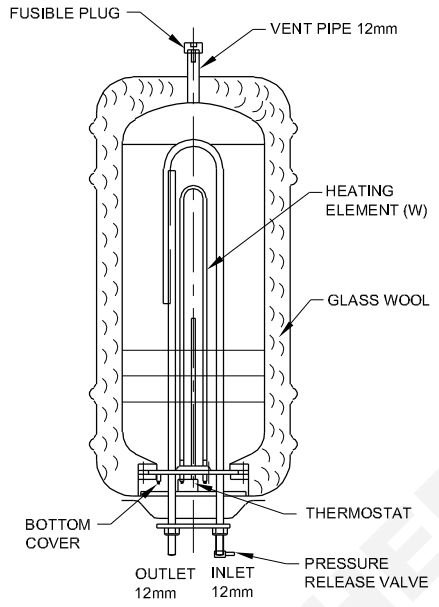
8 Observe that the heating process is cut off by the actuation of the thermostat. (The time depends on the capcity of the geyser and the thermostat setting).

9 Switch off the supply. Remove the plug. Measure the insulation resistance value between the terminals and the body of the heater/thermostat while it is hot and record the value in Table 1

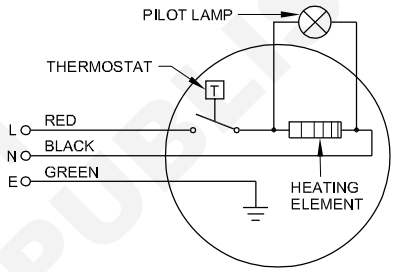
10 Replace the thermostat if unit in the insulation value is less than one megohm.

11 Refit the inspection cover. If the insulation value is normal (i.e. above one megohm) apply grease over the screw before fitting.

Fig 9



(a) GEYSER



(b) SCHEMATIC DIAGRAM OF A GEYSER

ELN26102H9

Table 2

Name of the appliance :		Serial No :	
Voltage :		Current :	
Supply :		Wattage :	
Capacity :		Make :	
Cord Insulation	Between lines	Between line/body	Date of servicing
	..... Megohm	..... Megohm	
Element insulation	Between terminal and body / thermostat		Recommended Repair Replacement if any
	Cold		
	Hot		

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Service and repair of induction heater and oven

Objectives: At the end of this exercise you shall be able to
- **dismantle the induction heater and identify or locate the faults**
- **replace the faulty parts with good ones**
- **dismantle the oven and identify or locate the faults**
- **replace the faulty parts with good ones**
- **assemble the induction heater and oven and test for its working.**

Scan the QR Code to view the video for this exercise

Requirements

Tools / Instruments

• Electrcian Tool Kit	- 1 Set
• Screw driver 250 mm	- 1 No.
• Connector screw driver 150mm	- 1 No.
• Electrician Knife 150 mm	- 1 No.
• Metal brush	- 1 No.
• Soldering iron 60W, 230V	- 1 No.
• Tile cutter	- 1 No.
• Multimeter	- 1 No.

Equipment / Machines

• Induction heater 1 kW, 250V	- 1 No.
• Electric oven 1 kW, 250V	- 1 No.

Materials

• Cotton waste	- as reqd.
• Thinner	- as reqd.
• Resin core solder	- as reqd.

PROCEDURE

TASK 1 : **Perform service and repair of induction heater**

1 Note the name plate details of the induction heater and record them in the Table.

Name Plate Details	
SL No. _____	Power _____KW
Make _____	1ϕ / 3ϕ
Voltage _____V	
Current _____A	

2 Disconnect the power supply from the induction heater.

3 Check the power cord for continuity of the cable

If found defective, replace the power cord

4 Open the induction heater.

5 Do a thorough cleaning of PCB and other parts.

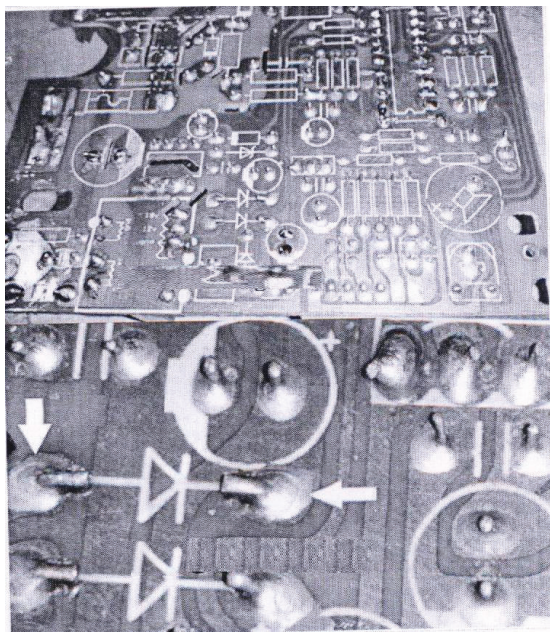
6 Remove the main board for visual inspection and trouble shooting.

7 Check whether PCB is covered by varnish.

8 Apply thinner and rub with metal brush and scrap with a knife and expose the dry solder points. (Fig 1)

9 Retouch all the points with fresh solder.

Fig 1



DRY SOLDERS

ELN26103H1

10 Check whether any capacitor cracked in the PCB (Fig 2). If so remove it from the PCB with the help of tile cutter (Fig 4) .

11 Check the electrolytic capacitors on the board and replace with a new one if they are found at the brim.

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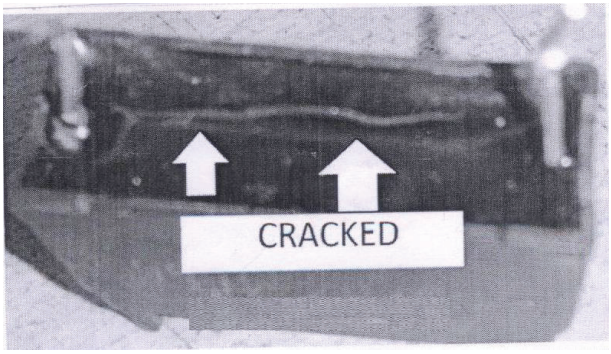
12 Press the switches on the control board and if they show resistance, it may be due to improper contact.

13 Replace all the Press-to-on button switches.

If buttons are slightly longer than the one on the board, nip the extra length with tile cutter tool

14 Defective switch is shown below (Fig 5)

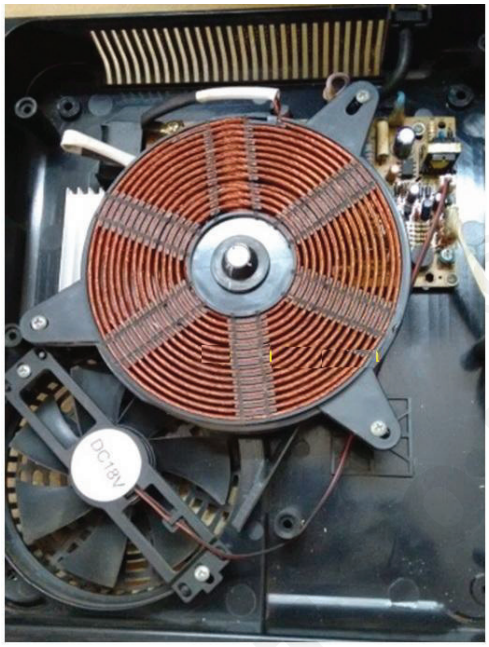
Fig 2



0.27/1200V CAP

ELN26103H2

Fig 3

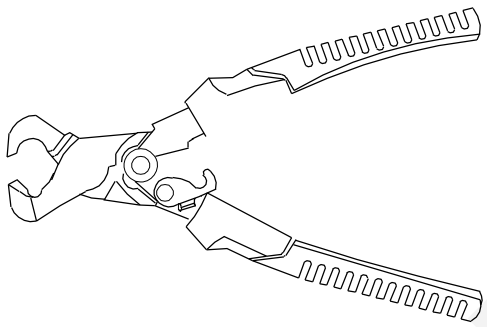


ELN26103H3

15 After completing the work put the PCB and other parts back into the cabinet, (Fig 3). Fig 6 shows the cook top of induction heater.

16 Test the appliances with supply for its working.

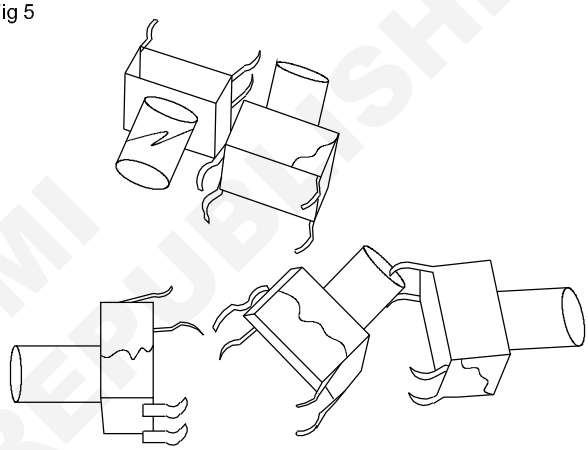
Fig 4



TILE CUTTER

ELN26103H4

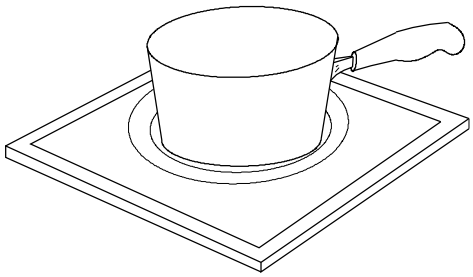
Fig 5



DEFECTIVE SWITCH

ELN26103H5

Fig 6



INDUCTION COOK TOP

ELN26103H6

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TASK 2 : **Service and repair of oven**

1 Identify the oven model number or part number on the element

The package (Fig 8b) of the new element will list the manfacturers, model numbers and part numbers for which it serves as a replacement

2 Turn off the power to the oven at the breaker box and unplug the oven

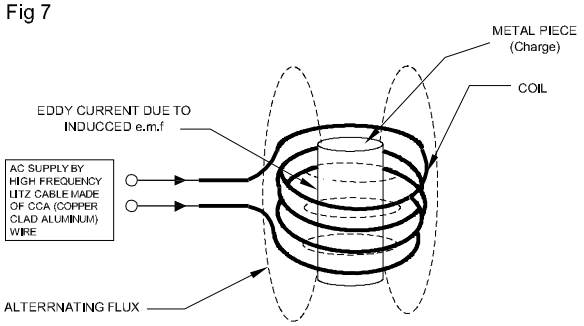
3 Remove the screws that secure the element to the oven

4 Pull the element 10 to 12.5 cms away from the back wall of the oven (Fig 7)

5 Remove the screws that hold the wires of element

6 Install the new oven element attaching the wires as they were before

Fig 7



INDUCTION COOKER

ELN26103H7

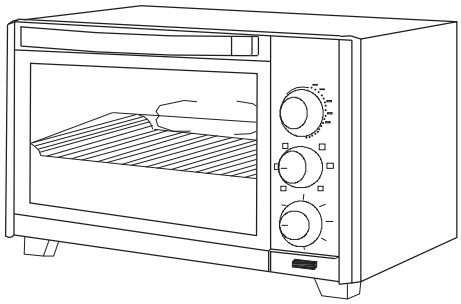
7 Secure the new element to the back wall of the oven (Fig 8a) shows element.

8 Plug the oven back in and return the breaker back to the “ON” position

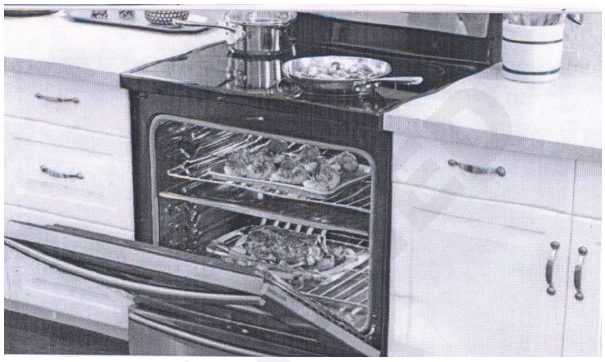
9 Test the oven with supply for its working.

There may be little smoke when the new element heats up it’s likely just the factory coating burning off.

Fig 8



(a)



(b) ELECTRIC OVEN

ELN26103H8

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Service and repair of mixer and grinder

Objectives: At the end of this exercise you shall be able to

- **read and interpret the data of the given mixer**
- **identify the area of problem in the mixer by visual inspection and tests**
- **dismantle the mixer**
- **trace, identify and locate faults in the mixer**
- **replace faulty parts with good ones**
- **clean and lubricate the bearings**
- **assmble mixer and test for its working**
- **read and interpret data of wet grinder**
- **test the line cord for continuity**
- **measure insulation resistance between the terminals**
- **trace, identify and locate faults in a wet grinder**
- **replace faculty parts with good ones.**

Requirements

Tools and Instruments

- Electrician Tool kit - 1 Set
- Test lamp 100 W, 240 V - 1 No.
- D.E. spanner set of six 6 mm to 22 mm - 1 Set
- Plastic spanner for opening the jar screw - 1 No.
- Box spanner set of 6mm to 22 mm - 1 No.
- Multimeter - 1 No.
- Megger 500 V - 1 No.
- Philips screwdriver 4 mm blade dia - 1 No.
- Pulley puller 3leg 200 mm - 1 No.

Equipment / Machines

- Mixer 250 V 50 Hz. 400 watts - 1 No.
- Grinder 250 V 50 Hz 0.25 HP - 1 No.
- AC Ceiling Fan 60 W, 250V - 1 No.

Materials

- Grease/lubricating oil - as reqd.
- Kerosene - as reqd.
- Cleaning brush - 1 No.
- Sandpaper smooth - as reqd.
- Soldering lead, 40:60, soldering flux - as reqd.
- Service manual (if available) - 1 No.

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PROCEDURE

TASK 1 : **Service a mixer**

1 Note down the name-plate details in the maintenance cards. (Table 1)

2 Enter the details of the complaint from the customer in the maintenance card.

3 Switch on the mixer and check for its functioning.

4 Isolate the mixer from the supply.

5 Open the bottom cover and conduct visual inspection for :

- damages in the supply cord and loose terminal connections
- good condition of switches
- proper mounting of the motor.

Check whether the nyon/rubber coupling of the jar and motor are properly seated, if not replace.

Sometimes the retaining spring and washer might have got spoiled and need to be replaced.

Table 1

Maintenance Card

Name of the customer _____ Address _____

Name of the appliance _____ Serial No _____

Wattage _____ Current _____ Voltage _____

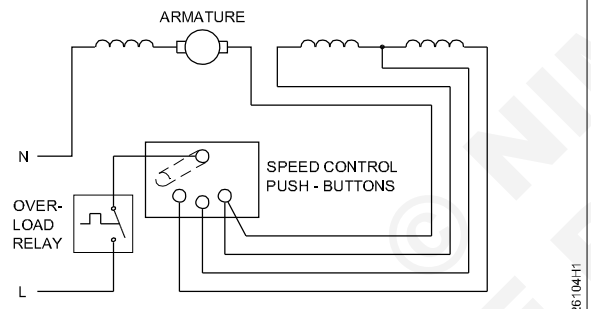
Supply _____ Make _____

Date of servicing	Consumer's complaint	Defects noticed by visual inspection	Details of repair and replacement

Enter the mixer details in the maintenace card (Table 1)

6 Conduct an insulation test of the motor and record in the maintenance card (Table 2). The schematic digaram of a mixer circuit is given in Fig 1.

Fig 1



SCHEMATIC DIAGRAM OF A TYPICAL PORTABLE 3 - SPEED FOOD MIXER

The insulation resistance value should not be less than one megohm.

7 Improve the insulation value by heating or varnishing, if the insulation value is less than one megohm and enter the test results in the maintenance card. (Table 2)

8 If the motor is opened for varnishing, clean thoroughly the stator and armature and bush bearings. (Fig 2)

9 Conduct the insulation test after varnishing and enter the results in the maintenance card (Table 2).

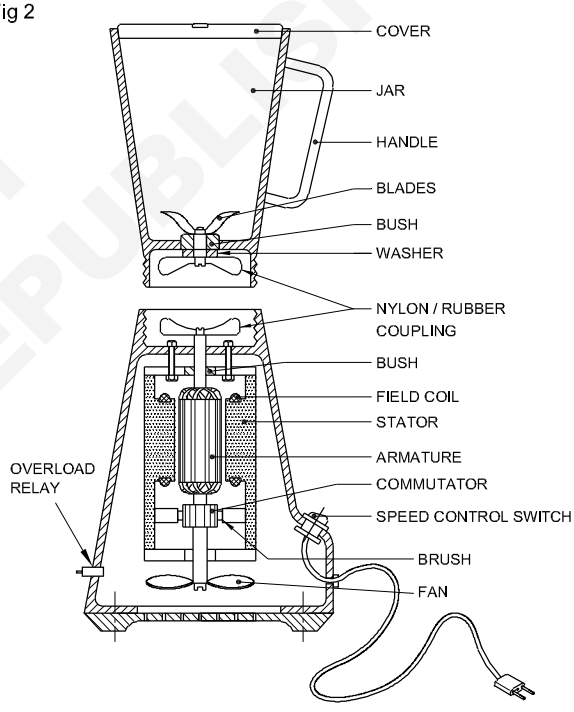
Remember that the nuts at the blades and the centre shaft holding nut are to be loosened by clockwise movement and tightened by anti-clockwise movement in most of the mixers.

10 Lubricate the bearing as recommended by the manufacturer before assembly.

Most of the bearings need no lubrication. If required,a drop of light oil like 3-in-1 oil could be used.

11 Clean the commutator surface. A black carbon deposit could be removed by CTC. Seat the bushes properly over the commutator. Check for adequate length of brushes to exert spring pressure.

Fig 2



PARTS OF A FOOD MIXER

If the brush length is shorter by 1/3 of its original length it is better to replace with the brushes of the same grade and size. The new brush has to be bedded on the commutator properly.

12 Assemble the motor and tighten the terminal screws.

13 Assemble the blade with the jar and nylon coupling at the bottom.

14 Connect the motor to the supply and start the mixer.

15 Observe the working of the mixer for smooth running.

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Table 2

Date of servicing	Insulation resistance before varnishing/heating		Insulation resistance after varnishing/heating		Details for repair and replacment
	Between terminal and body	Between Armature and field	Between terminal and body	Between Armature and field	

— — — — — — — —

TASK 2 : **Repairing of mixer**

1 Listen to the complaints of the customer/user and enter in the maintenance card (Table 1).

Common complaints are listed in the troubleshooting chart along with reasons for the possible cause and the corrective action to be taken.

2 Inspect visually the following parts for trouble.

- Power cord and plug
- Terminal connections at the switch (back cover to)
- Couplings
- Freeness of the shaft
- Burnt smell or discolouring of windings.

— — — — — — — —

TASK 3 : **Service a grinder**

1 Switch on the grinder and check for its functioning.

2 Isolate the grinder from the supply.

3 Open the inspection cover. Note down the name-plate details in Table 3.

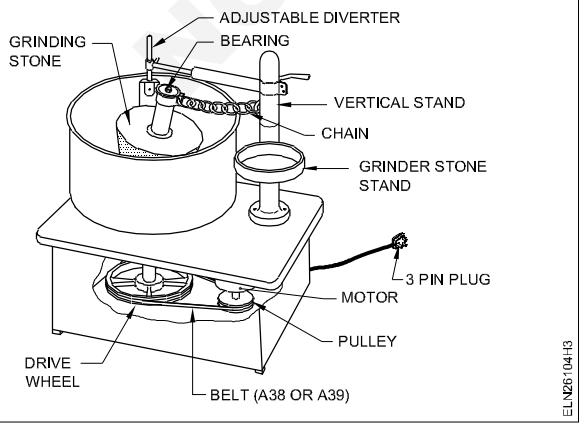
Table 3

Name of appliance_____	**r.p.m** _____
Serial No. _____	**Volt** _____
Capacity H.P_____	**Current** _____
Phase _____	**Frequency** _____

4 Conduct visual inspection:

- for supply cord
- for good condition of switches
- for proper mounting of motor and drive alignment (Fig 3)

Fig 3



5 Conduct an insulation test of the motor and record in Table 4. If the insulation value is above 1 megohm, switch on the grinder and observe its function.

6 If the insulation resistance is less than 0.5 megohm, improve the insulation value by heating or varnishing, provided the motor is opened for varnishing.

Table 4

Insulation resistance	Between terminals and body	Between winding
Date of servicing		
Recommended repair		
Replacement if any		

7 Clean thoroughly the motor and the bearing of the grinder.

8 Lubricate the bearing as recommended by the manufacturer before assembly.

9 Assemble the motor and tighten the terminal screws, pulley screws, flywheel nuts, motor fixing bolts etc. (After adjusting belt tension)

10 Connect the motor to the supply and start the grinder. Observe the working of the motor and the grinder for smooth running.

— — — — — — — —

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TASK 4 : **Repairing of grinder**

1 Listen to the complaints of the customer/user complaints may be:

i) Grinder not working

ii) fails to start, but runs in either direction, when started manually

iii) starts but heats rapidly

iv) reduction in speed - motor gets too hot

v) grinder is noisy

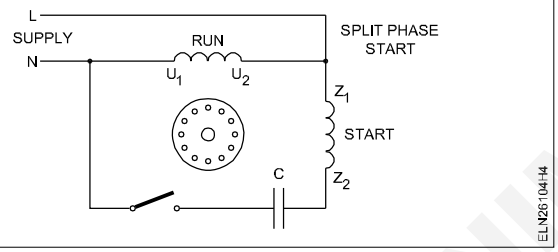
vi) grinder gives shock.

Grinder not working

Check whether there is open connection in line. Rectify the fault if observed.

Check for any open circuit in motor winding (starting and running winding). Send it for repairs, if open circuited. (Fig 4)

Fig 4



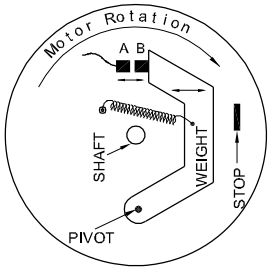
Check tightness of the belt. Adjust the belt for proper tension as recommended by the manufaturer. (Fig 3)

Check whether it is due to tight bearings. Test by turning the shaft by hand. If lubrication does not help, the bearing must be replaced.

Fails to start, but runs in either direction when started manually.

Check the contact of the centrifugal switch. If the contact of the centrifugal switch is not closed, repair it or replace it. (Fig 5)

Fig 5



THE CENTRIFUGAL SPEED-CONTROL MECHANISM USED ON SOME ELECTRIC MOTORS.

Check the capacitor. Replace it if defective.

Starts but heats rapidly.

Check the cetrifugal switch. If it is not opening, rectify or replace.

Reduction in speed - motor gets too hot.

Check the winding for its short circuiting and grounding (earthing).

Check the bearing to know whether it is sticky. Repair or replace, if found defective

Grinder is noisy

Check for worn out bearings - replace the bearings and inspect the shaft for scoring.

Check the end play, add additional end for preventing wahers, if the play is too much.

Check the loose parts (that is loose hold-down bolts, loose fan, pulleys etc). Tighten them.

Check whether there is misalignment. Align the pulleys correctly. (Fig 3)

Check the belt. Replace if it is worn out. (Fig 3)

Check the shaft of the motor. Replace or send the motor for repair, if found bent.

Grinder gives shock

Open the inspection cover and check for any line contact with the metallic body. Also ensure earthing is proper.

Rectify the accidental contact, if any, and insulate them properly.

— — — — — — — —

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Service and repair of washing machine

Objectives: At the end of this exercise you shall be able to
- **recod the name plate details of the wahing machine**
- **listen to the complaint of the customer and identify the type of fault**
- **rectify the fault in the washing machine**
- **service the washing machine through general checks and visual inspection**
- **conduct insulation resistance test on a wahing machine**
- **record the details of maintenance in the service card.**

Scan the QR Code to view the video for this exercise

Requirements

Tools and Instruments

- Megger 500 V - 1 No.
- Test lamp 60W,240V - 1 No.
- Combination plier 150 mm - 1 No.
- D.E spanner set 6 of 22mm set of 8 - 1 Set
- Philips screw driver 150 mm - 1 Set
- Grease gun 1.2 litre cap - 1 No.
- Oil cane 1/2 litre cap - 1 No.
- Geal pulley puller 3 leg 150 mm - 1 No.
- Multimeter - 1 No.

Equipment/Machines

- Washing machine ordinary or semi automatic type 240V, 50Hz - 1 No.

Materials

- Washing machine spares - as reqd.
- Oil/grease - as reqd.
- Oil/grease - as reqd.
- Water proofing kit - 1 No.
- Teflon tape/m seal - as reqd.

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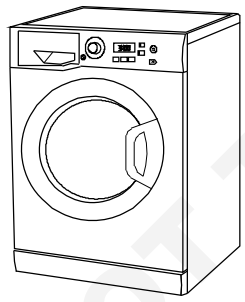
PROCEDURE

TASK 1 : **Repair washing machine**

1 Record the details of the washing machine (Fig 1) in Table- 1.

Fig 1



WASHING MACHINE

ELN26105H1

Table 1

Name-plate details

Manufacturer

Sl.No. _____ Phase _____

Capacity _____ R.P.M _____

H.P/K.W _____ Voltage _____Hz

Max.weight of clothes/ _____ Current _____

drum capacity_____

2 Listen to the complaints of the customer/user. The complaints may be anyone listed in the left side column of the table 2 The causes and remedies are given in the right side column of the table 2

Table - 2

Troubleshooting chart for washing machine

Sl.No.	Complaints	Causes and remedies
1	Machine not Swiching “ON”	I Check for open connection and rectify the same II Check the incoming supply III Check the fuse on the machine IV Check the motor windings and repair of minor repairs can be carried out, if needed send it for repairs/rewinding for internal open circuit. V Check the speed governing starting switch, repair or replace with a new switch.
2	Water not filling up in the washing drum	I The inlet pipe is chocked. Open the inlet valve, clean it and reconnect it using water proofing teflon tape II Check incoming water supply and replace the same.
3	Water does not drain out of the wash drum	I Check the outgoing valve, clean and reconnect it with proper water proofing II Check the outgoing pipe for any kinks - repair or replace the same.
4	Machine becomes ‘ON only for a very short duration and then switches off	I The timer setting may be incorrect;set the timer properly. II The speed governor switch may be faulty; dismantle the motor and repair the same, If possible, or replace the starting speed governor swivel mechanism. III The running winding impedance could have increased due to open circuit and insulation failure. Check the running winding impedance and rewind the motor, if necessary.
5	The machine is noisy	I Check the balancing of the drum and correct the same if found off balance. II The motor shaft pulley/drum driver pulley may be loose,tighten the same. III The belt of the machine drive might have loosened thus giving play. IV Check the bearings of the motor, replace the worn out or grease the same using the recommended grease. V Check all rubber bushings that are used in the machine for absorbing mechanical vibration, and replace, if found spoilt or missing.
6	When power is swiched ‘ON’ motor is not working	I Check if the motor shaft is rotating; the pulley to the hum is heard but the wash agitator does motor shaft may be loose, tighten the same. II Check the belt tension. If the belt has become loose tighten the same by the tension adjustor or replace the belt with a new one. III Check if the agitator of the machine is sufficiently loose,i.e. the bearing if free and not tight; carry out lubrication of the bearing if necessary.
7	When the machine control switch is switched ‘ON’ the fuse blows	I Isolate the machine from the supply, isolate the motor terminals and check if there is an insulation failure/short circuit in the motor or in the wiring of the machine. II If short circuit/insulation failure in the motor, rewind the motor. III If short circuit/insulation failure is present in the rest of the machine, trace the same and remove the short circuit.

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TASK 2 : **Servicing of washing machine**

1 Read the instruction manual of the washing machine.

2 Connect the machine to the supply and switch on the machine in steps as indicated by the operating/ instruction manual.

3 Check the water flow at the inlet to the machine. If found incorrect clean the inlet and reconnect the water supply using proper waterproofing method. If leakage is present at the connecting point between the machine and the water pipe, use teflon tape between the couplings to prevent leakage.

4 Check the water flow at the outlet and check whether all the water is drained out of the wash drum. If it does not, disconnect the machine from the supply then level the machine on the floor and let the water is drained out.

5 Isolate the machine from the supply. Open the inspection cover of the machine and carry out visual inspection of :

- the supply cord and its terminations i.e. between plug and machine terminals
- condition of the motor pulley-belt and drive alignment
- all internal connections between the control panel and the machine motors, timer and switches, shown in Fig 2.

6 Lubricate the bearings of the motor with a suitable grease as recommended by the manufacturer with the help of the grease pump.

7 and especially where maximum vibration of the machines is felt, use a dot of grease or oil in the threads.

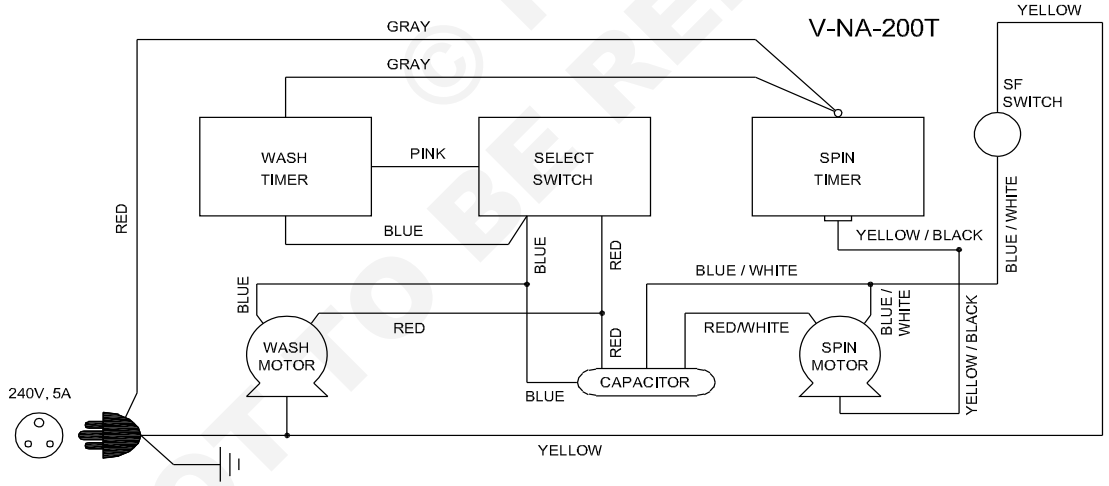
8 Conduct an insulation test of the motor and record it in Table 3, using a 500V Megger. Insulation resistance should be around 1 megohm; if found less then check the wiring and internal accessories and all Powerly live parts for moisture and weak insulation. Remove the moisture and prevent any water leakage near the Power parts suitably. Reconduct the insulation test.

9 Close the inspection hatch/cover and connect the machine to the supply and load the machine with the number of clothes recommended by the manufacturer for the smooth running of the washig machine.

Table 3

Insulation resistance between terminal & body windings	
Date of servicing	
Recommended repair	
Replacement of parts	

Fig 2



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Verify terminals identify components and calculate transformation ratio of single phase transformers

Objectives: At the end of this exercise you shall be able to
- **read and interpret the details of the name-plate of single phase transformer**
- **identify H.T & L.T. winding**
- **determine transformation ratio (turns ratio) by the**
  - **voltmeter method**
  - **ammeter method.**

Requirements

Tools/Instruments

- VoltmeterM.I. 0 - 250/300V - 2 Nos.
- Ohmmeter (0 - 500 ohms) - 1 No.
- Ammeter M.I. type (0 - 10 Amp) - 1 No.
- Ameter M.I. 100 mA - 1 No.
- Voltmeter M.C. 0-15V - 1 No.

Materials

- Knife switch DPST 16A 250V - 1 No.
- Push-button 6A, 250V - 1 No.
- Connecting cables - as reqd.

Equipment/Machines

- D.C. supply 12 volts - 1 No.
- Single phase transformer 115/230 volts, 1KVA - 1 No.
- Auto-transformer (IP-240V) OP 0-270V, 5A - 1 No.

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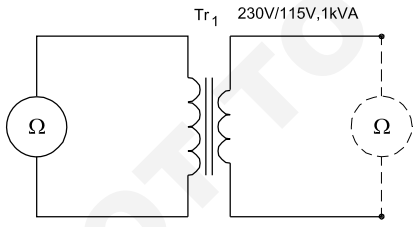
PROCEDURE

TASK 1 : **Identify terminals**

1 Find out the corresponding terminals of two windings (H.T. & L.T) with ohmmeter as shown in Fig 1, by checking the continuity.

Fig 1



CIRCUIT FOR IDENTIFICATION OF TERMINALS OF SINGLE PHASE TRANSFORMER

2 Determine HT and LT winding by measuring resistances with the ohmmeter.

L.T. windings will have low resistance in the case of step down transformer.

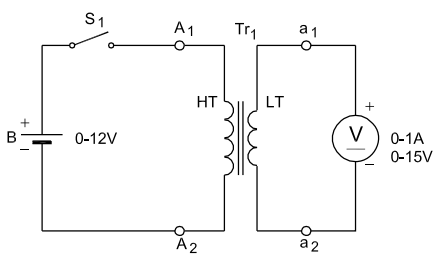
Record resistance of both pairs.

1st pair _____ ohms. This is HT/LT winding.

2nd pair _____ ohms This is HT/LT winding.

3 Connect DC supply to HT through push-button swithch and connect the voltmeter to LT as shown in Fig 2.

Fig 2



CIRCUIT FOR IDENTIFICATION OF POLARITY OF TRANSFORMER

4 Mark HT terminals as A_1 and A_2. Mark at LT terminals as a_1 and a_2.

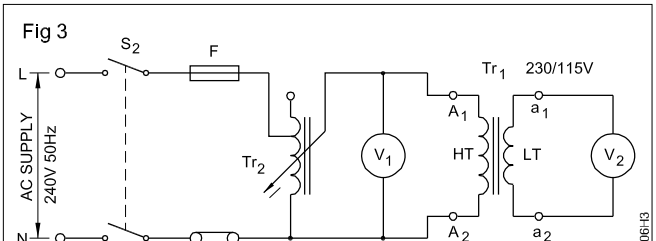
5 Press the push-button switch. Observe the deflection of the pointer of the voltmeter. If the pointer deflects in the right direction, retain the markings made on terminals.

6 Change the voltmeter connections made to LT terminals and change the marking made on the LT terminals if the deflection is in the reverse direction. Now press the push-button switch once again and observe that the voltmeter deflects in right direction.

TASK 2 : **Verification of transformation ratio (by voltmeter method)**

1 Connect the auto-transformer and the voltmeters to the transformer as shown in Fig 3. Check and set the auto-transformer at zero volt output position.

Fig 3



CIRCUIT FOR VERIFICATION OF TRANSFORMATION RATIO

2 Switch on 'S_2' and adjust the autotransformer to get the output voltage V_1 = 100 volts and read V_2 record the value in Table 1.

The output voltage of the auto-transformer should be adjusted to about 50% of the rating of the H.T. side.

3 Set the V_1 value for the values indicated in Table 1 and record the corresponding readings of V_2 in Table 1.

4 Calculate the transformation ratio from the measured V1 & V2 values.

Applying the formula -

$$\text{Transformation ratio} = \frac{V_2}{V_1}$$

Table 1

Sl. No.	V_1	V_2	Transformation ratio $K=V_2/V_1$
1	100 Volts		
2	125 Volts		
3	150 Volts		
4	200 Volts		
5	225 Volts		

5 Compare the calculated transformation ratio with the marking of name plate.

6 Transformation ratio calculated

from measurements =

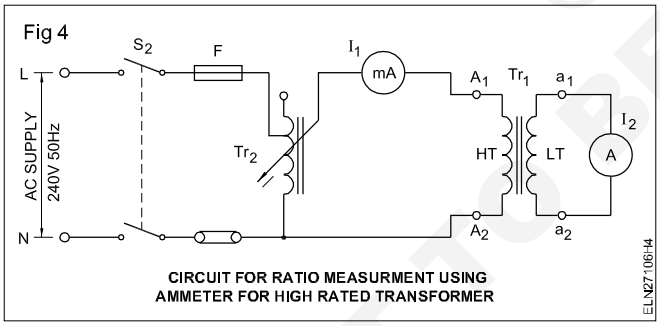
from markings =

— — — — — — — —

TASK 3 : **Verification of transformation ratio (by ammeter method)**

1 Connect the auto-ransformer output to the transformer H.T. winding through a milliammeter in the line as shown in Fig 4.

Fig 4



CIRCUIT FOR RATIO MEASURMENT USING AMMETER FOR HIGH RATED TRANSFORMER

The current in the H.T. winding should be kept low, but should be large enough to be measured accurately with a milliammeter.

2 Connect the L.T. winding to the ammeter. The ammeter should carry the rated current of L.T. side.

Use the current transformer and ammeter if the secondary rating is very high.

3 Increase the voltage to give the required current in H.T. winding.

4 Read the L.T. current. Record in Table 2.

5 Change the H.T. current to different values and record the corresponding L.T. current.

Table 2

Sl. No.	I_1	I_2	Transformation ratio $K=I_1/I_2$
1			
2			
3			
4			

6 Verify the transformation ratio with the markings on the name-plate and record your findings.

_____

_____

_____

_____

— — — — — — — —

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Perform open circuit and short circuit test to determine the efficiency of single phase transformer

Objectives: At the end of this exercise you shall be able to
- **conduct open circuit test to determine iron or core loss**
- **conduct short circuit test to determine full load copper loss**
- **determine effiiciency of the transformer at different loads.**

Requirements

Tools/Instruments

- Voltmeter M.I. 100V - 1 No.
- Voltmeter M.I. 150V - 1 No.
- Wattmeter 250V, 5A - 1250W - 1 No.
- Ammeter M.I. 5A - 1 No.
- Ammeter M.I. 15A - 1 No.
- Frequency meter 45 to 55Hz. - 1 No.
- Power factor meter 0.5 lag -1-0.5 lead 250V rating - 1 No.

Equipment/Machines

- Transformer 100/250V 1 kVA 50 Hz - 1 No.
- Auto-transformer input 240V Voutput 0 to 270V, 5A - 1 No.

Materials

- Knife switch DPST 16A, 240V - 1 No.
- Connecting cables - as reqd.

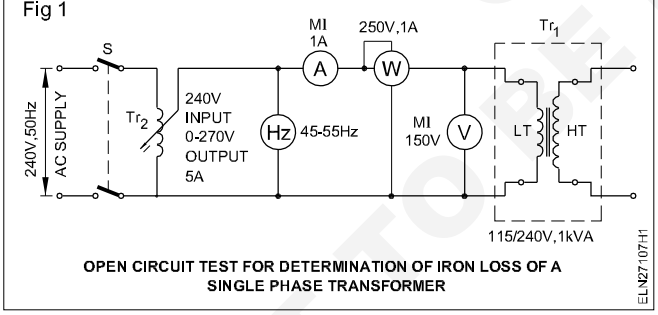
PROCEDURE

TASK 1 : **Conduct open circuit test to determine iron or core loss**

1 Identify the LT and HT windings of the given transformer.

2 Connect the Auto-transformer, frequency meter, ammeter, wattmeter. Voltmeter to the LT side of the transformer as shown in Fig 1.

Fig 1



OPEN CIRCUIT TEST FOR DETERMINATION OF IRON LOSS OF A SINGLE PHASE TRANSFORMER

Ensure that the auto-transformer is initially set at zero volt output position.

3 Close the switch 'S'.

Increase the voltage slowly up to (100%) of the rated value of the transformer L.T.

4 Check for the supply frequency is at rated value.

5 Observe the meters and record the readings in Table.

6 Repeat the above steps for 110% rated value of transformer voltage and record the readings in Table.

TABLE

Sl.No.	Rated	Voltage V	Current A	Total Iron loss W
1	100%			
2	110%			

From the above data the No load loss is equal to iron loss. Since the copper loss is negligible.

— — — — — — — —

TASK 2 : **Conduct shot circuit test to determine full load copper loss of a transformer**

Short circuit test

1 Connect the auto-transformer, ammeters, voltmeter and wattmeter in the HT side of the transformer as shown in Fig 2.

Ensure the auto-transformer is initially set at zero volt output position.

2 Close the switch 'S'

The secondary is short circuited by the ammeter.

3 Increase the voltage gradually to obtain full load current in the secondary winding of the transformer.

4 Observe the wattmeter and record the readings.

W = Copper loss (full load).

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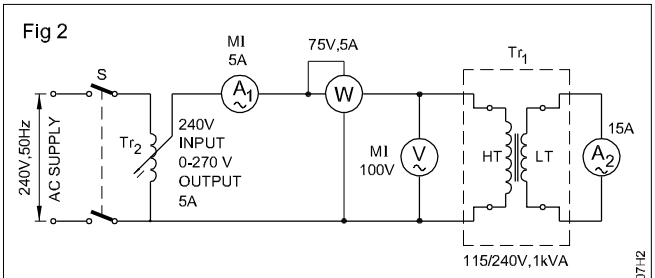
Fig 2



SHORT CIRCUIT TEST FOR DETERMINATION OF COPPER LOSS OF A SINGLE PHASE TRANSFORMER

— — — — — — — —

TASK 3 : **Determine efficiency of transformer or different loads**

1 Prepare and draw the circuit diagram for the said task and get approved by your instructor.

2 Collect the equipments and materials and check their condition.

3 Connect the circuit as per the approved circuit diagram (Fig 3).

Keep the switches s_1 and s_2 open. Set the auto transformer for zero volt output.

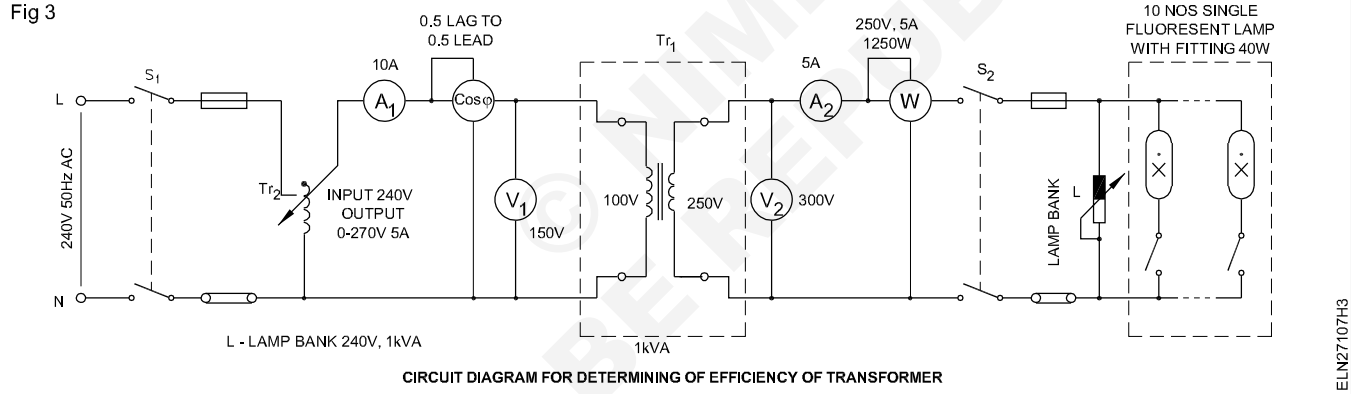
4 Close switch S_1 and gradually increase the output of the auto-transformer to reach the rated voltage.

Keep all the switches in the lamp bank in 'off' position.

5 Close switch S_2 and switch 'on' the incandescent lamps one by one till ammeter A_2 reads 25% of the load.

6 Adjust the auto-transformer Tr_2 if necessary to keep the primary voltage constant.

Fig 3



CIRCUIT DIAGRAM FOR DETERMINING OF EFFICIENCY OF TRANSFORMER

7 Record the readings of the instruments in Table 1.

8 Increase the incandescent lamp load to 50% of the full load 75% of the full load and 100% of the full load and record the reading in each case.

9 Reapeat the above steps by switching on the tube lights to get a power factor of about 0.9, 0.8 and 0.7 and record the readings in Table 2.

10 Switch 'OFF' supply after bringing the knob of the auto transformer to minimum (zero) postition.

11 Calculate the efficiency using the formula

$$\text{Percentage efficiency } \frac{\text{Output}}{\text{Input}} \times 100 \text{ OR}$$

$$\text{Percentage efficiency } = \frac{\text{Output}}{\text{Output} + \text{losses}} \times 100$$

$$= \frac{W}{W + W_1} \times 100$$

where W_1= Iron loss + copper loss.

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Table - 1

(Unity P.F)

Sl.No.	Load	V_1	A_1	P.F (Cos φ)	V_2	A_2	W	% Efficiency $= \frac{W}{V_1 A_1 \cos\varphi} \times 100$
1	No load							
2	1/4th load							
3	1/2 load							
4	3/4 load							
5	Full load							

Table - 2

(Different P.Fs)

Sl.No.	Load	V_1	A_1	P.F (Cos φ)	V_2	A_2	W	% Efficiency $= \frac{W}{V_1 A_1 \cos\varphi} \times 100$
1	No load							
2	1/4th load							
3	1/2 load							
4	3/4 load							
5	Full load							

12 Complete the tasks and get approved by your instructor and disconnect the circuit.

Conclusion

1 The relationship between load and efficiency _____

2 The relationship between power factor and efficiency _____

3 The efficiency will be maximum when _____

— — — — — — — —

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Determine voltage regulation of single phase transformer at different loads and power factors

Objectives: At the end of this exercise you shall be able to
- **connect the transformer with suitable instruments to measure load and power factor**
- **calcutlate the regulation of single phase transformer from the readings of instruments in primary and secondary side.**

Requirements

Tools/Instruments

- Ammeter M.I.-0 to 5A, 0 to 10A each - 1 No.
- Voltmeter M.I.-0 to 300 V, 0 to 150 V - 1 No. each
- P.F.meter 0.5 lag -1 - 0.5 lead 250 V rating - 1 No.

Materials

- Connecting cable - as reqd.
- 40 watts-tube light fitting - 10 Nos.
- DPST switch 250V 16A - 2 Nos.
- SPT switch 6 A - 2 Nos.

Equipment/Machines

- Induciton motor with starter & loading
- arrangement 240V 50Hz 1 HP - 1 No.
- Auto-transformer Input 40V Output 0 to 270 V, 5 amps - 1 No.
- Single phase transformer 115/230V 1 kVA, 50 cycle air cooled - 1 No.
- Lamp bank 5 A, 250V - 1 No.

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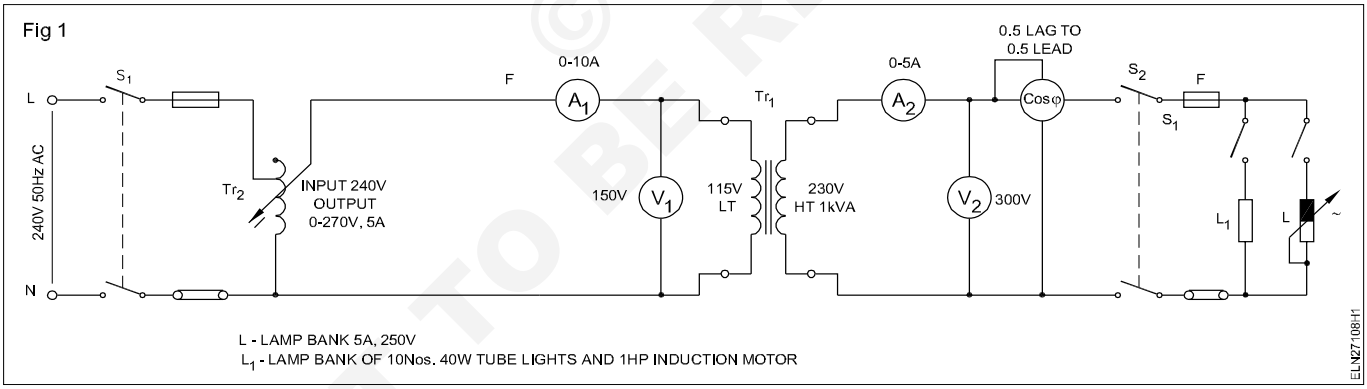
PROCEDURE

Fig 1



1 Form the circuit as shown in Fig 1.

2 Note down the name-plate details of the transformer. (Table 2)

Table 1

Sl. No.	Load (Lamp)	Secondary Terminal Voltage V_s	Change of volts V_o-V_s	Regulation
1	No load V_o			
2	1/4 F.L.			
3	1/2 F.L.			
4	3/4 F.L.			
5	F.L.			

Check the auto-transformer T_{r2} is set at zero volts output position.

3 Switch on 'S_1' and adjust the voltage of primary to rated secondary voltage (V_o) of transformer.

4 Close the load switch S_2

5 Adjust the lamp load as indicated in Table 1 and record the secondary voltages at each load. (V_s)

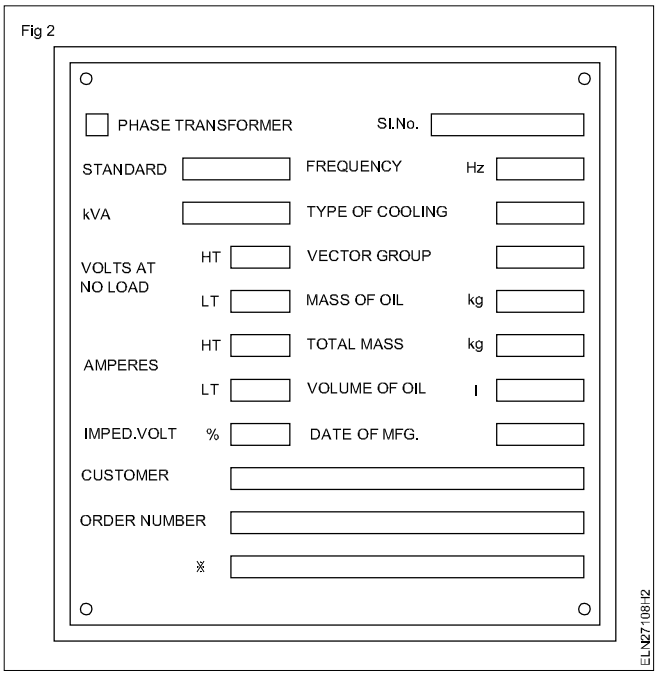
6 Calculate % of regulation at different resistive loads.

$$\left(\%\text{ of regulation} = \frac{V_o - V_s}{V_s} \times 100\right)$$

7 Put the inductive load with lamp bank (mixed load) so that the load power factor is lagging.

Table - 2

Fig 2



8 Gradually increase the mixed load and measure the terminal voltage, power factor and record in Table 3. Calculate the % of regulation at different loads and power factors.

9 Describe the relationship between p.f. and % of regulation when P.F. changes. Switch off 'S_2' and 'S_1'.

Table 3

Sl. No.	Load (Mixed)A_2	V_s	PF	Change of volts	Regulation
1					
2					
3					

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Perform series and parallel operation of two single phase transformers

Objectives: At the end of this exercise you shall be able to
- **connect two single phase transformers in parallel**
- **connect two single phase transformers secondary in series.**

Requirements

Tools/Instruments

- Voltmeter MI, 150V - 1 No.
- Voltmeter MI, 300V - 2 Nos.

Equipment/Machines

- Single phase transformer 230/115, 1 KVA 50 H1. - 2 Nos.
- DC supply 12V/Battery 12V - 1 No.

Materials

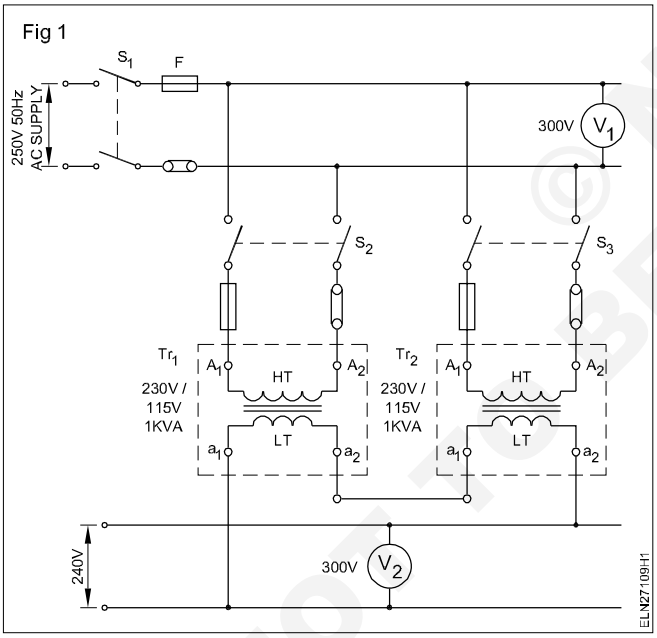
- ICDP switch 16A 250V 50Hz - 4 Nos.
- Connecting cables - as reqd.

PROCEDURE

TASK 1 : **Connect the transformer secondary in series**

1 Connect the transformer as per diagaram. (Fig 1)

Fig 1



2 Close the switches S_1, S_2 and S_3.

3 Measure the primary voltage V_1 and secondary voltage V_2 and record in Table 1

Table 1

	Transformer in series	
	Primary V_1	**Secondary V_2**
Tr_1		
Tr_2		

4 Disconnect the transformers by opening S3, S2 and S1.

Table 2

Sl. No.		Type of cooling	
KVA		Frequency	
		Date of MFG	
AT NO LOAD VOLTS	HT		
	LT		
AT NO LOAD CURRENT	HT		
	LT		

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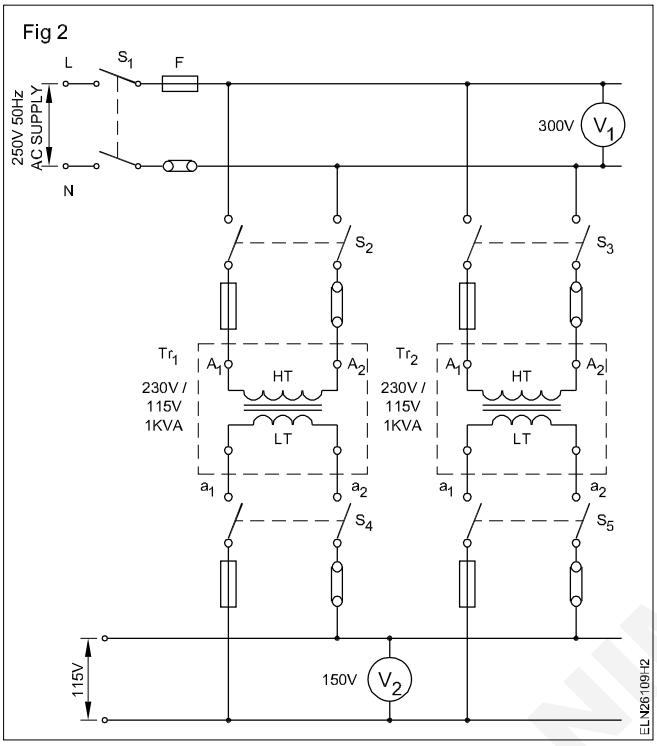
TASK 2 : **Connect the transformer in parallel**

1 Read and record the name-plate details of both the transformers, Tr_1 & Tr_2 in table 2.

2 Determine the polarity of the two given tranformers.

3 Connect the switches, transformers and meters as per diagram. (Fig 2)

Fig 2



4 Keep all the switches open.

5 Ensure that the transformers are identical for parallel connections.

6 Connect trasformer Tr_1 to the bus bar closing the switches S_1 & S_2. Measure the primary voltage V_1 and record in Table 3

Table 3

Transformer in parallel		
	Primary V_1	**Secondary V_2**
Tr_1		
Tr_2		

7 Check the secondary voltage of Tr_1 and record it table 2.

8 Close the switch S_3 and check the secondary voltage of the transformer Tr_2 and record. (Table 2)

9 Close the switch S_4 and S_5 and measure the secondary bus bar voltage and record in table 3.

10 Switch off all the switches and disconnect both the transformers.

CONCLUSIONS

11 The effect on secondary voltage of transformers when connected in series is

_____

_____

_____

12 The effect on the secondary voltage of transfomers when connected in parallel is

_____

_____

_____

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Verify the terminals and accessories of three phase transformer HT and LT side

Objectives: At the end of this exercise you shall be able to
- **read and interpret the name plate details of a three phase transformer**
- **verify the terminals of HT and LT winding**
- **Identify the accessories of a three phase transformer.**

Requirements

Tools/Instruments

- DE Spanner Set 5mm to 20mm - 1 Set
- Insulated cutting pliers 200mm - 1 No.
- Screw driver 200mm - 1 No.
- M.I.voltmeter 0-500 V - 1 No.
- Multimeter - 1 No.

Equipment/Machines

- 3 - Phase transformer 415/240V, 3 KVA - 1 No.
- 3 - Phase transformer Input 415 V Output 0-500 V, 3 kVA - 1 No.

Materials

- Test lamp 40 W, 230 Volts - 2 Nos.
- Connecting leads - as reqd.

PROCEDURE

TASK 1 : **Verify the terminals of three phase transformer**

1 Note down the name plate details and enter in Table 1

Table 1

Name plate details

SlNo	: _____	Type of cooling	: _____
KVA	: _____	Mass of Coil	: _____
Volts HT	: _____	Total mass	: _____
LT	: _____	Date of MFG	: _____
Amps HT	: _____	Volume of oil	: _____
LT	: _____		
Frequency	: _____		

2 Check the continuity test using a multimeter to find out the two groups of terminals. (Fig 1)

3 Apply 15V 3ϕ supply to U_1, V_1 and W_1 by switching on switch 'S'.

4 Measure the voltage between V_2 and W_2 and between V_2 and U_2. If the voltmeter shows less than 15 volts then those windings are LT winding. If the voltmeter shows more than 15 Volts then those windings are HT winding. (Fig 2)

Fig 1

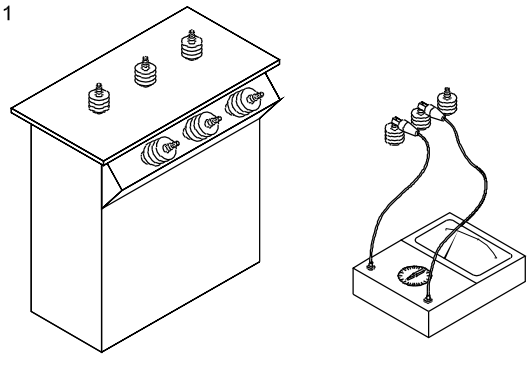

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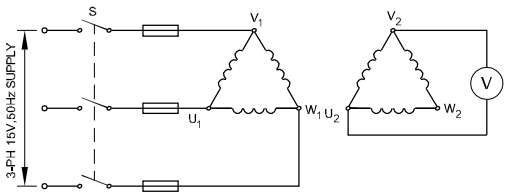
Fig 2



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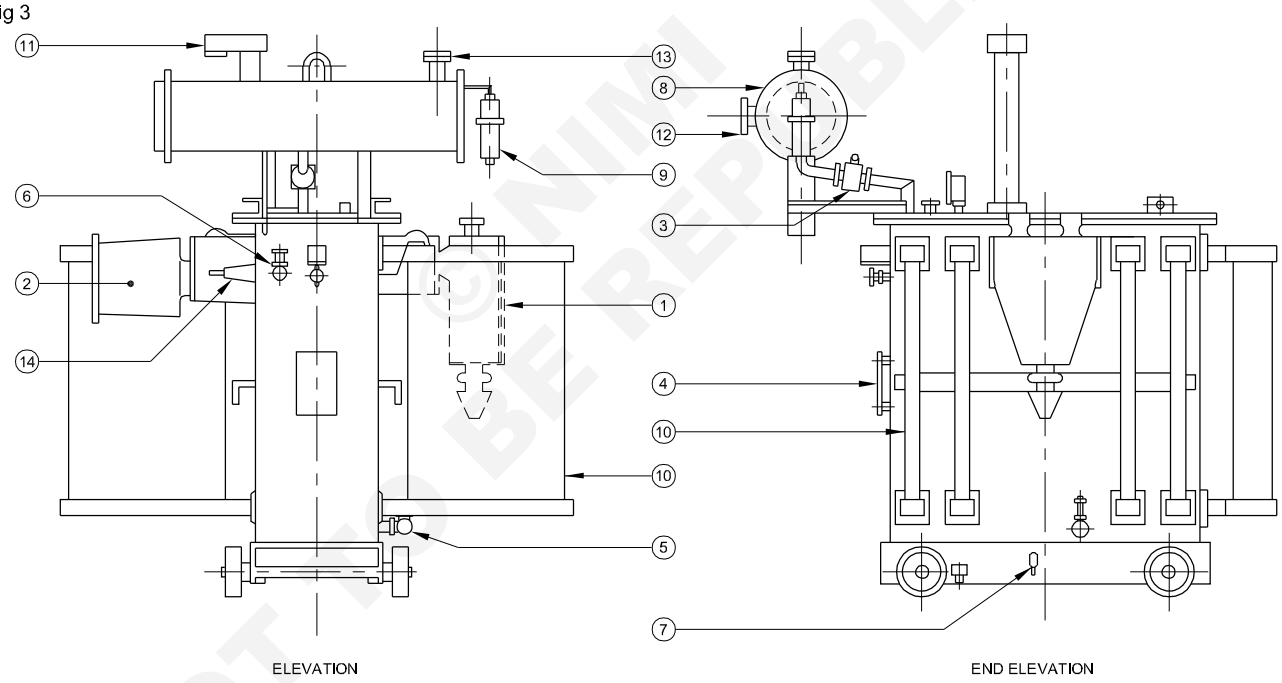
TASK 2 : **Identify the accessories of 3 phase tranformer**

1 Get permission to enter the 11 KV transformer substation yard from the appropriate authority

2 Identify the following accessories of a 100KVA three phase transformer. (Fig 3 and 4)

- a HV & LV Bushing
- b Buchholz relay
- c Conservator
- d Breather
- e Cooling pipes
- f Explosion vent with oil gauge
- g Earthing terminals
- h Oil level indicator.

Fig 3



No.	ACCESSORIES
7	EARTHING TERMINALS ON BOTH SIDES
6	FILTER VALVE
5	DRAIN VALVE
4	TERMINAL MARKING AND DIAGRAM PLATE
3	BUCHHOLZ RELAY
2	L.V TERMINALS IN BUS DUCT
1	H.V.CABLE BOX

No.	ACCESSORIES
14	L.V. BUSHING
13	FILLING HOLE WITH CAP
12	OIL LEVEL INDICATOR
11	EXPLOSION VENT WITH OIL GAUGE
10	COOLING PIPES
9	DEHYDRATING SILICA-GEL BREATHER
8	OIL CONSERVATOR

ACCESSORIES OF 3Ø TRANSFORMER

ELN27110H3

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Perform 3 phase operation (i) delta - delta (ii) delta - star (iii) star-star (iv) star - delta by use of three single phase transformes

Objectives: At the end of this exercise you shall be able to
- **connect three single phase transformers to 3-phase supply with different types of primary and secondary connection**
- **measure the primary and secondary line voltages in each type of connection**
- **determine the line volage ratio and compare with the theoretical ratio values.**

Requirements

Tools/Instruments
- Electrician tool kit - 1 No.
- Voltmeter M.I. - 0 to 500V - 1 No.
- Voltmeter M.I. - 0 to 300V - 1 No.

Equipment/Machines
- Single phase transformer 1 kVA 415/230 V 50Hz - 3 Nos.

Materials
- Connecting cables - as reqd.
- ICTP switch 500V, 16A, - 2 Nos.
- HRC fuses, 2 Amp - 3 Nos.

PROCEDURE

1 Connect the three single phase transformers and per form polarity test and voltage ratio test.

Note down the voltage ratio of each transformer in the table.

All the three transformers should have the same voltage ratio and same primary and secondary voltages.

2 Mark the termials of the primary (HT) and secondary (LT) of each single phase transformer as follows.

The Terminal Marking are as per Standards

Terminals	Transformer 1	Transformer 2	Transformer 3
Primary (HT)	1U	1V	1W
	Starting Ending	Starting Ending	Starting Ending
	1.1 1.2	1.1 1.2	1.1 1.2
Secondary(LT)	2U	2V	2W
	Starting Ending	Starting Ending	Starting Ending
	2.1 2.2	2.1 2.2	2.1 2.2

— — — — — — — —

TASK 1 : **Connect the transformers as three phase delta-delta transformer**

1 Connect the dissimilar ends of the primary together. i.e. (Fig 1)

Connect 1.1. of Tr.1 with 1.2 of tr.3 and mark it as 1 U

Connect 1.2. of Tr.1 with 1.1 of tr.2 and mark it as 1 V

Connect 1.2. of Tr.1 with 1.1 of tr.3 and mark it as 1 W

2 Connect the dissimilar ends of the secondary windings. i.e.

Connect 2.1. of Tr.1 with 2.2 of tr.3 and mark it as 2 U

Connect 2.2. of Tr.1 with 2.1 of tr.2 and mark it as 2 V

Connect 2.2. of Tr.2 with 2.1 of tr.3 and mark it as 2 W

3 Connect 1U, 1V, 1W to ICTP switch S1.

4 Connect a volmeter 0-500V across 1U and 1V.

5 Connect a voltmeter 0-300V across 2U and 2V.

6 Close the switch S1 and Note down the primary line voltage and secondary line voltage in tabular column under Delta-Delta connection.

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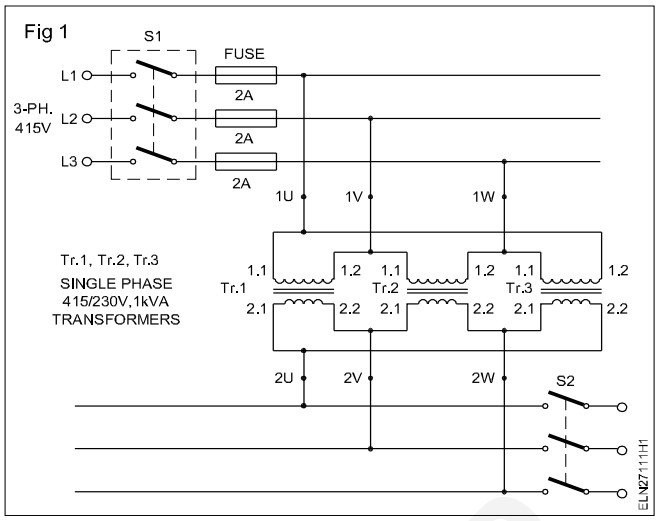
7 Calculate the ratio of secondary line voltage and primary line voltage. Compare the values with Theoretical values.



TASK 2 : **Connect in star-star connection**

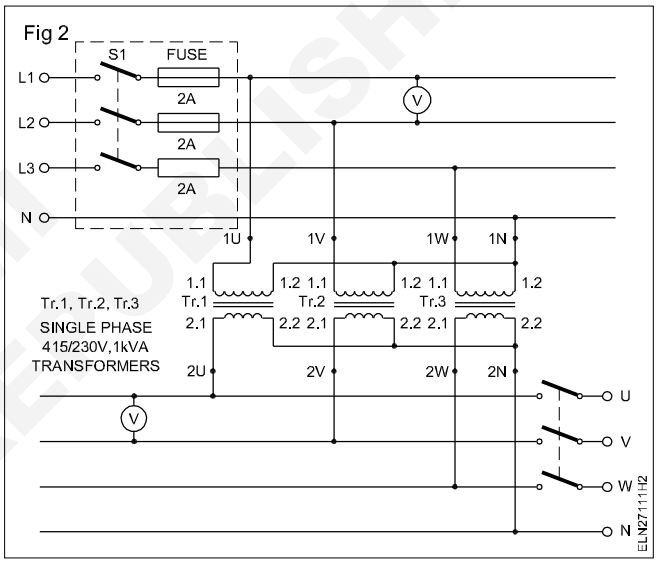
1 Connect any three similar ends of primary winding together. Say connect 1.2 of Tr.1, 1.2 of Tr.2, 1.2 of Tr.3 together and mark the junction as 1N. (Fig 2)

2 Mark 1.1 of Tr.1 as 1U,1.1 of Tr.2 as 1V and 1.1 of Tr.3 as 1W.

3 Connect any three similar ends of secondary winding together. Say connect 2.2 of Tr.1, 2.2 of Tr. 2, 2.2 of Tr.3 together and mark the junction as 2N as shown in circuit 2.

4 Mark 2.1 of Tr.1 as 2U, 2.1 if Tr.2 as 2V and 2.1 of Tr.3 as 2W.

5 Repeat the steps 3,4,5,6,7 of Task 1.



TASK 3 : **Connect in star-delta connection**

1 Connect three similar terminals of the primary windings together. Say connect 1.2 of Tr.1, 1.2 of Tr.2, 1.2 of Tr.3 and mark the junction as 1N. As shown in Fig 3.

2 Mark 1.1 of Tr.1 as 1U,1.1 of Tr.2 as 1V and 1.1 of Tr.3 as 1W.

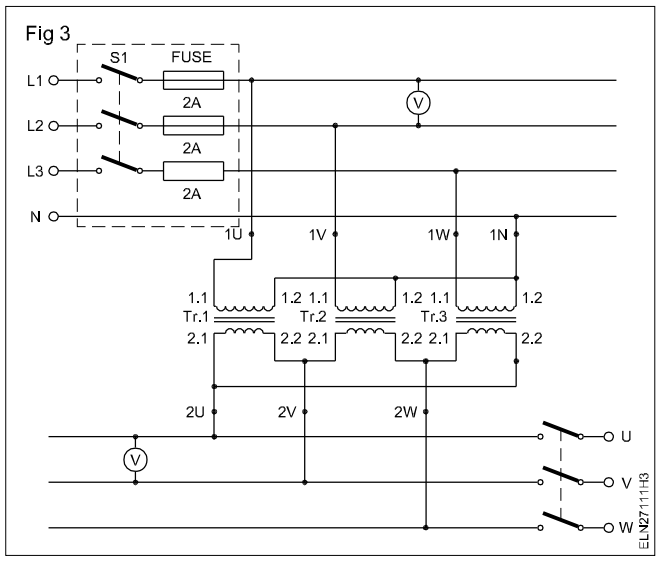
3 Connect the dissimilar terminals of the secondary windings.

Connect 2.1. of Tr.1 with 2.2 of tr.3 and mark it as 2 U

Connect 2.2. of Tr.1 with 2.1 of tr.2 and mark it as 2 V

Connect 2.2. of Tr.2 with 2.1 of tr.3 and mark it as 2 W

4 Repeat steps 3, 4, 5, 6, 7 of Task 1.



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TASK 4 : **To connect in delta-star connection**

1 Connect the dissimilar terminals of the primary windings as follows. (Fig 4)

Connect 1.1. of Tr.1 with 1.2 of tr.3 and mark it as 1 U

Connect 1.2. of Tr.1 with 1.1 of tr.2 and mark it as 1 V

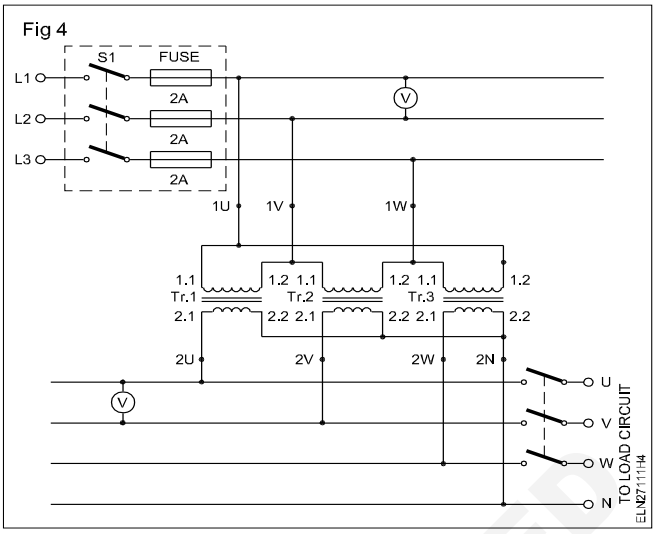
Connect 1.2. of Tr.2 with 1.1 of tr.3 and mark it as 1 W.

2 Connect the three similar terminals of secondary windings together. Say connect 2.2 of Tr.1,2.2 of Tr.2, 2.2 of Tr.3 and mark the junction as 2N as shown in Fig 4.

3 Mark2.1 of Tr.1 as 2U, 2.1 of Tr.2 as 2V and 2.1 of Tr.3 as 2W.

4 Repeat steps 3,4,5,6,7 of Task 1.

Fig 4



Voltage ratio of each transformer K =.....

Tabular Column

Type of Connection	Primary Line Voltage	Secondary Line Voltage	Line Voltage Ration (Theoretical) = Secondary Line Voltage / Primary Line Voltage (Practical)
Delta - Delta			
Star - Star			
Star - Star			
Delta - Star			

If a 3 single phase transformer is available with six secondary terminals brought out then follow the same procedure as given in above tasks with the following given terminal markings.

	Transformer Windings 1		Transformer Windings 2		Transformer Windings 3	
	Starting	Ending	Starting	Ending	Starting	Ending
Primary (HT)	1.1U	1.2U	1.1V	1.2V	1.1W	1.2W
Secondary (LT)	2.1U	2.2U	2.1V	2.2V	2.1W	2.2W

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Perform testing of transformer oil

Objectives: At the end of this exercise you shall be able to
- **conduct field test on the transformer oil**
- **conduct crackle test on transformer oil**
- **connect dielectric test on the transformer oil using standard test set.**

Scan the QR Code to view the video for this exercise

Requirements

Tools/Instruments

- Glass tumbler - 1 No.
- Pipette - 1 No.
- 200mm dia. metal tube with one side closing - 1 No.
- Insulated piler - 1 No.
- 100 mm connector screw driver - 1 No.
- Double end electrician knife - 1 No.

Equipments/Machines

- Standard transformer oil test kit with it's accesories - 1 No.
- Electric heater 1000 watts/250V - 1 No.

Materials

- Samples transfomer oil (different samples) - as reqd.
- Distilled water - as reqd.

PROCEDURE

TASK 1 : **Conduct field test**

1 Collect a glass tumbler, pipette, oil sample and distilled water on the work bench.

2 Fill the glass tumbler with the distilled water to 3/4th level.

3 Take a sample drop of transformer oil through a pipette and drop a single drop on the distilled water.

4 Observe, the field of the oil surface and record the field diameter and shape.

a The shape of the oil drop ....

b The dia for the field .....

c Condition of oil .... good/bad.

If the shape of drops retained, the oil is good. If the shape is flattened and the drop occupies the area of diameter less than 18mm, the oil may be used. If it is more, it is not suitable and it has to be reconditioned.

— — — — — — — —

TASK 2 : **Conduct Crackle test**

1 Collect, steel tube, heater and a sample of transformer oil.

2 Heat the close end of steel tube.

3 Pour the oil sample into the tube.

4 Take the open end of the tube to the ear and hear the sound.

5 Record the sound heard.

a Sound heard .....

b The condition of the oil is ..

If the oil contains moisture, a sharp crackle sound will be heard. Dry oil will only sizzle.

— — — — — — — —

TASK 3 : **To conduct dielectric test with oil testing kit**

1 Examine the oil testing set and read the instructions given by the manufacturer. (Fig 1)

2 Take a sample of the transformer oil in a clean, transparent and dry glass bottle. If there is a drain valve take the sample from the drain valve.

If it is not possible to take the sample from the drain valve then the sample may be drawn by syphoning off from the conservator tank.

3 Take atleast three samples in three bottles from the transformer to conduct atleast three tests.

4 Clean the standard test cup by washing it with clean oil and adjust the gap of the electrodes in such a way that it should be of 4 mm.

Measure the gap by the calibrated gauge, which is usually supplied with the equipment.

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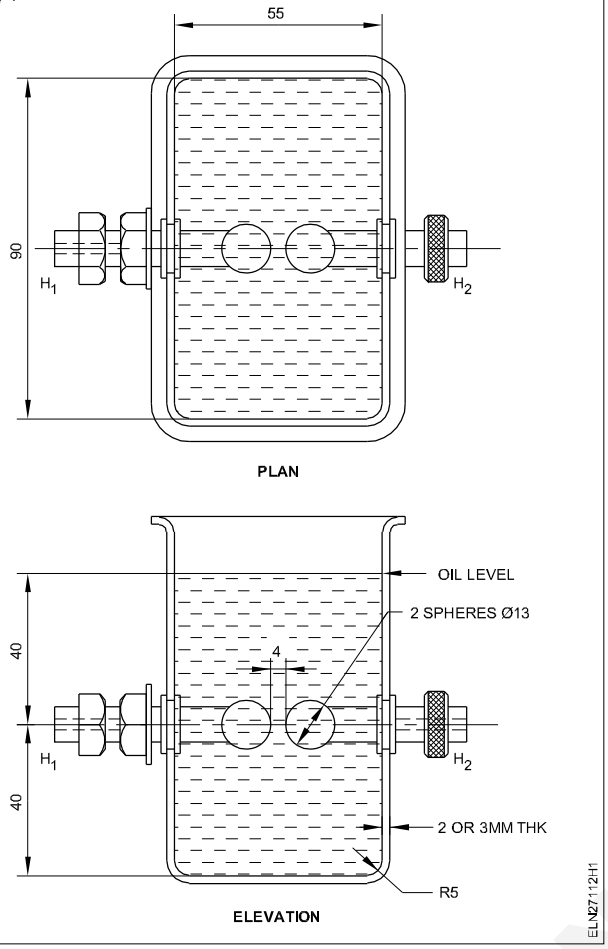
Fig 1



5 Fill the cup with a sample of oil to be tested 1 cm above the electrodes or the marked level on the cup.

6 Close the cup with a clean cover and allow 5 minutes for the oil to settle so that all air bubbles may disappear.

7 Make sure that the test area is clear of all the other persons.

8 Set voltage regulation at zero position.

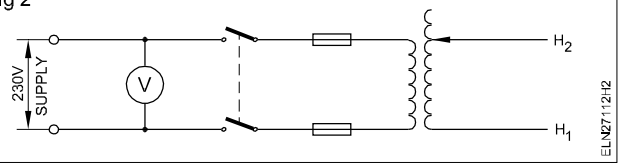
9 Switch 'ON' the supply.

10 Raise the voltage gradually from zero so that the full voltage is reached within 20 to 30 seconds.

It is quite possible that a spark may occur at a very early stage i.e even 20 kV due to some extraneous matter like microscopic strands of cotton, dust etc. which have a tendency to get aligned along the strong electrostatic field in the spark gap. It may burn out and may not affect the test.

11 Raise the voltage until the final breakdown of the oil. The circuit breaker will get tripped. Simultaneously watch the voltmeter and note the readings of the breakdown voltage. (Fig 2)

Fig 2



After sparking the oil near the electrode will turn black in colour.

12 Repeat the steps 5 to 11 with oil in the second sample.

Note that the breakdown voltage of the first and second samples should be approximately equal.

13 Prepare the test for the third sample.

14 Conduct the test by increasing the test voltage up 40 KV.

15 Apply the test voltage for about one minute and observe that there is no sparking.

Note that good oil should withstand 40 kV for one minute.

Conclusion

Since the water is heavier than oil, it settles down at the bottom of the tank.

16 If the tested oil is in good condition, fill this oil in the transformer tank up to the oil level marked on the body of the transformer tank.

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Practice on winding of small transformer

Objectives: At the end of this exercise you shall be able to
- **dismantle the transformer cores**
- **measure and determine the size of winding wire for primary and secondary winding**
- **take the dimensions of a bobbin and prepare the bobbin from suitable materials**
- **wind the primary and secondary windings layer by layer**
- **stack the cores and fasten them**
- **terminate the winding end in a terminal board**
- **test the transformer for insulation, transformation ratio and performance**
- **design a transformer when power and voltage ratings are known.**

Scan the QR Code to view the video for this exercise

Requirements

Tools/Instruments

• Scissors 150 mm	- 1 No.
• Steel rule 300 mm	- 1 No.
• Firmer chisel 20 mm	- 1 No.
• Hammer ball pein 0.5 kg	- 1 No.
• Iron soldering 25 W, 240V	- 1 No.
• DE spanner 6 mm to 25 mm	- 1 No.
• Mallet hardwood 0.5 kg	- 1 No.
• Nylon mallet 5 cm dia.	- 1 No.
• D.B. Knife 100 mm	- 1 No.

Materials

• Super-enamelled copper wires	- as reqd.
• Empire sleeves 1 mm, 2mm	- 1 m each
• Air-dry varnish	- 100 ml.
• Resin-core solder 16 SWG	- 10 G
• Soldering paste	- 5 g
• Smooth emery paper	- 1 piece
• Fabric based fibre sheet and 6 mm thick	- 3 mm
• Cotton cloth for cleaning	- 500sq.cm
• Insulation papers	- as reqd.

PROCEDURE

TASK 1 : **Dismantling the transformer for rewinding**

1 Note down the name plate details in Table 1.

2 Draw the end connection terminal marking of the transformer in your record.

3 De-solder the leads and remove the terminal strips if they are attached to the core.

4 Loosen the nuts of the core assembly and remove the screws if any.

5 Remove the clamps attached to the core.

6 Gently tap the transformer core with a nylon mallet so that the core gets loosened.

7 Remove the stampings starting from the centre of the core using Hylam/fibre knife.

In the case of hard stacked stamping, occasionally use a thinner to loosen the stamping.

Table 1

Transformer raring plate

No of Phases	Sl.No.....
V.A rating	Frequency .....
Primary voltage.....volt	Secondary voltage.....volt
Primary current.....amp	Secondary current.....amp
Manufacturer	

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If a metal knife is used to remove the tight and sticky stampings, care should be taken not to damage the stampings.While stripping the core see that the stampings are taken out straight without bends.

8 Remove all the stampings and record the following in Table 2.

Table 2

Core details

Type of core .....

No.of.stampings of shape..... No.....

No. of . stamping of shape..... No.....

9 Wipe the bobbin and winding with a cloth.

10 Record the dimensions of the coil in Table 3 with and without insulation and prepare a template to check the winding's height and length.

Table 3

Size of the coil

Description	With insulation	Without insulation	Remarks
Coil height	.....cm	..... cm.	
Coil height	.....cm.	..... cm.	

11 Strip off the winding carefully. During the stripping process record all the particulars in Table 4.

12 Draw the schematic diagram of the primary and secondary sides of the transformer from the above findings in your record.

13 Clean the bobbin, write down the bobbin particulars in Table 5 for your guidance.

The same bobbin can be used if it is not damaged.

Fig 1

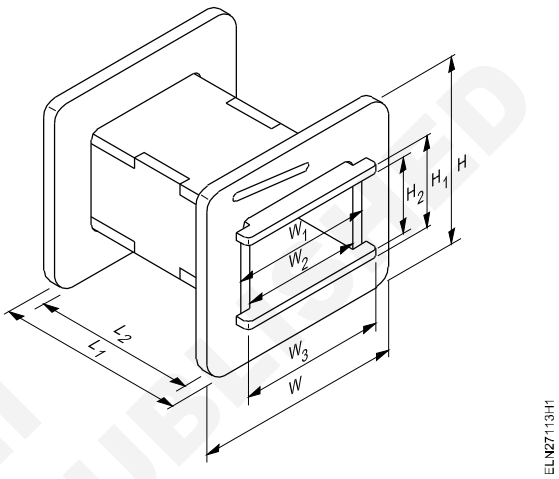

Table 4

Winding details

Total No. of winding/turns .....

No. of layers .....

No. of turns/layer .....

Layer insulation Type .....Thickness .....mm.

	With Insulation	Without Insulation	Wt.of thecoil
Primary winding			
1 st Tapping, No. of turns ....diameter of wire	.....mm.	.....mm	.....g
2 nd Tapping, No. of turns ...diameter of wire	.....mm.	.....mm	.....g
3 rd Tapping, No. of turns ... diameter of wire	.....mm.	.....mm	.....g
Secondary winding			
Winding 1, No. of turns ....diameter of wire	.....mm.	.....mm	.....g
Winding 2, No. of turns ...diameter of wire	.....mm.	.....mm	.....g
Winding 3, No. of turns ... diameter of wire	.....mm.	.....mm	.....g
Coil insulation - type .....thickness .....mm.			
Connecting lead .....size			

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Table 5
Bobbin details

1 Type of bobbin .....Injection moulded/Built up

2 Bobbin material .....Thickness .....mm.

3 Length of the bobbin L.....mm, L_1.....mm, L_2.....mm.

4 Width of the bobbin W.....mm, W_1.....mm, W_2.....mm, W_3.....mm.

5 Height of the bobbin H .....mm, H_1.....mm, H_2 .....mm

TASK 2 : **Preparation of bobbin**

1 Referring to the data taken in Table 5 and as per Fig 1, prepare the bobbin parts from a hylam/fibre sheet of the same thinckness. (Fig 2)

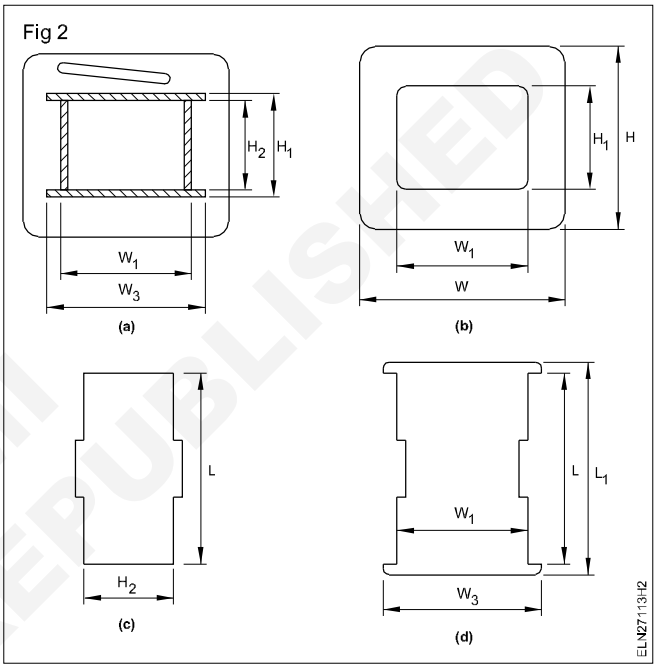
Bobbin parts of standard sizes are also available in the market which can be assembled to form the bobbin.

2 Assemble the parts of the bobbin as shown in Fig 2 which is given for your guidance.

3 Check the size of the assembled bobbin and verify it with the data taken and recorded in Table 5.

In the case of an injuction moulded bobbin it can be purchased from the market assuming it is of standard size.

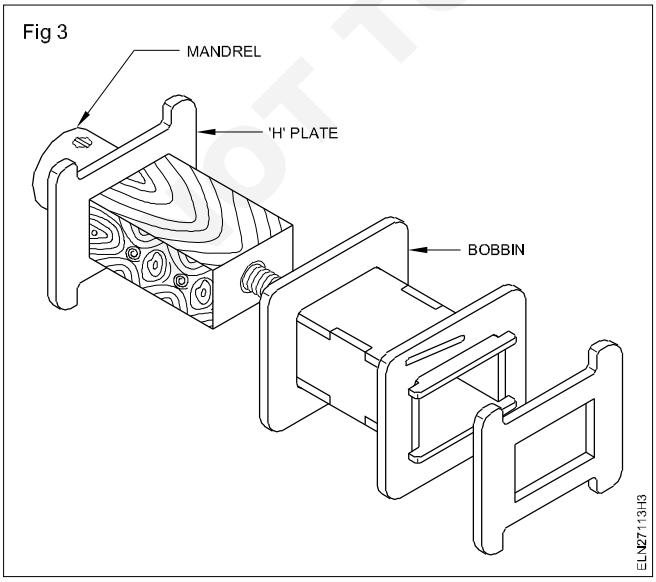
Fig 2



TASK 3 : **Rewinding of transformer**

1 Prepare/select a suitable mandrel for the prepared bobbin as shown in Fig 3 depending upon the design of the winding machines.

Fig 3



2 Clamp the mandrel/wooden block in the winding machine.

See to it that while clamping the mandrel under no circumstances the work becomes loose during winding.

3 Fit the bobbin tightly to the mandrel of the winding machine with the help of fasteners as the bobbin must turn along with the mandrel without play. (Fig 4).

4 Adjust the feed of the winding machine to suit the selected winding wire size by friction drive or by changing the gear as shown in number 1 of Figs 5 and 6.

5 Adjust the transverse feed of the winding machine guides such that the length of the inner side of the bobbin so as to maintain the length of the coil as in the original. Refer to number 2 of Figs 5 and 6. You may need several trials before final setting.

6 Place one layer of paper or cloth as core insulation on the bobbin smoothly without crease.

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Fig 4

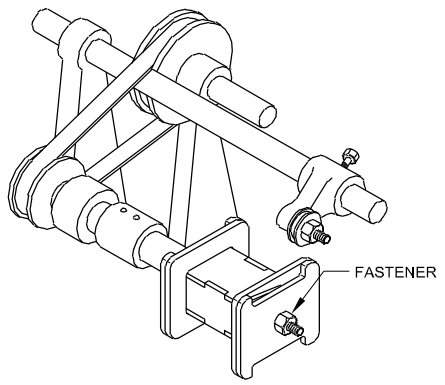


Fig 5

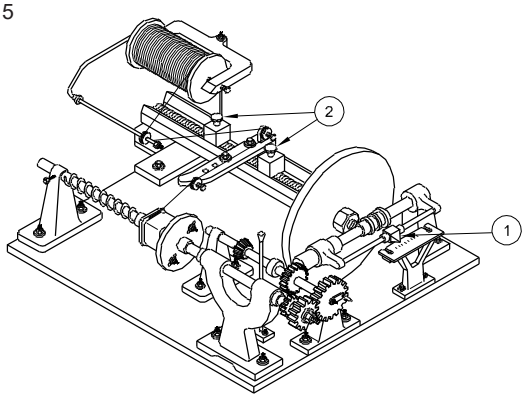
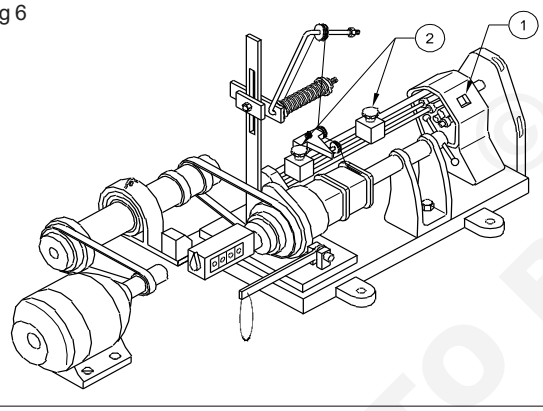


Fig 6



If the winding wire thickness is sufficiently large, soldering of connecting lead wire is not necessary.

7 Start the winding and complete atleast one layer to check whether the coil length is well within the bobbin as in the original. If not, readjust the transverse feed.

Adjacent turns of the winding wire should not overlap or have a gap in between them. if incorrect, readjust the feed.

8 Start and continue the winding layer by layer providing the necessary in-between insulation and specified number of turms in each layer as per data taken in Table 4.

9 After the designated number of turns are wound, solder the end lead and take it out through the bobbin flange outlet.

If a coil has a number of taps of winding, never cut the wire. Instead fold the length into a long loop and carry the wire to continue the winding. The looped wire can then be bared and connected outside the coil.

10 After inspecting the primary winding, wrap the winding as shown in Fig 7 with sufficient insulation according to the data taken in Table 4.

11 Select a suitable secondary winding wire as shown in the data taken in Table 4 and proceed as in steps 4 to 7.

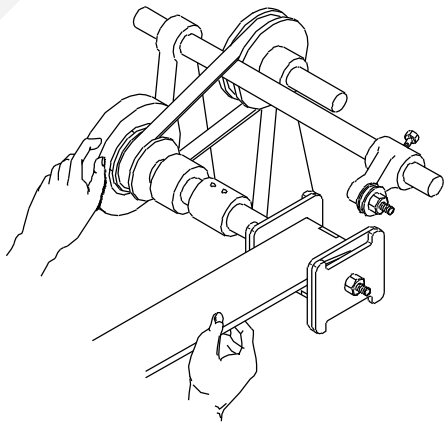
12 At the end of the winding, wrap and bind the insulation on the winding tightly.

13 Inspect the coil for proper termination of lead and check the size by using a template and data taken in Table 3.

14 Test the windings for continuity and short circuit.

If winding data is not available or a new transformer has to be designed and wound.

Fig 7



TASK 4 : **Stacking of transformer cores (E & I)**

1 Insert an 'E' lamination into the bobbin from both sides as shown in Fig 8a.

2 Place the right hand side (R.H.S.) laminations below the one inserted from the left hand side (L.H.S.).

3 Place an 'I' lamination to the free end of the L.H.S. 'E' piece as in Fig 8b.

Ensure that the slot in the 'I' is above the corresponding slot in the R.H.S. 'E' lamination.

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Fig 8a

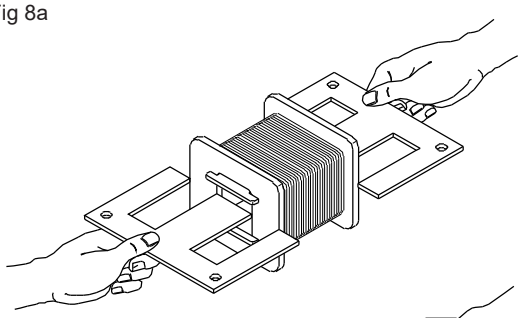
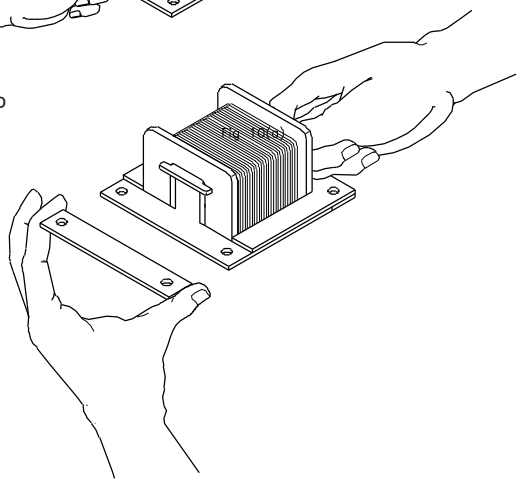


Fig 8b



ELN27113-HA

The laminated assembly should be flush and lying flat.

4 Insert the second ‘E’ shaped laminations from the opposite side.

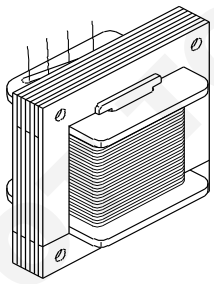
Ensure that it fits snugly against the bobbin.

5 Place an ‘I’ shaped lamination in position.

Ensure that it lies flat on the first “E” lamination.

6 Likewise insert the laminations alternately without any gap as shown in Fig 9.

Fig 9



ELN27113-HB

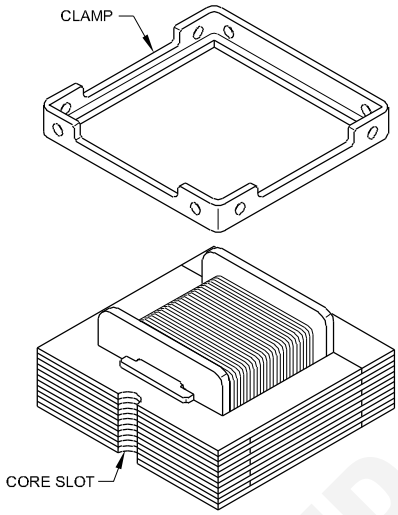
Ensre that when all of the specified quantity of laminations are inserted, the assembly has the right dimension, from loose laminations and correct interpolated laminations.

7 Fit both top and bottom clamp plates on the assembly as in the original. (Fig 10)

Pay particular attention to align the core slots in the laminations.

Ensure that the fixing bolts can be easily inserted.

Fig 10



ELN27113-HC

8 Push the fixing bolts through the clamp plates.

9 Use the specified fasteners and tighten the assembly.

10 Varnish the transformer by dipping in an air-dry varnish and drain it.

11 Fit the specified insulating sleeves over the lead-out wires.

12 Obtain the specified terminal board and pass each lead-out through the specified hole.

Ensure that all the sleeved leads are correclty positioned.

Check that all the sleeved leads terminate at each hole i.e. no bare leads should be visible in the terminal board.

13 Place the terminal board in position as shown in Fig 11.

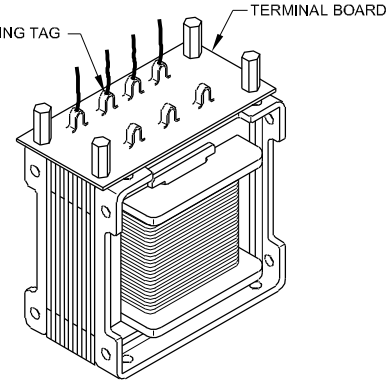
14 Secure the terminal board with the specified studs.

15 Check that no leads have been trapped between the terminal board and the core.

16 Make the specified mechanical joint between each lead-out wire and its soldering tag.

17 Solder each joint and cut off the surplus wire ends as seen in Fig 11.

Fig 11



ELN27113-HD

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TASK 5 : **Testing of transformer after winding**

1 Test the primary and secondary windings for continuity with a megger.

2 Measure and record the primary and secondary winding resistance in Table 6.

Table 6

Transformer winding resistance

Primary	resistance ..... ohm
Secondary 1 resistance	..... ohm
Secondary 2 resistance	..... ohm
Secondary 3 resistance	..... ohm

3 Measure and record the insulation resistance, between windings and frame in Table7.

Table 7

Insulation resistance between

Primary & secondary windings	..... megohm
Secondary windings (in case of seperate windings)	..... megohm
Windings and frame	..... megohm

4 Connect the primary winding of the transformer with the rated voltage. Keeping the secondary open, test the primary and the secondary voltage. Record the finding in Table 8.

Table 8

No-load measurement

Primary voltage ..... volt
Secondary voltage
1 ..... volt
2 ..... volt
3 ..... volt

5 Observe for vibration sound of the core. If it is abnormal, tighten the stampings, also check for tightness of the coil.

6 Connect the transformer with suitable load so that full load current passes through the secondary, and record the voltage and current at load in Table 9.

Table 9

Load measurement

Primary voltage ..... volt
Primary current..... amp
Secondaryvoltage ..... volt
Primary current..... amp

7 Keep the transformer on full load for eight hours continously. Observe the change in temperature of the winding and core by touching. If the temperature raise is within the class of insulation, the transformer is O.K.

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Practice of general maintenance of transformer

Objectives: At the end of this exercise you shall be able to
- **carry out hourly maintenance of transformer**
- **carry out daily maintenance of trasformer.**

Requirements

Tools/Instruments

- Electrician tool kit - 1 No.

Materials

- Items required for reactivating silica gel.
- Spare relief diaphragm.

Note: The instructor may take the trainess to the transformer yard and demonstrate the maintenance procedures.

PROCEDURE

TASK 1 : **Carry hourly maintenance**

1 Note down the secondary load current of the transformer read by the ammeter provided.

2 Check this value with the rated value as per name plate details.

3 If the load current is more than the rated value then reduce the load on transformer by the following sequence.

a Trip off the circuit breaker

b Switch off the load feeders which are not very essential

c Again charge and switch on the circuit breaker.

4 Record the values of primary line voltage and line current and secondary line voltage and line current and PF in Table 1.

5 Note down the oil temperature which is indicated by thermostat dial or thermometer in Table 1.

Table1

Maintenance chart for hourly maintenance of 3ϕ transfomer

Sl. No.	Date & Time	Primary Line Voltage		Secondary Line Voltage		Secondary Current		Power Factor	Oil Temp	Remarks
		Phases	Voltage (V)	Phases	Voltage (V)	Phases	Current in Amps			
1		1U - 1V		2U - 2V		2U				
2		1V - 1 W		2V - 2W		2V				
3		1W - 1U		2W - 2U		2W				

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TASK 2 : **Carry out daily maintenance of transformer**

1 Inspect the dehydrating breather, by following sequence.

a Check whether the air passages are clear, if not clean it

b Check the colour of the active agent i.e. silicagel

c If the silicagel is pink in colour, reactivate it in following sequence.

2 Collect the sillica gel crystals in a shallow tray and brake them at 200°C.

3 When the crystals become blue in colour, fill the breather with reactivated blue crystals.

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4 Inspect the oil level in the transformer.

5 Observe the conservator sight glass and check the oil level of the transformer.

6 If the oil level is low, top up the level through drain value by filling clean transformer oil.

7 If the oil level drops appreciably over a short period, then check the tank for any oil leakage.

8 If there is a leak in the transformer tank, take suitable actions to prevent leakage by consulting the instructor.

9 Inspect the relief diaphragm.

10 Observe the explosion vent of the transformer and check the condition of relief diaphragm and record the observations in Table 2.

11 If it is cracked or broken replace it after isolating the primary supply to the transformer.

Table 2

Maintenance chart for daily maintenance of 3ϕ oil cooled transfomer

Date	Time	Oil level	Colour of Silicagel	Condition of relief diaphragm	Remarks action taken

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Project Work

Objectives: The Trainees/Participants shall be able to

- **select a project work of their choice**
- **prepare the list of materials required and collect them**
- **list out the tools required**
- **prepare a brief note on the project**
- **complete the project and submit the project report with all the details.**

Note: Instructor has to explain in detail regarding the project works to be carried out in the section. The trainees may be divided in groups according to the strength available in section and give all details how to prepare and finish the work with complete workmanship and accuracy.

- Step to start and follow the project work
- Motivate the group by emphasising the technical work involved and its future influences.
- Divide the work equally and make sure in yoke participating with full interest.
- Start the project work, test it stage by stage and complete it.
- Test the completed project job for its functionality and its utility.
- Prepare a project report containing its technical parameters, specification, material requirement and its cost, operational procedure, maintenance, utility and marketing etc.
- Indicate the scope of future expansion, easy conversion to other project for advanced version in the report.
- Get it checked with your instructor.
- The project should complete with all operational instructions and carry necessary procedure with switches, controls, labels, symbols etc.
- Safety devices has to be placed according to the project and its functions.
- Maintenance and repair instructions should be indicated clearly.

Note: Instructor has to evaluate the project work with all records and reports. Marks to be awarded for the project working, accuracy, workmanship, safety features and its work performance related to the viva questions.

Project work

1 Overload protection of electrical equipment.

2 Automatic control of street light/night lamp.

3 Fuse and power failure indicator using relays.

4 Door alarm/indicator.

5 Decorative light with electrical flasher.

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