WORKSHOP CALCULATION & SCIENCE

(NSQF)

(As per Revised Syllabus July 2022)

Mechanic Two & Three Wheeler

Directorate General of Training

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

NATIONAL INSTRUCTIONAL MEDIA INSTITUTE, CHENNAI

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

Workshop Calculation & Science

Mechanic Two & Three Wheeler - 1 Year NSQF

As per Revised Syllabus July 2022

Developed & Published by

National Instructional Media Institute
Post Box No.3142
Guindy, Chennai - 600032
INDIA
Email: chennai-nimi@nic.in
Website: www.nimi.gov.in

First Edition : February 2023 Copies: 1000

Rs: 85/-

FOREWORD

The Government of India has set an ambitious target of imparting skills one out of every four Indians, 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 comprising various stakeholder's viz. Industries, Entrepreneurs, Academicians and representatives from ITIs.

The National Instructional Media Institute (NIMI), Chennai, has now come up with instructional material to suit the revised curriculum for **Workshop Calculation & Science - Mechanic Two & Three Wheeler** NSQF (Revised 2022) under CTS 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 trainees will also get the opportunities to promote life long learning and skill development. I have no doubt that with NSQF 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

Director General (Training),
Ministry of Skill Development & Entrepreneurship,
Government of India.

New Delhi - 110 001

PREFACE

The National Instructional Media Institute(NIMI) was set up at Chennai, by the Directorate General of Training, Ministry of skill Development and Entrepreneurship, Government of India, with the technical assistance from the Govt of the Federal Republic of Germany with the prime objective of developing and disseminating instructional Material for various trades as per prescribed syllabus and Craftsman Training Programme(CTS) under NSQF levels.

The Instructional materials are developed and produced in the form of Instructional Media Packages (IMPs), consisting of Trade Theory, Trade Practical, Test and Assignment Book, Instructor Guide. The above material will enable to achieve overall improvement in the standard of training in ITIs.

A national multi-skill programme called SKILL INDIA, was launched by the Government of India, through a Gazette Notification from the Ministry of Finance (Dept of Economic Affairs), Govt of India, dated 27th December 2013, with a view to create opportunities, space and scope for the development of talents of Indian Youth, and to develop those sectors under Skill Development.

The emphasis is to skill the Youth in such a manner to enable them to get employment and also improve Entrepreneurship by providing training, support and guidance for all occupation that were of traditional types. The training programme would be in the lines of International level, so that youths of our Country can get employed within the Country or Overseas employment. The **National Skill Qualification Framework (NSQF)**, anchored at the National Skill Development Agency(NSDA), is a Nationally Integrated Education and competency-based framework, to organize all qualifications according to a series of **levels of Knowledge, Skill and Aptitude.** Under NSQF the learner can acquire the Certification for Competency needed at any level through formal, non-formal or informal learning.

The **Workshop Calculation & Science** - Mechanic Two & Three Wheeler NSQF (Revised 2022) under CTS is one of the book developed by the core group members as per the NSQF syllabus.

The **Workshop Calculation & Science** - Mechanic Two & Three Wheeler NSQF (Revised 2022) under CTS as per NSQF is the outcome of the collective efforts of experts from Field Institutes of DGT, Champion ITI's for each of the Sectors, and also Media Development Committee **(MDC)** members and Staff of **NIMI.** NIMI wishes that the above material will fulfill to satisfy the long needs of the trainees and instructors and shall help the trainees for their Employability in Vocational Training.

NIMI would like to take this opportunity to convey sincere thanks to all the Members and Media Development Committee (MDC) members.

Chennai - 600 032 **EXECUTIVE DIRECTOR**

ACKNOWLEDGEMENT

The National Instructional Media Institute (NIMI) sincerely acknowledge with thanks the co-operation and contribution of the following Media Developers to bring this IMP for the course **Workshop Calculation & Science - Mechanic Two & Three Wheeler** as per NSQF Revised 2022.

MEDIA DEVELOPMENT COMMITTEE MEMBERS

Shri. M. Sangara pandian	-	Training Officer (Retd.) CTI, Govt. of India, Guindy, Chennai - 32.
Shri. G. Sathiamoorthy	-	Jr.Training Officer - SG (Retd.) Govt I.T.I, Trichy, DET - Tamilnadu.

NIMI CO-ORDINATORS

Shri. Nirmalya Nath	-	Deputy General Manager, NIMI, Chennai - 32.
Shri. G. Michael Johny	-	Manager, NIMI, Chennai - 32.

NIMI records its appreciation of the **Data Entry, CAD, DTP Operators** for their excellent and devoted services in the process of development of this IMP.

NIMI also acknowledges with thanks, the efforts rendered by all other staff who have contributed for the development of this book.

INTRODUCTION

The material has been divided into independent learning units, each consisting of a summary of the topic and an assignment part. The summary explains in a clear and easily understandable fashion the essence of the mathematical and scientific principles. This must not be treated as a replacment for the instructor's explanatory information to be imparted to the trainees in the classroom, which certainly will be more elaborate. The book should enable the trainees in grasping the essentials from the elaboration made by the instructor and will help them to solve independently the assignments of the respective chapters. It will also help them to solve the various problems, they may come across on the shop floor while doing their practical exercises.

The assignments are presented through 'Graphics' to ensure communications amongst the trainees. It also assists the trainees to determine the right approach to solve the problems. The required relevent data to solve the problems are provided adjacent to the graphics either by means of symbols or by means of words. The description of the symbols indicated in the problems has its reference in the relevant summaries.

At the end of the exercise wherever necessary assignments, problems are included for further practice.

Time allotment:

Duration of 1 Year : 28 Hrs

Time allotment for each title of exercises has been given below. **Workshop Calculation & Science - Mechanic Two & Three Wheeler** NSQF Revised Syllabus 2022.

S.No	Title	Exercise No.	Time in Hrs
1	Unit, Fractions	1.1.01 - 1.1.07	4
2	Square root, Ratio and Proportions, Percentage	1.2.08 - 1.2.14	6
3	Material Science	1.3.15 - 1.3.17	4
4	Speed and Velocity, Work, Power and Energy	1.4.18 - 1.4.20	4
5	Basic Electricity	1.5.21 - 1.5.24	6
6	Levers and Simple machines	1.6.25	2
7	Trigonometry	1.7.26 & 1.7.27	2
		Total	**28 Hrs**

LEARNING / ASSESSABLE OUTCOME

On completion of this book you shall be able to

- **Demonstrate basic mathematical concept and principles to perform practical operations.**
- **Understand and explain basic science in the field of study.**

CONTENTS

SYLLABUS

1 Year

Workshop Calculation & Science - Mechanic Two & Three Wheeler
Revised syllabus July 2022 under CTS

S.No.	Title	Time in Hrs
I	**Unit, Fractions** 1 Classification of Unit System 2 Fundamental and Derived Units F.P.S, C.G.S, M.K.S and SI Units 3 Measurement Units and Conversion 4 Factors, HCF, LCM and Problems 5 Fractions – Addition, Subtraction, Multiplication & Division 6 Decimal Fractions – Addition, Subtraction, Multiplication & Division 7 Solving Problems by using calculator	4
II	**Square root, Ratio and Proportions, Percentage** 1 Square and Square root 2 Simple problems using calculator 3 Applications of Pythagoras theorem and related problems 4 Ratio and Proportion 5 Ratio and Proportion - Direct and Indirect proportions 6 Percentage 7 Percentage - Changing percentage to decimal and fraction	6
III	**Material Science** 1 Types of metal, types of ferrous and non ferrous metals 2 Physical and Mechanical Properties of metals 3 Properties and uses of rubber and insulating materials	4
IV	**Speed and Velocity, Work, Power and Energy** 1 Speed and velocity - Rest, motion, speed, velocity, difference between speed and velocity, acceleration and retardation 2 Speed and velocity - Related problems on speed & velocity 3 Work, power, energy, HP, IHP, BHP and efficiency	4

S.No.	Title	Time in Hrs
V	**Basic Electricity** 1 Introduction and uses of electricity, molecule, atom, how electricity is produced, electric current AC, DC their comparison, voltage, resistance and their units 2 Conductor, Insulator, types of connections - Series and Parallel 3 Ohm's Law, relation between VIR & related problems 4 Electrical Power, HP, Energy and units of electrical energy	6
VI	**Levers and Simple Machines** 1 Levers & Simple Machines - Lever and its types	2
VII	**Trigonometry** 1 Measurement of angles 2 Trigonometrical ratios	2
	Total	**28**

Unit, Fractions - Classification of unit system

Necessity

All physical quantities are to be measured in terms of standard quantities.

Unit

A unit is defined as a standard or fixed quantity of one kind used to measure other quantities of the same kind.

Classification

Fundamental units and derived units are the two classifications.

Fundamental units

Units of basic quantities of length, mass and time.

Derived units

Units which are derived from basic units and bear a constant relationship with the fundamental units.E.g. area, volume, pressure, force etc.

Systems of units

- F.P.S system is the British system in which the basic units of length, mass and time are foot, pound and second respectively.
- C.G.S system is the metric system in which the basic units of length, mass and time are centimeter, gram and seconds respectively.
- M.K.S system is another metric system in which the basic units of length, mass and time are metre, kilogram and second respectively.
- S.I. units are referred to as Systems International units which is again of metric and the basic units, their names and symbols are as follows.

Fundamental units and derived units are the two classifications of units.

Length, mass and time are the fundamental units in all the systems (i.e) F.P.S, C.G.S, M.K.S and S.I. systems.

Example

Length: What is the length of copper wire in the roll , if the roll of copper wire weighs 8kg, the dia of wire is 0.9cm and the density is 8.9 gm/cm^3?

Solution

mass of copper wire in the roll = 8kg (or)8000grams
Dia of copper wire in the roll = 0.9cm
Density of copper wire = 8.9 gm/cm^3

Area of cross section of copper wire

$$= \frac{\pi d^2}{4} = \frac{\pi \times (0.9^2)}{4} = 0.636cm^2$$

Volume of copper wire

$$= \frac{\text{Mass of copper wire}}{\text{Density of copper wire}} = \frac{8000\text{grams}}{8.9\text{ gm/cm}^3} = 898.88\text{cm}^3$$

Length of copper wire

$$= \frac{\text{Volume of copper wire}}{\text{Area of cross section of copper wire}} = \frac{898.88\text{cm}^3}{0.636\text{cm}^2}$$

$$= 1413.33 \text{ cm}$$

Length of copper wire =1413cm.

Time: The S.I. unit of time, the second, is another base units of S.I., it is defined as the time interval occupied by a number of cycles of radiation from the calcium atom. The second is the same quantity in the S.I. in the British and in the U.S. systems of units.

Fundamental units of F.P.S, C.G.S, M.K.S and S.I

S.No.	Basic quantity	British units		Metric units				International units	
		F.P.S	Symbol	C.G.S	Symbol	M.K.S	Symbol	S.I Units	Symbol
1	Length	Foot	ft	Centimetre	cm	Metre	m	Metre	m
2	Mass	Pound	lb	Gram	g	Kilogram	kg	Kilogram	Kg
3	Time	Second	s	Second	s	Second	s	Second	s
4	Current	Ampere	A	Ampere	A	Ampere	A	Ampere	A
5	Temperature	Fahrenheit	°F	Centigrade	°C	Centigrade	°C	Kelvin	K
6	Light intensity	Candela	Cd	Candela	Cd	Candela	Cd	Candela	Cd

Unit, Fractions - Fundamental and Derived units F.P.S, C.G.S, M.K.S and SI units

Derived units of F.P.S, C.G.S, M.K.S and SI system

S.No	Physical quantity	British units		Metric units				International units	
		FPS	Symbol	CGS	Symbol	MKS	Symbol	SI Units	Symbol
1	Area	Square foot	ft^2	Square centimetre	cm^2	Square metre	m^2	Square metre	m^2
2	Volume	Cubic foot	ft^3	Cubic centimetre	cm^3	Cubic metre	m^3	Cubic metre	m^3
3	Density	Pound per cubic foot	lb/ft^3	Gram per cubic centimetre	g/cm^3	Kilogram per cubic metre	kg/m^3	Kilogram per cubic metre	Kg/m^3
4	Speed	Foot per second	ft/s	Centimetre per second	cm/sec	Metre per second	m/sec	Metre per second	m/sec
5	Velocity (linear)	Foot per second	ft/s	Centimetre per second	cm/sec	Metre per second	m/sec	Metre per second	m/sec
6	Acceleration	Foot per square second	ft/s^2	Centimetre per square second	cm/sec^2	Metre per square second	m/sec^2	Metre per square second	m/sec^2
7	Retardation	Foot per square Second	ft/s^2	Centimetre per square second	cm/sec^2	Metre per square second	m/sec^2	Metre square second	m/sec^2
8	Angular velocity	Degree per second	Deg/sec	Radian per second	rad/sec	Radian per second	rad/sec	Radian per second	rad/sec
9	Mass	Pound (slug)	lb	Gram	g	Kilogram	kg	Kilogram	kg
10	Weight	Pound	lb	Gram	g	Kilogram weight	kg	Newton	N
11	Force	Pounds	lbf	dyne	dyn	Kilogram force	kgf	Newton	$N(kgm/sec^2)$
12	Power	Foot pound per second	ft.lb/sec	Gram.centimetre/sec	g.cm/ sec	kilogram metre per second	kg.m/ sec	-	-
		Horse power	hp	Erg per second		watt	W	watt	W(J/sec)
13	Pressure,Stress	Pound per square inch	lb/in^2	Gram per square centimetre	g/cm^2	Kilogram per square metre	kg/m^2	Newton per square metre	N/m^2
14	Energy, Work	Foot.pound	ft.lb	Gram centimetre	g.cm	Kilogram metre	kg.m	joule	J(Nm)
15	Heat	British thermal unit	BTU	calorie	Cal	joule	J	joule	J(Nm)
16	Torque	Pound force foot	lbf.ft	Newton millimetre	N mm	Kilogram metre	kg.m	Newton metre	Nm
17	Temperature	Degree Fahrenheit	°F	Degree Centigrade	°C	Kelvin	K	Kelvin	K

Unit, Fractions - Measurement units and conversion

Units and abbreviations

Quantity	Units	Abbreviation of unit
Calorific value	kilojoules per kilogram	kJ/kg
Specific fuel consumption	kilogram per hour per newton	kg/hr/N
Length	millimetre, metre, kilometre	mm, m, km
Mass	kilogram, gram	kg, g
Time	seconds, minutes, hours	s, min, h
Speed	centimetre per second, metre per second kilometre per hour, miles per hour	cm/s, m/s km/h, mph
Acceleration	metre-per-square second	m/s^2
Force	newtons, kilonewtons	N,kN
Moment	newton-metres	Nm
Work	joules	J
Power	horsepower, watts, kilowatts	Hp, W, kW
Pressure	newton per square metre kilonewton per square metre	N/m^2 kN/m^2
Angle	radian	rad
Angular speed	radians per second radians-per-square second revolutions per minute revolutions per second	rad/s rad/s^2 Rpm rev/s

Decimal multiples and parts of unit

Decimal power	Value	Prefixes	Symbol	Stands for
10^{12}	1000000000000	tera	T	billion times
10^{9}	1000000000	giga	G	thousand millintimes
10^{6}	1000000	mega	M	million times
10^{3}	1000	kilo	K	thousand times
10^{2}	100	hecto	h	hundred times
10^{1}	10	deca	da	ten times
10^{-1}	0.1	deci	d	tenth
10^{-2}	0.01	centi	c	hundredth
10^{-3}	0.001	milli	m	thousandth
10^{-6}	0.000001	micro	μ	millionth
10^{-9}	0.000000001	nano	n	thousand millionth
10^{-12}	0.000000000001	pico	p	billionth

SI units and the British units:

Quantity	SI unit → British unit	British unit → SI unit
Length	1 m = 3.281 ft 1 km = 0.621 mile	1 ft = 0.3048 m 1 mile = 1.609 km
Speed	1 m/s = 3.281 ft/s 1 km/h = 0.621 mph	1 ft/s = 0.305 m/s 1 mph = 1.61 km/h
Acceleration	1 m/s^2 = 3.281 ft/s^2	1 ft/s^2 = 0.305 m/s^2
Mass	1 kg = 2.205 lb	1 lb = 0.454 kg
Force	1 N = 0.225 lbf 1 MN	1 lbf = 4.448 N 1 million newtons
Torque	1 Nm = 0.738 lbf ft	1 lbf ft = 1.355 Nm
Pressure	1 N/m^2 = 0.000145 lbf/in^2 1 Pa = 1 N/m^2 1 bar = 14.5038 lbf/in^2	1 lbf/in^2 = 6.896 kN/m^2 1 lbf/in^2 = 6.895 kN/m^2
Energy, work	1 J = 0.738 ft lbf 1 J = 0.239 calorie 1 kJ = 0.948 BTU (1 therm = 100 000 BTU) 1 kJ = 0.526 CHU	1 ft lbf = 1.355 J 1 calorie = 4.186 J 1 BTU = 1.055 kJ 1 CHU = 1.9 kJ
Power	1 kW = 1.34 hp	1 hp = 0.7457 kW
Fuel consumption	1km/L = 2.82 mile/gallon	1 mpg = 0.354 km/L
Specific fuel consumption	1 kg/kWh = 1.65 lb/bhp h 1 litre/kWh=1.575 pt/bhp h	1 lb/bhp h = 0.606 kg/kWh 1 pt/bhp h = 0.631 litre/kWh
Calorific value	1 kJ/kg = 0.43 BTU/lb 1 kJ/kg = 0.239 CHU/lb	1 BTU/lb = 2.326 kJ/kg 1 CHU/lb = 4.188 kJ/kg

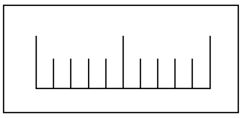
Prefixes for decimal multiples and submultiples

Use		
1 Megapascal	= 1 MPa	= 1000000 Pa
1 Kilowatt	= 1 kW	= 1000 W
1 Hectolitre	= 1 hL= 100 L	
Decanewton	= 1 daN	= 10 N
Decimetre	= 1 dm	= 0.1 m
1 Centimetre	= 1 cm	= 0.01 m
1 Millimetre	= 1 mm	= 0.001 m
1 Micrometre	= 1 um	= 0.000001 m

Conversion factors

1 inch	=	25.4 mm
1 mm	=	0.03937 inch
1 metre	=	39.37 inch
1 micron	=	0.00003937"
1 kilometre	=	0.621 miles
1 pound	=	453.6 g
1 kg	=	2.205 lbs
1 metric ton	=	0.98 ton

Units of physical quantities

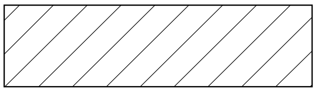


UNITS OF LENGTH

Units of length

Micron	1 µ	=	0.001 mm
Millimetre	1 mm	=	1000 µ
Centimetre	1 cm	=	10 mm
Decimetre	1 dm	=	10 cm
Metre	1 m	=	10 dm
Kilometre	1 km	=	1000 m
Inch	1"	=	25.4 mm
Foot	1'	=	0.305 m
Yard	1 Yd	=	0.914 m
Nautical mile	1 NM	=	1852 m
Geographical mile	1	=	1855.4 m

Units of area



UNITS OF AREA

Square millimetre	1 mm^2	
Square centimetre	1 cm^2	= 100 mm^2
Square decimetre	1 dm^2	= 100 cm^2
Square metre	1 m^2	= 100 dm^2
Are	1 a	= 100 m^2
Hectare	1 ha	= 100 a
Square kilometre	1 km^2	= 100 ha
Square inch	1 sq.in	= 6.45 cm^2
Square foot	1 sq.ft	= 0.093 m^2
Square yard	1 sq.yd	= 0.84 m^2
Square metre	1 m^2	= 10.76 ft^2
Acre	1	= 40.5 a

1 Acre = 100 cent

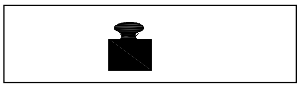
1 Cent = 436 Sq. ft.
1 Ground = 2400 Sq.ft.

1 Hectare = 2.47 acres

1 acre = 0.4047 Hectare

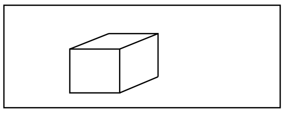
1 Hectare = 10000 sq. metre

Units of weight



UNITS OF WEIGHT

Milligram - force	1 mgf	
Gram-force	1 gf	1000 mgf
Kilogram-force	1 kgf	= 1000 gf
Tonne	1 t	= 1000 kgf
Ounce	1	= 28.35 gf
Pound	1 lbs	= 0.454 kgf
Long ton	1	= 1016 kgf
Short ton	1	= 907 kgf

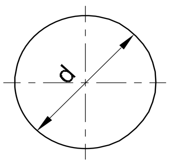


UNITS OF VOLUME AND CAPACITY

Units of volume and capacity

Cubic millimetre	1 mm^3	
Cubic centimetre	1 cm^3	= 1000 mm^3
Cubic decimetre	1 dm^3	= 1000 cm^3
Cubic metre	1 m^3	= 1000 dm^3
Litre	1 l	= 1 dm^3
Hectolitre	1 hl	= 100 l
Cubic inch	1 cu. in	= 16.387 cm^3
Cubic foot	1 cu. ft	= 28317 cm^3
Gallon (British)	1 gal	= 4.54 l
1cubic metre	1 m^3	= 1000 litres
1000 Cu.cm	1000 cm^3	= 1 litre
1 cubic foot	1 ft^3	= 6.25 Gallon
1 litre	1lt	= 0.22 Gallon

Circular unit



CIRCULAR OF UNIT

Radian

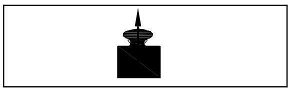
Relationship between Radian and Degree

1 Radian $= \frac{180^\circ}{\pi}$

$180^0 = \pi$ Radian;

1 Degree $= \frac{\pi}{180}$ Radian

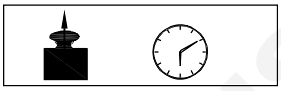
Work



WORK

Kilogram-force	1 kgfm	= 9.80665 J
Metre	1 kgfm	= 9.80665 Ws
Joule	1 J	= 1 Nm
Watt-second	1 Ws	= 0.102 kgfm
Kilowatt hour	1 kWh	= 3.6 x 10^6 J
		= 859.8456 $kcal_{IT}$
I.T.Kilocalorie	1 $kcal_{IT}$	= 426.kgfm

Power



POWER

Kilogram-force metre/second

1 kgfm/s	= 9.80665 W
Kilowatt	1 kW = 1000 W = 1000 J/s
	= 102 kgfm/s (approx.)
Metric horse power	1 HP = 75 kgfm/s
	= 0.736 kW
1 Calorie	= 4.187J

I.T.Kilocalorie/hour = 1 $kcal_{IT/h}$ = 1.163 W

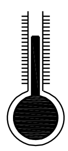
Pressure

Pascal	1 Pa	= 1 N/m^2	1 atm	= 101325 Pa
Bar	1 bar = 10N/cm^2	= 100000 Pa–Torr	1 torr	$= \frac{101325}{760} \approx 133.32$ pa
Atmosphere	1 atm	= 1 kgf/cm^2	1 kgf/cm^2 = 735.6 mm of mercury	

TEMPERATURE

Scale	Freezing point	Boiling point
Centigrade (˚C)	0°C	100°C
Fahrenheit (°F)	32°F	212°F
Kelvin (K)	273K	373K
Reaumur (°R)	0°R	80°R

TEMPERATURE



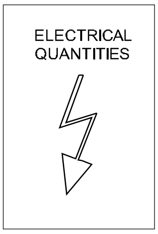
$$\frac{^\circ R}{80} = \frac{^\circ C}{100} = \frac{K-273}{100} = \frac{^\circ F-32}{180}$$

FORCE

Force	In C.G.S. System : Force (Dyne)	= Mass (gm)XAcceleration (cm/sec^2)
	In F.P.S. System : Force (Poundal)	= Mass (Ib) X Acceleration (ft./sec^2)
	In M.K.S System : Force (Newton)	= Mass (Kg) x Acceleration (mtr./sec^2)
	1 Dyne	= 1 gm x1 cm/sec^2
	1 Poundal	= 1 Ib x 1 ft/sec^2
	1 Newton	= 1 kg x 1 mtr/sec^2 = 10^5 dynes
	1gm weight	= 981 Dynes
	1 Ib weight	= 32 Poundals
	1 kg weight	= 9.81 Newtons

ELECTRICAL QUANTITIES

V	Electric potential	V	Volt	V(W/A)
E	Electromotive force	V	Volt	V(W/A)
I	Electric current	A	Ampere	A
R	Electric resistance	Ω	Ohm	Ω (V/A)
e	Specific resistance	Ω m	Ohm metre	Vm/A
G	Conductance	Ω^{-1}	Siemens	S



Assignment - Answer the following question.

1 Convert 320 kilometres into miles ______

2 Convert 16 tons into kilograms ______

3 Convert 40 inches into centimetres ______

4 Convert 8 metres into feet ______

5 Convert 2.5 gallons into litres ______

6 Convert 5 litres into gallons ______

7 120°C = ______ °F.

8 Expand the abbreviations of the following

a N/m^2

b RPM

9 Convert the following S.I. units as required.

a Length

i 3.4 m = ______mm

ii 10.2 km = ______mile

b Mass

i 650 g = ______kg

ii 120 mg = ______g

c Force

i 1.2 N = ______kg

ii 25 kg = ______N

d Work, energy, amount of heat

i 120 KJ = ______J

ii 300 wh = ______kwh

e Power

i 0.2 kW = ______W

ii 350 W = ______kW

f Convert as required.

i 5 N = ______KN

Unit, Fractions - Factors, HCF, LCM and problems

Prime Numbers and whole Numbers

Factor

A factor is a small number which divides exactly into a bigger number.e.g.

To find the factors of 24, 72, 100 numbers

24 = 2 x 2 x 2 x 3

72 = 2 x 2 x 2 x 3 x 3

100 = 2 x 2 x 5 x 5

The numbers 2,3,5 are called factors.

Definition of a prime factor

Prime factor is a number which divides a prime number into factors.e.g.

57 = 3 x 19

The numbers 3 and 19 are prime factors.

They are called as such, since 3 & 19 also belong to prime number category.

Definition of H.C.F

The Highest Common Factor

The H.C.F of a given group of numbers is the highest number which will exactly divide all the numbers of that group.e.g.

To find the H.C.F of the numbers 24, 72, 100

24 = 2 x 2 x 2 x 3

72 = 2 x 2 x 2 x 3 x 3

100 = 2 x 2 x 5 x 5

The factors common to all the three numbers are

2 x 2 = 4. So HCF = 4.

Definition of L.C.M

Lowest common multiple

The lowest common multiple of a group of numbers is the smallest number that will contain each number of the given group without a remainder.e.g.

- Factorise the following numbers

  7,17,20,66,128

  7,17 - These two belong to Prime numbers. Hence no factor except unity and itself.

2	20
2	10
	5

Factors of 20 = 2 x 2 x 5

2	66
3	33
	11

Factors of 66 = 2 x 3 x 11

2	128
2	64
2	32
2	16
2	8
2	4
	2

Factors of 128 = 2 x 2 x 2 x 2 x 2 x 2 x 2

- Select prime numbers from 3 to 29

  3,5,7,11,13,17,19,23,29

- Find the HCF of the following group of numbers HCF of 78, 128, 196

2	78
3	39
	13

78 = 2 x 3 x 13

2	128
2	64
2	32
2	16
2	8
2	4
	2

128 = 2 x 2 x 2 x 2 x 2 x 2 x 2

2	196
2	98
	49

196 = 2 x 2 x 49

HCF = 2

- Find LCM of 84,92,76

LCM =

2	84, 92, 76
2	42, 46, 38
3	21, 23, 19
	7, 23, 19

LCM = 2 x 2 x 3 x 7 x 23 x 19 = 36708

- To find out the LCM of 36, 108, 60

2	36, 108, 60
2	18, 54, 30
3	9, 27, 15
3	3, 9, 5
	1, 3, 5

LCM of the number

36, 108, 60 = 2 x 2 x 3 x 3 x 3 x 5 = 540

The necessity of finding LCM and HCF arises in subtraction and addition of fractions.

Unit, Fractions - Fractions - Addition, subtraction, multiplication & division

Description

A minimal quantity that is not a whole number. For e.g. .

$\frac{1}{5}$ a vulgur fraction consists of a numerator and denominator.

Numerator/Denominator

The number above the line in a vulgar fraction showing how many of the parts indicated by the denominator are taken is the numerator. The total number of parts into which the whole quantity is divided and written below the line in a vulgar fraction is the denominator. e.g.

$\frac{1}{4}, \frac{3}{4}, \frac{7}{12}$

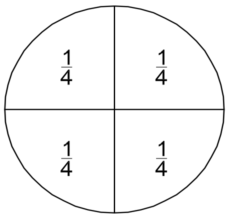
1,3,7 - numerators 4,12 - denominators

Fraction: Concept

Every number can be represented as a fraction.e.g.

$1\frac{1}{4} = \frac{5}{4}$, A full number can be represented as an apparent fraction.e.g. (Fig 1)

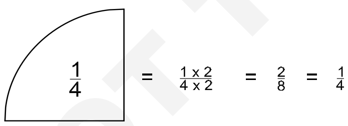
Fig 1



Fraction: Value

The value of a fraction remains the same if the numerator and denominator of the fraction are multiplied or divided by the same number.(Fig 2)

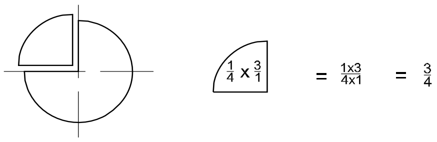
Fig 2



Multiplication

When fractions are to be multiplied, multiply all the numerators to get the numerator of the product and multiply all the denominators to form the denominator of the product. (Fig 3)

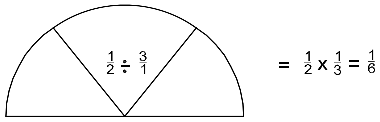
Fig 3



Division

When a fraction is divided by another fraction the dividend is multiplied by the reciprocal of the divisor. (Fig 4)

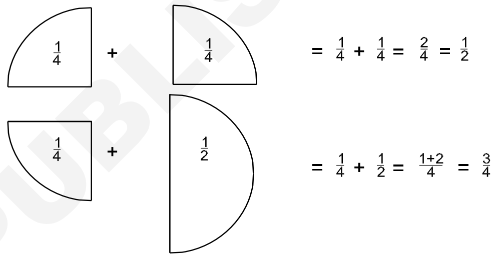
Fig 4



Addition and Subtraction

The denominators of the fractions should be the same when adding or subtracting the fractions. Unequal denominators must first be formed into a common denominator. It is the lowest common denominator and it is equal to the product of the most common prime numbers of the denominators of the fractions in question.(Fig 5)

Fig 5



Examples

- Multiply $\frac{3}{4}$ by $\frac{2}{3}$,

$$\frac{3}{4} \times \frac{2}{3} = \frac{6}{12} = \frac{1}{2}$$

- Divide $\frac{3}{8}$ by $\frac{3}{4}$,

$$\frac{3}{8} \div \frac{3}{4} = \frac{3}{8} x \frac{4}{3} = \frac{1}{2}$$

- Add $\frac{3}{4}$ and $\frac{2}{3}$,

$$\frac{3}{4} + \frac{2}{3} = \frac{9}{12} + \frac{8}{12} = \frac{17}{12} = 1\frac{5}{12}$$

- sub $\frac{7}{16}$ from $\frac{17}{32}$

$$\frac{17}{32} - \frac{7}{16} = \frac{17}{32} - \frac{14}{32} = \frac{(17 - 14)}{32} = \frac{3}{32}$$

Types of fractions

- Proper fractions are less than unity. Improper fractions have their numerators greater than the denominators.
- A mixed number has a full number and a fraction.

Addition of fraction

Add $\frac{1}{2}+\frac{1}{8}+\frac{5}{12}$

To add these fractions we have to find out L.C.M of denominators 2,8,12.

Find L.C.M of 2,8,12

Step 1 L.C.M

$$\begin{array}{r|l} 2 & 2,8,12 \\ \hline 2 & 1,4,6 \\ \hline & 1,2,3 \end{array}$$

Factors are 2,2,2,3

Hence L.C.M = 2 x 2 x 2 x 3 = 24

Step 2

$$\frac{1}{2}+\frac{1}{8}+\frac{5}{12}=\frac{12}{24}+\frac{3}{24}+\frac{10}{24}$$

$$=\frac{12+3+10}{24}=\frac{25}{24}=1\frac{1}{24}.$$

Subtraction of fraction

subtract $9\frac{15}{32}$ from $17\frac{9}{16}$ or $(17\frac{9}{16}-9\frac{15}{32})$

Step 1: Subtract whole number first 17 - 9 = 8

Step 2: L.C.M of 16,32 = 32

Since number 16 divides the number 32

Subtracting fractions = $\frac{3}{32}$

Adding with whole number from Step 1

we get $8+\frac{3}{32}=8\frac{3}{32}$

Common fractions

Problems with plus and minus sign

Example

solve $3\frac{3}{4}+6\frac{7}{8}-4\frac{5}{16}-\frac{9}{32}$

Rule to be followed

1 Add all whole numbers

2 add all + Numbers

3 Add all - Numbers

4 Find L.C.M of all denominators

Solution

Step 1: Add whole numbers = 3 + 6 - 4 = 5

Step 2: Add fractions = $\frac{3}{4}+\frac{7}{8}-\frac{5}{16}-\frac{9}{32}$

L.C.M of 4,8,16,32 is 32

$$\frac{24+28-10-9}{32}$$

$$=\frac{52-19}{32}$$

$$=\frac{33}{32}=1\frac{1}{32}$$

Step 3: Adding again with the whole number

we get $5+1\frac{3}{32}=6\frac{3}{32}$

Examples

Common fractions

- Multiply

a $\frac{3}{8}$ by $\frac{4}{7}=\frac{3}{8}\text{x}\frac{4}{7}=\frac{3}{14}$ b $\frac{2}{3}\text{x}\frac{3}{4}\text{x}\frac{5}{8}=\frac{5}{16}$

- Division

a $\frac{5}{16}\div\frac{5}{32}=\frac{5}{16}\text{x}\frac{32}{5}=2$

b $4\frac{2}{3}\div3\frac{1}{7}=\frac{14}{3}\div\frac{22}{7}=\frac{14}{3}\text{x}\frac{7}{22}=\frac{49}{33}=1\frac{16}{33}$

- Addition

$\frac{1}{2}+\frac{1}{4}+\frac{1}{8}$

L..C.M = 2,4,8 = 8

$\frac{1}{2}+\frac{1}{4}+\frac{1}{8}=\frac{4+2+1}{8}=\frac{7}{8}$

- Subtraction

$$5\frac{1}{4}-3\frac{3}{4}=5-3+\frac{1}{4}-\frac{3}{4}$$

$$=2+\frac{1}{4}-\frac{3}{4}=2\frac{1}{4}-\frac{3}{4}$$

$$=\frac{9}{4}-\frac{3}{4}=\frac{9-3}{4}$$

$$=\frac{6}{4}=\frac{3}{2}=1\frac{1}{2}$$

Assignment

1 Convert the following into improper fractions.

a $1\frac{2}{7}$ = ___________

b $4\frac{3}{5}$ = ___________

c $3\frac{3}{5}$ = ___________

2 Convert the following into mixed numbers.

a $\frac{12}{11}$ = ___________

b $\frac{36}{14}$ = ___________

c $\frac{18}{10}$ = ___________

3 Place the missing numbers.

a $\frac{11}{13} = \frac{x}{91}$ ___________

b $\frac{3}{5} = \frac{42}{x}$ ___________

c $\frac{9}{14} = \frac{x}{98}$ ___________

4 Simplify.

a $\frac{45}{60}$ = ___________

b $\frac{8}{12}$ = ___________

5 Multiply.

a $5 \times \frac{2}{3}$ = ___________

b $\frac{3}{4} \times 2$ = ___________

c $\frac{3}{4} \times \frac{5}{6}$ = ___________

6 Divide

a $\frac{1}{4} \div \frac{3}{4}$ = ___________

b $6 \div \frac{3}{4}$ = ___________

c $\frac{3}{4} \div \frac{2}{7}$ = ___________

7 Place the missing numbers.

a $\frac{2}{3} = \frac{1}{12}$ x___________

b $\frac{14}{24} = \frac{1}{12}$ x___________

c $\frac{7}{8} = \frac{1}{12}$ x___________

8 Add the followings:

a $\frac{3}{4} + \frac{7}{12}$ = ___________

b $\frac{7}{8} + \frac{3}{4}$ = ___________

9 Subtract

a $\frac{4}{5} - \frac{2}{5}$ = ___________

b $\frac{5}{6} - \frac{3}{4}$ = ___________

10 Simplify

a $2\frac{6}{7} - \frac{3}{8} - \frac{1}{3} - 1\frac{1}{16}$ = ___________

b $2\frac{2}{7} - \frac{5}{6} + 8$ = ___________

11 Express as improper fractions

a $5\frac{3}{4}$

b $3\frac{5}{64}$

c $1\frac{5}{12}$

Unit, Fractions - Decimal fractions - Addition, subtraction, multiplication & division

Description

Decimal fraction is a fraction whose denominator is 10 or powers of 10 or multiples of 10 (i.e.) 10, 100, 1000, 10000 etc. Meaning of a decimal number:-

12.3256 means

$$(1 \times 10) + (2 \times 1) + \frac{3}{10} + \frac{2}{100} + \frac{5}{1000} + \frac{6}{10000}$$

Representation

The denominator is omitted. A decimal point is placed at different positions of the number corresponding to the magnitude of the denominator

$$Ex. \frac{5}{10} = 0.5, \frac{35}{100} = 0.35 \; \frac{127}{10000} = 0.0127, \frac{3648}{1000} = 3.648$$

Addition and subtraction

Arrange the decimal fractions in a vertical order, placing the decimal point of each fraction to be added or subtracted, in succession one below the other, so that all the decimal points are arranged in a straight line. Add or subtract as you would do for a whole number and place the decimal point in the answer below the column of decimal points.

Decimal fractions less than 1 are written with a zero before the decimal point. Example: 45/100 = 0.45 (and not simply .45)

Add 0.375 + 3.686

```
 0.375
 3.686
 -----
 4.061
```

Subtract 18.72 from 22.61

```
 22.61
 18.72
 -----
  3.89
```

Multiplication

Ignore the decimal points and multiply as whole numbers. Find the total number of digits to the right of the decimal point. Insert the decimal point in the answer such that the number of digits to the right of the decimal point equals to the sum of the digits found to the right of the decimal points in the problem.

Multiply 2.5 by 1.25

= 25 x 125 = 3125. The sum of the figures to the right of decimal point is 3. Hence the answer is 3.125.

Division

Move the decimal point of the divisor to the right to make it a full number. Move the decimal point in the dividend to the same number of places, adding zeroes if necessary. Then divide.

Divide 0.75 by 0.25

$0.25\overline{)0.75}$

$$\frac{0.75}{0.25} \times \frac{100}{100} = \frac{75}{25}$$

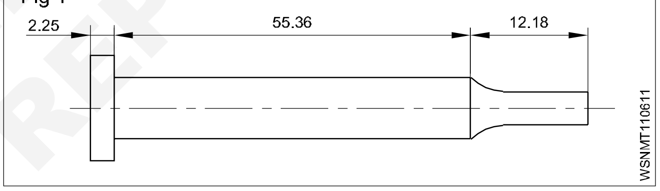
$25\overline{)75} = 3$

Move the decimal point in the multiplicand to the right to one place if the multiplier is 10, and to two places if the multiplier is 100 and so on. When dividing by 10 move the decimal point one place to the left, and, if it is by 100, move them point by two places and so on.

Example

Allowance allowing 3 mm for cutting off each pin, how many pins can be made from a 900 mm long bar and how much material will be left out?

Fig 1



Total Length of pin = 2.25 + 55.36 + 12.18

= 69.79 mm

Cutting allowance = 3 mm

Total Length = length of pin + cutting allowance

= 69.79 mm + 3 mm

= 72.79 mm

Length of the bar = 900 mm

No.of pins to be cut $= \frac{900}{72.79} = 12.394$

= 12 pins

Left out material = Total length - length of pin + cutting allowance

= 900 - 12 x 69.79 + 12 x 3

= 900 - 837.48 + 36

= 900 - 873.48

Left out length = 26.52 mm

Conversion of Decimals into fractions and vice-versa

- Convert decimal into fractions

Example

Convert 0.375 to a fraction

Now place 1 under the decimal point followed by as many zeros as there are numbers

$$0.375 = \frac{375}{1000} = \frac{15}{40} = \frac{3}{8}$$

$$0.375 = \frac{3}{8}$$

- Convert fraction into decimal

Example

- Convert $\frac{9}{16}$ to a decimal

Proceed to divide $\frac{9}{16}$ in the normal way of division but put zeros (as required) after the number 9 (Numerator)

```
     0.5625
16 ) 90000
     80
     ---
     100
      96
     ---
       40
       32
     ----
        80
        80
     ----
         0
     ----
```

$\frac{9}{16} = 0.5625$

Recurring decimals

While converting from fraction to decimals, some fractions can be divided exactly into a decimal. In some fractions the quotient will not stop. It will continue and keep recurring. These are called recurring decimals.

Examples

- convert $\frac{1}{3}, \frac{2}{3}, \frac{1}{7}$

a $\frac{1}{3} = \frac{10000}{3} = 0.3333 - \text{Recurring}$

b $\frac{2}{3} = \frac{20000}{3} = 0.666 - \text{Recurring}$

c $\left(\frac{1}{7} = \frac{10000}{7} = 0.142857142 - \text{Recurring}\right)$

Method of writing approximations in decimals

1.73556	= 1.7356	Correct to 4 decimal places
5.7343	= 5.734	Correct to 3 decimal places
0.9345	= 0.94	Correct to 2 decimal places

Multiplication and division by 10,100,1000

Multiplying decimals by 10

A decimal fraction can be multiplied by 10,100,1000 and so on by moving the decimal point to the right by as many places as there are zeros in the multiplier.

- 4.645 x 10 = 46.45 (one place)
- 4.645 x 100 = 464.5 (two places)
- 4.645 x 1000 = 4645 (three places)

Dividing decimals by 10

A decimal fraction can be divided by 10,100,1000 and so on, by moving the decimal point to the left by as many places as required in the divisor by putting zeros

Examples

- 3.732 ÷ 10 = 0.3732 (one place)
- 3.732 ÷ 100 = 0.03732 (two places)
- 3.732 ÷ 1000 = 0.003732 (three places)

Examples

- Rewrite the following number as a fraction

  453.273

$$= (4 \times 100) + (5 \times 10) + (3 \times 1) + \frac{2}{10} + \frac{7}{100} + \frac{3}{100}$$

$$= 453\frac{273}{1000}$$

- Write the representation of decimal places in the given number 0.386

  3 - Ist decimal place
  8 - IInd decimal place
  6 - IIIrd decimal place

- Write approximations in the following decimals to 3 places.

  a 6.9453 ——> 6.945
  b 8.7456 ——> 8.746

- Convert fraction to decimal

$$\frac{21}{24} = \frac{7}{8} = 0.875$$

- Convert decimal to fraction

$$0.0625 = \frac{625}{10000} = \frac{5}{80} = \frac{1}{16}$$

Assignment

1 Write down the following decimal numbers in the expanded form.

a 514.726

b 902.524

2 Write the following decimal numbers from the expansion.

a $500 + 70 + 5 + \frac{3}{10} + \frac{2}{100} + \frac{9}{1000}$

b $200 + 9 + \frac{1}{10} + \frac{3}{100} + \frac{5}{1000}$

3 Convert the following decimals into fractions in the simplest form.

a 0.72

b 5.45

c 3.64

d 2.05

4 Convert the following fraction into decimals

a $\frac{3}{5}$

b $\frac{10}{4}$

c $24\frac{54}{1000}$

d $\frac{12}{25}$

e $\frac{8}{25}$

f $1\frac{3}{25}$

5 Addition of decimals

a 4.56 + 32.075 + 256.6245 + 15.0358

b 462.492 + 725.526 + 309.345 + 626.602

6 Subtract the following decimals

a 612.5200 – 9.6479

b 573.9246 – 215.6000

7 Add and subtract the following

a 56.725 + 48.258 – 32.564

b 16.45 + 124.56 + 62.7 - 3.243

8 Multiply the following

a By 10,100,1000

i 3.754 x 10

ii 8.964 x 100

iii 2.3786 x 1000

iv 0.005 x 1000

b By whole numbers

i 8.4 x 7

ii 56.72 x 8

c By another decimal figure (use calculator)

i 15.64 x 7.68

ii 2.642 x 1.562

9 Divide the following

a $\frac{62.5}{25}$

b $\frac{64.56}{10}$

c $\frac{0.42}{100}$

d $\frac{48.356}{1000}$

10 Division

a $\frac{16.8}{1.2}$

b $\frac{1.54}{1.1}$

11 Change the fraction into a decimal

i $1\frac{5}{8}$

ii $\frac{12}{25}$

12 Find the value

20.5 x 40 ÷ 10.25 + 18.50

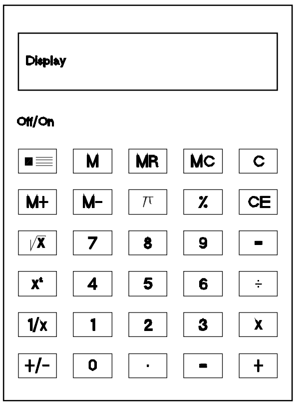
Unit, Fractions - Solving problems by using calculator

A pocket calculator allows to spend less time in doing tedious calculations. A simple pocket calculator enables to do the arithmetical calculations of addition, subtraction, multiplication and division, while a scientific type of calculator can be used for scientific and technical calculations also.

No special training is required to use a calculator. But it is suggested that a careful study of the operation manual of the type of the calculator is essential to become familiar with its capabilities. A calculator does not think and do. It is left to the operator to understand the problem, interpret the information and key it into the calculator correctly.

Constructional Details (Fig 1)

Fig 1



The key board is divided into five clear and easily recognizable areas and the display.

- **Data entry keys**

The entry keys are from [0] ....to [9]

and a key for the decimal point [.] .

- **Clearing keys**

These keys have the letter 'C'

[C] [CLR] Clear totally

[CE] Clear entry only

[CM] , [MC] Clear memory

[+] Addition key

[-] Subtraction key

[x] Multiplication key

[÷] Division key

[=] Equals key to display the result

- **Function keys**

[π] Pi key

[$\sqrt{x}$] Square root key

[%] Percentage key

[+/-] Sign change key

[x^2] Square key

[$\frac{1}{X}$] Reciprocal key

- **Memory keys**

[M] Store the display number

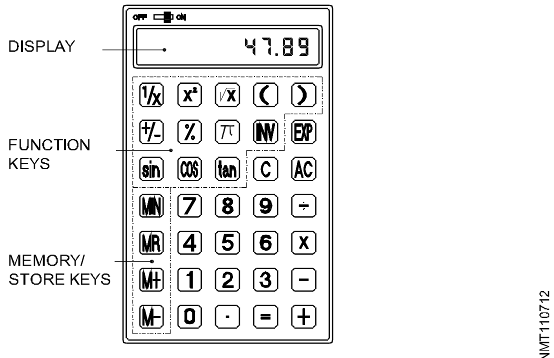
[M+] The displayed value is added to the memory

[M-] The displayed value is subtracted from the memory

[MR] [RCL] The stored value is recalled on to the display

Further functional keys included in Scientific calculators are as shown in Fig 2.

Fig 2



SCIENTIFIC CALCULATOR

Sin Cos Tan ( ) For trigonometric functions and for brackets

Exp Exponent key

INV Some of the keys have coloured lettering above or below them. To use a function in coloured lettering, press INV key. INV will appear on the display. Then press the key that the coloured lettering identifies. INV will disappear from the display.

log , INV 10^x to obtain the logarithm of the displayed number and the antilogarithm of the displayed value.

INV R–P to convert displayed rectangular coordinates into polar coordinates.

INV P–R to convert displayed polar coordinates into rectangular coordinates.

- **The display**

The display shows the input data, interim results and answers to the calculations.

The arrangement of the areas can differ from one make to another. Keying in of the numbers is done via. an internationally agreed upon set of ten keys in the order that the numbers are written.

Rules and Examples:

- **Addition:** Example 18.2 + 5.7

Sequence	Input	Display
Input of the 1st term of the sum	1 8 . 2	18.2
Press + key	+	18.2
Input 2nd term of the sum. the first term goes into the register	5 . 7	5.7
Press the = key	=	23.9

- **Subtraction:** Example 128.8 - 92.9

Sequence	Input	Display
Enter the subtrahend	1 2 8 . 8	128.8
Press - key	-	128.8
Enter the minuend. The subtrahend goes into the register	9 2 . 9	92.9
Press the = key	=	35.9

- **Multiplication:** Example 0.47 x 2.47

Sequence	Input	Display
Enter multiplicand	. 4 7	0.47
Press x key	x	0.47
Enter multiplier, multiplicand goes to register	2 . 4 7	2.47
Press = key	=	1.1609

- **Division:** Example 18.5/2.5

Sequence	Input	Display
Enter the dividend	1 8 . 5	18.5
Press ÷ Key	÷	18.5
Enter the divisor goes to the register	2 . 5	2.5
Press = key	=	7.4

- **Multiplication & Division:**
  Example : 2.5 x 7.2 / 4.8 x 1.25

Sequence	Input	Display
Enter 2.5	2 . 5	2.5
Press x key	x	2.5
Enter 7.2	7 . 2	7.2
Press ÷ key	÷	18
Enter Open bracket	(	
Enter 4.8	4 . 8	4.8
Press x key	x	4.8
Enter 1.25	1 . 2 5	1.25
Enter Close bracket	)	6
Press = key	=	3.0

- Store in memory Example (2+6) (4+3)

Sequence	Input	Display
Workout for the first bracket	2	2
	+	2
	6	6
	=	8
Store the first result in	STO , M	8
x	or M+	
Workout for the 2nd bracket	4	4
	+	4
	3	3
	=	7
Press x key	x	7
Recall memory	RCL or MR	8
Press = key	=	56

- **Percentage:** Example 12% of 1500

Sequence	Input	Display
Enter 1500	1 5 0 0	1500
Press x key	x	1500
Enter 12	1 2	12
Press INV %	INV %	12
Press = key	=	180

- **Square root:** Example $\sqrt{2}+\sqrt{3\times5}$

Sequence	Input	Display
Enter 2	2	2
Press $\sqrt{a}$ key	$\sqrt{a}$	1.414
Press + key	+	1.414
Press bracket key	(	1.414
Enter 3	3	3
Press $\sqrt{a}$ key	$\sqrt{a}$	1.732
Press x key	x	1.732
Enter 5	5	5
Press $\sqrt{a}$ key	$\sqrt{a}$	2.236
Press bracket close key	)	3.873
Press = key	=	5.2871969
2 √ + (3 √ x 5 √) =		5.2871969

$\sqrt{2}+\sqrt{3\times5} = 5.287$

- **Common logarithm:** Example log 1.23

Sequence	Input	Display
1 . 2 3 log	=	0.0899051

- **Power:** Example 123 + 30^2

Sequence	Input	Display
1 2 3 + 3 0 INV X^2	=	1023

- **Before starting the calculations be sure to press the 'ON' key and confirm that '0' is shown on the display.**
- **Do not touch the inside portion of the calculator. Avoid hard knocks and unduly hard pressing of the keys.**
- **Maintain and use the calculator in between the two extreme temperatures of 0° and 40° C.**

- **Never use volatile fluids such as lacquer, thinner, benzine while cleaning the unit.**
- **Take special care not to damage the unit by bending or dropping.**
- **Do not carry the calculator in your hip pocket.**

Assignment

1 Using calculator solve the following

a 625 + 3467 + 20 + 341 + 6278 = ______

b 367.4 + 805 + 0.7 + 7.86 + 13.49 = ______

c 0.043 + 1.065 + 13.0 + 34.76 + 42.1 = ______

d 47160 + 1368.4 + 0.1 + 1.6901 + 134.267 = ______

2 Using calculator simplify the following

a 24367 - 4385 = ______

b 9.643 - 0.7983 = ______

c 4382.01 - 381.3401 = ______

d 693.42 - 0.0254 = ______

3 Using calculator find the values of the following

a 23 x 87 = ______

b 1376 x 0.81 = ______

c 678 x 243 = ______

d 0.75 x 0.24 = ______

4 Using calculator solve the following

a 22434 ÷ 3 = ______

b 4131 ÷ 243 = ______

c 469890 ÷ 230 = ______

d 3.026 ÷ 0.89 = ______

5 Solve the following

a $\dfrac{1170 \times 537.5}{13 \times 215}$ = ______

b $\dfrac{28.2 \times 18 \times 3500}{1000 \times 3 \times 0.8}$ = ______

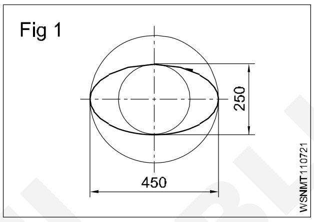
6 Solve the following

a $\dfrac{(634 + 128) \times (384 - 0.52)}{8 \times 0.3}$ = ______

b $\dfrac{(389 - 12.2) \times (842 - 0.05 - 2.6)}{(3.89 - 0.021) \times (28.1 + 17.04)}$ = ______

7

Fig 1



2a = 450 mm(major axis)

2b = 250mm(minor axis)

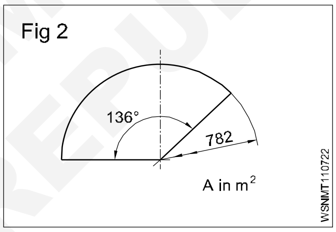
Perimeter of the ellipse

A = ______ metre^2

Hint A = π x a x b unit^2

8

Fig 2



ø = 782 mm

α = 136°

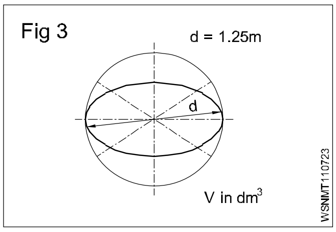
Area of the sector

A = ______

$$\text{Hint } A = \frac{\pi \times d^2}{4} \times \frac{\alpha}{360°}$$

9

Fig 3



d = 1.25 metre

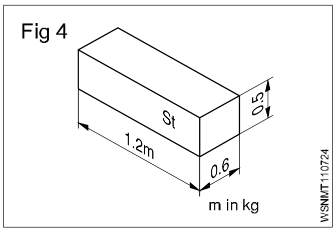
V = ______ dm^3

Volume of sphere

$$\text{Hint } V = \frac{4}{3}\pi r^3$$

10

Fig 4



L = 1.2 metres

B = 0.6 metre

H = 0.5 metre

'ρ' (rho) density of steel

= 7.85 kg/dm^3'

m = ______ kg

(mass 'm = V x ρ)

Square root, Ratio and Proportions, Percentage - Square and square root

a basic number
2 exponent

$\sqrt{\ }$ radial sign indicating the square root.

$\sqrt{a^2}$ square root of 'a' square

a^2 radicand

Square number

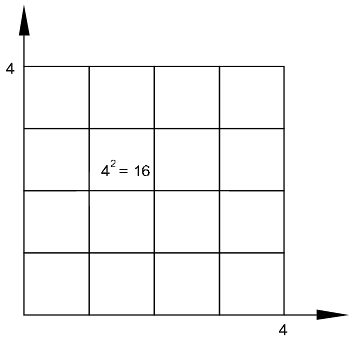
The square of a number is the number multiplied by itself.

Basic number x basic number = Square number

$a \times a = a^2$

$4 \times 4 = 4^2 = 16$

Fig 1



Splitting up

A square area can be split up into sub-areas. The largest square of 36 is made up of a large square 16, a small square 4 and two rectangles 8 each.

Large square 4 x 4 = 16 a^2

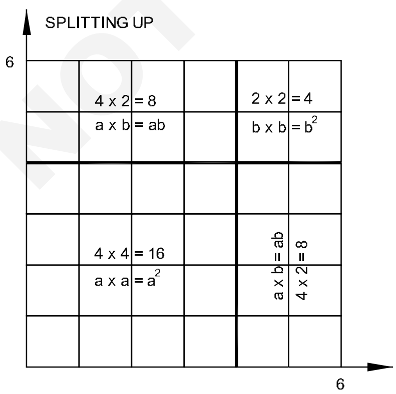
Two rectangles 2 x 4 x 2 = 16 2ab

Small square 2 x 2 = 4 b^2

Sum of sub-areas = 36 = $a^2 + 2ab + b^2$

$$\sqrt{36} = \sqrt{a^2 + 2ab + b^2}$$

Fig 2

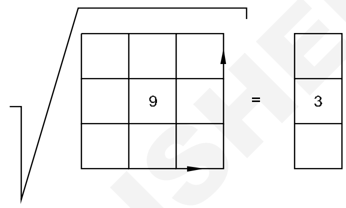


Result: In order to find the square root, we split up the square numbers.

Extracting the square root procedure

- Starting from the decimal point form groups of two figures towards right and left. Indicate by a prime symbol. $\sqrt{4624.00}$
- Find the root of the first group, calculate the difference, bring down the next group.
- Multiply the root by 2 and divide the partial radicand.
- Enter the number thus calculated in the divisor for the multiplication.

Fig 3



If there is a remainder, repeat the procedure.

	68
6	46,24
	36
128	1024
	1024
	0

$\sqrt{4624} = 68$

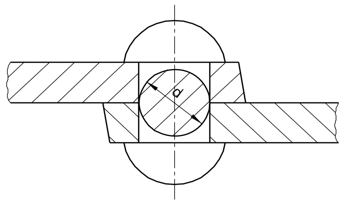
Basic number x basic number = Square

$\sqrt{\text{Square number}}$ = basic number

Example

The cross-section of a rivet is 3.46 cm^2. Calculate the diameter of the hole.

Fig 4



Rivet cross-section is the hole cross-section.

To find 'd',

Given that Area = 3.46 cm^2

Area = 0.785 x d^2 (formula)

3.46 cm^2 = d^2 x 0.785

$$d^2 = \frac{3.46\ cm^2}{0.785}$$

$$d = \sqrt{\frac{3.46}{0.785}}\ cm$$

$$d = 2.1\,cm\ (or)\ 21\,mm$$

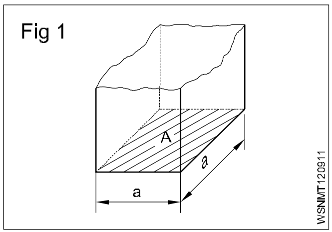
Square root, Ratio and Proportions, Percentage - Simple problems using calculator

1 a $\sqrt{2916}$ = ____________.

b $\sqrt{45796}$ = ____________.

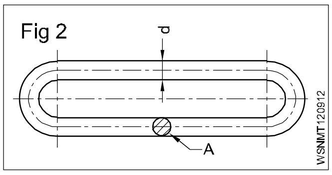
c $\sqrt{8.2944}$ = ____________.

d $\sqrt{63.845}$ = ____________.

2 

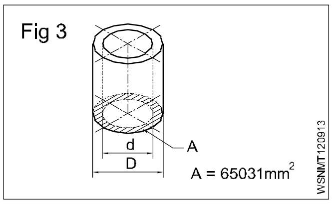
A = 2025 mm^2

a = ____________mm

3 

A = 176.715 mm^2

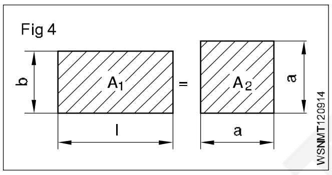
d = ____________mm

4 

A = 65031 mm^2

d = 140 mm

D = ____________mm

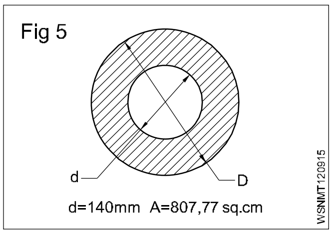
5 

l = 58 cm

b = 45 cm

$A_1 = A_2$

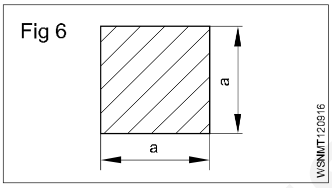
a = ____________cm

6 

A = 807.77 cm^2

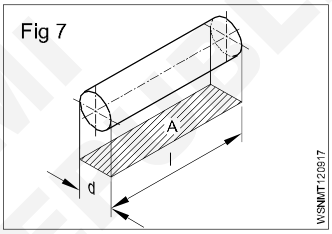
d = 140 mm

D = ____________mm

7 

a x a = 543169 mm^2

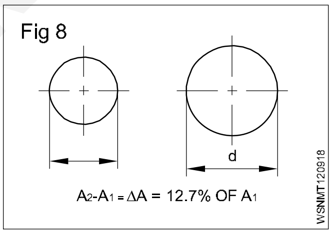
a = ____________mm

8 

d : l = 1:1.5

A = 73.5 mm^2

d = ____________mm

9 

increase in area

A = 12.7%

A = 360 mm^2

d = ____________mm

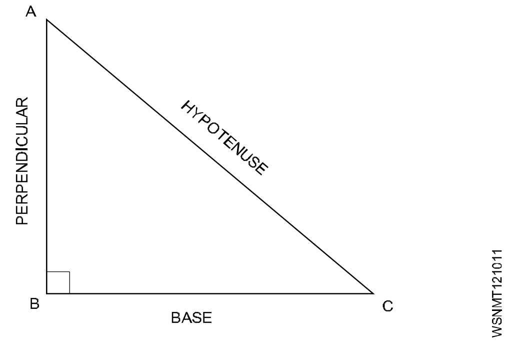
(d = diameter after the increase in area)

Square root, Ratio and Proportions, Percentage - Applications of pythagoras theorem and related problems

Applications of Pythagoras Theorem

Some of the applications of the Pythagoras theorem are; (Fig 1)

Fig 1



1 The Pythagoras theorem is commonly used to find the lengths of sides of a right-angled triangle.

2 It is used to find the length of the diagonal of a square.

3 Pythagoras theorem is used in trigonometry to find the trigonometric ratios like sin, cos, tan, cosec, sec and cot.

4 Pythagoras theorem is used in security cameras for face recognition.

5 Architects use the technique of the Pythagoras theorem for engineering and construction fields.

6 The Pythagoras theorem is applied in surveying the mountains.

7 It is also used in navigation to find the shortest route.

8 By using the Pythagoras theorem, we can derive the formula for base, perpendicular and hypotenuse.

9 Painters use ladders to paint on high buildings with the help of the Pythagoras theorem.

10 Pythagoras theorem is used to calculate the steepness of slopes of hills or mountains.

11 The converse of the Pythagoras theorem is used to check whether a triangle is a right triangle or not.

Application of pythagoras theorem in real life

Pythagoras theorem states that

"In a right-angled triangle, the square of the hypotenuse side is equal to the sum of squares of the other two sides".

1 The sides of this triangle have been named Perpendicular, Base and Hypotenuse.

2 The hypotenuse is the longest side, as it is opposite to the angle 90°.

3 The sides of a right triangle (say AB, BC and CA) which have positive integer values, when squared, are put into an equation, also called a Pythagorean triplet.

4 To calculate the length of staircase required to reach a window

5 To find the length of the longest item can be kept in your room.

6 To find the steepness of the hills or mountains.

7 To find the original height of a tree broken due to heavy rain and lying on itself

8 To determine heights and measurements in the construction sites.

Examples

1 What is the side AC if AB = 15 cm, BC = 25 cm.

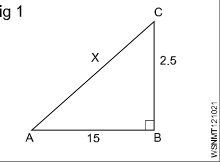
$AC^2 = AB^2 + BC^2$

$= 15^2 + 25^2$

$= 225 + 625 = 850$

$AC = \sqrt{850} = 29.155$ cm

Fig 1



2 What is the side BC if AB = 10 cm, AC = 30 cm.

$AC^2 = AB^2 + BC^2$

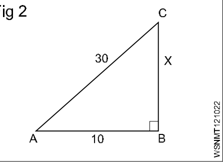
$30^2 = 10^2 + BC^2$

$900 = 100 + BC^2$

$BC^2 = 900 - 100 = 800$

$BC = 28.284$ cm

Fig 2



3 What is the side AB if BC = 20 cm, AC = 35 cm.

$AC^2 = AB^2 + BC^2$

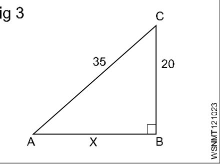
$35^2 = AB^2 + 20^2$

$1225 = AB + 400$

$AB^2 = 1225 - 400 = 825$

$AB = 28.72$ cm

Fig 3



4 What is the value of side BC if AB = 8 cm, AC = 24 cm.

$AC^2 = AB^2 + BC^2$

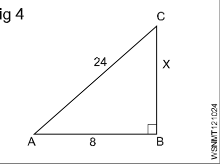
$24^2 = 8^2 + BC^2$

$576 = 64 + BC^2$

$BC^2 = 576 - 64 = 512$

$BC = \sqrt{572} = 22.63$ cm

Fig 4



5 What is the value side AC if AB = 6.45 cm, BC = 8.52 cm.

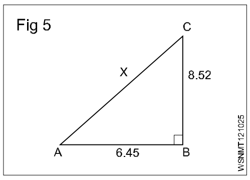


Fig 5

$AC^2 = AB^2 + BC^2$

$AC^2 = 6.45^2 + 8.52^2$

$AC^2 = 41.60 + 72.59$

$= 114.19$

$AC = \sqrt{114.19} = 10.69$ cm

6 What is the value of side AB if BC = 3.26 cm, AC = 8.24 cm.

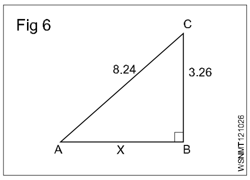


Fig 6

$AC^2 = AB^2 + BC^2$

$8.24^2 = AB^2 + 3.26^2$

$67.9 = AB + 10.63$

$AB^2 = 67.9 - 10.63$

$= 57.27$

$AB = \sqrt{57.27} = 7.57$ cm

7 What is the value of side AB if AC = 12.5 cm, BC = 8.5 cm.

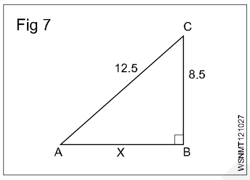


Fig 7

$AC^2 = AB^2 + BC^2$

$12.5^2 = AB^2 + 8.5^2$

$156.25 = AB + 72.25$

$AB^2 = 156.25 - 72.25$

$= 84$

$AB = \sqrt{84} = 9.17$ cm

8 A ladder of 12.5 metre long is placed with upper end against a wall. The lower end being 7.5 metres from the wall. What height is the upper end above the ground.

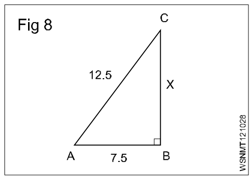


Fig 8

$AC^2 = AB^2 + BC^2$

$BC^2 = AC^2 - AB^2$

$BC^2 = x^2$

$AC^2 = AB^2 + BC^2$

$12.5^2 = x^2 + 7.5^2$

$x^2 = (12.5)^2 - (7.5)^2$

$= (12.5 + 7.5)\ (12.5 - 7.5)^2$

$= 20 \times 5$

$= \sqrt{100} = 10$

$x = 10$ m

9 What is the value of AB.

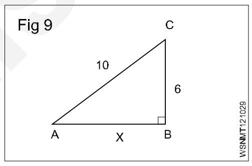


Fig 9

$AC^2 = AB^2 + BC^2$

$AB^2 = AC^2 - BC^2$

$AB^2 = x^2$

$AC^2 = AB^2 + BC^2$

$10^2 = x^2 + 6^2$

$x^2 = 10^2 - 6^2$

$= 100 - 36 = 64$

$x = \sqrt{64}$

$= 8$

$AB = 8$

Assignment

1 What is the value of side AB, in a right angled triangle of side AC = 10 cm and BC = 5 cm.

2 What is the value of side AC, in a right angled triangle of side AB = 6.5 cm and BC = 4.5 cm.

3 What is the value of side BC, in a right angled triangle of side AC = 14.5 cm and AB = 10.5 cm.

4 What is the value of side AC, in a right angled triangle of side AB = 7 cm and BC = 5 cm.

5 What is the value of side BC, in a right angled triangle of side AC = 13.25 cm and AB = 8.75 cm.

Square root, Ratio and Proportions, Percentage - Ratio and proportion

Ratio

Introduction

It is the relation between two quantities of the same kind and is expressed as a fraction.

Expression

a, b two quantities of the same kind. $\frac{a}{b}$ or a:b or a $\div$ b or a in b is the ratio.

Ratio is always reduced to the lowest terms.

Example

$$7:14=\frac{7}{14}=\frac{1}{2}=1:2$$

Proportion

It is the equality between the ratios, a : b is a ratio and c: d is another ratio. Both ratios are equal. Then

a :b :: c : d or $\frac{a}{b}=\frac{c}{d}$

Example

250 : 2000 :: 1 : 8

Proportion fundamentals

If $\frac{a}{b}=\frac{c}{d}$ then

- ad = bc
- $\frac{a}{c}=\frac{b}{d}$
- $\frac{b}{a}=\frac{d}{c}$
- $\frac{a+b}{b}=\frac{c+d}{c}$ and $\frac{a+b}{a}=\frac{c+d}{c}$
- $\frac{a-b}{b}=\frac{c-d}{d}$
- $\frac{a+b}{b+d}=\frac{a}{c}=\frac{c}{d}$

3:4::6:8 or $\frac{3}{4}=\frac{6}{8}$

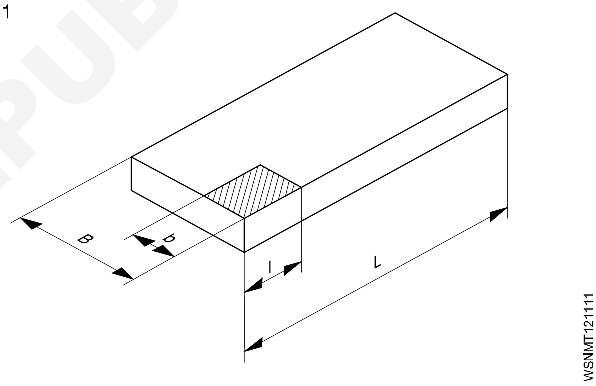
- 3 x 8 = 6 x 4
- $\frac{3}{6}=\frac{4}{8}$
- $\frac{4}{3}=\frac{8}{6}$
- $\frac{3+4}{4}=\frac{6+8}{8}$
- $\frac{3-4}{4}=\frac{6-8}{8}$
- $\frac{3+6}{4+8}=\frac{9}{12}=\frac{3}{4}$

Ratio - relation of two quantities of the same kind.
Proportion - equality between two ratios.

Example

- A steel plate of 800 x 1400 mm is to be drawn to a scale of 1:20. What will be the lengths in the Fig 1.

Fig 1



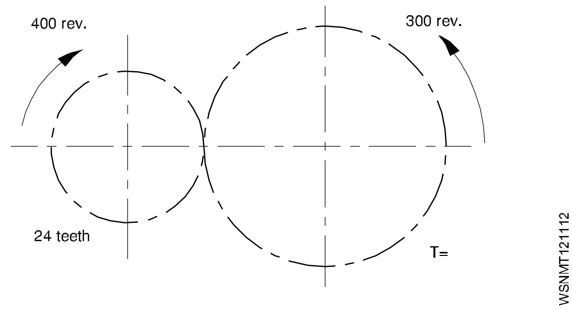
The reduction ratio is $\frac{1}{20}$.

B is reduced from 800 to 800 x $\frac{1}{20}$ = 40 mm.

L is reduced from 1400 x $\frac{1}{20}$ = 70 mm.

- Find the number of teeth of the larger gear in the gear transmission shown in the Fig 2.

Fig 2



Speed ratio = 400 : 300

Teeth ratio = 24:T

$$\frac{400}{300} = \frac{T}{24}$$

$$\therefore T = \frac{24 \times 400}{300} = 32 \text{ Teeth}$$

Find the ratio of A:B:C

If A:B= 2:3 and B:C=4:5

A:B = 2:3

B:C = 4:5

A:B = 8 :12 (Ratio 2:3 multiply by 4)

B:C = 12:15 (Ratio 4:5 multiply by 3)

∴ A:B:C = 8:12:15

Assignment

1

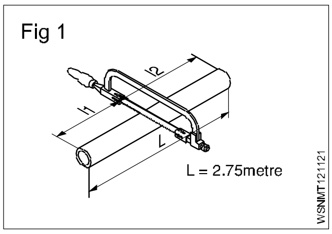


Fig 1

$l_1 : l_2 = 2:3$

L = 2.75 metres

l_1 = ______ metres

l_2 = ______ metres

2

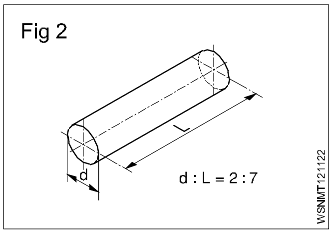


Fig 2

d: L of shaft = 2:7

d = 40 mm

L = ______ mm

3

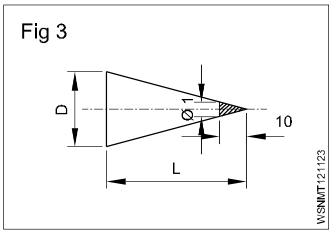


Fig 3

D : L=1:10

L=150mm

D=______mm

4

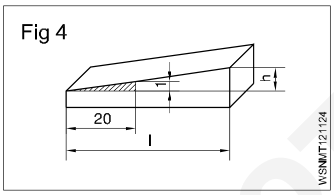


Fig 4

$$\frac{\Delta h}{l} = \frac{1}{20}$$

l = 140 mm

Δh = _____ mm

5

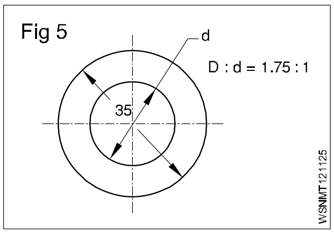


Fig 5

D : d = 1.75: 1

D = 35 mm

d = ______ mm

6

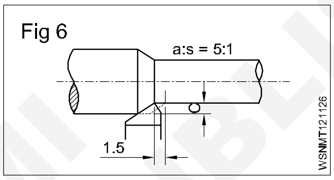


Fig 6

a:s = 5:1

s = 1.5mm

a =______ mm

7 A:B=9:12

B:C=8:10

Then A:B:C=__________

8 A:B=5:6

B:C=3:4

Then A:B:C=______

9 A:55=9:11

A = __________

10 15:9.3=40:x

x = __________

Square root, Ratio and Proportions, Percentage - Ratio and Proportions - Direct and indirect proportions

Proportion

Description

It is the equality between the ratios, a:b is a ratio and c:d is another ratio. Both ratios are equal. Then

a : b::c : d or e.g. 250 : 2000::1 : 8

Rule of three

A three step calculation

statement

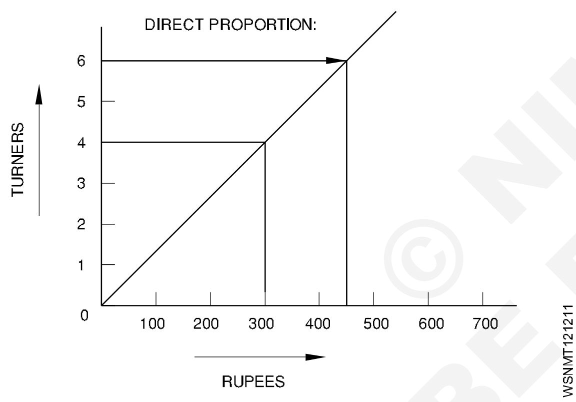
single

multiple.

Direct proportion

The more in one the more in the other - An increase in one denomination produces an increase in the other. (Fig 1)

Fig 1



Examples

1 4 turners earn 300 Rupees. How much will 6 Turners earn?

Statement
4 turners = 300 Rupees

Single
1 Turner = 75 Rupees

Multiple
6 Turners = 6 x 75 = 450 Rupees

2 One vehicle consumes 30 litres of petrol per day how much petrol is used by 6 Vehicles operating under similar condition.

One vehicle uses petrol = 30 litres per day.

Then six vehicles will use = 6 Times as much

= 6 x 30 = 180 litres/day.

3 4 vehicles consumes 120 gallons of petrol per day how much petrol will be used by 12 vehicles operating under the same condition.

4 vehicles use 120 gallons per day

1 Vehicle will use $\frac{120}{4}$ = 30 gallons/day

12 vehicles will use 12 x 30 = 360 gallons/day

Both examples are called simple proportion because only two quantities were used and the day is common for both ratios.

4 If 2 litres of petrol costs Rs 60. Find the cost of 50 litres.

Quantity of Petrol	Cost of Petrol
2 litres	Rs.60
50 litres	x

1 litre petrol $= \frac{60}{2}$ = Rs.30

50 litres petrol = 30 x 50 = Rs 1500

5 A 150mm dia gear meshes with 50mm dia gear. If the larger gear has 30 teeth. How many teeth will have the smaller gear have?

Gear dia	No. of Teeth
150 mm	30
50 mm	x

$x = \frac{50}{150}$ x 30 = 10 teeth.

6 A mechanic assembles 7 machines in 2½ days. How long will it take time to assemble 70 machines at the same rate.

Machines	Days
7	2½
70	x

$x = \frac{70 \times 2.5}{7}$ = 25 days

Assemble for 70 machines will take 25 days.

7 A roll of wire weighs 1.24 kg from this roll a piece of 3.7cm long is cut and it is found to weigh 2.93 gm. What is the length of the wire in the roll?

Weight of wire	Length of wire
2.93 gm	3.7 cm
1.24 kg (1240 gm)	x

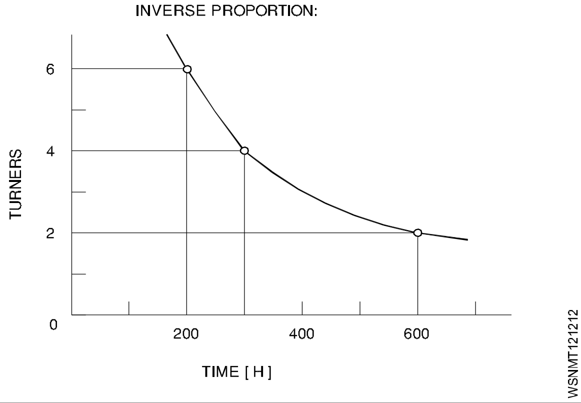
$$x = \frac{1240}{2.93} \times 3.7 = 1566 \text{ cm}$$

Length of wire = 1566 cm.

Indirect or inverse proportion

The more in one the lesser other - Increase in one quantity will produce a decrease in the other. (Fig 2)

Fig 2



Example

1 4 turners finish a job in 300 hours. How much time will 6 turners take to do the same job?

Solution procedure in three steps:

Statement 4 turners taken = 300 hours

The time will reduce if 6 turners to do the same job. Therefore this is inverse proportion.

Multiple fraction $\frac{4 \text{ Turners}}{6 \text{ Turners}} \times 300 \text{ hours}$

6 Turners = 200 hours

Result - The more the less.

2 8 workman take 6 days to complete a job. How many days it will take for 4 workman to complete the same job?

Workman	Days
8	6
4	x

$$x = \frac{8}{4} \times 6 = 12 \text{ days}$$

4 workers complete the work = 12 days.

3 5 men working on a job finished it in 32 days. Find out in how many days 8 men will finish the same job?

Men	Days
5	32
8	x

$$x = \frac{5 \times 32}{8} = 4 \times 5 = 20 \text{ days}$$

8 men will complete the job = 20 days.

4 An engine running at 150 rpm drives a shaft by pulley diameter is 55cm and that of the driven shaft pulley is 33 cm. Find the speed of the shaft?

Dia of pulley	Rpm of shaft
55 cm	150
33 cm	x

$$x = \frac{55 \times 150}{33} = 250 \text{ rpm.}$$

Speed of the 33cm diameter will run 250 rpm.

5 A pulley of 80 cm diameter is rotating at 100 rpm and drives another pulley of 40 cm diameter. Find the rpm of driven pulley. If slip is 2.5% find the rpm?

Dia of pulley	Rpm of pulley
80 cm	100
40 cm	x

40 cm diameter = 200 rpm.

Slip is 2.5% = 195 rpm.

Problems involving both

Example

2 turners need 3 days to produce 20 pieces. How long will it take for 6 turners to produce 30 such pieces?

Statement

2 turners, 20 pieces = 3 days

6 turners, 30 pieces = how many days.

First step (Fig 3)

Statement 2 turners for 20 pieces = 3 days

1 turner for 20 pieces = 3 x 2 = 6 days

Multiple 6 turners for 20 pieces = $\frac{6}{6}$ = 1 day

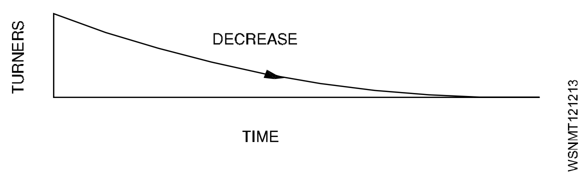
Statement 6 turners for 20 pieces = 1 day

Single 6 turners for 1 piece = $\frac{1}{20}$ days

Multiple 6 turners for 30 pieces = $\frac{1}{20} \times 30$ = 1.5 days

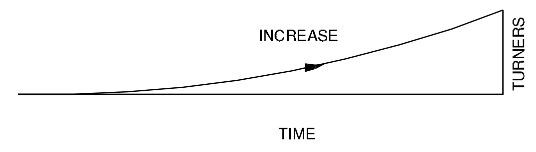
Inverse proportion - More the less.

Fig 3



Second step (Fig 4)

Fig 4



WSNMT121214

Direct proportion - More the more.

Solve the problem by first writing the statement and proceed to single and then to the multiple according to the type of proportion that is involved.

Introduction

Proportional fundamentals, as applicable to motor vehicle calculations are discussed below.

Simple Proportion

- Proportion

This is an equality between two ratios

Compound and Inverse proportions

- Compound proportions

Example

5 Fitter take 21 days to complete overhauling of 6 vehicles how long 7 Fitters will take to over haul 8 vehicles (Assume time of overhauling each vehicle is constant)

In this both direct and indirect proportions are used.

- 1 Fitter will overhauling 1 vehicle in days (shorter time).
- Quantities (No. of days) are taken in last as that is the answer required in this case.

Fitters	Vehicle	Days
5	6	21
7	8	x

$$\left(\frac{21 \times 5}{6 \times 7} \times 8\right) = 20 \text{ days}$$

Ans: 7 Fitters will overhaul 8 vehicles in 20 days.

Inverse proportion

Some times proportions are taken inversely.

Examples

- If one water pump fills the fuel tank in 12 minutes, two pumps will take half the time taken.

The time should not be doubled.

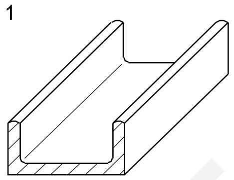
- 2 pumps will take 30 minutes to fill up a tank how long will 6 similar pumps take this to fill this tank.

Pump	Time
2	30
6	x

Ans: Time taken by 6 pumps = $\frac{30 \times 2}{6} = 10$ minutes

Assignment

1 Fig 1



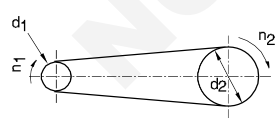
WSNMT121221

Length = 6.1 metre

Weight = 32 kgf

Weight of 1 metre of the same channel = _______ kgf

2 Fig 2



WSNMT121222

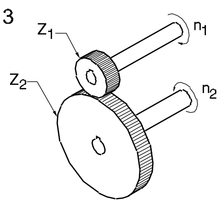
d_1 = 120 mm

d_2 = 720 mm

n_1 = 1200 rpm

n_2 = _______ rpm

3 Fig 3



WSNMT121223

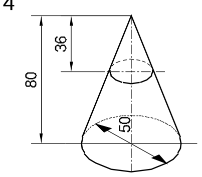
Z_1 = 42 T

n_2 = 96 rpm

n_1 = 224 rpm

Z_2 = _______ T

4 Fig 4



WSNMT121224

D = 50 mm

H = 80 mm

h = 36 mm

d = ______ mm

5 If a mechanic assembles 8 machines in 3 days, how long he will take to assemble 60 machines.

6 In an auto shop the grinding wheel makes 1000 rpm and the driven pulley is 200 mm dia. If the driving pulley is 150 mm dia. Find out the rpm of the driving pulley.

7 In a gearing of a vehicle the following facts are found.

A 180 mm dia of gear meshes with 60mm dia gear. If the bigger gear makes 60 rpm. What will be the rpm of smaller gear.

8 A vehicular job is completed by 5 mechanics in 4 days. If only 3 mechanics are available, in how many days the work can be completed.

Square root, Ratio and Proportions, Percentage - Percentage

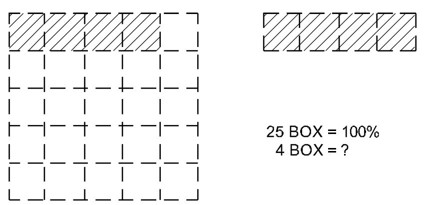
Percentage

Percentage is a kind of fraction whose denominator is always 100. The symbol for percent is %, written after the number. e.g. 16%.

Ex. $\frac{16}{100} = 0.16$

In decimal form, it is 0.16. Percentage calculation also involves rule of three. The statement (the given data), for unit, and then to multiple which is for calculating the answer. (Fig 1)

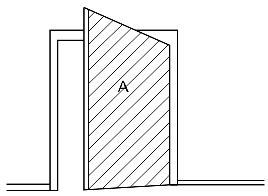
Fig 1



Example

The amount of total raw sheet metal to make a door was 3.6 metre^2 and wastage was 0.18 metre^2. Calculate the % of wastage. (Fig 2)

Fig 2



Solution procedure in three steps.

Statement:

Area of door (A) =3.6 m^2 = 100 %.

Wastage = 0.18 m^2

Single: $\frac{100}{3.6}$ x 1 m^2

Multiple: for 0.18 m^2= $\frac{100}{3.6}$ x 0.18.

Wastage = 5%.

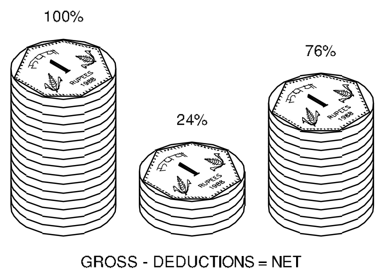
Analyse the given data and proceed to arrive at the answer through the unit.

Example

A fitter receives a take-home salary of 984.50 rupees.

If the deduction amounts to 24%, what is his total salary? (Fig 3)

Fig 3



Total pay 100%

Deduction 24%

Take home salary 76%

If the take home pay is Rs.76, his salary is 100.

For 1% it is $\frac{1}{76}$

For Rs.984.50, it is $\frac{1}{76}$ x 984.50.

For 100% it is $\frac{984.50}{76}$X100 = 1295.39

100% i.e. gross pay = Rs.1295.40.

Example 1

75 litres of oil is taken out from a oil barrel of 200 litres capacity. Find out the percentage taken in this.

Solution

% of oil taken = Oil taken out (litres) / Capacity of Barrel (litres) x 100

$= \frac{75}{200} \times 100 = 37\frac{1}{2}\%$

Example 2

A spare part is sold with 15%. Profit to a customer, to a price of Rs.15000/-. Find out the following (a) What is the purchase price (b) What is the profit.

Solution: CP = x,

CP = cost price

SP = sale price

SP=CP+15%of CP

$15000 = x + \frac{15x}{100} = \frac{100x + 15x}{100}$

$x = \frac{1500000}{115} = 13043.47$

Profit = SP-CP = 15000-13043.47 = 1956.53

Purchase price = Rs.13,043/,Profit = Rs. 1957

Example 3

Out of 80000 cars, which were tested on road, only 16000 cars had no fault. What is the percentage in this acceptance.

$$= \frac{16000}{80000} \times 100 = \frac{100}{5} = 20\%$$

Example 4

The price of a motor cycle dropped to 92% of original price and now sold at Rs.18000/- What was the original price.

Solution

Present price of Motor cycle Rs.18000

This is the value of 92% of original price

$$\text{Original Price} = 18000 \times \frac{100}{92} = \frac{1800000}{92}$$

= Rs.19565

Example 5

A Motor vehicle uses 100 litres of Petrol per day when travelling at 30 kmph. After top overhauling the consumption falls to 90 litres per day. Calculate percentage of saving.

Solution

Percentage of saving = Decrease in consumption/Original consumption x 100

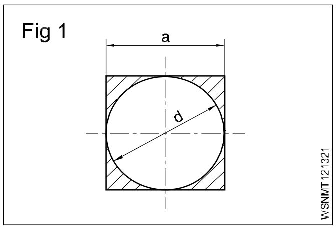
$$= (100-90)\frac{\text{litres}}{100} \times 100$$

$$= \frac{10}{100} \times 100$$

= 10% Saving in fuel.

Assignment

1

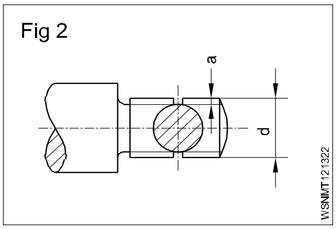


a = 400mm (side of square)

d = 400 mm

Wastage = ______ %.

2



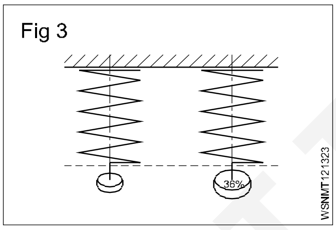
d = 26mm

'a' depth of u/cut = 2.4mm

reduction of area at cross-section

= ______ %

3

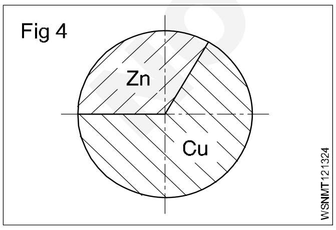


Percentage of increase = 36%

Value of increase = 611.2 N/mm^2

Original tensile strength = ______ N/mm^2.

4



Copper in alloy = 27 kg

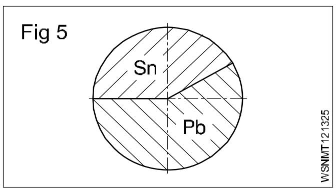
Zinc in alloy = 18 kg

% of Copper

= ______ %

% of Zinc = ______ %.

5



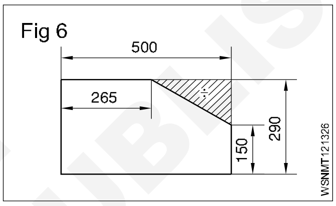
Weight of alloy = 140 Kgf

Weight of Sn 40%

Pb = ______ Kgf

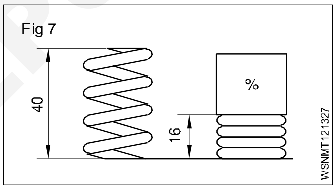
Sn = ______ Kgf.

6



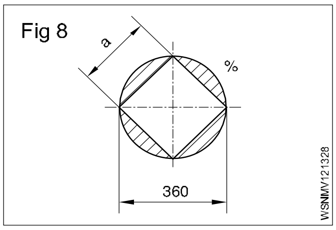
Shaded portion = ______ %.

7



Compression length = ______ %.

8

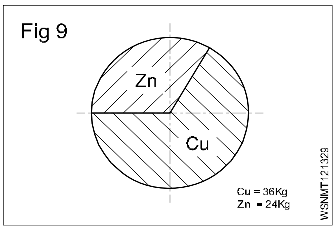


d = 360 mm

a = 0.707 x d

Wastage = ______ %.

9



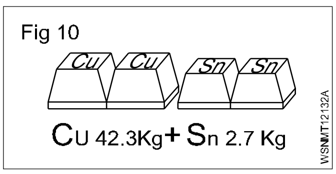
Cu = 36 Kg

Zn = 24 Kg

Cu = ______ %

Zn = ______ %

10



Cu = 42.3 Kg

Sn = 2.7 Kg

Cu ______ %

Sn = ______ %.

Square root, Ratio and Proportions, Percentage - Changing percentage to decimal and fraction

Conversion of Fraction into Percentage

1 Convert $\frac{1}{2}$ into percentage.

Solution: $\frac{1}{2}$ x 100

= 50%

2 Convert $\frac{1}{11}$ into percentage

Solution: $\frac{1}{11}$ x 100 = $\frac{100}{11}$

= 9.01%

Convert the following fraction into percentage.

1 $\frac{1}{4}$

2 $\frac{1}{5}$

3 $\frac{2}{3}$

4 $\frac{3}{8}$

Conversion of Percentage into Fraction

1 Convert 24% into fraction.

Solution: $\frac{24}{100} = \frac{6}{25}$

2 Convert $33\frac{1}{3}$% into fraction.

Solution: $\frac{33\frac{1}{3}}{100} = \frac{\frac{100}{3}}{100} = \frac{100}{3} \times \frac{1}{100}$

$= \frac{1}{3}$

Convert the following percentage into fraction

1 15%

2 $87\frac{1}{2}$%

3 80%

4 12.5%

Conversion of Decimal Fraction into Percentage

1 Convert 0.35 into percentage.

Solution: 0.35 x 100

= 35%

2 Convert 0.375 into percentage.

Solution: 0.375 x 100

= 37.5%

Convert the following Decimal Fraction into Percentage

1 0.2

2 0.004

3 0.875

4 0.052

Conversion of Percentage into Decimal fraction

1 Convert 30% into decimal fraction.

Solution: $\frac{30}{100}$ = 0.3

2 Convert $33\frac{1}{3}$% into decimal fraction.

Solution: $\frac{33\frac{1}{3}}{100} = \frac{\frac{100}{3}}{100} = \frac{100}{3} \times \frac{1}{100}$

$= \frac{1}{3}$ = 0.333

Convert the following percentage into decimal fraction

1 15%

2 7%

3 $12\frac{1}{2}$%

4 90%

Material science - Types of metal, types of ferrous and non ferrous metals

Types of metals

The metals is of two types:

1 Ferrous metal   2 Non-ferrous metal

1 Ferrous metals : The metals that contains major part of iron and contain carbon are called ferrous metals such as pig iron, mild steel, nickel etc., they have iron properties such as rusting, magnetisations etc.

2 Non-ferrous metals : The metals that do not contains iron or carbon and do not have the property of iron are called non-ferrous metals such as copper, aluminum etc.

Ferrous and Non ferrous alloys

Alloying metals and ferrous alloys

An alloy is formed by mixing two or more metals together by melting.

For ferrous metals and alloys, iron is the main constituent metal. Depending on the type and percentage of the alloying metal added, the property of the alloy steel will vary.

Metals commonly used for making alloy steels

Nickel (Ni)

This is a hard metal and is resistant to many types of corrosion rust.

It is used in industrial applications like nickel, cadmium batteries, boiler tubes, valves of internal combustion engines, engine spark plugs etc. The melting point of nickel is 1450°C. Nickel can be magnetised. In the manufacture of permanent magnets a special nickel steel alloy is used. Nickel is also used for electroplating. Invar steel contains about 36% nickel. It is tough and corrosion resistant. Precision instruments are made of Invar steel because it has the least coefficient of expansion.

Nickel-steel alloys are available containing nickel from 2% to 50%.

Chromium (Cr)

Chromium, when added to steel, improves the corrosion resistance, toughness and hardenability of steel. Chromium steels are available which may contain chromium up to 30%.

Chromium, nickel, tungsten and molybdenum are alloyed for making automobile components and cutting tools.

Chromium is also used for electroplating components. Cylinder liners are chrome-plated inside so as to have wear resistance properties. Stainless steel contains about 13% chromium. Chromium-nickel steel is used for bearings. Chrome-vanadium steel is used for making hand tools like spanners and wrenches.

Manganese (Mn)

Addition of manganese to steel increases hardness and strength but decreases the cooling rate.

Manganese steel can be used to harden the outer surface for providing a wear resisting surface with a tough core. Manganese steel containing about 14% manganese is used for making agricultural equipment like ploughs and blades.

Silicon (Si)

Addition of silicon for alloying with steel improves resistance to high temperature oxidation.

This also improves elasticity, and resistance against corrosion. Silicon alloyed steels are used in manufacturing springs and certain types of steel, due to its resistance to corrosion. Cast iron contains silicon about 2.5%. It helps in the formation of free graphite which promotes the machinability of cast iron.

Tungsten (W)

The melting temperature of tungsten is 3380° C. This can be drawn into thin wires.

Due to this reason it is used to make filaments of electric lamps.

Tungsten is used as an alloying metal for the production of high speed cutting tools. High speed steel is an alloy of 18% tungsten, 4% chromium and 1% vanadium.

Stellite is an alloy of 30% chromium, 20% tungsten, 1 to 4% carbon and the balance cobalt.

Vanadium (Va)

This improves the toughness of steel. Vanadium steel is used in the manufacture of gears, tools etc. Vanadium helps in providing a fine grain structure in tool steels.

Chrome-vanadium steel contains 0.5% to 1.5% chromium, 0.15% to 0.3% vanadium, 0.13% to 1.10% carbon.

This alloy has high tensile strength, elastic limit and ductility. It is used in the manufacture of springs, gears, shafts and drop forged components.

Vanadium high speed steel contains 0.70% carbon and about 10% vanadium. This is considered as a superior high speed steel.

Cobalt (Co)

The melting point of cobalt is 1495°C. This can retain magnetic properties and wear- resistance at very high temperatures. Cobalt is used in the manufacture of magnets, ball bearings, cutting tools etc. Cobalt high speed steel (sometimes known as super H.S.S.) contains about 5 to 8% cobalt. This has better hardness and wear resistance properties than the 18% tungsten H.S.S.

Molybdenum (Mo)

The melting point of molybdenum is 2620°C. This gives high resistance against softening when heated. Molybdenum high speed steel contains 6% of molybdenum, 6% tungsten, 4% chromium and 2% vanadium. This high speed steel is very tough and has good cutting ability.

Cadmium (cd)

The melting point of cadmium is 320°C. This is used for coating steel components.

Alloying Metals and Non Ferrous Alloys

Non-ferrous Metals And Alloys

Copper and its alloys

Metals without iron are called non-ferrous metals. Eg. Copper, Aluminium, Zinc, Lead and Tin.

Copper

This is extracted from its ores 'MALACHITE' which contains about 55% copper and 'PYRITES' which contains about 32% copper.

Properties

Reddish in colour. Copper is easily distinguishable because of its colour.

The structure when fractured is granular, but when forged or rolled it is fibrous.

It is very malleable and ductile and can be made into sheets or wires.

It is a good conductor of electricity. Copper is extensively used as electrical cables and parts of electrical apparatus which conduct electric current.

Copper is a good conductor of heat and also highly resistant to corrosion. For this reason it is used for boiler fire boxes, water heating apparatus, water pipes and vessels in brewery and chemical plants. Also used for making soldering iron.

The melting temperature of copper is 1083^{o} C.

The tensile strength of copper can be increased by hammering or rolling.

Copper Alloys

Brass

It is an alloy of copper and zinc. For certain types of brass small quantities of tin or lead are added. The colour of brass depends on the percentage of the alloying elements. The colour is yellow or light yellow, or nearly white. It can be easily machined. Brass is also corrosion-resistant.

Brass is widely used for making motor car radiator core and water taps etc. It is also used in gas welding for hard soldering/brazing. The melting point of brass ranges from 880 to 930^{o}C.

Brasses of different composition are made for various applications.

Bronze

Bronze is basically an alloy of copper and tin. Sometimes zinc is also added for achieving certain special properties. Its colour ranges from red to yellow. The melting point of bronze is about 1005^{o}C. It is harder than brass. It can be easily machined with sharp tools. The chip produced is granular. Special bronze alloys are used as brazing rods.

Bronze of different compositions are available for various applications.

Lead and its alloys

Lead is a very commonly used non-ferrous metal and has a variety of industrial applications.

Lead is produced from its ore 'GALENA'. Lead is a heavy metal that is silvery in colour when molten. It is soft and malleable and has good resistance to corrosion. It is a good insulator against nuclear radiation. Lead is resistant to many acids like sulphuric acid and hydrochloric acid.

It is used in car batteries, in the preparation of solders etc. It is also used in the preparation of paints.

Lead Alloys

Babbitt metal

Babbitt metal is an alloy of lead, tin, copper and antimony. It is a soft, anti-friction alloy, often used as bearings.

An alloy of lead and tin is used as 'soft solder'.

Zinc and its alloys

Zinc is a commonly used metal for coating on steel to prevent corrosion. Examples are steel buckets, galvanized roofing sheets, etc.

Zinc is obtained from the ore-calamine or blende.

Its melting point is 420^{o} C.

It is brittle and softens on heating; it is also corrosion-resistant. Due to this reason it is used for battery containers and is coated on roofing sheets etc.

Galvanized iron sheets are coated with zinc.

Tin and tin alloys

Tin

Tin is produced from cassiterite or tinstone. It is silvery white in appearance, and the melting point is 231^{o} C. It is soft and highly corrosion-resistant.

It is mainly used as a coating on steel sheets for the production of food containers. It is also used with other metals, to form alloys.

Example: Tin with copper to form bronze. Tin with lead to form solder. Tin with copper, lead and antimony to form Babbitt metal.

Aluminium

Aluminium is a non-ferrous metal which is extracted from 'BAUXITE'. Aluminium is white or whitish grey in colour. It has a melting point of 660^{o} C. Aluminium has high electrical and thermal conductivity. It is soft and ductile, and has low tensile strength. Aluminium is very widely used in aircraft industry and fabrication work because of its lightness. Its application in the electrical industry is also on the increase. It is also very much in use in household heating appliances.

Material science - Physical and mechanical properties of metals

Metal:

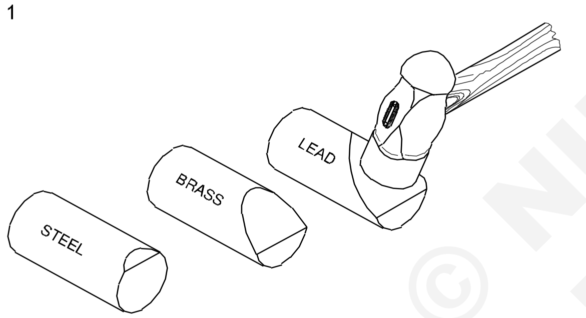
Metal is a mineral used in all types of engineering works such as machineries, bridges, aero planes etc., so we must have basic knowledge about the metals.

Understanding the physical and mechanical properties of metals has become increasingly important for a machinist since he has to make various components to meet the designed service requirements against factors, such as the raise of temperature, tensile, compressive and impact loads etc. A knowledge of different properties of materials will help him to do his job successfully. If proper material/ metal is not used it may cause fracture or other forms of failures, and endanger the life of the component when it is put into function.

Fig 1 shows the way in which the metals get deformed when acted upon by the same load.

Note the difference in the amount of deformation.

Fig 1



Physical properties of metals

- Colour
- Weight/specific gravity
- Structure
- Conductivity
- Magnetic property
- Fusibility

Colour

Different metals have different colours. For example, copper is distinctive red colour. Mild steel is blue/black sheen.

Weight

Metals may be distinguished, based on their weights for given volume. Metals like aluminium lighter weight (Specific gravity 2.7) and metals like lead have a higher weight. (Specific gravity 11.34)

Structure (Figs 2&3)

Generally metals can also be differentiated by their internal structures while seeing the cross-section of the bar through a microscope. Metals like wrought iron and aluminium have a fibrous structure and metals like cast Iron and bronze have a granular structure.

Fig 2

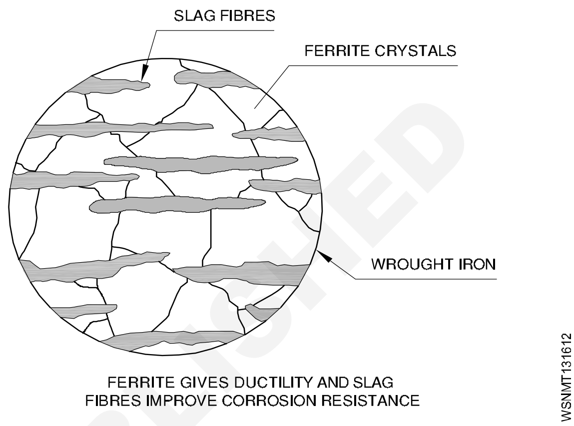
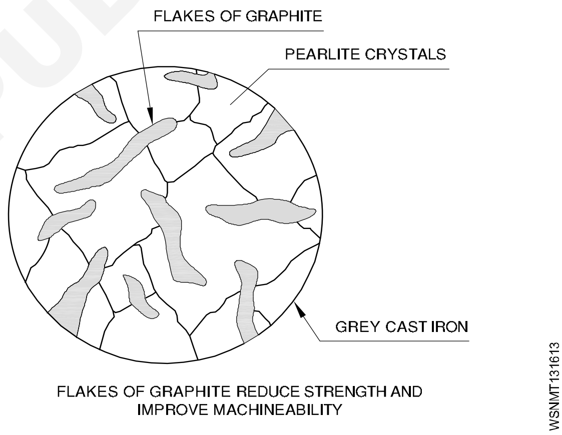


Fig 3



Conductivity (Figs 4&5)

Thermal conductivity and electrical conductivity are the measures of ability of a material to conduct heat and electricity. Conductivity will vary from metal to metal. Copper and aluminium are good conductors of heat and electricity.

Fig 4

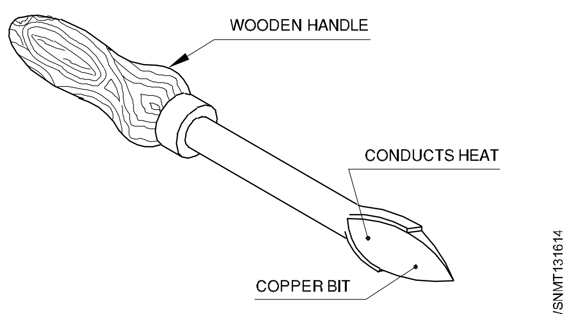
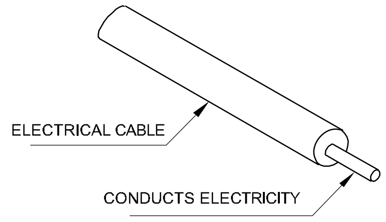


Fig 5



Magnetic property

A metal is said to possess a magnetic property if it is attracted by a magnet.

Almost all ferrous metals, except some types of stainless steel, can be attracted by a magnet, and all non-ferrous metals and their alloys are not attracted by a magnet.

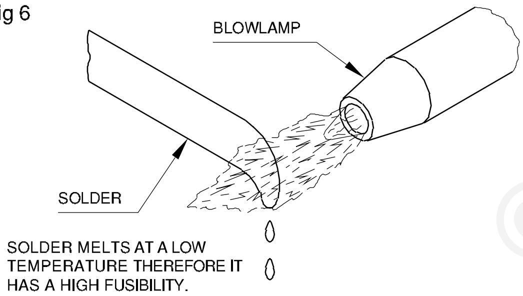
Fusibility (Fig 6)

It is the property possessed by a metal by virtue of which it melts when heat is applied. Many materials are subject to transformation in the shape (i.e) from solid to liquid at different temperatures. Lead has a low melting temperature while steel melts at a high temperature.

Tin melts at 232°C.

Tungsten melts at 3370°C.

Fig 6



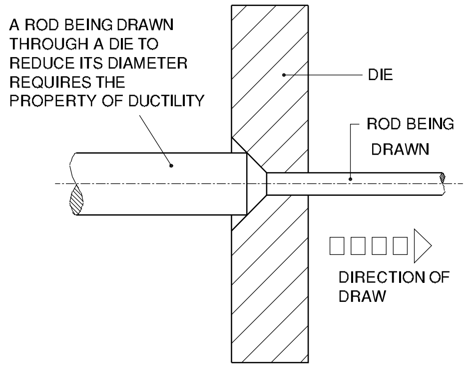
Mechanical properties

- Ductility
- Malleability
- Hardness
- Brittleness
- Toughness
- Tenacity
- Elasticity

Ductility (Fig 7)

A metal is said to be ductile when it can be drawn out into wires under tension without rupture. Wire drawing depends upon the ductility of a metal. A ductile metal must be both strong and plastic. Copper and aluminium are good examples of ductile metals.

Fig 7



Malleability (Figs 8 and 9)

Malleability is the property of a metal by which it can be extended in any direction by hammering, rolling etc. without causing rupture. Lead is an example of a malleable metal.

Fig 8

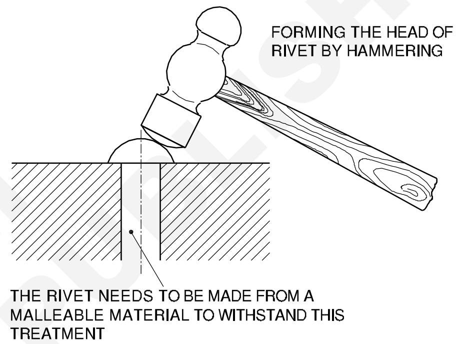
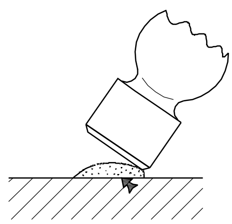


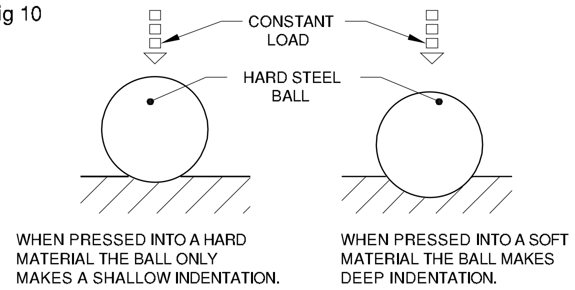
Fig 9



Hardness (Fig 10)

Hardness is a measure of a metal's ability to withstand scratching, wear and abrasion, indentation by harder bodies. The hardness of a metal is tested by marking by a file etc.

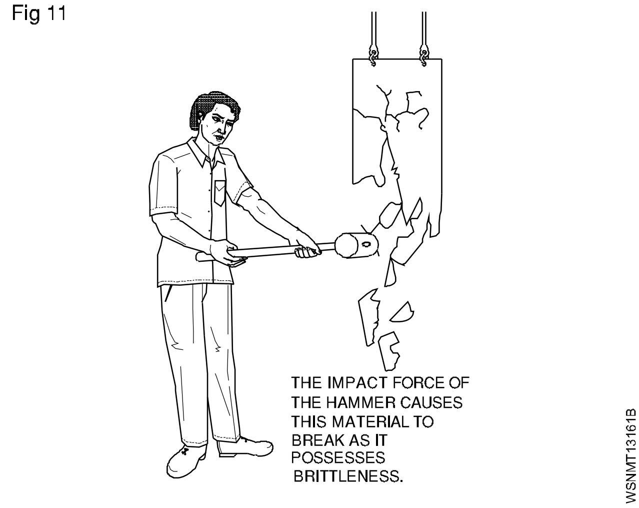
Fig 10



Brittleness (Fig 11)

Brittleness is that property of a metal which permits no permanent distortion before breaking. Cast iron is an example of a brittle metal which will break rather than bend under shock or impact.

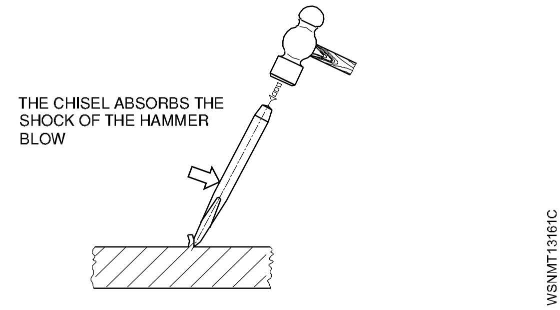
Fig 11



Toughness (Fig 12)

Toughness is the property of a metal to withstand shock or impact. Toughness is the property opposite to brittleness. Wrought iron is an example of a tough metal.

Fig 12



Tenacity

The tenacity of a metal is its ability to resist the effect of tensile forces without rupturing. Mild steel, Wrought Iron and copper are some examples of tenacious metals.

Elasticity

Elasticity of a metal is its power of returning to its original shape after the applied force is released. Properly heat-treated spring is a good example for elasticity.

Material science - Properties and uses of rubber and insulating materials

Properties and uses of rubber

Rubber

Rubber is an elastic material. It can be classified into

- Natural rubber
- Hard rubber
- Synthetic rubber

Natural rubber

It is obtained from the secretion of plants. It softens on heating, becomes sticky at 30°C and hardens at about 5°C.

Sulphur is added to rubber and the mixture is heated. This process is called vulcanising. By this process, stronger, harder and more rigid rubber is obtained. Further, it becomes less sensitive to changes of temperature and does not dissolve in organic solvents. Its oxidisation is also minimised by increasing its weathering properties.

By adding carbon black, oil wax, etc, the deformation properties are minimised. Rubber is moisture-repellent and possesses good electrical properties. The main disadvantages of the rubber are as given under.

- Low resistance to petroleum oils.
- Cannot be exposed to sunlight.
- Cannot be used for high-voltage insulation.
- Low operating temperature (as it becomes brittle and develops cracks at a temperature of 60°C)
- Sulphur in rubber reacts with copper. Hence, copper wires are to be tinned.

Hard rubber

By increasing the sulphur content and prolonged vulcanization, a rigid rubber product called hard rubber or ebonite is obtained. It possesses good electrical and mechanical properties.

Uses

It is used for battery containers, panel boards, bushing, ebonite tubes, etc.

Synthetic rubber

This is similar to natural rubber and is obtained from thermoplastic vinyl high polymers. Some of the important synthetic rubbers are:

- Nitrile butadiene rubber
- Butyl rubber
- Hypalon rubber
- Neoprene rubber
- Silicon rubber

Sl.No.	Name	Properties	Uses
1	Nitrite butadiene rubber	Good resilience, wear resistance, flexibility at low temperature, resistance to ageing, oxidation, low tensile strength, high thermal conductivity, low hygroscopicity	Automobile tyre inner tubes.
2	Butyl	It is attacked by petroleum oils, gases and alcoholic solvents. It has thermal and oxidation stability and high resistance to ozone.	Used as insulation in hot and wet conditions, used as tapes in repair work.
3	Hypalon rubber	Resistance to deterioration when exposed to sunlight and temperature (up to 150°C).	Used in jacketing of electric wires and cables
4	Neoprene rubber	Better resistance to ageing, oxidation and gas diffusion, better thermal conductivity and flame resistance, poor mechanical properties.	Used for wire insulation and cable sheating.
5	Silicon	High operating temperature (200°C) flexibility, moisture and corrosion resistance, resistance to oxidation, ozone, arcing, good insulating properties and thermal conductivity. It is a good insulator.	Insulation for power cables and control wires of blast furnace coke ovens, steel mills and nuclear power stations high frequency generators, boiler, airport lighting cranes.

Properties and uses of Insulating materials

Description

These are the materials which offer very high resistance to the flow of current and make current flow very negligible or nil. These materials have very high resistance - usually of may megohms (1 Megohm = 10^6 ohms) are centimetre cubed. The insulators should also posseses high dielectric strength. This means that the insulating material should not break down or puncture even on application of a high voltage (or high electrical pressure) to a given thickness.

Properties of insulators

The main requirements of a good insulating material are:

- High specific resistance (many megohms/cm cube) to reduce the leakage currents to a negligible value.
- Good dielectric strength i.e. high value of breakdown voltage (expressed in kilovolts per mm).
- Good mechanical strength, in tension or compression (It must resist the stresses set up during erection and under working conditions.)
- Little deterioration with rise in temperature (The insulating properties should not change much with the rise in temperature i.e. when electrical machines are loaded.)
- Non-absorption of moisture, when exposed to damp atmospheric condition. (The insulating properties, specially specific resistance and dielectric strength decrease considerably with the absorption of even a slight amount of moisture.)

Products and insulators

Insulators		Uses in electric field
1	Mica	In elements or winding (Slot insulation)
2	Rubber	Insulation in wires
3	Dry cotton	Winding
4	Varnish	Winding
5	Asbestos	In the bottom of irons and kettles, etc.
6	Gutta percha	Submarine cables
7	Porcelain	Overhead lines insulators
8	Glass	-do-
9	Wood dry	Cross arms in overhead lines
10	Plastic	Wires insulation or switches body
11	Ebonite	Bobbin of transformer
12	Fibre	Bobbin making and winding insulation
13	Empire cloth	Winding insulation
14	Leatheroid paper	-do-
15	Milinex paper	-do-
16	P.V.C.	Wire insulation
17	Bakelite	Switch etc. making, for insulation
18	Shellac	-do-
19	Slate	Making panel board
20	Paraffin Wax	Sealing

Speed and Velocity, Work, Power and Energy - Speed and velocity - Rest, motion, speed, velocity, difference between speed and velocity, acceleration and retardation

Body at rest

When a body does not change its position, with respect to its surroundings, it is said to be at rest.

Body at motion

When a body changes its position, with respect to its surroundings, it is said to be in motion. The motion may be linear if the body moves in a straight line or it may be circular when it moves in a curved path.

Terms relating to motion

Displacement

When a body is in motion from one place to another, the displacement is the distance from the starting position to the final position.

Speed

It is the rate of change of displacement of a body in motion. It has got no direction and it is a scalar quantity.

Speed = distance travelled per unit time $\frac{s}{t} = \frac{\text{(Distance)}}{\text{Time}}$

Unit = m/s, km/Hr.mile/Hr.

Velocity

It is the rate of change of displacement of a body in motion in a given direction. It is a vector quantity and can be represented both in magnitude and direction by a straight line. Velocity may be linear or angular. The unit of linear velocity is metre/sec,

Velocity = $\frac{S}{t} = \frac{\text{Displacement}}{\text{Time}}$

Unit = m/s, km/Hr,mile/Hr.

Difference between speed & velocity

Speed	Velocity
The rate of change of place of an object is its speed.	The speed in a definite direction is called velocity.
In the speed, direction is not indicated. Only the magnitude is expressed.	Both the magnitude and direction are expressed.
Speed $= \frac{\text{Distance covered}}{\text{Time}}$	Velocity $= \frac{\text{Distance in definite direction}}{\text{Time}}$

Acceleration

Rate of change of velocity is known as acceleration or it is the change of velocity in unit time. Its unit is metre/sec^2. It is a vector quantity.

$a = \frac{\text{change in velocity}}{\text{Time}}$ m/sec^2

unit = m/s^2 (metre per square second)

u = Initial velocity in metre per second(m/sec)

v = Final velocity in metre per second(m/sec)

s = Distance in metre (m)

t = Time in second (sec)

a = Acceleration m/sec^2 (positive value)

R = Retardation m/sec^2 (negative value of acceleration)

Equations of motion

Then $v = u + at$

$s = ut + \frac{1}{2}at^2$ and $v^2 - u^2 = 2as$

$v^2 = u^2 + 2as$

Retardation

When the body has its initial velocity lesser than its final velocity it is said to be in acceleration. When the final velocity is lesser than the initial velocity the body is said to be in retardation. Then the three equation of motion will be

$v = u - at$

$s = ut - at^2$

$u^2 - v^2 = 2as$

Average speed

Vm - Average speed in metre/min, (metre/sec)

n - Revolutions per minute or number of strokes per minute

s - Distance travelled, length of stroke.

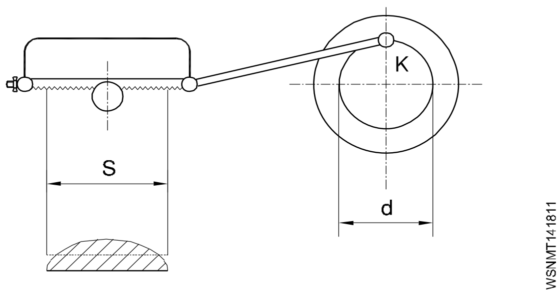
Stroke speed (Fig 1)

For one revolution of the point k, of the crank pin the distance the power saw blade moves = 2 x s

Therefore 'n' revolutions in a minute the distance = 2 x s x n. Since the stroke of the blade will be given in metre to determine the average speed

Vm = 2 x s x n

Fig 1



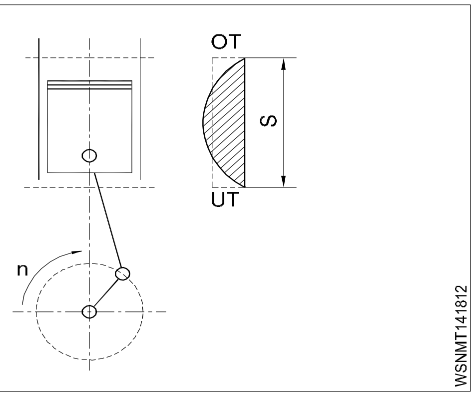
Piston speed (Fig 2)

As the piston moves backward and forward, its speed constantly changes between the upper and lower dead centres. Hence in this case also the average speed Vm = 2 x s x n. Since s is expressed in mm and n in number of revolutions/per minute and since Vm is given in metre/sec, we have

$$Vm = 2 \times s \times \frac{n}{1000} \text{ metre/min.}$$

$$= \frac{2xsxn}{1000x60} \text{ m/sec}$$

Fig 2



If s is given in metres then

$$\mathbf{Vm = 2 \times s \times \frac{n}{60} = s \times \frac{n}{60} \text{ metre/sec.}}$$

2 x s denotes a double stroke.

In case of the reciprocating motion the average speed is taken into account for calculations.

Vm = 2 x s x n metre/min if s is given in metres

Example (Fig 3)

An extrusion press has a crank radius of 20 cm and an rpm of 30/min. Calculate the average speed in metre/min, metre/sec.

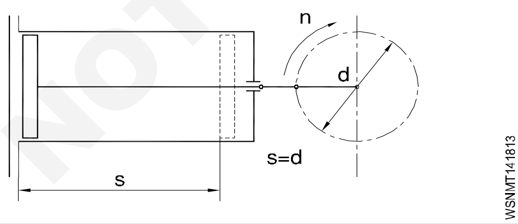
s = The diameter = 40 cm.

One crank revolution makes the piston to travel in 2s=80cm

$$Vm = 2 \times 40 \times \frac{30}{100} \text{ metre/min.}$$

= 24 metre/min = 0.4 metre/sec

Fig 3



NEWTON'S LAWS OF MOTION

Equations of motions under gravity

Upward	**Downward**
$V = u - gt$	$v = u + gt$
$s = ut - \frac{1}{2}gt^2$	$s = ut + \frac{1}{2}gt^2$
$u^2 - v^2 = 2gs$	$v^2 - u^2 = 2gs$

Motion under gravity

A body falling from a height, from rest, has its velocity goes on increasing and it will be maximum when it hits the ground. Therefore a body falling freely under gravity has a uniform acceleration. When the motion is upward, the body is subjected to a gravitational retardation. The acceleration due to gravity is denoted with 'g'.

Momentum

It is the quantity of motion possessed by a body and is equal to the product of its mass, and the velocity with which it is moving. Unit of momentum will be kg metre/sec.

Momentum = mass x velocity

Newton's laws

First law

Every body continues to be in a state of rest or of uniform motion in a straight line unless it is compelled to change that state of rest or of uniform motion by some external force acting upon it.

Second law

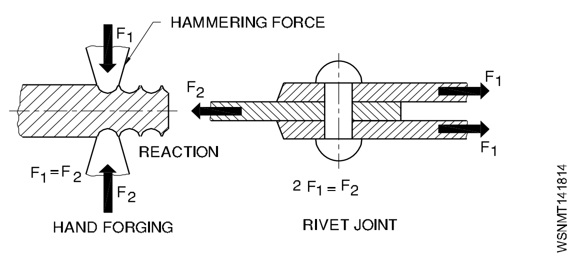
The rate of change of momentum of a moving body is directly proportional to the external force acting upon it and takes place in the direction of the force.

Third law

To every action there is always an equal and opposite reaction.

In the rivet joint equal forces act on the strap and they opposite force F_2. (Fig 4)

Fig 4



Law of conservation of momentum

When two moving bodies have an intentional or unintentional impact, then sum of the momentum of the bodies before impact = sum of the momentum after impact, or the change in momentum after the impact is zero.

m_1 - mass of one body and

v_1 - velocity with which it moves

m_2 - mass of second body

v_2 - velocity with which it moves

Momentum = m x v= mass of the body x its velocity

Rate of change of momentum = force acting on the body

$$m\left(\frac{(V-u)}{t}\right) = F$$

force = mass x acceleration

Momentum of two bodies before impact = momentum after impact

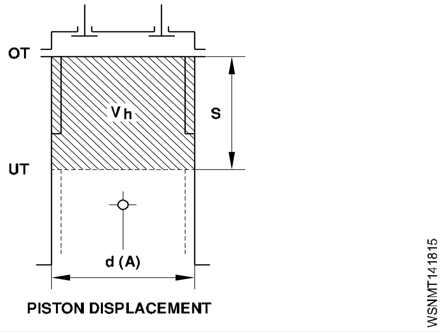
$m_1 \times v_1 + m_2 \times v_2 = (m_1 + m_2)V$

Terms - Some Examples in vehicles

Displacement

The piston displacement is the space between 2 dead centres (TDC and BDC) where in the piston moves in the cylinder. (Fig 5)

Fig 5



Speed

This is reckoned in 2 ways in a vehicle

– Vehicle speed in kmph/mph

– Engine speed in rpm

Velocity

A motor vehicle, normally changes its speed and direction on road. Hence used in velocity calculation.

Acceleration (Fig 6)

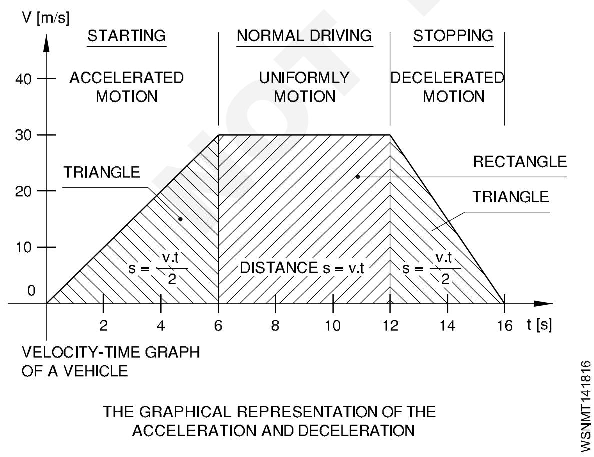
When the speed of the vehicle is increased on road, it is said to be accelerated.

Deceleration (Fig 6)

Deceleration or Retardation (this is further explained)

During the application of brakes of a vehicle the speed of the vehicle is decreased. Then it is said to be decelerated or retarded.

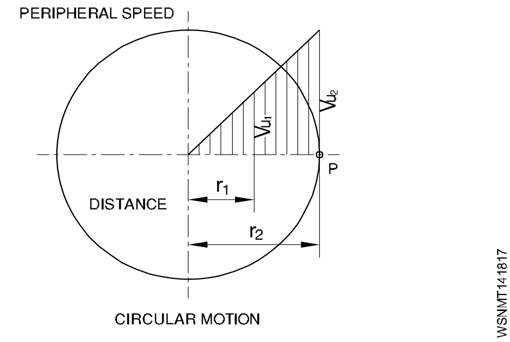
Fig 6



Circular or Angular motion (Fig 7)

When a body rotates about an axis, it is said to have angular motion or circular motion.

Fig 7



Example

In circular motion bodies (like shafts, axles, gear-wheels, pulleys, flywheels, grinding wheels) turn with constant speed around its axis.

The angular of circular motion is also called Angular velocity or Peripheral speed.

Expressed in Metre/sec or Radians per second.

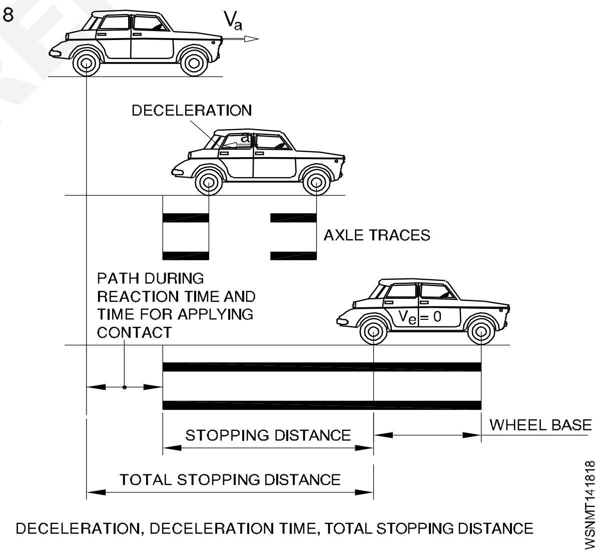
Bodies at rest and in motion

Terms related to brake system

Every vehicle has a brake system. When brakes are applied on a moving vehicle (with certain velocity) its velocity is reduced and vehicle is decelerated and it stops at a certain distance. So the definition of the terms related to Brake application are set forth below.

Deceleration (a) (Fig 8)

Fig 8



This is the decrease in velocity within a certain time. e.g A car travelling at 90 kmph stops after 10 Sec.

The deceleration = $90 \times \frac{1000}{3600} \times 1/10$

= 25 m/s/10 sec

= 2.5 m/sec^2

Deceleration time

The time 10 seconds is called the above time to stop the vehicle.

Stopping distance

During the deceleration time the car travels a distance called i.e Stopping distance 'd'.

But the total stopping distance is reckoned as equal to normal stopping distance and distance travelled by the car during reaction time of the driver.

The reaction time is explained as below

During the application of brakes, the driver takes sometime to recognise the danger and then apply the brakes. The time (thus elapsed) is called reaction time. During this time the vehicle travels some more distance before coming to a stop. So the total stopping distance actually varies due to the reaction time of the driver and it is longer than the normal stopping distance. The reaction time varies between driver to driver.

Example

A car is travelling with a speed of 72 kmph and its acceleration (a) = 5 m/sec^2. The reaction time of driver to apply brakes is 1.5 seconds. calculate the total stopping distance.

Solution

Velocity of car = 72 kmph

$$\left(1\,\text{kmph} = \frac{1000\ \text{m}}{3600\ \text{sec}} = \frac{5}{18}\,\text{m/sec}\right)$$

$$= \frac{5}{18} \times 72$$

= 20 m/sec

acceleration = 5 m/sec^2

$$\text{Normal stopping distance } S = \frac{V^2}{2a}\ (\text{m}) = \frac{(20)^2}{2(5)} = 40$$

Total stopping distance

= 40 metre + Velocity x Reaction time

= 40 m + (20 x 1.5) m

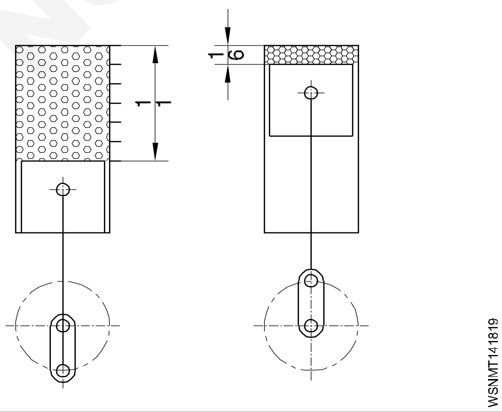
= 70 metres.

Newton's Law of Motion

Some Examples in vehicles

First law (with examples) (Fig 9)

Fig 9



Bodies at rest or in Uniform motion

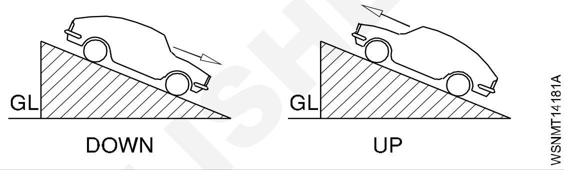
The diesel engine piston remains at rest at TDC or BDC due to its inertia. Expansion of gas pressure or flywheel momentum moves the piston from TDC or BDC.

Second law (with examples) (Fig 10)

The rate of change of momentum of a moving body (say Engine part or Vehicle)is directly proportional to external force acting take place in the direction of force.

– A connecting rod in motion is brought to rest at BDC.
– The direction of movement of a vehicle is altered by force of wind.
– When a vehicle travels in a down gradient its speed increases.
– The speed of vehicle is decreased when travelling up gradient.

Fig 10



Third law (with examples) (Fig 11&12)

Fig 11

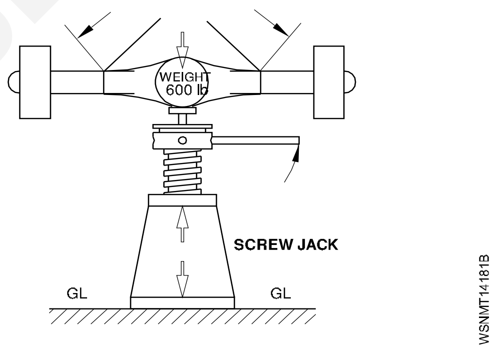
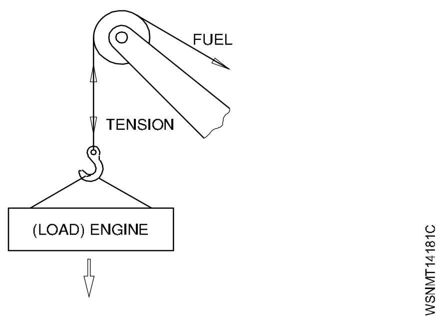


Fig 12



To every action there is always an equal and opposite reaction.

All upward force = All downward forces

– Jack is lifting a differential

– Crane rope is lifting an engine.

Speed and Velocity, Work, Power and Energy - Speed and velocity - Related problems on speed & velocity

Examples

- A body travels a distance of 168 metres in a straight line in 21 secs. What velocity the body is travelling.

  Velocity = distance travelled/time

  = 168 metre / 21 sec

  = 8m/sec

- A train covers a distance of 150 kilometres, between two stations, in 2 1/2 hours. Determine the average velocity with which the train is moving.

  Average velocity = Distance travelled/time taken

  = 150 Km/2 1/2 hrs = $\frac{150}{\frac{5}{2}} = 150 \times \frac{2}{5}$ Km/hr

  = 60 Km/hr

- A vehicle accelerates uniformly from a velocity of 8 km/hr to 24 km/hr in 4 secs. Determine the acceleration and the distance travelled by it during that time.

  Initial velocity = 8 km/hr (u)

  Final velocity = 24 km/hr (v)

  time = 4 sec (t)

  $a = \frac{v - u}{t}$ m/sec^2 acceleration (a)

  ∴v = u + at

  24 km/hr = 8 km/hr + a x 4 sec

  (24km/hr - 8km/hr = 16km/hr)

  ∴ 4a sec = 16 km/hr = 16000 metre/3600 sec

  ∴ acceleration (a) = 16000 metre/3600 x 4 sec^2

  4a = 4.44

  Acceleration (a) = 1.1 metre/sec^2

  Distance travelled (4a) = 4 x 1.1m = 4.4 m

- A car moving with a velocity of 50 km/hr is brought to rest in 45 secs. Find out the retardation.

  Initial velocity = 50 km/hr (1km= 1000 metres)

  Final velocity = 0 km/hr (1 Hour = 3600 seconds)

  Time = 45 secs

  v = u – at

  0 = u – at

  u = at

  50km/hr x $\frac{5}{18}$ m/sec = 13.88 m/sec

  $a = \frac{u}{t} = \frac{13.88 \text{ m/sec}}{45 \text{ sec}} = 0.3 \text{m/sec}^2$

  50000/3600 metre/sec = a x 45 sec

  ∴Retardation = 50000/3600 x 45 metre/sec^2

  = 0.30 metre/sec^2

- A body falling freely under the action of gravity reaches the ground in one second. Determine the height from which the body fell. Take g = 9.81 metre/sec^2.

  Initial velocity = 0 metre/sec (U)

  Acceleration due to gravity = 9.81 metre/sec^2 (g)

  Time taken = 1 sec (t)

  = ut + $\frac{1}{2}$ gt^2 = 0 x 1 sec + $\frac{1}{2}$ x 9.81 m/sec^2 x 1^2 sec

  = 0 x 1 sec + $\frac{1}{2}$ x 9.81 metre/sec^2 x 1 sec^2

  1 Sec^2 = 4.905 metres. s = 4.905 metres

- A force of 30 N acts on a body at rest. The mass of the body is 50 kg. Determine the velocity of the body after 4 secs, the distance it covers during that period and the acceleration

  F = m x a

  30 N = 50 kg x a

  30 kg x metre/sec^2 = 50 kg x a

  ∴ acceleration = 30/50 metre/sec^2

  = 0.6 metre/sec^2 a = 0.6 m/sec^2

  v = u + at

  = 0 + 0.6 metre/sec^2 x 4 sec = 2.4 metre/sec

  s = ut + 1/2 at^2 = 0 + 1/2 x 0.6 metre/sec^2 x 16 sec^2

  = 4.8 metre s = 4.8 metre

- A stone is thrown vertically upwards with a velocity of 120 metre/sec. Determine (a) the maximum height to which it travels before starting to return to earth. (b) The total time taken by the stone to go up and come down. (c) The velocity with which it will strike the ground.

  Initial velocity of throw = 120 metre/sec (u)

  Final velocity = 0 metre/sec (v) (taken g = 10 m/sec^2)

  Retardation due to gravity = 10 metre/sec^2

  u^2–v^2 = 2g.s

  ∴ 120^2 metre^2/sec^2 – 0 = 2 x 10 metre/sec^2 x s

  ∴ s = 120 x120/2 x 10 metre = $\frac{120 \times 120}{2 \times 10}$

  = 720 metre

  when it comes down its velocity at start = 0 metre/sec.

The acceleration due to gravity = 10 metre/sec^2 and the distance travelled = 720 metre

$\therefore$ $v^2 - u^2 = 2as$ $\quad$ $v^2 - 0 = 2 \times 10\ m/sec^2 \times 720\ m$

$v^2 - 0 = 2 \times 10 \times 720\ metre^2/sec^2$ $\quad$ $v = \sqrt{14400\ m^2/sec^2}$

$\therefore$ v = 120 metre/sec

Time taken to go up and reach a velocity of 0 metre/sec = u/g = 120 metre/sec/10 metre/sec^2 = 12 sec.

Time taken to start from rest and attain a velocity of 120 metre/sec = v/g = 12 sec.

$\therefore$ Total time taken = 24 sec.

- Calculate the Angular velocity in radian/second of an engine flywheel when it is rotating at 2800 rpm. (Fig 1 & 2)

Angular velocity (W) = This is the rate of change of displacement or angle turned through per unit time.

Solution

Angular velocity of flywheel W = $2\pi N/60$ rad/sec. [N = 2800 rpm]

= $2\pi \times 2800/60$ radian/sec.

= 293.3 radian/sec.

Fig 1

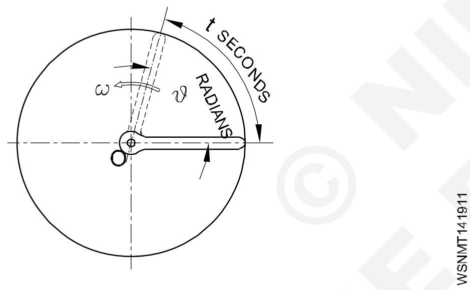
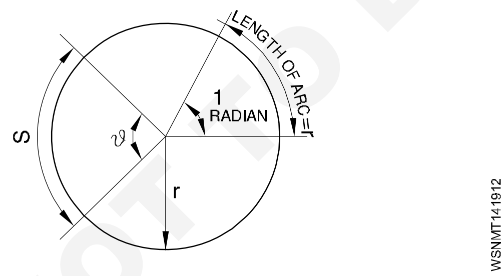


Fig 2



- A motor car road wheel of dia 540 mm turns through an angle of 120°. Calculate the distance moved by a point on tyre tread of the wheel.

Solution

There are 2π radians in one turn of wheel. i.e 2π radians = 360°

Since wheel turns 120° angle, 120° = 120 x $2\pi/360$

= 2.094 radians

Distance moved by a point on tyre S = $r\theta$

[where r = 270 mm

θ = 2.094 radian]

S = 270 x 2.094 mm

= 565.38 mm

Circumferential distance moved by the point = 565.38 mm

- The rear wheels of a car have diameter of 600 mm. The rear axle makes 250 rpm. Find out the peripheral speed of rear wheels in m/sec.

Solution

$$\text{Peripheral speed } V = \frac{\pi dN}{1000} \times \frac{1}{60}\ (m/s)$$

$$= \frac{3.14 \times 600}{60} \times \frac{250}{1000} = 7.85\ m/sec$$

- Calculate the stopping distance of a car travelling with a speed of 72 km/h and being accelerated with a = 5 m/ sec^2.

Solution

Va (initial speed of a car) = 72 kmph

$$(1\ kmph \times \frac{1000}{3600} m/sec) = 72\ \frac{5}{18}\ m/sec$$

= 20 metres/sec

$$\text{Stopping distance } S = \frac{Va^2}{2a}\ (metre)$$

$$= \frac{20^2}{2 \times 5} = \frac{400}{10}$$

= 40metre

Assignment

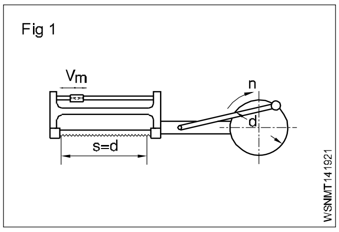
1 

Fig 1

S = 180 mm

n = 65 (double stroke)

Vm = ______metre/min

Vm is average cutting speed)

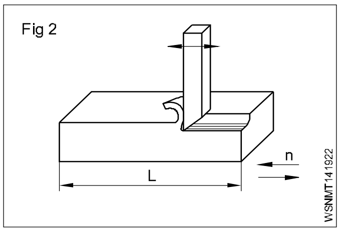
2 

Fig 2

V = 16 metre/min

s = 210 mm

n = ______

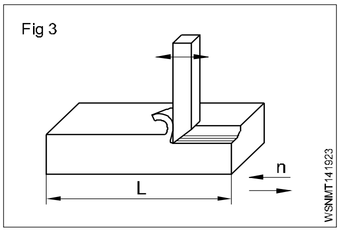
3 

Fig 3

(V is the cutting speed)

n = 22 strokes (Double stroke)/min

V = 18 metre/min

s = ______ mm

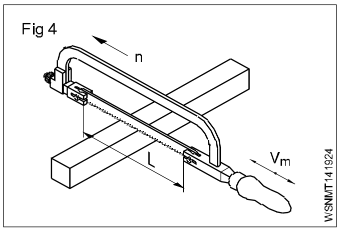
4 

Fig 4

s = 240 mm

n = 30 (working stroke)

V = ______ metre/min

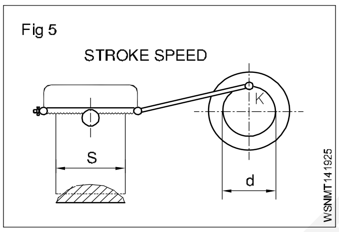
5 

Fig 5

n = 50 cutting strokes

V = 32 metre/min

d = ______ mm

s = 64 mm

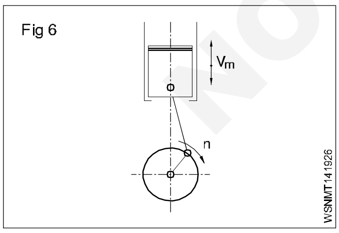
6 

Fig 6

n = 3600 rpm

Vm = ______metre/sec

Vm is the average piston speed)

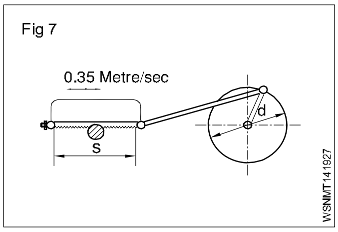
7 

Fig 7

Vm = 0.35 metre/sec

s = 200 mm

n = ______ rpm

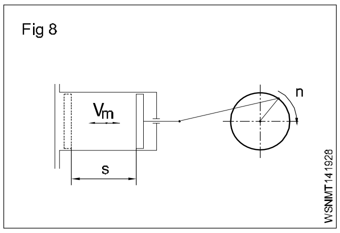
8 

Fig 8

s = 650 mm

Vm = 90 metre/min

n = ______ rpm

9 Vm_1 = 5.2 metre/sec

Increased to

Vm_2= 6.3 metre/sec

Increase in n (rpm) = ______ %

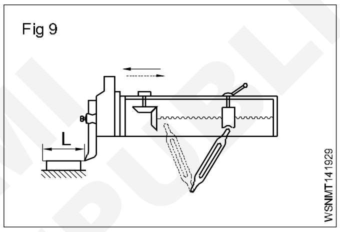
10 

Fig 9

s = 250 mm

n = 45 (double strokes)

V = ______metre/min

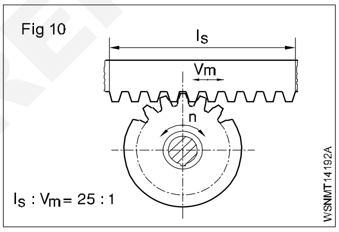
11 

Fig 10

ls : Vm = 25 : 1

n=_____(double strokes)

ls = rack travel

Vxm = stroke speed/ min

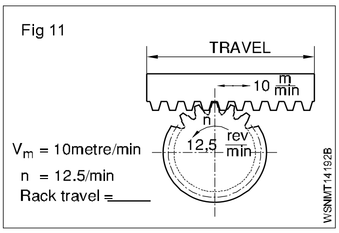
12 

Fig 11

Vm = 10 metre/min.

n = 12.5 / min.

Rack travel = ______

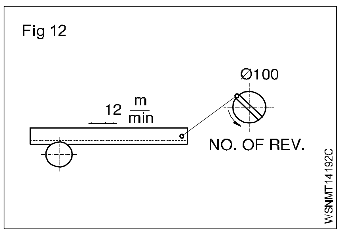
13 

Fig 12

dia of crank = 100 mm

Rack speed = 12 metre/min

Crank disc 'n'' = _____ rpm

14

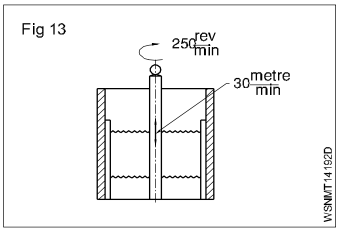


Fig 13

spindle 'n' = 250 rpm

Average stroke speed = 30 metre/min

stroke length = ________mm

15

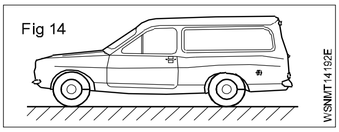


Fig 14

Car Speed = 90 km/hr

Time to stop = 10 sec

Deceleration = ________metre/ sec^2

16

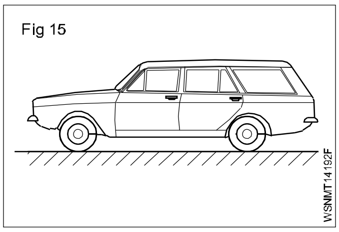


Fig 15

Car speed = 80 km/hr

Distance stopped = 60 metre

Deceleration of car =________metre/sec^2

17

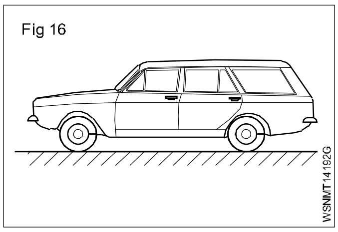


Fig 16

Deceleration = 4.5 m/ sec^2

Stopping distance = 50 metres

Velocity of car =________km/hr

18

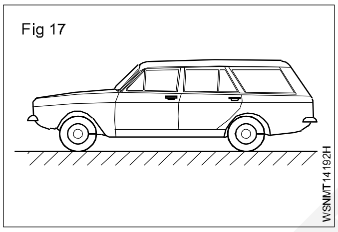


Fig 17

Distance travelled by car = 600 km

Time = 8 hrs 20 min

Average velocity =________km/hr

19

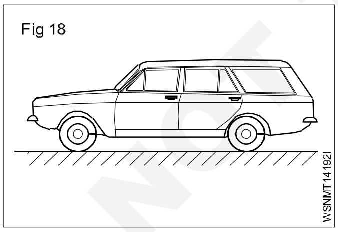


Fig 18

Average velocity = 56.3 km/hr

Distance travelled = 464.475 km

Travelling time =________hrs

20

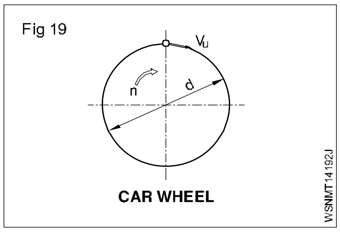


Fig 19

Car wheel

n = 720 rpm

Peripheral speed = 18.84 m/sec

d = ________

21

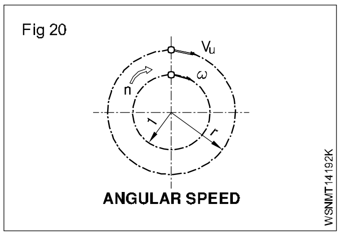


Fig 20

Angular speed

n = 2000 rpm

Angular velocity =_______radians/sec

Use

W = 2πN/60 rad/sec

22

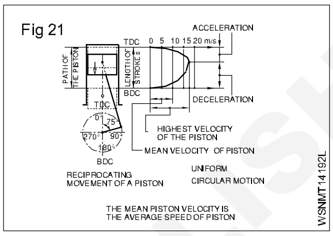


Fig 21

Piston Velocity/Speed

S = 74 mm

n = 4500 rpm

Mean velocity = _______m/sec

Maximum velocity = _______m/sec

(Average Speed of Piston)

23 Total Stopping Distance $= \frac{V^2}{2a} + \text{velocity} \times \text{reaction time}$

(Use = $V^2/2a$)

V = Vehicle speed = 80 km/hr

Deceleration = 5m/sec^2

Reaction Time of driver = 2 seconds

Total Stopping Distance = _______ meter

Speed and Velocity, Work, Power and Energy - Work, power, energy, HP, IHP, BHP and efficiency

Work (Fig 1)

Work is said to be done by a force, when it moves, its point of application through a distance. Applied force 'F' moves a body through a distance's.

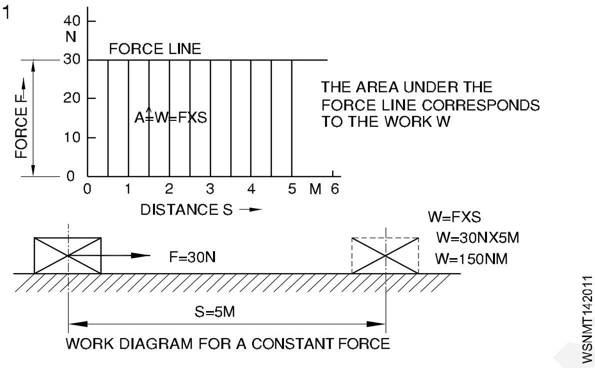
Work done 'W' = F x s.

The S.I. unit of work is 1 joule which is the work done by a force of moving the body through a distance of 1 metre.

Therefore joule = 1 N x 1 metre = 1 Nm

Also 1 joule = 1 Nm = 10^5 dynes x 100 cm = 10^7 dynes cm = 10^7 ergs.

Fig 1



F - force or weight force in N

s - distance the body on which force acts is moved in metres

t - time in seconds

v - speed in metre/sec

w - work done by the force in joules

P - Power in Watts

P_{out} - Power output

P_{in} - Power input

Force

A Force is that which changes or tends to change the state of rest or motion of a body.

Force = Mass x Acceleration

F = Ma

Unit

F = M x a

= kg x m/sec^2

= 1 Newton (SI unit)

(Newton: If 1 kg of mass accelerates at the rate of 1m/sec^2 then the force exerted on the mass is 1 newton)

FPS = 1 pound x 1 Feet/$second^2$

= 1 pound

CGS = 1 gm x 1cm/$second^2$

= Dyne

MKS = 1 kg x 1m/$second^2$

= Newton.

1 Newton = 10^5 dynes

1kg wt = 9.81N

1 pound = 4.448N,

Newton = 0.225 pound.

Absolute units

In C.G.S. system unit of work = 1 erg = 1 dyne x 1 cm

In F.P.S system unit of work = 1 Foot poundal = 1 poundal x 1 foot

In M.K.S. system unit of work = 1 joule = 1 Newton x 1 metre

Derived units

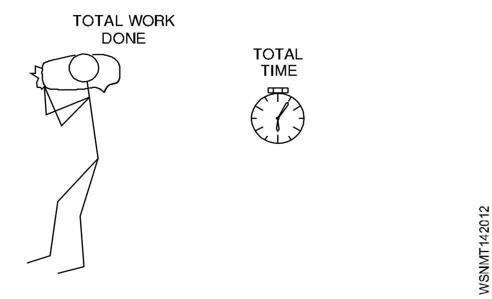
C.G.S. system 1 gm Wt x 1 cm = 981 ergs.

F.P.S. system 1 ft lb = 981 foot poundal

M.K.S. system 1 kgf metre = 981 joule.

Power (Fig 2)

Fig 2



It is the work done in unit time.

$$\text{Power } P = \frac{\text{total work done}}{\text{total time}}$$

$$P = \frac{Nm}{sec}$$

$$\text{The S.I units of power} = 1Nm/sec = \frac{1\text{ joule}}{sec}$$

$$\text{which is} = 1\text{ watt. power in watts} = \frac{w}{t} = \frac{F.s}{t} = FXV$$

which is equal to 1 Watt. Power in watts = w/t = F.s/t = F x V

In M.K.S. system the unit is 1 kgf meter/sec. One horse power is = 75 kg metre/sec or 4500 kgf metre/min.

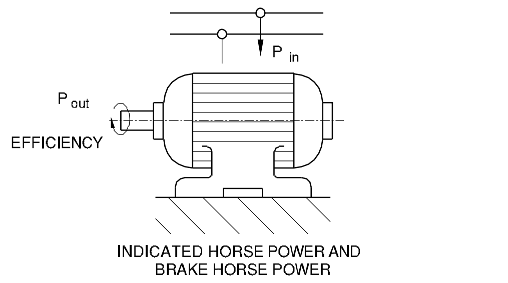
1HP (metric) = 735.5 Watts

1HP (British) = 746 Watts = 0.746 KW

1 KW = 1.34 HP

Power input is the power given to a machine to do work. Power output is what we get out of the machine. Power output is always less than power input due to friction in the machine. The ratio between power output to power input is efficiency of the machine and it is expressed in percentage. (Fig 3)

Fig 3



$$\text{efficiency} = \frac{\text{power output}}{\text{power input}} \times 100\%$$

Indicated Horse Power and Brake Horse Power

The power actually generated by the engine or generator is the indicated horse power which is indicated on the plate.

The Brake horse power is the power available to do useful work. B.H.P is always less than I.H.P. due to losses to overcome frictional resistance.

$$\therefore \text{mechanical efficiency} = \frac{\text{B.H.P}}{\text{I.H.P}} \times 100\%$$

Work done by a force = Magnitude of the force x distance moved by the body

Power = Total work done / total time taken

$$\text{efficiency} = \frac{\text{power output}}{\text{power input}} \times 100\%$$

Energy

The energy of a body is its capacity to do work. It is equal to power x time. Hence the unit of energy is the same as the unit of work in all systems.

Forms of energy

Mechanical energy, Electrical energy, Atomic energy, Heat energy, Light energy, Chemical energy, sound energy. Energy of one form can be transformed into energy of another form.

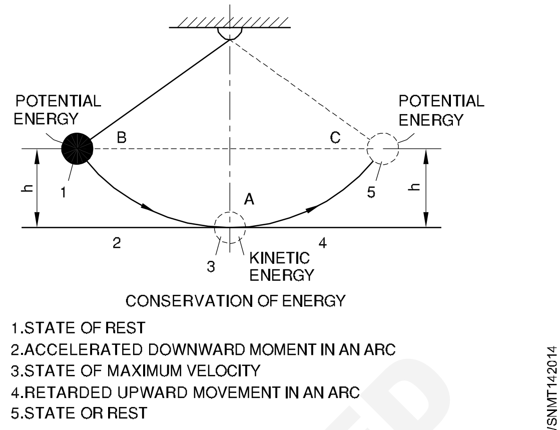
Law of conservation of energy

– The energy can neither be created nor destroyed.

– Total energy possessed by a body remains the same.(Fig 4)

Depending upon the position of the body or body in motion, mechanical energy possessed by the body may be potential energy or kinetic energy respectively.

Fig 4



Examples

1 A man weighting 75kg climp 200 metre high hill. Find the Work done by a man?

Formula: Work done (W) = F x S

Given data: F = 75 kg

S = 200m

To find: Work done (W) = ?

Solution: Work done (W) = F x S

= 75 x 200 = 15000

Ans: Work done (w) = 15000 kgm

2 Find the work required to lift a mass of 36.3 Newtons through a height of 3.7 metres?

Formula: Work done (W) = F x S

Given data: F = 36.3 N

S = 3.7m

To find: Work done (W) = ?

Solution: Work done (W) = F x S

= 36.3 x 3.7 N.m

= 134.31 Joules

Ans: Work done (W) = 134.31 Joules

3 Calculate the Work done by a man weighing 50kg in carrying a mass of 20kg over his head when he covers a distance of 15metres in vertical direction.

Formula: Work done (W) = F x S

Given data: F = 50kg + 20kg = 70kg

S = 15 m

To find: Work done (W) = ?

Solution: Work done (W) = F x S

= 70 x 15 = 1050

Ans: Work done (W) = 1050 kg.m

4 A man weighing 60kg lifts a weight of 40kg to the top of building 12 metres height. Find the useful Work done by him and also the efficiency?

Formula: Work done (W) = F x S

Given data: Man weight = 60kg

Lifts a weight = 40kg

Total weight = 60 + 40 = 100kg

Distance (S) = 12 m

To find: a) Work done (W) = ?

b) Efficiency (η) = ?

Solution:

a) Work done (W) = F x S

= 100 x 12 = 1200 kg.m

b) Efficiency (η) $= \frac{\text{Output}}{\text{Input}} \times 100\%$

$= \frac{40 \times 12}{60 \times 12} \times 100\%$

$= \frac{480}{720} \times 100\%$

= 66.67%

Ans: a) Work done (W) = 1200 kg.m

b) Efficiency (η) = 66.67%

5 A pump pumps 4000kg of water from 50 metres depth in 40 minutes. Find the Work done by pump in one second?

Formula: Work done (W) = F x S

Given data: F = 4000 kg

S = 50 m

To find: Work done per second = ?

Solution:

Work done in 40 minutes,

Work done (W) = F x S

= 4000 x 50 = 200000 kgm

$= \frac{200000}{40} = 5000$

Work done in 1 second $= \frac{5000}{60} = 83.3$

Ans: Work done in 1 second (W) = 83.33 kg.m

6 A body of 225 kg is moved by 300 metres in 90 seconds. Find the power required to lift this body?

Formula: Power (P) $= \frac{FxS}{t}$

Given data: F = 225 kg

S = 300m

t = 90 sec

To find: Power (P) = ?

Solution: Power (P) $= \frac{FxS}{t}$

$= \frac{225 \times 300}{90}$ kg.m/sec

= 750 kg.m/sec

Ans: Power (P) = 750 kg.m/sec

7 A hydraulic press lifts a load of 5 tonnes in 5 minutes to a height of 5 metres. Calculate the power of the press?

Formula: Power (P) $= \frac{FxS}{t}$

Given data: F = 5 tonnes = 5000 kg

S = 5 metres

t = 5 minutes = 5 x 60 = 300 sec

To find: Power (P) = ?

Solution: Power (P) $= \frac{FxS}{t}$

$= \frac{5000 \times 5}{300} = 83.33$

Ans: Power (P) = 83.33 kg.m/sec

8 A machine weighing 750N takes 25N material to a height of 10 metres in one minute. calculate the power of machine?

Formula: Power (P) $= \frac{FxS}{t}$

Given data:

Machine weight = 750N

Material weight = 25N

F = 750 + 25 = 775N

S = 10 m

t = 1 min = 60 sec

To find: Power (P) = ?

Solution: Power (P) $= \frac{FxS}{t}$

$= \frac{775 \times 10}{60}$ = 129.17N m/sec

Ans: Power (P) = 129.17N m/sec (or) watts

9 What is the power of pump which takes 15 seconds to lift 90kg of water to a tank situated at a height of 30 metres. (Take g = 10m/sec^2)?

Formula: Power (P) = $\frac{FxS}{t}$

Given data: F = 90 kg

S = 30 m

t = 15 sec

To find: Power (P) = ?

Solution: Power (P) = $\frac{FxS}{t}$

$= \frac{f \times g \times s}{t}$

$= \frac{90 \times 10 \times 30}{15}$

= 1800 Nm/sec ∵ (1 Nm/sec = 1 watt)

Ans: Power (P) = 1800 watts

10 A hoist lifts a weight of 1000kg through a height of 33 metres in one minute. Find out the horsepower of the hoist?

Formula: Horsepower HP = $\frac{FxS}{t} \times \frac{1}{75}$

Given data: F = 1000 kg

S = 33 m

t = 1 minute = 60 sec

To find: Horsepower HP = ?

Solution: Horsepower HP = $\frac{FxS}{t} \times \frac{1}{75}$

(∵ 75 kg.m/sec = 1 HP)

$= \frac{1000 \times 33}{60} \times \frac{1}{75}$

= 7.33 H.P.

Ans: Horsepower, HP = 7.33 H.P.

11 A pump can raise 900 litres of water per minute to a height of 45 metres. Calculate the H.P of pump?

Formula: Horsepower HP = $\frac{FxS}{t} \times \frac{1}{75}$

Given data: F = 900 litres = 900 kg

S = 45 m

t = 1 minute = 60 sec

To find: Horsepower HP = ?

Solution: Horsepower HP = $\frac{FxS}{t} \times \frac{1}{75}$

(∵ 1 HP = 75 kg.m/sec)

$= \frac{900 \times 45}{60} \times \frac{1}{75}$ = 9 H.P

Ans: Horsepower, HP = 9 H.P.

12 Find the horsepower of an engine to lift a weight of 2 tonnes to a height of 30 metres in two minutes?

Formula: Horsepower HP = $\frac{FxS}{t} \times \frac{1}{75}$

Given data: F = 2 tonnes = 2000 kg

S = 30 m

t = 2 minutes = 120 sec

To find: Horsepower HP = ?

Solution: Horsepower HP = $\frac{FxS}{t} \times \frac{1}{75}$

(∵ 1 HP = 75 kg.m/sec)

$= \frac{2000 \times 30}{120} \times \frac{1}{75}$ = 6.67 H.P.

Ans: Horsepower, HP = 6.67 H.P.

13 Find out horsepower of a pump required to lift 10000 litres of water in 3 minutes at height of 16 metres. Assume efficiency of pump as 94%?

Formula: Horsepower HP = $\frac{FxS}{t} \times \frac{1}{75}$

$\eta = \frac{Output}{Input} \times 100\%$

Given data: F = 10000 litres = 10000 kg

S = 16 litres

t = 3 minute = 180 sec

To find: Horsepower HP = ?

Solution: Horsepower HP = $\frac{FxS}{t} \times \frac{1}{75}$

(∵ 1 HP = 75 kg.m/sec)

$= \frac{10000 \times 16}{180} \times \frac{1}{75}$

= 11.85 H.P.

$\eta = \frac{Output}{Input} \times 100\%$

$94 = \frac{11.85}{Input} \times 100$

Input $= \frac{11.85 \times 100}{94} = \frac{1185}{94}$

= 12.606 H.P.

Ans: Input H.P of Pump = 12.606 H.P.

14 Find the horsepower of a motor which is required to lift 500 tonnes of coal per hour from a mine of 320 metre depth. Efficiency of motor is 0.75?

Formula: $\eta = \frac{Output}{Input} \times 100\%$

Output H.P $= \frac{FxS}{t} \times \frac{1}{75}$

Given data:

F = 500 tonnes = 500000 kg

S = 320 metres

t = 1 hour = 3600 sec

η = 0.75 = 75%

To find: Pump HP = ?

Solution:

Output HP $= \frac{FxS}{t} \times \frac{1}{75}$

($\because$ 1 HP = 75 kg.m/sec)

$= \frac{500000 \times 320}{3600} \times \frac{1}{75}$

= 592.59 H.P.

$\eta = \frac{Output}{Input} \times 100\%$

$75 = \frac{592.59 \times 100}{Input}$

Input $= \frac{59259}{75}$

Ans: Input = 790.12 H.P

15 A train weighing 25 tonnes is moving at a speed of 90km/hour. Find the horsepower of the engine, if the frictional force is 5kg per tonnes?

Formula: Horsepower HP $= \frac{FxS}{t} \times \frac{1}{75}$

Given data: Train speed = 90 km/hour

$= 90 \times \frac{1000}{3600} = 25$ m/sec

Train weight = 25 tonnes

Frictional force per tonnes = 5 kg

25 tonnes frictional force

(F) = 25 x 5 = 125kg

To find: Horsepower of the engine = ?

Solution: HP $= \frac{FxS}{t} \times \frac{1}{75}$

$= \frac{125 \times 25}{1} \times \frac{1}{75}$

Ans: HP = 41.67 H.P.

16 A pump delivers 9000 litres of water per minute to a height of 14 metres. The efficiency of the pump is 78%. The efficiency of electric motor which drives the pump is 92%. Find out the input of the motor?

Formula: $\eta = \frac{Output}{Input} \times 100\%$

Output H.P $= \frac{FxS}{t} \times \frac{1}{75}$

1 H.P = 0.7355 KW (metric)

Given data:

F = 9000 litres = 9000 kg

S = 14 metres

t = 1 minute = 60 sec

pump η = 75%

motor η = 92%

To find: Electric motor (KW) = ?

Solution:

Pump Output HP $= \frac{FxS}{t} \times \frac{1}{75}$

$= \frac{9000 \times 14}{60} \times \frac{1}{75}$

= 28 H.P.

Input of the pump

$\eta = \frac{Output}{Input} \times 100\%$

$78 = \frac{28}{Input} \times 100$

Input $= \frac{28 \times 100}{78} = 35.9$ H.P

Output of the motor = Input of the pump

Output = 35.9 H.P

Input of the motor

Motor $\eta = \frac{Output}{Input} \times 100\%$

$92 = \frac{35.9}{Input} \times 100$

Input $= \frac{35.9 \times 100}{92} = 39.02$ H.P

Ans: Motor input = 39.02 H.P

17 I.H.P of generator is 6 H.P and its efficiency is 90%. Find tis B.H.P.

Formula: $\eta = \frac{B.H.P}{I.H.P} \times 100\%$

Given data:

I.H.P = 6 H.P

η = 90%

To find: B.H.P = ?

Solution: $\eta = \frac{B.H.P}{I.H.P} \times 100\%$

$90 = \frac{B.H.P}{6} \times 100\%$

$\frac{90 \times 6}{100}$ = B.H.P

B.H.P = 5.4 H.P

Ans: B.H.P of generator = 5.4 H.P

18 A machine is working on 80% efficiency I.H.P of machine is 50. Calculate the power lost in friction.

Formula: I.H.P = B.H.P + Frictional loses

$\eta = \frac{B.H.P}{I.H.P} \times 100\%$

Given data: Efficiency η = 80%

I.H.P = 50

To find: Friction = ?

Solution: $\eta = \frac{B.H.P}{I.H.P} \times 100\%$

$80 = \frac{B.H.P}{I.H.P} \times 100\%$

$80 = \frac{B.H.P}{50} \times 100\%$

$\frac{80 \times 50}{100}$ = B.H.P

B.H.P = 40

B.H.P = I.H.P - F.H.P

40 = 50 - F.H.P

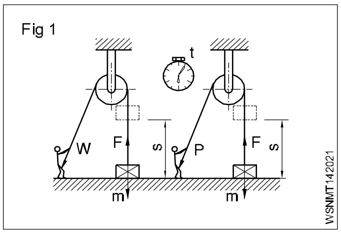
40 + F.H.P = 50

F.H.P = 50 - 40 = 10

Ans: Loss of friction = 10 H.P

Assignment

1



m= 55 kg

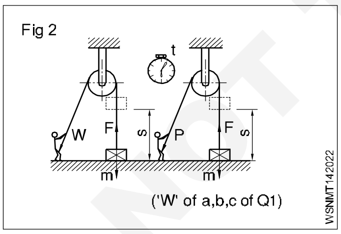
a) s = 1.82 metres
W = _______ joules

b) s = 1.40 metres
W= _____ joules

c) s = 0.85 metres

W =Joules

2



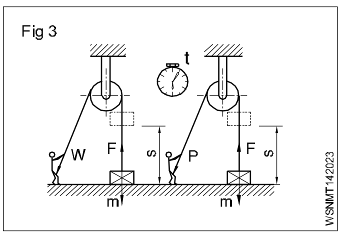
t = 8 secs

a) P = ______ Watts

b) P = ______ Watts

c) P = ______ Watts

3

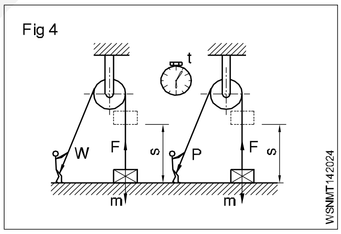


W = 1312.5 Joules

m = 350 kg

s = ______ metres

4



m = 75 kg

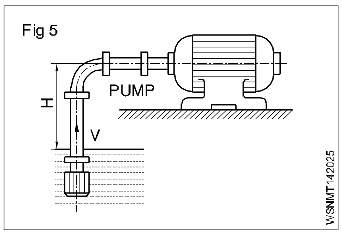
s = 100 metres

t = 12 secs

W = _______ N

P = _______ Watts

5



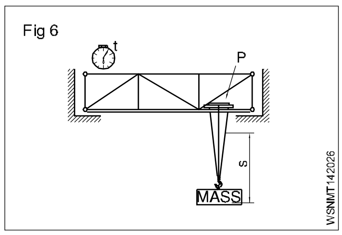
V = 1 m^3/min

H = 2 m

η = 0.75

Power input = _______ kW

6



P = 12 kw

s = 4 metres

t = 20 secs

m = _______ kg

Basic Electricity - Introduction and uses of electricity, molecule, atom, how electricity is produced, electric current AC,DC their comparison, voltage, resistance and their units

Electricity is a kind of energy. It is the most useful sources of energy which is not visible but its presence can be felt by its effects. Electricity is obtained by conversion of other forms of energy like heat energy, chemical energy, nuclear energy, mechanical energy and energy stored in water etc.,

To understand electricity, one must understand the structure of an atom.

Basically an atom contains electrons, protons and neutrons. The protons and neutrons are located in the centre of an atom and the electrons, a negative electric charge particle revolving around the nucleus in an atom. The proton has a positive charge. Neutrons are neutral and have no charge.

Sources of electricity

Battery

Battery stores electrical energy in the form of chemical energy and it gives power when required. Battery is used in automobiles and electronics, etc.,

Generator

It is a machine which converts the mechanical energy into electrical energy.

When a conductor rotates between a magnetic field using prime mover an emf will be induced. By using this method all types of AC and DC generator - generates power.

E.g. Thermal power station
Hydro power station
Nuclear power station
Wind power station
Solar power station

Thermo couple

If two dissimilar pieces of metals are twisted together and its joined end is heated in a flame, then a potential difference or voltage will be induced across the ends of the wires. Such a device is known as a Thermo couple. Thermo couple is used to measure very high temperature of furnaces.

Effects of electric current

When an electric current flows through a medium, its presence can be felt by its effects, which are given below.

1 Physical effect

Human body is a good conductor. when the body touches the bare current carrying conductor, current flows through the human body to earth and body gets severe shock or cause even death in many cases.

2 Magnetic effect

When an electric current passes through a coil, a magnetic field is produced around it.

E.g. : Electromagnet Motor, Generator, Electric bell

3 Chemical effect

When an electric current passes through an electrolyte, chemical action takes place. Because of that, an electrical energy is stored in a battery as a chemical energy.

E.g.: Electroplating, Cells and battery charging, refining of metals etc.,

4 Heating effect

When an electric current passes through any conductor, heat is produced in the conductor due to its resistance.

E.g. : Electric heater, Electric iron box, Electric lamp, Geyser, Soldering iron, Electric kettles, Electric welding etc.,

5 X-ray and Laser rays effect

When a high frequency voltage is passed through a vacuum tube, a special type of rays come out, which is not visible. These rays are called x-rays. Laser rays also can be produced by electric current.

6 Gas effect

When electrons pass through a certain type of sealed glass shell containing gas, then it emits light rays.

E.g: Mercury vapour lamp, Sodium vapour lamp, Fluorescent lamp, Neon lamp etc.,

Uses of Electricity

1	Lighting	- Lamps
2	Heating	- Heaters, ovens
3	Power	- Motor, fan
4	Traction	- Electromotive, lift, crane
5	Communication	- Telephone, telegraph, radio, wireless
6	Entertainment	- Cinema, radio, T.V.
7	Medical	- x-rays, shock treatment
8	Chemical	- Battery charging, electroplating
9	Magnetic	- Temporary magnets
10	Engineering	- Magnetic chucks, welding, x-rays of welding

Classification

- Static electricity
- Dynamic electricity

STATIC ELECTRICITY

If a dry glass rod is rubbed with silk cloth the glass rod gives out negative electrons, and therefore, becomes positively charged. The silk cloth receives negative electrons and therefore it becomes negatively charged. They acquire the property of attracting small pieces of paper etc. because like charges repel and unlike charges attract each other. The electric charge on the silk cloth is stationary and is called static electricity. This type of electricity cannot be transmitted from one place to another.

DYNAMIC ELECTRICITY

The electrons in motion are called current electricity or electric current. This type of electricity is carried through wires and cables. Therefore, this electricity can be transmitted from one place to another. This type of electricity can be produced by cells, batteries, generators alternators etc.

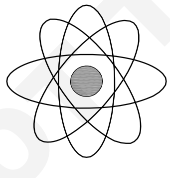
What is the difference between an atom and an element? How are molecules different from atoms? I am often asked these questions in my sessions over and over again and so I finally decided to write a comprehensive post on them. Find answers to all your questions in this section that is designed to help students explore and understand the relationship between atoms, elements, molecules, compounds and mixtures in a manner that is simple and easy to understand.

What is an Atom?

All the matter in the universe is made of tiny particles called atoms. There are 92 different kinds of atoms in nature. These 92 different atoms combine with one another to form different kinds of matter that we see in nature. (Fig 1)

Gold, for example, is made of only gold atoms. When matter is made of only one kind of atom, it is called an element. In the same way, silver is another element which is made of only silver atoms. Because there are 92 different kinds of atoms in nature, there are 92 different kinds of elements. Other examples of an atom are K (potassium) and Fe (iron).

Fig 1



WSNMT152111

What is a Molecule?

A molecule is the smallest unit of a chemical compound and it exhibits the same chemical properties of that specific compound. As molecules are made up of atoms jointly held by chemical bonds, they can vary greatly in terms of complexity and size. The oxygen we breathe has a molecular formula O_2. Should we consider this as an element or compound? When two or more atoms of the same elements combine together, we call them Molecules. So, we call O_2 as an oxygen molecule. In the same way, we find hydrogen molecules H_2, chlorine molecules Cl_2 and others in nature.

Types of electric current

- Direct current
- Alternating current

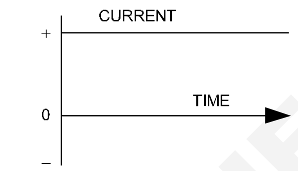
Direct current

In direct current (DC) the direction and magnitude of the current does not change (Fig 2). The steady current flow will be from the positive terminal to the negative terminal. (Fig 3)

Examples

DC Sources : Cells, batteries and DC generators (Fig 3)

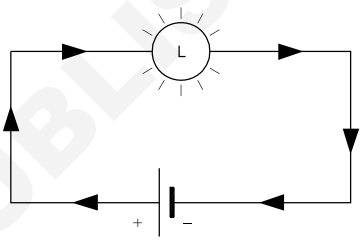
Fig 2



DIRECT CURRENT (GRAPHIC REPRESENTATION)

WSNMT152112

Fig 3



CURRENT FLOWS FROM +VE TERMIINAL TO –VE TERMINAL

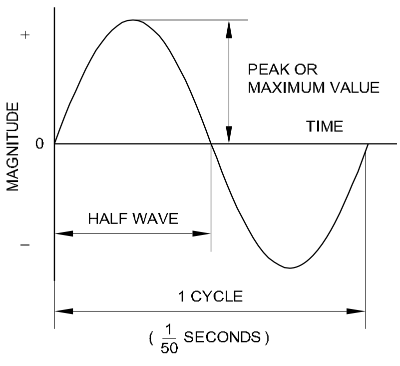
DIRECT CURRENT (D.C)

WSNMT152113

Alternating current (Fig 4)

The current flow will be from the phase terminal to the Neutral terminal. In the alternating current (AC) both the direction and magnitude of the current will be changing at definite intervals of time. The graph shows how an AC current or voltage changes with time. The current increases to the maximum value in one direction, falls to zero and increases to the maximum value in the other (opposite) direction before falling to zero again. Thus a cycle is one complete series of changes. The normal supply frequency is 50 cycles per second.

Fig 4



ALTERNATING CURRENT OR VOLTAGE

WSNMT152114

Difference between AC and DC

AC	DC
1 It is generated in the ranges of 6,600 V, 11000 V and 33,000 V.	It is generated up to 6,600 V only
2 Voltage can be stepped up or stepped down by using transformer	It is not possible
3 Transmission cost is less	Cost High
4 Less maintenance	High maintenance
5 Power up to 5,00,000 kw can be generated in a single alternator.	Power up to 10,000 kw can be generated in a single generator
6 AC generator can run at high speeds. So, speed control is not easy.	It can't run at high speeds. Speed control is easy.
7 Slip rings and brushes are used to collect the current.	Commutator and brushes are used to collect the current

Advantages of A.C.

i In transmission there is saving in copper wire.

ii Since there is no spark in A.C. machine there is no interference in Radio sound.

iii This can be produced to maximum voltage i.e. 33000volts.

iv Voltage can be dropped or raised with the help of transformers.

v Its mechanism is simple and cheap.

vi Output is more due to availability of more than one phase.

Disadvantages of A.C.:

i A single phase motor is not self-starter.

ii Due to thin wire in A.C., the voltage drop is more.

iii It cannot be used for electroplating and in charging secondary cells.

iv The speed of motors run by it is difficult to change.

v There is danger to security due to high voltage.

Electrical terms and units

Quantity of electricity

The strength of the current in any conductor is equal to the quantity of electrical charge that flows across any section of it in one second. If 'Q' is the charge and 't' is the time taken

then $I = \frac{Q}{t}$ $Q = I \times t$

The SI unit of current is coulomb. Coulomb is equivalent to the charge contained in nearly 6.24×10^{18} electrons.

Coulomb

In an electric circuit if one Ampere of current passes in one second, then it is called one coulomb. It is also called ampere second (As). Its larger unit is ampere hour (AH)

1 AH = 3600 As (or) 3600 coulomb

Electro motive force (EMF)

It is the force which causes to flow the free electrons in any closed circuit due to difference in electrical pressure or potential. It is represented by 'E.' Its unit is Volt.

Potential difference (P.D)

This is the difference in electrical potential measured across two points of the circuit. Potential difference is always less than EMF. The supply voltage is called potential difference. It is represented by V.

Voltage

It is the electric potential between two lines or phase and neutral. Its unit is volt. Voltmeter is used to measure voltage and it is connected parallel between the supply terminals.

Volt

It is defined as when a current of 1 ampere flows through a resistance of 1 ohm, it is said to have potential difference of 1 volt.

Current

It is the flow of electrons in any conductor is called current. It is represented by 'I' and its unit is Ampere. Ammeter is used to measure the current by connecting series with the circuit.

Ampere

When 6.24×10^{18} electrons flow in one second across any cross section of any conductor, the current in it is one ampere.(or) If the potential difference across the two ends of a conductor is 1 volt and the resistance of conductor is 1 ohm then the current through is 1 ampere.

Resistance

It is the property of a substance to oppose to the flow of electric current through it, is called resistance. Symbol: R, Unit : Ohm (Ω), Ohm meter is used to measure the resistance.

Ohm

If the potential difference across the two ends of conductor is 1 volt and the current through it is 1 ampere, then the resistance of the conductor is 1 Ohm.

Laws of resistance

The resistance offered by conductor depends on the following factors.

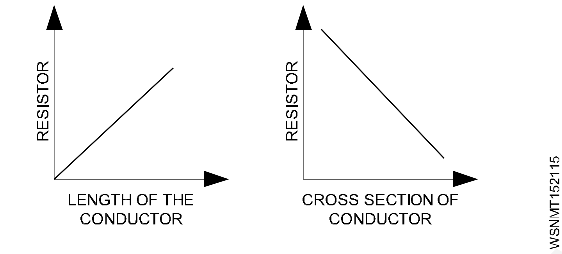
The resistance of the conductor

1 is directly proportional to the length of the conductor ($R \alpha L$)

2 Varies inversely proportional to its cross sectional area of the conductor $\left(R \alpha \frac{1}{A}\right)$

3 Depends on the material with which it is made.

Fig 5



4 depends on the temperature of the conductor

$$R \alpha L \; ; \; R \alpha \frac{1}{A}; \; R \alpha \frac{L}{A}; \; R = \rho \frac{L}{A}$$

Specific resistance

The specific resistance of a material is the resistance offered to a current it passed between the opposite faces of the unit cube of the material. Specific resistance is measured in Ohm - m or micro ohm - cm.

Each material has its own specific resistance or resistivity.

E.g. : Copper - 1.72 $\mu\Omega$ cm, Silver - 1.64 $\mu\Omega$ cm, Eureka - 38.5 $\mu\Omega$ cm, Iron - 9.8 $\mu\Omega$ cm,

Aluminium - 2.8 $\mu\Omega$ cm, Nickel - 7.8 $\mu\Omega$ cm.

$R = \frac{\rho l}{A}$ ohm cm

R = Resistance in ohms

l = Length of the conductor in cm

ρ = Specific Resistance in ohm cm (symbol pronounced as rho)

A = Area of cross - section in cm^2

Electric Power

In mechanical terms we defined power as the rate of doing work. The unit of power is Watt. In an electrical circuit also the unit of electrical power is 1 Watt. In mechanical terms 1 Watt is the work done by a force of 1 N to move the body through 1 metre in one second. In an electrical circuit, the electromotive force overcomes the resistance and does work. The rate of doing work depends upon the current flowing in the circuit in amperes. When an e.m.f of one volt causes a current of 1 ampere to flow the power is 1 Watt.

Hence Power = Voltage x Current

$$P = V \times I$$

Power in Watts = Voltage in Volts x Current in Amperes

Electric work, energy

Electrical work or energy is the product of electrical power and time

Work in Watt seconds = Power in Watts x time in sec

$$W = P \times t$$

Since 1 joule represents 1 Watt x 1 sec, which is very small, larger units such as 1 Watt hour and 1 kilowatt hour are used.

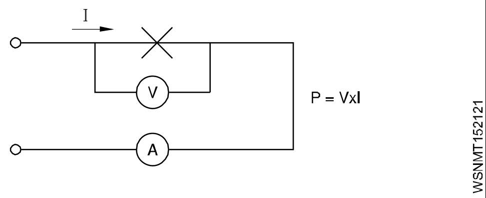
1 W.h = 3600 Watt sec.

1 Kwh = 1000 Wh = 3600000 Watt sec

FPS System	**Metric System**
1 HP = 746 watts	1 HP = 735.6 watts
= 0.746 K.W	= 0.7356 K.W

Note: The charge for electric consumption is the energy cost per Kwh and it varies according to the country and states.

Fig 1



V - Voltage (Volts) V

i - Current Intensity (Amperes) A

P - Power (Watts, Kilowatts) W, kW

W - Work, Energy (Watt hour, Kilowatt hour) wh, Kwh

t - time (hours) h

Fig 2

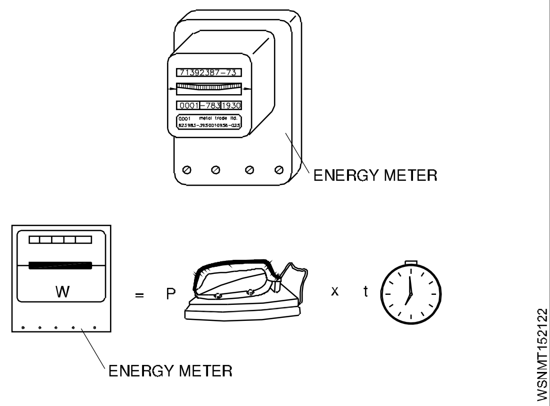


Table of analogies between mechanical and electrical quantities

Mechanical quantity	Unit	Electrical quantity	Unit
Force 'F'	N	Voltage 'V'	V
Velocity $v = \frac{\text{Displacement}}{\text{Time}}$	m/s	Current I	A
Time t	seconds	Time t	seconds
Power $P = F \times v$	$N \frac{m}{sec}$	Power $P = V \times i$	$W = V \times A$
Energy = $F \times v \times t$	j = Nm	Energy $W = V \times i \times t$	$j = W \times s$

$$W = VI = I^2R = \frac{V^2}{R}$$

$$R = \frac{V}{I} = \frac{V^2}{W} = \frac{W}{I^2}$$

$$V = IR = \frac{W}{I} = \sqrt{WR}$$

$$I = \frac{V}{R} = \frac{W}{V} = \sqrt{\frac{W}{R}}$$

Basic Electricity - Conductor, insulator, types of connections - series and parallel

Conductors

Some materials and metals readily allow passage for electric current to flow. In such materials, called conductors, electrons are able to pass readily from atom to atom.

Properties of conductors

A good conductor should have the following properties.

Electrical properties

- The conductivity must be good.
- Electrical energy spent in the form of heat must be low.
- Resistivity must be low (to reduce voltage drop and loss).
- Increase in resistance with temperature must be low.

Mechanical properties

- Ductility (the property of being drawn into thin wires).
- Solderability: the joint should have minimum contact resistance.
- Resistance to corrosion: should not get rusted when used outdoors.
- Should withstand stress and strain.
- It should be easy to fabricate.

Economical factors

- Low cost.
- Easy availability.
- Easy to manufacture.

Classification of conductors

Conductors

Metallic Electrolytic Gaseous

The best conductors are metallic. The commonly used conductors in electrical appliances and machines are described hereunder.

Silver

It is a soft and extremely malleable metal. Even though it is the best conductor, its use is limited because of its high cost.

Copper

It is a very good conductor. It is malleable and ductile, and also has high resistance to corrosion by liquids. Therefore, it is widely used for wires, cables, overhead conductors, bus bars and conducting parts of various electrical appliances.

Aluminium

It is a metal light in weight. It is also ductile, malleable and a good conductor of electricity. Nowadays, it is more widely used (since it is cheaper than copper) for wires and cables. All aluminium conductors (AAC) and aluminium conductors (steel reinforced) (ACSR) are used in overhead and transmission lines. (More details on copper and aluminium are furnished under the topic 'non-ferrous metals and alloys as applicable to electrical trades').

RESISTANCE WIRES

These are conductors with very high resistance for specific applications like filaments of incandescent lamps, heating elements etc. The following are a few examples:

1 Tungsten	2 Nichrome	3 Eureka
4 German silver	5 Manganin	6 Platinum
7 Mercury	8 Carbon	9 Brass.

The resistance values of the metallic resistances will increase with increase in temperature.

insulators

Description

These are the materials which offer very high resistance to the flow of current and make current flow very negligible or nil. These materials have very high resistance - usually of many megohms (1 megohm = 10^6 ohms) per centimetre cube. The insulators should also possesses high dielectric strength. This means that the insulating material should not break down or puncture even on application of a high voltage (or high electrical pressure) to a given thickness.

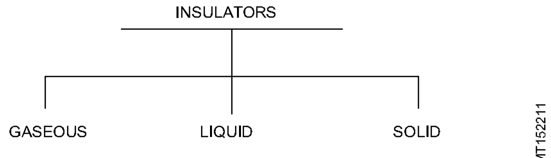
Properties of insulators

The main requirements of a good insulating material are:

- high specific resistance (many megohms/cm cube) to reduce the leakage currents to a negligible value
- good dielectric strength i.e. high value of breakdown voltage (expressed in kilovolts per mm)
- good mechanical strength, in tension or compression (It must resist the stresses set up during erection and under working conditions.)
- little deterioration with rise in temperature (The insulating properties should not change much with the rise in temperature i.e. when electrical machines are loaded.)
- non-absorption of moisture, when exposed to damp atmospheric condition. (The insulating properties, specially specific resistance and dielectric strength decrease considerably with the absorption of even a slight amount of moisture.)

Classification of insulators (Fig 1)

Fig 1



CLASSIFICATION OF INSULATORS

Air is an example of a gaseous insulator. Other examples are hydrogen, nitrogen and inert gases.

Liquid insulators

Mineral oils, synthetic liquids, resins and varnishes are the liquid insulators.

Transformer oil

In transformers the oil is used as an insulator and also for cooling of the transformer windings by convection. Therefore, the transformer oil should be dry and purified, since the presence of moisture will reduce the dielectric strength of the oil.

Purpose of transformer oil

- Transfer of heat by convection, from winding and core to the cooling surfaces.
- It maintains the insulation of winding and also extinguishes fire that occurs due to faults occurring in the windings.

Precaution

The insulating value of a transformer oil is reduced due to the formation of sludge as a result of oxidation due to air and temperature. To minimise oxidation, the oil should not be exposed to air.

Sludge is also formed due to the presence of acids and alkalis.

Sludge formation

- Reduces the rate of heat transfer.
- Blocks the ducts.
- Increases the operating temperature.

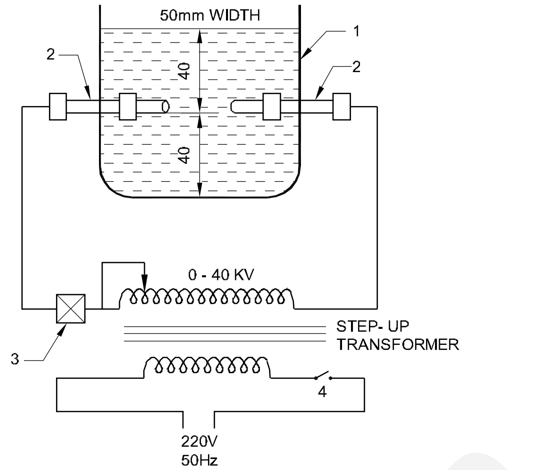
To prevent moisture from entering the oil, the whole apparatus is made airtight, and calcium chloride, silicagel fillets are used.

Testing of transformer oil as per ISI Standard (Fig 2)

Dielectrical strength test (Refer to Fig 2) : The oil should be 40 mm above and 40 mm below the electrodes. The gap between the two electrodes should be kept at 4 mm ± 0.02 mm).

A high voltage is applied across the electrodes through a step-up transformer, and increased till there is a spark in between the electrodes. The voltage noted on the voltmeters, when the spark occurs, is the breakdown voltage or dielectric strength of the oil. This is the maximum voltage the oil can withstand.

Fig 2



1. OIL CONTAINER
2. ELECTRODES
3. CIRCUIT BREAKER (AUTOMATICALLY OPERATED)
4. SWITCH

APPARATUS FOR TRANSFORMER OIL TESTING

According to ISI specifications, the oil should be able to withstand 40 kV for one minute with a gap (4 mm ± 0.02 mm) between the electrodes and with the diameter of the electrodes as 13 mm.

Moisture test : In this test, an oil sample is cooled in a closed vessel down to 15-25°. A dry test tube, 12.5 mm in diameter and 125 mm long, is taken and an adequate quantity of oil is poured into it.

The tube containing the oil is heated rapidly with the help of an electric heater till the oil begins to boil. During the process, oil should not produce cracking.

The other tests are:

- acidity test
- sludge resistance test.

Electrical insulating varnishes

They are of two types

Oil and resin varnishes.

Solid insulators/insulating materials

Sl. No.	Classification	Examples
1	Mineral insulators	Mica, marble, slate.
2	Vitreous materials	Glass, quartz, procelain.
3	Rubber and rubber products	Rubber, vulcanised (India) rubber (V.I.R) ebonite
4	Waxes and compounds	Paraffin wax, bitumen.
5	Fibrous materials	Asbestos, paper, wood, Press pahn, leatheroid, cotton, silk, tapes etc.
6	Synthetic products	Bakelite, shellac, oil (for Transformer, Switchgear etc).

Paper

Various grades of insulating paper are available for use in capacitors, cables, etc. Paper, if moist, loses its insulating property. Therefore, it is used in an impregnated condition.

Wood

It is impregnated with oil or other substance for use as an insulator.

For example, in machine windings, bamboo wood is used as slot wedges.

Press board

It is widely used in windings to insulate parts which support windings. It is also used as spacers in electrical devices and transformers.

Asbestos

A fibrous, incombustible, fire- proof material - used for panel boards and as frames for winding resistance wires of regulators, rheostats etc.

Cotton

It is soaked in paraffin to avoid moisture. It is a good insulator for low voltages. It is used in conductors for armatures and field coils.

Silk

Like cotton, it is used for small jobs like telephone coils.

Tapes

Tapes of various types are used, such as cotton, silk, jute etc either pure or in impregnated form.

Empire cloth

It is made by varnishing a cotton cloth, silk or paper. It is not effected by moisture. It is available in yellow and black colours in different sizes. It is used as slots insulation in winding works and for coil insulation.

Press pahn

Press pahn is a form of paper made from hemp, rags, and wood pulp by special chemical treatment. It is widely used for lining armature slots, insulating coil sides, etc.

Leatheroid

It is a tough material made from cotton rags with chemical treatment. It is unaffected by grease or oil and is used for slot and coil insulation, transformer core coverings, etc.

Adhesive tape

It is used widely for taping of ends of conductors, leads and connections. Adhesive tape is made from cotton fabric coated with a compound of rubber, bitumen, resin, gum, etc. It dries when exposed to air. It is available in sizes $\frac{1"}{2}$, 3/4", 1" etc. These are also available as P.V.C. adhesive tape, cotton and bitumen tapes.

Bitumen

It is used for filling cable jointing boxes and for sealing the tops of the batteries etc. It is waterproof, but it will crack under certain conditions. It can be valcanised in the same manner as rubber.

Mica

It is a mineral and available as large slabs. It can be easily separated into thin sheets. It is fireproof, waterproof, and is a good insulator. It should be used carefully since it is liable to crack. It is used in heating elements of electric iron etc.

Marble and slate

Marble and slate are mechanically strong insulators and are non- hygroscopic. When polished they form good mountings for switchboards, switches, resistance frames, etc. Slate is used generally for low voltages.

Micanite

It is made by sticking together pieces of mica with insulating cement like shellac. It can be bent to any shape by heating and pressing. Therefore, it is used as insulator for slots of armatures and to insulate the commutator from the shaft.

Paraffin wax

It melts at 55°C and does not absorb water. It is used to impregnate paper, wood, pressboard etc to reduce their moisture absorption.

Bakelite

It can be moulded to any shape. It is heat-resistant and highly insulating. It will not absorb oil and moisture. It is used for bodies of switches, plugs, holders, regulators etc.

Rubber

It has high insulating properties. It is used mainly on lighting cables and for flexible cables. It deteriorates gradually when exposed to atmosphere. Rubber is being replaced now by elastic plastics such as PVC or polyethylene which can resist alkalis, acids and mineral oils.

Valcanised India Rubber (VIR)

This is manufactured by treating pure rubber with sulphur. It is stronger than pure rubber and is not affected much by change in temperatures. It is used as coverings for low and medium voltage wires and cables.

Ebonite or vulcanite

Ebonite or Vulcanite is vulcanised rubber containing about 30% to 50% of sulphur, and subjected to a prolonged heating at 150°C. The material is hard and can be moulded into different shapes. It is less affected by chemicals and moisture. It is used for making containers of lead acid batteries, cases for instruments and switchgears, terminal plates and low voltage panel boards etc. It should not be subjected to heat.

Shellac

It is a good varnish which is used to improve the insulation and moisture resisting properties of paper, cloth, wood, slate etc.

Enamel

By this, an insulation coating is given on winding wires.

Polychloroprene (PCP)

It is a plastic material used for insulation of cables. It is resistant to oil and petrol. It can be used in conditions of exposure to sulphur fumes, steam, ammonia, lactic acid and direct sunlight.

Glass

It is heat-resistant and suitable for high temperatures. It is used as insulators, envelopes for lamps, radio tubes etc.

Quartz

Quartz (Silica) is a good insulator. As it has a very low temperature coefficient of expansion, it does not crack with sudden variations in temperature. It is used for pyrometer sheaths, for heating elements, sparking plugs, etc.

Porcelain

Porcelain is not so brittle as glass and is very widely used for carrying bare conductors, for making fuse carriers and other electrical fittings.

Red fibre

Mainly used in motor and transformer winding work, for slot insulation, separators etc.

Insulators classified according to their temperature limits

The permissible temperature limit at which the insulators may be worked safely without deterioration, depends upon the type and class of the insulation as detailed below. (IS:1271/1958)

Class Y – maximum temperature 90°C

Cotton, silk, paper products, press board, wood, valcanised fibre - not impregnated or immersed in oil.

Class A – maximum temperature 105°C

Cotton, silk, paper products, wood, valcanised fibre when impregnated or immersed in liquid dielectric, varnished paper and wire enamel (class A).

Class E – maximum temperature 120°C

Wire enamel, cotton fabric and paper laminates treated with oil, modified asphalt and synthetic resins, varnished polyethylene, textile treated with suitable varnish.

Class B – Maximum temperature 130°C

Glass fibre, asbestos, varnished glass fibre, textile, varnished asbestos, built up mica treated with synthetic resin varnishes.

Class F – maximum temperature 155°C

Similar to class B materials but treated with silicone resins.

Class H – maximum temperature 180°C

Same as class F materials but treated with silicone resins of higher thermal stability than class F.

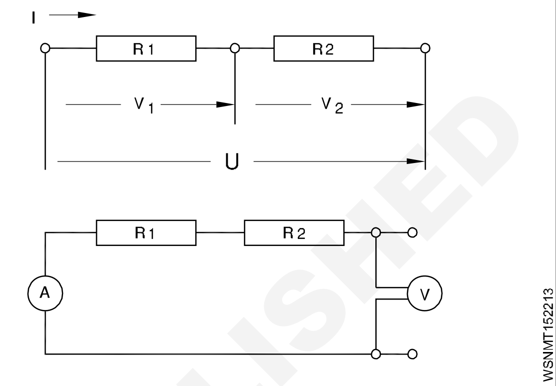
Class C – maximum temperature above 180°C

Mica, porcelain and other ceramics, glass, quartz, asbestos, treated glass fibre textile, treated asbestos, built up mica treated with silicone resins possessing superior thermal stability (limited stability up to 225°C).

Series Connection

The total resistance is equal to the sum of all the resistances. In a series connection the end of the first load is connected to the beginning of the second load and all loads are connected end to end. (Fig 3)

Fig 3



Features of series connection:

- The same current flows through all the loads.
- The voltage across each load is proportional to the resistance of the load.
- The sum of the voltages across each load is equal to the applied voltage.
- The Total resistance is equal to the sum of all the resistances.

$I = I_1 = I_2 = ...$

$V = V_1 + V_2 + ...$

$R = R_1 + R_2 + ...$

Example

Three resistances of 3 ohms, 9 ohms and 5 ohms are connected in series. Find their resultant resistance.

Solution

R = R1 + R2 + R3

= 3 Ω + 9 Ω + 5 Ω

Total resistance = 17 Ω

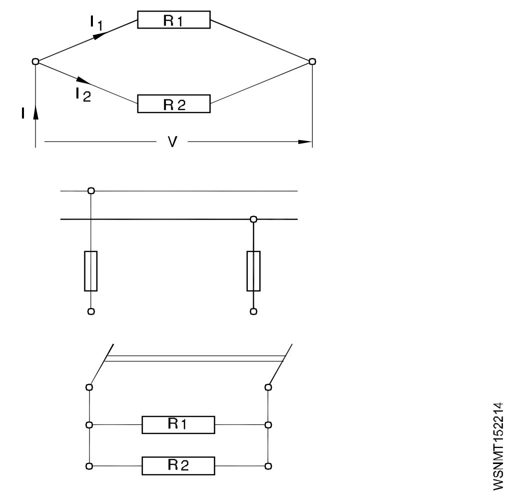
Parallel connection

In a parallel connection the beginning and the ends of the loads are connected together.

Features of parallel connection:

- The current flowing through each load depends upon the resistance of the load.
- The voltage across each load is the same and is equal to the voltage applied to the circuit.

Fig 4



- The total resistance of a parallel connection is always smaller than the smallest resistance in the circuit.
- In parallel connection the reciprocal of the total resistance is equal to the sum of the reciprocals of all resistances in the circuit.

$I = I_1 + I_2 + ...$

$V = V_1 = V_2 ...$

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + ...$$

Example

Two resistances of 4 ohms and 6 ohms are connected in parallel. Determine the total resistance.

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \quad \text{(since parallel connection)}$$

Therefore $\frac{1}{R} = \frac{1}{4} + \frac{1}{6} = \frac{10}{24} = \frac{5}{12}$

Therefore R $= \frac{24}{10}$ ohms = 2.4 ohms

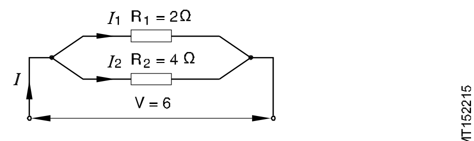
Example

Two resistors of 2 and 4 ohms are switched in parallel to a 6V battery

– Calculate the total resistance

– Find the total current and partial current.

Fig 5



RESISTORS IN PARALLEL

Solution

Total resistance

$$\frac{1}{R_{tot}} = \frac{1}{R_1} + \frac{1}{R_2}$$

$$= \frac{1}{2} + \frac{1}{4} = \frac{2+1}{4}$$

$$= \frac{3}{4}\Omega$$

$$R_{tot} = \frac{4}{3} = 1\frac{1}{3}\Omega$$

I Total = $I_1 + I_2$ current

$$But\, I_1 = \frac{U}{R_1} = \frac{6V}{2\Omega} = 3A$$

$$I_2 = \frac{U}{R_2} = \frac{6V}{4\Omega} = 1.5A$$

I total = 3A + 1.5A

= 4.5 Amp

Basic Electricity - Ohm's law, relation between V.I.R & related problems

Ohm's law

V - Voltage in volts

I - Current in Ampere

R - Resistance in ohms.

In any closed circuit the basic parametres of electricity (Voltage, Current and resistance) are in a fixed relationship to each other.

Basic values

To clarify the basic electrical values, they can be compared to a water tap under pressure

Water pressure	- electron pressure	- Voltage
Amount of water	- electron flow	- Current
throttling of tap	- obstruction to electron flow	- Resistance

Fig 1

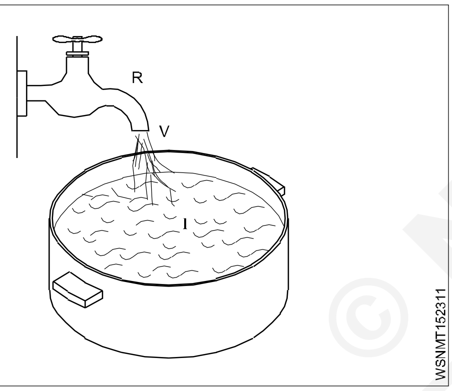


Fig 2

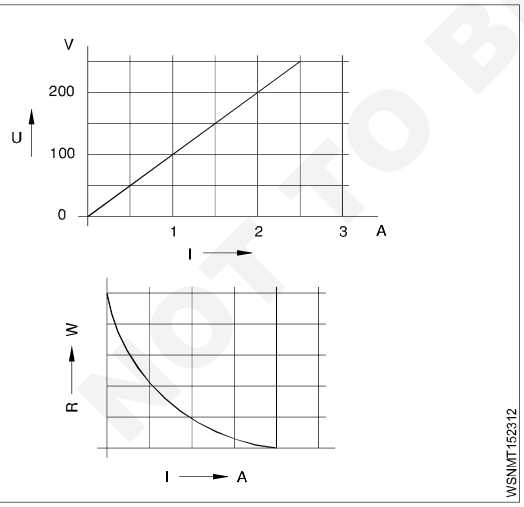


Fig 3

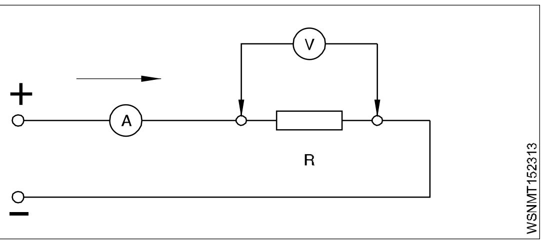
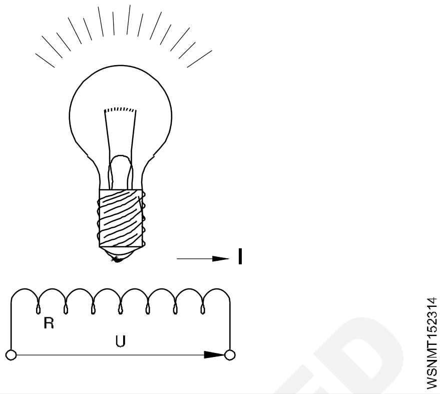


Fig 4



Relationships

If the resistance is kept constant and the voltage is increased, the current is increased

$$I \propto V$$

If voltage is constant and the resistance is increased, current is decreased

$$I \propto \frac{1}{R}$$

Ohm's law

From the above two relationships we obtain Ohm's law,

$I = \frac{V}{R}$ which is conveniently written as V = R.I.

Ohm's law states that at constant temperature the current passing through a closed circuit is directly proportional to the potential difference, and inversely proportional to the resistance.

By Ohm's law $I = \frac{V}{R}$

EXAMPLE

A bulb takes a current of 0.2 amps at a voltage of 3.6 volts. Determine the resistance of the filament of the bulb to find R. Given that V = 3.6 V and *I* = 0.2 A.

To find 'R'. Given that V = 3.6V and I = 0.2 A

Therefore V = I x R

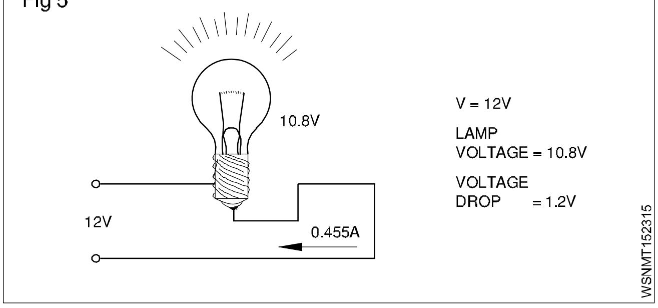
3.6 V = 0.2 A x R

Therefore $R = \frac{3.6V}{0.2A} = 18\,ohms$

Example

The voltage supply to a filament lamp is 10.8V. The voltage should be 12V. Find out loss of voltage.(Fig 5)

Fig 5



Voltage drop = 12V – 10.8 = 1.2V

The supply voltage is called Potential difference.

Example

The Internal resistance of a dynamo is 0.1 ohm. The voltage of dynamo is 12V. What is the Voltage of dynamo when a current of 20 amps being supplied to an outside circuit.

Solution

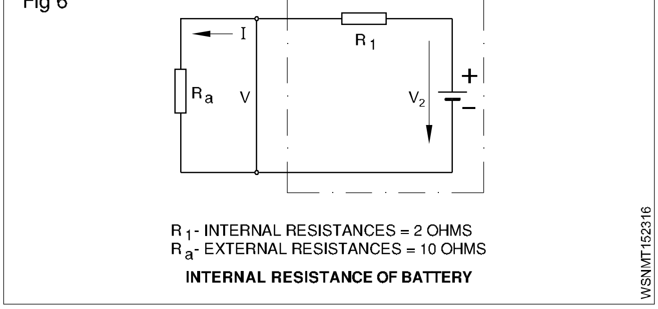
Voltage drop = Current x Internal resistance

= 20 x 0.1 volts

= 2 volts

Example (Fig 6)

Fig 6



The Internal resistance of a Battery is 2 ohms. When a resistance of 10 ohms is connected to a battery it draws 0.6 amps. What is the EMF of the battery.

P.D = Current flowing x Resistance

= 0.6 A x 10Ω

= 6 volts

V.D = Current flowing x Internal resistance of battery

= 0.6 x 2 volts

= 1.2 volts

EMF of the Battery = (6.00 + 1.2)V

= 7.2 volts

Resistance connections

V - Voltage (in volts)

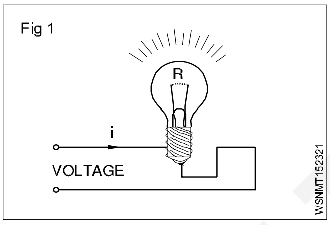
R - Resistance (in ohms)

I - Current intensity (in Amperes)

Assignment

1

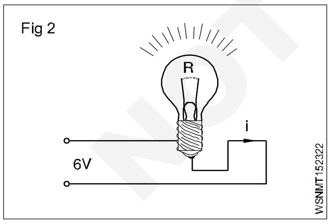
Fig 1



R = 40 Ohms
I = 6.5 Amps
V = ______Volts

2

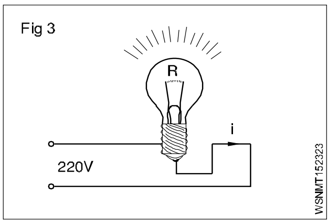
Fig 2



V = 6 Volts
I = 0.5 Amps
R = ______Ohms

3

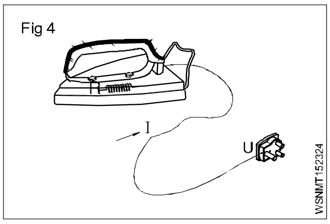
Fig 3



V = 220 Volts
R = 820 Ohms
I = ______Amps

4

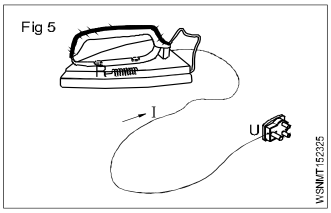
Fig 4



I = 4.5 Amps
V = 220 Volts
R = ______Ohms

5

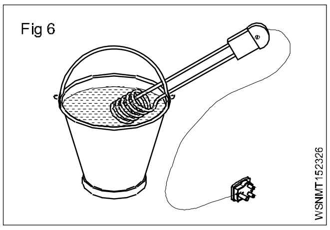
Fig 5



R = 50 Ohms
V = 220 Volts
I = _____ Amps

6

Fig 6



V = 110 Volts
I = 4.55 Amps
R = _____Ohms

Basic Electricity - Electrical power, HP, energy and units of electrical energy

Electric Power

In mechanical terms we defined power as the rate of doing work. The unit of power is Watt. In an electrical circuit also the unit of electrical power is 1 Watt. In mechanical terms 1 Watt is the work done by a force of 1 N to move the body through 1 metre in one second. In an electrical circuit, the electromotive force overcomes the resistance and does work. The rate of doing work depends upon the current flowing in the circuit in amperes. When an e.m.f of one volt causes a current of 1 ampere to flow the power is 1 Watt.

Hence Power = Voltage x Current

$P = V \times I$

Power in Watts = Voltage in Volts x Current in Amperes

Electric work, energy

Electrical work or energy is the product of electrical power and time

Work in Watt seconds = Power in Watts x time in seconds

$W = P \times t$

Since 1 joule represents 1 Watt x 1 sec, which is very small, larger units such as 1 Watt hour and 1 kilowatt hour are used.

1 W.h = 3600 Watt sec.

1 Kwh = 1000 Wh = 3600000 Watt sec

FPS System	**Metric System**
1 HP = 746 watts	1 HP = 735.6 watts
= 0.746 K.W	= 0.7356 K.W

EXAMPLE

1 **Calculate the power rating of the lamp in the circuit, if 0.25 amperes of current flows and the voltage is 240 volts.**

P = V x I

V = 240 Volts

I = 0.25 Amp

Therefore Power = 240 Volts x 0.25 Amperes

= 60 Volts Amps

But 1 Watt = 1 Volt x 1 Amp

Therefore Power = 60 Watts

2 **Calculate the power in kilowatts consumed. if a current of 15 amps flow through a resistance of 10 Ohms.**

Given that R = 10 and *I* = 15A

Power = $V \times I = I \times R \times I = I^2 \times R$

Therefore Power = $15^2 \times 10$ = 2250 Watts = 2.25 kW

3 **calculate the work in Wh to find the work given that V = 200 Volts if a line voltage of 200 Volts a bulb consumes a current of 0.91 amps. If the bulb is on for 12 hour**

I = 0.91 Amps.

t = 12 hours

Therefore Power = V x *I* = 200 Volts x 0.91 Amps

= 182 Watts

Therefore Work = P x *t* = 182 Watts x 12 hours

= 2184 Watt hour.

4 **What is its rated power if an adjustable resistor bears the following label: 1.5 k Ohms/0.08 A?**

Given: R = 1.5 k Ohms; I = 0.08 A

Find: P

V = R.I = 1500 Ohms.0.08 A = 120 volts

P = V.I = 120 volts.0.08 A = 9.6 W alternatively: $P = I^2.R = (0.08\ A)^2.1500$ Ohms = 9.6 W.

5 **Find the current and power consumed by an electric iron having 110 Ω resistance when feed from a 220 v supply**

Resistance of electric iron (R) = 110 ohm

Voltage (V) = 220 volt

Current (I) = $\frac{V}{R}$

= $\frac{220}{110}$ 2 ampere

Power (w) = V x I

= 220 x 2

= 440 watt

6 **Find the total power if four 1000 W, 180 volt heaters are connected in series across 240 V supply and current carrying capacity is 15 amp.**

Connection = Series

No. of heaters = 4

Heater power (W) = 1000 watt

Heater voltage = 180 V

Supply voltage = 240 V

Heater resistance (R) = $\frac{V^2}{W}$

= $\frac{180 \times 180}{1000} = \frac{324}{10}$

= 32.4 ohm

Total resistance = 32.4 x 4 = 129.6 ohm

Total current (I) = $\frac{V}{R}$

= $\frac{240}{129.6}$ = 1.85 ampere

Total Power (W) = V x I

= 240 x 1.85 = 444 watt

7 How much voltage will be required to illuminate if a 40 watt florescent lamp draws a current of 0.10 ampere?

Lamp power (W) = 40 watt

Current (I) = 0.10 ampere

Voltage (V) = $\frac{W}{I}$

= $\frac{40}{0.1}$ = 400 volt

8 Find the cost if running 15 HP motor for 15 days @ 6 hrs per day. If the cost of energy is Rs. 3 per unit.

Motor power (w) = 15 HP

= 15 x 746 = 11,190 watt

Consumption per day = 11,190 x 6

= 67140 = 67.14 KWH

Consumption for 15 days = 67.14 x 15 (1000 watts = 1 KW)

= 1007 KWh (or) unit

(1 KWh = 1 unit)

Cost per unit = Rs. 3

Cost for total energy = 3 x 1007 = Rs. 3021

9 What is the percentage reduction in power consumption and How much power is consumed by series resistance if the rating of an electric iron is 220 V and 500 watts. The equipment appears abnormally hot. To reduce this a 10 W resistance is connected in series?

Electric iron power (W) = 500 watt

Voltage (V) = 220 volt

Resistance (R) = $\frac{V^2}{W}$

= $\frac{220 \times 220}{500} = \frac{484}{5}$

= 96.8 ohm

Circuit total resistance (R) = 96.8 + 10 = 106.8 ohm

Current (I) = $\frac{V}{R}$

= $\frac{220}{106.8}$ = 2.06 ampere

Consumed power (W) = I^2R

= 2.06 x 2.06 x 106.8

= 453 watt

Reduction in power Consumption = 500 - 453 = 47 watt

Percentage = $\frac{47}{500}$ x 100 = 9.4 %

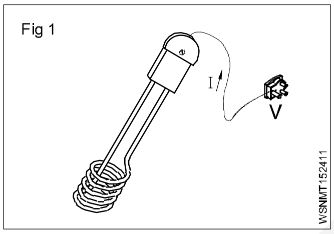
Power consumed by series resistance = I^2R

= 2.06 x 2.06 x 10

= 42.44 watt

Assignment

1



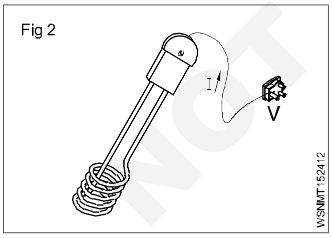
Current Consumed

I = 0.127 A

Voltage 'V' = 220 v

P = ______ Watts

2

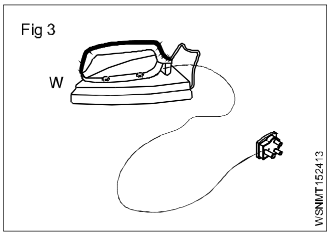


P = 500 Watts

I = 2.61 A

V = ______ v

3

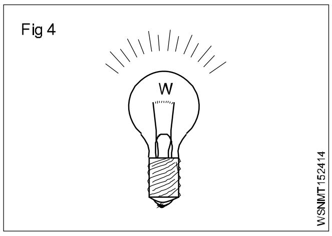


P = 650 W

V = 220 v

I = ______ A

4

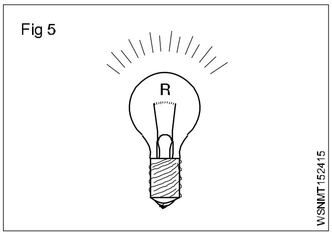


P = 50 W

V = 200 v

R = ______ W

5

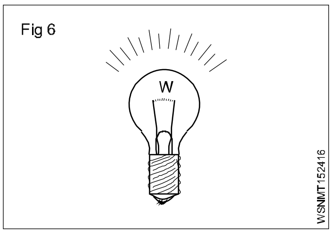


I = 0.455 A

R = 242 ohms

P = ______ Watts

6



P = 440 W

R = 22 ohms

I = ______ A

Levers & Simple machines - Lever and its types

Lever

A lever is a rigid rod which rotates about a fixed point called the fulcrum.

E.g. : Cutting plier, A pair of scissors, Crow bar, Beam balance, Hand pump.

The distance of the load from the fulcrum is called the load arm. The distance of the effort from the fulcrum is called the effort arm.

Principle of Lever

- All levers are functioning in the following principle

  Load x Load arm = Effort x Effort arm

- **Classification of lever**

1 Straight lever

2 Curved lever

1 Straight lever

There are three types :

1 First order lever

2 Second order lever

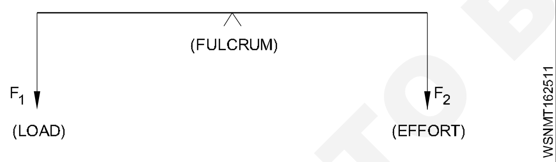
3 Third order lever

First order lever

In this type the fulcrum lies between the load and the effort.

E.g : A pair of scissors, See-saw, Crow bar, Beam balance, Hand pump, etc.,

Fig 1



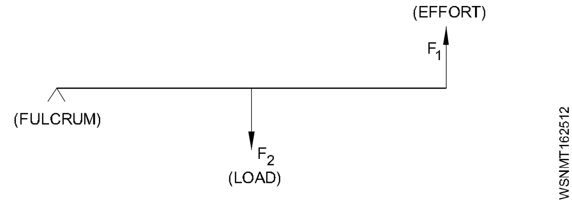
In this type of lever the mechanical advantage will be equal or less than or greater than 1 (M.A < = > 1)

Second order lever

In this type, the load lies between the fulcrum and the effort.

E.g : Nut cracker, Wheel barrow, Paper sheet cutter, Bottle openers, Lime squeezer, etc.,

Fig 2



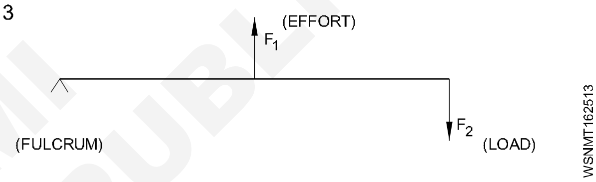
In this type of lever, the mechanical advantage will be greater than 1 (M.A. > 1). Less effort is used to lift more load.

Third order lever

In this type, the effort lies between the fulcrum and the load.

E.g. The human force arm, forceps, broom, fire tongs, fishing rod.

Fig 3



In this type of lever, the mechanical advantage will be less than 1 (M.A < 1) more effort is used to lift less load.

Bell cranked levers (Curved levers) (Fig 4)

In addition to the above types of levers, two rods may be joined together at an angle to increase leverage without utilising much space. Such levers are cranked levers and the special form in which included angle is 90°, is called the bell cranked lever.

E.g : Motor cycle breaks system clutch pedal.

Fig 4

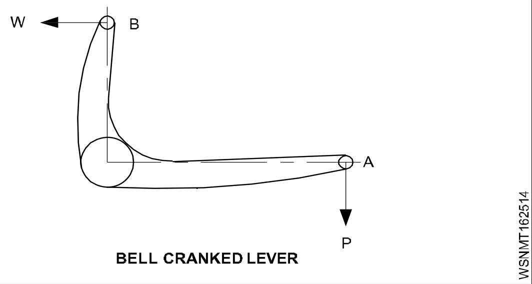
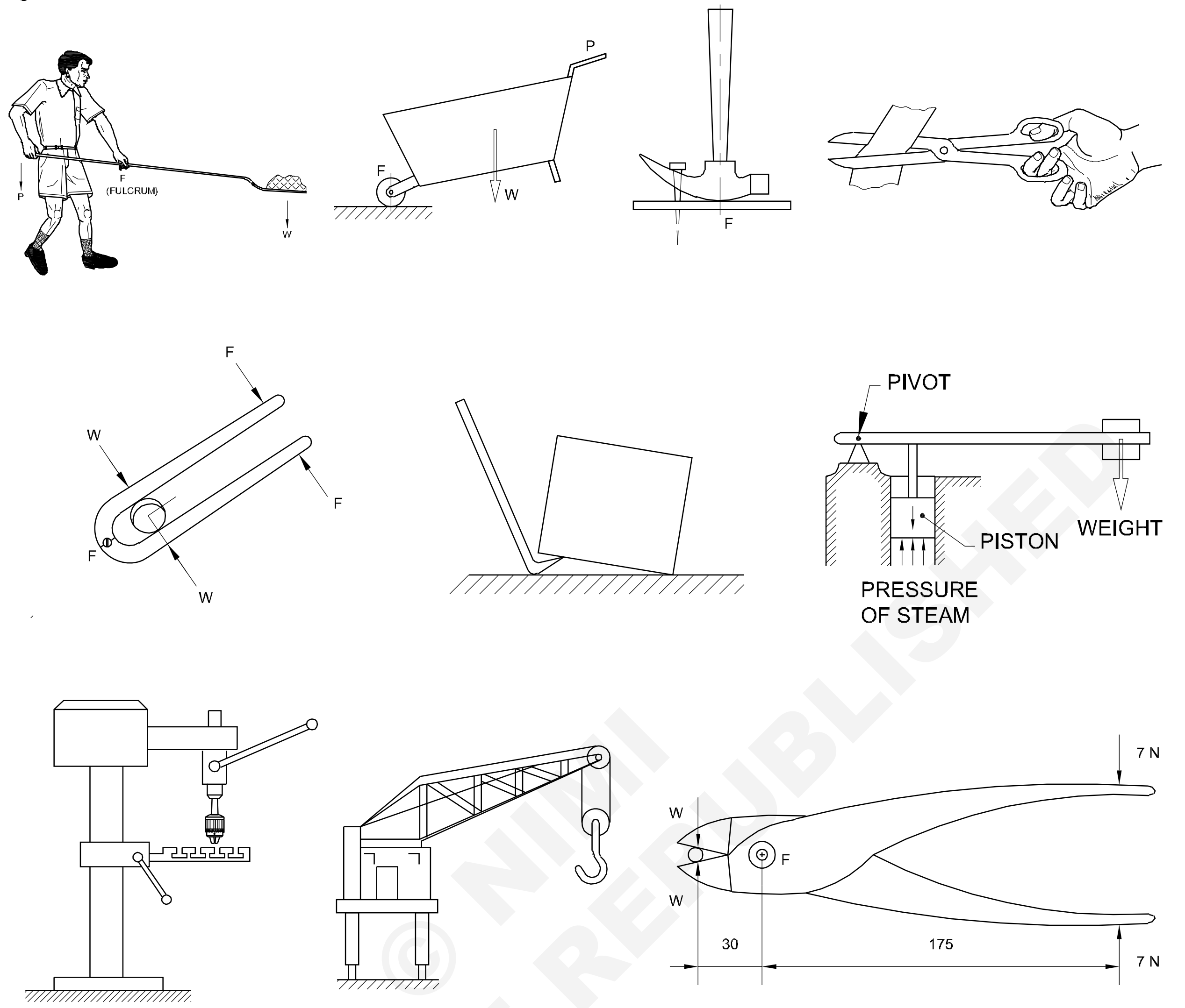


Fig 5



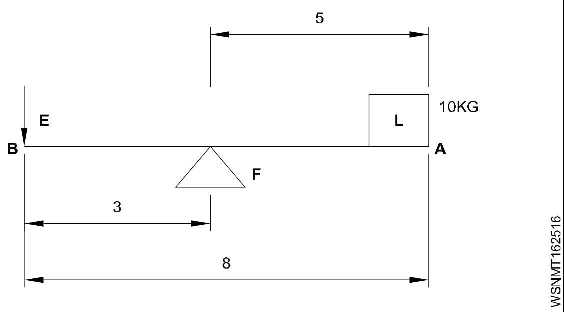
EXAMPLES OF SIMPLE LEVERS

Examples

1 Calculate the load at B, if the load is in the balance condition if a rod AB is 8 metre long and has got a weight of 10 kg at A. The fulcrum is 3 metre from B.

Load x Load arm	=	Effort x Effort arm
10 x 5	=	P x 3
50	=	3 P
P	=	50 / 3
	=	16.67 kg

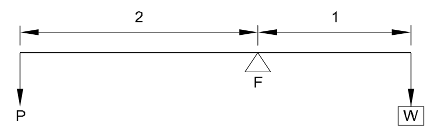
Fig 6



When load and effort are not given separately in the sum consider which one having more weight is as a load.

2 Find the effort required and mechanical advantage of the system if a weight of 3000 kg is to be lifted by a bar of length 3 metre. The load arm is 1 metre and the effort arm is 2 metre.

Fig 7



As per lever principle

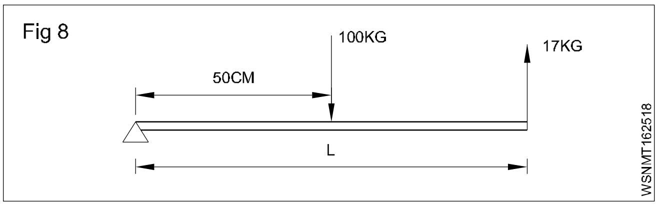
Load x Load arm	=	Effort x Effort arm
3000 x 1	=	P x 2
3000	=	P x 2
P	=	3000/2
	=	1500 kg

$$\text{Mechanical advantage} = \frac{\text{Load}}{\text{Effort}} = \frac{3000}{1500}$$

$$= 2$$

3 According to Fig. the lever has to support a 100 kg load with a 17 kg equivalent force supplied to it. Find the distance between the load and point of force.

Fig 8



Solution.

Load = 100 kg; Effort = 17 kg.

Load arm = 50 cm

Let effort arm = x cm

As per principle of levers:

Effort x Effort arm = Load x Load arm

$$17x = 100 \times 50$$

$$x = \frac{100 \times 50}{17} = 294.1 \text{ cm}$$

$$x = 294.1 \text{ cm}$$

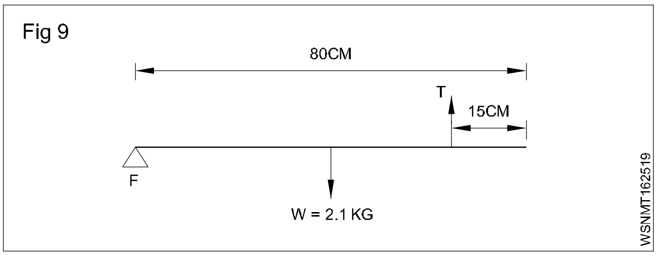
Distance between the load and point of force = 294.1 - 50

= 244.1 cm

= 2.4410 m

4 Find the tension of the string if an uniform bar of length 80 cm and weighing 2.1 kg is supported on a smooth peg at one end and by a vertical string at a distance of 15 cm from the other end.

Fig 9



W = 2.1 kg

Tension = T kg

P x dp = 2.1 x dv

$$T \text{ kg} \times (80 - 15) \text{ cm} = 2.1 \text{ kg} \times \frac{80}{2} \text{ cm}$$

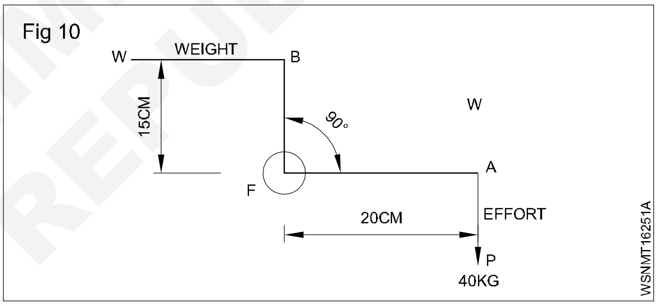
$$T \times 65 = 2.1 \times 40$$

$$T = \frac{2.1 \times 40}{65} \text{ kg.}$$

Tension = 1.292 kg

5 In the figure given below in bell cranked lever AFB on perpendicular AF the force P is 40 kg. Weight W is on perpendicular FB. Find the measure of W.

Fig 10



Solution. By principle of momentum

P x AF = W x BF

40 x 20 = W x 15

$$W = \frac{40 \times 20}{15} = \frac{160}{3} = 53.3 \text{ kg.}$$

Assignment

1 a Which order belongs to forearm of a human body.

b Which order belongs to a pair of sugar tongs.

c Which order belongs to carburetor Throttle Valve.

d Which order belongs to a common balance.

e Which order belongs to a pair of scissors.

f Which order belongs to a safety valve.

g Which order belongs to a Crow bar.

h Which order belongs to a Brake lever.

2 a What is the principle of levers?

b Write two examples of first order lever.

c Write two examples of second order lever.

d Write two examples of third order lever.

e Which order belongs to bell cranked lever.

f What is the Mechanical advantage?

g What is the Velocity ratio?

h What is the Efficiency?

Trigonometry - Measurement of angles

Introduction:

Trigonometry is the branch of mathematics which deals with the study of measurement and relationship of the three sides and three angles of a triangle.

Units:

Measurement of Angles

There are three systems of measuring the angle:

(i) Sexagesimal System

This is called British System. In this system, one right angle is divided into 90 equal parts which are called degrees.Each part is divided into 60 parts which are called minutes.Each minute is divided into 60 parts which are called seconds.The parts so divided respectively are called:

One degree (1°), one minute (1') and one second (1")

It means 1 right angle = 90° (90 degrees)

1 degree (1°) = 60' (60 minutes)

1 minute (1') = 60" (60 seconds)

In Trigonometry, mostly this system is used.

(ii) Centesimal System

This is called French System. In this system, the right angle is divided into 100 equal parts which are called grades. Each grade is divided into 100 minutes and each minute is divided into 100 seconds.

Parts so divided are respectively called:

One grade (1 g), one minute (1'), one second (1").

It means 1 right angle = 100 grades (100g)

1 grade (1 g) = 100 minutes (100')

1 minute (1') = 100 seconds (100")

90° = 100g (because each is a right angle)

This system is easier than Sexagesimal System. But to use this system many other systems will have to be devised that is why this system is not used.

(iii) Circular System

In this system, the unit of measuring angles is radian. It is that angle which is formed at the centre and is formed of an arc of length equal to radius in a circle.

There is one constant ratio between the circumference and dia of a circle. This is represented by π.

$$\frac{\text{Circumference}}{\text{Diameter}} = \text{constant point} = \pi$$

Circumference $= \pi \times \text{dia}$

$= 2\pi r$ (where r is radius of the circle)

$$\pi = \frac{22}{7}$$

Circumference makes an angle $(2\pi r) = 360°$

Radius of the circle makes an angle (r) = 1 Radian

$$\text{ie : } \frac{C}{r} = \frac{360^\circ}{1\text{Radian}}$$

$$\frac{2\pi r}{r} = \frac{360^\circ}{1\text{Radian}}$$

$$2\pi = \frac{360^\circ}{1\text{Radian}}$$

$$2\pi \text{ Radian} = 360^\circ$$

$$\pi \text{ Radian} = 180^\circ$$

$$1 \text{ Radian} = \frac{180^\circ}{\pi}$$

$$1^\circ = \frac{\pi}{180^\circ} \text{ Radian}$$

Examples

1 Convert 45°36'20" into degree and decimal of degree.

60 seconds = 1 minute

$$20 \text{ seconds} = \frac{20}{60} = 0.333'$$

60 minutes = 1 degree

$$36.333 \text{ minutes} = \frac{36.333}{60} = 0.606^\circ$$

$45^0 36'20" = 45.606°$

2 Convert 24.59° into degree, minute and second

1 degree = 60 minutes

0.59 degree = 0.59 x 60 = 35.4'

1 minute = 60 seconds

0.4 minute = 60 sec x 0.4

= 24"

Therefore 24.59° = $24^0 35'24"$

3 Change $50^0 37'30"$ into degrees

By changing angle degrees into decimals

$$30" = \frac{30}{60} = 0.50'$$

37'30" = 37.5'

$$37.5' = \frac{37.5}{60} = 0.625^0$$

$50^0 37'30" = 50.625^0$

4 Convert $23^0 25' 32''$ into radians

We know $1^0 = 60' = 3600''$

Therefore $23^0 25' 32''$

$$= \left(23 + \frac{25}{60} + \frac{32}{3600}\right) degrees$$

$$= \frac{82800 + 1500 + 32}{3600}$$

$$= \frac{84332}{3600}$$

But $180^0 = \pi$ radians

Therefore 23.4255 degrees

$$= \frac{23.4255}{180} \pi \text{ radians}$$

$$= \frac{23.4255}{180} \times \frac{22}{7} \text{ radians}$$

= 0.4089 radians

5 Convert $87^0 19' 57''$ into Radian.

$19'57'' = 19' + \frac{57''}{60}$

$= 19' + 0.95'$

$= 19.95'$

$87°19.95' = 87° + \frac{19.95'}{60}$

$= 87° + 0.332° = 87.33°$

$1° = \frac{\pi}{180}$ radian

$87.33° = \frac{\pi}{180} \times 87.33$ radian

$= 1.524$ radian

6 Convert $67°11'43''$ into Radian

$11'43'' = 11' + \frac{43''}{60}$

$= 11' + 0.716'$

$= 11.72'$

$67°11.72' = 67° + \frac{11.72'}{60}$

$= 67° + 0.195°$

$= 67.2°$

$1° = \frac{\pi}{180}$ radian

$67.2° = \frac{\pi}{180} \times 67.2$ radian

$= 1.173$ radian

7 Convert $\frac{4}{7}\pi$ radian into degrees

1 radian $= \frac{180}{\pi}$ degree

$\frac{4}{7}\pi$ radian $= \frac{180}{\pi} \times \frac{4}{7}\pi$ degree

$= 102.9$ degree

$= 102^0\ 0.9 \times 60'$

$= 102^0\ 54'$

8 Convert 0.8357 radian into degrees

1 radian $= \frac{180}{\pi}$ degree

0.8357 radian $= \frac{180}{\pi} \times 0.8357$ degree

$= 47.88^0$

$= 47^0\ 0.88 \times 60'$

$= 47^0\ 52.80'$

$= 47^0\ 52' 0.8 \times 60''$

$= 47^0\ 52' 48''$

9 Convert 2.752 radian into degrees

1 Radian $= \frac{180}{\pi}$ degree

2.7520 radian $= \frac{180}{\pi} \times 2.752$ degree

$= 157.7^0$

$= 157.7^0 \times 60'$

$= 157^0\ 42'$

10 Convent $\frac{3}{5}\pi$ radian into degrees

1 Radian $= \frac{180}{\pi}$ degree

$\frac{3}{5}\pi$ radian $= \frac{180}{\pi} \times \frac{3}{5}\pi$ degree

$= 108^0$

Assignment

Convert into Degree

1 12 Radian

Convert into Radians

2 78^o

3 $47^0 20'$

4 $52^0 36' 45''$

5 $25^0 38''$

Convert into degree, minute and seconds

6 46.723^o

7 68.625^o

8 0.1269 Radian

9 2.625 Radians

10 3/5 Radian

Trigonometry - Trigonometrical ratios

Dependency

The sides of a triangle bear constant ratios for a given definite value of the angle. That is, increase or decrease in the length of the sides will not affect the ratio between them unless the angle is changed. These ratios are trigonometrical ratios. For the given values of the angle a value of the ratios $\frac{BC}{AB}, \frac{AC}{AB}, \frac{BC}{AC}, \frac{AB}{BC}, \frac{AB}{AC}$ and $\frac{AC}{BC}$ do not change even when the sides AB, BC, AC are increased to AB', BC' and AC' or decreased to AB", BC" and AC".

For the angle

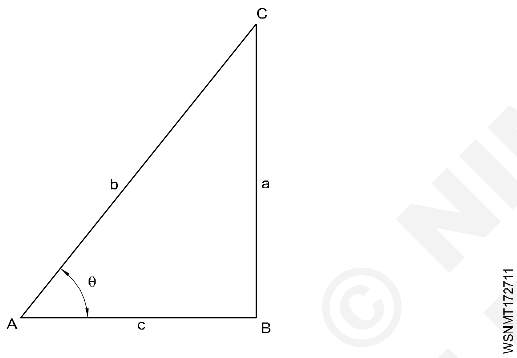
AC is the hypotenuse

AB is the adjacent side

BC is the opposite side.

The ratios

Fig 1



The six ratios between the sides have precise definitions.

$$\text{Sine } \theta = \frac{BC}{AC} = \frac{\text{Opposite side}}{\text{Hypotenuse}} = \text{Sin } \theta$$

$$\text{Cosine } \theta = \frac{AB}{AC} = \frac{\text{Adjacent side}}{\text{Hypotenuse}} = \text{Cos } \theta$$

$$\text{Tangent } \theta = \frac{BC}{AB} = \frac{\text{Opposite side}}{\text{Adjacent side}} = \text{Tan } \theta$$

$$\text{Cosecant } \theta = \frac{AC}{BC} = \frac{\text{Hypotenuse}}{\text{Opposite side}} = \text{Cosec } \theta$$

$$\text{Secant } \theta = \frac{AC}{AB} = \frac{\text{Hypotenuse}}{\text{Adjacent side}} = \text{Sec } \theta$$

$$\text{Cotangent } \theta = \frac{AB}{BC} = \frac{\text{Adjacent side}}{\text{Opposite side}} = \text{Cot } \theta$$

Relationship between the ratios

$$\text{Cosec } \theta = \frac{AC}{BC} = \frac{1}{\frac{BC}{AC}} = \frac{1}{\sin \theta}$$

$$\sec \theta = \frac{AC}{AB} = \frac{1}{\frac{AB}{AC}} = \frac{1}{\cos \theta}$$

$$\cot \theta = \frac{AB}{BC} = \frac{1}{\frac{BC}{AB}} = \frac{1}{\tan\theta}$$

$$\sin \theta = \frac{\text{sideBC}}{\text{sideAC}} = \frac{a}{b}$$

$$\cos \theta = \frac{\text{side AB}}{\text{sideAC}} = \frac{c}{b}$$

$$\frac{\sin \theta}{\cos \theta} = \frac{\frac{a}{b}}{\frac{c}{b}} = \frac{a}{b} \times \frac{b}{c} = \frac{a}{c}$$

$$= \frac{\text{side BC}}{\text{side AB}} = \tan \theta$$

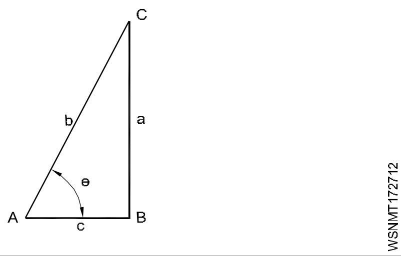
$$\sin \theta = \frac{1}{\text{cosec } \theta} \text{ or cosec } \theta = \frac{1}{\sin \theta} \text{ or } \sin\theta.\text{cosec } \theta = 1$$

$$\cos\theta = \frac{1}{\sec \theta} \text{ or } \sec \theta = \frac{1}{\cos \theta} \text{ or } \cos \theta . \sec\theta = 1$$

$$\tan \theta = \frac{1}{\cot \theta} \text{ or } \cot \theta = \frac{1}{\tan \theta} \text{ or } \cot \theta . \tan \theta = 1$$

By pythogoras theorem we have, $AC^2 = AB^2 + BC^2$

Fig 2



Dividing both sides of the equation by AC^2, we have

$$\frac{AC^2}{AC^2} = \frac{AB^2}{AC^2} + \frac{BC^2}{AC^2}$$

$$= \left[\frac{AB}{AC}\right]^2 + \left[\frac{BC}{AC}\right]^2$$

$1 = (\cos \theta)^2 + (\sin \theta)^2$

$\sin^2 \theta + \cos^2 \theta = 1$

Sine, Cosine, Tangent, Cosec, Sec and Cotangent are the six trigonometrical ratios

$\tan \theta = \frac{\text{Sin } \theta}{\text{Cos } \theta}$ and $\sin^2\theta + \cos^2\theta = 1$

$$\sin^2\theta + \cos^2\theta = 1$$

It can be transformed as

$$\sin^2\theta = 1 - \cos^2\theta$$

$$\sin\theta = \sqrt{1-\cos^2\theta}$$

$$\text{or } \cos^2\theta = 1 - \sin^2\theta$$

$$\cos\theta = \sqrt{1-\sin^2\theta}$$

$$\tan\theta = \frac{\sin\theta}{\cos\theta} = \frac{\sqrt{1-\cos^2\theta}}{\cos\theta}$$

$$\tan\theta = \frac{\sin\theta}{\sqrt{1-\sin^2\theta}}$$

We know $\sin^2\theta + \cos^2\theta = 1$

Dividing both sides by $\cos^2\theta$.

$$\frac{\sin^2\theta}{\cos^2\theta} + \frac{\cos^2\theta}{\cos^2\theta} = \frac{1}{\cos^2\theta}$$

$$\text{or } 1 + \tan^2\theta = \sec^2\theta$$

Using the same equation

$$\sin^2\theta + \cos^2\theta = 1.$$

Dividing both sides by $\sin^2 q$,

$$\frac{\text{Sin}^2\theta}{\text{Sin}^2\theta} + \frac{\text{Cos}^2\theta}{\text{Sin}^2\theta} = \frac{1}{\text{Sin}^2\theta}$$

$$1 + \frac{\cos^2\theta}{\sin^2\theta} = \frac{1}{\sin^2\theta}$$

$$1 + \cot^2 q = \text{cosec}^2 q$$

$$1 + \tan^2 q = \sec^2 q$$

Trigonometrical Tables

Ratio	0°	30°	45°	60°	90°
$\sin\theta$	0	$\frac{1}{2}$	$\frac{1}{\sqrt{2}}$	$\frac{\sqrt{3}}{2}$	1
$\cos\theta$	1	$\frac{\sqrt{3}}{2}$	$\frac{1}{\sqrt{2}}$	$\frac{1}{2}$	0
$\tan\theta$	0	$\frac{1}{\sqrt{3}}$	1	$\sqrt{3}$	∞

When q increases,

Sine value increases;

Cosine value decreases;

Tangent value increases to more than 1 when the angle is more than 45° (tan60° = 1.732)

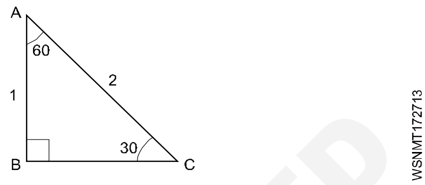
Sine of an angle	**=**	**Cosine of its complementary angle**
Cosine of an angle	**=**	**Sine of its complementary angle**

Examples

If $\sin 30^0 = \frac{1}{2}$ find the value of $\sin 60^0$

By applying pythagores theorem

Fig 3



$BC^2 = AC^2 - AB^2$

$BC^2 = 2^2 - 1^2$

$= 4 - 1$

$= 3$

$BC = \sqrt{3}$

$$\sin 60^0 = \frac{\sqrt{3}}{2}$$

$\text{Cos}\theta = \frac{3}{5}$ Find the other trigonometrical ratios

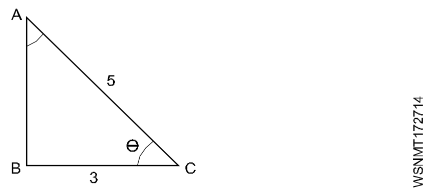
By applying pythagores theorem

$AB^2 = AC^2 - BC^2$

$= 5^2 - 3^2 \quad = 25 - 9$

$= 16$

Fig 4



$AB = \sqrt{16} = 4$

Now $\sin\theta = \frac{4}{5}$

$\tan\theta = \frac{4}{3}$

$\text{Cosec}\ \theta = \frac{5}{4}$

$\sec\theta = \frac{5}{3}$

$\cot\theta = \frac{3}{4}$

Signs of trigonometrical functions for angles more than 90^0

Ratio	90 - θ	90 + θ	180 - θ	180 + θ	270 - θ	270 + θ	360 - θ	- θ
sin	cos	cos	sin	- sin	- cos	- cos	- sin	- sin
cos	sin	- sin	- cos	- cos	- sin	sin	cos	cos
tan	cot	- cot	- tan	tan	cot	- cot	- tan	- tan
cosec	sec	sec	cosec	- cosec	- sec	- sec	- cosec	- cosec
sec	cosec	- cosec	- sec	- sec	- cosec	cosec	sec	sec
cot	tan	- tan	- cot	cot	tan	- tan	- cot	- cot

Simplify :

cot θ + tan (180+θ) + tan(90-θ) + (tan 360 - θ)

= cot θ + tan θ - cot θ - tan θ

= 0

Simplify :

$$\frac{\cos(90+\theta)\sec(-\theta)\tan(180-\theta)}{\sec(360-\theta)\sin(180+\theta)\cos(90-\theta)}$$

$$= \frac{(-\sin\theta)x(\sec\theta)x(-\tan\theta)}{(\sec\theta)x(-\sin\theta)x(-\sin\theta)}$$

$$= \frac{\tan\theta}{\sin\theta} = \frac{1}{\cos\theta} = \sec\theta$$

simplify:

$$\frac{\cos(90^\circ+\theta)\sec(-\theta)\tan(180^\circ-\theta)}{\sec(360^\circ-\theta)\sin(180^\circ+\theta)\cot(90^\circ-\theta)}$$

cos (90^0 + θ) = - sin θ

sec (- θ) = sec θ

tan (180^0 - θ) = - tan θ

sec (360^0 - θ) = sec θ

sin (180^0 + θ) = - sin θ

cot (90^0 + θ) = - tan θ

$$\frac{\cos(90^\circ+\theta)\sec(-\theta)\tan(180^\circ-\theta)}{\sec(360^\circ-\theta)\sin(180^\circ+\theta)\cot(90^\circ-\theta)}$$

$$= \frac{(-\sin\theta)(\sec\theta)(\tan\theta)}{(\sec\theta)(-\sin\theta)(-\tan\theta)}$$

= 1

Simplify:

Cot θ + tan (180^0 + θ) + tan (90^0 + θ) + tan (360^0 - θ)

tan (180^0 - θ) = tan θ

tan (90^0 + θ) = - cot θ

tan (360^0 - θ) = - tan θ

cot θ + tan (180^0 + θ) + tan (90^0 + θ) + tan (360^0 - θ)

cot θ + tan θ - cot θ - tan θ = 0

Assignment

1 Given sin 30^0 = 1/2, find the value of tan 60^0

2 If cos θ = 4/5, find the other radios

3 If sin A = 3/5, find cos θ, tan θ & sec θ

4 If tan θ = 24/7, find sin θ and cos θ

5 Find the value of cos θ and tan θ, if sin θ = 1/2

6 If cos θ = 5/13, find the value of tan θ

7 If sin θ = 1/2, find the value of $\sin^2\theta - \cos^2\theta$

8 What is the value of

$$\frac{\sin^2 30^\circ}{\cos^2 45^\circ} + \frac{\tan 45^\circ}{\sec 60^\circ} - \frac{\sin 60^\circ}{\cot 45^\circ} - \frac{\cos 30^\circ}{\sin 90^\circ}$$

Simplify :

1 tan (90 + A) + (tan 180 + A) tan (90 + A)

2 $$\frac{\cos(90+\theta)\cdot\sec(-\theta)\cdot\tan(180-\theta)}{\sec(360+\theta)\cdot\sin(180+\theta)\cdot\cot(90+\theta)}$$