WORKSHOP CALCULATION & SCIENCE

(NSQF)

(As per Revised Syllabus July 2022)

Interior Design & Decoration

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Directorate General of Training

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

NATIONAL INSTRUCTIONAL MEDIA INSTITUTE, CHENNAI

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

Workshop Calculation & Science

Interior Design & Decoration - 1 Year NSQF

As per Revised Syllabus July 2022

Developed & Published by

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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 - Interior Design & Decoration** NSQF (Revised 2022) under CTS will help the trainees to get an international equivalency standard where their skill proficiency and competency will be duly recognized across the globe and this will also increase the scope of recognition of prior learning. NSQF trainees will also get the opportunities to promote life long learning and skill development. I have no doubt that with NSQF the trainers and trainees of ITIs, and all stakeholders will derive maximum benefits from these IMPs and that NIMI's effort will go a long way in improving the quality of Vocational training in the country.

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

Jai Hind

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

New Delhi - 110 001

PREFACE

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

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

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

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

The **Workshop Calculation & Science** - Interior Design & Decoration 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** - Interior Design & Decoration 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.

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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 - Interior Design & Decoration** as per NSQF Revised 2022.

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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.

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INTRODUCTION

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

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

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

Time allotment:

Duration of 1 Year : 32 Hrs

Time allotment for each title of exercises has been given below. **Workshop Calculation & Science - Interior Design & Decoration** NSQF Revised Syllabus 2022.

S.No	Title	Exercise No.	Time in Hrs
1	Unit, Fractions	1.1.01 - 1.1.07	4
2	Square root, Ratio and Proportions, Percentage	1.2.08 - 1.2.14	6
3	Material Science	1.3.15 - 1.3.17	6
4	Basic Electricity	1.4.18 & 1.4.19	6
5	Mensuration	1.5.20 - 1.5.24	8
6	Levers and Simple machines	1.6.25	2
		Total	**32 Hrs**

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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.**

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SYLLABUS

1 Year

Workshop Calculation & Science - Interior Design & Decoration
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
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VI	**Levers and Simple Machines** 1 Levers & Simple Machines - Lever and its types	2
	Total	32

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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

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

Length of copper wire

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

$$= 1413.33 \text{ cm}$$

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.

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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

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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

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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

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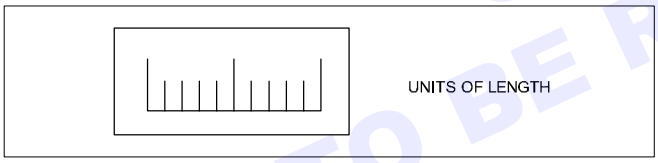
Prefixes for decimal multiples and submultiples

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

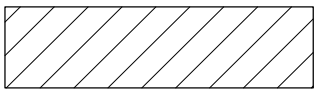
Units of physical quantities



Units of length

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



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



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

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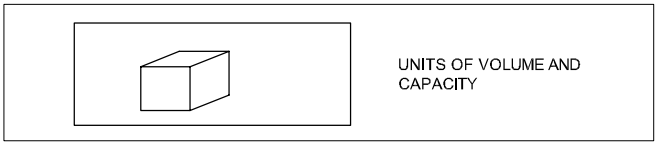
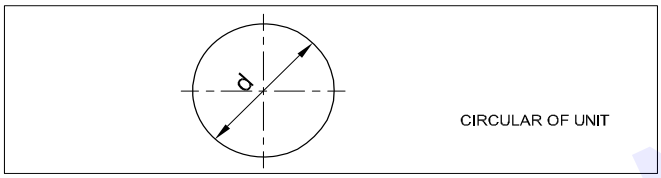


Units of volume and capacity

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



Radian

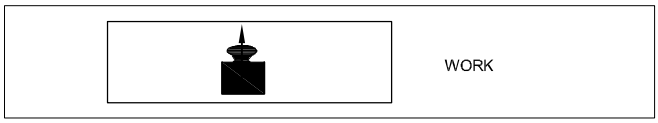
Relationship between Radian and Degree

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

180^0 = π Radian;

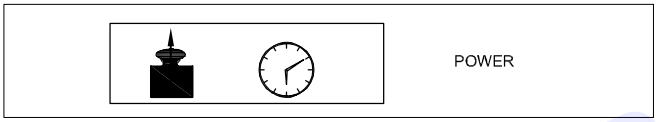
1 Degree = $\frac{\pi}{180}$ Radian

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



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

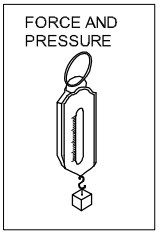
I.T.Kilocalorie/hour = 1 $kcal_{IT/h}$ = 1.163 W

Pressure

Pascal	1 Pa	= 1 N/m^2	1 atm	= 101325 Pa
Bar	1 bar = 10N/cm^2	= 100000 Pa–Torr	1 torr	= $\frac{101325}{760}$ ≈ 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



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

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FORCE

Force	In C.G.S. System : Force (Dyne)	= Mass (gm)XAcceleration (cm/sec^2)
	In F.P.S. System : Force (Poundal)	= Mass (lb) 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 lb x 1 ft/sec^2
	1 Newton	= 1 kg x 1 mtr/sec^2 = 10^5 dynes
	1gm weight	= 981 Dynes
	1 lb 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



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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.

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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.

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

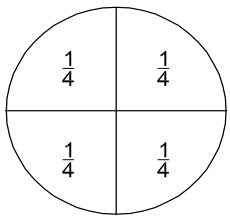
1,3,7 - numerators 4,12 - denominators

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



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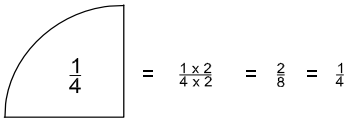
Fraction: Value

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



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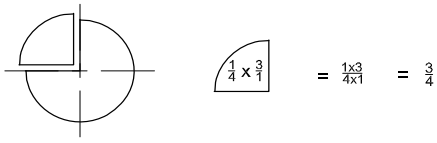
Multiplication

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



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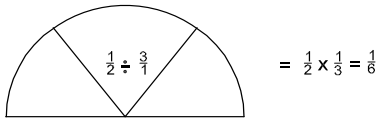
Division

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

Fig 4



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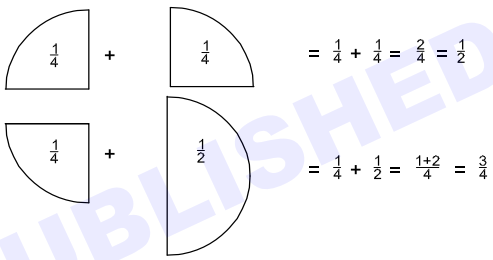
Addition and Subtraction

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



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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 $\frac{3}{4}$,

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

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

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

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

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

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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

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

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

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

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

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

Common fractions

Problems with plus and minus sign

Example

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

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

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

Examples

Common fractions

- Multiply

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

- Division

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

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

- Addition

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

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

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

- Subtraction

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

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

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

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

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Assignment

1 Convert the following into improper fractions.

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

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

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

2 Convert the following into mixed numbers.

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

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

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

3 Place the missing numbers.

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

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

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

4 Simplify.

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

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

5 Multiply.

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

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

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

6 Divide

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

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

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

7 Place the missing numbers.

a $\frac{2}{3} = \frac{1}{12} x$_____

b $\frac{14}{24} = \frac{1}{12} x$_____

c $\frac{7}{8} = \frac{1}{12} x$_____

8 Add the followings:

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

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

9 Subtract

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

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

10 Simplify

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

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

11 Express as improper fractions

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

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

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

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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

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

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

$$\begin{array}{r} 0.375 \\ 3.686 \\ \hline 4.061 \end{array}$$

Subtract 18.72 from 22.61

$$\begin{array}{r} 22.61 \\ 18.72 \\ \hline 3.89 \end{array}$$

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

$$0.25\overline{)0.75}$$

$$\frac{0.75}{0.25} \text{ x } \frac{100}{100} = \frac{75}{25}$$

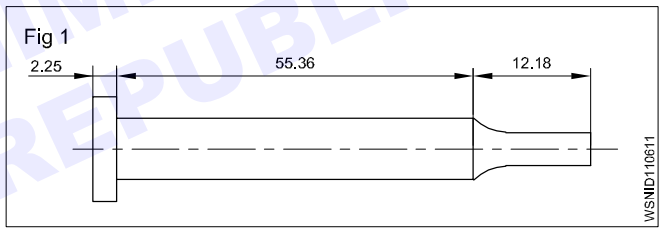
$$25\overline{)75} = 3$$

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

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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)

$$\begin{array}{r} 0.5625 \\ 16\overline{)90000} \\ 80 \\ \hline 100 \\ 96 \\ \hline 40 \\ 32 \\ \hline 80 \\ 80 \\ \hline 0 \end{array}$$

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

Recurring decimals

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

Examples

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

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

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

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

Method of writing approximations in decimals

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

Multiplication and division by 10,100,1000

Multiplying decimals by 10

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

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

Dividing decimals by 10

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

Examples

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

Examples

- Rewrite the following number as a fraction

  453.273

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

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

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

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

- Write approximations in the following decimals to 3 places.

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

- Convert fraction to decimal

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

- Convert decimal to fraction

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

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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

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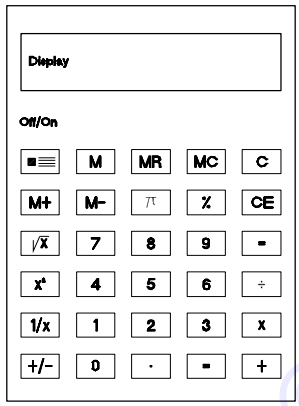
Unit, Fractions - Solving problems by using calculator

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

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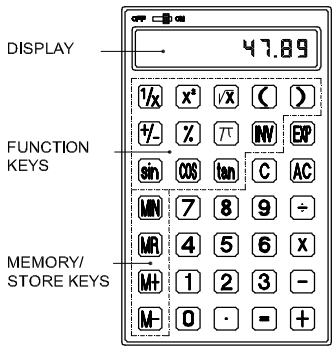
Further functional keys included in Scientific calculators are as shown in Fig 2.

Fig 2



SCIENTIFIC CALCULATOR

Sin Cos Tan ( ) For trigonometric functions and for brackets

Exp Exponent key

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

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

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

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

- **The display**

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

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

Rules and Examples:

- **Addition:** Example 18.2 + 5.7

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

- **Subtraction:** Example 128.8 - 92.9

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

- **Multiplication:** Example 0.47 x 2.47

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

- **Division:** Example 18.5/2.5

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

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- **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

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

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

Assignment

1 Using calculator solve the following

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

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

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

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

2 Using calculator simplify the following

a 24367 - 4385 = _____

b 9.643 - 0.7983 = _____

c 4382.01 - 381.3401 = _____

d 693.42 - 0.0254 = _____

3 Using calculator find the values of the following

a 23 x 87 = _____

b 1376 x 0.81 = _____

c 678 x 243 = _____

d 0.75 x 0.24 = _____

4 Using calculator solve the following

a 22434 ÷ 3 = _____

b 4131 ÷ 243 = _____

c 469890 ÷ 230 = _____

d 3.026 ÷ 0.89 = _____

5 Solve the following

a $\frac{1170 \times 537.5}{13 \times 215}$ = _____

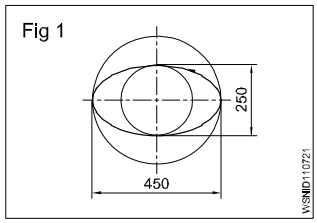
b $\frac{28.2 \times 18 \times 3500}{1000 \times 3 \times 0.8}$ = _____

6 Solve the following

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

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

7



2a = 450 mm(major axis)

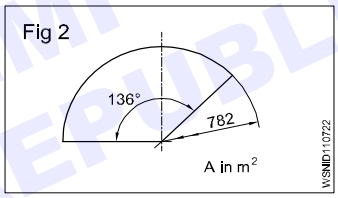
2b = 250mm(minor axis)

Perimeter of the ellipse

A = _____ metre^2

Hint A = π x a x b unit^2

8



ø = 782 mm

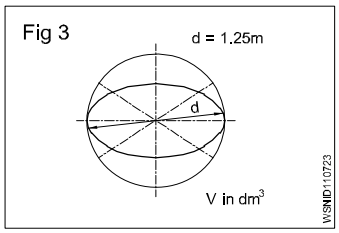
α = 136°

Area of the sector

A = _____

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

9



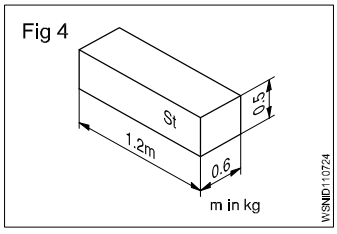
d = 1.25 metre

V = _____ dm^3

Volume of sphere

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

10



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)

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

a basic number
2 exponent

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

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

a^2 radicand

Square number

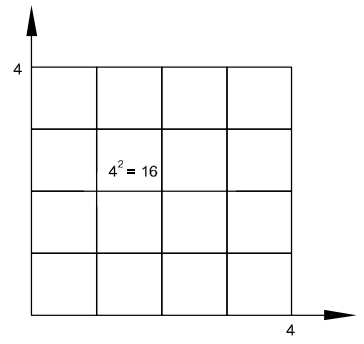
The square of a number is the number multiplied by itself.

Basic number x basic number = Square number

$a \times a = a^2$

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

Fig 1



Splitting up

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

Large square 4 x 4 = 16 a^2

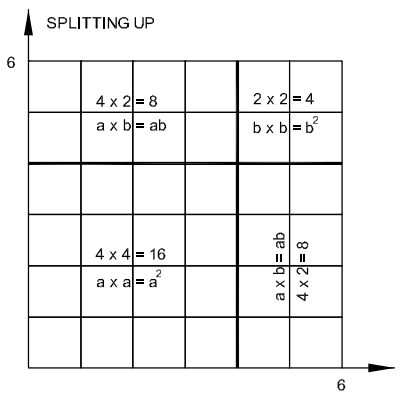
Two rectangles 2 x 4 x 2 = 16 2ab

Small square 2 x 2 = 4 b^2

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

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

Fig 2

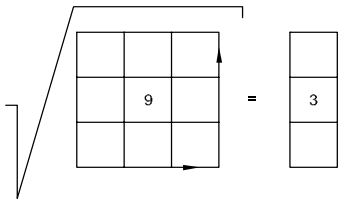


Result: In order to find the square root, we split up the square numbers.

Extracting the square root procedure

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

Fig 3



If there is a remainder, repeat the procedure.

	68
6	46,24
	36
128	1024
	1024
	0

$\sqrt{4624} = 68$

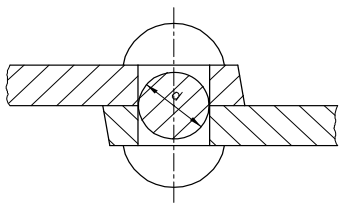
Basic number x basic number = Square

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

Example

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

Fig 4



Rivet cross-section is the hole cross-section.

To find 'd',

Given that Area = 3.46 cm^2

Area = 0.785 x d^2 (formula)

3.46 cm^2 = d^2 x 0.785

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

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

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

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

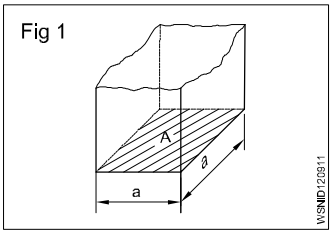
1 a $\sqrt{2916}$ = _____.

b $\sqrt{45796}$ = _____.

c $\sqrt{8.2944}$ = _____.

d $\sqrt{63.845}$ = _____.

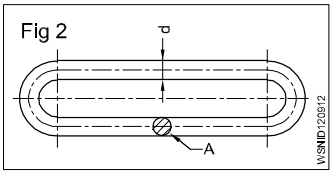
2



A = 2025 mm²

a = _____mm

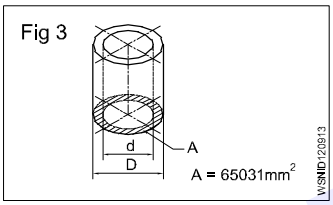
3



A = 176.715 mm²

d = _____mm

4

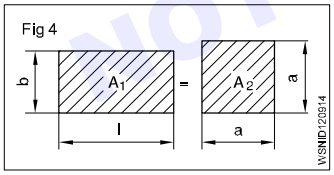


A = 65031 mm²

d = 140 mm

D = _____mm

5



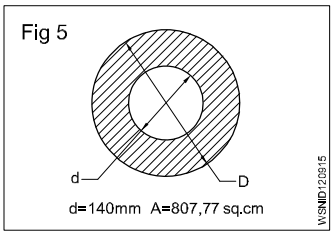
l = 58 cm

b = 45 cm

$A_1 = A_2$

a = _____cm

6

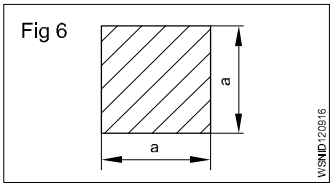


A = 807.77 cm²

d = 140 mm

D = _____mm

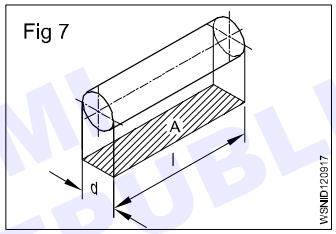
7



a x a = 543169 mm²

a = _____mm

8

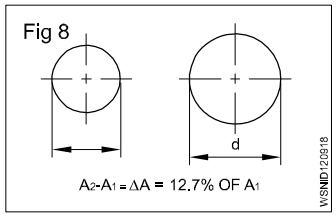


d : l = 1:1.5

A = 73.5 mm²

d = _____mm

9



increase in area

A = 12.7%

A = 360 mm²

d = _____mm

(d = diameter after the increase in area)

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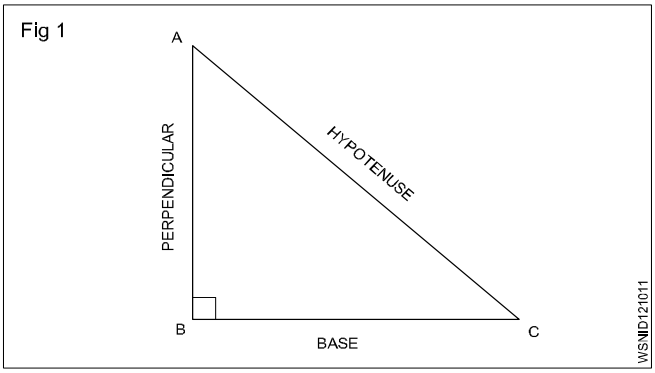
Square root, Ratio and Proportions, Percentage - Applications of pythagoras theorem and related problems

Applications of Pythagoras Theorem

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

Fig 1



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

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

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

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

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

6 The Pythagoras theorem is applied in surveying the mountains.

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

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

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

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

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

Application of pythagoras theorem in real life

Pythagoras theorem states that

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

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

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

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

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

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

6 To find the steepness of the hills or mountains.

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

8 To determine heights and measurements in the construction sites.

Examples

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

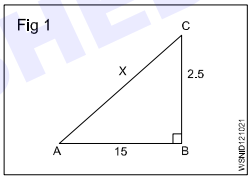
$AC^2 = AB^2 + BC^2$

$= 15^2 + 25^2$

$= 225 + 625 = 850$

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

Fig 1



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

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

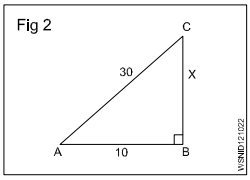
$30^2 = 10^2 + BC^2$

$900 = 100 + BC^2$

$BC^2 = 900 - 100 = 800$

$BC = 28.284$ cm

Fig 2



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

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

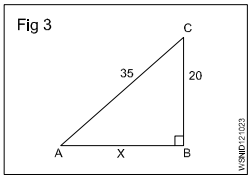
$35^2 = AB^2 + 20^2$

$1225 = AB + 400$

$AB^2 = 1225 - 400 = 825$

$AB = 28.72$ cm

Fig 3



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

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

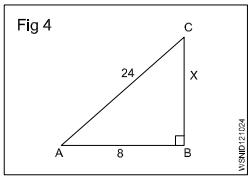
$24^2 = 8^2 + BC^2$

$576 = 64 + BC^2$

$BC^2 = 576 - 64 = 512$

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

Fig 4



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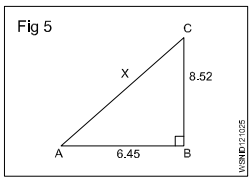
5 What is the value side AC if AB = 6.45 cm, BC = 8.52 cm.



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

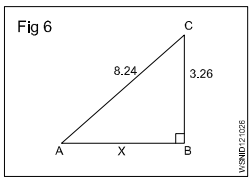
$AC^2 = 6.45^2 + 8.52^2$

$AC^2 = 41.60 + 72.59$

$= 114.19$

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

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



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

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

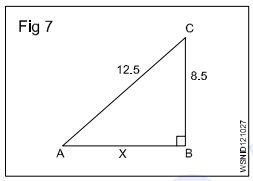
$67.9 = AB + 10.63$

$AB^2 = 67.9 - 10.63$

$= 57.27$

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

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



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

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

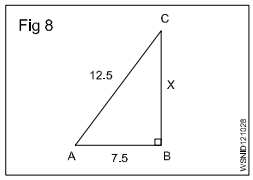
$156.25 = AB + 72.25$

$AB^2 = 156.25 - 72.25$

$= 84$

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



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

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

$BC^2 = x^2$

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

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

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

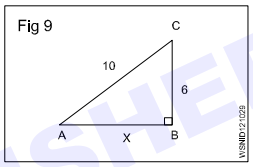
$= (12.5 + 7.5)(12.5 - 7.5)^2$

$= 20 \times 5$

$= \sqrt{100} = 10$

$x = 10$ m

9 What is the value of AB.



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

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

$AB^2 = x^2$

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

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

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

$= 100 - 36 = 64$

$x = \sqrt{64}$

$= 8$

$AB = 8$

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Assignment

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

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

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

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

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

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

Ratio

Introduction

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

Expression

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

Ratio is always reduced to the lowest terms.

Example

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

Proportion

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

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

Example

250 : 2000 :: 1 : 8

Proportion fundamentals

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

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

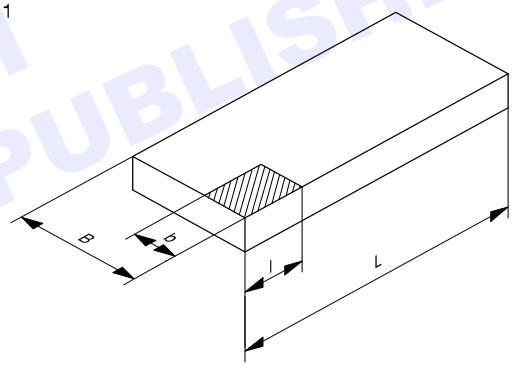
  3:4::6:8 or $\frac{3}{4} = \frac{6}{8}$
- 3 x 8 = 6 x 4
- $\frac{3}{6} = \frac{4}{8}$
- $\frac{4}{3} = \frac{8}{6}$
- $\frac{3+4}{4} = \frac{6+8}{8}$
- $\frac{3-4}{4} = \frac{6-8}{8}$
- $\frac{3+6}{4+8} = \frac{9}{12} = \frac{3}{4}$

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

Example

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

Fig 1



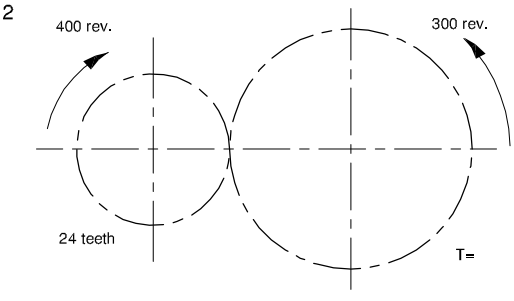
The reduction ratio is $\frac{1}{20}$.

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

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

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

Fig 2



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Speed ratio = 400 : 300

Teeth ratio = 24:T

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

$$\therefore T=\frac{24\times400}{300}=32\,\text{Teeth}$$

Find the ratio of A:B:C

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

A:B = 2:3

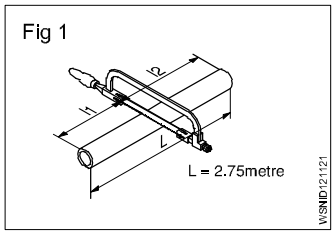
B:C = 4:5

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

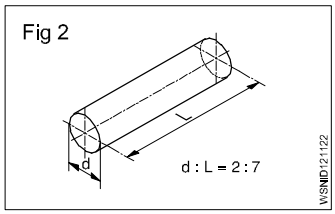
1 

$l_1 : l_2$ = 2:3

L = 2.75 metres

l_1 = _____ metres

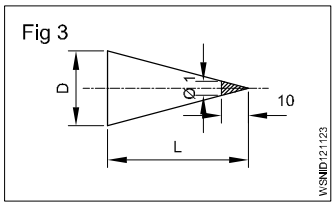
l_2 = _____ metres

2 

d: L of shaft = 2:7

d = 40 mm

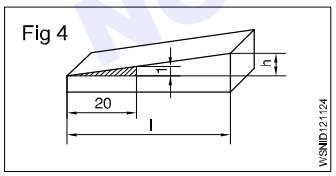
L = _____ mm

3 

D : L=1:10

L=150mm

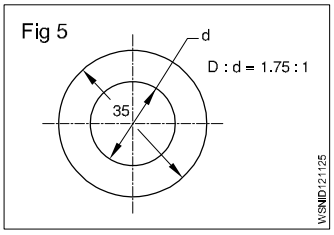
D=_____mm

4 

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

l = 140 mm

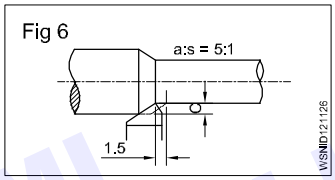
Δh = _____ mm

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 = _____

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

Proportion

Description

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

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

Rule of three

A three step calculation

statement

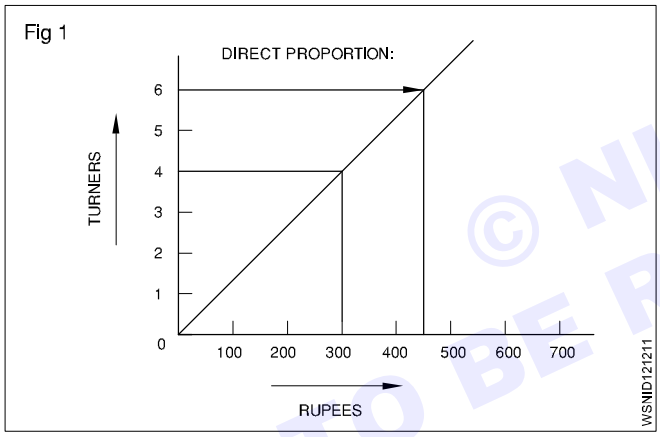
single

multiple.

Direct proportion

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

Fig 1



Examples

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

Statement

4 turners = 300 Rupees

Single

1 Turner = 75 Rupees

Multiple

6 Turners = 6 x 75 = 450 Rupees

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

One vehicle uses petrol = 30 litres per day.

Then six vehicles will use = 6 Times as much

= 6 x 30 = 180 litres/day.

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

4 vehicles use 120 gallons per day

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

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

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

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

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

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

50 litres petrol = 30 x 50 = Rs 1500

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

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

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

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

Machines	Days
7	2½
70	x

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

Assemble for 70 machines will take 25 days.

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

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

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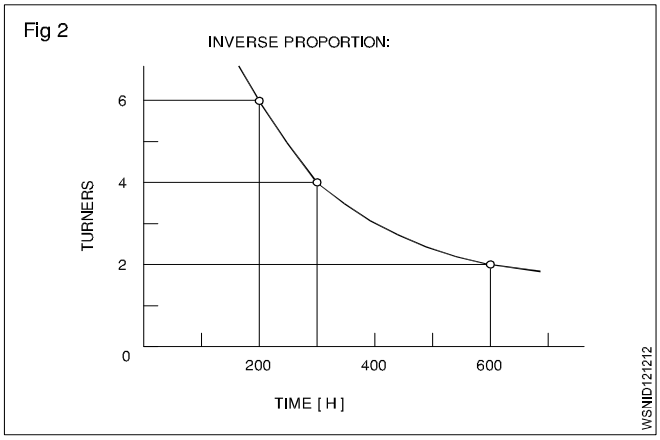
$$x = \frac{1240}{2.93} \times 3.7 = 1566 \text{ cm}$$

Length of wire = 1566 cm.

Indirect or inverse proportion

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

Fig 2



Example

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

Solution procedure in three steps:

Statement 4 turners taken = 300 hours

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

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

6 Turners = 200 hours

Result - The more the less.

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

Workman	Days
8	6
4	x

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

4 workers complete the work = 12 days.

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

Men	Days
5	32
8	x

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

8 men will complete the job = 20 days.

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

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

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

Speed of the 33cm diameter will run 250 rpm.

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

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

40 cm diameter = 200 rpm.

Slip is 2.5% = 195 rpm.

Problems involving both

Example

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

Statement

2 turners, 20 pieces = 3 days

6 turners, 30 pieces = how many days.

First step (Fig 3)

Statement 2 turners for 20 pieces = 3 days

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

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

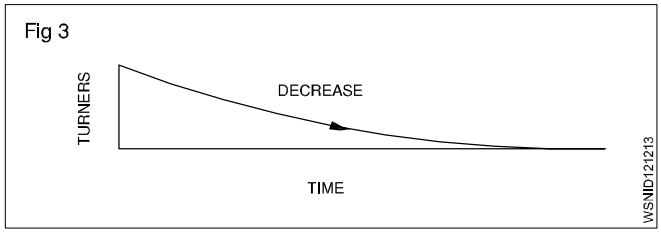
Statement 6 turners for 20 pieces = 1 day

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

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

Inverse proportion - More the less.

Fig 3



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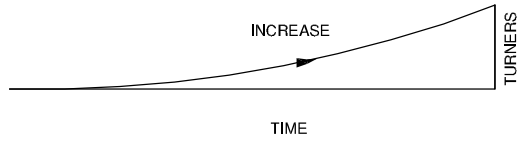
Second step (Fig 4)

Fig 4



Direct proportion - More the more.

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

Introduction

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

Simple Proportion

- Proportion

This is an equality between two ratios

Compound and Inverse proportions

- Compound proportions

Example

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

In this both direct and indirect proportions are used.

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

Fitters	Vehicle	Days
5	6	21
7	8	x

$$\left(\frac{21\times5}{6\times7}\times8\right)=20 \text{ days}$$

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

Inverse proportion

Some times proportions are taken inversely.

Examples

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

The time should not be doubled.

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

Pump	Time
2	30
6	x

Ans: Time taken by 6 pumps = $\frac{30\times2}{6}=10$ minutes

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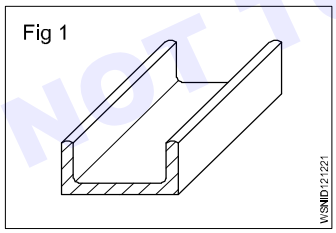
Assignment

1 Fig 1

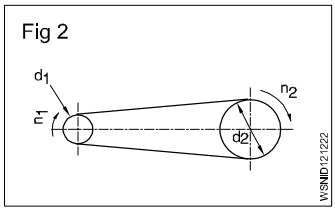


Length = 6.1 metre

Weight = 32 kgf

Weight of 1 metre of the same channel = _____ kgf

2 Fig 2



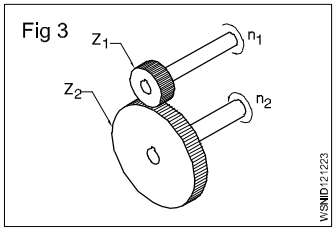
d_1 = 120 mm

d_2 = 720 mm

n_1 = 1200 rpm

n_2 = _____ rpm

3 Fig 3



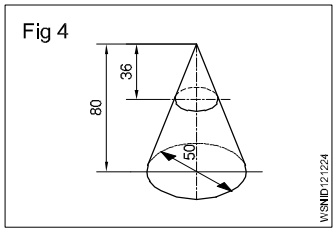
Z_1 = 42 T

n_2 = 96 rpm

n_1 = 224 rpm

Z_2 = _____ T

4 Fig 4



D = 50 mm

H = 80 mm

h = 36 mm

d = _____ mm

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

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

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

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

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

Square root, Ratio and Proportions, Percentage - Percentage

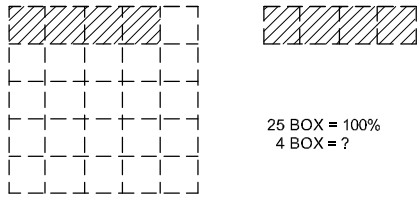
Percentage

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

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

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

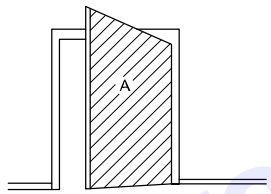
Fig 1



Example

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

Fig 2



Solution procedure in three steps.

Statement:

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

Wastage = 0.18 m^2

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

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

Wastage = 5%.

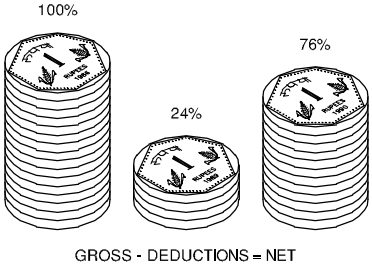
Analyse the given data and proceed to arrive at the answer through the unit.

Example

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

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

Fig 3



Total pay 100%

Deduction 24%

Take home salary 76%

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

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

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

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

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

Example 1

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

Solution

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

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

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

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Example 3

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

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

Example 4

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

Solution

Present price of Motor cycle Rs.18000

This is the value of 92% of original price

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

= Rs.19565

Example 5

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

Solution

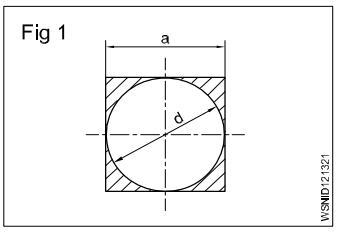
Percentage of saving = Decrease in consumption/Original consumption x 100

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

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

= 10% Saving in fuel.

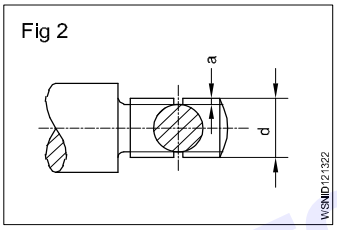
Assignment

1 

a = 400mm (side of square)

d = 400 mm

Wastage = _____ %.

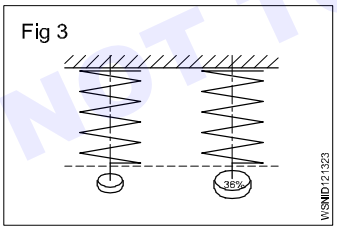
2 

d = 26mm

'a' depth of u/cut = 2.4mm

reduction of area at cross-section

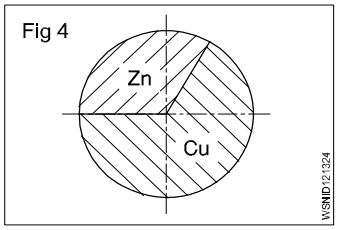
= _____ %

3 

Percentage of increase = 36%

Value of increase = 611.2 N/mm^2

Original tensile strength = _____ N/mm^2.

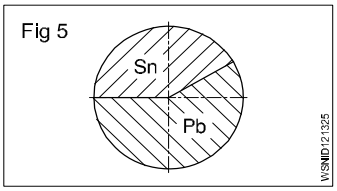
4 

Copper in alloy = 27 kg

Zinc in alloy = 18 kg

% of Copper = _____ %

% of Zinc = _____%.

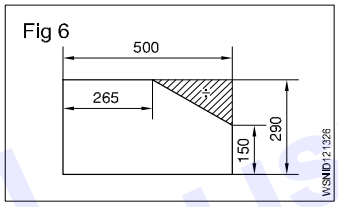
5 

Weight of alloy = 140 Kgf

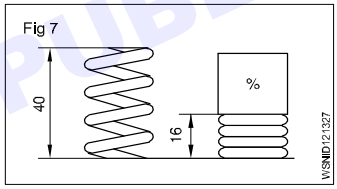
Weight of Sn 40%

Pb = _____ Kgf

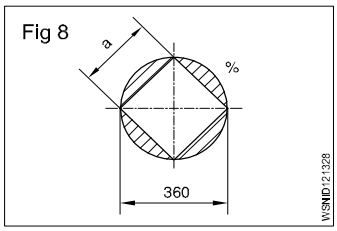
Sn = _____ Kgf.

6 

Shaded portion = _____ %.

7 

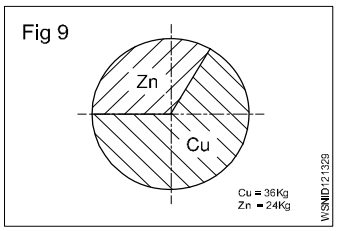
Compression length = _____%.

8 

d = 360 mm

a = 0.707 x d

Wastage = _____ %.

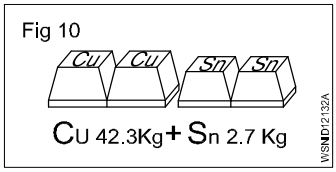
9 

Cu = 36 Kg

Zn = 24 Kg

Cu = _____ %

Zn = _____ %

10 

Cu = 42.3 Kg

Sn = 2.7 Kg

Cu _____ %

Sn = _____ %.

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

Conversion of Fraction into Percentage

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

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

= 50%

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

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

= 9.01%

Convert the following fraction into percentage.

1 $\frac{1}{4}$

2 $\frac{1}{5}$

3 $\frac{2}{3}$

4 $\frac{3}{8}$

Conversion of Percentage into Fraction

1 Convert 24% into fraction.

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

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

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

$= \frac{1}{3}$

Convert the following percentage into fraction

1 15%

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

3 80%

4 12.5%

Conversion of Decimal Fraction into Percentage

1 Convert 0.35 into percentage.

Solution: 0.35 x 100

= 35%

2 Convert 0.375 into percentage.

Solution: 0.375 x 100

= 37.5%

Convert the following Decimal Fraction into Percentage

1 0.2

2 0.004

3 0.875

4 0.052

Conversion of Percentage into Decimal fraction

1 Convert 30% into decimal fraction.

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

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

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

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

Convert the following percentage into decimal fraction

1 15%

2 7%

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

4 90%

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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.

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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° 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°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°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° 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° 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° 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.

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Material science - Physical and mechanical properties of metals

Metal:

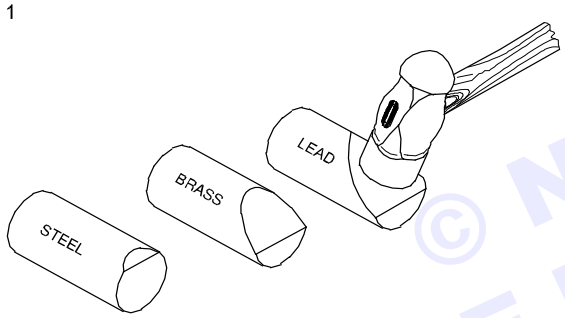
Metal is a mineral used in all types of engineering works such as machineries, bridges, aero planes etc., so we must have basic knowledge about the metals.

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

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

Note the difference in the amount of deformation.

Fig 1



Physical properties of metals

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

Colour

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

Weight

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

Structure (Figs 2&3)

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

Fig 2

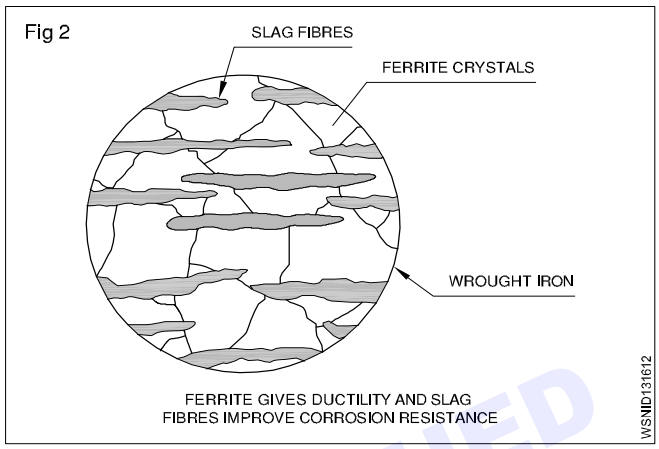
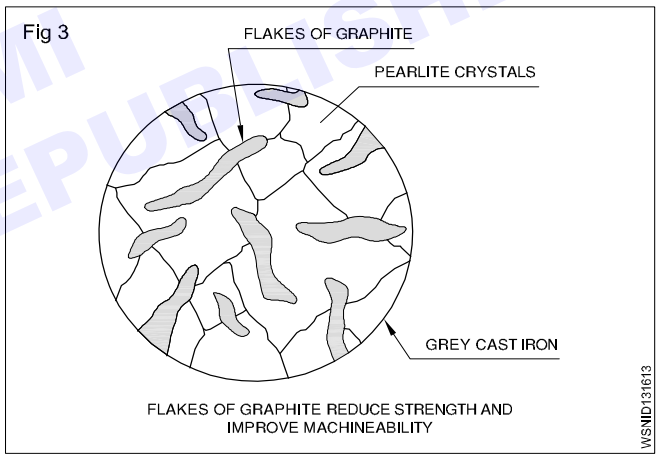


Fig 3



Conductivity (Figs 4&5)

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

Fig 4

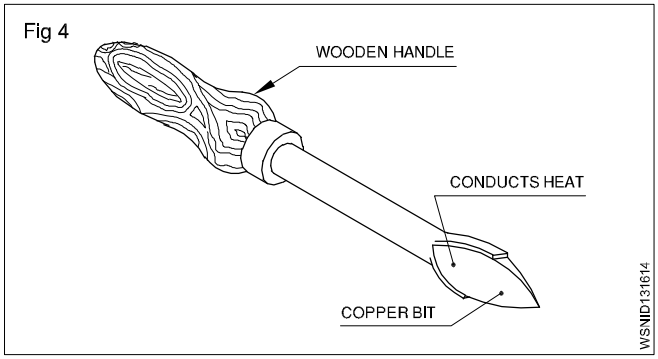


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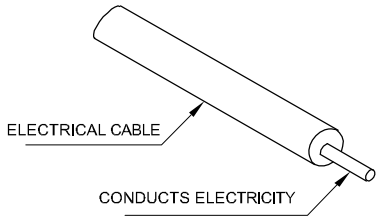
Fig 5



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.

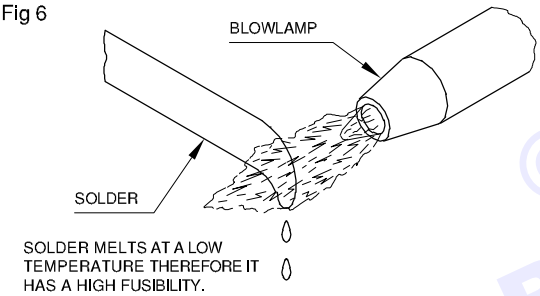
Fusibility (Fig 6)

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



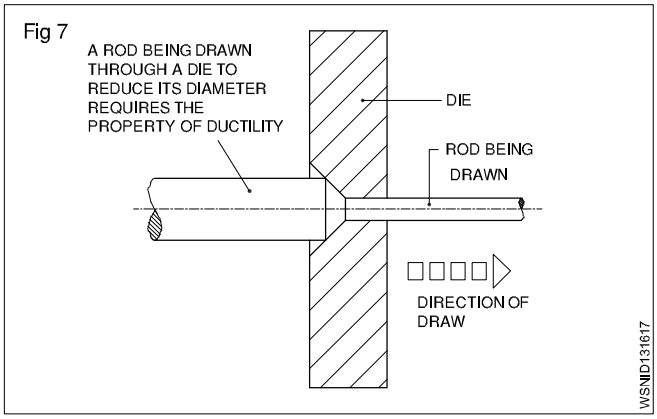
Mechanical properties

- 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

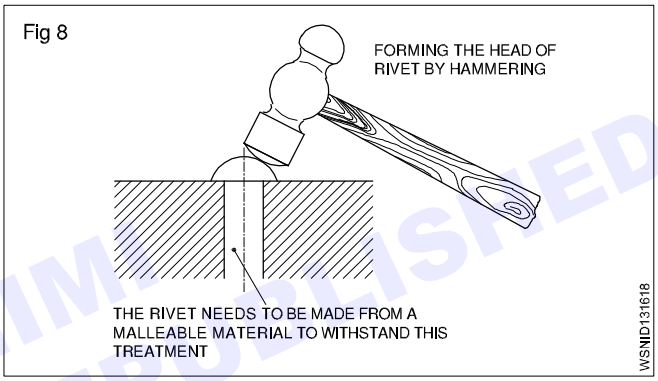
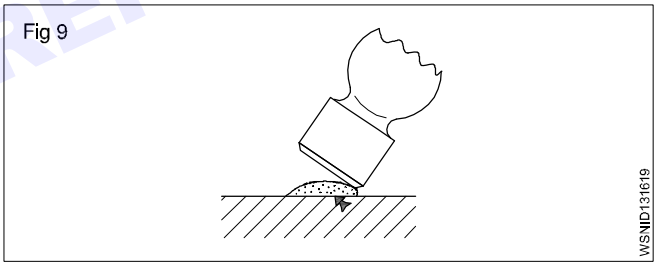


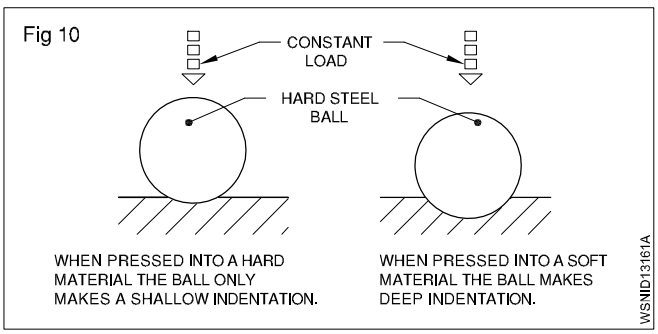
Fig 9



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



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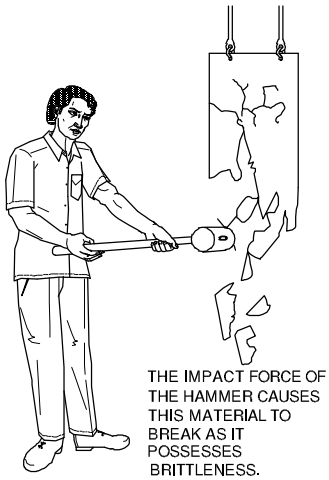
Brittleness (Fig 11)

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.

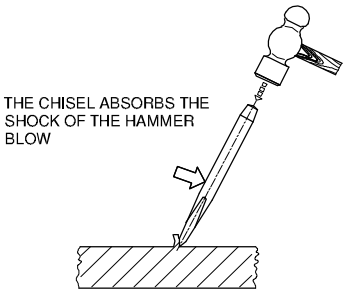
Fig 11



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.

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Material science - Properties and uses of rubber, timber and insulating materials

Properties and uses of rubber

Rubber

Rubber is an elastic material. It can be classified into

- Natural rubber
- Hard rubber
- Synthetic rubber

Natural rubber

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

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

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

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

Hard rubber

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

Uses

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

Synthetic rubber

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

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

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

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Properties and uses of timber

General properties

Timber should have the following properties

- Straight fibres.
- Silky lustre when planed.
- Uniform colour.
- Regular annual rings.
- Heaviness.
- Firm adhesion of fiber and compact modulary rays.
- Sweet smell.
- It should be free from loose or dead knots and shakes.
- The surface should not clog the teeth of the saw on cutting but should remain bright.

Classification

- Timbers are classified as
  - a Softwood
  - b hardwood

Softwood timber

- Usually all trees with needle leaves of softwood and those with broad leaves are of hard-wood.
- The wood contains resins and turpentines.
- The wood has a fragrant smell.
- Fibres are straight.
- Texture is soft and regular.
- Tough for resisting tensile stresses.
- Weak across the fibres.
- Annual rings are distinct, having one side soft, porous and light coloured. The other side is dense and dark.
- The general colour of the wood is pale tinted or light such as pine spruce, fir, ash, kail, deodar etc.

Properties of hardwood

- The wood generally contains a large percentage of acid.
- It is brightly coloured.
- Annual rings are not distinct.
- It is difficult and hard to work with.
- It resists shearing stress.
- Fibre are overlapped.
- The general colour is dark brown such as oak, walnut, teak, mahagony, sishim, babul, sal etc.

Uses

Soft timber

- Because of its cheapness it is used for low grade furniture, doors and windows for cheap type of houses.
- Used as fuel.
- Some timbers are used for baskets and mat making.
- The bark is used as garment is some places.

Hard timber

- Used for high quality furniture such as chairs, tables, sofas, dewans, beds, etc.
- Used for door, window frames for high quality houses as they can take good polish and painting finish.
- Used for manufacturing katha.

Wood as an electrical insulator

Wood is impregnated with oil or other substance, for use as insulator.

Example

It is used in electrical machine windings, as slot wedges.

Insulating materials

Description

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

Properties of insulators

The main requirements of a good insulating material are:

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

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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

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Basic Electricity - Introduction and uses of electricity electric current AC,DC their comparison, voltage, resistance and their units

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

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

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

Sources of electricity

Battery

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

Generator

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

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

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

Thermo couple

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

Effects of electric current

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

1 Physical effect

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

2 Magnetic effect

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

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

3 Chemical effect

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

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

4 Heating effect

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

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

5 X-ray and Laser rays effect

When a high frequency voltage is passed through a vacuum tube, a special type of rays come out, which is not visible. These rays are called x-rays. Laser rays also can be produced by electric current.

6 Gas effect

When electrons pass through a certain type of sealed glass shell containing gas, then it emits light rays.

E.g: Mercury vapour lamp, Sodium vapour lamp, Fluorescent lamp, Neon lamp etc.,

Uses of Electricity

1	Lighting	- Lamps
2	Heating	- Heaters, ovens
3	Power	- Motor, fan
4	Traction	- Electromotive, lift, crane
5	Communication	- Telephone, telegraph, radio, wireless
6	Entertainment	- Cinema, radio, T.V.
7	Medical	- x-rays, shock treatment
8	Chemical	- Battery charging, electroplating
9	Magnetic	- Temporary magnets
10	Engineering	- Magnetic chucks, welding, x-rays of welding

Classification

- Static electricity
- Dynamic electricity

STATIC ELECTRICITY

If a dry glass rod is rubbed with silk cloth the glass rod gives out negative electrons, and therefore, becomes positively charged. The silk cloth receives negative electrons and therefore it becomes negatively charged. They acquire the property of attracting small pieces of paper etc. because like charges repel and unlike charges attract each other. The electric charge on the silk cloth is stationary and is called static electricity. This type of electricity cannot be transmitted from one place to another.

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DYNAMIC ELECTRICITY

The electrons in motion are called current electricity or electric current. This type of electricity is carried through wires and cables. Therefore, this electricity can be transmitted from one place to another. This type of electricity can be produced by cells, batteries, generators alternators etc.

What is the difference between an atom and an element? How are molecules different from atoms? I am often asked these questions in my sessions over and over again and so I finally decided to write a comprehensive post on them. Find answers to all your questions in this section that is designed to help students explore and understand the relationship between atoms, elements, molecules, compounds and mixtures in a manner that is simple and easy to understand.

Types of electric current

- Direct current
- Alternating current

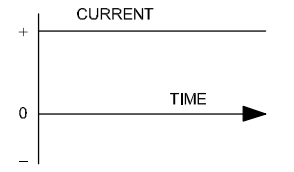
Direct current

In direct current (DC) the direction and magnitude of the current does not change (Fig 1). The steady current flow will be from the positive terminal to the negative terminal. (Fig 2)

Examples

DC Sources : Cells, batteries and DC generators (Fig 2)

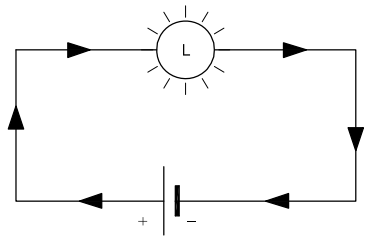
Fig 1



DIRECT CURRENT (GRAPHIC REPRESENTATION)

WSNID141811

Fig 2



CURRENT FLOWS FROM +VE TERMIINAL TO – VE TERMINAL

DIRECT CURRENT (D.C)

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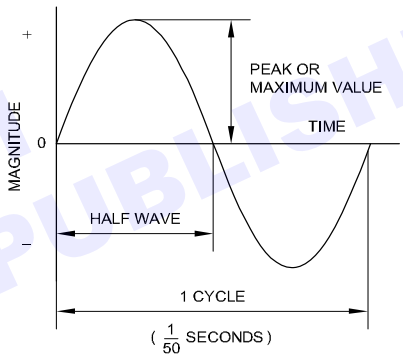
Alternating current (Fig 3)

The current flow will be from the phase terminal to the Neutral terminal. In the alternating current (AC) both the direction and magnitude of the current will be changing at definite intervals of time. The graph shows how an AC current or voltage changes with time. The current increases to the maximum value in one direction, falls to zero and increases to the maximum value in the other (opposite) direction before falling to zero again. Thus a cycle is one complete series of changes. The normal supply frequency is 50 cycles per second.

Fig 3



ALTERNATING CURRENT OR VOLTAGE

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Difference between AC and DC

	AC	DC
1	It is generated in the ranges of 6,600 V, 11000 V and 33,000 V.	It is generated up to 6,600 V only
2	Voltage can be stepped up or stepped down by using transformer	It is not possible
3	Transmission cost is less	Cost High
4	Less maintenance	High maintenance
5	Power up to 5,00,000 kw can be generated in a single alternator.	Power up to 10,000 kw can be generated in a single generator
6	AC generator can run at high speeds. So, speed control is not easy.	It can't run at high speeds. Speed control is easy.
7	Slip rings and brushes are used to collect the current.	Commutator and brushes are used to collect the current

Advantages of A.C.

i In transmission there is saving in copper wire.

ii Since there is no spark in A.C. machine there is no interference in Radio sound.

iii This can be produced to maximum voltage i.e. 33000volts.

iv Voltage can be dropped or raised with the help of transformers.

v Its mechanism is simple and cheap.

vi Output is more due to availability of more than one phase.

Disadvantages of A.C.:

i A single phase motor is not self-starter.

ii Due to thin wire in A.C., the voltage drop is more.

iii It cannot be used for electroplating and in charging secondary cells.

iv The speed of motors run by it is difficult to change.

v There is danger to security due to high voltage.

Electrical terms and units

Quantity of electricity

The strength of the current in any conductor is equal to the quantity of electrical charge that flows across any section of it in one second. If 'Q' is the charge and 't' is the time taken

then $I = \frac{Q}{t}$ $\quad Q = I \times t$

The SI unit of current is coulomb. Coulomb is equivalent to the charge contained in nearly 6.24×10^{18} electrons.

Coulomb

In an electric circuit if one Ampere of current passes in one second, then it is called one coulomb. It is also called ampere second (As). Its larger unit is ampere hour (AH)

1 AH = 3600 As (or) 3600 coulomb

Electro motive force (EMF)

It is the force which causes to flow the free electrons in any closed circuit due to difference in electrical pressure or potential. It is represented by 'E.' Its unit is Volt.

Potential difference (P.D)

This is the difference in electrical potential measured across two points of the circuit. Potential difference is always less than EMF. The supply voltage is called potential difference. It is represented by V.

Voltage

It is the electric potential between two lines or phase and neutral. Its unit is volt. Voltmeter is used to measure voltage and it is connected parallel between the supply terminals.

Volt

It is defined as when a current of 1 ampere flows through a resistance of 1 ohm, it is said to have potential difference of 1 volt.

Current

It is the flow of electrons in any conductor is called current. It is represented by 'I' and its unit is Ampere. Ammeter is used to measure the current by connecting series with the circuit.

Ampere

When 6.24×10^{18} electrons flow in one second across any cross section of any conductor, the current in it is one ampere.(or) If the potential difference across the two ends of a conductor is 1 volt and the resistance of conductor is 1 ohm then the current through is 1 ampere.

Resistance

It is the property of a substance to oppose to the flow of electric current through it, is called resistance. Symbol: R, Unit : Ohm (Ω), Ohm meter is used to measure the resistance.

Ohm

If the potential difference across the two ends of conductor is 1 volt and the current through it is 1 ampere, then the resistance of the conductor is 1 Ohm.

Laws of resistance

The resistance offered by conductor depends on the following factors.

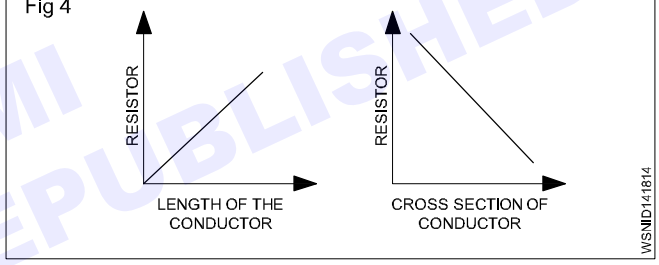
The resistance of the conductor

1 is directly proportional to the length of the conductor ($R \alpha L$)

2 Varies inversely proportional to its cross sectional area of the conductor $\left(R \alpha \frac{1}{A}\right)$

3 Depends on the material with which it is made.

Fig 4



4 depends on the temperature of the conductor

$$R \alpha L ; \quad R \alpha \frac{1}{A}; \quad R \alpha \frac{L}{A}; \quad R = \rho \frac{L}{A}$$

Specific resistance

The specific resistance of a material is the resistance offered to a current it passed between the opposite faces of the unit cube of the material. Specific resistance is measured in Ohm - m or micro ohm - cm.

Each material has its own specific resistance or resistivity.

E.g. : Copper - 1.72 $\mu\Omega$ cm, Silver - 1.64 $\mu\Omega$ cm, Eureka - 38.5 $\mu\Omega$ cm, Iron - 9.8 $\mu\Omega$ cm,

Aluminium - 2.8 $\mu\Omega$ cm, Nickel - 7.8 $\mu\Omega$ cm.

$R = \frac{\rho l}{A}$ ohm cm

R = Resistance in ohms

l = Length of the conductor in cm

ρ = Specific Resistance in ohm cm (symbol pronounced as rho)

A = Area of cross - section in cm^2

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Electric Power

In mechanical terms we defined power as the rate of doing work. The unit of power is Watt. In an electrical circuit also the unit of electrical power is 1 Watt. In mechanical terms 1 Watt is the work done by a force of 1 N to move the body through 1 metre in one second. In an electrical circuit, the electromotive force overcomes the resistance and does work. The rate of doing work depends upon the current flowing in the circuit in amperes. When an e.m.f of one volt causes a current of 1 ampere to flow the power is 1 Watt.

Hence Power = Voltage x Current

$$P = V \times I$$

Power in Watts = Voltage in Volts x Current in Amperes

Electric work, energy

Electrical work or energy is the product of electrical power and time

Work in Watt seconds = Power in Watts x time in sec

$$W = P \times t$$

Since 1 joule represents 1 Watt x 1 sec, which is very small, larger units such as 1 Watt hour and 1 kilowatt hour are used.

1 W.h = 3600 Watt sec.

1 Kwh = 1000 Wh = 3600000 Watt sec

FPS System

1 HP = 746 watts

= 0.746 K.W

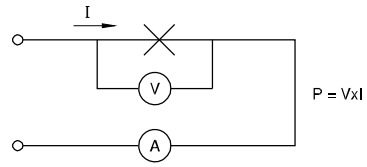
Metric System

1 HP = 735.6 watts

= 0.7356 K.W

Note: The charge for electric consumption is the energy cost per Kwh and it varies according to the country and states.

Fig 1



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V - Voltage (Volts) V

i - Current Intensity (Amperes) A

P - Power (Watts, Kilowatts) W, kW

W - Work, Energy (Watt hour, Kilowatt hour) wh, Kwh

t - time (hours) h

Fig 2

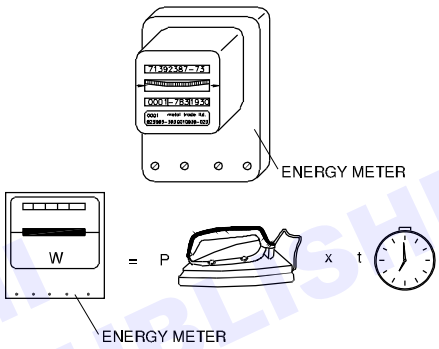

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Table of analogies between mechanical and electrical quantities

Mechanical quantity	Unit	Electrical quantity	Unit
Force 'F'	N	Voltage 'V'	V
Velocity $v = \frac{\text{Displacement}}{\text{Time}}$	m/s	Current *I*	A
Time *t*	seconds	Time *t*	seconds
Power $P = F \times v$	N $\frac{m}{sec}$	Power $P = V \times i$	$W = V \times A$
Energy = $F \times v \times t$	j = Nm	Energy $W = V \times i \times t$	$j = W \times s$

$$W = V I = I^2R = \frac{V^2}{R}$$

$$R = \frac{V}{I} = \frac{V^2}{W} = \frac{W}{I^2}$$

$$V = IR = \frac{W}{I} = \sqrt{WR}$$

$$I = \frac{V}{R} = \frac{W}{V} = \sqrt{\frac{W}{R}}$$

Basic Electricity - Conductor, insulator, types of connections - series and parallel

Conductors

Some materials and metals readily allow passage for electric current to flow. In such materials, called conductors, electrons are able to pass readily from atom to atom.

Properties of conductors

A good conductor should have the following properties.

Electrical properties

- The conductivity must be good.
- Electrical energy spent in the form of heat must be low.
- Resistivity must be low (to reduce voltage drop and loss).
- Increase in resistance with temperature must be low.

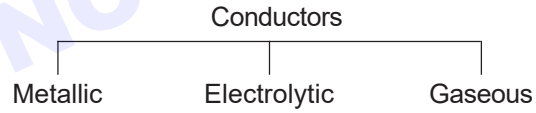
Mechanical properties

- Ductility (the property of being drawn into thin wires).
- Solderability: the joint should have minimum contact resistance.
- Resistance to corrosion: should not get rusted when used outdoors.
- Should withstand stress and strain.
- It should be easy to fabricate.

Economical factors

- Low cost.
- Easy availability.
- Easy to manufacture.

Classification of conductors



The best conductors are metallic. The commonly used conductors in electrical appliances and machines are described hereunder.

Silver

It is a soft and extremely malleable metal. Even though it is the best conductor, its use is limited because of its high cost.

Copper

It is a very good conductor. It is malleable and ductile, and also has high resistance to corrosion by liquids. Therefore, it is widely used for wires, cables, overhead conductors, bus bars and conducting parts of various electrical appliances.

Aluminium

It is a metal light in weight. It is also ductile, malleable and a good conductor of electricity. Nowadays, it is more widely used (since it is cheaper than copper) for wires and cables. All aluminium conductors (AAC) and aluminium conductors (steel reinforced) (ACSR) are used in overhead and transmission lines. (More details on copper and aluminium are furnished under the topic 'non-ferrous metals and alloys as applicable to electrical trades').

RESISTANCE WIRES

These are conductors with very high resistance for specific applications like filaments of incandescent lamps, heating elements etc. The following are a few examples:

1	Tungsten	2	Nichrome	3	Eureka
4	German silver	5	Manganin	6	Platinum
7	Mercury	8	Carbon	9	Brass.

The resistance values of the metallic resistances will increase with increase in temperature.

insulators

Description

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

Properties of insulators

The main requirements of a good insulating material are:

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

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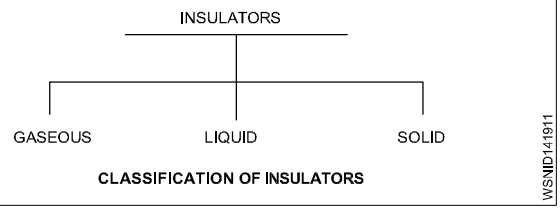
Classification of insulators (Fig 1)

Fig 1



CLASSIFICATION OF INSULATORS

Air is an example of a gaseous insulator. Other examples are hydrogen, nitrogen and inert gases.

Liquid insulators

Mineral oils, synthetic liquids, resins and varnishes are the liquid insulators.

Transformer oil

In transformers the oil is used as an insulator and also for cooling of the transformer windings by convection. Therefore, the transformer oil should be dry and purified, since the presence of moisture will reduce the dielectric strength of the oil.

Purpose of transformer oil

- Transfer of heat by convection, from winding and core to the cooling surfaces.
- It maintains the insulation of winding and also extinguishes fire that occurs due to faults occurring in the windings.

Precaution

The insulating value of a transformer oil is reduced due to the formation of sludge as a result of oxidation due to air and temperature. To minimise oxidation, the oil should not be exposed to air.

Sludge is also formed due to the presence of acids and alkalis.

Sludge formation

- Reduces the rate of heat transfer.
- Blocks the ducts.
- Increases the operating temperature.

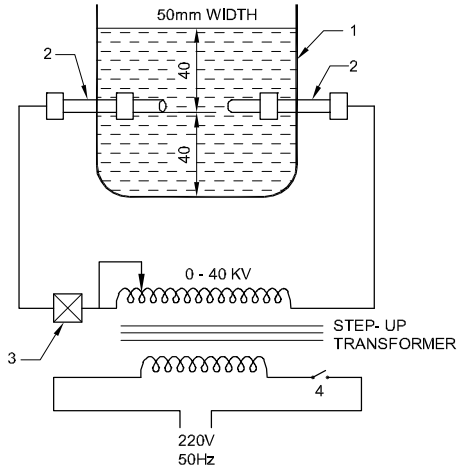
To prevent moisture from entering the oil, the whole apparatus is made airtight, and calcium chloride, silicagel fillets are used.

Testing of transformer oil as per ISI Standard (Fig 2)

Dielectrical strength test (Refer to Fig 2) : The oil should be 40 mm above and 40 mm below the electrodes. The gap between the two electrodes should be kept at 4 mm ± 0.02 mm).

A high voltage is applied across the electrodes through a step-up transformer, and increased till there is a spark in between the electrodes. The voltage noted on the voltmeters, when the spark occurs, is the breakdown voltage or dielectric strength of the oil. This is the maximum voltage the oil can withstand.

Fig 2



1. OIL CONTAINER
2. ELECTRODES
3. CIRCUIT BREAKER (AUTOMATICALLY OPERATED)
4. SWITCH

APPARATUS FOR TRANSFORMER OIL TESTING

According to ISI specifications, the oil should be able to withstand 40 kV for one minute with a gap (4 mm ± 0.02 mm) between the electrodes and with the diameter of the electrodes as 13 mm.

Moisture test : In this test, an oil sample is cooled in a closed vessel down to 15-25°. A dry test tube, 12.5 mm in diameter and 125 mm long, is taken and an adequate quantity of oil is poured into it.

The tube containing the oil is heated rapidly with the help of an electric heater till the oil begins to boil. During the process, oil should not produce cracking.

The other tests are:

- acidity test
- sludge resistance test.

Electrical insulating varnishes

They are of two types

Oil and resin varnishes.

Solid insulators/insulating materials

Sl. No.	Classification	Examples
1	Mineral insulators	Mica, marble, slate.
2	Vitreous materials	Glass, quartz, procelain.
3	Rubber and rubber products	Rubber, vulcanised (India) rubber (V.I.R) ebonite
4	Waxes and compounds	Paraffin wax, bitumen.
5	Fibrous materials	Asbestos, paper, wood, Press pahn, leatheroid, cotton, silk, tapes etc.
6	Synthetic products	Bakelite, shellac, oil (for Transformer, Switchgear etc).

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Paper

Various grades of insulating paper are available for use in capacitors, cables, etc. Paper, if moist, loses its insulating property. Therefore, it is used in an impregnated condition.

Wood

It is impregnated with oil or other substance for use as an insulator.

For example, in machine windings, bamboo wood is used as slot wedges.

Press board

It is widely used in windings to insulate parts which support windings. It is also used as spacers in electrical devices and transformers.

Asbestos

A fibrous, incombustible, fire- proof material - used for panel boards and as frames for winding resistance wires of regulators, rheostats etc.

Cotton

It is soaked in paraffin to avoid moisture. It is a good insulator for low voltages. It is used in conductors for armatures and field coils.

Silk

Like cotton, it is used for small jobs like telephone coils.

Tapes

Tapes of various types are used, such as cotton, silk, jute etc either pure or in impregnated form.

Empire cloth

It is made by varnishing a cotton cloth, silk or paper. It is not effected by moisture. It is available in yellow and black colours in different sizes. It is used as slots insulation in winding works and for coil insulation.

Press pahn

Press pahn is a form of paper made from hemp, rags, and wood pulp by special chemical treatment. It is widely used for lining armature slots, insulating coil sides, etc.

Leatheroid

It is a tough material made from cotton rags with chemical treatment. It is unaffected by grease or oil and is used for slot and coil insulation, transformer core coverings, etc.

Adhesive tape

It is used widely for taping of ends of conductors, leads and connections. Adhesive tape is made from cotton fabric coated with a compound of rubber, bitumen, resin, gum, etc. It dries when exposed to air. It is available in sizes $\frac{1"}{2}$, 3/4", 1" etc. These are also available as P.V.C. adhesive tape, cotton and bitumen tapes.

Bitumen

It is used for filling cable jointing boxes and for sealing the tops of the batteries etc. It is waterproof, but it will crack under certain conditions. It can be valcanised in the same manner as rubber.

Mica

It is a mineral and available as large slabs. It can be easily separated into thin sheets. It is fireproof, waterproof, and is a good insulator. It should be used carefully since it is liable to crack. It is used in heating elements of electric iron etc.

Marble and slate

Marble and slate are mechanically strong insulators and are non- hygroscopic. When polished they form good mountings for switchboards, switches, resistance frames, etc. Slate is used generally for low voltages.

Micanite

It is made by sticking together pieces of mica with insulating cement like shellac. It can be bent to any shape by heating and pressing. Therefore, it is used as insulator for slots of armatures and to insulate the commutator from the shaft.

Paraffin wax

It melts at 55°C and does not absorb water. It is used to impregnate paper, wood, pressboard etc to reduce their moisture absorption.

Bakelite

It can be moulded to any shape. It is heat-resistant and highly insulating. It will not absorb oil and moisture. It is used for bodies of switches, plugs, holders, regulators etc.

Rubber

It has high insulating properties. It is used mainly on lighting cables and for flexible cables. It deteriorates gradually when exposed to atmosphere. Rubber is being replaced now by elastic plastics such as PVC or polyethylene which can resist alkalis, acids and mineral oils.

Valcanised India Rubber (VIR)

This is manufactured by treating pure rubber with sulphur. It is stronger than pure rubber and is not affected much by change in temperatures. It is used as coverings for low and medium voltage wires and cables.

Ebonite or vulcanite

Ebonite or Vulcanite is vulcanised rubber containing about 30% to 50% of sulphur, and subjected to a prolonged heating at 150°C. The material is hard and can be moulded into different shapes. It is less affected by chemicals and moisture. It is used for making containers of lead acid batteries, cases for instruments and switchgears, terminal plates and low voltage panel boards etc. It should not be subjected to heat.

Shellac

It is a good varnish which is used to improve the insulation and moisture resisting properties of paper, cloth, wood, slate etc.

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Enamel

By this, an insulation coating is given on winding wires.

Polychloroprene (PCP)

It is a plastic material used for insulation of cables. It is resistant to oil and petrol. It can be used in conditions of exposure to sulphur fumes, steam, ammonia, lactic acid and direct sunlight.

Glass

It is heat-resistant and suitable for high temperatures. It is used as insulators, envelopes for lamps, radio tubes etc.

Quartz

Quartz (Silica) is a good insulator. As it has a very low temperature coefficient of expansion, it does not crack with sudden variations in temperature. It is used for pyrometer sheaths, for heating elements, sparking plugs, etc.

Porcelain

Porcelain is not so brittle as glass and is very widely used for carrying bare conductors, for making fuse carriers and other electrical fittings.

Red fibre

Mainly used in motor and transformer winding work, for slot insulation, separators etc.

Insulators classified according to their temperature limits

The permissible temperature limit at which the insulators may be worked safely without deterioration, depends upon the type and class of the insulation as detailed below. (IS:1271/1958)

Class Y – maximum temperature 90°C

Cotton, silk, paper products, press board, wood, valcanised fibre - not impregnated or immersed in oil.

Class A – maximum temperature 105°C

Cotton, silk, paper products, wood, valcanised fibre when impregnated or immersed in liquid dielectric, varnished paper and wire enamel (class A).

Class E – maximum temperature 120°C

Wire enamel, cotton fabric and paper laminates treated with oil, modified asphalt and synthetic resins, varnished polyethylene, textile treated with suitable varnish.

Class B – Maximum temperature 130°C

Glass fibre, asbestos, varnished glass fibre, textile, varnished asbestos, built up mica treated with synthetic resin varnishes.

Class F – maximum temperature 155°C

Similar to class B materials but treated with silicone resins.

Class H – maximum temperature 180°C

Same as class F materials but treated with silicone resins of higher thermal stability than class F.

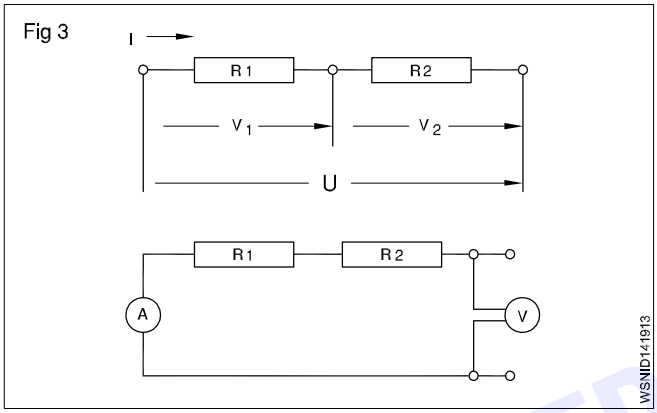
Class C – maximum temperature above 180°C

Mica, porcelain and other ceramics, glass, quartz, asbestos, treated glass fibre textile, treated asbestos, built up mica treated with silicone resins possessing superior thermal stability (limited stability up to 225°C).

Series Connection

The total resistance is equal to the sum of all the resistances. In a series connection the end of the first load is connected to the beginning of the second load and all loads are connected end to end. (Fig 3)

Fig 3



Features of series connection:

- The same current flows through all the loads.
- The voltage across each load is proportional to the resistance of the load.
- The sum of the voltages across each load is equal to the applied voltage.
- The Total resistance is equal to the sum of all the resistances.

$I = I_1 = I_2 = ...$

$V = V_1 + V_2 + ...$

$R = R_1 + R_2 + ...$

Example

Three resistances of 3 ohms, 9 ohms and 5 ohms are connected in series. Find their resultant resistance.

Solution

$R = R1 + R2 + R3$

$= 3\ \Omega + 9\ \Omega + 5\ \Omega$

Total resistance $= 17\ \Omega$

Parallel connection

In a parallel connection the beginning and the ends of the loads are connected together.

Features of parallel connection:

- The current flowing through each load depends upon the resistance of the load.
- The voltage across each load is the same and is equal to the voltage applied to the circuit.

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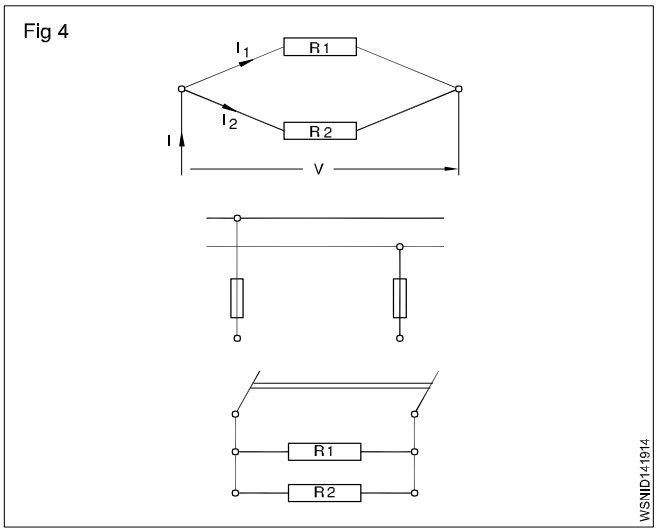
Fig 4



- The total resistance of a parallel connection is always smaller than the smallest resistance in the circuit.
- In parallel connection the reciprocal of the total resistance is equal to the sum of the reciprocals of all resistances in the circuit.

$I = I_1 + I_2 + \ldots$

$V = V_1 = V_2 \ldots$

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots\ldots\ldots$$

Example

Two resistances of 4 ohms and 6 ohms are connected in parallel. Determine the total resistance.

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \quad \text{(since parallel connection)}$$

Therefore $\frac{1}{R} = \frac{1}{4} + \frac{1}{6} = \frac{10}{24} = \frac{5}{12}$

Therefore $R = \frac{24}{10}$ ohms = 2.4 ohms

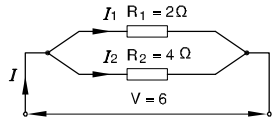
Example

Two resistors of 2 and 4 ohms are switched in parallel to a 6V battery

– Calculate the total resistance

– Find the total current and partial current.

Fig 5



Solution

Total resistance

$$\frac{1}{R_{tot}} = \frac{1}{R_1} + \frac{1}{R_2}$$

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

$$= \frac{3}{4}\Omega$$

$$R_{tot} = \frac{4}{3} = 1\frac{1}{3}\Omega$$

I Total = $I_1 + I_2$ current

$$But\ I_1 = \frac{U}{R_1} = \frac{6V}{2\Omega} = 3A$$

$$I_2 = \frac{U}{R_2} = \frac{6V}{4\Omega} = 1.5A$$

I total = 3A + 1.5A

= 4.5 Amp

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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

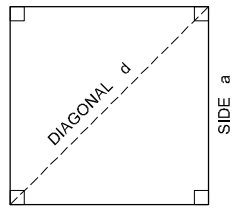
Lateral surface area - L.S.A unit^2

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



SQUARE

$A = a^2$ (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) = $\sqrt{2}$ x a

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

= 25.45 cm

Area (A) = a^2

= 18 x 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) = $\frac{\text{Perimeter of 1st square}}{4}$

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

Area (A) $= a^2$

= 187 x 187

= 34,969 cm^2

2nd square

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

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

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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.

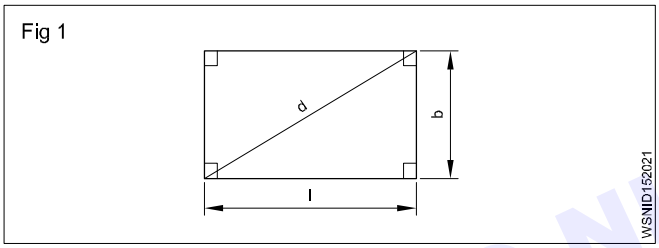
6 Find the perimeter of a square whose diagonal is 144 m.

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

$= 2(144 + 60)$

$= 2 \times 204 = 408$ 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 $= P = 2(l + b)$

$2(l + 9) = 42$

$l + 9 = 42 \div 2$

$l + 9 = 21$

$l = 21 - 9$

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**

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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 x 20 = 100 m

b = $3x$ = 3 x 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.

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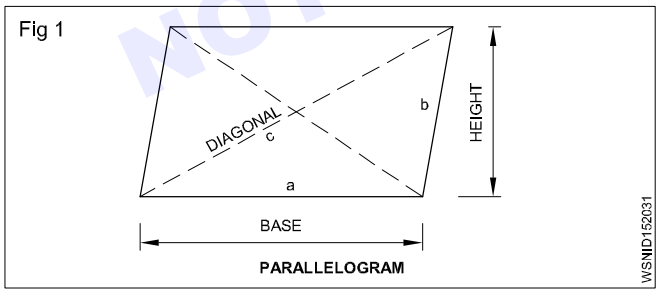
Parallelogram

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

Fig 1



Area of parallelogram = base x height

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

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

$= 2x\sqrt{1575}$

$= 2 \times 39.686$

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

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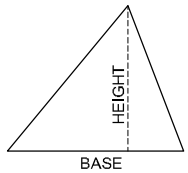
Mensuration - Area and perimeter of triangles

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



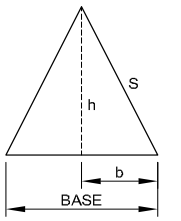
TRIANGLE WSNID152111

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 WSNID152112

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

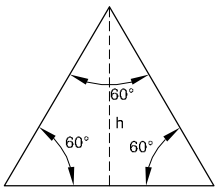
b = Base

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 = $\frac{180}{3} = 60^\circ$

Fig 3



EQUILATERAL TRIANGLE WSNID152113

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

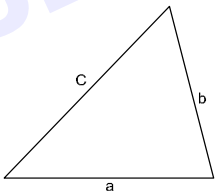
Perimeter P = 3a unit

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 WSNID152114

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

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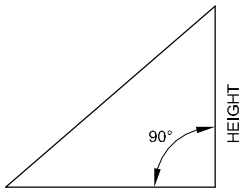
Fig 5



RIGHT ANGLED TRIANGLE

WSNID152115

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) = ?

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

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

= 17.5 cm²

2 Calculate the base of a triangle having an area of 15 cm² and height is 3.5 cm.

Area (A) = 15 cm²

Height (h) = 3.5 cm

Base (b) = ?

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

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

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

= 8.57 cm

3 Calculate the height of a triangle whose area is 60 cm² and base is 10 cm.

Area (A) = 60 cm²

Base (b) = 10 cm

Height (h) = ?

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

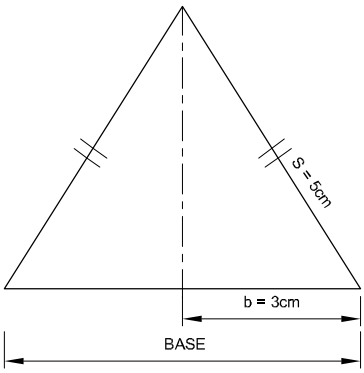
$\frac{1}{2} \times 10 \times h = 60$

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

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

WSNID152116

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

Equal sides or slant height 's' = 5 cm

Area (A) = ?

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

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

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

$= 3 \times \sqrt{16}$

$= 3 \times 4$

$= 12 \text{ cm}^2$

or

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

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

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

= 12 cm²

5 Find its height if an isosceles triangle has base of 200 mm and its area is 2000 mm².

Base = 200 mm

Area = 2000 mm²

h = ?

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

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

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

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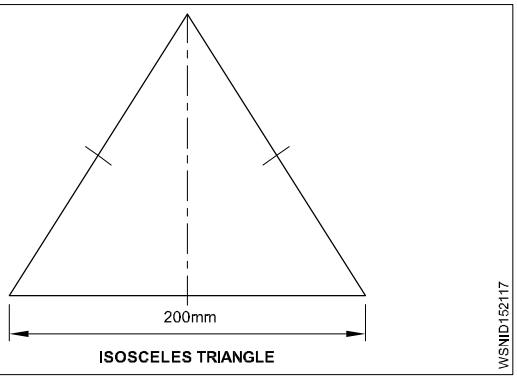
Fig 7



ISOSCELES TRIANGLE

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

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

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

$= 10.825 \text{ cm}^2$

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.

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

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

= 15.5 cm

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

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

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

$$= \sqrt{1939.4375}$$

$= 44.03 \text{ cm}^2$

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

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

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

= 65 cm

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

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

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

$= 468.4 \text{ cm}^2$

Area of polish on both sides = 2 x 468.4

= 936.8 cm^2

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

$\therefore$ 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) = ?

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

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

$= 80 \text{ cm}^2$

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

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

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

$= 43.05 \text{ cm}^2$

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.

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

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

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

= 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.

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

$$\frac{1}{2} \text{ x b x 2.5} = 12.5$$

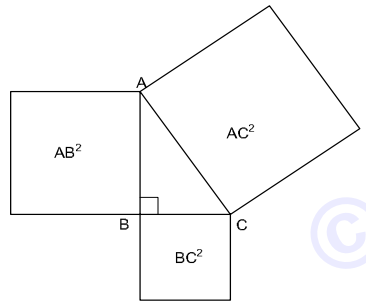
$$b = \frac{12.5 \times 2}{2.5}$$

= 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



$\angle B = 90^o$

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.

As per pythagoras theorem,

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

$= 12^2 + 5^2$

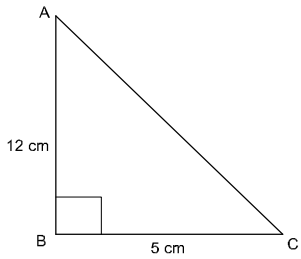
$= 144 + 25$

$= 169$

$AC = \sqrt{169}$

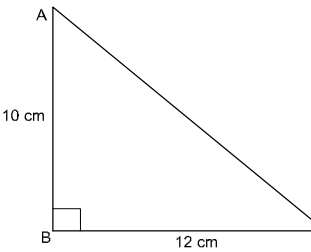
= 13 cm

Fig 9



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



As per pythagoras theorem,

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

$= 10^2 + 12^2$

$= 100 + 144$

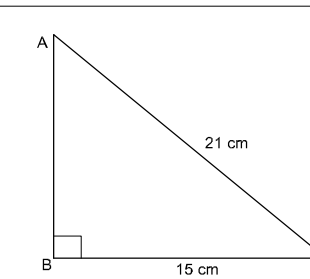
$= 244$

$AC = \sqrt{244}$

= 15.62 cm

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

Fig 11



As per pythagoras theorem,

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

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

$AB^2 = 441 - 225$

$= 216$

$AB = \sqrt{216}$

= 14.7 cm

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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.

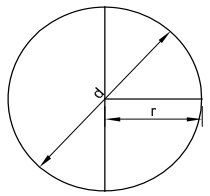
r = radius of the circle

d = diameter of the circle

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

Area of the circle = πr^2

Fig 1



PROPERTIES OF CIRCLE

WSNID152211

(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 = πr^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 = πr^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

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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

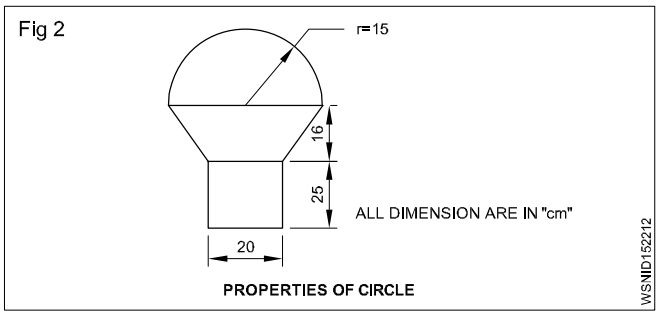
$\sqrt{2}a = 50$

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

$= \frac{50}{1.414}$

= 35.36 cm

6 Calculate the area of the figure given below.



Area of rectangle = lb unit^2

= 25 x 20 cm^2

= 500 cm^2

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

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

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

= 400 cm^2

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

= π x 15^2 x $\frac{1}{2}$ cm^2

= 353.57 cm^2

Total area of the figure = 500 + 400 + 353.57

= 1253.57 cm^2

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 x 12

= 192 cm^2

No. of holes = 6

Radius of hole = 2 cm

Area of 6 holes = 6 x πr^2 unit^2

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

= 75.43 cm^2

Area of remaining plate = 192 - 75.43

= 116.57 cm^2

— — — — — — —

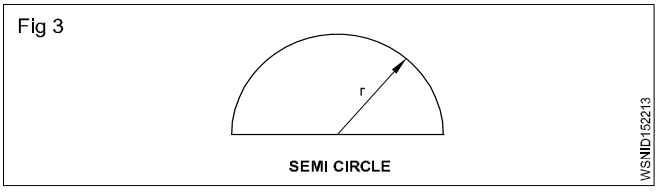
Semi circle

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

Length of arc ℓ = $2\pi r$ x $\frac{180}{360}$

= $2\pi r$ x $\frac{1}{2}$ = πr unit

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



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

= πr + 2r

= r (π + 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

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

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

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

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

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

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

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

$= \frac{216}{7}$

= 30.86 cm

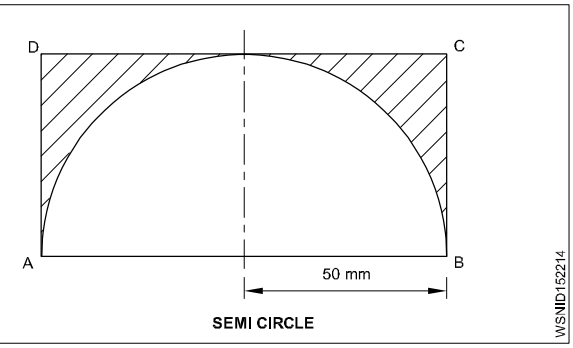
2 From the figure given below ABCD is a steel plate, a semi circular plate of radius 50 mm has been prepared by gas cutting. Find the waste area.

Plate length AB = 100 mm

Breadth BC = 50 mm

Radius = 50 mm

Fig 4



Waste area = Plate area - Area of semi circle

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

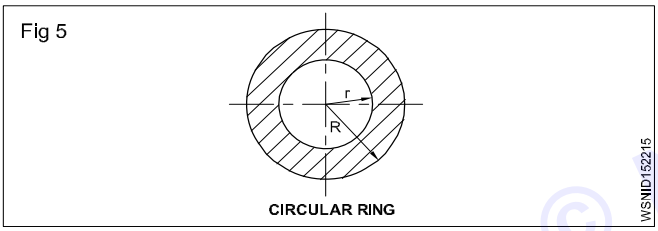
$= 100 \times 50 - \frac{22 \times 50 \times 50}{7 \times 2}$

$= 5000 - 3928.57$

$= 1071.43\ mm^2$

Circular ring

Fig 5



R = Outer radius of circular ring

r = Inner radius of circular ring

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

or

$A = \pi (R + r)(R - r)\ unit^2$

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 $= \pi (R + r)(R - r)\ unit^2$

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

$= \frac{22}{7} \times 15.5 \times 1.5\ cm^2$

$= 73\ cm^2$

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 $= \pi (R + r)(R - r)\ unit^2$

$= \pi (21.32 + 14.32)(21.32 - 14.32)\ cm^2$

$= \frac{22}{7} \times 35.64 \times 7\ cm^2$

$= 784.08\ cm^2$

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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 = 2π x 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

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

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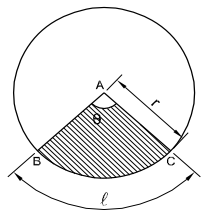
Sector of Circle

Fig 6



SECTOR OF CIRCLE

WSNID152216

θ = Angle of sector of circle

l = Arc length

r = radius

Length of Arc $\ell = \frac{\theta}{360^0}$ x $2\pi r$ unit

Perimeter P = $2r + \ell$ unit

Area = $\frac{\theta}{360^0}$ x πr^2 unit^2 (or) A = $\frac{\ell r}{2}$ unit^2

1 Find the perimeter and area of a sector of circle of radius 7 cm and its angle is 120^0.

Given:

Angle of sector of circle = 120^0

Radius = 7 cm

To find:

Perimeter = ? , Area = ?

Solution:

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

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

= 14.67 cm

Perimeter = $2r + \ell$ unit

= 2 x 7 + 14.67 cm

= 28.67 cm

Area = $\frac{\theta}{360^0}$ x πr^2 unit^2

Area = $\frac{120^\circ}{360^\circ}$ x $\frac{22}{7}$ x 7^2 cm^2 = 51.33 cm^2

2 Find the radius of the circle if the angle is 60^0 and the area of a sector of a circle is 144 cm^2,

Given:

Area of sector of circle (A) = 144 cm^2

Angle of sector of circle θ = 60^0

To find:

Radius of circle = ?

Solution:

Area (A) = $\frac{\theta}{360^0}$ x πr^2 unit^2

144 = $\frac{60^0}{360^0}$ x $\frac{22}{7}$ x r^2 cm^2

r^2 = 274.91 cm^2

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

3 Find the area of the sector whose angle is 105^0, 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 (ℓ) = $\frac{\theta}{360^0}$ x $2\pi r$ unit

ℓ = $\frac{105^0}{360^0}$ x 2 x $\frac{22}{7}$ x r

= 1.83r

Perimeter (P) = ℓ + 2r unit

18.6 = 1.83r + 2r

3.83r = 18.6 cm

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

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Area A $= \frac{\theta}{360^0}$ x πr^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 = ℓ + 2r unit

ℓ = P - 2r unit

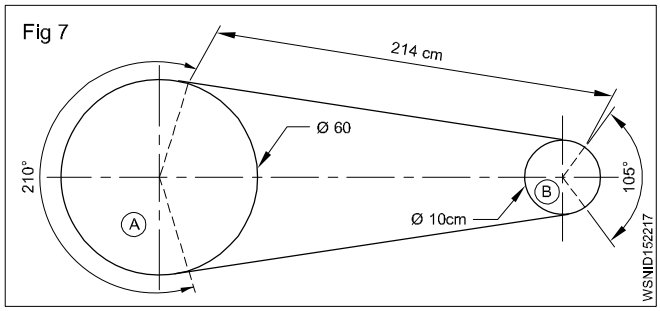
= 64.8 - 2 (12.4) cm

= 64.8 - 24.8 = 40 cm

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

= 248 cm^2

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



Solution:

Length $\ell_A = \frac{\theta}{360^0}$ x 2πr unit

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

Length $\ell_B = \frac{\theta}{360^0}$ x 2πr unit

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

$= \ell_A + \ell_B$ + 2 x 214 cm

= 110 + 9.17 + 428 cm

= 547.17 cm

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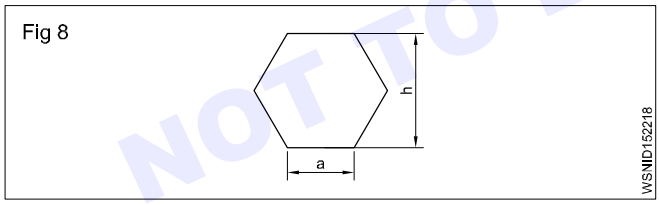
Hexagon



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

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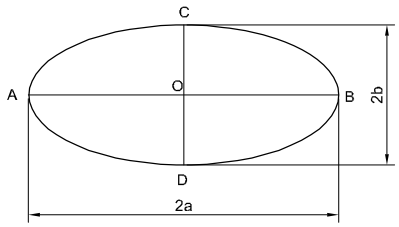
Ellipse

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

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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.

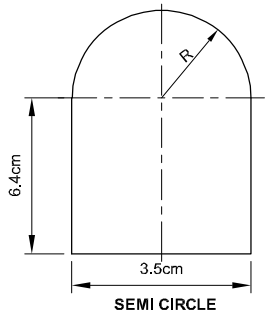
5 Find its area if the circumference of a circle is 44 cm.

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

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

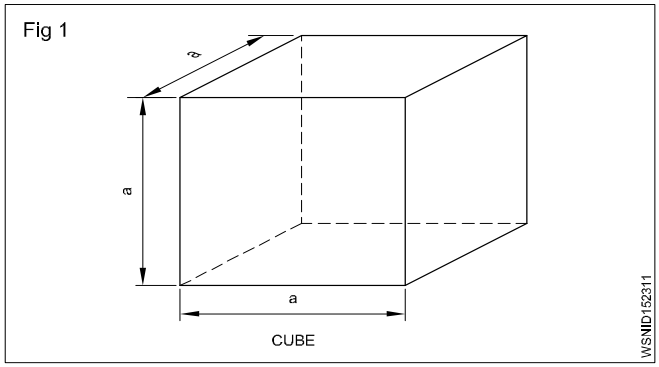
$= a^3$ unit^3

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

Total surface area = 6 x side x side

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

Diagonal d $= \sqrt{3}a$



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

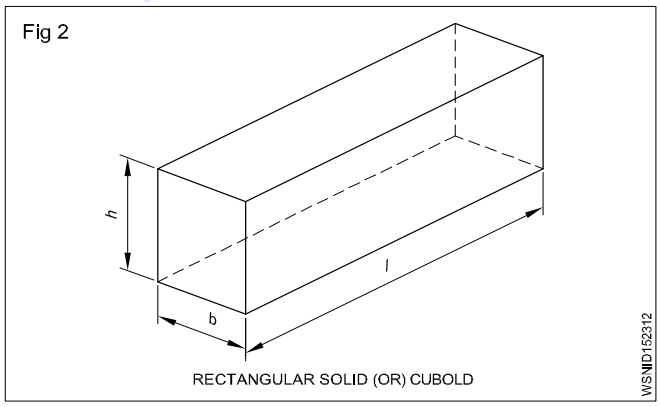
$= l \cdot b \cdot h$ unit^3

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

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

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

l = length, b = breadth and h = height



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

$= 1.732 \times 4.5$

= 7.794 cm

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

$= 4 \times 4.5 \times 4.5$

$= 81$ cm^2

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

$= 6 \times 4.5 \times 4.5$

$= 121.5$ cm^2

V $= a^3$ unit^3

$= 4.5 \times 4.5 \times 4.5$

= 91.125 cc.

2 Calculate volume of a cube where side is 9 cm

a = 9 cm

V = ?

$V = a^3$

$= 9 \times 9 \times 9$

= 729 cm^3

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

V = 3375 cm^3

a = ?

$a^3 = 3375$

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

$= \sqrt{3x3x3x5x5x5}$

$= 3 \times 5$

= 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

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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

$a^2 \times h$ = 50

$a^2 \times 2$ = 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

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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.

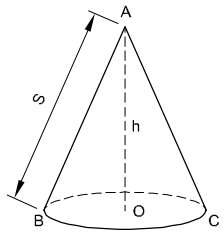
4 Find the volume of the sheet if a brass sheet is of 25 cm square and 0.4 cm thick.

Mensuration - Finding the lateral surface area, total surface area of conical and cylindrical shaped vessels

Cone

Cone is a pyramid with a circular base.

Fig 1



CONE

WSNID152411

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

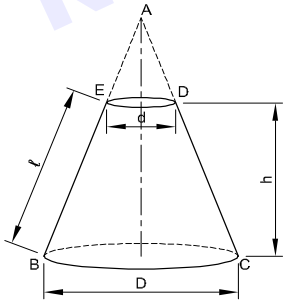
s = slant height $\sqrt{r^2 + h^2}$

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 = π l (R + r) unit^2

Fig 2



D = BASE DIA

d = UPPER DIA

ℓ = SLANT HEIGHT

h = VERTICAL HEIGHT

A_1 = TOP AREA (πr^2)

A_2 = BASE AREA (πR^2)

WSNID152412

TSA = π l (R + r) + A_1 + A_2 unit^2

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

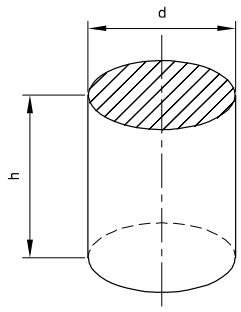
[A_1 = Top area ; A_2 = Bottom area]

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 3



CYLINDER

WSNID152413

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

$\therefore$ 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

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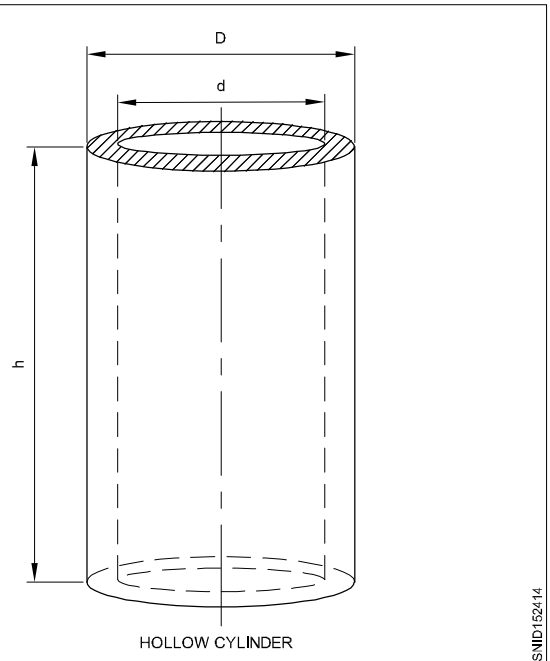
Fig 4



Example

1 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.

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

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

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

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

Lateral surface area = $\frac{1}{2}$ π X 210 X 284.9mm^2

= 94017 mm^2 = 940.17 cm^2

2 Determine its diameter in mm if the height of a rod of 1.6 metres and its volume is 1.017 $metre^3$.

V = A x H

V = πr^2 x 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 = 0.785d^2 x 1.6 metres

0.785d^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

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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

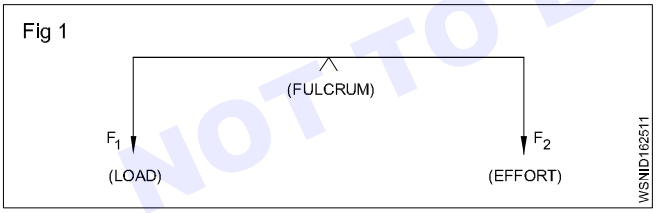
3 Third order lever

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



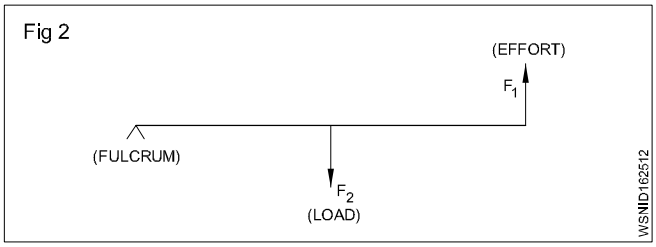
In this type of lever the mechanical advantage will be equal or less than or greater than 1 (M.A < = > 1)

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



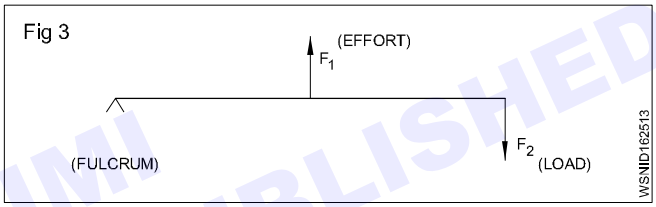
In this type of lever, the mechanical advantage will be greater than 1 (M.A. > 1). Less effort is used to lift more load.

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

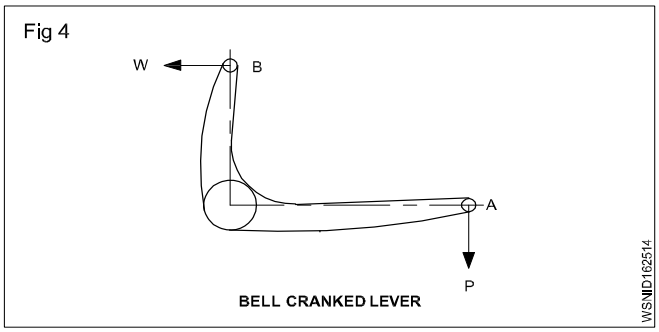


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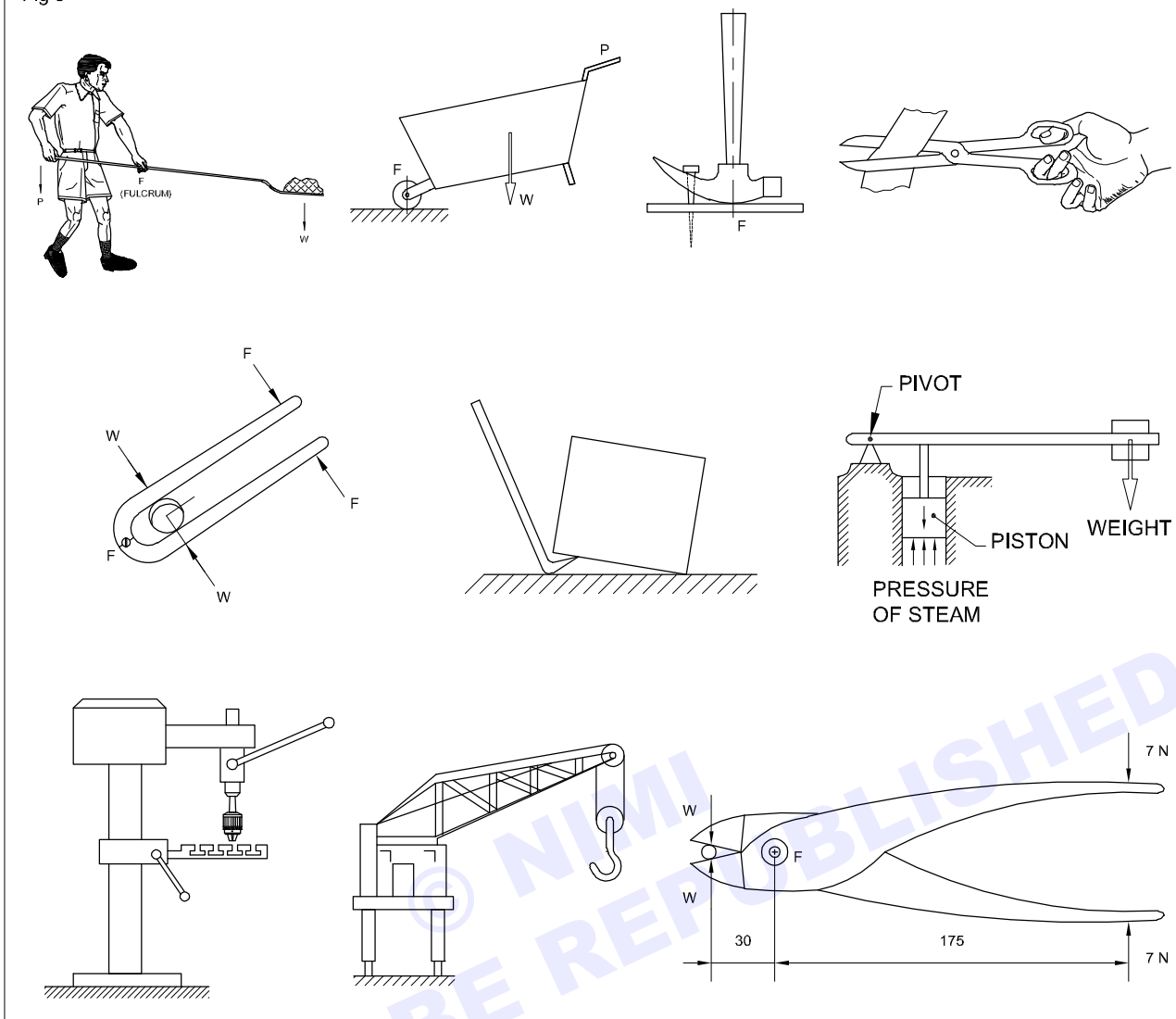
Fig 5



EXAMPLES OF SIMPLE LEVERS

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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

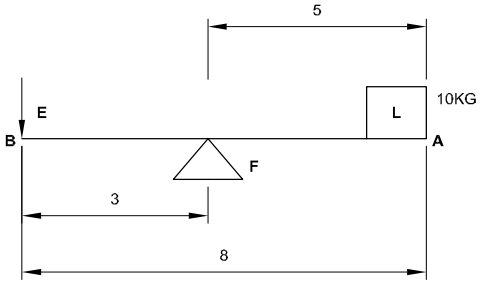
10 x 5 = P x 3

50 = 3 P

P = 50 / 3

= 16.67 kg

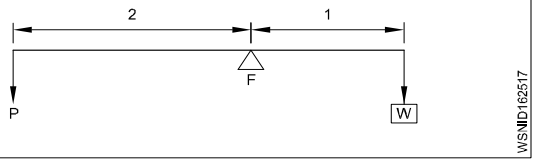
Fig 6



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

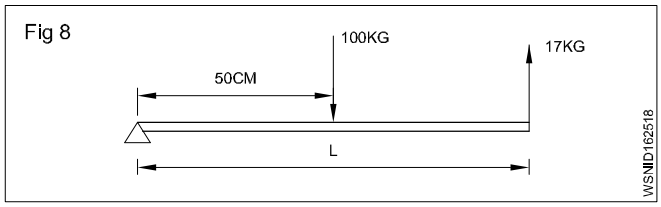
P = 3000/2

= 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.



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

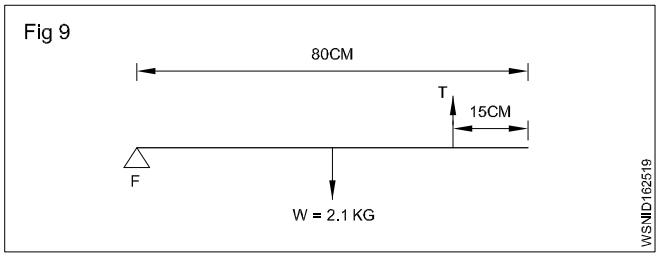
$x = 294.1$ cm

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.



W = 2.1 kg

Tension = T kg

P x dp = 2.1 x dv

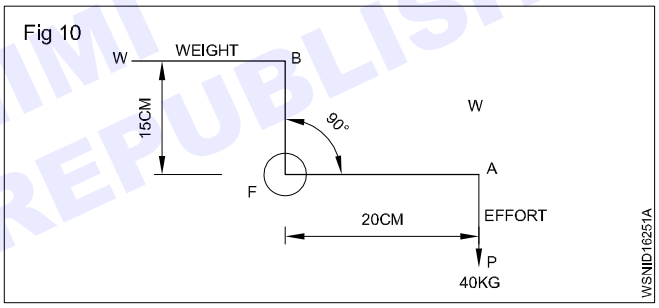
T kg x (80 - 15) cm $= 2.1$ kg $\times \frac{80}{2}$ cm

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.



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.

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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?