WORKSHOP CALCULATION & SCIENCE

(NSQF)

(As per Revised Syllabus July 2022)

Stone Mining Machine Operator

Directorate General of Training

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

NATIONAL INSTRUCTIONAL MEDIA INSTITUTE, CHENNAI

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Workshop Calculation & Science

Stone Mining Machine Operator - NSQF

As per Revised Syllabus July 2022

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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 - Stone Mining Machine Operator** 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 Director General of Training, Executive Director & Staff of NIMI and members of Media Development Committee deserve appreciation for their contribution in bringing out this publication.

Jai Hind

ATUL KUMAR TIWARI, ***I.A.S.***
Secretary
Ministry of Skill Development & Entrepreneurship,
Government of India.

December 2023
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** - Stone Mining Machine Operator 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** - Stone Mining Machine Operator 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 - Stone Mining Machine Operator** as per NSQF Revised 2022.

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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 - 1 Year : 32 Hrs

Time allotment for each title of exercises has been given below. **Workshop Calculation & Science - Stone Mining Machine Operator** 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 - 1.2.13	4
3	Material Science	1.3.14 - 1.3.18	6
4	Mass, Weight, Volume and Density	1.4.29	2
5	Speed and Velocity, Work, Power and Energy	1.5.20	2
6	Heat & Temperature and Pressure	1.6.21 - 1.6.23	2
7	Basic Electricity	1.7.24 - 1.7.26	2
8	Mensuration	1.8.27 - 1.8.31	8
9	Levers and Simple machines	1.9.32	2
		Total	**32 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 **Duration: 1 Year**

Workshop Calculation & Science - Stone Mining Machine Operator
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 Percentage 6 Percentage - Changing percentage to decimal and fraction	4
III	**Material Science** 1 Types of metal, types of ferrous and non ferrous metals 2 Physical and Mechanical Properties of metals 3 Introduction of iron and cast iron 4 Difference between iron & steel, alloy steel 5 Properties and uses of insulating materials	6
IV	**Mass, Weight, Volume, and Density** 1 Mass, volume, density, weight and specific gravity	2
V	**Speed and Velocity, Work Power and Energy** 1 Work, power, energy, HP, IHP, BHP and efficiency	2

S.No.	Title	Time in Hrs
VI	**Heat & Temperature and Pressure** 1 Concept of heat and temperature, effects of heat, difference between heat and temperature, boiling point & melting point of different metals and non-metals 2 Scales of temperature, Celsius, Fahrenheit, Kelvin and Conversion between scales of temperature 2 Concept of pressure - Units of pressure	2
VII	**Basic Electricity** 1 Introduction and uses of electricity 2 Ohm's Law, relation between VIR & related problems 3 Electrical Power, HP, Energy and units of electrical energy	2
VIII	**Mensuration** 1 Area and perimeter of square, rectangle and parallelogram 2 Area and Perimeter of triangles 3 Area and Perimeter of circle, semi-circle, circular ring, sector of circle, hexagon and ellipse 4 Surface area and Volume of solids - cube, cuboid, cylinder, sphere and hollow cylinder 5 Finding the lateral surface area, total surface area and capacity in litres of hexagonal, conical and cylindrical shaped vessels	8
IX	**Levers and Simple Machines** 1 Levers & Simple Machines - Lever and its types	2
	Total	**32**

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

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

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

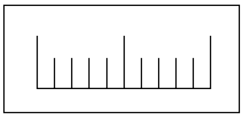
Prefixes for decimal multiples and submultiples

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

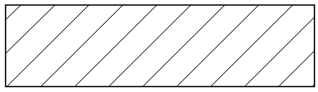


UNITS OF LENGTH

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

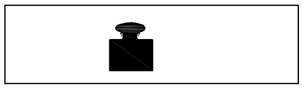
1 Cent = 436 Sq. ft.
1 Ground = 2400 Sq.ft.

1 Hectare = 2.47 acres

1 acre = 0.4047 Hectare

1 Hectare = 10000 sq. metre

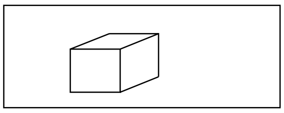
Units of weight



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

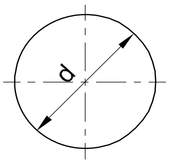
Units of volume and capacity



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

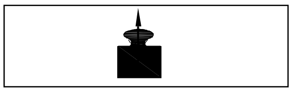
Relationship between Radian and Degree

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

180^0 $= \pi$ Radian;

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

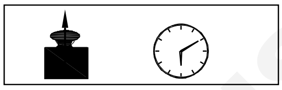
Work



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

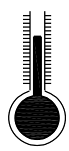
Pressure

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



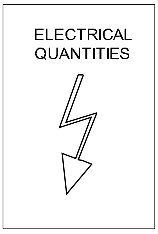
$$\frac{°R}{80} = \frac{°C}{100} = \frac{K-273}{100} = \frac{°F-32}{180}$$

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.

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

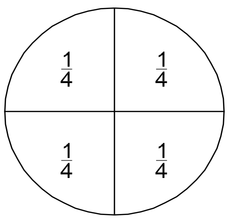
1,3,7 - numerators 4,12 - denominators

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)

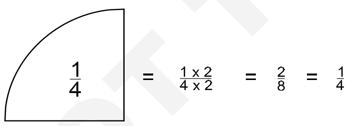
Fig 1



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)

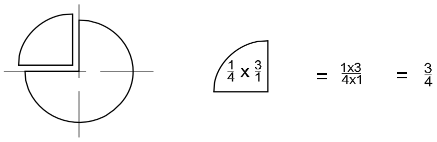
Fig 2



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)

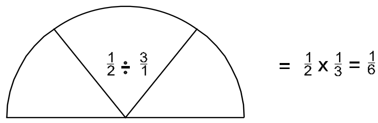
Fig 3



Division

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

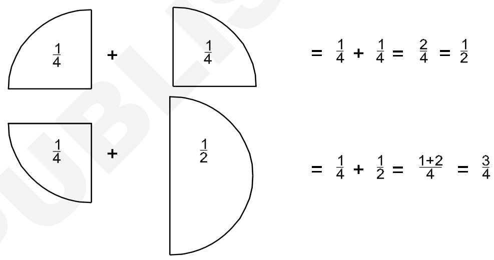
Fig 4



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 $\frac{3}{4}$,

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

- 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

2	2,8,12
2	1,4,6
	1,2,3

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 $\frac{4}{7}=\frac{3}{8}\times\frac{4}{7}=\frac{3}{14}$ b $\frac{2}{3}\times\frac{3}{4}\times\frac{5}{8}=\frac{5}{16}$

- Division

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

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

- 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 $\frac{2}{3} = \frac{1}{12} \times$ ________

b $\frac{14}{24} = \frac{1}{12} \times$ ________

c $\frac{7}{8} = \frac{1}{12} \times$ ________

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

$$0.25\overline{)0.75}$$

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

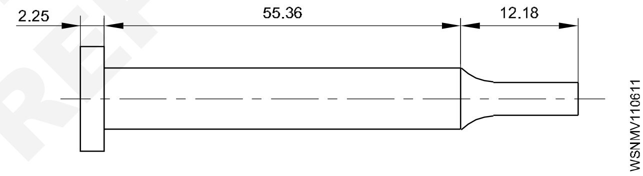
$$25\overline{)75} = 3$$

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 — 0.3
  8 - IInd decimal place — 0.08
  6 - IIIrd decimal place — 0.006

- 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

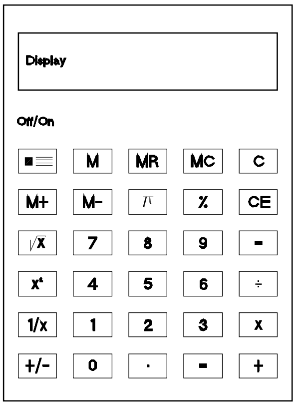
Unit, Fractions - Solving problems by using calculator

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

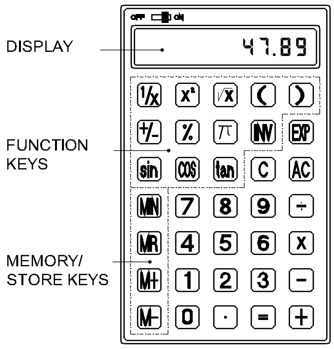
[M+] The displayed value is added to the memory

[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

WSNMV110712

[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, benzene 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

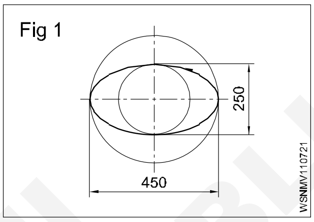


Fig 1

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

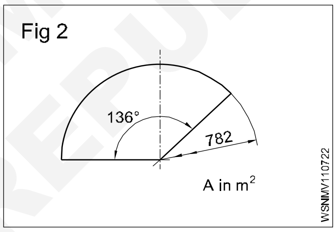


Fig 2

ø = 782 mm

α = 136°

Area of the sector

A = ______

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

9

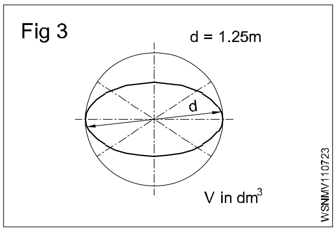


Fig 3

d = 1.25 metre

V = ______ dm^3

Volume of sphere

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

10

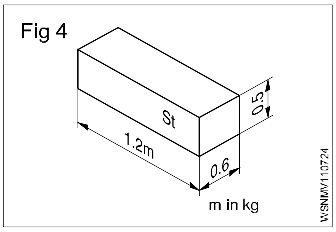


Fig 4

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

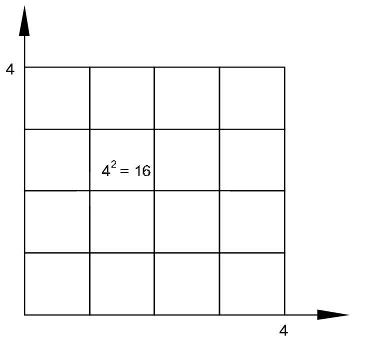
The square of a number is the number multiplied by itself.

Basic number x basic number = Square number

$a \times a = a^2$

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

Fig 1



Splitting up (Fig 2)

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

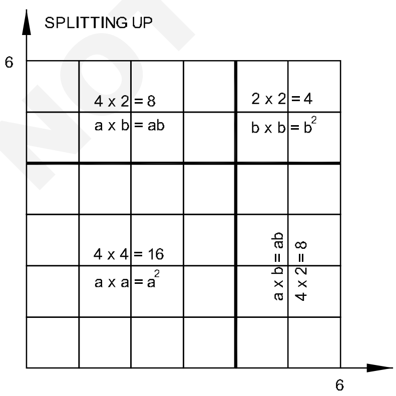
Two rectangles 2 x 4 x 2 = 16 $2ab$

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

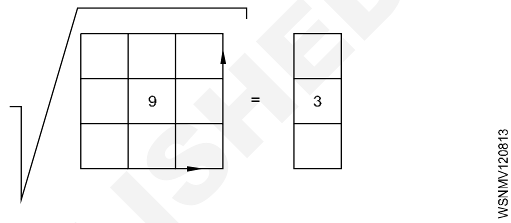


Result: In order to find the square root, we split up the square numbers.

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

$\sqrt{4624} = 68$

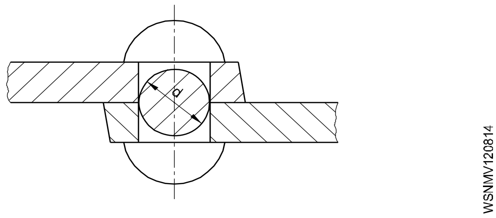
Basic number x basic number = Square

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

Example

The cross-section of a rivet is 3.46 cm². Calculate the diameter of the hole.

Fig 4



Rivet cross-section is the hole cross-section.

To find 'd',

Given that Area = 3.46 cm²

Area = 0.785 x d^2 (formula)

3.46 cm² = $d^2 \times 0.785$

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

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

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

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

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

b $\sqrt{45796}$ = ____________.

c $\sqrt{8.2944}$ = ____________.

d $\sqrt{63.845}$ = ____________.

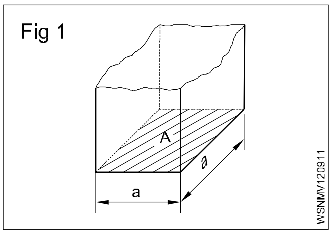
2 

Fig 1

A = 2025 mm^2
a = ____________mm

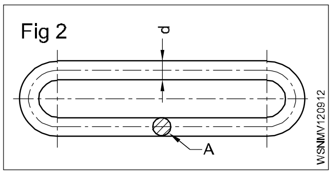
3 

Fig 2

A = 176.715 mm^2

d = ____________mm

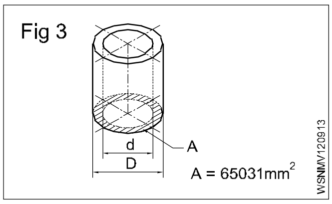
4 

Fig 3

A = 65031 mm^2

d = 140 mm

D = ____________mm

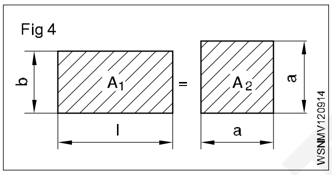
5 

Fig 4

l = 58 cm

b = 45 cm

$A_1 = A_2$

a = ____________cm

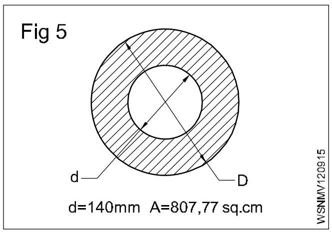
6 

Fig 5

A = 807.77 cm^2

d = 140 mm

D = ____________mm

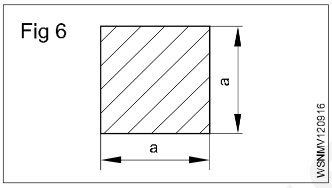
7 

Fig 6

a x a = 543169 mm^2

a = ____________mm

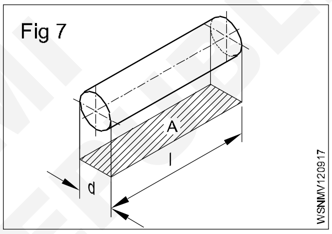
8 

Fig 7

d : l = 1:1.5

A = 73.5 mm^2

d = ____________mm

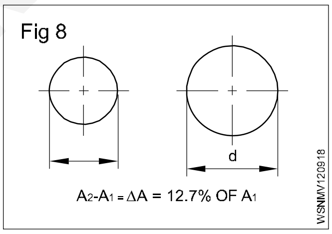
9 

Fig 8

increase in area

A = 12.7%

A = 360 mm^2

d = ____________mm

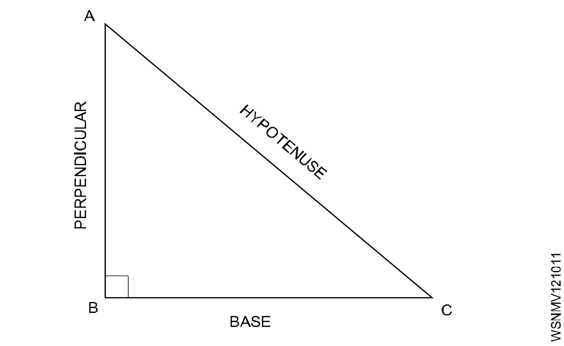
(d = diameter after the increase in area)

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 first floor.

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.

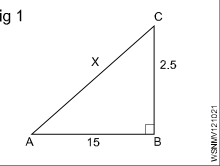
$AC^2 = AB^2 + BC^2$

$= 15^2 + 25^2$

$= 225 + 625 = 850$

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

Fig 1



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

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

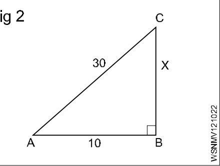
$30^2 = 10^2 + BC^2$

$900 = 100 + BC^2$

$BC^2 = 900 - 100 = 800$

$BC = 28.284$ cm

Fig 2



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

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

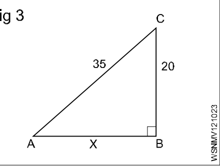
$35^2 = AB^2 + 20^2$

$1225 = AB + 400$

$AB^2 = 1225 - 400 = 825$

$AB = 28.72$ cm

Fig 3



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

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

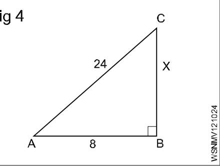
$24^2 = 8^2 + BC^2$

$576 = 64 + BC^2$

$BC^2 = 576 - 64 = 512$

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

Fig 4



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

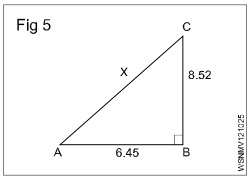
$AC^2 = AB^2 + BC^2$

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

$AC^2 = 41.60 + 72.59$

$= 114.19$

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



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

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

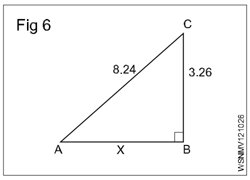
$8.24^2 = AB^2 + 3.26^2$

$67.9 = AB + 10.63$

$AB^2 = 67.9 - 10.63$

$= 57.27$

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



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

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

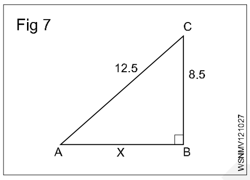
$12.5^2 = AB^2 + 8.5^2$

$156.25 = AB + 72.25$

$AB^2 = 156.25 - 72.25$

$= 84$

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

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

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

$BC^2 = x^2$

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

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

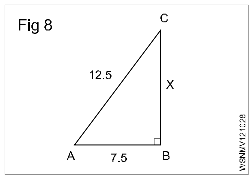
$x^2 = (12.5)^2 - (7.5)^2$

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

$= 20 \times 5$

$= \sqrt{100} = 10$

$x = 10$ m



9 What is the value of AB.

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

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

$AB^2 = x^2$

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

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

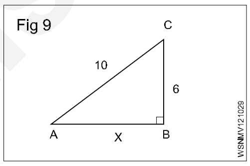
$x^2 = 10^2 - 6^2$

$= 100 - 36 = 64$

$x = \sqrt{64}$

$= 8$

$AB = 8$



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.

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

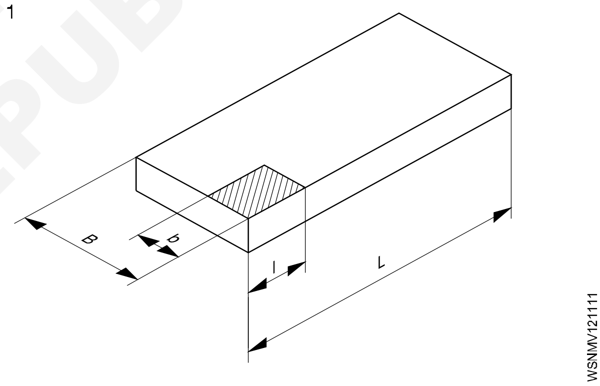
- 3 x 8 = 6 x 4
- $\frac{3}{6} = \frac{4}{8}$
- $\frac{4}{3} = \frac{8}{6}$
- $\frac{3+4}{4} = \frac{6+8}{8}$
- $\frac{3-4}{4} = \frac{6-8}{8}$
- $\frac{3+6}{4+8} = \frac{9}{12} = \frac{3}{4}$

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



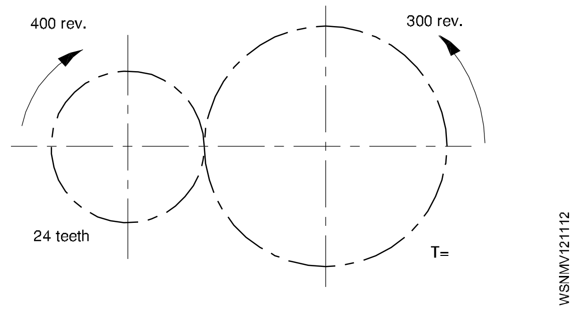
The reduction ratio is $\frac{1}{20}$.

B is reduced from 800 = 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

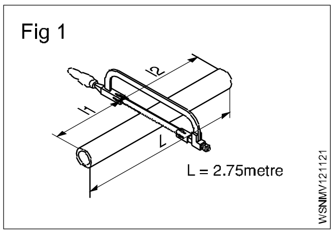
B:C = 4:5

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

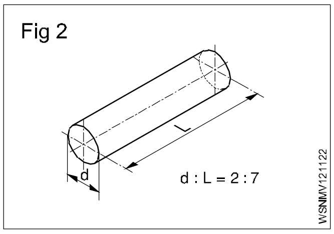
1 

$l_1 : l_2 = 2:3$

L = 2.75 metres

l_1 = ______ metres

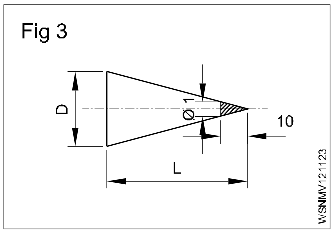
l_2 = ______ metres

2 

d: L of shaft = 2:7

d = 40 mm

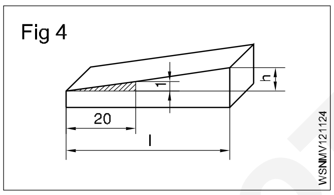
L = ______ mm

3 

D : L=1:10

L=150mm

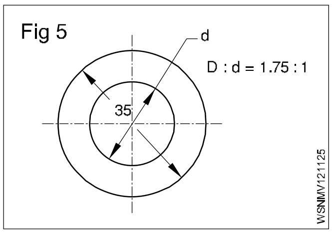
D=______ mm

4 

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

l = 140 mm

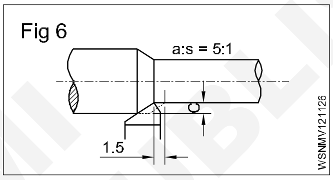
Δh = _____ mm

5 

D : d = 1.75: 1

D = 35 mm

d = ______ mm

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 - Percentage

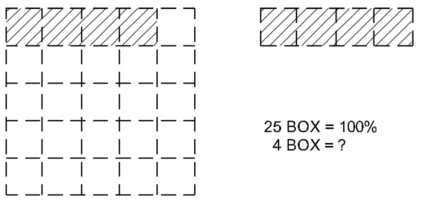
Percentage

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)

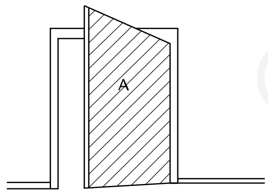
Fig 1



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%.

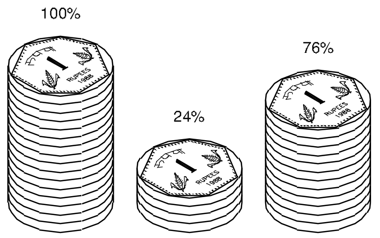
Analyse the given data and proceed to arrive at the answer through the unit.

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

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

= 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

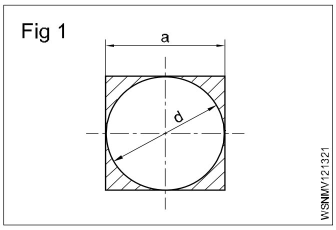
Percentage of saving = Decrease in consumption/Original consumption x 100

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

$$= \frac{10}{100} \text{ x } 100$$

= 10% Saving in fuel.

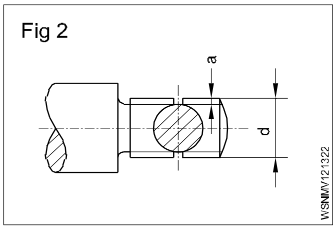
Assignment

1 

a = 400mm (side of square)

d = 400 mm

Wastage = ______ %.

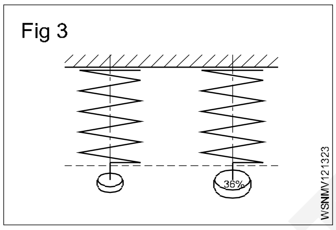
2 

d = 26mm

'a' depth of u/cut = 2.4mm

reduction of area at cross-section

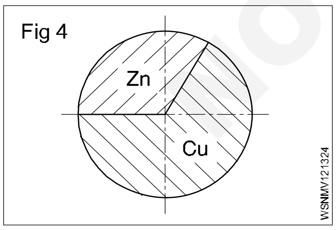
= ______ %

3 

Percentage of increase = 36%

Value of increase = 611.2 N/mm^2

Original tensile strength = ______ N/mm^2.

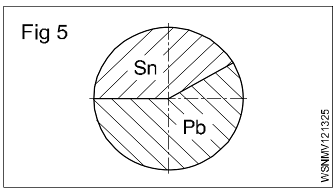
4 

Copper in alloy = 27 kg

Zinc in alloy = 18 kg

% of Copper = _______ %

% of Zinc = _______%.

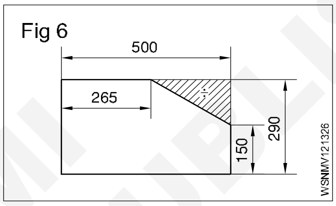
5 

Weight of alloy = 140 Kgf

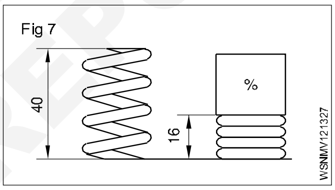
Weight of Sn 40%

Pb = ______ Kgf

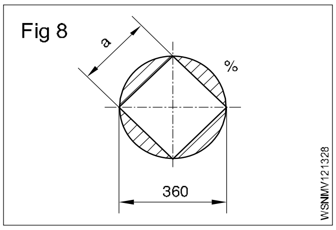
Sn = ______ Kgf.

6 

Shaded portion = ______ %.

7 

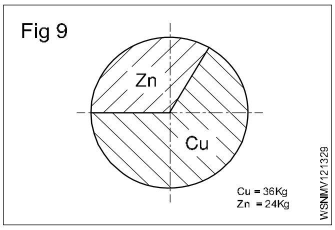
Compression length = ______ %.

8 

d = 360 mm

a = 0.707 x d

Wastage = ______ %.

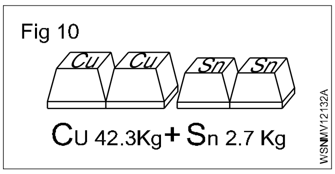
9 

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: $\frac{1}{2} \times 100$

$= 50\%$

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

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

$= 9.01\%$

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:

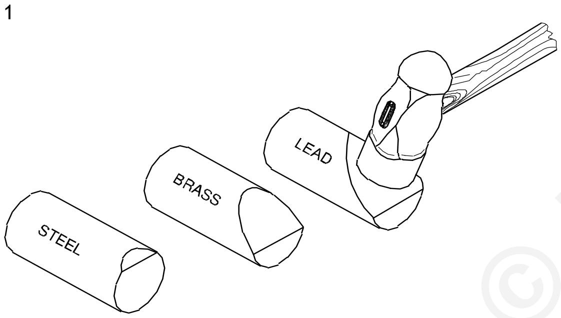
Metal is a mineral used in all types of engineering works such as machineries, bridges, aero planes etc., so we must have basic knowledge about the metals.

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.

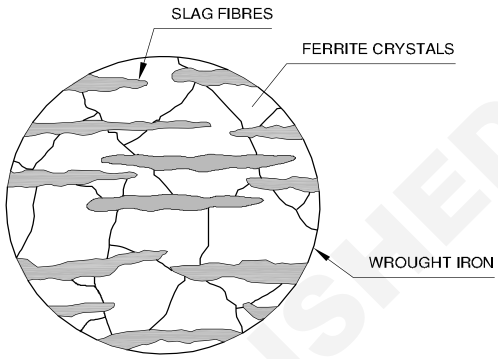
Weight

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)

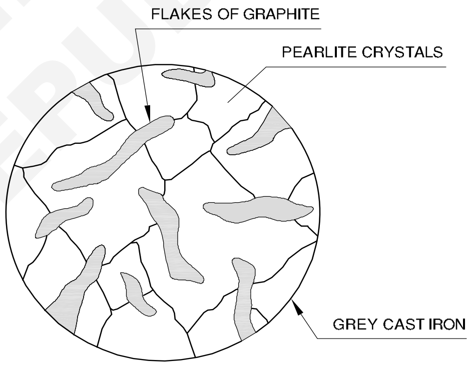
Generally metals can also be differentiated by their internal structures while seeing the cross-section of the bar through a microscope. Metals like wrought iron and aluminium have a fibrous structure and metals like cast Iron and bronze have a granular structure.

Fig 2



FERRITE GIVES DUCTILITY AND SLAG FIBRES IMPROVE CORROSION RESISTANCE

Fig 3



FLAKES OF GRAPHITE REDUCE STRENGTH AND IMPROVE MACHINEABILITY

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

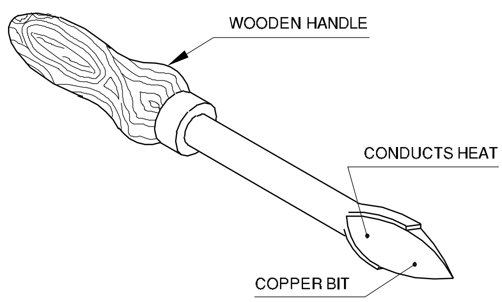
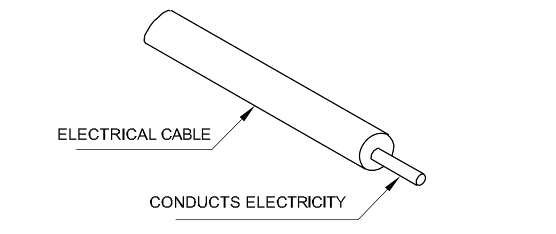


Fig 5



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.

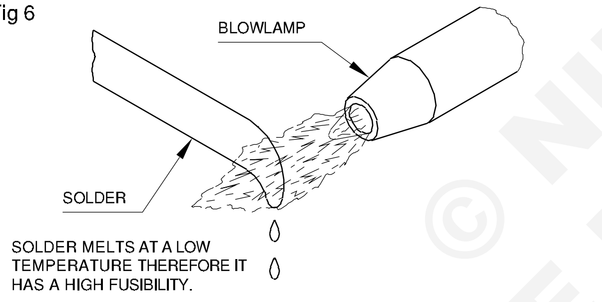
Fusibility (Fig 6)

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



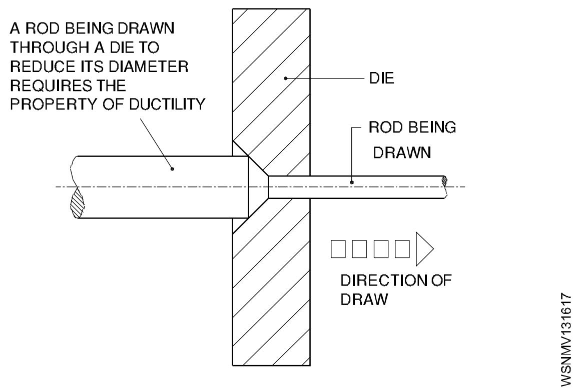
Mechanical properties

- 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

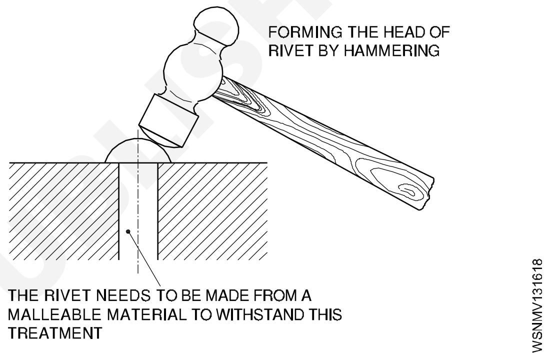
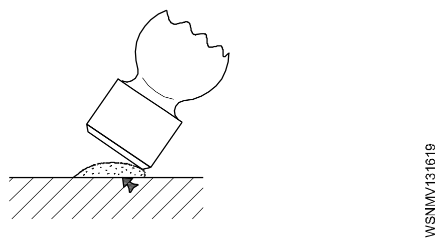


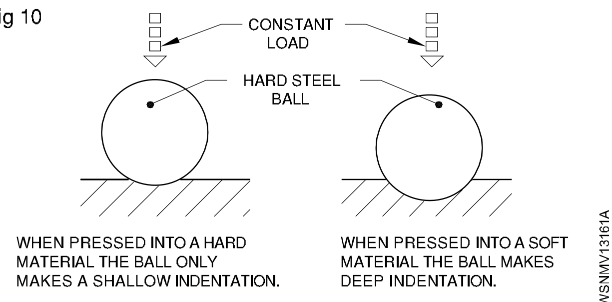
Fig 9



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.

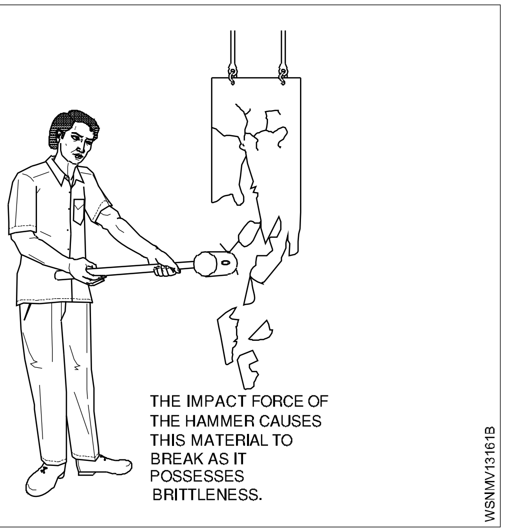
Fig 10



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.

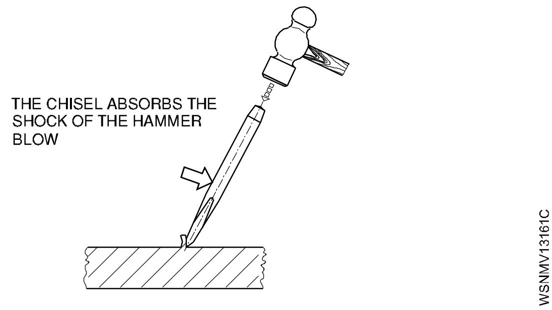
Fig 11



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 - Introduction of iron and cast iron

Ferrous Metals

Metals which contain iron as a major content are called ferrous metals. Ferrous metals of different properties are used for various purposes.

Introduction of Iron, Cast Iron, wrought Iron and steel

The ferrous metals and alloys used commonly are:

- Pig-iron
- Cast Iron
- Wrought Iron
- Steels and Alloy steels

Different processes are used to produce iron and steel.

Pig-iron (Manufacturing process)

Pig-iron is obtained by the chemical reduction of iron ore. This process of reduction of the iron ore to Pig-iron is known as SMELTING.

The main raw materials required for producing Pig-iron are:

- Iron ore
- Coke
- Flux

Iron ore

The chief iron ores used are:

- magnetite
- hematite
- limonite
- carbonite.

These ores contain iron in different proportions and are naturally available.

Coke

Coke is the fuel used to give the necessary heat to carry on the reducing action. The carbon from the coke in the form of carbon monoxide combines with the iron ore to reduce it to iron.

Flux

This is the mineral substance charged into a blast furnace to lower the melting point of the ore, and it combines with the non-metallic portion of the ore to form a molten slag.

Limestone is the most commonly used flux in the blast furnace.

Properties and use of Pig-iron

Pig-iron is, therefore, refined and remelted and used to produce other varieties of iron and steel.

Cast Iron (Manufacturing process)

The pig-iron which is tapped from the blast furnace is the crude form of raw material for the cupola, and should be further refined for making castings. This refining is carried out in the cupola furnace which is a small form of a blast furnace.

Generally cupolas are not worked continuously like blast furnaces but are run only as and when required.

Cast Iron (Types)

Cast iron is an alloy of iron, carbon and silicon. The carbon content ranges from 2 to 4%.

Types of cast iron

The following are the types of cast iron.

- Grey cast iron
- White cast iron
- Malleable cast iron
- Nodular cast iron

Grey cast iron

This is widely used for the casting of machinery parts and can be machined easily.

Machine base, tables, slideways are made of cast iron because it is dimensionally stable after a period of aging.

Because of its graphite content, cast iron provides an excellent bearing and sliding surface.

The melting point is lower than that of steel and as grey cast iron possesses good fluidity, intricate casting can be made.

Grey cast iron is widely used for machine tools because of its ability to reduce vibration and minimize tool chatter.

Grey cast iron, when not alloyed, is quite brittle and has relatively low tensile strength. Due to this reason it is not used for making components subjected to high stress or impact loads.

Grey cast iron is often alloyed with nickel, chromium, vanadium or copper to make it tough.

Grey cast iron is weldable but the base metal needs preheating.

White cast iron

This is very hard and is very difficult to machine, and for this reason, it is used in components which should be abrasion-resistant.

White cast iron is produced by lowering the silicon content and by rapid cooling. When cooled in this manner, it is called chilled cast iron.

White cast iron cannot be welded.

Malleable cast iron

Malleable cast iron has increased ductility, tensile strength and toughness when compared with grey cast iron.

Malleable cast iron is produced from white cast iron by a prolonged heat-treatment process lasting for about 30 hours.

Nodular cast iron

This is very similar to malleable cast iron. But this is produced without any heat treatment. Nodular cast iron is also known as: **Nodular Iron - Ductile Iron - Spheroidal Graphite Iron**

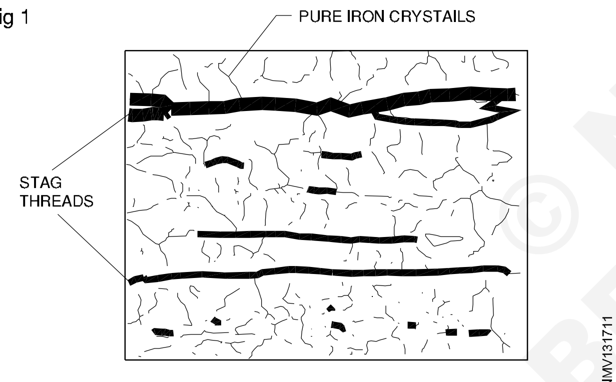
This has good machinability, castability, resistance to wear, low melting point and hardness.

Malleable and nodular castings are used for machine parts where there is a higher tensile stress and moderate impact loading. These castings are less expensive and are an alternative to steel castings.

Wrought Iron (Manufacturing process) (Fig 1)

Wrought iron is the purest form of iron. The analysis of Wrought iron shows as much as 99.9% of iron. (Fig 1) When heated, wrought iron does not melt, but only becomes pasty and in this form it can be forged to any shape.

Fig 1



MICROSTRUCTURE OF WROUGHT IRON

Modern methods used to produce wrought iron in large quantities are the

- puddling process
- aston or Byers process

Steel

This is pure iron. Carbon content is more. Due to excessive carbon it is harder and tougher. Carbon content is from 0.15 to 1.5%. Besides there are other impurities like sulphur, phosphorous etc. are there which cannot be separated. This is hardened and tempered by heating it to a definite temperature and cooling it in oil or water.

The following methods are adopted for making different types of steel:

1 Cementation process	2 Crucible process
3 Bessemer process	4 Open hearth process
5 Electro thermo process	6 High frequency process.

Types of steel

Main two types of steel are:

1 Plain steel

2 Alloy steel

1 Plain steel. In this carbon and iron are mixed. According to the percentage of carbon plain steels are classified as:

A Low carbon steel

B Medium carbon steel

C High carbon steel

A Low carbon steel: It is also called mild steel. In this. the percentage of carbon is from 0.15%to0.25%. Due to less quantity of carbon is sufficiently soft and tolerates the strain. It can be put in different shapes through forging and rolling. This is not very hard or strong. This cannot be hardened or tempered by ordinary methods. Nuts, bolts, rivets, sheets, wires, T-iron and angle iron etc. are made out of it.

B Medium carbon steel: The carbon content is from 0.25% to 0.5%. Due to excess of carbon, it is harder and tougher than mild steel. The tenacity is more. This can be hardened or tempered. Various things are made by forging and rolling. This is used for making high tensile tubes, wires, agricultural implements, connecting rods, cam shafts, spanners, pulleys etc.

C High carbon steel: It has carbon content from 0.5% to 1.5%. It is very hard and wears least. This can be hardened by heat treatment. This can neither be cast nor rolled. This is very hard and tough. It acquires permanent magnetic properties. This is used for making pointed tools, springs, pumps, files, cutleries, cold chisels press die etc.

2 Alloy Steel

When the steel is mixed with other metals like vinoleum, manganese tungsten etc., it is called an alloy steel. Alloy steel has properties of its ingredients.

Types of Alloy Steel

Two types of alloy steel are:

A Low alloy steel

B High alloy steel

A Low Alloy steel: Besides carbon other metals are in lesser quantity. Its tensile strength is more. The welding can work on it. This can also be hardened and tempered. It is used in manufacturing various parts of an aeroplane and cam shaft etc.

B High Alloy Steel: Besides carbon it has a high percentage of the metals higher than low steel alloy. This is classified into following types:

a **High Speed Steel:** It is also called high tungsten alloy steel because it has more quantity of tungsten. According to the quantity of tungsten it is classified into three types:

1 Tungsten 22%, Chromium4%, Vanadium 1%

2 Tungsten 18%, Chromium 4%, Vanadium 1%

3 Tungsten 14%, Chromium 4%, Vanadium 1%

Cutting tools are made out of it because it is very hard but becomes soft at low critical temperature. This temperature is raised out of cutting process of tool, then the cutting tool becomes useless and is unfit for work. But due to high percentage of tungsten it keeps working upto high temperature. It is used for cutting tools, drills, cutters, reamers, hacksaw blades etc.

b **Nickel Steel:** In this 0.3% carbon and 0.25 to 0.35% nickel is present. Due to nickel its tensile strength, elastic limit and hardness is increased. It does not catch rust. Its cutting resistance increases 6 times more than plain carbon and steel due to 0.35% nickel present in it. This is used for making rivets, pipes, axle shafting, parts of buses and aeroplanes. If 5% of cobalt is mixed with 30-35% nickel, it becomes invar steel. It is mainly used for making precious instruments.

c **Vanadium Steel:** It contains 1.5% carbon 12.5% tungsten, 4.5% chromium, 5% vanadium and 5% cobalt. Its elastic limit, tensile strength and ductility is more. It has strength to bear sharp jerks. It is mainly used to manufacture of tools.

d **Manganese Steel:** It is also called special high alloy steel. It contains 1.6 to 1.9% of manganese and 0.4 to 0.5% carbon. It is hard and less wear. It is not affected by magnet. It is used in grinders and rail points etc.

e **Stainless Steel:** Along with iron it contains 0.2 to 90.6% carbon, 12 to 18% chromium, 8% nickel and 2% molybdenum. It is used for making knives, scissors, utensils, parts of aeroplane, wires, pipes and gears etc.

Properties of stainless steel:

1 Higher corrosion resistance

2 Higher cryogenic toughness

3 Higher work hardening rate

4 Higher hot strength

5 Higher ductility

6 Higher strength and hardness

7 More attractive appearance

8 Lower maintenance

f **Silicon Steel:** It contains 14% of silicon. Its uses are multifarious according to the percentage of silicon. 0.5% to 1% silicon, 0.7 to 0.95% manganese mixture is used for construction work. 2.5 to 4% silicon content mixture is used for manufacturing electric motors, generators, laminations of transformers. In chemical industries 14% silicon content mixture is used.

g **Cobalt Steel:** High carbon steel contains 5 to 35% cobalt. Toughness and tenacity is high. It has magnetic property therefore used to make permanent magnets.

Material science - Difference between iron & steel, alloy steel

Difference between iron and steel:

S.No	Basic distinction	Iron	Steel
1	Formation	Pure substance	Made up of iron and carbon
2	Types	Cast iron, Wrought iron and steel	Carbon steel and alloy steel
3	Rusting	Quickly gets oxidised and result in rust	Have different elements that protect from rusting
4	Surface	Its surface is rusty	Its surface stays shiny
5	Usage	Used in buildings,tools and automobiles	Used in buildings, cars, railways and automobiles
6	Existence	Available in nature	Has to be formed

Steel Plants in India

S.No	Name of the Steel plant	State
1	Tata Iron	Bihar
2	Indian Iron Steel	West Bengal
3	Vishweshvaraiah Iron Steel	Karnataka
4	Bhilai Steel Plant	Chhattisgarh
5	Durgapur Steel Plant	West Bengal
6	Alloy Steel Plant (Durgapur)	West Bengal
7	Bokaro Steel Plant	Bihar
8	Rourkela Steel Plant	Orissa
9	Salem Steel Plant	Tamilnadu
10	Visakhapatnam Steel Plant	Andhra Pradesh

Comparison of the Properties of Cast Iron, Mild Steel and steel

Property	Cast Iron	Mild Steel	Steel
Composition	Carbon contents from 2 to 4.5%	Carbon contents from 0.1 to 0.25%	Carbon contents from 0.5 to 1.7%
Strength	- High compressive strength - Poor tensile strength - Poor shearing strength	- Moderate compressive strength - Moderate tensile strength - High shearing strength	- High compressive strength - High tensile strength - High shearing strength
Malleability	Poor	High	High
Ductility	Poor	High	High
Hardness	Moderately hard and can be hardened by heating to hardening temperature and quenching	Mild	Hard
Toughness	Possesses poor toughness	Very tough with carbon content	Toughness varies
Brittleness	Brittle	Malleable	Malleable
Forgeability	Cannot be forged	Can be forged	Can be forged
Weldability	Cannot be welded with difficulty	Can be welded very easily	Can be welded
Casting	Can be easily cast	Can be cast but not easily	Can be cast
Elasticity	Poor	High	High

Ferrous metals	Non Ferrous metals
1 Iron content is more	1 Iron content is missing
2 The melting point is high	2 The melting point is low.
3 This is of brown and black colour	3 This is of different colours
4 This catches rust	4 This doesn't catch rust.
5 This can be magnetised	5 This cannot be magnetised
6 This is brittle in cold state.	6 This becomes brittle in hot state.

Difference between cast Iron and steel

Cast Iron	Steel
1 Carbon content is high	Carbon content is less
2 Carbon is in free state	Carbon is mixed
3 Melting point is low	Melting point is high
4 It cannot be magnetised	It can be magnetised
5 Because it is brittle, it cannot be forged	In can be forged
6 It rusts with difficulty	It rusts quickly
7 It cannot be welded	It can be welded

Difference between metals and non-metals

Metals	Non Metals
Shiny	Dull
Usually good conductors of heat and electricity	Usually poor conductors of heat and electricity
Most are ductile	Not ductile
Opaque (opposite of 'transparent')	Transparent when as a thin sheet
Most are malleable	Usually brittle when solid
Form alkaline oxides	Form acidic oxides
Sonorous (make a bell -like sound when struck)	Not sonorous
Usually have 1-3 valence electrons	Usually have 4-8 valence electrons
Most corrode easily	
Usually high melting point (usually solid at room temperature except for mercury)	

Difference between Carbon steel and alloy steel

Carbon Steel	Alloy Steel
1 Melting point is low	Melting point is high
2 Easy to work	Hard to work
3 Uniform hardness is not obtained	Uniform hardness is achieved
4 Cutting tool blunt at high temperature during operation	Cutting tool does not blunt at high temperature during operation
5 Rust easily	Does not rust easily
6 Corrosion in acid	Does not corrosion in acid
7 Magnetically attracted	Not attractive by magnetism
8 Low cost	High cost

Material science - Properties and uses of insulating materials

Properties and uses 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 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.)

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

Mass, Weight, Volume and Density - Mass, volume, density, weight and specific gravity

Mass

Mass of a body is the quantity of matter contained in a body. The unit of mass in F.P.S system is pound (lb), in C.G.S. system gram (gr) and in M.K.S and S.I systems kilogram (kg). 1ton which is 1000 kg is also used sometimes. The conversion factor is 1000. Three decimal places are shifted during conversion.E.g.1 ton = 1000 kg 1g = 1000mg.

m - mass of a body

g - acceleration due to gravity in metre/sec^2 = 9.81 m/sec^2

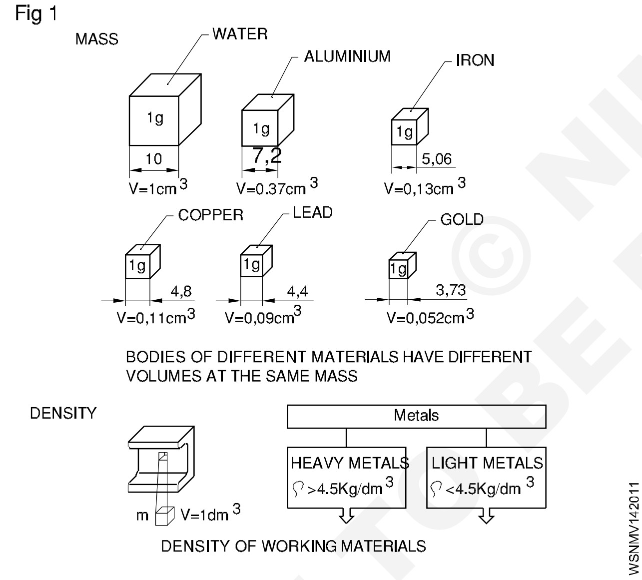
V - volume of the body

ρ - density (pronounced as `rho')

W or FG - weight or weight force

Mass (Fig 1)

Fig 1



Density

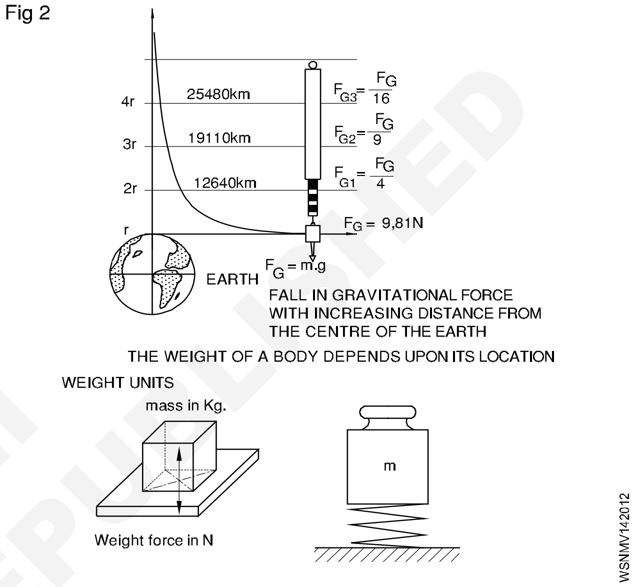
Density is the mass of a body per unit volume. Hence its unit will be gr/cm^3 or kg/dm^3 or ton/m^3.

$$\text{Density} = \frac{\text{mass}}{\text{volume}} = \frac{m}{v} = \rho$$

Weight (Fig 2)

Weight is the force with which a body is attracted by the earth towards its centre. It is the product of the mass of the body and the acceleration due to gravity. The weight of a body depends upon its location.

Fig 2



weight = W or FG = mass x gravitational force
= m x g

System	Absolute unit	Derived unit	Conversion
F.P.S. system	1 poundal	1 Lb wt	32.2 poundals (1 lb x 1 ft/sec^2 = 1 pound)
C.G.S. system	1 dyne 1 gr x 1 cm/sec^2	1 Gr.wt	981 dynes
M.K.S.	Newton	1 kg.wt	1 Newton =
S.I.system	Newton	Newton	1 kg x 1 m/sec^2

1 kg.wt = 9.81 Newton (approximately 10N)   1 Newton = 10^5 dynes.

Difference between mass and weight

S. No	Mass	Weight
1	Mass is the quantity of matter in a body (ie) measurement of matter in a body	Weight is measure of amount of force acting on mass due to acceleration due to gravity
2	It does not depend on the position or space	It depends on the position, location and space
3	Mass of an object will not be zero	Weight of an object will be zero if gravity is absent
4	It is measured using by physical balance	It is measured using by spring balance
5	It is a scalar quantity	It is a vector quantity
6	When immersed in water mass does not change	When immersed in water weight will change
7	The unit is in grams and kilogram	The unit is in kilogram weight, a unit of force

Mass and weight are different quantities.

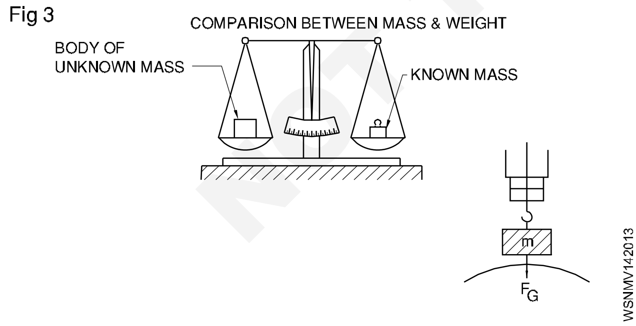
Mass of a body is equal to volume x density.

Weight force is equal to mass x acceleration due to gravity.

Weight , Density and Specific gravity

It is now seen that the mass of a substance is measued by its weight only without any reference to volume. But if equal weights of lead & aluminium, are compared the volume of lead is much smaller than volume of aluminium. So we can now say that lead is more dense than aluminium,. i.e In other words the density of lead is greater than aluminium. (Fig 3 & 4)

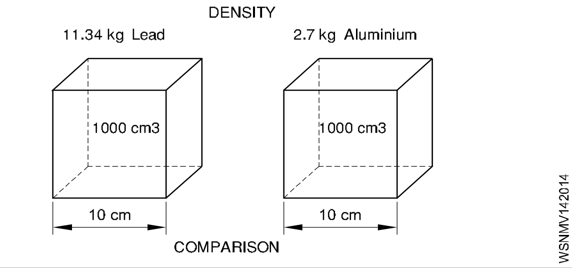
Fig 3



The relation of mass and volume is called density.

The density expresses the mass of volume E.g. 1 dm^3 of water has the mass of 1kg - thus the density of 1kg/dm^3 (Fig 2)

Fig 4



Unit

The density is measured as below

MKS/SI= Kg/m^3, CGS = 1 gm/cm^3 FPS = lbs/c ft

	Solids	gm/cc	Liquids	gm/cc
1	Aluminum	2.7	Water	1.00
2	Lead	11.34	Petrol	0.71
3	Cast iron	6.8 to 7.8	Oxygen	1.43
4	Steel	7.75 to 8.05	Diesel Oil	0.83

The specific gravity of a substance is also called its relative density.

Formula

$$\text{Specific gravity (or) Relative density} = \frac{\text{Density of the substance}}{\text{Density of the water at } 4^\circ C}$$

$$= \frac{\text{Mass of any volume of a substance}}{\text{Mass of an equal volume of water at } 4^\circ C}$$

Comparison Between Density And Specific Gravity (Relative Density)

Density	Relative density or Specfic gravity
Mass per unit volume of a substance is called its density	The density of substance to density of water at 4°C is its relative density
Its unit is gm per cu cm; lbs per cu.ft and kg/cubic meter	It has no unit of measurement simply expressed in a number
$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$	Relative density $= \frac{\text{Density of the substance}}{\text{Density of water at } 4^\circ C}$

	Solids	Sp.gy	Liquids	Sp.gy
1	Aluminium	2.72	Petrol	0.71
2	Lead	11.34	Battery acid	1.2 to 1.23
3	Cast iron	6.8 to 7.8	Water	1.00
4	Steel	7.82	Diesel Oil	0.83

From the above table, we can calculate the weight of any given volume of a substance (say Diesel oil) in any units provided we know the specific gravity of the substance. Also vice-versa for volume of density is known.

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.

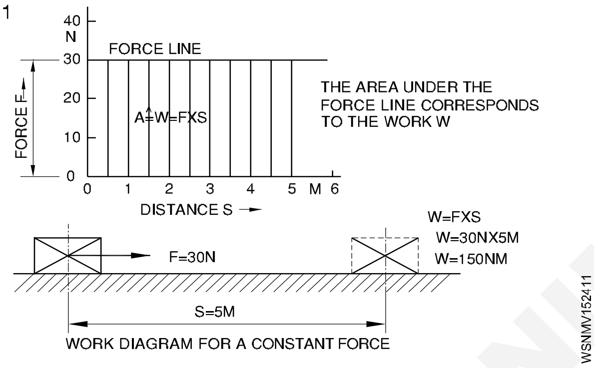
Work done 'W' = F x s.

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

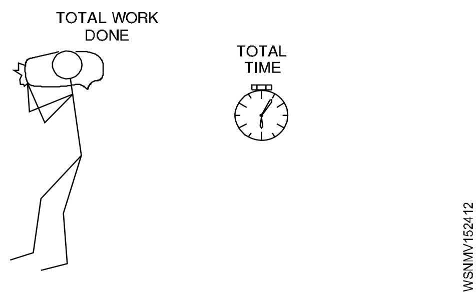
C.G.S. system 1 gm Wt x 1 cm = 981 ergs.

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.

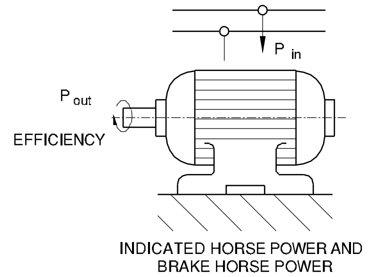
1HP (metric) = 735.5 Watts

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

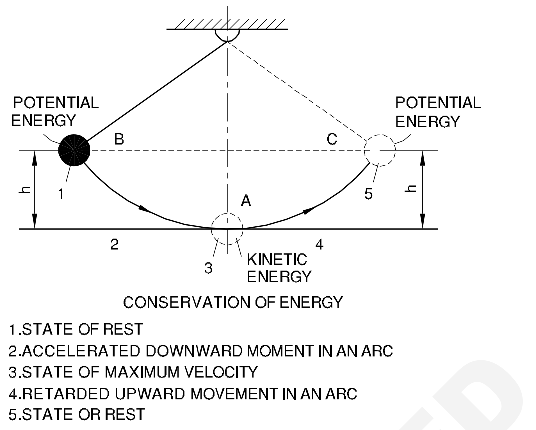
Mechanical energy, Electrical energy, Atomic energy, Heat energy, Light energy, Chemical energy, sound energy. Energy of one form can be transformed into energy of another form.

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) $= \frac{FxS}{t}$

$= \frac{775 \times 10}{60} = 129.17$N 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: $\eta = \frac{Output}{Input} \times 100\%$

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

Given data:

F = 500 tonnes = 500000 kg

S = 320 metres

t = 1 hour = 3600 sec

η = 0.75 = 75%

To find: Pump HP = ?

Solution:

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

(∵ 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

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

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

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

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:

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

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

= 28 H.P.

Input of the pump

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

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

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

Output of the motor = Input of the pump

Output = 35.9 H.P

Input of the motor

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

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

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

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

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

$\frac{90x6}{100}$ = 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: $\eta = \frac{B.H.P}{I.H.P} \times 100\%$

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

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

$\frac{80x50}{100}$ = B.H.P

B.H.P = 40

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

40 = 50 - F.H.P

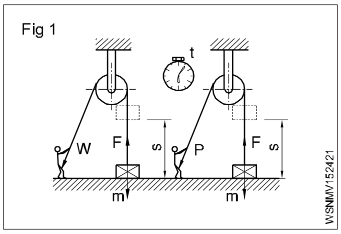
40 + F.H.P = 50

F.H.P = 50 - 40 = 10

Ans: Loss of friction = 10 H.P

Assignment

1



m= 55 kg

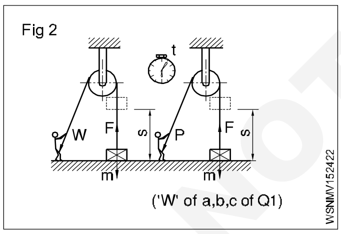
a) s = 1.82 metres
W = ______ joules

b) s = 1.40 metres
W= ____ joules

c) s = 0.85 metres

W =Joules

2



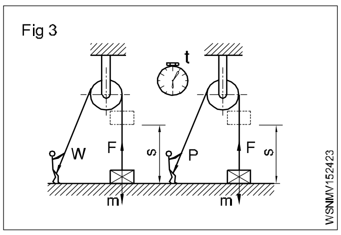
t = 8 secs

a) P = _____ Watts

b) P = _____ Watts

c) P = _____ Watts

3

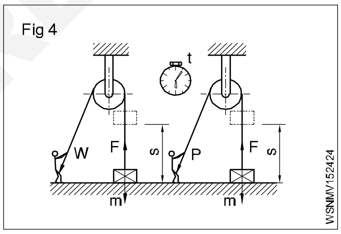


W = 1312.5 Joules

m = 350 kg

s = _____ metres

4



m = 75 kg

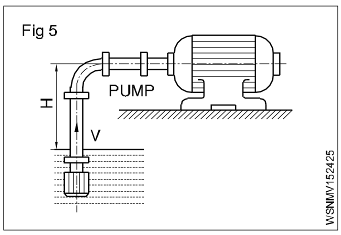
s = 100 metres

t = 12 secs

W = ______ N

P = ______ Watts

5



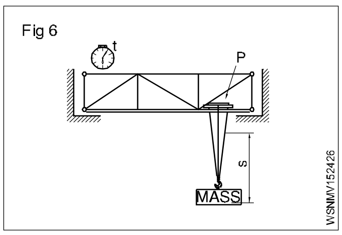
V = 1 m^3/min

H = 2 m

η = 0.75

Power input = ______ kW

6



P = 12 kw

s = 4 metres

t = 20 secs

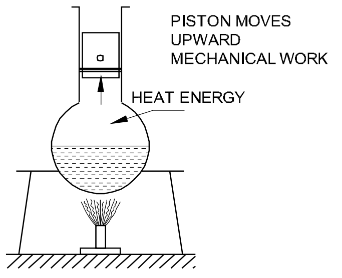
m = ______ kg

Heat & Temperature and Pressure - Concept of heat and temperature, effects of heat, difference between heat and temperature, boiling point & melting point of different metals and non-metals

Heat

It is a form of energy. Heat energy can be transformed into other forms of energies. Heat flows from a hotter body to a colder body. (Fig 1)

Fig 1



Units of heat

Calorie: It is the quantity of heat required to raise the temperature of 1 gram of water through 1°C.

BTHU: It is the quantity of heat required to raise 1 lb of water through 1°F. (British thermal unit).

C.H.U; It is the quantity of heat required to raise 1 lb of water through 1°C.

Joule : S.I. Unit (1 Calorie = 4.186 joule)

Effects of heat

- Change in temperature
- Change in size
- Change in state
- Change in structure
- Change in Physical properties

Specific heat

The quantity of heat required to raise the temperature of one gm of a substance through 1^0C is called specific heat. It is denoted by the letter 's'.

Specific heat of water	= 1
Aluminium	= 0.22
Copper	= 0.1
Iron	= 0.12

Thermal capacity:

It is the amount of heat required to raise the temperature of a substance through 1^0C is called the thermal capacity of the substance.

Thermal capacity = ms calories.

Calorific value: The amount of heat released by the complete combustion of unit quantity of the fuel (Mass or volume) is known as calorific value of fuels.

Water equivalent

It is the mass of water which will absorb the same amount of heat as the given substance for the same temperature rise. Water equivalent = Mass of the substance x specific heat of the substance.

Therefore water equivalent = ms

Types of heat

1 Sensible heat

2 Latent heat

1 Sensible heat

Sensible heat is the heat absorbed or given off by a substance without changing its physical state. It is sensible and can be absorbed by the variation of temperature in the thermometers.

2 Latent heat

The heat gained or given by the substance during a change of state (from solid to liquid to gas) is called latent heat or hidden heat. The heat absorbed or given off does not cause any temperature change in the substance.

Types, 1. Latent heat of fusion of solid

2. Latent heat of vaporisation of solid.

1 Latent heat of fusion of solid

The amount of heat required per unit mass of a substance at melting point to convert it from the solid to the liquid state is called latent heat of fusion of solid. Its unit is cal/gram.

Latent heat of fusion of ice

The amount of heat required to convert per unit mass of the ice into water at 0^0C temperature is called latent heat of fusion of ice.

Latent heat of fusion of ice(L) = 80 cal/gram

2 Latent heat of vaporisation of liquid

The amount of heat required to vaporise a unit mass of liquid at its boiling point is called latent heat of vaporisation.

Latent heat of vaporisation of water or latent heat of steam

The amount of heat required to convert into steam of a unit mass of water at its boiling point (100^0C) is called latent heat of vaporisation of water or latent heat of steam.

Latent heat of steam(L) = 540 cal/gram

Temperature

It is the degree of hotness or coldness of a body. The temperature is measured by thermometers.

Difference between heat and temperature

Heat	Temperature
1 It is a form of energy.	This tells the state of heat.
2 Its unit is calorie.	Its unit is degree.
3 Heat is measured by calorimeter.	Temperature is measured by thermometer.
4 By adding quantity of heat of two substances their total heat can be calculated.	By adding two temperatures we cannot find the temperature of the mixture.
5 By heating a substance the quantity of heat is increased regardless of increase in temperature.	Two substances may read the same temperature though they might be having different amount of heat in them.

Boiling point

Any substance starts turning into a gas shows the temperature at which it boils this is known as the boiling point. The boiling point of water is 100^0C.

Melting point

The temperature at which any solid melts into liquid or liquid freezing to solid is called the melting point of substance. ` The melting point of ice is 0^0C.

List of melting point and boiling point of metals and Non -metals

Metals and Non-metals	Melting point °C	Boiling point °C
Aluminium	660.25	2519
Argon	-189.19	-185.85
Arsenic	817	614
Barium	729	1897
Beryllium	1287	2469
Bromine	-7.1	58.8
Cadmium	321.18	767
Calcium	839	1484
Carbon (diamond)	3550	4827
Carbon (graphite)	3675	4027
Chlorine	-100.84	-34.04
Cobalt	1495	2927
Copper	1084.6	2562
Gold	1064.58	2856
Helium	-	-268.93
Hydrogen	-259.98	-252.87
Iodine	113.5	184.3
Iridium	2443	4428
Iron	1535	2861
Lead	327.6	1749
Lithium	180.7	1342
Magnesium	650	1090

Metals and Non-metals	Melting point °C	Boiling point °C
Manganese	1246	2061
Mercury	-38.72	357
Molybdenum	2617	4639
Nickel	1453	2913
Nitrogen	-209.86	-195.79
Oxygen	-226.65	-182.95
Phosphorus (white)	44.1	280
Plutonium	640	3228
Potassium	63.35	759
Radium	700	1737
Silicon	1410	3265
Silver	961	2162
Sodium	98	883
Sulfur	115.36	444.6
Tin	232.06	2602
Titanium	1660	3287
Tungsten (wolfram)	3422	5555
Uranium	1132	4131
Zinc	419.73	907

Heat & Temperature and Pressure - Scales of temperature, celsius, fahrenheit, kelvin and conversion between scales of temperature

Temperature Scales

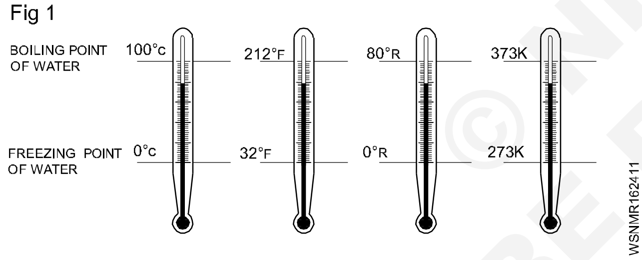
Temperature is calibrated between two fixed reference points namely the freezing point of water, and the boiling point of water. These two fixed points on different temperature scales are:

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

Heat is a form of energy. Temperature is the degree of hotness or coldness of a body. The relationship for conversion from one temperature scale to the others is

$$\frac{^0R}{80} = \frac{^0C}{100} = \frac{^0K - 273}{100} = \frac{^0F - 32}{180}$$

Fig 1



1 Convert 0^0C into ^0F

$$\frac{^0F - 32}{180} = \frac{^0C}{100}$$

$$^0F - 32 = \frac{^0C}{100} \times 180$$

$$^0F - 32 = \frac{0}{100} \times 180$$

°F = 0 + 32

= 32^0F

0^0C = 32^0F

2 Convert -40^0C into ^0F

$$\frac{^0F - 32}{180} = \frac{^0C}{100}$$

$$^0F - 32 = \frac{^0C}{100} \times 180$$

$$^0F - 32 = \frac{-40}{100} \times 180$$

F - 32 = -72

°F = -72 + 32

= -40^0F

-40^0C = -40^0F

3 Convert 37^0C into K

$$\frac{^0C}{100} = \frac{^0K - 273}{100}$$

°K-273 = C

°K = C + 273

°K = 37 + 273

= 310 K

37^0C = 310K

4 Convert 70^0C into Reaumur

$$\frac{^0C}{100} = \frac{^0R}{80}$$

$$^0R = \frac{C}{100} \times 80$$

$$^0R = \frac{70}{100} \times 80 = 56$$

70^0C = 56^0R

5 Convert -25^0F into ^0C

$$\frac{^0C}{100} = \frac{^0F - 32}{180}$$

$$\frac{^\circ C}{100} = \frac{-25 - 32}{180}$$

$$^0C = \frac{-57}{180} \times 100$$

$$^0C = \frac{-285}{9} = -31.66$$

$-25^0F = -31.7^0C$

6 Convert 98.6^0F into ^0C

$$^0C = \frac{^0F - 32}{180} \times 100$$

$$^0C = \frac{98.6 - 32}{180} \times 100$$

$$= \frac{66.6}{180} \times 100$$

$$= \frac{6660}{180} = 37^0C$$

$98.6^0F = 37^0C$

Assignment

Convert the following

1 10.5^0C = ___ ^0F

2 40^0C = ___ ^0F

3 60^0C = ___ ^0F

4 80^0C = ___ ^0F

5 105^0C = ___ ^0F

6 100^0C = ___ ^0F

7 -80^0C = ___ ^0F

8 200^0C = ___ ^0F

9 605^0C = ___ ^0F

10 1250^0C = ___ ^0F

11 77^0F = ___ ^0C

12 20^0F = ___ ^0C

13 428^0F = ___ ^0C

14 -210^0F = ___ ^0C

15 88^0F = ___ ^0C

16 110^0F = ___ ^0C

17 72^0F = ___ ^0C

18 50^0F = ___ ^0C

19 900^0F = ___ ^0C

20 72^0R = ___ ^0C

21 143^0C = ___ K

22 373^0K = ___ ^0C

23 746^0K = ___ ^0F

24 At what temperature will the reading of a fahrenheit thermometer be double of a centigrade one.

Heat & Temperature and Pressure - Concept of pressure - Units of pressure

Concept of pressure

Continuous physics force exerted on or against an object by something in contact with it.

Definition

Pressure is an expression of force exerted on a surface per unit area, i.e., the force applied is perpendicular to the surface of object per unit area.

$$\text{Pressure} = \frac{\text{Force}}{\text{Area}} = \frac{\text{Newton}}{\text{sq.meter}} = P = \frac{F}{A} \text{N/m}^2$$

As the amount of gas increases assuming the volume of chamber and the temperature remain constant the pressure increases.

Unit: Standard unit and also the S.I. unit of pressure is Pascal (Pa) and Metric unit of pressure is Bar.

1 Pascal is defined as a force of one newton per square metre

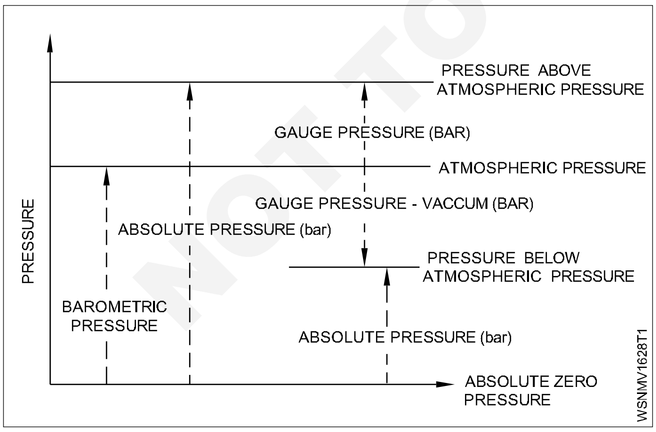
i.e., 1 Pascal = 1 N/m^2

1 Bar = 10^5 N/m^2

Pressure units in different systems

British unit FPS	Pounds per square inch	lb/in^2
Metric units CGS	Gram per square centimetre	g/cm^2
MKS	Kilogram per square metre	kg/m^2
International unit SI	Newtons per square metre	N/m^2

Types of Pressure



1 Absolute pressure

2 Atmosphere pressure

3 Gauge pressure

Measuring Instruments

I Manometers

a Simple manometer

i Piezometer

ii 'U' tube manometer

iii single column manometer

b Differential manometer

i 'U' tube differential manometer

ii Inverted 'U' tube manometer

II Mechanical Gauges

a Diaphragm pressure gauge

b Bourdon's tube pressure gauge

c Dead weight pressure gauge

d Bellows pressure gauge

Example

A liquid gives force of 100 N over an area of $2m^2$. What is the pressure?

Force = 100 N

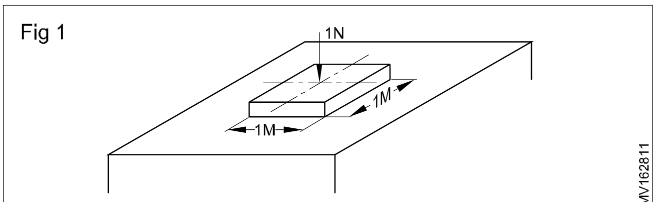
Area = 2 m^2

Pressure = ?

$$P = \frac{F}{A} = \frac{100}{2}$$

$= 50\ N/m^2$

Fig 1



CONCEPT OF PRESSURE

Unit of pressure N/m^2, 1 N/m^2 = 1 pascal.

This unit is too small (Pressure of a fly on a area of 1 cm^2). Hence 'bar' is introduced as the unit of pressure. 1 bar = 10^5 pascal.

$$10^5\ P_a = 10^5\ \frac{N}{m^2} = 10\frac{N}{cm^2} = 1 \text{ bar}$$

1 bar = 1000 mbar. [SI unit of Pressure is Pascal (Pa) and Metric unit of Pressure is bar]

Properties of Pressure

1 Liquid pressure increase with depth.

2 Liquid pressure depends upon the density of the liquid

3 The pressure is same in all directions about a point in liquid at rest

4 Upward pressure at a point in a liquid is equal to downward pressure

Pascal's Law

A French scientist, Pascal stated that the pressure applied at any point in liquid, at rest is transmitted equally in all directions. This is known as Pascal' law.

Applications of Pascal's law

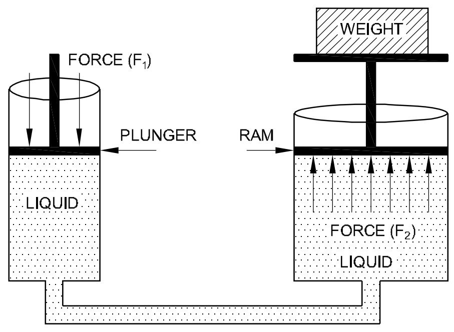
Pascal's law is applied in many devices like the siphon, hydraulic press, hydraulic lift, brahma press, air compressor, rotary pump and hydraulic brake. These hydraulic machines are based on the principle of transmission of pressure in liquids.

Principle of Hydraulic press

Two cylinders having different cross sectional area are connected to each other by a horizontal connecting tube. The apparatus is filled with a liquid. The two cylinders are fitted with air tight piston .

By giving a small input force on a plunger of a small cross sectional area cylinder a large output force are produced on the ram of large cross sectional area cylinder. According to Pascal's law, small input pressure exerted on plunger is transmitted by the liquid to the ram without any loss. Therefore a small force can be used to lift a much large force or weight. (Fig 2)

Fig 2



PRINCIPLE OF HYDRAULIC PRESS

$$\frac{\text{Force on plunger(F)}}{\text{Plunger area(a)}} = \frac{\text{Weight on the ram(W)}}{\text{Ram area(A)}}$$

$$\frac{F}{a} = \frac{W}{A}$$

$$\text{Weight on the ram (W)} = \frac{FxA}{a}$$

Properties of Air

- Actually speaking, air is a mixture of gases. Air is invisible, colourless, odourless, and tasteless.
- Composition: The main constituents of air by volume are 78% nitrogen, 21% oxygen, and 1% other gases such as argon and carbon dioxide.
- The gaseous layer of air around the earth is known as atmosphere

S. No.	Place	Unit of Pressure	Mercury column	Inch units
1	Sea level	1013 m bar	750 mm	14.7 psi
2	520 metres above sea level	951.5 m bar	700 mm	13.7 psi

Basic Electricity - Introduction and uses of electricity

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.

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

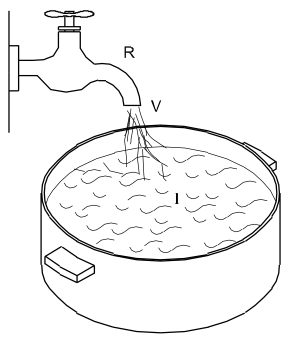


Fig 2

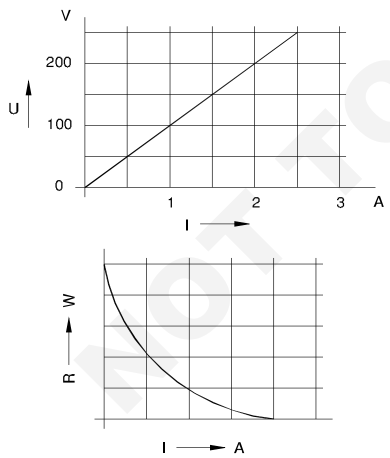


Fig 3

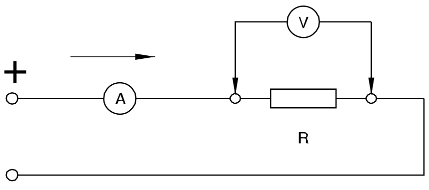
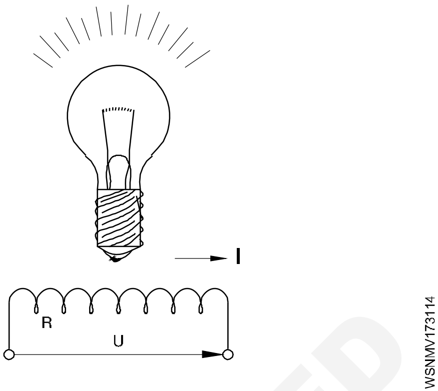


Fig 4



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

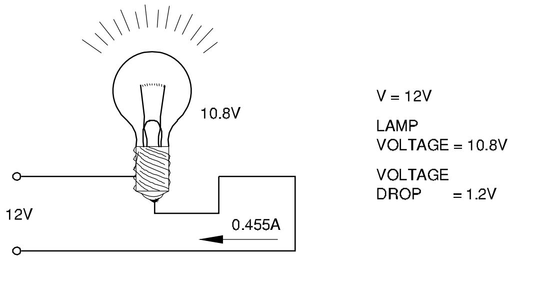
3.6 V = 0.2 A x R

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

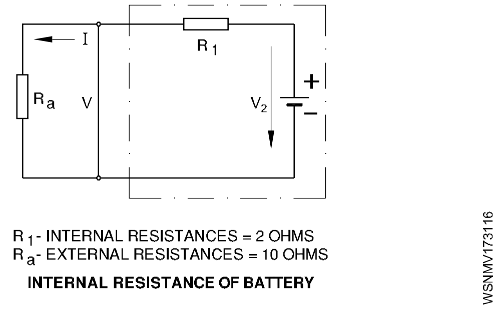
Voltage drop = Current x Internal resistance

= 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

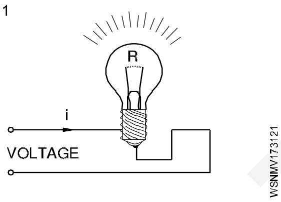
V - Voltage (in volts)

R - Resistance (in ohms)

I - Current intensity (in Amperes)

Assignment

1 Fig 1

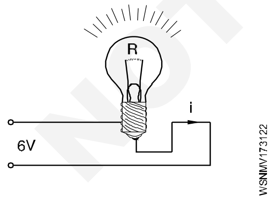


R = 40 Ohms

I = 6.5 Amps

V = ______Volts

2 Fig 2

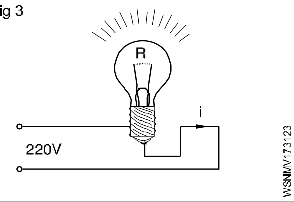


V = 6 Volts

I = 0.5 Amps

R = ______Ohms

3 Fig 3

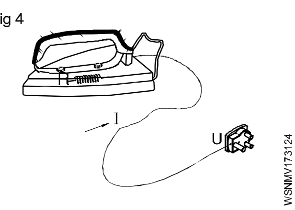


V = 220 Volts

R = 820 Ohms

I = ______Amps

4 Fig 4

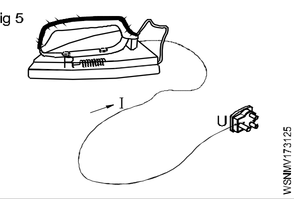


I = 4.5 Amps

V = 220 Volts

R = ______Ohms

5 Fig 5

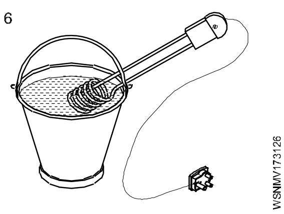


R = 50 Ohms

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 x 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 x I = I x R x I = I^2 x R

Therefore Power = 15^2 x 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 %

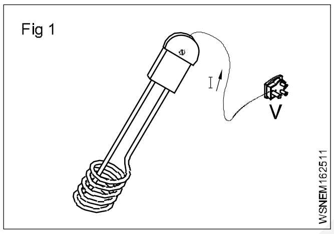
Power consumed by series resistance = I^2R

= 2.06 x 2.06 x 10

= 42.44 watt

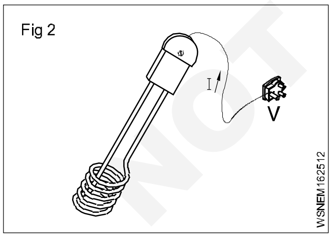
Assignment

1



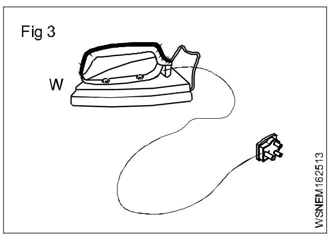
Current Consumed
I = 0.127 A
Voltage 'V' = 220 v
P = ______ Watts

2



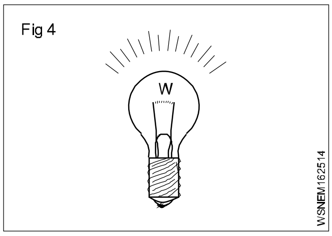
P = 500 Watts
I = 2.61 A
V = ______ v

3



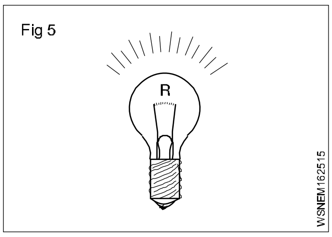
P = 650 W
V = 220 v
I = ______ A

4



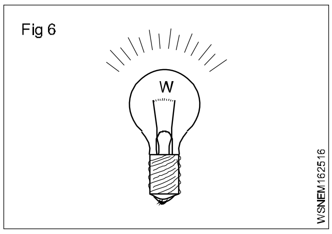
P = 50 W
V = 200 v
R = ______ W

5



I = 0.455 A
R = 242 ohms
P = ______ Watts

6



P = 440 W
R = 22 ohms
I = ______ A

Mensuration - Area and perimeter of square, rectangle and parallelogram

In Engineering field, an Engineer has to estimate the material, manpower, machinery, etc. required to prepare the geometrical objects. Hence we must be very conversant with all relevant formulae connected with geometrical objects.

Length - l unit

Breadth or width - b unit

Diagonal - d unit

Diameter - d unit

Radius - r unit

Semi perimeter - S unit

Perimeter - P unit

Circumference - C unit

Area - A unit^2

Total surface area - T.S.A unit^2

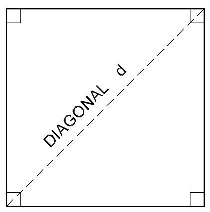
Lateral surface area - L.S.A unit^2

Volume - V unit^3

Square

This is also a four sided figure, opposite sides are parallel. All the four sides are equal. Angle between adjustment side are 90º.

Fig 1



SIDE a

SQUARE

WSNFI172111

$A = a^2$ (or) unit^2

$P = 4a$ unit

$d = \sqrt{2}\,a$ unit

$a = \frac{d}{\sqrt{2}}$ unit where $\sqrt{2} = 1.414$

Find the area of a brass sheet in the form of a square whose perimeter is 31.2 cm.

Perimeter(P) = 4a = 31.2 cm

$\therefore a = \frac{31.2}{4} = 7.8$ cm

Area (A) $= a^2$

$= 7.8 \times 7.8 = 60.84$ cm^2

Examples

1 Find out the circumference, diagonal and area of a square, whose side is 18 cm.

Side of the square (a) = 18 cm

Perimeter (P) = 4a

= 4 x 18 = 72 cm

Diagonal (d) $= \sqrt{2} \times a$

$= \sqrt{2} \times 18 = 1.414 \times 18$

= 25.45 cm

Area (A) $= a^2$

$= 18 \times 18 = 324$ cm^2

Perimeter of square = 72 cm

Diagonal = 25.45 cm ; Area = 324 cm^2

2 If the diagonal of a square measure 10 cm. Find area of the square.

Diagonal of the square (d) $= \sqrt{2}\,a = 10$ cm

Side (a) $= \frac{d}{\sqrt{2}}$

Area (a^2) $= \frac{d}{\sqrt{2}} \times \frac{d}{\sqrt{2}} = \frac{d^2}{2}$

$= \frac{10^2}{2} = \frac{100}{2}$

= 50 cm^2

Area of the square = 50 cm^2

3 The perimeter of one square is 748 cm and that of Another is 336 cm. Find the total area of the two squares.

Side of the square (a) $= \frac{\text{Perimeter}}{4}$

1st square

Side (a) $= \frac{\text{Perimeter of 1}^{st}\text{ square}}{4}$

$= \frac{748}{4} = 187$ cm

Area (A) $= a^2$

= 187 x 187

= 34,969 cm^2

2nd square

Side (a) $= \frac{\text{Perimeter of 2}^{nd}\text{ square}}{4}$

$= \frac{336}{4} = 84$ cm

Area (A) $= a^2$

$= 84 \times 84$

$= 7{,}056\ cm^2$

Total area of two squares = 34,969 + 7,056

$= 42{,}025\ cm^2$

Assignment

1 Find the Area, Perimeter and diagonal of a square steel plate whose side measures 28.1 cm.

2 Find the area of a square whose diagonal is equal to 8.5 cm.

3 Find the area of the square if the side of the square is 28 cm.

4 Find its side if the area of the square field is 169 m^2.

5 Find the area of the square if the diagonal of the square is 20 cm.

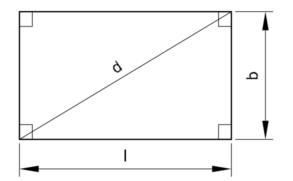
6 Find the perimeter of a square whose diagonal is 144 m.

7 Find the area if the perimeter of a square plot is 48 m.

Rectangle

This is a four sided figure. Opposite sides are parallel. Angles between adjacent sides are 90°.

Fig 1



A = Area = length x breadth = $l.b.unit^2$

P = Perimeter = 2 (l + b) unit

Diagonal = $\sqrt{l^2 + b^2}$ unit

Examples

1 Find the Area, Perimeter and diagonal of a rectangle whose length and breadth are 144 mm and 60 mm respectively.

Area = A $= l \times b\ unit^2$

$= 144 \times 60 = 8640\ mm^2$

Perimeter = P = 2 (l + b) unit

= 2(144 + 60)

= 2 x 204 = 408 mm

Diagonal = d $= \sqrt{l^2 + b^2}$ unit

$= \sqrt{144^2 + 60^2}$

$= \sqrt{20736 + 3600}$

$= \sqrt{24336} = 156$ mm

2 The perimeter of a rectangle is equal to 42 cm. If its breadth is 9 cm. Find the length of the rectangle.

Perimeter = 42 cm

Breath = 9 cm

Length = ?

Perimeter = P = 2(l + b)

2(l + 9) = 42

l + 9 = 42 ÷ 2

l + 9 = 21

l = 21 - 9

l = 12 cm

3 The perimeter of a rectangle is 48 cm and its length is 4 cm more than its width. Find the length and breadth of the rectangle.

Perimeter (P) = 48 cm

Breath (b) = x

Length (l) = $x + 4$

2(l + b) = Perimeter

$2(x + 4 + x) = 48$

$2(2x + 4) = 48$

$4x + 8 = 48$

$4x = 48 - 8$

$x = \frac{40}{4} = 10$

x = breadth = 10 cm

length = x + 4 = 10 + 4 **= 14 cm**

4 How many rectangular pieces of 50 cm x 20 cm can be cut out from a sheet of 1000 cm x 500 cm.

Sheet size = 1000 cm x 500 cm

Size of the rectangular piece to be cut = 50 cm x 20 cm

No. of pieces to be cut in lengthwise = $\frac{1000}{50}$ = 20

No. of pieces to be cut in breadthwise = $\frac{500}{20}$ = 25

Total no. of pieces to be cut out = 20 x 25

= 500

5 The perimeter of a rectangle is 320 metre. Its sides are in the ratio of 5:3. Find the area of the rectangle.

Ratio = 5:3 = l : b

length l = $5x$

breadth b = $3x$

2(l + b) = Perimeter

$2(5x + 3x) = 320$

$2(8x) = 320$

$16x = 320$

$x = \frac{320}{16} = 20$

$l = 5x = 5 \times 20 = 100$ m

$b = 3x = 3 \times 20 = 60$ m

Area = l x b (length = 100m, breath = 60m)

= 100 x 60

Area = 6000 m^2

Assignment

1 Find the area of a rectangular plot whose sides are 24 metres and 20 metres respectively. Also find the perimeter of the plot.

2 How many rectangular pieces of 5 cm x 4 cm will you get out of 65 cm x 30 cm brass sheet?

3 Find its breadth and area if the perimeter of a rectangle is 400 metre and its length is 140 m. .

4 Find its area, if the opposite sides of a rectangle are 64 cm and 25 cm respectively.

5 What is the width of the rectangle if a rectangle has an area of 224 cm^2 and length 16 cm.

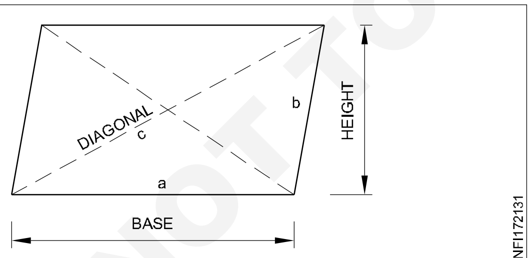
6 What is the length of the diagonal of a rectangle with sides 16 cm and 12 cm?

7 Find the area of the rectangle if the perimeter of the rectangle is 100 cm and the ratio of its length and breadth is 3:2.

Parallelogram

This is also a four sided figure, opposite side being parallel to each other.

Fig 1



PARALLELOGRAM

Area of parallelogram = base x height

$$\text{or} = 2x\sqrt{s(s-a)(s-b)(s-c)}$$

Where

$$s = \frac{a+b+c}{2}$$

a and b are adjacent sides.

P = 2(a+b)

Examples

1 The base and height of a parallelogram are 7.1 cm and 2.85 cm. Calculate its area.

A = base x height $units^2$

= 7.1 x 2.85

= 20.235 cm^2

2 Find the height of a parallelogram whose area is 20 cm^2 and base is 10 cm.

A = base x height $units^2$

$h = \frac{area}{base}$

$= \frac{20}{10}$

= 2 cm

3. Two sides of a parallelogram are 12 cm and 8 cm. The diagonal is 10 cm long. Find the area of the parallelogram.

Area A $= 2x\sqrt{s(s-a)(s-b)(s-c)}$ units^2

s $= \frac{a+b+c}{2}$

$= \frac{12+8+10}{2}$

$= \frac{30}{2}$

$= 15$

A $= 2 \times \sqrt{15(15-12)(15-8)(15-10)}$

$= 2 \times \sqrt{15 \times 3 \times 7 \times 5}$

$= 2 \times \sqrt{1575}$

$= 2 \times 39.686$

Area A $= 79.37$ cm^2

Assignment

1 Find the area of a parallelogram, if its base and height are 8.1 cm and 30.8 cm respectively.

2 Find the area of a parallelogram, if the sides of a field in the shape of parallelogram are 12 m and 17 m and one of the diagonal is 25 m.

3 Find the base of a parallelogram whose height is 12 cm and area is 120 cm^2.

4 Find the height of a parallelogram whose base is 40 cm and area is 320 cm^2.

5 Find the area of the land if the sides of a land in the shape of a parallelogram are 24 m and 28 m respectively and one of the diagonal is 30 m.

6 What is the perimeter of parallelogram if base is 10 cm and other side is 5 cm?

7 Find the area of parallelogram if its base and height are 25 cm and 12 cm.

8 Find the base of a parallelogram if height is 15 cm and area is 150 cm^2.

9 Find the height of a parallelogram if base is 80 cm and area is 640 cm^2.

10 Find the area of parallelogram if its base and height are 15 cm and 8 cm.

11 Calculate the perimeter and area of parallelogram if base, height are 12.7 cm, 5.5 cm and other side is 6.5 cm

12 Find the height of parallelogram if the area is 20 cm^2 and base is 10 cm

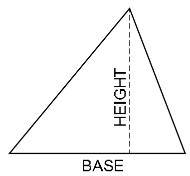
Mensuration - Area and perimeter of triangles

Triangles

Tri means three. Hence tri- angle means three angled figure. For construction of three angled figure, there should be three sides. Hence triangle means three sided figure. Sum of the three angles of any triangle = 180°.

i Any triangle.

Fig 1



TRIANGLE

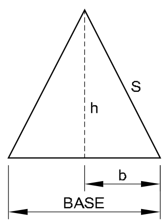
WSNFI172211

Area of any triangle = $\frac{1}{2}$ x Base x Height unit^2

ii Isosceles Triangle

In this triangle two of its sides are equal.

Fig 2



ISOSCELES TRIANGLE

WSNFI172212

Area of isosceles triangle = $\frac{1}{2}$ x Base x Height

Where

base = 2.b

s = One of equal sides (or) Slant height

h = Height = $\sqrt{s^2 - b^2}$

Area of isosceles triangle = $\frac{1}{2}$ x 2b x $\sqrt{s^2 - b^2}$

= b . $\sqrt{s^2 - b^2}$ unit^2

(Where b= half of base)

(or) Area of Isosceles triangle = $\frac{1}{4} b \sqrt{4a^2 - b^2}$ unit^2

a = Equal sides

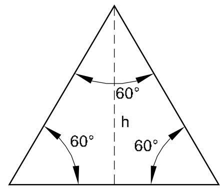
b = Base

iii Equilateral triangle

In this triangle all the three sides are equal. Hence angle between adjacent sides is 60° (Three angles total = 180°)

angle between sides = $\frac{180}{3}$ = 60°

Fig 3



EQUILATERAL TRIANGLE

WSNFI172213

Area of equilateral triangle = $\frac{\sqrt{3}}{4}$ x side^2

= $\frac{\sqrt{3}}{4}$ x a^2 unit^2

Where $\sqrt{3}$ = 1.732

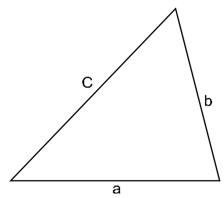
Perimeter P = 3a unit

P = $\frac{\sqrt{3}}{2}$a unit

iv Scalene triangle

In this triangle the sides are not equal. Angles between the sides, are also not equal. we may also call this triangle as irregular triangle.

Fig 4



SCALENE TRIANGLE

WSNFI172214

Area of triangle = $\sqrt{s(s-a)(s-b)(s-c)}$ unit^2

where

a,b,c are sides of triangle

s = Semi perimeter = $\frac{a+b+c}{2}$ unit

v Right angled triangle

In this triangle, angle between one of two adjacent sides is 90^0. Right angle means 90°. That's why right angled triangle means, one of the angles of this triangle is definitely 90°.

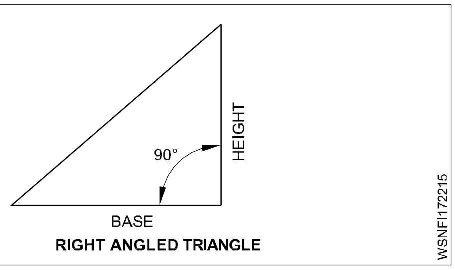
Area of right angled triangle

= $\frac{1}{2}$ x Base x Height

= $\frac{1}{2}$ bh unit^2

Hypotenuse = $\sqrt{Base^2 + Height^2}$

Fig 5



RIGHT ANGLED TRIANGLE

Where hypotenuse means, the diagonal or largest length of the side of right angled triangle.

Examples

1 Calculate its area if the base and height of a Right angled triangle are 10 cm and 3.5 cm respectively.

Base (b) = 10 cm

Height (h) = 3.5 cm

Area (A) = ?

$$A = \frac{1}{2} \times b \times h$$

$$= \frac{1}{2} \times 10 \times 3.5$$

$$\mathbf{= 17.5\ cm^2}$$

2 Calculate the base of a triangle having an area of $15\ cm^2$ and height is 3.5 cm.

Area (A) = $15\ cm^2$

Height (h) = 3.5 cm

Base (b) = ?

$$\frac{1}{2} \times b \times h = A$$

$$\frac{1}{2} \times b \times 3.5 = 15$$

$$\mathbf{b} = \frac{15 \times 2}{3.5}$$

$$\mathbf{= 8.57\ cm}$$

3 Calculate the height of a triangle whose area is $60\ cm^2$ and base is 10 cm.

Area (A) = $60\ cm^2$

Base (b) = 10 cm

Height (h) = ?

$$\frac{1}{2} \times b \times h = A$$

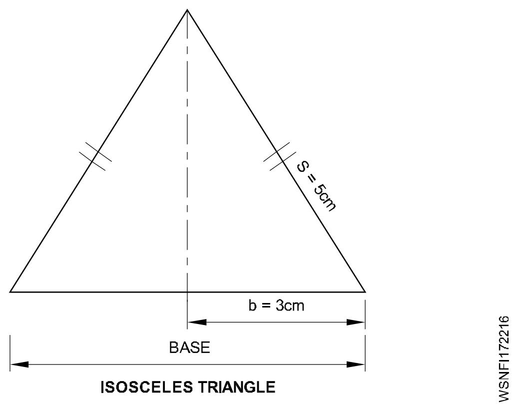
$$\frac{1}{2} \times 10 \times h = 60$$

$$h = \frac{60 \times 2}{10}$$

height h = 12 cm

4 Find the area of an isosceles triangle whose base is 6 cm long and each of the other two sides 5 cm long.

Fig 6



ISOSCELES TRIANGLE

Base (b) = 6 cm = $\frac{6}{2}$ = 3 cm

Equal sides or slant height 's' = 5 cm

Area (A) = ?

$$A = b \times \sqrt{s^2 - b^2}$$

$$= 3 \times \sqrt{5^2 - 3^2}$$

$$= 3 \times \sqrt{25 - 9}$$

$$= 3 \times \sqrt{16}$$

$$= 3 \times 4$$

$$= 12\ cm^2$$

or

$$A = \frac{1}{4} b \sqrt{4a^2 - b^2}$$

$$= \frac{1}{4} \times 6 \sqrt{4 \times 5^2 - 6^2}$$

$$= \frac{1}{4} \times 6 \times 8$$

$$\mathbf{= 12\ cm^2}$$

5 Find its height if an isosceles triangle has base of 200 mm and its area is $2000\ mm^2$.

Base = 200 mm

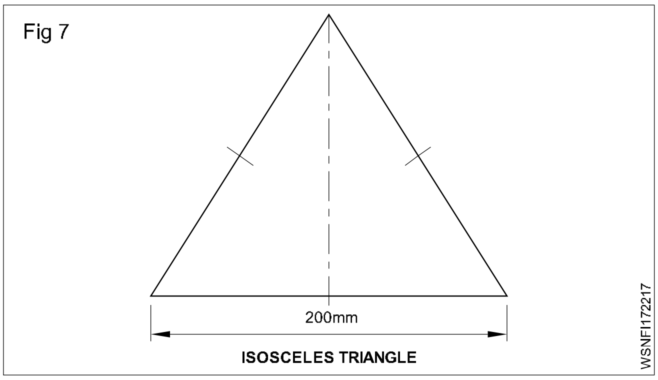
Area = $2000\ mm^2$

h = ?

$$\frac{1}{2} \times b \times h = A$$

$$\frac{1}{2} \times 200 \times h = 2000$$

$$h = \frac{2000 \times 2}{200} \mathbf{= 20\ mm}$$



6 Find the area of an equilateral triangle whose side is 5 cm.

Area $= \frac{\sqrt{3}}{4} a^2$ unit^2

$= \frac{1.732}{4} \times 5 \times 5$

= 10.825 cm^2

7 Calculate its perimeter if one side of an equilateral triangle is 55 mm long.

Side = 55 mm

Perimeter (P) = ?

P = 3a unit

= 3 x 55

= 165 mm

8 Find the area of the triangle having its sides are 9cm, 10cm and 12 cm.

Semi Perimeter $= \frac{a+b+c}{2}$ unit

$= \frac{9+10+12}{2} = \frac{31}{2}$

= 15.5 cm

Area A $= \sqrt{s(s-a)(s-b)(s-c)}$ unit^2

$= \sqrt{15.5(15.5-9)(15.5-10)(15.5-12)}$

$= \sqrt{15.5 \times 6.5 \times 5.5 \times 3.5}$

$= \sqrt{1939.4375}$

= 44.03 cm^2

9 Find the cost of polishing on both sides of a triangular metal plate has sides 60 cm, 50 cm and 20 cm at the rate of Rs.1.35 per 100 cm^2

Semi Perimeter $= \frac{a+b+c}{2}$ unit

$= \frac{60+50+20}{2} = \frac{130}{2}$

= 65 cm

Area A $= \sqrt{s(s-a)(s-b)(s-c)}$ unit^2

$= \sqrt{65(65-60)(65-50)(65-20)}$

$= \sqrt{65 \times 5 \times 15 \times 45}$

= 468.4 cm^2

Area of polish on both sides = 2 x 468.4

= 936.8 cm^2

Cost of polish per 100 cm^2 = Rs. 1.35

∴ Cost of polish is 936.8 cm^2 $= \frac{936.8}{100} \times 1.35$

= Rs. 12.65

10 Find the area of the right angled triangle with base 20 cm and height 8 cm.

Base b = 20 cm

Equal sides or slant height = 8 cm

Area (A) = ?

Area (A) $= \frac{1}{2}$ x base x height unit^2

$= \frac{1}{2} \times 20 \times 8$

= 80 cm^2

11 Find the area of the right angled triangle if the sides containing the right angle being 10.5 cm and 8.2 cm.

Area (A) $= \frac{1}{2}$ x base x height unit^2

$= \frac{1}{2} \times 10.5 \times 8.2$

= 43.05 cm^2

12 Calculate the perpendicular height of the triangle if the area of the right angled triangle is 19.44 m^2 and its one of the adjacent side containing the right angle being 5.4 m.

$\frac{1}{2}$ x base x height unit^2 = Area

$\frac{1}{2} \times 5.4 \times h = 19.44$

$$h = \frac{19.44 \times 2}{5.4}$$

$$= \mathbf{7.2\ m}$$

13 Calculate the base of a right angled triangle having an area of 12.5 cm². If its height is 2.5 cm.

$$\frac{1}{2} \times \text{base} \times \text{height unit}^2 = \text{Area}$$

$$\frac{1}{2} \times b \times 2.5 = 12.5$$

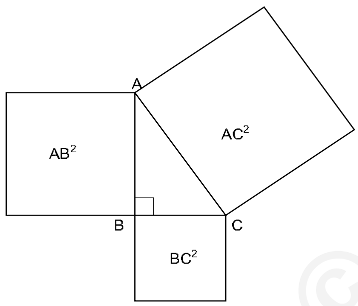
$$b = \frac{12.5 \times 2}{2.5}$$

$$= \mathbf{10\ cm}$$

Pythagoras theorem

In a right angled triangle the area of the square drawn with the hypotenuse as the side is equal to the sum of the areas of the squares drawn with the other two sides.

Fig 8



PYTHAGORAS THEOREM

WSNFI172218

$\angle B$ = 90°

AC = Hypotenuse

AB & BC = Adjacent sides

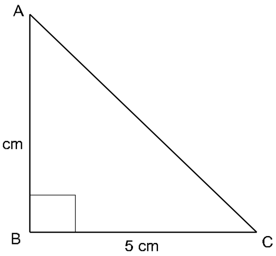
As per pythagoras theorem,

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

$$\therefore \quad AC = \sqrt{AB^2 + BC^2}$$

1 Calculate the hypotenuse of a right angled triangle whose base is 5 cm and height is 12 cm.

Fig 9



PYTHAGORAS THEOREM

WSNFI172219

As per pythagoras theorem,

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

$$= 12^2 + 5^2$$

$$= 144 + 25$$

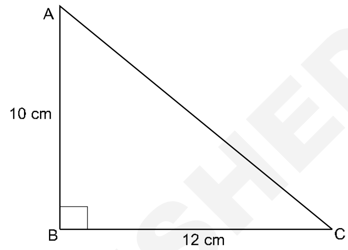
$$= 169$$

$$AC = \sqrt{169}$$

$$= \mathbf{13\ cm}$$

2 What is the length of the hypotenuse of a right angled triangle, when the sides containing the right angles are 10 cm and 12 cm.

Fig 10



PYTHAGORAS THEOREM

WSNFI17221A

As per pythagoras theorem,

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

$$= 10^2 + 12^2$$

$$= 100 + 144$$

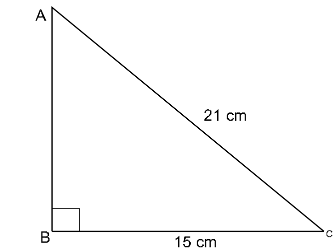
$$= 244$$

$$AC = \sqrt{244}$$

$$= \mathbf{15.62\ cm}$$

3 Find the height of a right angled triangle whose base is 15 cm and hypotenuse is 21 cm.

Fig 11



PYTHAGORAS THEOREM

WSNFI17221B

As per pythagoras theorem,

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

$$AB^2 + 15^2 = 21^2$$

$$AB^2 = 441 - 225$$

$$= 216$$

$$AB = \sqrt{216}$$

$$= \mathbf{14.7\ cm}$$

Mensuration - Area and perimeter of circle, semi-circle, circular ring, sector of circle, hexagon and ellipse

Circle

It is the path of a point which is always equal from its centre is called a circle.

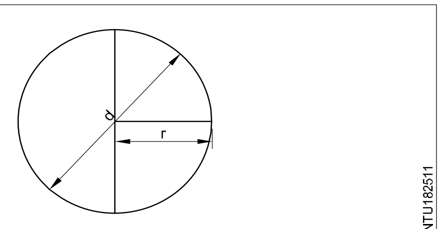
r = radius of the circle

d = diameter of the circle

$\pi = \frac{22}{7} = 3.14$

Area of the circle = πr^2

Fig 1



PROPERTIES OF CIRCLE

(or) $= \frac{\pi}{4} d^2$ unit^2

Circumference of the circle $2\pi r$ (or) πd unit

Examples

1 Find the area of a circle whose radius is 1.54 m. Also find its circumference.

radius r = 1.54 cm

Area A = ?

Circumference C = ?

A $= \pi r^2$ unit^2

$= \frac{22}{7} \times 1.54 \times 1.54$

$= 7.4536$ m^2

C $= 2\pi r$ unit

$= 2 \times \frac{22}{7} \times 1.54$

= 9.68 m

2 Find out the circumference if the area of a circular shape of land is 616 m^2.

A $= \pi r^2$ unit^2

$r^2 = \frac{616}{\pi}$

$= \frac{616 \times 7}{22}$

$= 196$

r $= \sqrt{196}$

= 14 m

Circumference $= 2\pi r$ unit

$= 2 \times \frac{22}{7} \times 14$

= 88 m

3 Find the side of square into which it can be bent if a wire is in the form of a circle of radius 49 cm.

radius of circle r = 49 cm

side of square = ?

Perimeter of the square = Perimeter of the circle

$4a = 2\pi r$

$4a = 2 \times \frac{22}{7} \times 49$

$4a = 308$

$a = \frac{308}{4}$

= 77 cm

4 Find its radius if the difference between the circumference and diameter of a circle is 28 cm.

Circumference - Diameter = 28 cm

$2\pi r - d = 28$

$2\pi r - 2r = 28$

$2r(\pi - 1) = 28$

$2r(\frac{22}{7} - 1) = 28$

$2r(\frac{22-7}{7}) = 28$

$2r \times \frac{15}{7} = 28$

$r = \frac{28 \times 7}{15 \times 2}$

= 6.53 cm

5 What is the side of the largest square cut out from a circle of 50 cm dia.?

Diagonal of a square = Diameter of the circle

$\sqrt{2}a = 50$

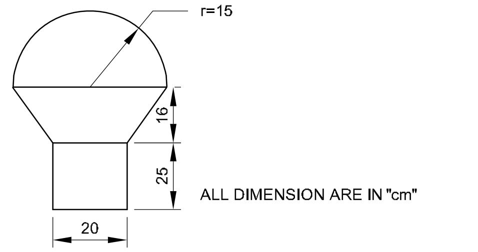
$a = \frac{50}{\sqrt{2}}$

$= \frac{50}{1.414}$

= 35.36 cm

6 Calculate the area of the figure given below.

Fig 2



PROPERTIES OF CIRCLE

Area of rectangle $= lb$ unit^2

$= 25 \times 20$ cm^2

$= 500$ cm^2

Area of Trapezium $= \frac{1}{2} \times (a + b)\ h$

$= \frac{1}{2} \times (30 + 20)\ 16$ cm^2

$= \frac{1}{2} \times 50 \times 16$ cm^2

$= 400$ cm^2

Area of Semi circle $= \frac{\pi r^2}{2}$ unit^2

$= \pi \times 15^2 \times \frac{1}{2}$ cm^2

$= 353.57$ cm^2

Total area of the figure $= 500 + 400 + 353.57$

= 1253.57 cm²

7 Find the area of remaining steel plate if in a rectangular steel plate 16 cm x 12 cm, there are 6 holes each 4 cm in diameter.

Area of a rectangular plate = length x breadth unit^2

$= 16 \times 12$

$= 192$ cm^2

No. of holes = 6

Radius of hole = 2 cm

Area of 6 holes $= 6 \times \pi r^2$ unit^2

$= 6 \times \frac{22}{7} \times 2 \times 2$ unit^2

$= 75.43$ cm^2

Area of remaining plate $= 192 - 75.43$

= 116.57 cm²

— — — — — — — —

Semi circle

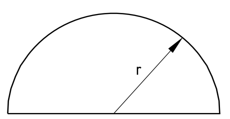
A semi circle is a sector whose central angle is 180º. Length of arc of semi circle.

Length of arc 2)21 $= 2\pi r \times \frac{180}{360}$

$= 2\pi r \times \frac{1}{2} = \pi r$ unit

Area of semi circle $= \frac{\pi r^2}{2}$ Sq. units

Fig 3



SEMI CIRCLE

Perimeter of a semi circle $= \frac{2\pi r}{2} + 2r$

$= \pi r + 2r$

$= r(\pi + 2)$ unit

Examples

1 Calculate the circumference and area of a semi circle whose radius is 6 cm.

radius r = 6 cm

Area A = ?

Circumference c = ?

$A = \frac{\pi r^2}{2}$ unit^2

$= \frac{22}{7} \times \frac{1}{2} \times 6^2$

Area (A) $= \frac{22}{7} \times \frac{1}{2} \times 36$

$= \frac{396}{7} = 56.57$ cm^2

Perimeter of a semicircle $= \frac{2\pi r}{2} + 2r = \pi r + 2r$

$= r(\pi + 2) = 6\left(\frac{22}{7} + 2\right)$

$= 6\left(\frac{22+14}{7}\right)$

$= 6 \times \frac{36}{7}$

$= \frac{216}{7}$

= 30.86 cm

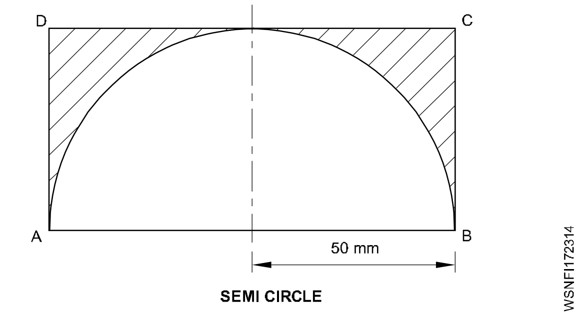
2 From the figure given below ABCD is a steel plate, a semi circular plate of radius 50 mm has been prepared by gas cutting. Find the waste area.

Plate length AB = 100 mm

Breadth BC = 50 mm

Radius = 50 mm

Fig 4



Waste area = Plate area - Area of semi circle

$= lb - \frac{\pi r^2}{2}$

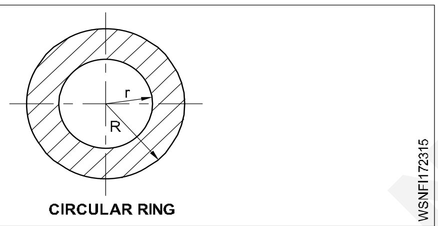
$= 100 \times 50 - \frac{22 \times 50 \times 50}{7 \times 2}$

= 5000 - 3928.57

= 1071.43 mm²

Circular ring

Fig 5



R = Outer radius of circular ring

r = Inner radius of circular ring

Area of circular ring = $\pi (R^2 - r^2)$ unit²

or

$A = \pi (R + r)(R - r)$ unit²

1 Calculate the area of cross section of pipe having outside dia of 17 cm and inside dia of 14 cm.

Given:

Outer dia of pipe = 17 cm

Outer radius of pipe (R) = $\frac{17}{2}$ = 8.5 cm

Inner dia of pipe = 14 cm

Inner radius of pipe (r) = $\frac{14}{2}$ = 7 cm

To find:

Area of cross section of pipe = ?

Solution:

Area of cross section of pipe $= \pi (R + r)(R - r)$ unit²

$= \pi (8.5 + 7)(8.5 - 7)$

$= \frac{22}{7} \times 15.5 \times 1.5$ cm²

= 73 cm²

2 Find the distance between the boundaries and the area of the circular ring, if the circumference of two concentric circle are 134 cm and 90 cm.

Given:

Circumference of outer circle = 134 cm

Circumference of inner circle = 90 cm

To find:

Distance between the circles = ?

Area of circular ring = ?

Solution:

Circumference of outer circle = 134 cm

$2\pi R$ = 134 cm

R $= \frac{134}{2\pi} = 21.32$ cm

Circumference of inner circle = 90 cm

$2\pi r$ = 90 cm

r $= \frac{90}{2\pi} = 14.32$ cm

Distance between the circle = R - r

= 21.32 - 14.32 cm

= 7 cm

Area of circular ring $= \pi (R + r)(R - r)$ unit²

$= \pi (21.32 + 14.32)(21.32 - 14.32)$ cm²

$= \frac{22}{7} \times 35.64 \times 7$ cm²

= 784.08 cm²

3 A wire can be bend in the form of a circle of radius 56 cm. If it is bend in a form of a square, find the side.

Given:

Radius of circle = 56 cm

To find:

Side of square = ?

Solution:

Radius of circle = 56 cm

Circumference of circle = $2\pi r$ unit = $2\pi \times 56$ cm

Side of square = x cm

Wire can be bend from the form of round to square

Perimeter of square = circumference of circle

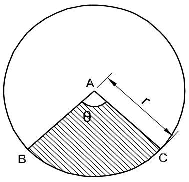
4 x a = 352 cm

$a = \frac{352}{4} = 88$ cm

— — — — — — —

Sector of Circle

Fig 6



SECTOR OF CIRCLE

WSNFI172316

θ = Angle of sector of circle

l = Arc length

r = radius

Length of Arc 2)21 = $\frac{\theta}{360^0} \times 2\pi r$ unit

Perimeter P = 2r + 2)21 unit

Area = $\frac{\theta}{360^0} \times \pi r^2$ unit² (or) A $= \frac{\ell r}{2}$ unit²

1 Find the perimeter and area of a sector of circle of radius 7 cm and its angle is 120⁰.

Given:

Angle of sector of circle = 120^0

Radius = 7 cm

To find:

Perimeter = ? , Area = ?

Solution:

Length of arc (2)21) $= \frac{\theta}{360^0} \times 2\pi r$ unit

$= \frac{120}{360} \times 2 \times \frac{22}{7} \times 7$ cm

= 14.67 cm

Perimeter = 2r + 2)21 unit

= 2 x 7 + 14.67 cm

= 28.67 cm

Area $= \frac{\theta}{360^0} \times \pi r^2$ unit²

Area $= \frac{120^\circ}{360^\circ} \times \frac{22}{7} \times 7^2$ cm² = 51.33 cm²

2 Find the radius of the circle if the angle is 60⁰ and the area of a sector of a circle is 144 cm²,

Given:

Area of sector of circle (A) = 144 cm²

Angle of sector of circle θ = 60^0

To find:

Radius of circle = ?

Solution:

Area (A) $= \frac{\theta}{360^0} \times \pi r^2$ unit²

$144 = \frac{60^0}{360^0} \times \frac{22}{7} \times r^2$ cm²

$r^2 = 274.91$ cm²

$r = \sqrt{274.91} = 16.58$ cm

3 Find the area of the sector whose angle is 105⁰, and the perimeter of sector of circle is 18.6 cm.

Given:

Perimeter of a sector of a circle = 18.6 cm

Angle of sector of circle = 105^0

To find:

Area = ?

Solution:

Length of Arc (2)21) $= \frac{\theta}{360^0} \times 2\pi r$ unit

2)21 $= \frac{105^0}{360^0} \times 2 \times \frac{22}{7} \times r$

= 1.83r

Perimeter (P) = 2)21 + 2r unit

18.6 = 1.83r + 2r

3.83r = 18.6 cm

$r = \frac{18.6}{3.83} = 4.86$ cm

Area A $= \frac{\theta}{360^0} \times \pi r^2$ unit^2

$= \frac{105^0}{360^0} \times \frac{22}{7}$ x (4.86) cm^2

= 21.65 cm^2

4 Find the area, if the radius is 12.4 cm and the perimeter of a sector of a circle is 64.8 cm.

Given:

Perimeter P = 64.8 cm

Radius r = 12.4 cm

To find:

Area A = ?

Solution:

Perimeter P = 2)21 + 2r unit

2)21 = P - 2r unit

= 64.8 - 2 (12.4) cm

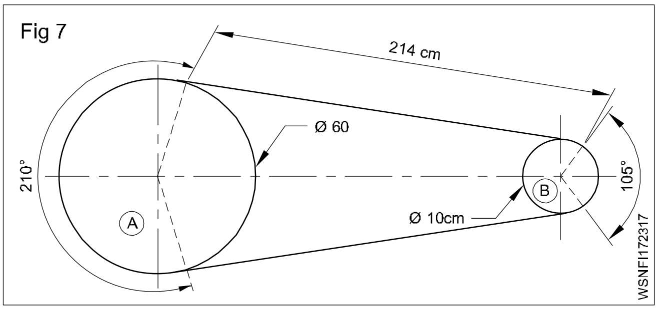
= 64.8 - 24.8 = 40 cm

Area A $= \frac{\ell r}{2}$ unit^2 $= \frac{40 \times 12.4}{2}$

= 248 cm^2

5 Find out the length of the belt , if the arrangement of a belt is shown in the figure below.

Fig 7



Solution:

Length 2)21$_A$ $= \frac{\theta}{360^0} \times 2\pi r$ unit

$= \frac{210^0}{360^0} \times 2 \times \frac{22}{7} \times 30 = 110$ cm

Length 2)21$_B$ $= \frac{\theta}{360^0} \times 2\pi r$ unit

$= \frac{105^0}{360^0} \times 2 \times \frac{22}{7} \times 5 = 91.7$ cm

= 2)21$_A$ + 2)21$_B$ + 2x214 cm

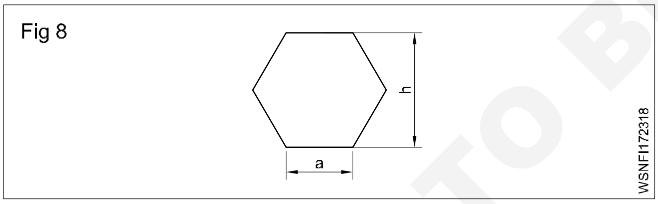
= 110 + 9.17 + 428 cm

= 547.17 cm

— — — — — — —

Hexagon

Fig 8



Side = a unit

Perimeter P = 6a unit

Area A $= 6 \times \frac{\sqrt{3}}{4} \times a^2$ units^2 (Area of 6 equilateral triangle)

DAF (Distance Across Flats) $= \sqrt{3} \times a$ unit

DAC (Distance Across Corners) = 2 x a unit

1 Find out the perimeter, area, DAF and DAC of a regular hexagon whose side is 2cm.

(DAF - Distance Across Flats)

(DAC - Distance Across Corners)

Given: Side of hexagon (a) = 2cm

To Find: P = ?, A = ?, DAF = ?, DAC = ?

Solution:

Perimeter of hexagon (P) = 6a unit

= 6a unit = 6 x 2 cm = 12 cm

Area of hexagon A $= 6 \times \frac{\sqrt{3}}{4} \times a^2$ unit^2

$= 6 \times \frac{1.732}{4} \times 2^2$

= 10.392 cm^2

DAF (Distance Across Flats) $= \sqrt{3} \times a$ unit

$= \sqrt{3} \times 2$ = 1.732 x 2

= 3.464 cm

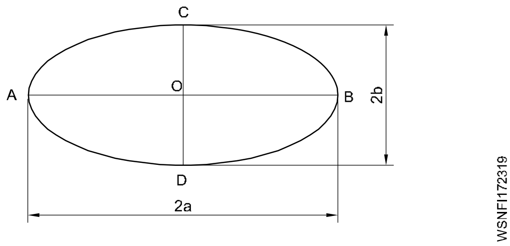
DAC (Distance Across Corners) = 2 x a unit

= 2 x 2 = 4 cm

— — — — — — —

Ellipse

Fig 9



Major axis AB = 2a

Half of Major axis OB = a,

Minor axis CD = 2b

Half of Minor axis OC = b

Area of ellipse A = π x a x b unit^2

Perimeter of ellipse P = $2\pi\sqrt{\frac{(a^2+b^2)}{2}}$ unit

1 Find its area and perimeter, if the major and minor axis of an ellipse are 12 cm and 8 cm respectively.

Solution:

Major axis 2a = 12 cm

a = $\frac{12}{2}$ = 6 cm

Minor axis 2b = 8 cm

b = $\frac{8}{2}$ = 4 cm

Area A = π x a x b unit^2

= $\frac{22}{7}$ x 6 x 4 cm^2

= 75.43 cm^2

Perimeter (P) = $2\pi\sqrt{\frac{(a^2+b^2)}{2}}$ unit

= $2\times\frac{22}{7}\sqrt{\frac{(6^2+4^2)}{2}}$ unit

= $2\times\frac{22}{7}\sqrt{\frac{36+16}{2}}$ unit

= $2\times\frac{22}{7}\times\sqrt{26}$

= 2 x $\frac{22}{7}$ x 5.1 = 32.06 cm

— — — — — — —

Assignment

Circle

1 Find the circumference and area of a circle whose radius is 10 metre.

2 Find its diameter if the area of a circle is 330 cm^2.

3 Find its area if the circumference of a circle is 50 cm.

4 Find out the area and circumference of a circle of diameter is 50 cm.

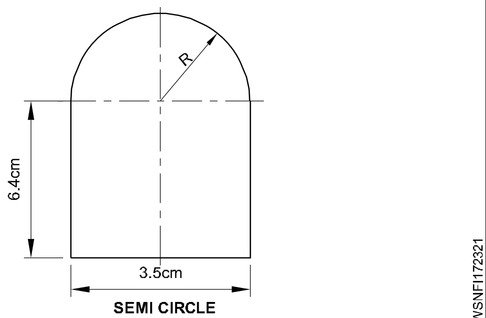
5 Find its area if the circumference of a circle is 44 cm.

Semi circle

1 Calculate the circumference and area of semi circle whose radius is 14 cm.

2 Find area of the given figure.

Fig 1



Circular ring

1 Find out area of a ring washer, whose inner radius and outer radius are 13 cm and 15 cm respectively.

2 Find the area of a ring portion of a washer whose outer dis is 30 m and inner dis is 20 m. Also calculate the difference between the circumference of circles.

Sector of circle

1 Find the perimeter and area of a sector of a circle of radius 5cm and its angle is 96^0.

2 Find the radius of the circle if the angle is 90^0 and the area of sector of a circle is 196 cm^2.

Hexagon

1 Find out the Area, perimeter, DAF,and DAC of hexagon of side 4cm.

2 Find the area of cross section of a regular hexagon rod whose side is 7.5 cm.

Ellipse

1 Find the area of the biggest ellipse that can be inscribed in a rectangle of length 18 cm and breadth 12 cm. Also calculate its perimeter.

2 How much fencing will be required to enclose an elliptical plot of ground the axes of the ellipse being 200 and 170 meter respectively.

Mensuration - Surface area and volume of solids - cube, cuboid, cylinder, sphere and hollow cylinder

Cube

All sides of cube are same i.e length,breadth and height have same value. It is bounded by six equal square faces.

Volume of cube = side x side x side

= a^3 unit^3

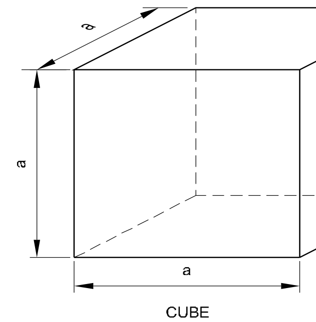
Lateral surface area = $4a^2$ unit^2

Total surface area = 6 x side x side

= $6a^2$ unit^2 $\sqrt{3} = 1.732$

Diagonal d = $\sqrt{3}a$

Fig 1



Rectangular solid (or) cuboid

Rectangular soild is bounded by six rectangular surfaces and opposite surfaces are equal and parallel to each other.

Volume of rectangular solid

= Length x breadth x height

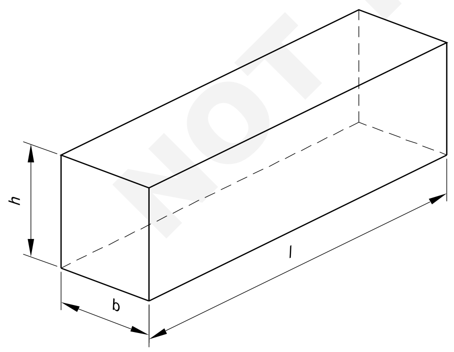
= l . b . h unit^3

Lateral surface area = 2h(l+b) unit^2

Total surface area = 2lb + 2bh + 2hl

= 2(lb+bh+hl) unit^2

Fig 2



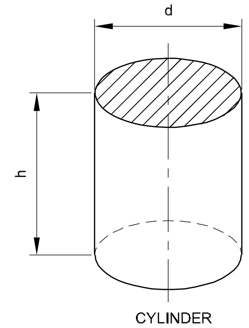
l = length, b = breadth and h = height

Cylinder

This is a prism whose top and bottom surfaces are equal and circular.

Volume of cylinder = $\pi r^2 h$ or $\frac{\pi}{4} d^2 h$

Fig 3



Curved area of cylinder = $2\pi rh$ unit^2

Total surface area of cylinder = $2\pi r(h+r)$ unit^2

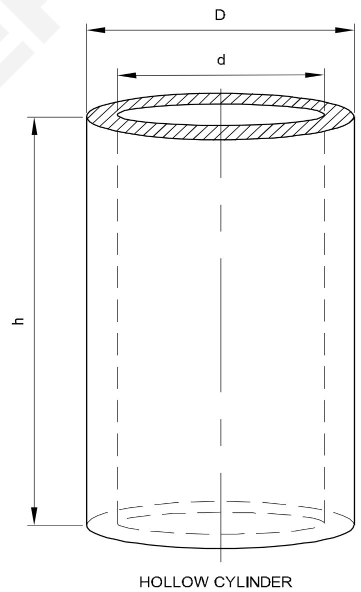
r = Radius of base , d = Diameter of base

h = Height of cylinder

Hollow cylinder

Hollow means empty space. In hollow cylinder there is an empty place. Water pipe is an example of hollow cylinder.

Fig 4



Volume of hollow cylinder = $\pi (R^2 - r^2)$ h (or)

= π (R + r) (R - r) h (or)

= $\frac{\pi}{4}(D^2 - d^2)$ h unit^3

= $\frac{\pi}{4}(D+d)(D-d)h$

Total surface area of hollow cylinder =

Inner + outer curved area + area of top and bottom circular part

$\therefore$ TSA : $2\pi Rh + 2\pi rh + 2\pi(R^2 - r^2)$

R = outer radius

r = inner radius

D = outer diameter

d = inner diameter

h = height of cylinder

t = thickness

Mean dia = $\frac{D-d}{2}$

If thickness given then:

Volume of hollow cylinder = π x mean dia x thickness x height

Finding out volumes of solids

The space occupied by a body is known its volume. The volume of a body indicates the capacity to hold substance in it.

The general form of Lateral surface area Total surface area and Volume is :

Lateral surface area = perimeter of the base x height

Total surface area = LSA + 2 (base area)

Volume = Area of base x height

Important and commonly used solids are described below one after another:

Cube

1 Find the diagonal, lateral surface area,, total surface area and volume of a cube of side 4.5 cm.

side a = 4.5 cm

diagonal d = $\sqrt{3}$a unit

= 1.732 x 4.5

= 7.794 cm

L.S.A = $4a^2$ unit^2

= 4 x 4.5 x 4.5

= 81 cm^2

T.S.A = $6a^2$ unit

= 6 x 4.5 x 4.5

= 121.5 cm^2

V = a^3 unit^3

= 4.5 x 4.5 x 4.5

= 91.125 cc.

2 Calculate volume of a cube where side is 9 cm

a = 9 cm

V = ?

V = a^3

= 9 x 9 x 9

= 729 cm^3

3 Find out side of the cube if a cube has volume of 3375cm^3.

V = 3375 cm^3

a = ?

a^3 = 3375

a = $\sqrt[3]{3375}$

= $\sqrt{3x3x3x5x5x5}$

= 3 x 5

= 15 cm

4 Find the side of a cube, if its surface area is 216 cm^2

Surface area = T.S.A = 216 cm^2

$6a^2$ = 216

a^2 = $\frac{216}{6}$

= 36

a = $\sqrt{36}$

= 6 cm

5 Find the side of the square tank, if its height is 2 metre and has the capacity to hold 50,000 litre of water.

Height of square shape tank (h) = 2 m

Capacity = 50,000 litre

1000 litre = 1 m^3

50,000 Litre = $\frac{50000}{1000}$

= 50 m^3

Capacity of tank = 50 m^3

a^2 x h = 50

a^2 x 2 = 50

a^2 = $\frac{50}{2}$ = 25 m^2

a = $\sqrt{25}$ = 5 m

Side of the square tank = 5 m

Rectangular Solid (or) Cuboid

1 Find its volume and T.S.A if a tank is 20 m long, 15 m broad and 12 m high.

l = 20m

b = 15 m

h = 12 m

v = ?

T.S.A = ?

Volume v = lbh unit^3

= 20 x 15 x 12

= 3600 m^3

T.S.A = 2(lb + bh + hl) unit^2

= 2((20 x 15) + (15 x 12) + (20 x 12))

= 2 (300 + 180 + 240)

= 1440 m^2

2 Find out its height if the cross section is 260 mm length and 180 mm wide rectangular and the capacity of a fuel tank is 10500 cm^3.

l = 260mm = 26 cm

b = 180 mm =18 cm

v = 10500 cm^3

h = ?

l.b.h = volume

26 x 18 x h = 10500

$h = \frac{10500}{26 \times 18}$

= 22.44 cm

3 How many litres of water it can store if a water tank has the following dimensions length = 1 metre, width = 0.8 metre and height = 1.2 metre?

Volume = l x b x h unit^3

= 1 x 0.8 x 1.2

= 0.96 m^3 [1 m^3 = 1000 litres]

= 0.96 x 1000

= 960 litres of water can store in the tank.

4 Find its volume if the base of a prism is a rectangle having 5m length, 4m breadth and the height of the prism is 15m.

The base of prism is rectangle

Area of base = length x breadth

= 5 x 4

= 20 square m

Volume of prism = Area of base x Height

= 20 x 15

= 300 cm^3

Cylinder

1 Find the volume and total surface are of a cylinder having 9cm diameter and 15 cm height.

diameter = 9 cm

radius r = 4.5 cm

height h = 15 cm

Volume V = ?

T.S.A = ?

V = $\pi r^2 h$ unit^3

$= \frac{22}{7} \times 4.5 \times 4.5 \times 15$

= 954.4 cm^3

T.S.A = $2\pi r(h+r)$ unit^2

$= 2 \times \frac{22}{7} \times 4.5\ (15 + 4.5)$

$= 2 \times \frac{22}{7} \times 4.5 \times 19.5$

= 551.4 cm^2

2 Calculate the radius if the curved surface area of a cylindrical roller is 48π cm^2 and the roller is 10 cm long

C.S.A = 48π cm^2

length = 10 cm

radius = ?

$2\pi rh = 48\pi$

$2 \times \pi \times r \times 10 = 48\pi$

$r = \frac{48 \times \pi}{2 \times \pi \times 10}$

= 2.4 cm

3 Find its radius if the volume of a cylinder is 5544 cm^3 and its height is 16 cm.

$\pi r^2 h = v$

$3.14 \times r^2 \times 16 = 5544$

$r^2 = \frac{5544}{3.14 \times 16}$

$r^2 = \frac{5544}{50.24}$

= 110.35

$r = \sqrt{110.35}$

= 10.5 cm

4 Find the diameter of the tank if the volume of a circular tank is 68.46 m^3, its height is 2 m.

$\pi r^2 h = 68.46$

$r^2 = \frac{68.46}{3.14 \times 2}$

$r^2 = 10.9$

$r = \sqrt{10.9}$

= 3.3 m

diameter = 2r

= 2 x 3.3

= 6.6 m

5 A cylindrical vessel is to be made of 3 metre long and 1.9994 metre diameter. Calculate its total surface area, if it is in a closed form on one end.

h = 3m

d = 1.9994 m

r = 0.9997 m

T.S.A = C.S.A + Base area

$= 2\pi rh + \pi r^2$

$= (2 \times \frac{22}{7} \times 0.9997 \times 3) + (\frac{22}{7} \times 0.99997^2)$

= 18.85 + 3.14

= 21.99 m²

6 How many litres of water a cylinder of radius 75 cm and height 100 cm can hold.

$V = \pi r^2 h \text{ unit}^3$

= 3.142 x 75 x 75 x 100

$= 1767375 \text{ cm}^3$

$= \frac{1767375}{1000}$ [1000 cc = 1 litre]

= 1767.375 litres.

7 Calculate the height of cylindrical tin if a closed rectangular box 40 cm long, 30 cm wide and 25 cm deep has the same volume as that of cylinder tin of radius 17.5 cm.

Volume of cylinder = Volume of rectangular box

$\pi r^2 h = l \times b \times h$

$\frac{22}{7} \times 17.5 \times 17.5 \times h = 40 \times 30 \times 25$

$h = \frac{40 \times 30 \times 25 \times 7}{22 \times 17.5 \times 17.5}$

$= \frac{210000}{6737.5}$

= 31.17 cm

8 An oxygen cylinder is 15 cm in diameter and 100 cm in length. It is filled with gas under pressure so that every cm³ of the cylinder contains 120 cm³ of gas. How much cc of oxygen does this hold?

Volume of cylinder $= \pi r^2 h \text{ unit}^3$

$= \frac{22}{7} \times 7.5 \times 7.5 \times 100$

$= 17678.57 \text{ cm}^3$

Gas contain in 1 cm³ = 120 cm³ of gas

Gas contain in 17678.57 cm³ = 17678.57 x 120

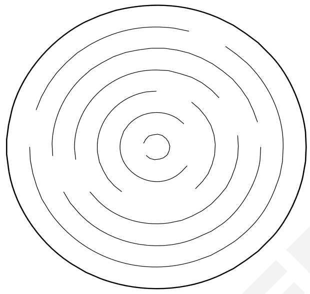
$= 2121428 \text{ cm}^3$

Volume of oxygen = 2121428 cc.

Sphere

Sphere is a solid circular body.

Fig 5



SPHERE

WSNMD183115

Volume of sphere $= \frac{4}{3}\pi r^3$ or

$= \frac{\pi}{6} d^3 \text{ unit}^3$

Total surface area of sphere $= 4\pi r^2 \text{ unit}^2$

Where r = Radius of sphere

d = Diametre of sphere

Radius $= \frac{1}{2}$ of diameter

1 Find the volume and surface area of a sphere of 3 cm radius.

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

$= \frac{4 \times 22 \times 3 \times 3 \times 3}{3 \times 7}$

$= 113.1 \text{ cm}^3$

Total Surface Area $= 4\pi r^2 \text{ unit}^2$

$= 4 \times \frac{22}{7} \times 3 \times 3$

= 113.1 cm²

2 Find the diameter of sphere having volume of 15625 cc.

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

$\frac{4}{3} \times \frac{22}{7} \times r^3 = 15625$

$r^3 = \frac{15625 \times 3 \times 7}{4 \times 22}$

$= \frac{328125}{88}$

$= 3728.69$

r $= \sqrt[3]{3728.69}$

= 15.51 cm

diameter = 2 x radius

= 2 x 15.51

= 31.02 cm

3 How many spherical balls of 1 cm radius can be made from a sphere of 32 cm diameter.

No. of balls x volume of small sphere = Volume of bigger sphere

$N \times \frac{4}{3} \times \pi r^3 = \frac{4}{3}\pi r^3$

$N \times \frac{4}{3} \times \pi \times 1^3 = \frac{4}{3} \times \pi \times r^3$

N = 16 x 16 x 16

= 4096 balls

4 Three brass balls of diameters 3 cm, 4 cm and 5 cm are melted and make into one solid ball, if there is no wastage. Find the diameter of the solid ball.

1st ball d_1 = 3 cm,

r_1 = 1.5 cm

2nd ball d_2 = 4 cm,

r_2 = 2 cm

3rd ball d_3 = 5 cm,

r_1 = 2.5 cm

Diameter of new ball = ?

Volume of new ball = Volume of 3 spherical balls

$\frac{4}{3}\pi r^3 = \frac{4}{3}\pi r_1^3 + \frac{4}{3}\pi r_2^3 + \frac{4}{3}\pi r_3^3$

$\frac{4}{3}\pi r^3 = \frac{4}{3}\pi (1.5^3 + 2^3 + 2.5)^3$

$r^3 = 3.375 + 8 + 15.625$

$r^3 = 27$

$r = \sqrt[3]{27}$

$r = \sqrt[3]{3x3x3}$

r = 3 cm

Diameter of the ball = 2 x r

= 2 x 3

= 6 cm

Assignment

Cube

1 Find the diagonal, lateral surface area, total surface area and volume of cube, whose side is 15 cm.

2 Find the volume of 10 cubes where each side is 5 cm.

3 Find its volume if a solid cube has each of its sides 60 mm long.

4 What is its side if the total surface area of a cube is 384 m^2.

Cuboid

1 Find the volume of the tank in m^3, if the length is 60 m, breadth 40 m and height 20 m.

2 Find the volume of a C.I. casting of a rectangular block having 25 cm x 20 cm x 8 cm size.

3 Calculate the total surface area of a box whose length, width and height are 120 cm, 50 cm and 60 cm respectively.

4 Find the volume of the sheet if a brass sheet is of 25 cm square and 0.4 cm thick.

Cylinder

1 Find the curved surface area of cylinder whose diameter is 18 cm and height 34 cm?

2 Find the total surface area of cylinder whose diameter is 24 cm and height 40 cm?

3 Find out the volume of cylinder whose base is 10 cm radius and height is 40 cm?

Sphere

1 Find the volume of sphere having diameter 3.5cm?

2 Find the total surface area of a sphere having radius 1.75 cm?

3 How many spherical balls of 1 cm radius can be made from a sphere of 16 cm diameter.

4 Three balls of diameter 2m, 4cm and 6 cm are melted and made into one solid ball. If there is no wastage, find the diameter of solid ball.

Mensuration - Finding the lateral surface area, total surface area and capacity in litres of hexagonal, conical and cylindrical shaped vessels

Hexagonal bar

Volume of Hexagonal bar = Area of hexagonal x height

Lateral surface area of hexagonal bar

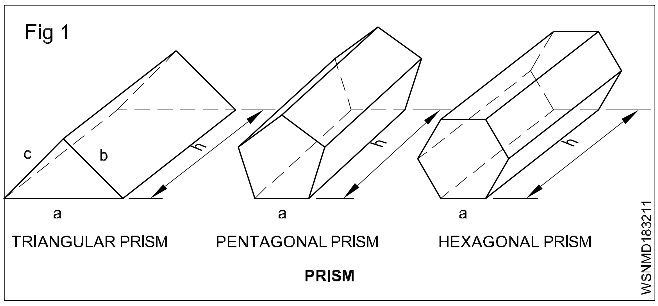
= 6 x side of hexagon x length of the bar

or = 3.464 x length of the bar x flat of hexagon

Total surface area of hexagonal bar

= lateral surface area + (2 x area of hexagon)

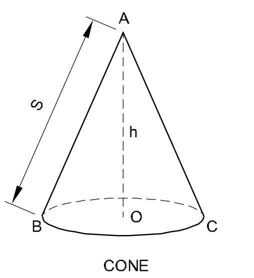
Fig 1



Cone

Cone is a pyramid with a circular base.

Fig 2



Volume of cone = $\frac{1}{3}\pi r^2 h$

or $= \frac{\pi}{12} d^2 h$

Curved area = πrs

Total surface area = $\pi r(s+r)$

Where r = radius of base

d = diametre of base

h = vertical height of cone

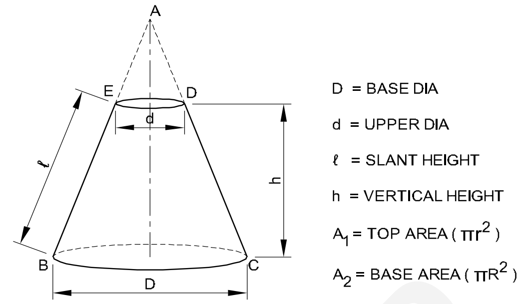
s = slant height $\sqrt{r^2+h^2}$

Frustum of a cone

When a cone is cut by a plane parallel to the base, and upper part is removed, the formation appears, is termed as frustum of a cone. Buckets, oil cans etc.are such frustums in shape.

L.S.A = $\pi l (R + r)$ unit²

Fig 3



TSA = $\pi l (R + r) + A_1 + A_2$ unit²

$V = \frac{\pi}{3} h (R^2 + Rr + r^2)$ unit³

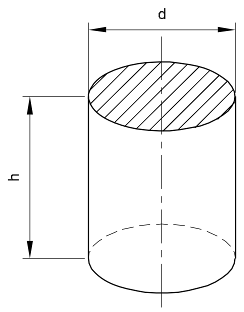
[A_1 = Top area ; A_2 = Bottom area]

Cylinder

This is a prism whose top and bottom surfaces are equal and circular.

Volume of cylinder = $\pi r^2 h$ or $\frac{\pi}{4} d^2 h$

Fig 4



Curved area of cylinder = $2\pi rh$

Total surface area of cylinder = $2\pi r(h+r)$

r = Radius of base, d = Diameter of base

h = Height of cylinder

Hollow cylinder

Hollow means empty space. In hollow cylinder there is an empty place. Water pipe is an example of hollow cylinder.

Volume of hollow cylinder $= \pi (R^2 - r^2) h$ (or)

$= \pi (R + r) (R - r) h$ (or)

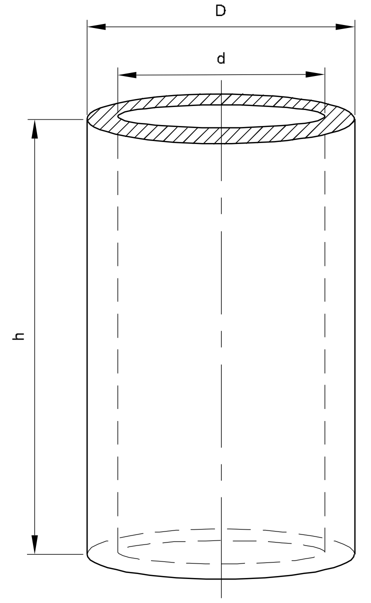
$= \frac{\pi}{4} (D^2 - d^2) h$

$= \frac{\pi}{4} (D + d)(D - d) h$

Total surface area of hollow cylinder =

Inner + outer curved area + area of top and bottom circular part

Fig 5



HOLLOW CYLINDER

WSNMD183215

$\therefore$ TSA : $2\pi Rh + 2\pi rh + 2\pi(R^2 - r^2)$

R = outer radius

r = inner radius

D = outer diameter

d = inner diameter

h = height of cylinder

t = thickness

Mean dia = $\frac{D - d}{2}$

If thickness given then:

Volume of hollow cylinder = π x mean dia x thickness x height

Example

1 Find the volume of an hexagonal prism having its side 20 cm and height 200 cm.

Side of hexagonal prism (a) = 20 cm

Height (h) = 200 cm

Volume (V) = Base side area x Height

$= 6 \times \frac{\sqrt{3}}{4} \times a^2 \times h$

$= 6 \times \frac{\sqrt{3}}{4} \times 20 \times 20 \times 200$

$= 1{,}20{,}000 \times \sqrt{3}$

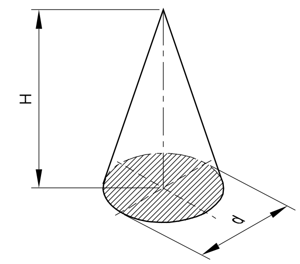
$= 1{,}20{,}000 \times 1.732$

= 2,07,840 cm³

Volume of the hexagonal prism = 2,07,840 cm³

2 Calculate the height. Also find the lateral surface area if a cone has a base diameter of 210 mm and its volume is 3056 cm3.

Fig 6



WSNMD183216

Volume of a cone = $\frac{1}{3}$ x Area of base x height

$3056\ cm^3 = \frac{1}{3} \times 0.785 \times 210^2 mm^2 \times H$

$H = \frac{3056 \times 3 \times 1000 mm^3}{0.785 \times 210^2\ mm^2} = 264.82\ mm$

L = Slant height = $\sqrt{264.83^2 + 105^2} = 284.9mm$

Lateral surface area = $\frac{1}{2}\pi \times 210 \times 284.9 mm^2$

= 94017 mm² = 940.17 cm²

3 Determine its diameter in mm if the height of a rod of 1.6 metres and its volume is 1.017 metre³.

V = A x H

V = $\pi r^2 \times h$ (or) $\frac{\pi d^2}{4} \times h$

Volume = Area x Height

$= \frac{\pi d^2}{4} = 0.785 d^2$

$1.017 m^3 = 0.785 d^2 \times 1.6$ metres

$0.785 d^2 = \frac{1.017}{1.6} m^2$

$d^2 = \frac{1.017}{1.6 \times 0.785} m^2$

$= \frac{1.017}{1.6 \times 785} m^2$

$d = \sqrt{\frac{10170}{16 \times 785}}$ metre

$= \sqrt{\frac{10170}{12560}}$

$= \sqrt{0.8097}$

$= 0.8998$

= 899.8mm

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

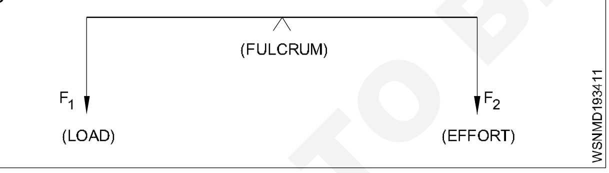
3 Third order lever

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



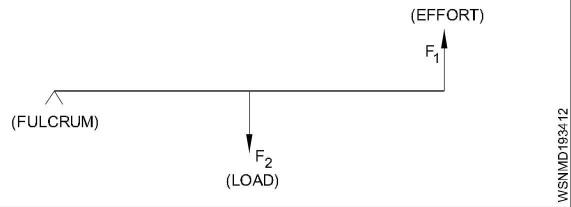
In this type of lever the mechanical advantage will be equal or less than or greater than 1 (M.A < = > 1)

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



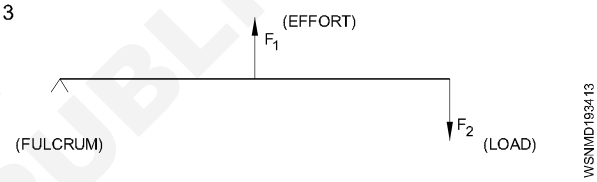
In this type of lever, the mechanical advantage will be greater than 1 (M.A. > 1). Less effort is used to lift more load.

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

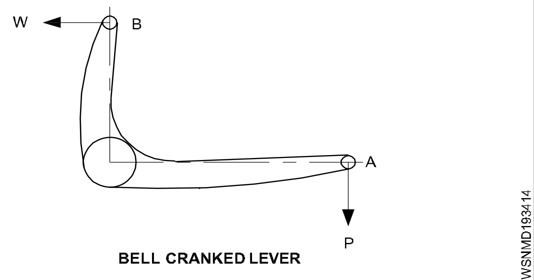
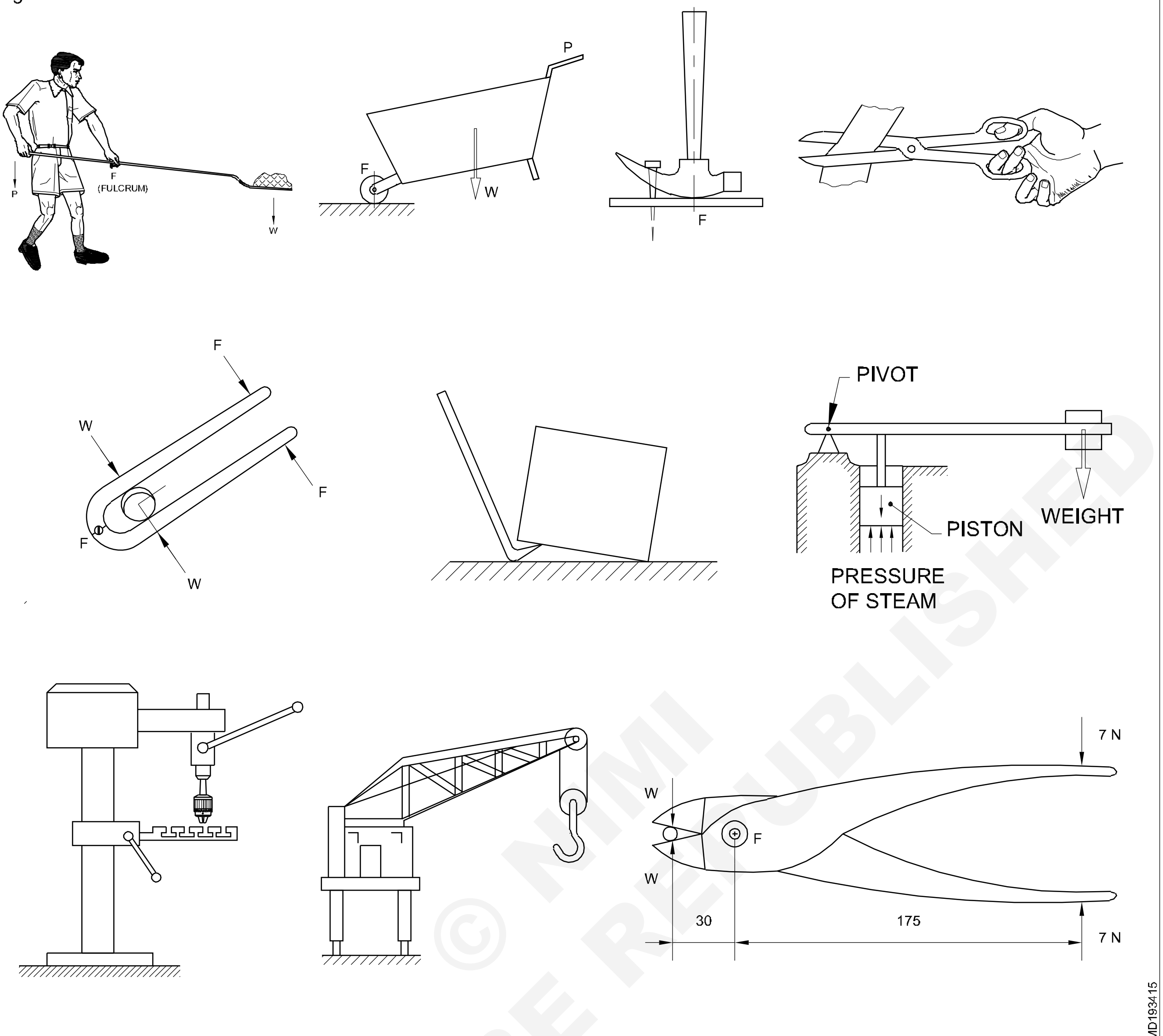


Fig 5



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

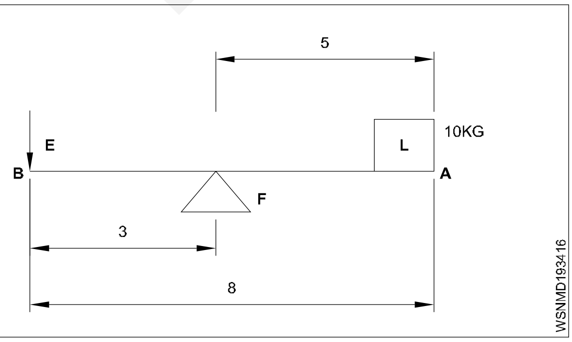
10 x 5 = P x 3

50 = 3 P

P = 50 / 3

= 16.67 kg

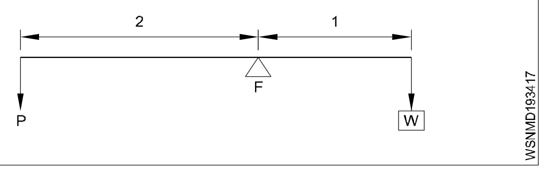
Fig 6



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

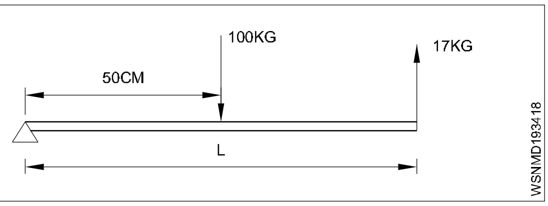
= 1500 kg

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

$17x = 100 \times 50$

$x = \frac{100 \times 50}{17} = 294.1$ cm

$x = 294.1$ cm

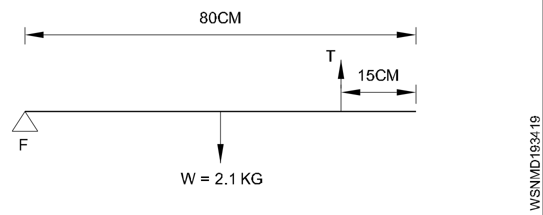
Distance between the load and point of force = 294.1 - 50

= 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 kg x (80 - 15) cm $= 2.1 \text{ kg} \times \frac{80}{2}$ cm

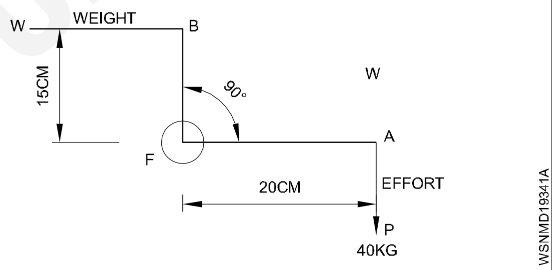
T x 65 = 2.1 x 40

$T = \frac{2.1 \times 40}{65}$ 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

$W = \frac{40 \times 20}{15} = \frac{160}{3} = 53.3$ 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?