# WORKSHOP CALCULATION & SCIENCE

## (NSQF)

## 2nd YEAR

## (As per Revised Syllabus July 2022)

## Electrician - Power Distribution



Directorate General of Training

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

NATIONAL INSTRUCTIONAL MEDIA INSTITUTE, CHENNAI

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**Workshop Calculation & Science**

**Electrician - Power Distribution - 2nd 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 - Electrician - Power Distribution 2nd Year** NSQF (Revised 2022) under CTS will help the trainees to get an international equivalency standard where their skill proficiency and competency will be duly recognized across the globe and this will also increase the scope of recognition of prior learning. NSQF trainees will also get the opportunities to promote life long learning and skill development. I have no doubt that with NSQF the trainers and trainees of ITIs, and all stakeholders will derive maximum benefits from these IMPs and that NIMI's effort will go a long way in improving the quality of Vocational training in the country.

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

Jai Hind

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

December 2023
New Delhi - 110 001

# PREFACE

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

The Instructional materials are developed and produced in the form of Instructional Media Packages (IMPs), consisting of Trade Theory, Trade Practical, Test and Assignment Book, Instructor Guide and Wall charts. 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 -** Electrician - Power Distribution 2nd Year 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 -** Electrician - Power Distribution 2nd Year NSQF (Revised 2022) under CTS as per NSQF is the outcome of the collective efforts of experts from Field Institutes of DGT, Champion ITI's for each of the Sectors, and also Media Development Committee **(MDC)** members and Staff of **NIMI.** NIMI wishes that the above material will fulfill to satisfy the long needs of the trainees and instructors and shall help the trainees for their Employability in Vocational Training.

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



**Chennai - 600 032** **EXECUTIVE DIRECTOR**

# ACKNOWLEDGEMENT

The National Instructional Media Institute (NIMI) sincerely acknowledge with thanks the co-operation and contribution of the following Media Developers to bring this IMP for **Workshop Calculation & Science - Electrician - Power Distribution 2nd Year** 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.

# 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 - 2nd Year : 28 Hrs**

Time allotment for each title of exercises has been given below. **Workshop Calculation & Science - Electrician - Power Distribution** 2nd Year NSQF Revised Syllabus 2022.

| S.No | Title | Exercise No. | Time in Hrs |
|---|---|---|---|
| 1 | Friction | 2.1.01 | 2 |
| 2 | Algebra | 2.2.02 & 2.2.03 | 10 |
| 3 | Elasticity | 2.3.04 | 2 |
| 4 | Profit and Loss | 2.4.05 & 2.4.06 | 4 |
| 5 | Estimation and Costing | 2.5.07 - 2.5.12 | 10 |
| | | **Total** | **28 Hrs** |



# LEARNING / ASSESSABLE OUTCOME

On completion of this book you shall be able to

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

## CONTENTS

# SYLLABUS

**2nd Year**

**Workshop Calculation & Science - Electrician - Power Distribution**
**Revised syllabus July 2022 under CTS**

| S.no. | Syllabus | Time in Hrs |
|---|---|---|
| I | **Friction**<br>1 Friction – Lubrication | 2 |
| II | **Algebra**<br>1 Addition, Subtraction, Multiplication & Divisions<br>2 Algebra – Theory of indices, Algebraic formula, related problems | 10 |
| III | **Elasticity**<br>1 Elastic, plastic materials, stress, strain and their units and young's modulus | 2 |
| IV | **Profit and Loss**<br>1 Simple problems on profit & loss<br>2 Simple and compound interest | 4 |
| V | **Estimation and Costing**<br>1 Simple estimation of the requirement of material etc., as applicable to the trade<br>2 Problems on estimation and costing | 10 |
| | **Total** | 28 |

# Friction - Lubrication

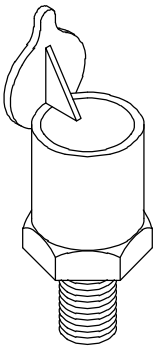
There are 3 systems of lubrication.

- Gravity feed system
- Force feed system
- Splash feed system

### Gravity feed

The gravity feed principle is employed in oil holes, oil cups and wick feed lubricators provided on the machines. (Figs 1 & 2)

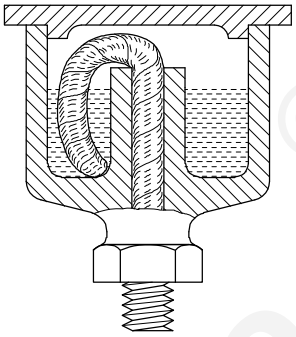
Fig 1



OIL CUP

WSNPD210111

Fig 2



WICK FEED

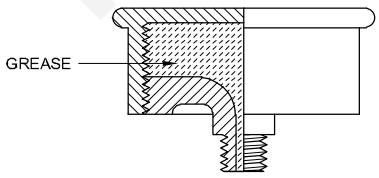
WSNPD210112

### Force feed/Pressure feed

### Oil, grease gun and grease cups

The oil hole or grease point leading to each bearing is fitted with a nipple, and by pressing the nose of the gun against this, the lubricant is forced to the bearing. Greases are also force fed using grease cup. (Fig 3)

Fig 3

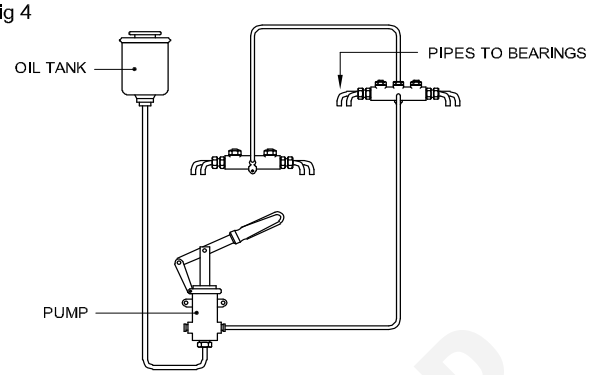



MANUAL SCREW DOWN GREASER

WSNPD210113

Oil is also pressure fed by hand pump and a charge of oil is delivered to each bearing at intervals once or twice a day by operating a lever provided with some machines. (Fig 4) This is also known as shot lubricator.

Fig 4




HAND PRESSURE FEED ( SHOT LUBRICATED )

WSNPD210114

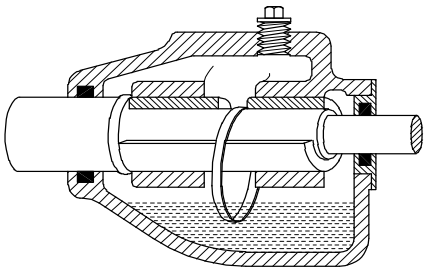
### Oil pump method

In this method an oil pump driven by the machine delivers oil to the bearings continuously, and the oil afterwards drains from the bearings to a sump from which it is drawn by the pump again for lubrication.

### Splash lubrication

In this method a ring oiler is attached to the shaft and it dips into the oil and a stream of lubricant continuously splashes around the parts, as the shaft rotates. The rotation of the shaft causes the ring to turn and the oil adhering to it is brought up and fed into the bearing, and the oil is then led back into the reservoir. (Fig 5) This is also known as ring oiling.

Fig 5

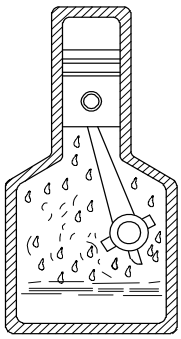


RING OILING

WSNPD210115

In other systems one of the rotating elements comes in contact with that of the oil level and splash the whole system with lubricating oil while working. (Fig 6) Such systems can be found in the headstock of a lathe machine and oil engine cylinder.

Fig 6



SPLASH-LUBRICATING SYSTEM

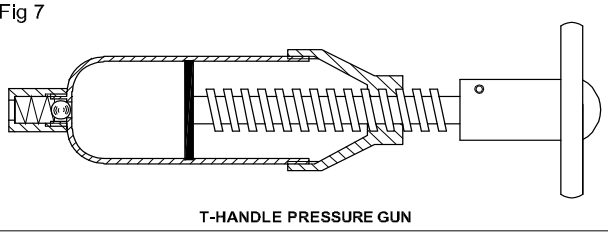
WSNPD210116

### Types of grease guns

The following types of grease guns are used for lubricating machines.

- 'T' handle pressure gun (Fig 7)

Fig 7



T-HANDLE PRESSURE GUN

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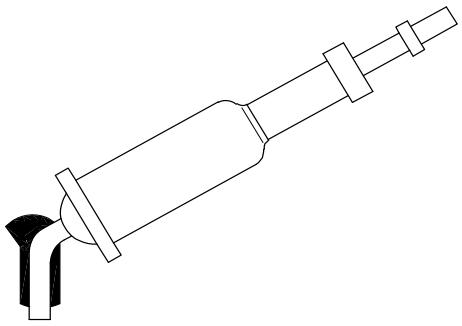
- Automatic and hydraulic type pressure gun (Fig 8)

Fig 8

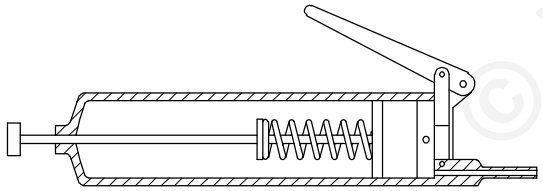


AUTOMATIC HYDRAULIC-TYPE PRESSURE GUN

WSNPD210118

- Lever-type pressure gun (Fig 9)

Fig 9



PRESSURE GREASE GUN

WSNPD210119

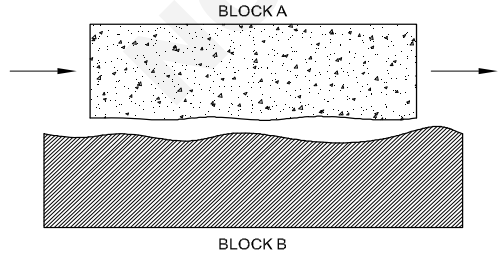
### Lubrication to exposed slideways

The moving parts experience some kind of resistance even when the surface of the parts seems to be very smooth.

The resistance is caused by irregularities which cannot be detected by the naked eyes.

Without a lubricant the irregularities grip each other as shown in the diagram. (Fig 10)

Fig 10

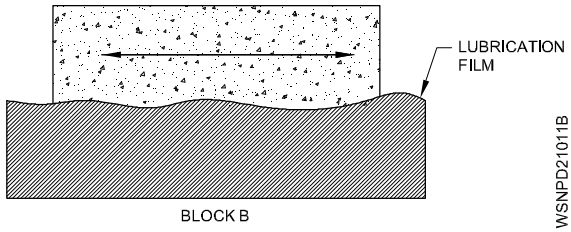



WSNPD21011A

With a lubricant the gap between the irregularities fills up and a film of lubricant is formed in between the mating components which eases the movement. (Fig 11)

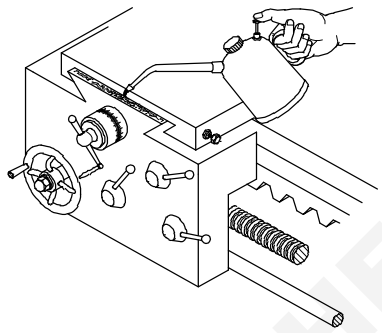
The slideways are lubricated frequently by an oilcan. (Fig 12)

Fig 11




WSNPD21011B

Fig 12

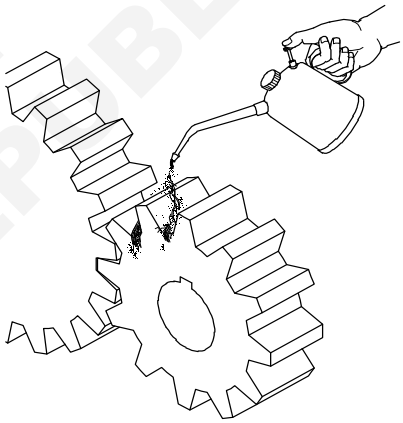


OIL THE SLIDES FREQUENTLY

WSNPD21011C

After cleaning the open gears, oil them and repeat lubrication regularly. (Fig 13)

Fig 13



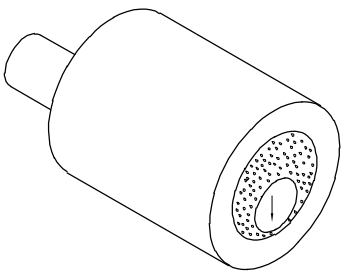
WSNPD21011D

### Lubricate bearings

A shaft moving in a bearing is also subjected to frictional resistance. The shaft rotates in a bush bearing or in ball/ roller bearing, experiencing friction.

When the shaft is at rest on the bottom of the bush bearing, there is hardly any lubricant between the shaft and the bush. (Fig 14)

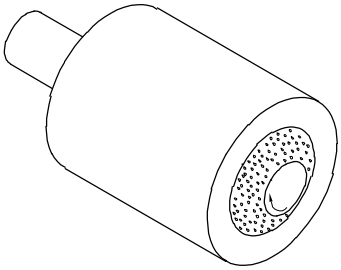
Fig 14



WSNPD21011E

When the shaft starts rotating the lubricant maintains a film between the shaft and the bush and an uneven ring of lubricant builds up. (Fig 15)

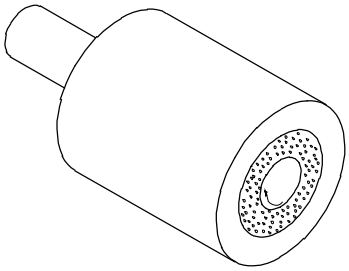
Fig 15



WSNPD21011F

When the shaft is rotating at full speed a full ring of lubricating film surrounds the shaft (Fig 16) which is known as hydro dynamic lubrication.

Fig 16

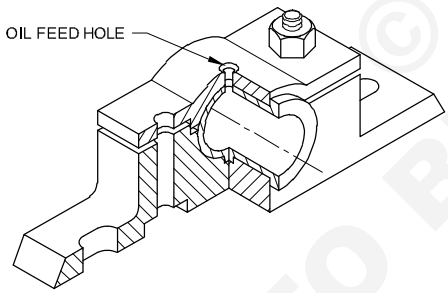


WSNPD21011G

This lubrication ring decreases the frictional resistance very much and at the same time protects the mating members against wear and changes.

Some bush bearings have oil feeding holes over which the oil or grease cup is mounted and the lubricant is fed through the holes into the bearing by gravity feed system.(Fig 17)

Fig 17




WSNPD21011H

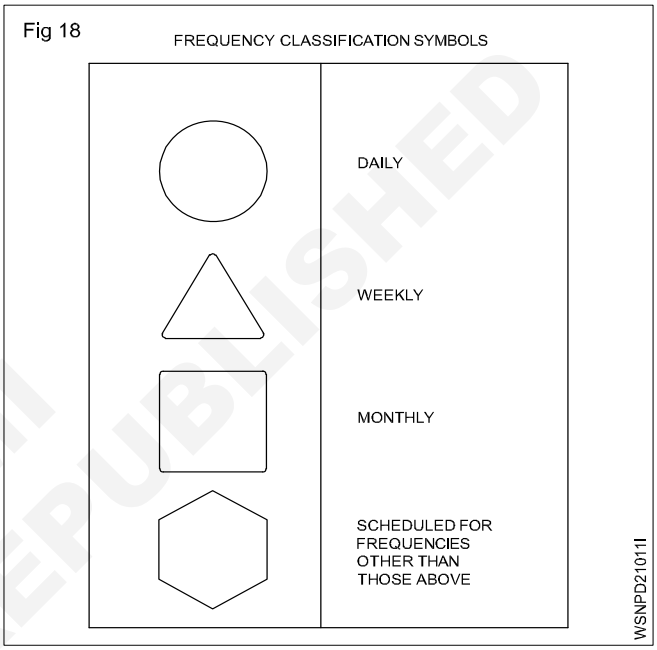
**Hints for lubricating machines:**

- identify the oiling and greasing points
- select the right lubricants and lubricating devices
- apply the lubricants.

The manufacturer's manual contains all the necessary details for lubrication of parts in machine tools. Lubricants are to be applied daily, weekly, monthly or at regular intervals at different points or parts as stipulated in the manufacturer's manual.

These places are indicated in the maintenance manuals with symbols as shown in Fig 18.

Fig 18




WSNPD21011I

# Algebra - Addition, subtraction, multiplication & division

### Introduction

Algebra is a form of mathematics in which letters may be used in place of unknown. In this mathematics numbers are also used in addition to the letters and the value of number depends upon its place. For example in $3x$ and $x^3$, the place of $x$ is different. In $3x$ =3 is multiplied with $x$, whereas in $x^3$ - 3 is an Index of $x$.

### Positive and negative numbers

Positive numbers have a + sign in front of them, and negative numbers have – sign in front of them. The same applies to letters also.

**Example** + $x$, – y.

+8 or simply 8 positive number.

– 8 negative number.

### Addition and subtraction

Two positive numbers are added, by adding their absolute magnitude and prefix the plus sign.

To add two negative numbers, add their absolute magnitude and prefix the minus sign.

To add a positive and a negative number, obtain the difference of their absolute magnitudes and prefix the sign of the number having the greater magnitude.

+7 + 22 = +29
(–8) – 34 = – 42
(–27) + 19 = –8
44 + (–18) = +26
37 + (–52) = –15

### Multiplication of positive and negative numbers

The product of two numbers having like signs is positive and the product of two numbers with unlike signs is negative. Note that, where both the numbers are negative, their product is positive.

**Ex.**
–20 x –3 = 60
5 x 8 = 40
4 x –13 = – 52
–5 x 12 = –60

### Division

The number that is divided is the dividend, the number by which we are dividing is the divisor and the answer is the quotient. If the signs of the dividend and the divisor are the same then the quotient will have a + sign. If they are unlike then the quotient will have a negative sign.

$$\frac{+28}{+4} = +7$$

$$\frac{+56}{-4} = -14$$

$$\frac{-72}{+9} = -8$$

$$\frac{-96}{-6} = +16$$

**When an expression contains addition, subtraction, multiplication and division, perform the multiplication and division operations first and then do the addition and subtraction.**

### Example

12 x 8 – 6 + 4 x 12 = 96 – 6 + 48 = 138

102 ÷ 6 – 6 x 2 + 3 = 17 – 12 + 3 = 8

### Parentheses and grouping symbols

( ) Brackets

{ } Braces

7 + (6–2) = 7 + 4 = 11

6 x (8–5) = 6 x 3 = 18

### Parentheses

These are symbols that indicate that certain addition and subtraction operations should precede multiplication and division. They indicate that the operations within them should be carried out completely before the remaining operations are performed. After completing the grouping, the symbols may be removed.

In an expression where grouping symbols immediately preceded or followed by a number but with the signs of operation omitted, it is understood, that multiplication should be performed.

Grouping symbols are used when subtraction and multiplication of negative number is done.

To remove grouping symbols which are preceded by negative signs, the signs of all terms inside the grouping symbols must be changed (from plus to minus and minus to plus).

Parentheses which are preceded by a plus sign may be removed without changing the signs of the terms within the parentheses.

When one set of grouping symbols is included within another set, remove the innermost set first.

When several terms connected by + or – signs contain a common quantity, this common quantity may be placed in front of a parentheses.

8 + 6(4–1) = 8 + 6 x 3 = 26

(6+2) (9–5) = 8 x 4 = 32

Plus 4 less negative 7 is written as 4 – (–7).

Plus 4 times negative 7 is written as 4(–7).

$4 – (–7) = 4 + 7 = 11$

$8 – (7–4) = 8 – 3 = 5$

$3 + (–8) = 3 – 8 = –5$

$7 + (4 – 19) = 7 + (–15) = 7 – 15 = – 8$

$3 \{40 + (7 + 5) (8–2)\}$

$= 3 \{40 + 12 \times 6\}$

$= 3 \times 112 = 336.$

$8x + 12$ - quantity 4 may be factored out giving the expression $8x + 12$ as $4 (2x + 3)$.

The innermost set in a grouping symbols of an expression is to be simplified first.

**Algebraic symbols and simple equations**

**Algebraic symbol**

An unknown numerical value of a quantity is represented by a letter which is the algebraic symbol.

**Factor**

A factor is any one of the numbers or letters or groups which when multiplied together give the expression. Factors of 12 are 4 and 3 or 6 and 2 or 12 and 1.

$8x + 12$ is the expression and this may be written as $4(2x + 3)$, 4 and $(2x + 3)$ are the factors.

**Algebraic terms**

If an expression contains two or more parts separated by either + or –, each part is known as the term.

$y – 5x$ is the expression. y and $– 5x$ are the terms.

The sign must precede the term.

**Kinds of terms:**

**1 Like terms**

a 13a, 15a, 19a, -12a, -18a

b $5x$y, $11x$y, $-x$y, $-14x$y

c $27m^2$, $25m^2$, $-3m^2$, $11m^2$

**2 Unlike terms**

a 3ac, - 4b, $8x$, 3yz

b $2x$y, $y^2$, $a^2$b, $x$z, 3bc

c $13m^2n$, $3mn^2$, $14lm^2$, $15a^2b$, 5lm

**Examples :**

1 Add 7a, - 2a, a, 3a

7a + (- 2a) + (a) + 3a

7a - 2a + a + 3a

= 11a - 2a

= 9a

2 Add $25x$y, + $2x$y, - $6x$y, - $3x$y

$25x$y + $2x$y + (- $6x$y) + (- $3x$y)

= $27x$y - $9x$y

= $18x$y

3 Add 9m, + 4m, - 2

9m + 4m + (- 2)

9m + 4m - 2

= 13m - 2

**Coefficient**

When an expression is formed into factors whose product is the expression, then each factor is the coefficient of the remaining factors.

$48x = 4 \times 12 \times x$

4 is the coefficient of $12x$ . $x$ is the coefficient of 48.

**Equation**

It is a statement of equality between numbers or numbers and algebraic symbols.

$12 = 6 \times 2$, $13 + 5 = 18$.

$2x + 9 = 5$, $y – 7 = 4y + 5$.

**Simple equation**

Equations involving algebraic symbols to the first power are simple equations.

$2x + 4 = 10$. $4x + 12 = 14$.

**Addition**

1 8a + 12b - a - 14b

= 8a - a + 12b - 14b

= 7a - 2b

2 14a + 3a + 25b + 2b + b

= 17a + 28b

3 (2a + 3b - c) + (4a - b - c) + (a - 8)

2a + 3b - c + 0

4a - b - c + 0

a + 0 + 0 - 8

7a + 2b - 2c - 8

4 Add : $(3x + 3z)$ ; $(5x - 4y)$; $(9y - 3z)$

$3x + 0 + 3z$

$5x - 4y + 0$

$0 + 9y - 3z$

$8x + 5y$

**Subtraction**

1 $38xy - 15xy = 23xy$

2 Subtract $3xy$ from $-4xy$

$-4xy$

$(-)\ +3xy$

$-7xy$

3 Subtract $5x$ from $12x$

$= 12x - (5x)$

$= 12x - 5x$

$= 7x$

4 Subtract $18x$ from $7x$

$= 7x - (18x)$

$= 7x - 18x$

$= -11x$

5 Subtract $3x - 2y$ from $4y - 2x$

$= (4y - 2x) - (3x - 2y)$

$= 4y - 2x - 3x + 2y$

$= 6y - 5x$

**Addition and subtraction**

Quantities with algebraic symbols are added or subtracted by considering those terms involving same symbols and powers.

Example

1. $10x + 14 - 7y^2 - 11a + 2x - 4 - 3y^2 - 4a + 8$

   $= 10x + 2x - 7y^2 - 3y^2 - 11a - 4a + 14 - 4 + 8$

   $= 12x - 10y^2 - 15a + 18$

2. $2x = 10$, $2x + 6 = 10 + 6$

3. $y + 12 = 20$, $y + 12 - 8 = 20 - 8$

4. $x + 10 = 12$,

   $x + 10 - 10 = 12 - 10$

5. $3x = 6$, $2 \times 3x = 2 \times 6$, $6x = 12$

6. $5y = 20$, $\frac{5y}{5} = \frac{20}{5}$.

The same number may be added or subtracted to both members of an equation without changing its equality.

Each member of an equation may be multiplied or divided by the same number or symbol without changing its equality.

The equality of an equation is not altered when the numbers or symbols are added or subtracted from both sides. Multiplication and division by the same numbers or symbols on both sides also will not affect the equality.

**Transposition of the terms of the equations**

= equals to

\+ plus

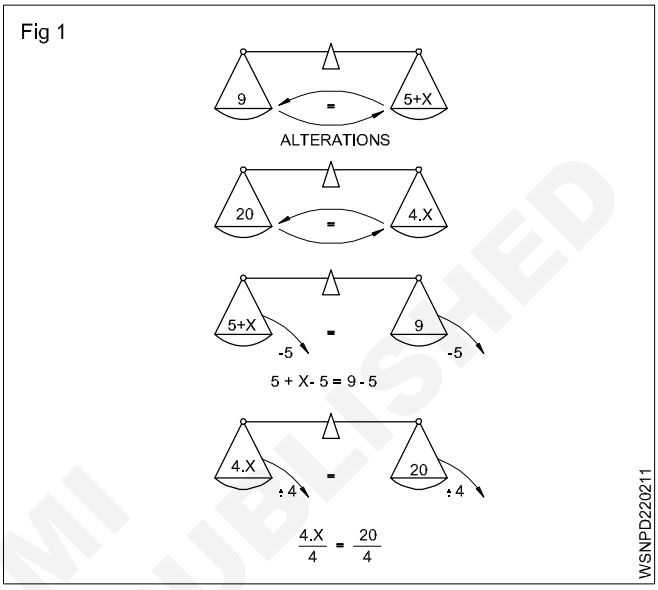
– minus

x multiply

÷ divided by

**Concept of equality** (Fig 1)

Fig 1




An equation can be compared to a pair of scales which always remain in equilibrium. The two sides of the equation can fully be transposed. $9 = 5 + x$ may also be written as $5 + x = 9$.

We must always perform the same operation on both sides of the equation to keep the equilibrium. Add or subtract the same amount from both sides. $5 + x = 9$ By adding 3 on both sides, the equation becomes $5 + x + 3 = 9 + 3$ or $x + 8 = 12$.

$5 + x = 9$ Subtract 5 from both sides then $5 + x - 5 = 9 - 5$.

$x = 4$.

5 is transposed from left side to the right side by changing its sign from + to –.

$\frac{x}{4} = 20$. Multiply both sides by 4. Then $\frac{x}{4} \times 4 = 20 \times 4$.

$x = 80$,

$5x = 25$.

Divide both sides by 5 then $\frac{5x}{5} = \frac{25}{5}$

$x = 5$.

When transposing numbers or letter symbols from one side to the other side multiplication becomes division and the division becomes multiplication.

**The equality of an equation remains unchanged when both sides of the equation are treated in the same way. When transposing from one side to the other side,**

**a plus quantity becomes minus quantity.**

**a minus quantity becomes a plus quantity**

**a multiplication becomes a division**

**a division becomes a multiplication.**

**To solve simple equations isolate the unknown quantity which is to be found on the left side of the equation.**

**Example**

- Solve for x if $4x = 3(35 - x)$

  $4x = 105 - 3x$ (brackets removed)

  $4x + 3x = 105$ (By transposing $-3x$ on the right side to the left side)

  $7x = 105$

  $x = 15$ (dividing both sides by 7)

## Assignment

**Add**

1 14f - 2f + 5f - 7f + 9f

2 $3xy + 5xy - 2xy + 8xy - 4xy$

3 $17xy - 4xy + 13 - xy - 6$

4 2a + a + 3a + 6a - 5b

5 8c + 5c + 3c + 2c

6 14d + 3d + 25e + 2e

7 5p + 3r - r - 2p

8 8t + 12u - t - 14u

9 $x$ - z + y + z

10 15a + 13a - 37a

11 17a - 4b - 7a + 3b

12 9c - 15e + 4c + 3e

13 13f + 40g - 16f + 7f + 2g - 17g

14 $30x + 45y - 17x - 16y$

15 8a + 3c - 6b - 5c + 4a + 8b

16 27i + 17k - 5l + 12i - 31k + 19l

17 230m + 472P - 320n - 75m + 180n - 141p

18 230m + 420s + 370y + 225m - 510y - 110s

19 45b + 25c + 18b + 40c

20 14d + 3d + 25e + 2e + e + d

21 15a - (4a + 3a - 5a)

22 $5x + 3y - (2x - 5y)$

23 $(x + 2y + 3z) + (4x - y + z)$

24 $(2x + 5y) + (4x - 8z) + (15z - 6y) + (z - 2x)$

25 $(-2x + 3y - 3z) + (-6y - 5x + z)$

26 (a - 3b + 4c) + (-7c - a + 4b)

27 $(2x + 5y) + (4x - 8z) + (15z - 2y)$

**Subtract**

1 $38xy - 25xy$

2 Subtract 2a - 3b - c from 3a - 2b + 4c

3 2a - 3(a - (a - b))

**Add and Subtract**

1 230a + 420b + 370c + 225a - 510c - 110b

2 15d - (4d + 3d - 5d)

3 $8x + 3z - 6y - 5z + 4x + 8y$

**Multiplication**

1 $5yzx$ x (-5ab)

2 3ax -9b

3 2ab x -7pq

**Division**

1 $\frac{10a}{2a}$

2 $-3ax \div -6x$

3 $15xy \div -5$

4 $-\frac{8ac}{2bc}$

5 $\frac{-5m \text{ x } -6n - 7p}{-28\,mn}$

6 $\frac{5a + 20}{7a + 28}$

# Algebra - Theory of indices, Algebraic formula, related problems

**Calculations involving powers**

**Power : Concept**

a.a.a... upto n times is = $a^n$

a is the base, n is the exponent.

When a number, say 2 is multiplied by itself 4 times, we write it as $2^4$ (two to the power of 4) and it is equal to 2 x 2 x 2 x 2 = 16.

The exponent denotes how many times the base number is multiplied by itself.

Powers with a positive base have a positive result.

Powers with a negative base and with an exponent that is even will have a positive result.

The sign

$(+a)^n = a^n$

$(-a)^{2n} = a^{2n}$

$(2)^2 = 2 \times 2 = 4$ and

$(-2)^2 = -2 \times -2 = +4$ but

$(-2)^3 = -2 \times -2 \times -2 = -8$

**Addition and subtraction of powers**

Powers with the same base and exponents can be added or subtracted by addition or subtraction of the coefficients.

$x.a^n + y.a^n = a^n(x + y)$

$x.a^n - y.a^n = a^n(x - y)$

Ex .$4x^2 + x^2 - 3x^2 = x^2(4 + 1 - 3) = 2x^2$.

**Multiplication**

Powers with the same bases are multiplied by involving the common base raised to the power of sum of the exponents.

$a^m \times a^n = a^{m+n}$.

$2^3 \times 2^2 = 2^{3+2} = 2^5$

$(2 \times 2 \times 2) \times (2 \times 2) = 2 \times 2 \times 2 \times 2 \times 2 = 2^5$

$8 \times 4 = 32$.

Powers with the same exponent of different base numbers are multiplied by involving the product of the base numbers raised to the common exponent.

$a^n \times b^n = (a \times b)^n$

$2^2 \times 3^2 = (2 \times 3)^2$

$2 \times 2 \times 3 \times 3 = 6 \times 6 = 36$

**Division**

Powers with like bases are divided by involving the base raised to the difference between the exponents.

$$\frac{a^m}{a^n} = a^{m-n}$$

$$\frac{2^3}{2^2} = 2^{3-2} = 2^1 = 2$$

$$\frac{2 \times 2 \times 2}{2 \times 2} = \frac{8}{4} = 2$$

Powers with the same exponents are divided by involving the quotient of the bases by the common exponent.

$$\frac{a^n}{b^n} = \left(\frac{a}{b}\right)^n$$

$$\frac{2^2}{3^2} = \left(\frac{2}{3}\right)^2 = \frac{2 \times 2}{3 \times 3} = \frac{4}{9}$$

Only like powers can be added or subtracted.

**Examples**

(The exponent 1 is usually not written.)

$a^1 = a$

$2^1 = 2$

$2a^2 + 3a^2 = 5a^2$

(Any number raised to the power of 0 is 1.)

$a^0 = 1$

$2^0 = 1$

A number raised to a negative power corresponds to its reciprocal with the exponent's sign changed to +.

$$a^{-n} = \frac{1}{a^n}$$

$$2^{-2} = \frac{1}{2^2}$$

Powers are involved by multiplying the exponents.

$(a^n)^m = a^{nm}$

$(2^2)^3 = 2^{2.3} = 2^6$

Powers can be transposed without affecting the result.

$$\left(a^n\right)^m = \left(a^m\right)^n$$

$(2^2)^3 = (2^3)^2$

$(2 \times 2) \times (2 \times 2) \times (2 \times 2) = (2 \times 2 \times 2)(2 \times 2 \times 2)$

$4 \times 4 \times 4 = 64$

$8 \times 8 = 64$

A mixed number raised to a power is first converted into an improper fraction and then the result is evaluated.

$$\left(1\frac{3}{4}\right)^2 = \left(\frac{7}{4}\right)^2$$

$$= \frac{7}{4} \times \frac{7}{4} = \frac{49}{16}$$

**Indices**

- The indices are added in multiplication

  $a^m \times a^n = a^{m+n}$.

- The indices are subtracted in division

  $$\frac{a^m}{a^n} = a^{m-n}$$ .

- In case of index of an index, both the indices are multiplied mutually

  $[a^m]^n = a^{m.n}$

- A fractional index shows root of a number

  $a^{1/m} = \sqrt[m]{a}$

- In case of an index having minus sign, the sign can be changed by taking the number from numerator to denominator or vice versa

  $$a^{-m} = \frac{1}{a^m}$$

  and $$\frac{1}{a^{-m}} = a^m$$

- If an index contains both the numerator and denominator then it means that the number has 'index' as well as 'root'.

  $$a^{m/n} = \sqrt[n]{a^m}$$

**Basic problem**

**Addition**

1 $5x^2y + 3xy^2 + 8x^2y + 7xy^2$

$= 5x^2y + 8x^2y + 3xy^2 + 7xy^2$

$= 13x^2y + 10xy^2$

2 Add $5a^3$, $+ 12b^3$, $- c^3$, $+ a^3$, $- 4b^3$, $+ 3$

$5a^3 + 12b^3 + (- c^3) + a^3 + (- 4b^3) + 3$

$= 6a^3 + 8b^3 - c^3 + 3$

**Subtract**

1 Subtract $2x^2 - 3y^2$ from $3x^2 + 2y^2$

$3x^2 + 2y^2$

$2x^2 - 3y^2$

$x^2 + 5y^2$

**Multiplication**

1 $-4x^2 \times 8x^5 = -4 \times 8x^{2+5}$
(-) (+)

$= -32x^7$

2 $(3d^2 - 2d)\, 3d$

$= 9d^3 - 6d^2$

3 $(5x + 3y)(5x - 3y)$

$= (5x)^2 - (3y)^2$

$= 5x \times 5x - 3y \times 3y$

$= 25x^2 - 9y^2$

4 $5x^2y \times 8x^5y^3$

$= 40x^7y^4$

5 $(2a+b)(a+2b)$

$= 2a^2 + 4ab + ab + 2b^2$

$= 2a^2 + 2b^2 + 5ab$

6 $8a^3b^5c^{-5} \times 3a^2b^{-5}c^5$

$= 24a^5$

**Division**

1 $$\frac{12x^3y^2}{4x^2y} = 3xy$$

2 $$\frac{15y^{15}}{15y^5} = y^{10}$$

3 $9c^5d^3 \div c^2d^2$

$= 9c^3d$

4 $$\frac{3a^2 \times 4a \times 5a^3}{6a^4 \times 10a}$$

$$= \frac{60a^6}{60a^5} = a$$

5 $-25a^{15} \div -5a^{-8}$

$$= \frac{-25a^{15}}{-5a^{-8}}$$

$= 5a^{15}a^8 = 5a^{23}$

6 $4x^2y \div 2y$

$$= \frac{4x^2y}{2y} = 2x^2$$

7 $3x^2y^3 \div -6x^5y$

$$= \frac{3x^2y^3}{-6x^5y} = -\frac{y^2}{2x^3}$$

8 $3x^3y^2 \div xy$

$$= \frac{3x^3y^2}{xy} = 3x^2y$$

9 Divide $45a^2b^2c$ by $9a^2c$

$$= \frac{45a^2b^2c}{9a^2c}$$

$=5b^2$

## Algebraic Formulae

| | | | |
|---|---|---|---|
| 1 | $(a + b)^2$ | = | $a^2 + b^2 + 2ab$ |
| 2 | $(a - b)^2$ | = | $a^2 + b^2 - 2ab$ |
| 3 | $(a + b)^2$ | = | $(a - b)^2 + 4ab$ |
| 4 | $(a - b)^2$ | = | $(a + b)^2-4ab$ ; $(a + b)^2-(a - b)^2=4ab$ |
| 5 | $a^2 + b^2$ | = | $(a + b)^2 - 2ab = (a - b)^2 + 2ab$ |
| 6 | $a^2 - b^2$ | = | $(a + b)(a - b)$ |
| 7 | $a^3 + b^3$ | = | $(a + b)(a^2 + b^2 - ab)$ |
| 8 | $a^3 - b^3$ | = | $(a - b)(a^2 + b^2 + ab)$ |
| 9 | $(a + b)^3$ | = | $a^3 + b^3 + 3ab(a + b)$ |
| 10 | $(a - b)^3$ | = | $a^3 - b^3 - 3ab(a - b)$ |
| 11 | $(a + b + c)^2$ | = | $a^2 + b^2 + c^2 + 2(ab + bc + ca)$ |
| 12 | $a^4 - b^4$ | = | $(a^2 + b^2)(a + b)(a - b)$ |

### Examples

**1 If $x + y = 9$ and $xy = 20$**

Find i) $x^2 + y^2$ ii) $x - y$ iii) $x^2 - y^2$
iv) $x^3 + y^3$ v) $x^3 - y^3$ vi) $x$ and $y$

**i $(a + b)^2$ = $a^2 + b^2 + 2ab$**

$(x + y)^2 = x^2 + y^2 + 2xy$
$(9)^2 = x^2 + y^2 + 2(20)$
$81 = x^2 + y^2 + 40$
$x^2 + y^2 = 81 - 40$
$x^2 + y^2 = 41$

**ii $(a - b)^2$ = $(a + b)^2 - 4ab$**

$(x - y)^2 = (x + y)^2 - 4xy$
$= (9)^2 - 4(20)$
$= 81 - 80$
$= 1$
$x - y = \sqrt{1} = 1$

**iii $a^2 - b^2$ = $(a + b)(a - b)$**

$x^2 - y^2 = (x + y)(x - y)$
$= 9 \times 1$
$x^2 - y^2 = 9$

**iv $a^3 + b^3$ = $(a + b)(a^2 + b^2 - ab)$**

$x^3 + y^3 = (x + y)(x^2 + y^2 - xy)$
$= 9(41 - 20)$
$= 9 \times 21$
$x^3 + y^3 = 189$

**v $a^3 - b^3$ = $(a - b)(a^2 + b^2 + ab)$**

$x^3 - y^3 = (x - y)(x^2 + y^2 + xy)$
$= 1(41 + 20)$
$= 1 \times 61$
$= 61$
$x^3 - y^3 = 61$

vi $x + y = 9$
$x - y = 1$
---
$2x = 10$
---
$$x = \frac{10}{2} = 5$$

If $x = 5$, $5 + y = 9$
$y = 9 - 5 = 4$

**$x = 5$; $y = 4$**

**2 Solve $(x + 5)^2 - (x - 5)^2$**

If $x + 5 = a$ and $x - 5 = b$

$a^2 - b^2 = (a + b)(a - b)$

$(x + 5)^2 - (x - 5)^2 = [(x + 5) + (x - 5)][(x + 5) - (x - 5)]$
$= (x + 5 + x - 5)(x + 5 - x + 5)$
$= (2x)(10)$
$= 20x$

**3 If $(x - y) = 4$ and $xy = 12$, find the value of $(x^2 + y^2)$**

$(x - y)^2 = x^2 + y^2 - 2xy$
$(4)^2 = x^2 + y^2 - 2 \times 12$
$16 = x^2 + y^2 - 24$
$x^2 + y^2 - 24 = 16$
$x^2 + y^2 = 16 + 24$
$x^2 + y^2 = 40$

**4 If $x - y = 7$ and $xy = 60$ then find the value of $x^4 + y^4$**

$(x - y)^2 = x^2 + y^2 - 2xy = 7^2$
$x^2 + y^2 - 2 \times 60 = 49$
$x^2 + y^2 = 169$
$(x^2 + y^2)^2 = (169)^2$ (take square on both side)
$x^4 + y^4 + 2x^2y^2 = (169)^2$

$x^4 + y^4 + 2(xy)^2 = 28561$

$x^4 + y^4 + 2(60)^2 = 28561$

$x^4 + y^4 + 2(3600) = 28561$

$x^4 + y^4 + 7200 = 28561$

$x^4 + y^4 = 28561 - 7200$

$x^4 + y^4 = 21361$

5 $x + y = \sqrt{5}$; $x - y = \sqrt{3}$ Find the value of $8\,x\,y\,(x^2 + y^2)$

$x + y = \sqrt{5}$; $x - y = \sqrt{3}$ (take square on both sides)

$(x + y)^2 = 5$; $(x - y)^2 = 3$

Solve the equations

$(x + y)^2 = x^2 + y^2 + 2xy = 5$

$(x - y)^2 = x^2 + y^2 - 2xy = 3$

$2(x^2 + y^2) = 8$

$(x^2 + y^2) = \frac{8}{2} = 4$

$= x^2 + y^2 + 2xy = 5$

$= x^2 + y^2 - 2xy = 3$

(-) (-) (+) (-)

$4xy = 2$

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

$8\,xy\,(x^2 + y^2) = 8 \times \frac{1}{2} \times 4$

$= 4 \times 4 = 16$

6 If $(a - \frac{1}{a}) = 6$. Find the value of $a^2 + \frac{1}{a^2}$

$\left(a - \frac{1}{a}\right) = 6$

$\left(a - \frac{1}{a}\right)^2 = 6^2$ (take square on both sides)

$a^2 + \left(\frac{1}{a}\right)^2 - 2(a)\left(\frac{1}{a}\right) = 36$

$a^2 + \frac{1}{a^2} - 2 = 36$

$a^2 + \frac{1}{a^2} = 36 + 2$

$a^2 + \frac{1}{a^2} = 38$

7 If $x - \frac{1}{x} = 2$, Find the value of $x^3 - \frac{1}{x^3}$

$(a - b)^3 = a^3 - b^3 - 3ab(a - b)$

$\left(x - \frac{1}{x}\right)^3 = x^3 - \frac{1}{x^3} - 3(x)\left(\frac{1}{x}\right).\left(x - \frac{1}{x}\right)$

$= x^3 - \frac{1}{x^3} - 3\left(x - \frac{1}{x}\right)$

$2^3 = x^3 - \frac{1}{x^3} - 3\left(x - \frac{1}{x}\right)$

$8 = x^3 - \frac{1}{x^3} - 3(2)$

$8 = x^3 - \frac{1}{x^3} - 6$

$8 + 6 = x^3 - \frac{1}{x^3}$

$14 = x^3 - \frac{1}{x^3}$

$x^3 - \frac{1}{x^3} = 14$

8 If $x - \frac{1}{x} = 4$, Find the value of $x^4 + \frac{1}{x^4}$

$x - \frac{1}{x} = 4$ (take square on both sides)

$\left(x - \frac{1}{x}\right)^2 = 4^2$ $[(a - b)^2 = a^2 + b^2 - 2ab]$

$x^2 + \frac{1}{x^2} - 2 \times x \times \frac{1}{x} = 4^2$

$x^2 + \frac{1}{x^2} - 2 = 16$

$x^2 + \frac{1}{x^2} = 16 + 2$

$x^2 + \frac{1}{x^2} = 18$

$\left(x^2 - \frac{1}{x^2}\right)^2 = (18)^2$ (take square on both sides)

$(x^2)^2 + \left(\frac{1}{x^2}\right)^2 + 2 \times x^2 \times \frac{1}{x^2} = 324$

$x^4 + \frac{1}{x^4} + 2 = 324$

$x^4 + \frac{1}{x^4} = 324 - 2$

$x^4 + \frac{1}{x^4} = 322$

## Assignment

**Add**

1 $(5x^2 - 3y^2 + z) + (-x^2 + 2y^2 - 4z)$

2 $7a^2 - 5a^2 + a^2 + 3a^2$

3 $3m^2n - 2m^2n + 4m^2n - m^2n + 7m^2n$

4 $18 + 13x^2 - 13 + 2x^2 - 15x^2$

5 $6l^2m + 3lm^2 - 2l^2m - 17lm^2 + 1$

6 $3a^2b - 2ab - 2a^2b - 3ab - 2a^2b + ab$

**Subtract**

1 Subtract $2a^2 - 3b^2$ from $3a^2 + 2b^2$

2 Subtract $-2y^2 + 3xy - 5$ from $3x^2 - 4xy + 7y^2 - 5$

3 Subtract $3x - 4x^2 + 2y^2$ from $4y^2 - 2x + 8x^2$

**Add and Subtract**

1 $48m^2 + 24m^2n + 12m^2 - 6m^2 - 12m^2n$

2 $3x^2y - 2xy - 2x^2y - 3xy - 2x^2y + xy$

3 $10x + 14 - 7y^2 - 11a + 2x - 4 - 3y^2 - 4a + 8$

**Multiplication**

1 $7pq^2 \times 5r$

2 $(4x^2 + 3y^2) \times (-2z)$

3 $-7p \times 4q^2$

4 $p^2q^3 \times 3p^3q^2$

5 $(3b^2 - 2b)3b^2$

6 $5y \times 2y^3y^2$

7 $ab^{-1} \times ba^{-1}$

**Division**

1 $4a^8 \div 2a^3$

2 $-15a^8 \div 3a^5$

3 $\frac{8a^4}{12a^{-7}}$

4 $\frac{3p^2 \times 4p \times 5p^3 \times p}{6p^4 \times 10p}$

5 $\frac{25m^2n}{5m^3n^2}$

# Elasticity - Elastic, plastic materials, stress, strain and their units and young's modulus

**Elastic material**

The Elastic materials are those materials that have the ability to resist a distorting or deforming influence or force, and then return to their original shape and size when the same force is removed.

Linear elasticity is widely used in the design and analysis of structures such as beams, plates and sheets.

Elastic materials are of great importance to society since many of them are used to make clothes, tires, automotive spare parts, etc.

**Characteristics of elastic materials**

When an elastic material is deformed with an external force, it experiences an internal resistance to the deformation and restores it to its original state if the external force is no longer applied.

To a certain extent, most solid materials exhibit elastic behavior, but there is a limit of the magnitude of the force and the accompanying deformation within this elastic recovery.

A material is considered as elastic if it can be stretched up to 3 times of its original length.

For this reason there is an elastic limit, which is the greatest force or tension per unit area of a solid material that can withstand permanent deformation.

For these materials, the elasticity limit marks the end of their elastic behavior and the beginning of their plastic behavior. For weaker materials, the stress or stress on its elasticity limit results in its fracture.

The elasticity limit depends on the type of solid considered. For example, a metal bar can be extended elastically up to 1% of its original length.

However, fragments of certain gummy materials may undergo extensions up to 10 times. The elastic properties of most solid intentions tend to fall between these two extremes.

Maybe you might be interested How to Synthesize an Elastolic Material?

**Examples of elastic materials**

1 Natural gum
2 Spandex or lycra
3 Butyl Rubber (GDP)
4 Fluoroelastomer
5 Elastomers
6 Ethylene-propylene rubber (EPR)
7 Resilin
8 Styrene-butadiene rubber (SBR)
9 Chloroprene
10 Elastin
11 Rubber Epichlorohydrin
12 Nylon
13 Terpene
14 Isoprene Rubber
15 Poilbutadiene
16 Nitrile Rubber
17 Vinyl stretch
18 Thermoplastic elastomer
19 Silicone rubber
20 Ethylene-propylene-diene rubber (EPDM)
21 Ethylvinylacetate (EVA or foamy gum)
22 Halogenated butyl rubbers (CIIR, BIIR)
23 Neoprene

**Plastic Material**

**Plastic Material Classification**

"Plastic material" is a term that refers to a large class of polymers, separated into various groups and sub-groups. Before starting the chapter on the uses and subsequent recycling of plastic, let us establish a general classification of these thermosetting resins or thermo-plastics (the two big groups into which we include elastomers) by detailing their properties, their make-up, their aspect, and their final uses, while explaining which ones are recyclable.

**Thermoplastics**

Remember that thermoplastic is a material whose structure and viscosity can be modified both ways through heating or cooling. This large family of materials is commonly used by many industries and is easily integrated into France's recycling cycles.

The following polymers are some examples of plastic material:

1 Polyolefins
2 Vinyl polymers
3 Polystyrenes
4 Acrylate and methacrymate polymers
5 Polyamide
6 Polycarbonates
7 Celluloid
8 Linear polyesters
9 Polyfluorethane
10 Polyacetal
11 Polysulfone

12 Polyphenylene sulfide

13 Modified polyphenylene oxide (PPO)

**Thermosetting plastic**

Thermosetting plastic is a compound that, during condensation polymerisation and/or implementation, when submitted to a catalyst or a temperature increase, irreversibly cures. the structure, shape, or rigidity of the manufactured plastic object can not be modified again, and the material is rarely recycled.

This type of plastic includes the following types of compounds:

1 Unsaturated polyster

2 Phenol formaldehyde resins

3 Melamine resins

4 Polyepoxides

5 Polyimide

6 Polyurethane

7 Polyorganosiloxanes

Generally in any industry the material used are elastic in nature. Hence if a material is subjected to an external load, it undergoes deformation. During the deformation process the material will offer a resistance against the deformation. In case if the material fails to put up full resistance to the external load, the deformation continues until rupture takes place. Hence it is important to have a considerable knowledge about the materials and their properties for designing and fabricating.

**Force**

Force is defined as an external source which changes or tends to change the state of rest or of uniform motion of an object. In other words everybody preserves in its state of rest or of uniform motion unless it is forced by an external source to change that state. That external source is called as Force. It has both magnitude and direction. So it is a vector quantity. In SI system, its unit is Newton.

Unit in MKS - kgf

1 kgf = 9.81 Newton

Force is defined as the product of mass of the object and the acceleration.

Force = mass x acceleration

F = m x a

= Kg x m/sec$^2$

= 1 Newton

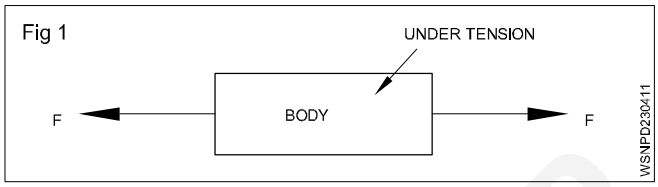
**Causes of force**

- Change in speed
- Change in direction
- Change in shape
- Change in dimension
- Change in condition (Rest to uniform motion and vice versa)

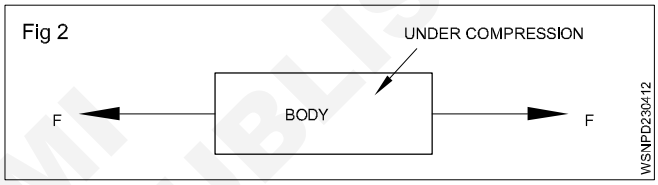
**Types of forces**

- tensile force
- compressive force
- shear force.

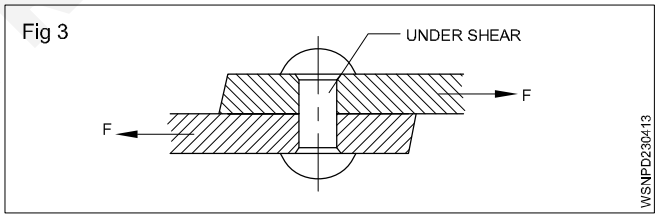
**Tensile force:** When two equal and opposite forces act on a body and have the same line of action, and if they tend to increase the length of the body, the applied forces are called tensile forces. (Fig 1)



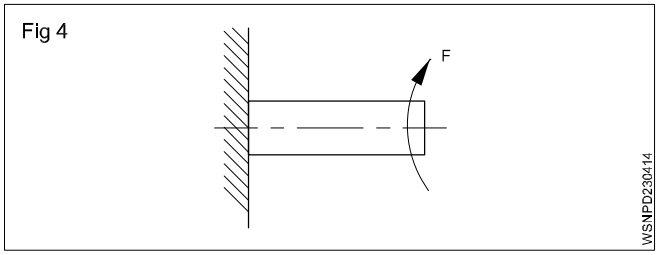

**Compressive force:** When two equal and opposite forces act on a body having the same line of action and if they tend to compress the body and try to reduce the length of the body, the forces applied are called compressive forces. (Fig 2)

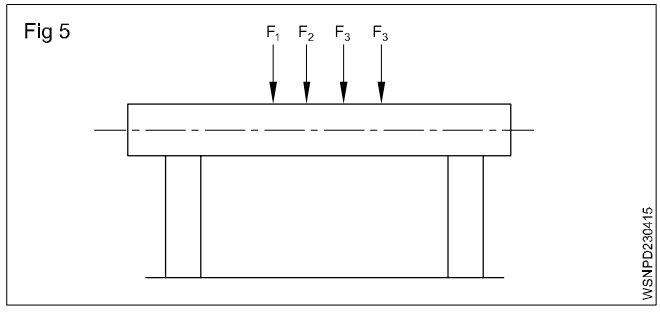



**Shear force:** When two equal and opposite forces having different lines of action act on a body such that one section of the body tends to slide over another section which results in a shearing action then the forces are referred to as shear forces. (Fig 3)




**Direct effect of forces:** Forces acting on a body can cause in the material. (Fig 4 & Fig 5)



- Tension
- Compression
- Shearing effect
- Twisting effect
- Bending effect.

**Force is mainly classified as tensile force, compressive force and shear force.**

**Stress**

The internal opposite force to the external load per unit area is known as stress. The unit of stress depends upon the force applied and area of original cross-section of material.

$$\therefore \text{Stress} = \frac{\text{Forced applied}}{\text{Area of original cross section}}$$

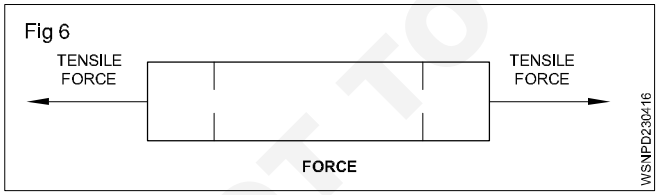
$$= \frac{\text{Load (or) Force}}{\text{Area}} \left( \frac{\text{N}}{\text{mm}^2} \text{ or } \frac{\text{Kg}}{\text{cm}^2} \right)$$

$$\text{Shear stress} = \frac{\text{F}}{\text{A}} \left( \frac{\text{N}}{\text{cm}^2} \text{ or } \frac{\text{Kg}}{\text{cm}^2} \right)$$

**Types of Stress**

1 Tensile stress
2 Compressive stress
3 Shear stress
4 Torsional Stress

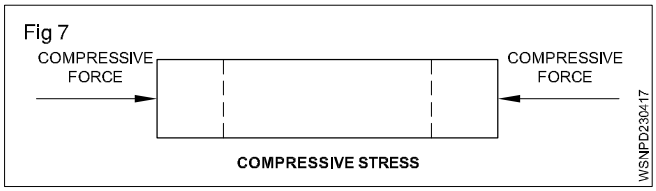
1 **Tensile stress:** When a material is subjected to two equal and opposite axial pulls, the material tends to increase in length. The resistance offered against this increase in length is called tensile stress. The corresponding strain is called tensile strain. (Fig 6)




**E.g.:**

1 When brake is applied the brake rod is under tensile stress.
2 During tightening of bolt or nut.
3 Belt driving motor.
4 Crane rope (When rope is pulling)

2 **Compressive stress:** When a material is subjected to two equal and opposite axial pushes, the material tends to decrease in length. The resistance offered against the decrease in length is called compressive stress. The corresponding strain is called compressive strain. (Fig 7)



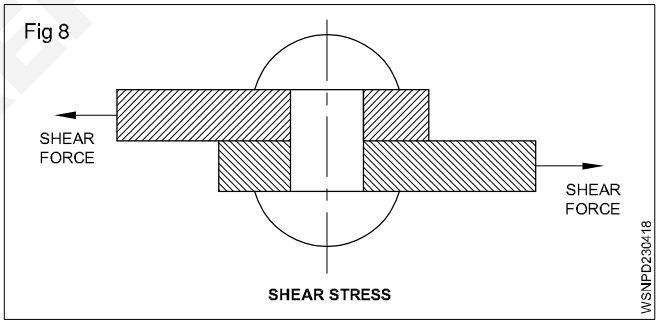

$$\text{Compressive stress} = \frac{\text{Axial push}}{\text{Area of cross section}}$$

$$\text{Compressive stress} = \frac{\text{Decrease in length}}{\text{Original length}}$$

**Eg.**

1 Compressive stress on connecting rod on the first part of power stroke
2 Compressive stress on push rod during valve opening
3 Clutch lining when the clutch is engaged

3 **Shear stress:** When a material is subjected to two equal and opposite forces acting tangentially across the resisting section, the body tends to be sheared off across the cross section. The stress included is called shear stress. It is represented by $\tau$. The corresponding strain is called shear strain. (Fig 8)




$$\text{Shear stress} = \frac{\text{F}}{\text{A}} \left( \frac{\text{N}}{\text{cm}^2} \text{ or } \frac{\text{Kg}}{\text{cm}^2} \right)$$

Eg.

1 Rivets
2 Gudgeon Pin
3 Spring shackle pin
4 Brake rod rivets
5 Chassis rivets
6 Fly wheel holding bolts
7 Swivel pins
8 Gear box shaft
9 Axle shaft

4 **Torsional stress:** When a shaft is subjected to the action of two equal and opposite couples acting in parallel planes, then the shaft is said to in torsion. The stress set up by the torsion is known as torsional shear stress.

Eg.

1 Rear axle

2 Crank shaft

3 Coil springs

4 Propeller shaft

5 Starter motor armature shaft

**Examples**

**1 A steel wire 3 mm dia. is loaded in tension with a weight of 50 kg. Find out the stress developed.**

Diameter of the steel wire = 3 mm

Radius = 1.5 mm

Weight = 50 kg

$$\text{Stress} = \frac{\text{Force(F)}}{\text{Area(A)}}$$

Area of circular wire (A) = $\pi r^2$ unit$^2$

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

$$= \frac{49.5}{7} = 7.07 \text{mm}^2$$

$$\text{Stress} = \frac{50}{7.07}$$

**= 7.072 Kg/mm$^2$**

**2 A force of 500 N is applied on a metallic wire of 5mm diameter. Find the stress.**

Diameter of the wire = 5 mm

Radius = 2.5 mm

Force = 500 Newton

$$\text{Stress} = \frac{\text{Force(F)}}{\text{Area(A)}}$$

Area of circular wire (A) = $\pi r^2$ unit$^2$

$$= \frac{22}{7} \times 2.5 \times 2.5$$

$$= \frac{137.5}{7} = 19.64 \text{mm}^2$$

$$\text{Stress} = \frac{500}{19.64}$$

**= 25.46 N/mm$^2$**

**3 A load of 600 kg is placed on a hollow cast iron cylinder of 200 mm outer diameter and 100 mm internal diameter. Find the stress on the cylinder.**

**Hollow cylinder**

Outer diameter (D) = 200 mm = 20 cm

Outer radius (R) = 10 cm

Internal diameter (d) = 100 mm = 10 cm

Inner radius (r) = 5 cm

Weight = 600 kg

$$\text{Stress} = \frac{\text{Force(F)}}{\text{Area(A)}}$$

$$\text{Area} = \pi (R+r)(R-r)$$

$$= \frac{22}{7} \times (10+5) \times (10-5)$$

$$= \frac{22}{7} \times 15 \times 5$$

$$= \frac{1650}{7} = 235.7 \text{cm}^2$$

$$\text{Stress} = \frac{600}{235.7} \text{ kg/cm}^2$$

**= 2.546 kg/cm$^2$**

**4 Calculate the minimum cross section area of a M.S. bar to withstand a load 6720 kg. Take the maximum stress of the material as 698.2 kg/cm$^2$.**

Weight = 6720 kg

Maximum stress = 698.2 kg/cm$^2$

$$\text{Stress} = \frac{\text{Force(F)}}{\text{Area(A)}}$$

$$\text{Area(A)} = \frac{6720}{698.2}$$

$$= 9.625 \text{ cm}^2$$

To calculate diameter

$$\text{Area} = \frac{\pi d^2}{4} \text{ unit}^2$$

$$d^2 = 4 \text{ x } 9.625 \text{ x } \frac{7}{22}$$

$$= \frac{134.75}{11}$$

$$d^2 = 12.25$$

**d = 3.5 cm**

**5 A load of 300 kg hanging from a rod of 3 metre length and 5 mm diameter extends it by 4 mm. Find the stress in the material and the strain it causes.**

Length of the rod = 3 m = 3000 mm

Increased length = 4 mm

Diameter = 5 mm;

Radius = 2.5 mm

Weight = 300 kg

$$\text{Strain} = \frac{\text{Change in length}}{\text{Original length}}$$

$$= \frac{4}{3000} = 0.00133$$

$$\text{Stress} = \frac{\text{Force(F)}}{\text{Area(A)}}$$

Area of circular rod (A) $= \pi r^2$ unit$^2$

$$= \frac{22}{7} \times 2.5 \times 2.5$$

$$= \frac{137.5}{7}$$

$= 19.643$ mm$^2$

$$\text{Stress} = \frac{300}{19.643}$$

**= 15.273 kg/mm$^2$**

**6 Find the force required to punch a hole of 10 mm dia. in a 1 mm thick plate, if the allowable shear stress is 50 N/mm$^2$.**

Thickness of the plate = 1 mm

Dia. of the punch = 10 mm

Shear stress = 50 Newton/mm$^2$

Force = Shear stress x area

Shear area = Circumference x thickness

$= \pi dt$

$$= \frac{22}{7} \text{ x } 10 \text{ x } 1$$

$$= \frac{220}{7} = 31.43 \text{ mm}^2$$

Force = 50 x 31.43

**= 1571.5 Newtons**

**7 A hole of 30 mm diameter is punched in a plate of 5 mm thickness. If the shear stress is 400 kg/cm$^2$. Find the force required to punch the hole.**

Thickness of the plate = 5 mm = 0.5 cm

Diameter of the punch = 30 mm = 3 cm

Shear stress = 400 kg/cm$^2$

Force = Shear stress x area

Shear area = Circumference x thickness

$= \pi dt$

$$= \frac{22}{7} \text{ x } 3 \text{ x } 0.5$$

$$= \frac{33}{7} = 4.71 \text{ mm}^2$$

Required force = 400 x 4.71

**= 1885.71 kg**

**8 What force will be required to shear off a bar of 30 mm dia. if the ultimate shear stress of the material is 35 kg/mm$^2$.**

Diameter of the bar = 30 mm

Shear stress = 35 kg/mm$^2$

$$\text{Stress} = \frac{\text{Force(F)}}{\text{Area(A)}}$$

$$35 = \frac{F}{\pi \times 15 \times 15}$$

F = 35 x $\pi$ x 15 x 15 kg

**Required Force = 24750 kg**

**9 A Hole of 2 cm dia is to be punched out of a plate of 1.4 cm thick. If the force applied to the punching die is 12 KN. Calculate the shear stress.**

Dia. of the hole = 2cm

Thickness = 1.4 cm

Force = 12 KN

Shear stress = ?

Punched out area = Circumference of the hole $\times$ Thickness

$= 2 \pi r \times t$ unit$^2$

$= 2 \times \pi \times 1 \times 1.4$

$= 2.8 \pi$ cm$^2$

$$\text{Shear stress} = \frac{F}{A}$$

$$= \frac{12KN}{2.8\pi \text{ cm}^2}$$

**Shear stress = 1.364 KN/cm$^2$**

**10 A square rod of 10 mm side is tested for a tensile load of 1016 kg. Calculate the tensile stress?**

Side of square rod (a) = 10 mm

Tensile force (F) = 1016 kg

Tensile stress ($\sigma$) = ?

$$\text{Stress} = \frac{\text{Force(F)}}{\text{Area(A)}}$$

$$= \frac{\text{Force}}{a^2}$$

$$= \frac{1016}{10x10}$$

**Tensile stress = 10.16 Kg/mm²**

**11 A M.S. tie bar 3.5 cm dia. is under a state of stress which carries a load of 6720 kg. Find the intensity of stress in the material.**

d = 3.5 cm

r = 1.75 cm

F = 6720 kg

$$\text{Stress} = \frac{\text{Force(F)}}{\text{Area(A)}}$$

$$= \frac{\text{Force}}{\pi r^2}$$

$$= \frac{6720}{3.14 \times 1.75 \times 1.75}$$

$$= \frac{6720}{9.616}$$

**Intensity of stress = 698.8 Kg/cm²**

**12 A rivet of 10 mm dia. is subjected to a double shear force of 1.5 KN. Find the shear stress in the rivet.**

dia. of the rivet = 10 mm

r = 5 mm

Shear stress = ?

Double shear force is acting on the rivet, consider the area as double.

$$\text{Stress} = \frac{F}{2\text{Area}}$$

$$= \frac{1.5}{2x3.14x5x5}$$

**Shear stress = 0.00955 KN/mm²**

**Strain**

When an external forces acting on a material, there is a change in its dimension and shape. The deformation is called strain. Thus, strain is the ratio between the change in dimension of a material to its original dimension. It has no unit. It is represented by E (Epsilon)

$$\text{Strain} = \frac{\text{Change in dimension } (\delta \ell)}{\text{Original dimension } (\ell)}$$

**Linear or Longitudinal strain**

It is the ratio between the change in length of the material to its original length.

$$\text{Linear Strain} = \frac{\text{Change in length } (\delta \ell)}{\text{Original length } (\ell)}$$

**Lateral Strain**

It is the ratio between change in cross sectional area of material to its original area.

$$\text{Lateral Strain} = \frac{\text{Change in area}}{\text{Original Area}}$$

**Volumetric Strain**

It is the ratio between change in volume of material to its original volume.

$$\text{Volumetric Strain} = \frac{\text{Change in volume}}{\text{Original Volume}}$$

**Poisson's ratio**

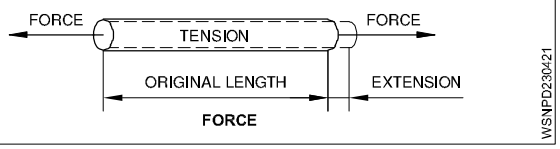
It is a ratio between lateral strain and linear strain.

$$\text{Poisson's ratio} = \frac{\text{Lateral strain}}{\text{Linear strain}} = \frac{1}{m}$$

**Examples**

**1 Calculate the tensile strain when a force of 3.2 kN is applied to a bar of original length 280 cm extends the bar by 0.5 mm (Fig 1 & Fig 2)**

Fig 1




Force = 3.2 kN

Original length (L) = 280 cm

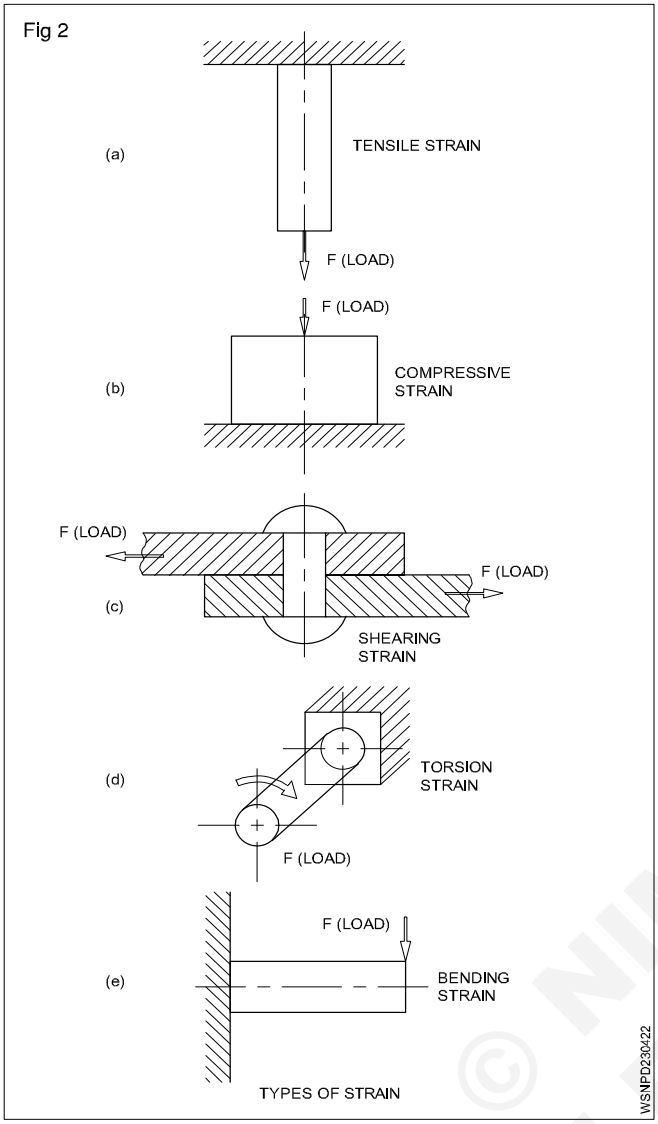
Increased length($\Delta \ell$) = 0.5 mm = 0.05 cm

$$\text{Tensile Strain} = \frac{\text{Increased length}}{\text{Original Length}}$$

$$= \frac{0.05}{280}$$

**Tensile strain = 0.0001786**

Fig 2




**2 A steel rod used for brake operation is 1.50 m long. When it is subjected to a tensile force the extension produced is 0.5 mm. Find the strain in the rod.**

$$\text{Tensile strain} = \frac{\text{Extension}}{\text{Original length}}$$

$$= \frac{0.5}{1.5 \times 1000}\left(\frac{\text{mm}}{\text{mm}}\right)$$

**Strain in the brake rod = 0.0003**

**3 A helical spring is loaded with a force of 600 Newton and is compressed by 30mm. What would be the load required to compress it to 10 mm. (Fig 3)**

Solution

$$\text{Spring stiffness} = \frac{\text{Applied load}}{\text{Compression}}$$

$$= \frac{600}{30}\left(\frac{\text{N}}{\text{mm}}\right) = 20\left(\frac{\text{N}}{\text{mm}}\right)$$

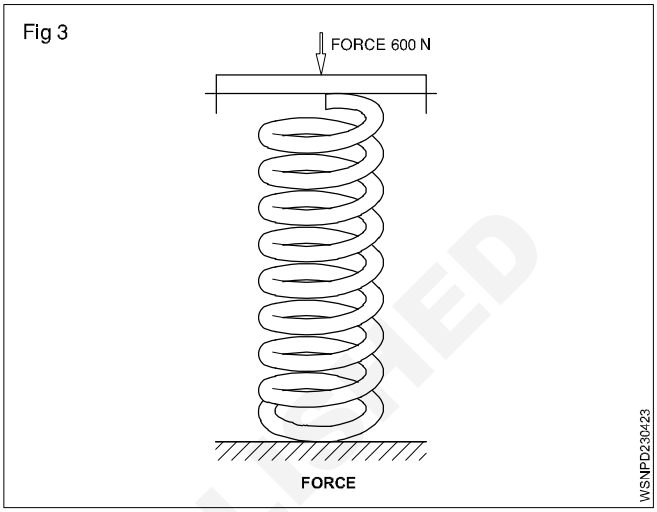
Load required to compress the spring by 10 mm

= spring stiffness x compression

= 20 (N/mm) x 10(mm)

**Load required = 200 N**

Fig 3




**4 Helical spring is loaded with a force of 400 Newton and it is compressed by 18 mm. What would be the load required to compress it to 6 mm?**

Given force = 400 Newton

Deflection = 18 mm

Spring Stiffness = Force / Compressed length

= 400 /18

= 22.22 Newton / mm

Force required to compress the spring into 6 mm = Spring stiffness $\times$ Compression

Load required = $22.22 \times 6$

**= 133.32 N**

**5 Calculate the tensile strain when a force of 3.2 KN is applied to a bar of original length 2.8 m extends the bar by 0.5 mm.**

Force F = 3.2 KN

Original length L = 280 cm

Increased length($\Delta\ell$) = 0.5 mm = 0.05 cm

Tensile strain = ?

$$\text{Strain} = \frac{\Delta\ell}{\text{L}}$$

$$= \frac{0.05}{280}$$

**Tensile strain = 0.0001786**

**6 A metal bar is 2m long. When 5.5 tonne is applied its length becomes 1.995 m. Find the compressive strain?**

Force F = 5.5 KN

Original length $L_1$ = 2 m

Final length $L_2$ = 1.995 m

Increased length($\Delta\ell$) = 2 - 1.995 = 0.005 m

Compressive strain $= \frac{\Delta\ell}{L}$

$= \frac{0.005}{2}$

**Compressive strain = 0.0025**

**7 When a steel rod of 4mm diameter experienced the load of 200 Kg. It is found to be elongated by 1.5 mm from the original length of 1500 mm. Calculate the strain.**

Force F = 200 Kg.

Original length $L_1$ = 1500 mm

$\Delta\ell$ = 1.5 mm

Strain = ?

strain $= \frac{\Delta\ell}{L}$

$= \frac{1.5}{1500}$

**strain = 0.001**

**8 An iron rod of length 1 metre and 1 cm diameter gets elongated by 1 cm. When a force of 100 Kg is applied at one end. Calculate the strain developed in the rod.**

Force F = 100 Kg.

Original length $L_1$ = 1 m = 100 cm

$\Delta\ell$ = 1 cm

Strain = ?

strain $= \frac{\Delta\ell}{L}$

$= \frac{1}{100}$

**Compressive strain = 0.01**

### Elasticity and Elastic limit

When an external force acts on a body, the body tends to under go some deformation. If the external force is removed and the body comes back to its original shape and size (Which means the deformation disappears completely). The body is known as elastic body. This property by virtue of which certain materials return back to their original position after the removal of the external force is called elasticity.

The body will regain its previous shape and size only when the deformation caused by the external force is with in a certain limit. Thus there is a limiting value of force up to and within which the deformation completely disappears on the removal of the force. The value of stress corresponding to this limiting force is known as elastic limit of the material.

If the external force is so large that the stress exceeds the limit, the material loses to some extent its property of elasticity. If now the force is removed, the material will not return to its original shape and size and there will be a residual deformation in material.

### Yield point

The yield point of a material is the point at which there is a marked increase in elongation without increase in load.

### Hooke's law

Robert Hooke discovered a relationship between stress and strain. According to Hooke's law stress is proportional to strain within elastic limit.

### Young's Modulus or Modulus of Elasticity

The ratio of stress to strain within elastic limit is known as young's modulus or modulus of elasticity. This is expressed by a symbol "E". The unit of Young's modulus is same that of stress.

$$\therefore \quad \text{Young's modulus (E)} = \frac{\text{Stress}}{\text{Strain}}$$

### Modulus of Rigidity

The ratio of shear stress to shear strain is known as "modulus of rigidity" represented by symbol "N".

$$\therefore \quad \text{Modulus of Rigidity (N)} = \frac{\text{Shear stress}}{\text{Shear strain}}$$

### Bulk Modulus

When a body is subjected to three mutually perpendicular forces of the same intensity, the ratio of volumetric stress to the volumetric strain is known as Bulk Modulus. It is usually represented by the letter K.

$$\therefore \quad \text{Bulk Modulus (K)} = \frac{\text{Volumetric stress}}{\text{Volumetric strain}}$$

### Relationship between three moduli for a given material

The relationship between three moduli for a given material is as follows :

$$E = 2N\left(1+\frac{1}{m}\right) = 3K\left(1-\frac{2}{m}\right).$$

Where

E = Young's modulus of elasticity

N = Modulus of rigidity

K = Bulk modulus

$\frac{1}{m}$ = Poisson's ratio

**Example**

**1 A steel rod of 10 mm diameter and 175 mm long is subjected to a tensile load of 15 kN. If E = 2 x10$^5$ N/mm$^2$, calculate the change in length.**

Tensile load = 15 kN = 15000 N

Area of cross section = $(\pi r^2) = \frac{22}{7} \times 5 \times 5\ mm^2 = 78.57$

$\therefore$ Stress $= \frac{15000N}{0.785 \times 100 mm^2} = 191\ N/mm^2$

Young's modulus E $= \frac{Stress}{Strain}$

E $= 2 \times 10^5\ N/mm^2 = \frac{191 N/mm^2}{Strain}$

$\therefore$ Strain $= \frac{191}{2 \times 10^5}$

Change in length $= \frac{175 \times 191}{2 \times 10^5} mm$

**= 0.167 mm.**

**2 A bar of steel 2.5 cm diameter was subjected to compressive load of 4500 kg. The compression in a length of 20 cm was found to be 0.008 cm. Find the Young's modulus of elasticity of bar.**

**Solution**

Diameter of bar (d) = 2.5 cm

Force applied i.e. compressive load = 4500 kg

Original length of bar = 20 cm

Change in length = 0.008 cm

$\therefore$ Area of original cross-section $= \frac{\pi}{4} d^2$

$= \frac{\pi}{4} \times 2.5^2$

$= \frac{\pi \times 6.25}{4}\ cm^2$

$\therefore$ Stress $= \frac{Force\ applied}{Area\ of\ original\ cross\ section}$

$= \frac{4500}{\frac{\pi \times 6.25}{4}}$

$= \frac{4500 \times 4}{\pi \times 6.25}$

$= \frac{2880}{\pi}$

$\therefore$ Stress $= \frac{2880}{\pi} Kg/cm^2$

$\therefore$ Strain $= \frac{Change\ in\ length}{Original\ length}$

$= \frac{0.008}{20} = \frac{8/1000}{20}$

$= \frac{8}{20 \times 1000} = \frac{4}{10000}$

$\therefore$ Strain $= \frac{4}{10000}$

$\therefore$ Young's modulus $= \frac{Stress}{Strain}$

$= \frac{2880}{\pi} \div \frac{4}{10000}$

$= \frac{2880}{\pi} \times \frac{10000}{4}$

$= \frac{7200000}{\pi}$

$= 2292000\ Kg/cm^2$

**= 2.292 x 10$^6$ Kg/cm$^2$**

**3 A force of 10 tonnes is applied axially on a rod of 1.2 cm dia. the original length is 100 mm.If modulus of elasticity is 2 x 10$^{12}$ kg/cm$^2$. Calculate stress and strain developed in the rod.**

**Solution**

Force applied = 10 tonnes = 10 x 1000 kg

$= 10^4$ kg

Diameter (d) = 1.2 cm

Young's modulus (E) = 2 x $10^{12}$ kg/cm$^2$

Stress $= \frac{Force\ applied}{Area\ of\ original\ cross\ section}$

$= \frac{4 \times 10^4}{\pi \times 1.2 \times 1.2}$

$$= \frac{10^4 \times 4}{1.2 \times 1.2 \times 3.142}$$

$$= \frac{40000}{4.52448}$$

$$= 8841 \text{ kg/cm}^2$$

$\therefore$ Stress $= 8841 \text{ kg/cm}^2$

We know

$$\frac{\text{Stress}}{\text{Strain}} = \text{Young's modulus}$$

Strain x Young's modulus = Stress

$$\text{Strain} = \frac{\text{Stress}}{\text{Young's Modulus}}$$

$$= \frac{8841}{2 \times 10^{12}}$$

$$= \frac{4420.5}{10^{12}}$$

$$= 4420.5 \times 10^{-12}$$

**Stress = 8841 kg/cm²**

**Strain = 4420.5 x $10^{-12}$**

**4 A bar of 100 cm elongates to 101.36 cm when a load of 15000 kg is applied to it. Take the area of cross section of bar as 10 cm². Find the stress, strain and young's modulus.**

$L_1 = 100$ cm

$L_2 = 101.36$ cm

$\Delta\ell = L_2 - L_1$

$= 101.36 - 100 = 1.36$ cm

$F = 15000$ kg

$A = 10 \text{ cm}^2$

$$\text{Stress} = \frac{\text{Force(F)}}{\text{Area(A)}}$$

$$= \frac{15000}{10}$$

$$= 1500 \text{ kg/cm}^2$$

$$\text{Strain} = \frac{\Delta\ell}{L}$$

$$= \frac{1.36}{100}$$

$$= 0.0136$$

$$\text{Young's modulus} = \frac{\text{Stress}}{\text{Strain}}$$

$$E = \frac{1500}{0.0136}$$

**= 110300 kg/cm²**

**5 What force is required to stretch a steel wire of 10 mm long and 10 mm dia. to double its length. E of steel is 205 KN/cm².**

$d = 10 \text{ mm} = 1 \text{ cm}$

$r = 0.5$ cm

$L_1 = 1$ cm

$L_2 = 2$ cm

$\Delta\ell = L_2 - L_1 = 2 - 1 = 1$ cm

$E = 205 \text{ KN/cm}^2$

$$\text{Strain} = \frac{\Delta\ell}{L} = \frac{1}{1} = 1$$

$$E = \frac{\text{Stress}}{\text{Strain}}$$

$$205 = \frac{\text{Stress}}{1}$$

Stress = 1 x 205 $= 205 \text{ KN/cm}^2$

$$\text{Stress} = \frac{\text{Force(F)}}{\text{Area(A)}}$$

$$205 = \frac{\text{Force}}{3.14 \times 0.5 \times 0.5}$$

Force $= 205 \times 3.14 \times 0.5 \times 0.5$

**= 161 KN**

**6 A wire of 1.6 cm diameter is subjected to a tensile load of 2000 Kg. Find the stress and strain if young's modulus = 2 x $10^6$ kg/cm².**

$F = 2000$ kg

$d = 1.6$ cm

$r = 0.8$ cm

$E = 2 \times 10^6 \text{ Kg/cm}^2$

$$\text{Stress} = \frac{F}{A}$$

$$= \frac{2000}{\pi r^2}$$

$$= \frac{2000}{3.14 \times 0.8 \times 0.8}$$

$$= \frac{2000}{2.0096}$$

$$= 995.2 \text{ kg/cm}^2$$

$$\text{Young's modulus} = \frac{\text{Stress}}{\text{Strain}}$$

$$2 \times 10^6 = \frac{995.2}{\text{Strain}}$$

$$\text{Strain} = \frac{995.2}{2 \times 10^6}$$

**= 0.0005**

**7 A tensile load of 2000 kg is applied on a rectangular rod of 2 cm x 1 cm whose length is 2 metres. Calculate the elongation in length as E = 2 x $10^6$ Kg/$cm^2$.**

F = 2000 Kg.

$L_1$ = 2 m = 200 cm

E = 2 x $10^6$ kg/$cm^2$

Rectangular rod length = 2 cm

Breadth = 1 cm

$$\text{Stress}(\sigma) = \frac{\text{Force(F)}}{\text{Area(A)}} = \frac{\text{Force}}{l \times b}$$

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

$$= 1000 \text{ kg/cm}^2$$

$$E = \frac{\text{Stress}}{\text{Strain}}$$

$$2 \times 10^6 = \frac{1000}{\text{Strain}}$$

$$\text{Strain} = \frac{1000}{2 \times 10^6}$$

$$= 0.0005$$

$$\frac{\Delta \ell}{L_1} = \text{Strain}$$

$$\frac{\Delta \ell}{200} = 0.0005$$

$$\Delta \ell = 200 \times 0.0005$$

$$= 0.1 \text{ cm}$$

**∴ Elongated length = 0.1 cm**



## Assignment

**Stress**

1 Calculate the intensity of stress in the material if a copper rod of 40 mm diameter is subjected by tensile load of 4000 Newton's.

2 Calculate the intensity of stress if a mild steel rod having a cross sectional area of 40 $mm^2$ is subjected to the load of 1000 kg.

3 Calculate the tensile stress if a square rod of 10 mm side is tested for a tensile load of 1000 kg.

4 Calculate the maximum stress if a bar of 9 $cm^2$ cross sectional area and 300 cm long carries a tensile load of 3500 kg.

5 Find out the stress on the rod. if a load of 500 kg is placed on a M.S.rod of dia. 35 mm.

6 A metallic bar of 8 cm diameter is under stress carrying a load of 8620 N. Calculate the intensity of stress.

7 A steel wire 2 mm diameter is loaded in tension with a weight of 20 kg. Find out the stress developed.

8 A rod having a cross sectional area of 25 $mm^2$ is subjected to a load of 1500 kg. Find out stress on the rod.

9 A square rod of 10 mm side is tested for a tensile load of 2500 kg. Calculate the tensile stress of the rod.

**Strain**

1 Find the compressive strain if a metal bar is 150 cm long. When 2.5 KN is applied, its length becomes 148.6 cm.

2 Calculate the strain if a metallic bar is 150 cm long. When 2500 kg is applied its length becomes 150.5 cm.

3 Find the strain it causes if a load of 300 kg hanging from a rod of 3 metres length and 5 mm diameter extends it by 4 mm.

4 A tensile force of 10 kg is applied on a copper wire of diameter 1 cm. So that the length of wire increases by 5 mm. If the original length of wire was 2 metres, find out the strain.

5 A steel rod whose diameter is 1 cm and 60 cm in length. This rod is pulled at both ends by a force of 700 kg. If modulus of elasticity of steel is $2.1 \times 10^6$ kg/cm$^2$, find out increase in length of rod and strain produced in it.

6 A steel rod 1.5 metres long and of 30 mm diameter is pulled at both ends by a force of 1500 kg. If modulus of elasticity of steel is $2.4 \times 10^6$ kg/cm$^2$, determine increase in length of rod and strain produced in it.

7 Calculate the change in length of a rod of dia 16 mm and 160 mm long when it carries a load of 40KN. Take E = 200000 N/mm$^2$.

8 A hollow C.I. column with a wall thickness of 2 cm is subjected to an axial compressive load of 80 tonnes. If the maximum stress is not to be exceeded 1 tonne per cm$^2$, determine the internal diameter of column. Calculate compressive strain, if E = 950 tonnes per cm$^2$.

**Young's modulus**

1 A piece of wire 2 m long, 0.8 mm$^2$ in cross section increases its length by 1.6 mm on suspension of 8 kg weight from it. Calculate the stress, strain and young's modulus.

2 A wire of 16 mm dia. is subjected to a tensile load of 2000 kg. Find the stress and strain if young's modulus E = 2 x $10^{16}$ kg/cm$^2$.

3 A wire of 2 metres long and its area of cross section is 0.78 mm$^2$. If 78 kg weight is suspended on this wire, then the length of the wire is increased by 1.4 mm. Find out stress, strain and young's modulus of elasticity.

4 A wire 2800 mm long is stretched by 0.5 mm, when a weight of 9 kg is hung on it, its diameter is 2 mm. Calculate stress and young's modulus for the substance of the wire.

5 A force of 1000 kg is applied axially on rod of 12 mm diameter the original length is 100 mm. If modulus of elasticity is 2 x $10^{12}$ kg/cm$^2$. Calculate the stress and strain developed in the rod.

6 A steel wire 3.2 mm diameter and 3.65 metre long stretches by 2.03 mm under the load of 115 kg. Calculate the stress and young's modulus of elasticity.

7 A mass of 10 kg is hung from a vertical wire 300.25 cm long and 0.0005 sq. cm cross section. When the load is removed the wire is found to be 300 cm long. Find the modulus of elasticity for the wire material.

8 A steel rod of 1.5 cm diameter and 8 metres long pulled by a forced of 80 kg at both ends. Find out the expansion and strain on the rod. The coefficient of elasticity E = $2.10 \times 10^6$ kg/cm$^2$.

9 A wire of length 3.5 m and diameter 0.35 mm is stretched by a force of 2kg weight. If the elongation is 4 mm. Calculate the young's modulus of the material of wire.

10 A mass of 1kg is suspended from a metal wire 100 cm long and 0.5 mm diameter. An increase in length of wire equal to 2 mm is observed. Calculate the young's modulus of wire.

11 A 4 metre long copper wire of diameter 3 mm is used to support a mass of 50kg. What will be the elongation of the wire. Young's modulus of elasticity for copper is $7x10^{10}$ N/mm$^2$.

# Profit and loss - Simple problems on profit & loss

**Definition of 'profit and loss statement (P&L)**

A profit and loss statement (P&L) is a financial statement that summarizes the revenues, costs and expenses incurred during a specific period of time, usually a year. These records provide information about a company's ability - to generate profit by increasing revenue, reducing costs, or both. The P&L statement is also referred to as "statement of profit and loss", "income statement", "statement of operations", "statement of financial results" and "income and expenditure statement".

**Profit and loss**

**Important facts**

**Cost price**

The price, at which an article is purchased is called its cost price, abbreviated as C.P.

**Selling price**

The price at which an article is sold, is called its selling prices, abbreviated as S.P.

**Profit or gain**

If S.P. is greater than C.P., the seller is said to have a profit or gain.

**Loss**

If S.P. is less than C.P., the seller is said to have incurred a loss.

**Discount**

The reduction given to the selling price of a product is the discount.

**Important formulae**

1 Profit or Gain=(S.P)-(C.P)

2 Loss=(C.P)-(S.P)

3 Loss or gain always depends on C.P.

4 Profit/gain is always expressed in %.

$$\text{Gain\%} = \left(\frac{\text{Gain x 100}}{\text{C.P.}}\right)$$

5 Loss percentage: (Loss %)

$$\text{Loss \%} = \left(\frac{\text{Loss x 100}}{\text{C.P.}}\right)$$

6 Selling price: (S.P)

$$\text{SP} = \left(\frac{100 + \text{Gain\%}}{100} \text{x C.P}\right)$$

7 Selling price: (S.P)

$$\text{SP} = \left(\frac{(100 - \text{loss \%})}{100} \text{x C.P}\right)$$

8 Cost price: (C.P)

$$\text{C.P} = \left(\frac{100}{(100 + \text{Gain \%})} \text{x S.P}\right)$$

9 Cost price: (C.P)

$$\text{C.P} = \left(\frac{100}{(100 - \text{Loss \%})} \text{x S.P}\right)$$

10 If an article is sold at a gain of say 35%, then S.P.=135% of C.P.

11 If an article is sold at a loss of say, 35% then S.P=65% of C.P.

**Example**

**1 A dealer bought a television set for Rs.10,000 and sold it for Rs.12,000. Find the profit made by him for 1 television set. If he had sold 5 television sets, find the total profit?**

**Solution**

Selling price of the television set = Rs.12,000

Cost price of the television set = Rs.10,000

S.P. > C.P., there is a profit

Profit = S.P. - C.P

= 12000-10000

Profit = Rs.2,000

Profit on 1 television set = Rs.2000

Profit on 5 television sets = 2000 x 5

**= Rs.10,000**

**2 Sanjay bought a bicycle for Rs.5000. He sold it for Rs.600 less after two years. Find the selling price and the loss percent?**

**Solution**

Cost price of the bicycle = Rs.5000

Loss = Rs.600

Selling price = Cost price - loss

= 5000 - 600

Selling price of the bicycle = Rs.4400

Loss % = $\frac{\text{Loss}}{\text{C.P.}}$ x 100

= $\frac{600}{5000}$ x 100

**Loss = 12%**

**3 A man bought an old bicycle for Rs.1250. he spent Rs.250 on its repairs. He then sold it for Rs.1400. Find his loss %?**

**Solution**

Cost price of the bicycle = Rs.1250

Repair Charges = Rs.250

Total cost price = 1250+250 = Rs.1500

Selling price = Rs.1400

C.P > S.P, there is a loss

Loss = Cost price - Selling price

1500 - 1400 = 100

Loss = Rs.100

$$\text{Loss \%} = \frac{\text{Loss}}{\text{C.P.}} \times 100$$

$$= \frac{100}{1500} \times 100$$

$$= \frac{20}{3} = 6\frac{2}{3}\% \text{ (or) } 6.67\%$$

**Loss = 6.67%**

**Profit percentage or loss percentage is always calculated on the cost price of the article.**

**4 A fruit seller bought 8 boxes of grapes at Rs.150 each. One box was damaged. He sold the remaining boxes at Rs.190 each. Find the profit percent?**

**Solution**

Cost price of 1 box of grapes = Rs.150

Cost price of 8 boxes of grapes = 150 x 8

= Rs.1200

Number of boxes damaged = 1

Number of boxes sold = 8 - 1 = 7

Selling price of 1 box of grapes = Rs.190

Selling price of 7 boxes of grapes = 190 x 7

= Rs.1330

S.P.>C.P, there is a profit

Profit = Selling price - Cost price

= 1330-1200

= 130

Profit = Rs.130

$$\text{Percentage of profit} = \frac{\text{Profit}}{\text{C.P}} \times 100$$

$$= \frac{130}{1200} \times 100$$

$$= 10.83$$

**Profit = 10.83%**

**5 Ram, the shopkeeper bought a pen for Rs.50 and then sold it at a loss of Rs.5. Find his selling price.**

**Solution**

Cost price of the pen = Rs.50

Loss = Rs.5

S.P. = C.P. - Loss

= 50 - 5 = 45

**Selling price of the pen = Rs.45**

**6 Find the initial amount if 12% of the total amount it is ₹ 1080**

Let the initial amount be '$x$ '

Given: 12% of the total amount = Rs.1080

$$\frac{12}{100} \times x = 1080$$

$$x = \frac{1080 \times 100}{12}$$

= ₹ 9000

**∴ The initial amount = Rs.9000**

**Applications of profit and loss**

In this section, we learn to solve problems on applications of profit and loss.

**i Illustration of the formula for S.P.**

Consider the following situation

Rajesh buys a pen for Rs.80 and sells it to his friend.

If he wants to make a profit of 5%, can you say the price for which he would have sold?

(Rajesh bought the pen for Rs.80 which is the cost price (C.P.). When he sold, he makes a profit of 5% which is calculated on the C.P.)

$$\therefore \text{Profit} = 5\% \text{ of C.P.} = \frac{5}{100} \times 80 = \text{Rs.}4$$

Since there is a profit, S.P > C.P.

S.P. = C.P. + Profit

= 80 + 4 = Rs.84

**∴ The price for which Rajesh would have sold = Rs.84**

**The same problem can be done using the formula.**

$$\text{Selling price (S.P)} = \frac{(100 + \text{Profit \%})}{100} \times \text{C.P}$$

$$= \frac{(100+5)}{100} \times 80$$

$$= \frac{105}{100} \times 80 = \text{Rs. } 84$$

**ii Illustration of the formula for C.P**

Consider the following situation

Suppose a shopkeeper sells a wrist watch for Rs. 540 making a profit of 5%, then what would have been the cost of the watch?

(The shopkeeper had sold the watch at a profit of 5% on the C.P. Since C.P. is not known, let us take it as Rs. 100)

Profit of 5% is made on the C.P.

$\therefore$ Profit = 5% of C.P.

$= \frac{5}{100} \times 100 = \text{Rs. } 5$

We know S.P. = C.P + Profit

= 100 + 5

= Rs. 105

Here, if S.P. is Rs.105, then C.P. is Rs. 100

When S.P. of the watch is Rs. 540, C.P $= \frac{540 \times 100}{105}$

= Rs. 514.29

$\therefore$ The watch would have cost Rs. 514.29 for the shopkeeper.

The above problem can also be solved by using the formula method.

$$\text{C.P.} = \left(\frac{100}{100 + \text{Profit \%}}\right) \times \text{S.P}$$

$$= \left(\frac{100}{100+5} \times 540\right)$$

$$= \frac{100}{105} \times 540 = \text{Rs. } 514.29$$

We now summarize the formulae to calculate S.P. and C.P. as follows.

| | |
|---|---|
| **1 When there is a profit** <br> $\textbf{C.P} = \left(\frac{\textbf{100}}{\textbf{100} + \textbf{Profit\%}}\right) \textbf{x S.P.}$ | **1 When there is a loss** <br> $\textbf{C.P} = \left(\frac{\textbf{100}}{\textbf{100} - \textbf{Loss\%}}\right) \textbf{X S.P.}$ |
| **2 When there is a profit** <br> $\textbf{S.P} = \left(\frac{\textbf{100} + \textbf{Profit\%}}{\textbf{100}}\right) \textbf{x C.P.}$ | **2 When there is a loss** <br> $\textbf{S.P} = \left(\frac{\textbf{100} - \textbf{Loss\%}}{\textbf{100}}\right) \textbf{X C.P.}$ |

**Example**

**1 Hameed buys a colour T.V. set for Rs. 15,200 and sells it at a loss of 20%. What is the selling price of the T.V. set?**

**Solution**

**Method - I**

Loss is 20% of the C.P.

$\frac{20}{100} \times 15200 = \text{Rs. } 3040$

S.P = C.P - Loss

15200 - 3040 = Rs.12160

**Method - II**

C.P = Rs 15,200

Loss = 20%

$\text{S.P} = \frac{100 - \text{Loss\%}}{100} \times \text{C.P.}$

$= \frac{100-20}{100} \times 15200$

$= \frac{80}{100} \times 15200$

= Rs. 12,160

**2 A scooty is sold for Rs. 13600 and fetches a loss of 15%. Find the cost price of the scooty.**

**Method - I**

Loss of 15% means,

If C.P. is Rs. 100, Loss = Rs. 15

Therefore, S.P. would be

(100-15) = Rs. 85

If S.P. is Rs. 85, C.P. is Rs. 100

When S.P is Rs. 13600 then

$\text{C.P} = \frac{100 \times 13600}{85} = \text{Rs. } 16000$

**Method - II**

Loss = 15%

S.P. = Rs. 13600

$\text{C.P.} = \left(\frac{100}{100 - \text{Loss\%}}\right) \times \text{S.P}$

$$= \frac{100}{100-15} \times 13600$$

$$= \frac{100}{85} \times 13600$$

= Rs. 16000

Hence the cost price of the scotty is Rs. 16000

**Discount**

Discount is the reduction in value on the marked price or list price of the article.

The market price of a product is Rs.550

Amount paid by pooja to the shop keeper is Rs. 440

Discount = Rs. 550 - Rs. 440

= Rs. 110

= Marked price - Selling price

Hence we conclude the following

| | |
|---|---|
| Discount | = Marked price - Selling price |
| Selling price | = Marked price - Discount |
| Marked price | = Selling price + Discount |

**Example**

**1 A bicycle marked at Rs. 1500 is sold for Rs. 1350. What is the percentage of discount?**

Marked price = Rs. 1500

Selling price = Rs. 1350

Amount of discount = Marked price - Selling price

= 1500 - 1350

= Rs. 150

Discount for Rs. 1500 = Rs. 150

Discount for Rs. 100 $= \frac{150}{1500} \times 100$

Percentage of discount = 10%

**2 The list price of a Frock is Rs.220. A discount of 20% on sales is announced. What is the amount of discount on it and its selling price?**

Amount of discount $= \frac{\text{Discount}}{100\%} \times \text{M.P.}$

Amount of discount $= \frac{20}{100} \times 220 = \text{Rs. } 44$

Selling price of the frock = Marked price - Discount

220 - 44 = Rs. 176

**3 An almirah is sold at Rs. 5225 after allowing a discount of 5%. Find its marked price.**

**Solution**

**Method - I**

The discount is given in percentage

Hence, the M.P. is taken as Rs. 100

Rate of discount = 5%

Amount of discount $= \frac{5}{100} \times 100$

Selling price = M.P - Discount

= 100 - 5 = Rs. 95

If S.P. is Rs. 95, then M.P. is Rs.100

When S.P. is Rs. 5225

M.P. $= \frac{100}{95} \times 5225$

M.P of the almirah = Rs. 5500

**Method - II**

S.P = Rs. 5225

Discount = 5%

M.P = ?

$$\text{M.P} = \left(\frac{100}{100 - \text{Discount\%}}\right) \times \text{S.P.}$$

$$= \left(\frac{100}{100-5}\right) \times 5225$$

= Rs. 5500

**4 A shopkeeper allows a discount of 10% to his customers and still gains 20%. Find the marked price of an article which costs Rs.450 to the shopkeeper.**

**Solution**

**Method - I**

Let M.P be Rs. 100

Discount = 10% of M.P

$= \frac{10}{100}$ of M.P $= \frac{10}{100} \times 100$

= Rs. 10

S.P = M.P - Discount

= 100 - 10

= Rs. 90

Gain = 20% of C.P.

$= \frac{20}{100} \times 450 = \text{Rs. } 90$

S.P = C.P + Gain

= 450 + 90 = Rs. 540

If S.P. is Rs. 90, then M.P is Rs. 100

$$\text{M.P.} = \frac{540 \times 100}{90} = \text{Rs. } 600$$

The M.P. of an article = Rs. 600

**Method - II**

Discount = 10%, Gain = 20%

C.P. = Rs. 450 , M.P. = ?

$$\text{M.P} = \frac{100 + \text{Gain}\%}{100 - \text{Discount}\%} \times \text{C.P}$$

$$= \frac{(100 + 20)}{(100 - 10)} \times 450$$

$$= \frac{120}{90} \times 450$$

$$= \text{Rs. } 600$$

**5 A dealer allows a discount of 10% and still gains 10%. What is the cost price of the book which is marked at Rs. 220?**

**Solution**

**Method - I**

M.P = Rs.220

Discount = 10% of M.P

$$= \frac{10}{100} \times 220$$

$$= \text{Rs. } 22$$

S.P = M.P - Discount

$$= 220 - 22$$

$$= \text{Rs. } 198$$

Let, C.P. be Rs. 100

Gain = 10% of C.P.

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

$$= \text{Rs. } 10$$

S.P. = C.P + Gain

$$= 100 + 10$$

$$= \text{Rs. } 110$$

If S.P. is Rs. 110, then C.P is Rs. 100

When S.P. is Rs. 198,

$$= \frac{198 \times 100}{110}$$

$$= \text{Rs. } 180$$

**Method - II**

Discount = 10%

Gain = 10%

M.P. = Rs. 220

$$\text{C.P.} = \frac{100 - \text{Discount}\%}{100 + \text{Gain}\%} \times \text{M.P}$$

$$= \frac{100 - 10}{100 + 10} \times 220$$

$$= \frac{90}{110} \times 220$$

$$= \text{Rs. } 180$$

**6 A trader buys an article for Rs. 1200 and marks it 30% above the C.P. He then sells it after allowing a discount of 20%. Find the S.P. and profit percent.**

**Solution**

Let C.P. of the article be Rs. 100

M.P. =30% above C.P. = Rs. 130

If C.P is Rs. 100, then M.P. is Rs. 130

When C.P. is Rs. 1200,

$$\text{M.P.} = \frac{1200 \times 130}{100} = \text{Rs. } 1560$$

$$\text{Discount} = 20\% \text{ of } 1560 = \frac{20}{100} \times 1560$$

$$\text{Discount} = 20\% \text{ of } 1560 = \frac{20}{100} \times 1560$$

$$= \text{Rs. } 312$$

S.P = M.P. - Discount

$$= 1560 - 312$$

$$= \text{Rs. } 1248$$

Profit = S.P - C.P

$$= 1248 - 1200$$

$$= \text{Rs. } 48$$

$$\text{Profit}\% = \frac{\text{Profit}}{\text{C.P.}} \times 100$$

$$= \frac{48}{1200} \times 100$$

$$= 4\%$$

**Summary**

Percent means per hundred. A fraction with its denominator 100 is called a percent.

**In case of profit, we have Profit = S.P - C.P.**

$$\text{Profit \%} = \frac{\text{Profit}}{\text{C.P.}} \times 100$$

$$\text{S.P} = \left(\frac{100 + \text{Profit\%}}{100}\right) \times \text{C.P.}$$

$$\text{C.P} = \left(\frac{100}{100 + \text{Profit\%}}\right) \times \text{S.P.}$$

**In case of loss, we have Loss = C.P - S.P.**

$$\text{Loss \%} = \frac{\text{Loss}}{\text{C.P.}} \times 100$$

$$\text{S.P} = \left(\frac{100 - \text{Loss\%}}{100}\right) \times \text{C.P.}$$

$$\text{C.P} = \left(\frac{100}{100 - \text{Loss\%}}\right) \times \text{S.P.}$$

$$\text{M.P.} = \frac{100}{100 - \text{Discount \%}} \times \text{S.P}$$

$$\text{S.P.} = \frac{100 - \text{Discount \%}}{100} \times \text{M.P}$$

$$\text{C.P.} = \frac{100 - \text{Discount \%}}{100 + \text{Profit \%}} \times \text{M.P}$$

$$\text{M.P.} = \frac{100 + \text{Profit \%}}{100 - \text{Discount \%}} \times \text{C.P}$$

$$\text{Discount percent} = \frac{\text{Discount}}{\text{M.P.}} \times 100$$

Discount is the reduction given on the Marked price.

Selling price is the price payable after reducing the discount from the marked price.

Discount = M.P. - S.P.



## Assignment

1 Find the cost price if the product is sold at Rs. 572 with a profit of Rs. 72.

2 Find the C.P if the product is sold at Rs.1973 with a profit of Rs. 273

3 Find the selling price if the cost price is Rs. 7282 with a profit of Rs. 208

4 Find out the S.P. if the C.P. is Rs. 9684 with a loss of Rs. 684

5 Find out the profit percentage if the C.P is Rs. 320 and S.P is Rs. 384.

6 Find out the profit amount if the C.P. and S.P. are Rs. 2500 and Rs. 2700 respectively.

7 Calculate the percentage of loss if the C.P. and S.P are Rs. 40 and Rs. 38 respectively.

8 A computer table bought at Rs. 1150 with Rs. 50 as a transport charge. Calculate the S.P. if the profit is of 5%

9 By selling a table for Rs. 1320 with a gain of 10%. Find the C.P.

10 The C.P. of 16 bolts is equal to the S.P. of 12 bolts. Find the gain percent.

# Profit and loss - Simple and compound interest

**Interest**

When we borrow (or lent) money we pay (or receive) some additional amount in addition to the original amount. This additional amount that we receive is termed as Interest. It is denoted as 'I'. Money can be borrowed/lent deposited in banks to get Interest. The amount borrowed//lent is called the principal. (P)

The principal added to the Interest is called the Amount(A).

Amount = Principal + Interest

$$A = P + I$$

Interest depends on principal and duration of time. But it also depends on one more factor called the rate of interest. Rate of interest is the amount calculated annually for ₹100. (ie) if rate of interest is 10% per annum, then interest is ₹10 for ₹100 for 1 year.

So,

Interest depends on

Amount deposited or borrowed/lent - Principal - P

Period of time - mostly expressed in years - n

Rate of interest - r

This interest is termed as Simple interest.

When the interest is paid on the principal only, it is called simple interest.

**Calculation of interest**

If 'r' is the rate of interest, Principal is 100,

The interest for 1 year = $100 \times 1 \times \frac{r}{100}$

for 2 years = $100 \times 2 \times \frac{r}{100}$

for 3 years = $100 \times 3 \times \frac{r}{100}$

for n years = $100 \times n \times \frac{r}{100}$

So,

$$I = \frac{Pnr}{100}$$

$$A = P + I$$

$$A = P + \frac{Pnr}{100}$$

$$A = P\left(1 + \frac{nr}{100}\right)$$

Interest = Amount - Principal

The other formulae derived from

$$I = \frac{Pnr}{100}$$

$$r = \frac{100I}{Pn}$$

$$n = \frac{100I}{Pr}$$

$$P = \frac{100I}{rn}$$

'n' is always calculated in years. When 'n' is given in months or days, convert it into years.

**Example :**

12 Months = 1 year

6 Months $= \frac{6}{12}$ year $= \frac{1}{2}$ year

3 Months $= \frac{3}{12}$ year $= \frac{1}{4}$ year

146 days $= \frac{146}{365}$ year $= \frac{2}{5}$ year

**Example**

**1 Vimal invested ₹ 3000 for 1 year at 7% per annum. Find the simple interest and the amount received by him at the end of one year.**

**Solution**

Principal (P) = ₹ 3,000

Number of years (n) = 1

Rate of interest (r) = 7%

$$\text{Interest}(I) = \frac{Pnr}{100} = \frac{3000 \times 1 \times 7}{100}$$

$$I = 210$$

Amount(A) = P + I

= 3000 + 210

**Amount received by him (A) = ₹ 3,210**

**2 Ramani invested ₹ 5000 for 2 years at 11% per annum. Find the simple interest and the amount received by him at the end of 2 years.**

**Solution**

Principal (P) = ₹ 5,000

Number of years (n) = 2 yrs

Rate of interest (r) = 11%

$$\text{Interest}(I) = \frac{Pnr}{100}$$

$$= \frac{5000 \times 2 \times 11}{100}$$

$$= 1100$$

$$I = ₹\ 1100$$

$$\text{Amount(A)} = P + I$$

$$= 5000 + 1100$$

**Amount received by him (A) = ₹ 6,100**

**3 Find the simple interest and the amount due on ₹ 7,500 at 8% per annum for 1 year 6 months.**

**Solution**

$$\text{Principal (P)} = ₹\ 7{,}500$$

$$\text{Number of years (n)} = 1 \text{ yr. } 6 \text{ months}$$

$$= 1\frac{6}{12} \text{ yrs}$$

$$= 1\frac{1}{2} \text{ yrs} = \frac{3}{2} \text{ yrs.}$$

$$r = 8\%$$

$$\text{Interest(I)} = \frac{Pnr}{100}$$

$$= \frac{7500 \times \frac{3}{2} \times 8}{100}$$

$$= \frac{7500 \times 3 \times 8}{2 \times 100}$$

$$= 900$$

$$I = ₹\ 900$$

$$\text{Amount} = P + I$$

$$= 7500 + 900$$

**Amount due on = ₹ 8,400**

**Interest = ₹ 900, Amount = ₹ 8,400**

**Alternative method**

$$\text{Principal (P)} = ₹\ 7{,}500$$

$$\text{Number of years (n)} = \frac{3}{2} \text{ yrs}$$

$$\text{Rate of interest (r)} = 8\%$$

$$A = P\left(1 + \frac{nr}{100}\right)$$

$$= 7500\left(1 + \frac{\frac{3}{2} \times 8}{100}\right)$$

$$= 7500\left(1 + \frac{3 \times 8}{2 \times 100}\right)$$

$$= 7500\left(\frac{28}{25}\right)$$

$$= 300 \times 28$$

$$= 8400$$

$$A = ₹\ 8400$$

$$\text{Interest (I)} = A - P$$

$$= 8400 - 7500$$

**Interest(I) = ₹ 900, Amount = ₹ 8,400**

**4 Find the simple interest and the amount due on ₹ 6,750 for 219 days at 10% per annum.**

**Solution**

$$\text{Principal (P)} = ₹\ 6{,}750$$

$$\text{Number of years (n)} = 219 \text{ days}$$

$$= \frac{219}{365} \text{ year} = \frac{3}{5} \text{ year}$$

$$r = 10\%$$

$$I = \frac{Pnr}{100}$$

$$= \frac{6750 \times 3 \times 10}{5 \times 100}$$

$$= 405$$

$$I = ₹\ 405$$

$$\text{Amount} = P + I$$

$$= 6750 + 405$$

$$\text{Amount due on} = ₹\ 7{,}155$$

**Interest(I) = ₹ 405, Amount = ₹ 7,155**

**5 Ravi borrowed ₹ 4000 on 7th june 2006 and returned it on 19th August 2006. Find the amount he paid, if the interest is calculated at 5% per annum.**

**Solution**

$$\text{Principal (P)} = ₹\ 4{,}000$$

$$r = 5\%$$

$$\text{Number of days, June} = 24(30 - 6)$$

$$\text{July} = 31$$

$$\text{August} = 18$$

$$\text{Total number of days} = 73$$

$$n = 73 \text{ days}$$

$$= \frac{73}{365} \text{ year}$$

$= \frac{1}{5}$ year

Amount $= P\left(1+\frac{nr}{100}\right)$

$= 4000\left(1+\frac{1 \times 5}{5 \times 100}\right)$

$= 4000\left(1+\frac{1}{100}\right)$

$= 4000\left(\frac{101}{100}\right)$

$= 4,040$

**Amount = ₹ 4,040**

**6 Find the rate percent per annum when a principal of ₹ 7,000 earns a S.I. of ₹ 1,680 in 16 months.**

**Solution**

Principal (P) = ₹ 7,000

n = 16 months

$= \frac{16}{12}$ yr $= \frac{4}{3}$ yr

I = ₹ 1,680

r = ?

$r = \frac{100I}{Pn}$

$= \frac{100 \times 1680}{7000 \times \frac{4}{3}}$

$= \frac{100 \times 1680 \times 3}{7000 \times 4}$

$= 18$

**Rate of interest (r) = 18%**

**7 Vijayan invested ₹10,000 at the rate of 5% simple interest per annum. He received ₹ 11,000 after some years. Find the number of years.**

**Solution**

A = ₹ 11,000

P = ₹ 10,000

r = 5%

I = A - P

= 11,000 - 10,000

= 1,000

I = ₹ 1,000

$n = \frac{100I}{Pr}$

$= \frac{100 \times 1000}{10000 \times 5}$

Number of years = 2 years.

**Alternative method**

$A = P\left(1+\frac{nr}{100}\right)$

$11000 = 10000\left(1+\frac{n \times 5}{100}\right)$

$\frac{11}{10} = \frac{20+n}{20}$

$\frac{11}{10} \times 20 = 20 + n$

$22 = 20 + n$

$22 - 20 = n$

**Number of years = 2**

**8 A sum of money triples itself at 8% per annum over a certain time. Find the number of years.**

**Solution**

Let principal = ₹ P

Amount = triple the principal

= ₹ 3P

Let, P = 100

3P = 3 x 100

r = 8%

n = ?

I = A - P

= 300 - 100

I = ₹ 200

$n = \frac{100I}{Pr} = \frac{100 \times 200}{100 \times 8}$

$n = \frac{200}{8} = 25$

**Number of years = 25**

**9 A certain sum of amounts to ₹ 10,080 in 5 years at 8%. Find the principal.**

**Solution**

A = ₹ 10,080

n = 5 years

r = 8%

P = ?

Amount (A) $= P\left(1+\frac{nr}{100}\right)$

₹ 10080 $= P\left(1+\frac{5 \times 8}{100}\right)$

₹ 10080 $= P\left(1+\frac{5 \times 8}{100}\right)$

₹ 10080 $= P\left(\frac{7}{5}\right)$

₹ 10080 x $\frac{5}{7}$ $= P$

7,200 $= P$

**Principal = ₹ 7,200**

**10 A certain sum of amounts to ₹ 7,920 in 4 years and ₹ 8,880 in 6 years respectively. Find the principal and rate percent.**

**Solution**

Amount at the end of 6 years = Principal + interest for 6 years

$= P + I_6 = 8880$

Amount at the end of 4 years = Principal + interest for 4 years

$= P + I_4 = 7920$

$I_2 = 8880 - 7920$

$= 960$

Interest at the end of 2 years = ₹ 960

Interest at the end of 1st years = $\frac{960}{2}$

$= 480$

Interest at the end of 4 years $= 480 \times 4$

$= 1,920$

$P + I_4 = 7920$

$P + 1920 = 7920$

$P = 7920 - 1920$

$P = 6,000$

Principal = ₹ 6,000

$r = \frac{100I}{Pn}$

$= \frac{100 \times 1920}{6000 \times 4}$

**Rate of interest (r) = 8%**

**Compound Interest**

Rajesh borrowed ₹ 50,000 from a bank for a fixed time period of 2 years. at the rate of 4% per annum.

Rajesh has to pay for the first year.

Simple interest = $\frac{P \times n \times r}{100}$

$= \frac{50000 \times 1 \times 4}{100} =$ ₹ 2,000

Suppose he fails to pay the simple interest ₹ 2,000 at the end of first year, then the interest ₹ 2,000 is added to the old principal ₹ 50,000 and now the sum = P + I = ₹ 52,000 becomes the new principal for the second year for which the interest is calculated.

Now in the second year he will have to pay an interest of

Simple interest = $\frac{P \times n \times r}{100}$

$= \frac{52000 \times 1 \times 4}{100} =$ ₹ 2,080

Therefore Rajesh will have to pay more interest for the second year.

This way of calculating interest is called compound Interest.

If the interest is paid on the principal as well as on the accrued interest, it is called compound interest.

Generally in banks, insurance companies, post offices and in other companies which lend money and accept deposits, compound interest is followed to find the interest.

**Example**

**Ram deposited ₹ 8,000 with a finance company for 3 years at an interest of 15% per annum. What is the compound interest that Ram gets after 3 years?**

**Solution**

**Step 1 :**

Principal for the first year = ₹ 8,000

Interest for the first year = $\frac{P \times n \times r}{100}$

$= \frac{80000 \times 1 \times 15}{100}$

= ₹ 1,200

Amount at the end of first year = P + I

= 8,000 + 1,200

= ₹ 9,200

**Step 2 :**

Principal for the 2nd year = ₹ 9,200

Interest for the 2nd year = $\frac{P \times n \times r}{100}$

$= \frac{9200 \times 1 \times 15}{100}$

= ₹ 1,380

Amount at the end of 2nd year $= P + I$

$= 9,200 + 1,380$

$= ₹\ 10,580$

**Step 3 :**

Principal for the 3rd year $= ₹\ 10,580$

Interest for the 3rd year $= \frac{P \times n \times r}{100}$

$= \frac{10580 \times 1 \times 15}{100}$

$= ₹\ 1,587$

Amount at the end of 3rd year $= P + I$

$= 10,580 + 1,587$

$= ₹\ 12,167$

Hence, the compound interest that Ram gets after 3 years is

$$A - P = 12,167 - 8,000 = ₹\ 4,167$$

**Deduction of formula for compound interest**

The above method which we have used for the calculation of compound interest is quite lengthy and cumbersome, especially when the period of time very large. Hence we shall obtain a formula for the computation of amount and compound interest.

**Example**

**If the principal is P, Rate of interest per annum is r% and the period of time or the number of years is n, then we deduce the compound interest formula as follows:**

Step 1:

Principal for the first year $= P$

Interest for the first year $= \frac{P \times n \times r}{100}$

$= \frac{P \times 1 \times r}{100} = \frac{Pr}{100}$

Amount at the end of first year $= P + I$

$= P + \frac{Pr}{100}$

$= P\left(1 + \frac{r}{100}\right)$

**Step 2 :**

Principal for the 2nd year $= P\left(1 + \frac{r}{100}\right)$

Interest for the 2nd year $= P\left(1 + \frac{r}{100}\right) \times \frac{1 \times r}{100}$

(using the Simple Interest formula)

$= P\left(1 + \frac{r}{100}\right) \times \frac{r}{100}$

Amount at the end of 2nd year $= P + I$

$= P\left(1 + \frac{r}{100}\right) + P\left(1 + \frac{r}{100}\right) \times \frac{r}{100}$

$= P\left(1 + \frac{r}{100}\right)\left(1 + \frac{r}{100}\right)$

$= P\left(1 + \frac{r}{100}\right)^2$

**Step 3 :**

Principal for the 3rd year $= P\left(1 + \frac{r}{100}\right)^2$

Interest for the 3rd year $= P\left(1 + \frac{r}{100}\right)^2 \times \frac{1 \times r}{100}$

(using the Simple interest formula)

$= P\left(1 + \frac{r}{100}\right)^2 \times \frac{r}{100}$

Amount at the end of 3rd year $= P + I$

$= P\left(1 + \frac{r}{100}\right)^2 + P\left(1 + \frac{r}{100}\right)^2 \times \frac{r}{100}$

$= P\left(1 + \frac{r}{100}\right)^2\left(1 + \frac{r}{100}\right)$

$= P\left(1 + \frac{r}{100}\right)^3$

Similarly, Amount at the end of $n^{th}$ year is $A = P\left(1 + \frac{r}{100}\right)^n$ and C.I. at the end of 'n' years is given by

Compound Interest (C.I) = A – P

(ie.) Compound Interest (C.I) $= P\left(1 + \frac{r}{100}\right)^n - P$

**To compute compound interest**

**Case 1 : Compounded Annually**

When the interest is added to the principal at the end of each year, we say that the interest is compounded annually.

Here,

$$A = P\left(1+\frac{r}{100}\right)^{n} \text{ and C.I } = A - P$$

**Case 2 : Compounded half-yearly (semi-annually)**

When the interest is compounded half-yearly, there are two conversion periods in a year each after 6 months. In such situations, the half-yearly rate will be half of the annual rate, that is ().

In this case,

$$A = P\left(1+\frac{1}{2}\left(\frac{r}{100}\right)\right)^{2n} \text{ and C.I } = A - P$$

**Case 3 : Compounded quarterly**

When the interest is compounded quarterly, there are four conversion periods in a year and the quarterly rate will be one-fourth of the annual rate, that is ().

In this case,

$$A = P\left(1+\frac{1}{4}\left(\frac{r}{100}\right)\right)^{4n} \text{ and C.I } = A - P$$

**Case 4 : Compounded when time being fraction of a year**

**When interest is compounded annually but time being a fraction.**

In this case, when interest is compounded annually but time being a fraction of a year, say $5\frac{1}{4}$ years, then amount A is given by

$$A = P\left(1+\frac{r}{100}\right)^{5}\left[1+\frac{1}{4}\left(\frac{r}{100}\right)\right] \text{ and C.I } = A - P$$

for 5 years  for $\frac{1}{4}$ years

**Example**

**Find the C.I. on ₹ 15,625 at 8% p.a. for 3 years compounded annually.**

**Solution**

We know,

$$\text{Amount after 3 years} = P\left(1+\frac{r}{100}\right)^{3}$$

$$= 15625\left(1+\frac{8}{100}\right)^{3}$$

$$= 15625\left(1+\frac{2}{25}\right)^{3}$$

$$= 15625\left(\frac{27}{25}\right)$$

$$= 15625 \times \frac{27}{25} \times \frac{27}{25} \times \frac{27}{25}$$

$$= ₹\ 19{,}683$$

Now, compound interest = A - P

$$= 19{,}683 - 15{,}625$$

$$= ₹\ 4{,}058$$

**To find the C.I. when the interest is compounded annually or half-yearly.**

Let us see what happens to ₹100 over a period of one year if an interest is compounded annually or half-yearly.

| S. No. | Annually | Half yearly |
|---|---|---|
| 1 | P = ₹ 100 at 10% per annum compounded annually. | P = ₹ 100 at 10% per annum compounded half-yearly. |
| 2 | The time period taken is 1 year. | The time period is 6 months or 1/2 year. |
| 3 | $I = \frac{100 \times 10 \times 1}{100} = ₹\ 10$ | $I = \frac{100 \times 10 \times 1/2}{100} = ₹\ 5$ |
| 4 | A = 100 + 10 = ₹ 110 | A = 100 + 5 = ₹ 105<br>For the next 6 months, P = ₹ 105<br>So, $I = \frac{105 \times 10 \times 1/2}{100} = ₹\ 5.25$ and<br>A = 105 + 5.25 = ₹ 110.25 |
| 5 | A = ₹ 110 | A = ₹ 110.25 |

Thus, if interest is compounded half-yearly, we compute the interest two times and rate is taken as half of the annual rate.

**Example**

**1 Find the compound interest on ₹ 1000 at the rate of 10% per annum for 18 months when interest is compounded half-yearly.**

**Solution**

Here, P = ₹ 1000, r = 10% per annum.

and n = 18 months = $\frac{18}{12}$ years = $\frac{3}{2}$ years = 1½ years

$$\therefore \text{Amount after 18 months} = P\left[1+\frac{1}{2}\left(\frac{r}{100}\right)\right]^{2n}$$

$$= 1000\left[1+\frac{1}{2}\left(\frac{10}{100}\right)\right]^{2x\frac{3}{2}}$$

$$= 1000\left[1+\frac{10}{200}\right]^{3}$$

$$= 1000\left(\frac{21}{20}\right)^{3}$$

$$= 1000 \times \frac{21}{20} \times \frac{21}{20} \times \frac{21}{20}$$

$$= ₹\ 1157.625$$

$$= ₹\ 1157.63$$

$$C.I = A - P$$

$$= 1157.63 - 1000$$

**Compound Interest = ₹ 157.63**

**2 Find the compound interest on ₹ 20,000 at 15% per annum for $2\frac{1}{3}$ years.**

**Solution**

Here, P = ₹ 20,000, r = 15% per annum. and n = $2\frac{1}{3}$ years.

Amount after $2\frac{1}{3}$ years $A = P\left(1+\frac{r}{100}\right)^{2}\left(1+\frac{1}{3}\left(\frac{r}{100}\right)\right)$

$$= 20000\left(1+\frac{15}{100}\right)^{2}\left(1+\frac{1}{3}\left(\frac{15}{100}\right)\right)$$

$$= 20000\left(1+\frac{3}{20}\right)^{2}\left(1+\frac{1}{20}\right)$$

$$= 20000\left(\frac{23}{20}\right)^{2}\left(\frac{21}{20}\right)$$

$$= 20000 \times \frac{23}{20} \times \frac{23}{20} \times \frac{21}{20}$$

$$= ₹\ 27,772.50$$

$$C.I = A - P$$

$$= 27,772.50 - 20,000$$

**Compound Interest = ₹ 7,772.50**

**Inverse problems on compound interest**

We have already learnt the formula, $A = P\left(1+\frac{r}{100}\right)^{n}$

Where four variable A, P, r and n are involved. Out of these four variables, if any three variables are known, then we can calculate the fourth variable.

**Example**

**1 At what rate per annum will ₹ 640 amount to ₹ 774.40 in 2 years, interest being compounded annually?**

**Solution**

Given : P = ₹ 640, A = ₹ 774.40, n = 2 years , r = ?

We know,

$$A = P\left(1+\frac{r}{100}\right)^{n}$$

$$774.40 = 640\left(1+\frac{r}{100}\right)^{2}$$

$$\frac{774.40}{640} = \left(1+\frac{r}{100}\right)^{2}$$

$$\frac{77440}{64000} = \left(1+\frac{r}{100}\right)^{2}$$

$$\frac{121}{100} = \left(1+\frac{r}{100}\right)^{2}$$

$$\left(\frac{11}{10}\right)^{2} = \left(1+\frac{r}{100}\right)^{2}$$

(∴ Remove square root on both side)

$$\frac{11}{10} = \frac{100+r}{100}$$

$$\frac{11}{10} \times 100 = 100 + r$$

$$110 = 100 + r$$

$$r = 110 - 100$$

$$r = 10\%$$

**Rate r = 10% per annum**

**2 In how much time will a sum of ₹ 1600 amount to ₹ 1852.20 at 5% per annum compound interest.**

**Solution**

Given : P = ₹1600, A = ₹ 1852.20, r = 5% per annum, n = ?

We know,

$$A = P\left(1+\frac{r}{100}\right)^n$$

$$1852.20 = 1600\left(1+\frac{5}{100}\right)^n$$

$$\frac{1852.20}{1600} = \left(\frac{105}{100}\right)^n$$

$$\frac{185220}{160000} = \left(\frac{21}{20}\right)^n$$

$$\frac{9261}{8000} = \left(\frac{21}{20}\right)^n$$

$$\left(\frac{21}{20}\right)^3 = \left(\frac{21}{20}\right)^n$$

**∴ n = 3 years**

**3 Find the principal that will yield a compound interest of ₹ 1632 in 2 years at 4% rate of interest per annum.**

**Solution**

Given : C.I = ₹ 1632, n = 2 years, r = 4% p.a

P = ?

We know,

Amount - Principal = Compound interest

A - P = C.I

- P = C.I - A

+ P = A - C.I

$$P = P\left(1+\frac{r}{100}\right)^n - C.I$$

$$= P\left(1+\frac{4}{100}\right)^2 - 1632$$

$$= P \times \frac{104}{100} \times \frac{104}{100} - 1632$$

P = 1.0816P - 1632

1P - 1.0816P = -1632

-0.0816P = -1632

0.0816P = 1632

$$P = \frac{1632}{0.0816}$$

= 20,000

**Principal = ₹ 20,000**

**Difference between simple interest and compound interest**

When P is the Principal, n = 2 years and r is the rate of interest.

Difference between C.I and S.I for 2 years = $P\left(\frac{r}{100}\right)^2$

**Example**

**Find the difference between simple interest and compund interest for a sum of ₹ 8,000 lent at 10% p.a. in 2 years.**

**Solution**

Here, P = ₹ 8000, n = 2 years, r = 10% p.a.

Difference between compound interest and simple interest for 2 years $= P\left(\frac{r}{100}\right)^2$

$$= 8000\left(\frac{10}{100}\right)^2$$

$$= 8000\left(\frac{1}{10}\right)^2$$

$$= 8000 \times \frac{1}{10} \times \frac{1}{10}$$

**= ₹ 80**

## Assignment A

1 If principal = Rs. 5000, Interest = Rs. 500. Find the amount.

2 If principal = Rs. 12500, Amount= Rs. 17500. Find the Interest.

3 If the amount is Rs. 25000, its interest is 6000, calcaulate its principal.

4 If principal = Rs. 8450, Interest is 750. Calculate the amount.

5 If principal = Rs. 12000, Amount= Rs. 15600. Find the Interest.

## Assignment B

**Convert the following**

1 6 Months = _____ year.

2 10 Months = _____ year.

3 259 days into week.

4 22 weeks into days.

5 170 days into year.

6 292 days into year.

7 The month of July and August = ____ days

8 2 year 6 months = ____ years

9 15 years = ____ months

10 144 Months = _____ years.

## Assignment C

1 Ramani invested Rs. 1000 for 2 years at 10% per annum. Find the simple interest.

2 Find the S.I. and the amount on ₹ 5,000 at 10% per annum for 5 years.

3 Find the S.I. and the amount on ₹ 1,200 at 12½% per annum for 3 years.

4 Kamesh invested ₹ 10,000 in a bank that pays an interest of 10% per annum. He withdraws the amount after 2 years and 3 months. Find the interest, he receives.

5 Find the amount when ₹ 2,500 is invested for 146 days at 13% per annum.

6 Find the S.I. and the amount on ₹ 12,000 from May 21" 1999 to August 2nd 1999 at 9% per annum.

7 Shanthi deposited ₹ 6,000 in a bank and received 7500 at the end of 5 years. Find the rate of interest.

8 Find the principal that earns ₹ 250 as S.I. in 2½ years at 10% per annum.

9 In how many years will a sum of ₹ 5,000 amount to ₹ 5,800 at the rate of 8% per annum.

10 A sum of money doubles itself in 10 years. Find the rate of interest.

11 A sum of money doubles itself in 12½ per annum over a certain period of time. Find the number of years.

12 A certain sum of money amounts to ₹ 6,372 in 3 years at 6%. Find the principal.

13 A certain sum of money amounts to ₹ 6,500 in 3 years and ₹ 5,750 in 1½ years respectively. Find the principal and the rate percent.

14 Find the S.I. and the amount on ₹ 3,600 at 15% per annum for 3 years and 9 months.

15 Find the principal that earns ₹ 2,080 as S.I. in 3¼ years at 16% p.a.

## Assignment D

1 Find the amount and compound interest in the following cases:

| Sl. No. | Principal in Rs. | Rate % per annum | Time in years |
|---|---|---|---|
| a | 1000 | 5% | 3 |
| b | 4000 | 10% | 2 |
| c | 18000 | 10% | 2½ |

2 Sankari borrowed Rs. 8,000 from Alex for 2 years at 12½% per annum. What interest did sankari pay to Alex if the interest is compounded annually.

3 Find the compound interest on Rs. 24000 compounded semi annually (half yearly) for 1½ years at the rate of 10% per annum.

4 Find the amount that Divakar would receive if he invests Rs. 8192 for 18 months at 12½% per annum, the interest being compounded half-yearly.

5 Anbu took a loan of Rs.80,000 from a bank for 1½ years at 10% per annum. What interest did Anbu pay to bank if the interest is compounded annually.

6 Find the amount that Manimegalai would receive if she invests Rs. 80,000 for 18 months at 10% per annum, the interest being compounded half-yearly.

7 Find the compound interest on Rs. 15625 for 9 months at 16% per annum compounded quarterly.

8 Raju took a loan of Rs. 80,000 from a bank. If the rate of interest is 10% p.a. Find the difference in amounts he would be paying after 1½ years if the interest compounded annually is Rs. 92400, compounded half yearly is Rs. 92610.

9 Guna borrowed Rs. 26400 from a bank to buy a scooter at the rate of 15% p.a. compounded yearly. What amount will he pay at the end of 2 years to clear the loan.

10 Find the difference between simple interest and compound interest on ₹ 2400 at 2 years at 5% per annum compounded annually.

11 Find the difference between simple interest and compound interest on ₹ 6400 for 2 years at 6¼% p.a. compounded annually.

## Assignment E

**I MCQ (Multiple Choise Questions)**

1 Reduction from original selling price is called ____

A loss B list price

C profit D marked price

2 A man buys an article for Rs. 27.50 and sells it for Rs. 28.60. Find his gain percent

A 1% B 2%

C 3% D 4%

3 A TV is purchased at Rs.5000 and sold at Rs. 4000, find the lost percent.

A 10% B 20%

C 25% D 28%

4 A person incurs a loss of 5% be selling a watch for Rs. 1140. At what price should the watch be sold to earn 5% profit.

A Rs. 1200 B Rs. 1230

C Rs. 1260 D Rs. 1290

5 A book was sold for Rs. 27.50 with a profit of 10%. If it were sold for Rs.25.75, What would have been percentage of profit and loss?

A 2% profit B 3% profit

C 2% loss D 3% loss

6 Alfred buys an old scooter for Rs. 4700 and spends Rs. 800 on its repairs. If he sells the scooter for Rs. 5800 his gain percent is _____

A 6.19% B 6.17%

C 5.4545% D 3.5111%

7 If the cost price is 25% of selling price. Then what is the profit percent?

A 150% B 200%

C 300% D 350%

8 The cost price of 20 articles is the same as the selling price of $x$ articles. If the profit is 25%, find out the value of $x$.

A 13 B 14

C 15 D 16

9 A man buys an item at Rs. 1200 and sells it all the loss of 20 percent. Then what is the selling price of that item.

A 660 B 760

C 860 D 960

10 A plot is sold for Rs. 18,700 with a loss of 15%. At what price it should be sold to get profit of 15%.

A Rs. 25300 B Rs. 22300

C Rs. 24300 D Rs. 21300

11 A man gains 20% by selling an article for a certain price. If he sells it at double the price, the percentage of profit will be

A 130% B 140%

C 150% D 160%

12 If the cost price of 12 pens is equal to the selling price of 8 pens, the gain percent is?

A 12% B 30%

C 50% D 60%

13 Ryan buys a clock for Rs. 75 and sells it for Rs. 100. His gain percent is _____

A 25% B $33\frac{1}{3}$%

C 20% D $37\frac{1}{2}$%

14 A bat is bought for Rs. 120 and sold for Rs. 105, the loss percent is _____

A $15\frac{1}{3}$% B $14\frac{1}{5}$%

C 15% D $16\frac{2}{3}$%

15 A man bought apples at the rate of 8 for Rs.34 and sold them at the rate of 12 for Rs. 57. How many apples should be sold to earn a net profit of Rs. 45?

A 90 B 100

C 135 D 150

16 A tradesman sold an article at a loss of 20%. Had he sold it for Rs. 100 more , he should have gained 5%. The cost price of the article was _____

A Rs. 360 B Rs. 400

C Rs. 425 D Rs. 450

17 At what percentage above the cost price must an article be marked so as to gain 33% after allowing a customer a discount of 5%?

A 35% B 38%

C 40% D 42%

18 A shopkeeper earns a profit of 12% on selling a book at 10% discount on the printed price. The ratio of the cost price and the printed price of the book is

A 45:56 B 45:51

C 47:56 D 47:51

19 By selling a bicycle for Rs. 2,850 a shopkeeper gains 14%. If the profit is reduced to 8%, then the selling price will be

A Rs. 2600 B Rs. 2700

C Rs. 2800 D Rs. 3000

20 A person sold a horse at a gain of 15%. Head he bought it for 25% less and sold it for Rs. 600 less, he would have made a profit of 32%. The cost price of the horse was:

A Rs. 3750 B Rs. 3250

C Rs. 2750 D Rs. 2250

21 If a man were to sell his chair for Rs. 720, he would lose 25%. To gain 25% he should sell it for:

A Rs. 1200 B Rs. 1000

C Rs. 960 D Rs. 900

22 If harsh sold a match ticket for Rs. 340 at a profit of 25%, at what price did he purchase the ticket?

A 280 B 255

C 300 D 272

23 Eleven bags are bought for Rs. 1000 and sold at 10 for Rs. 1100. What is the gain or loss in percentage?

A 10% B 21%

C 25% D 20%

24 A man buys an article for Rs. 27.50 and sells it for rs. 28.60. Find its gain percent?

A 1% B 2%

C 3% D 4%

## II MCQ

1 Find the simple interest on Rs. 5200 for 2 years at 6% per annum.

A Rs. 450 B Rs. 524

C Rs. 600 D Rs. 624

2 Rs. 1200 is lent out at 5% per annum simple interest for 3 years. Find the amount after 3 years

A Rs. 1380 B Rs. 1290

C Rs. 1470 D Rs. 1200

3 Interest obtained on a sum of Rs. 5000 for 3 years is Rs. 1500. Find the rate percent.

A Rs. 8% B Rs. 9%

C Rs. 10% D Rs. 11%

4 Rs. 2100 is lent at compound interest of 5% per annum for 2 years. Find the amount after two years.

A Rs. 2300 B Rs. 2315.25

C Rs. 2310 D Rs. 2320

5 Find the difference between the simple interest and the compound interest at 5% per annum for 2 years on principal of Rs. 2000?

A Rs. 5 B Rs. 10.5

C Rs. 4.5 D Rs. 5.5

6 A bank offers 5% compound interest calculated on half yearly basis. A customer deposits Rs. 1600 each on 1st January and 1st july of a year. At the end of the year, the amount he would have gained by way of interest is:

A Rs. 120 B Rs. 121

C Rs. 122 D Rs. 123

7 There is 60% increase in an amount in 6 years at simple interest. What will be the compound interest of Rs. 12,000 after 3 years at the same rate?

A Rs. 2160 B Rs. 3120

C Rs. 3972 D Rs. 6240

8 What is the difference between the compound interest on Rs. 5000 for $1\frac{1}{2}$ years at 4% per annum compounded yearly and half-yearly?

A Rs. 2.04 B Rs. 3.06

C Rs. 4.80 D Rs. 8.30

9 The compound interest on Rs. 30,000 at 7% per annum is Rs. 4347. Their period (in years) is

A Rs.2 B Rs.$2\frac{1}{2}$

C Rs.3 D Rs.4

10 What will be the compound interest on a sum of Rs. 25000 after 3 years at the rate of 12 p.c.p.a?

A Rs. 9000.30 B Rs. 9720

C Rs. 10123.20 D Rs. 10483.20

11 At what rate of compound interest per annum will a sum of Rs. 1200 become Rs. 1348.32 in 2 years?

A 6% B 6.5%

C 7% D 7.5%

12 Albert invested an amount of Rs. 8000 in a fixed deposit scheme for 2 years at compound interest rate 5 P.C.P.A. How much amount will Albert get on maturity of the fixed deposit?

A Rs. 8600 B Rs. 8620

C Rs. 8820 D Rs. 8940

# Estimation and Costing - Simple estimation of the requirement of material etc., as applicable to the trade

**Introduction**

Estimation is the method of calculating the various quantities and the expenditure to be incurred on a particular job or process.

Estimate is the method used to measure or quantify the different quantities and the expected expenditure to be incurred on a particular work or project.

We know that the estimation is a long procedure, and it is totally depends upon the projects,

In case the funds available are less than the estimated cost the work is done in part or by reducing it or specifications are altered,

The following essential details are required for preparing an estimate.

Drawings like plan, elevation and sections of important parts.

Detailed specifications about workmanship & properties of materials, etc.

Standard schedule of rates of the current year.

Estimating is the process of preparing an approximation of quantities which is a value used as input data and it is derived from the best information available.

An estimate that turns out to be incorrect will be an overestimate if the estimate exceeded the actual result, and an underestimate if the estimate fell short of the actual result.

A cost estimate contains approximate cost of a product process or operation. The cost estimate has a single total value and it is inclusive of identifiable component values.

**Purpose of Estimating and Costing**

1 Estimates provide a rough idea of the cost of the job and therefore its feasibility can be calculated, i.e. whether or not the project would be included in the funds available.

2 Estimate gives an idea of the time needed to complete the work.

3 Estimates are required to invite tenders and quotations and to arrange the contracts.

4 Estimates are also required to control expenditure during the execution of the work.

5 Estimates decide whether or not proposed plan matches the funds available.

**Estimation Methods**

Estimate involves the following operations

- Preparing detailed Estimate.
- Calculating the rate of each unit of work.
- Preparing abstract of estimate.

**Estimation** is the process of calculating or evaluating a quantity by estimation, that is, without reference to specific measurements. Estimating is a fundamental process in all engineering.

This is usually done before purchase or construction begins or during preliminary planning stages. Estimating is usually more accurate, but there are a few limitations - namely that if your estimate relies on labour costs, you'll need to know how many man-hours will take to complete the project.

Estimates are developed from observations and knowledge of past experience. The accuracy of an estimate often depends on the level of detail available and the amount of time for which data are available for analysis.

**Costing** is the process of estimating the cost of a project before it's completed. It can be done with an itemized list, or through estimation using a construction cost calculator.

Costing includes three steps: estimating, bidding, and finalizing. It helps predict how much money will be required to construct the project.

A "costing" typically refers to how much it will cost someone to produce a single unit.

**There are two types of costings**

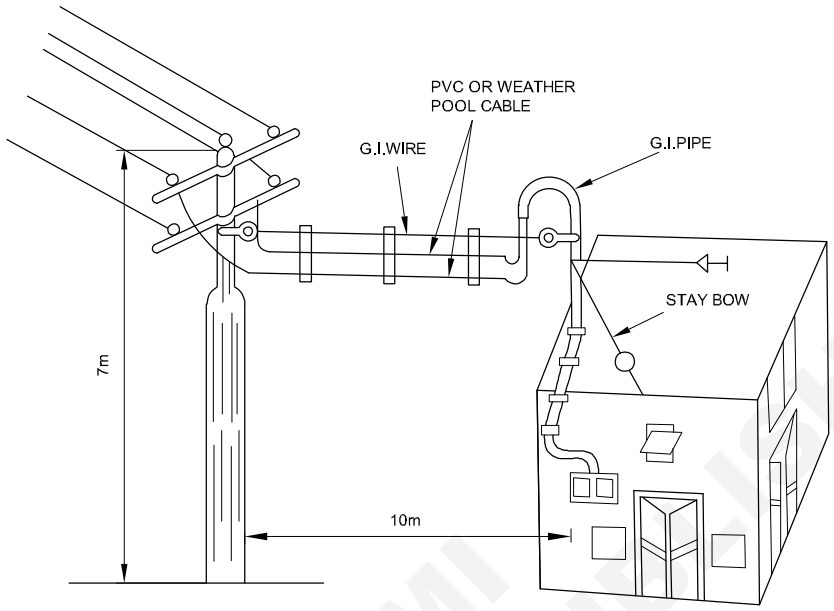
**Independent costing -** this is the cost of direct material and labour costs. This type of costing only takes into account the cost of a single-phase, so it's not representative of the overall project cost.

**Cumulative Costing -** this type of costing looks at the total cost for all phases of work, but it can be difficult to ensure that estimates are accurate.

**Exercise: Service connection to home**

Prepare a list of material and estimate the cost for providing service connection to a buildingm at 240 V single phase 50 Hz having a light and fan load of 2 KW and heating load of 2 KW. The supply is to be given from an overhead line 20m. away from the building. (Fig 1)

Fig 1




**Solution:** Materials used for service connection

To calculate the size of the first you need to calculate the total connected load in the house and then calculate the load current of the house using proper formula.

Connected load = lighting load + heating load

= 2 KW + 2 KW = 4000 W

**Example**

1 **To calculate to size of the wire for that calculate to total connected load in the house**

Connected load = lighting load + heating load

= 2 kw + 2 kw = 4000W

2 Total load of house = 4000W

3 Future additional demand load be twice the present load ie 2x4000w = 8000W

$$\text{load current in ampered} = \frac{\text{load in watts}}{\text{Voltage}}$$

$$= \frac{8000}{240} = 33 \text{ Amps}$$

4 Require the size of the aluminium cable is 10 sq mm from the wire table.

5 The length of cable required = $(20 + 6 + 3 + 4)^2$

| | |
|---|---|
| Horizonal length | = 20 m |
| Looseness and meter board connection | = 6 m |
| Service pipe length | = 3 m |
| Pole side connection | = 4 m |
| Total | = 33 Meter |

6 Single phase 2 wire is required

7 Total wire require = 33 x 2 = 66 Metre

**Material required**

1 length of cable = 66 metre

2 40 mm G.I. pipe 3 mm thick 1.8 metre for supporting

3 40 mm G.I. pipe 2.5 mm thick

4 8 SWG G.I. wire for earthing

5 30 mm PVC pipe of 2 m length and bends 3 Nos

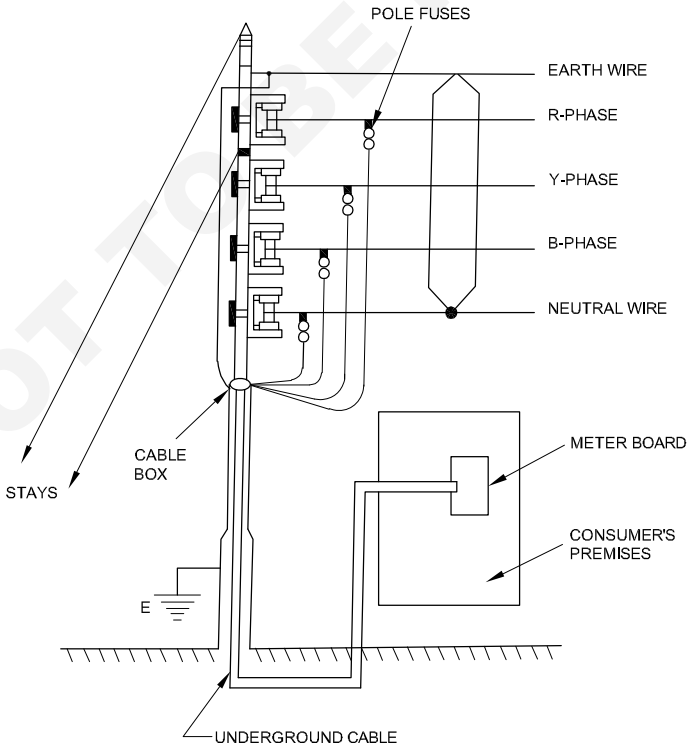
6 30 A fuse of 2 Nos and miscellance materials

7 Wooden board 500mm x 500 mm x 45mm

| S.No. | Particulars | Quantity | Rate in ruppes | Amount |
|---|---|---|---|---|
| 1 | 10 sq.mm | 66 M | 7000.00 | 5,100.00 |
| 2 | 1.1 KV porcelain break insulators | 2 Nos | 50.00 | 100.00 |
| 3 | Reel Insulators | 52 | 5.00 | 260.00 |
| 4 | 10 SWG GI wire for messenging | 2 | 500.00 | 1,000.00 |
| 5 | 40 mm 3mm thick | 1.8 | 600.00 | 1,080.00 |
| 6 | 30mm PVC pipe 2mm thick | 3M | 120.00 | 240.00 |
| 7 | PVC bends | 3 | 40.00 | 120.00 |
| 8 | 500*500*45mm | 1 | 1200.00 | 1,200.00 |
| 9 | 40mm GI pipe 3 mm thick for earthing | 2.5M | 600.00 | 1,500.00 |
| 10 | 8 SWG GI wire for earthing | 1 | 500.00 | 500.00 |
| 11 | 300A 500 voltage grade porcelain fuse | 2 | 400.00 | 800.00 |
| 12 | 12.5 mm dia 300 eye bolt buts of M.S | 2 | 50.00 | 100.00 |
| 13 | Miscellaneous (pipe bolts, nuts, coal, salt, etc.) | | | 600.00 |
| 14 | Labour charges | | | 5,000.00 |
| 15 | Unforesen things 5% on above amount | | | 880.00 |
| | | | **Total** | **Rs.18,230.00** |

**2 Three phases overhead service connection: select the size and prepare an estimate for overhead service connection to feed power supply to a factory of 10 HP load for a distance of 10 meters. (Fig 2)**

Fig 2

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**Materials used for service connection**

1 Assuming a supply voltae of 400V p.f. = 0.8 and the efficiency of the load is 80%.

2 Current = (10x735.5) ÷ (0.8 x 0.8 x 400 x $\sqrt{3}$ ) = 16.6 Amps

3 The future load be twice of present load or factor of safety as 2, the current rating is 33A.

4 The size of the aluminium cable required is 10 sq mm.

5 (a) Length of the cable = 10+3+3+4 = 20 x 4 = 80m.

**Note:** Length of the cable = Horizontal length (10 m) + Looseness and meter board connection (3m) + service pipe length (3 m) + Pole side connection (4m).

**Materials**

(b) G.I. Messenging wire = 10 + 1 = 11m = 1 kg.

(c) No of Break Insulators = 2 Nos.

(d) No of Reel Insulators = (10+3) 4 = 13 x 4 = 52 Nos.

(e) 30 mm PVC pipe of 2 m and of 3 bends.

(f) 50 mm G.I pipe of 3 mm thick 1.8 m for supporting

(g) 500 x 500 x 65 m WVTWB - 1 No.

(h) 40 mm G.I. pipe 2.5 m and 1 kg 8 SWG GI wire for earthing.

(i) 30 A fuse unit - 3 Nos.

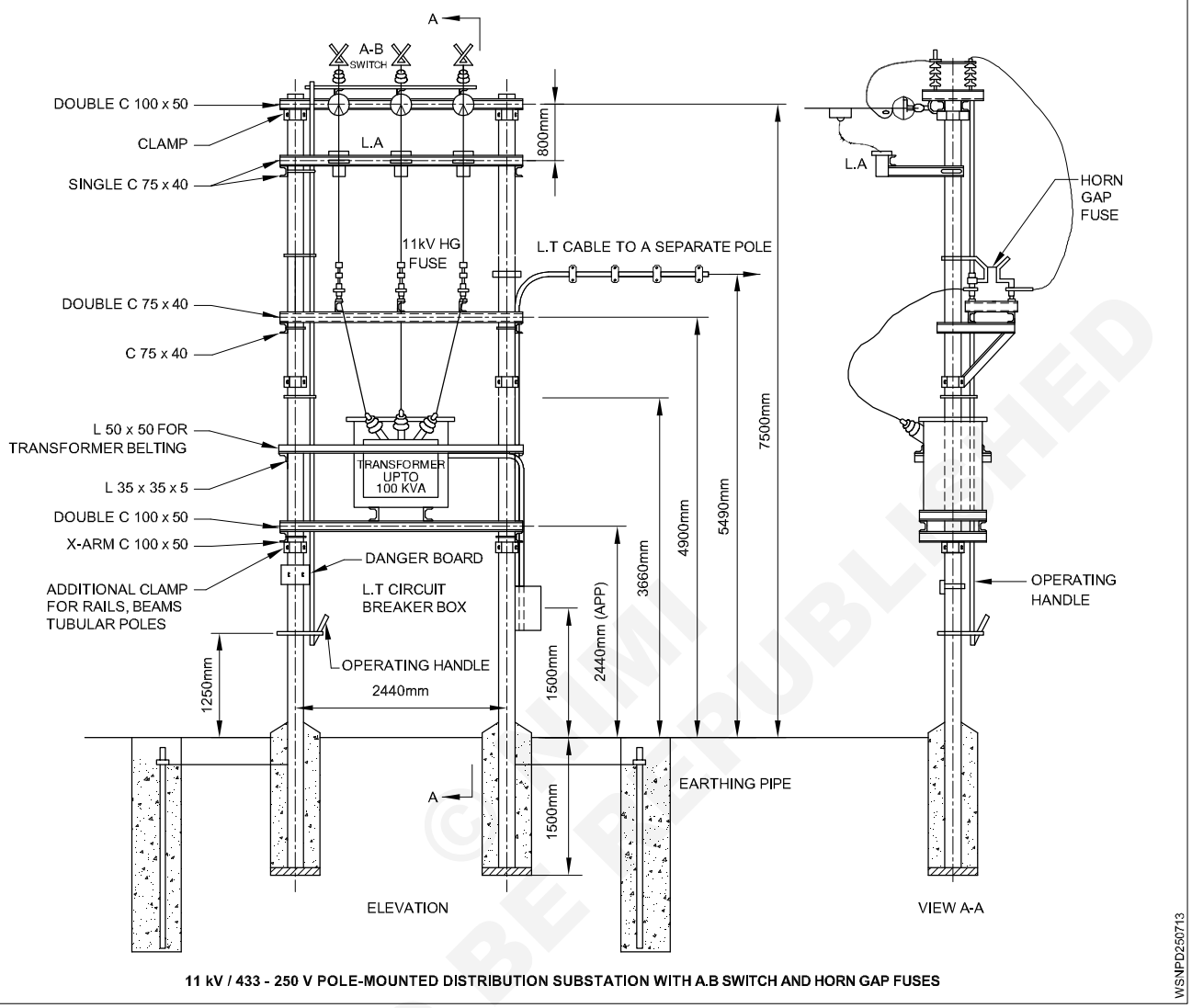
(j) M.S. clamps with nuts and bolts - 2 sets and miscellaneous materials.

| S.No. | Particulars | Quantity | Rate in ruppes | Amount |
|---|---|---|---|---|
| 1 | 10 sq.mm aluminium cable | 80 M | 7000 | 6,000.00 |
| 2 | 1.1 KV porcelain break insulators | 2 | 50 | 100.00 |
| 3 | Porcelain reel insulators | 5.2 | 500 | 260.00 |
| 4 | 10 SWG GI messanging wire | 2 | 500 | 1,000.00 |
| 5 | 30 mm PVC pipe of 2mm thick for servicing | 2 | 120.00 | 240.00 |
| 6 | PVC bends for 30 mm PVC pipe | 3 | 40.00 | 120.00 |
| 7 | 50 mm GI pipe 3mm thick 1.8M for supporting | 1.8 | 600 | 1,080.00 |
| 8 | 500 x 500 x 45 mm WVTWB | 1 | 1200 | 1,200.00 |
| 9 | 30 A porecelain fuse unit 500 Vg | 3 | 400 | 1,200.00 |
| 10 | 40 mm GI pipe 3mm thick | 2.5 | 600 | 1,500.00 |
| 11 | 8 SWG GI wire for earthing | 1 | 500 | 500.00 |
| 12 | 12.5mm dia 300mm eye bold nuts of M.S | 2 | 50.00 | 100.00 |
| 13 | Miscellaneous materials such as binding wire, nuts bolts, cement, salt, coal, etc. | Lump sum | | 600.00 |
| 14 | Labour charge | | | |
| | a) For earthing | | | 5,000.00 |
| | b) For servicing | | | 745.00 |
| 15 | Contingencies and unforseen things @ 5% on above amount | | | |
| | | | **Total** | **Rs.20,645.00** |

**3 Write the material required for 11/0.4 KV pole mounted substation and draw key diagram with one input and 2 output lines. (Fig 3)**

**List of material for pole types of transformer substation**

Fig 3




11 kV / 433 - 250 V POLE-MOUNTED DISTRIBUTION SUBSTATION WITH A.B SWITCH AND HORN GAP FUSES



| S.No. | Description of Material | Quantity |
|---|---|---|
| 1 | Materials for H.T. connection with main line | |
| | (a) M.S channel 10 cm x 5cm x 1.5mts | 1 No |
| | (b) H.T. 11 kv disc insulators with fittings | 3 Nos |
| | (c) 11 kv pin type insulators with pins | 2 Nos |
| | (d) Stau sets complete | 2 Nos |
| | (e) Concreting of existing line | 1 No |
| | (f) Earth wire clamp | 1 No |
| | (g) Tee clamp for M.S. channel | 1 No |
| | (h) Binding wire (aluminium) | 500 gms |
| 2 | Conductors ACSR gopher 6/1/2.36 mm diameter:length 50 x 3 = 150 mts sag allowed 1% = 1.5 mt. Total length Conductor required. | 151.5 gms Or 16 kg |

| S.No. | Description of Material | Quantity |
|---|---|---|
| 3 | Galvanised steel wire of 8 SWG = 50.5 mts or 6 kg | 6 kg |
| 4 | R.S. joist 175mm x 100mm x 10mts long | 2 Nos |
| 5 | Fitting on H.T. double pole structure for pole mounted substation | |
| | (i) Stone pad | 2 nos |
| | (ii) Sub-station plate | 1 No |
| | (iii) M.S. channel 100mm x 50mm x 8mm x 2.65 mts long | 1 No |
| | (iv) Eye bolt | 3 Nos |
| | (v) dropper angle iron 75mm x 75mm x 8mm x 2 mtr long | 1 No |
| | (vi) Stay complete | 2 Nos |
| | (vii) 11kv disc insulators with fittings | 3 Nos |
| | (viii) 11kv pin type insulators with pin | 3 Nos |
| | (ix) Binding wire 500 gms | 500 gms |
| | (x) Number plate with clamp | 1 No |
| | (xi) Danger plate with clamp | 1 No |
| | (xii) Barbed wire | 5 kg |
| | (xiii) Earthing plate | 1 set |
| | (xiv) Jumper wire for jumpering 1.1kg | 11 mts |
| | (xv) Nuts and bolts of size as required | 18 Nos |
| | (xvi) Concreating of poles | 2 Nos |
| | (xvii) T.P.M.O. switch | 1 No |
| | (xviii) Painting of poles and other attachments | 2 liters |
| | (xix) Fuse set | 1 Set |
| | (xx) Fabrication of some parts such as clamps etc | L.S |
| 6 | Transformer 100 KVA 11/0.4kv | 1 No |
| 7 | TPICN (Triple pole iron Clad and Neutral) main switch 100 amps rating | 1 No |
| 8 | Earthing of transformer | 1 No |
| 9 | Lighting arresters one set of three | One set |

**List of Materials required given below**

| S.No. | Description of Materials | Quantity Required | Remarks |
|---|---|---|---|
| 1 | 27 kg, 10 m long steel poles | 08 | |
| 2 | Teak wood X-arms, 100mm x 100mm x 1.5m | 06 | For single-pole structure |
| 3 | Top insulator brackets | 06 | |
| 4 | Teak wood X-arms 100 mm x 100mm 2.2m | 01 | For H-pole structure |

| S.No. | Description of Materials | Quantity Required | Remarks |
|---|---|---|---|
| 5 | 11 kV disc insulators complete with pins | 0.6 x 0.3 + 1 x3 = 21 | 3 insulators in each pole +3 in each H-pole |
| 6 | 6/1 x 2.59 mm ACSR conductor | 3060 m = 3.06 km | |
| 7 | 11 kV pin insulators complete with pins | 21 | 06 x 03 + 1 x 3 = 21 |
| 8 | Earth wire clamps | 0.7 | |
| 9 | Cross bracings | 1 set | |
| 10 | G.I. wire no 8 SWG | $\frac{3060}{3} = 1020\text{m}$ | |
| 11 | 14 SWG binding wires cu. | 4 kg | |
| 12 | Stay sets complete with anchor rod, RCC pole base plate, tension screw etc. including stay wire (7/8 SWG GI wire) | 06 | |
| 13 | Earthing sets complete | 03 | |
| 14 | 11 kV lightning arrestors | 1 set | |
| 15 | Danger plates 11 kV with clamps | 7 Nos | |
| 16 | Barved wires (anti-climbing devices) | 20 kg (7 x 3kg - 1) | |
| 17 | Pole foundation (muffs) | 8 Nos | |
| 18 | Knee bracing sets | 6 Sets | |
| 19 | CI reels support the conductors earth wire | | |
| 20 | Guard (GSL No 4) | 4 Nos | |
| 21 | MS channel or angle iron | 1 No | |

**Installation of 11/0.4 kV pole mounted substation, The cost of all materials including labour charges approximately 5 Lakhs.**

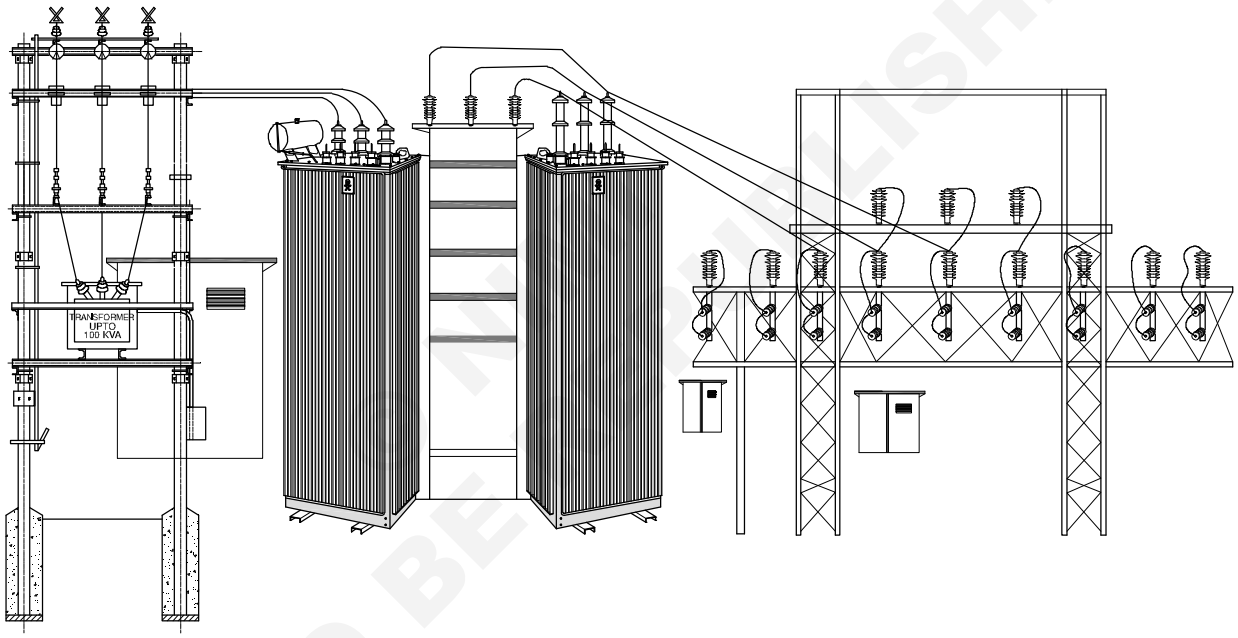
# Estimation and Costing - Problems on estimation and costing - Check and rectify the high voltage distribution system (HVDS)

**Check and rectify the high voltage distribution system (HVDS). (Fig 1)**

**Tools/Measuring Instruments - Service Persons Owns**

- PPE kit - 1 No.
- Safety gloves - 1 Set.
- Earthing/grounding kit - 1 Set.
- Electrician's tool kit - 1 Set.
- Safety belt - 1 No.
- Helmet - 1 No.
- Lock - as reqd.
- Tags(danger board) - as reqd.
- Ladder - 1 No.

Fig 1




DISTRIBUTION SUBSTATION

1 Working with high-voltage distribution systems is extremely dangerous.

2 Ensure that you have the necessary personal protective equipment (PPE) for working with high-voltage systems.

3 Always work with a partner, and establish clear communication procedures.

4 Familiarize yourself with the high-voltage distribution system's components, such as transformers, circuit breakers, switches, insulators, and conductors. Know the system's voltage rating and the specific components you'll be working with.

5 Inspect all tools and equipment for damage or defects before use.

6 Use specialized testing equipment to verify that the high-voltage system is de-energized and properly grounded before starting any work.

7 Identify the source of high voltage and isolate it. This may involve opening circuit breakers or switches and locking them out to prevent accidental energization.

8 Ensure that the system is properly grounded to dissipate any residual voltage.

9 Use grounding devices and mats as necessary.

10 Put on appropriate PPE, including voltage-rated gloves, clothing, safety glasses, and a helmet with a face shield.

11 Create a detailed work plan that includes step-by-step procedures and safety precautions. Consider potential hazards and develop contingency plans.

12 Execute the planned tasks while following safety protocols. Always maintain a safe distance from energized components and conductors.

13 After completing the work, use testing equipment to verify that the system is functioning correctly. Ensure that all safety measures are still in place.

14 Only after confirming that the work is completed safely and correctly, remove any lockout/tagout devices. Document the Work.

15 Be prepared for emergencies. Know the location of emergency shutdown switches, first aid equipment, and emergency contact numbers

16 Conduct a final inspection to ensure that the work area is safe and all equipment is properly stored.

17 After completing the work, review the job with your team to identify lessons learned and areas for improvement.

**Note:**

1 **Checking of high voltage distribution system should have the team of electrical person such as AE, Forman, trained persons etc.,**

2 **The defective circuit breaker insulator switches and cnonductors are requirements decided by Ispection team only.**

# Estimation and Costing - Problems on estimation and costing - Perform digging of pit, erection of supports and fitting various accessories on poles

**Perform digging of pit, erection of supports and fitting various accessories on poles. (Fig 1)**

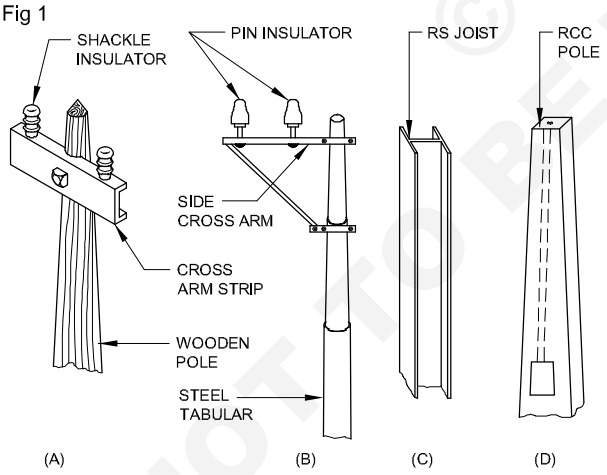
**Tools/Measuring Instruments - Service Persons Owns**

- D.E. spanner set 6mm to 32mm - 1 Set.
- Combination pliers 200mm - 1 No.
- Heavy duty screwdriver 300mm - 1 No.
- Safety belt to work on pole - 1 No.
- Crowbar 2m long 40mm dia - 1 No.
- Spade - 1 No.
- Shovel - 1 No.
- Plumb bob with thread - 1 No.
- Cotton or jute rope 15m long - 1 No.
- Hammer ballpein 500g - 1 No.
- Safety belt - 1 No.
- Bamboo ladder - 1 No.
- Draw pulley - 1 No.
- Aligning rod - 1 No.
- Metal ram - 1 No.

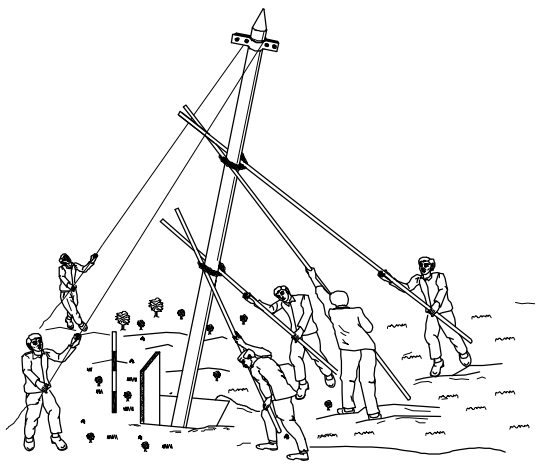
**Materials**

- Wooden/RCC/iron/tubular pole of 6m length - 1 No.
- M.S. angle iron cross-arm 50mm x 50mm x 6mm size suitable for 240V supply line - 1 No.
- 'C' clamp M.S. size as required with nuts, bolts and washers - 2 Sets.
- Country wood plank 2m long, 30cm width 5cm thick - 1 No.
- Cement, sand, blue metal chips etc as per the size of pit - as reqd.
- Stay insulator (egg insulator) - 2 Nos.
- Double screw stay tightener - 2 Nos.
- C.I. stay plate - 2 Nos.
- H.D.G. steel wire (stay wire) 7/16 SWG - 16 m.
- 50 x 12mm size M.S. bolts and nuts with washers - 2 Nos.
- Base plate for pole - 1 No
- Casuarina pole of suitable height - 4 Nos.
- Wooden box of suitable size having 2 side openings for concrete pedestal - 1 No.

Fig 1




TYPES OF POLES IN OVERHEAD SERVICE LINE



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1 Select the place for fixing the pole near the building based on the span.

2 Select the type of pole to be erected (Fig 1).

3 Dig a pit about 1/6th height of the pole having a diameter of minimum 3 times that of the dia of the pole bottom.

4 Prepare a mixture of concrete having a ratio 1:2:4 (one part cement, two part coarse sand and four part 2 cm blue metal chips) and pour the same in the bottom of the pit to a height of 15cms.

5 Ram the concrete and allow it to settle for a minimum period of 48 hours.

6 Keep the base plate for the pole at the bottom of the pit.

7 Fix a vertical straight pole on the plumb line in the pit Refer (Fig 2)

8 Bring the pole and place it near the pit so that the bottom of the pole is at the edge of the pit.

9 Insert the wooden plank (board) vertically at one side of the pit facing opposite to the bottom portion of the pole.

10 Fix the cross arms at the top of the pole below 30 cm from the top, with the help of 'C' clamps rigidly.

11 Tie the two ropes just below the cross arms.

12 Place the casuarina pole at a distance of 1/3 height of the top and also 1/3 height from the bottom of the pole.

13 Prepare concrete mixture in the ratio of 1:3:4 (cement, sand and 1 cm blue metal chips).

14 Lift the pole step by step with the help of a rope and casuarina pole (Fig 3) and place it on the pit exactly vertical.

15 Check the vertical position with the help of an aligning a rod and plumb bob.

16 Pour the concrete mixture around the pole inside the pit and then place the wooden box around the pole.

17 Pour the concrete mixture in the box to a height of 0.5m above the ground level. Ram the mixture properly.

19 Remove the wooden box and plaster the cement concrete above the ground surface to have a smooth finish.

20 Fix the stay rod to the ground at a distance so as to get 45° to 60° between ground level and stay wire should be placed in the opposite direction to the line.

21 Cut the stay wire into 2 pieces of equal length.

22 Fix one end of each piece of the stay wire to the strain insulator (egg insulator).

23 Fix the other end of the second piece of stay wire to the stay. Tighten using a thimble.

24 Fix the stay and tighten to the stay.

25 Tighten the stay tightener nut till there is no sag in the stay.

**Note: The cost of digging of pit and erection of supports and fitting of pole with accessories vary from place to place, soil condition, location of field and number of poles.**

# Estimation and Costing - Problems on estimation and costing - Maintenance of wave trap

**Mainteance of wave trap (Fig 1)**

**Tools/Measuring Instruments - Service Persons Owns**

- Personal protective equipment - 1 Set.
- Soft dry cloth/Brush - 1 No.
- Spanner - 1 No.
- Screw driver - 1 No.
- Non - contact volatge tester - 1 No.
- Wave trap with manual - 1 No.
- LMU with manual - 1 No.

Fig 1

1 Always follow safety procedures and wear appropriate personal protective equipment (PPE) when working with electrical equipment.

2 Visually inspect the wave trap for any signs of physical damage, such as cracks, rest, or loose connections.

3 Clean the wave trap's insulators and terminals using a soft, dry cloth or a brush to remove dust, dirt, or containments.

4 Check and tighten all connections to ensure proper elctrical contact and avoid potential hotspots.

5 If the wave trap is oil-filled, conduct regular oil analysis to monitor its condition and detect any degradation.

6 Conduct functional tests to ensure the wave trap is operating correctly and responding as expected.

7 If the wave trap has adjustable settings, make sure they are calibrated correctly.

8 Maintain detalied records of maintenance acticites, test results, and any abnormalities found.

**Calculation for Maintenance of Wave trap**

Material cost = Rs.1500

Labour charge = Rs.4000

Total cost = Material cost + Labour charge

= Rs.1500 + Rs.4000

**= Rs.5500**

# Estimation and Costing - Problems on estimation and costing - Maintenance of LMU

**Mainteance of LMU (Fig 1)**

**Tools/Measuring Instruments - Service Persons Owns**

- Personal protective equipment - 1 Set.
- Soft dry cloth/Brush - 1 No.
- Spanner - 1 No.
- Screw driver - 1 No.
- Non - contact volatge tester - 1 No.
- Wave trap with manual - 1 No.
- LMU with manual - 1 No.

Fig 1

1 Gather all necessary tools and equipment for maintenance.

2 Safely shut down the line matching unit according to established procedures.

3 Visually inspect the unit for any signs of wear, damage, or leaks. Check the surrounding area for any hazards.

4 Clean the unit thoroughly, removing any debris, dirt, or residue that may have accumulated.

5 Inspect individual components such as valves, connectors, sensors, and belts for signs of wear, corrosion, or malfunction. Replace any damaged or worn-out parts with approved replacements.

6 If applicable, lubricate moving parts according to manufacturer recommendations.

7 Check the alignment of the unit and its components to ensure proper functioning. Calibrate any sensors or measurement devices according to the manufacturer's guidelines.

8 Inspect electrical connections, wires, and control panels. Tighten loose connections and replace faulty wiring or components as needed.

9 Conduct thorough testing of the unit after maintenance.

10 Keep detailed records of the maintenance activities performed, including any parts replaced, adjustments made, and testing outcomes.

11 Before restarting the unit, perform safety checks to ensure that all guards, covers, and safety mechanisms are properly in place and functional.

12 Gradually start up the unit and monitor its operation closely, Look for any unusual noises, vibrations, or abnormal behaviors.

13 Perform a final inspection to confirm that the unit is operating as intended and that all maintenance tasks have been successfully completed.

14 If any issues are identified during the post-maintenance period, address them promptly.

Remember, the specific steps and requirements may vary based on the type of line matching unit you're dealing with.

**Calculation for Maintenance of LMU**

Material required (Valve, connectors, sensors cost) = Rs.4500

Labour charge = Rs.1500

Total cost = Material cost + Labour charge

= Rs.4500 + Rs.1500

**= Rs.6000**

# Estimation and Costing - Problems on estimation and costing - Test the control panel for its performance

**Test the control panel for its performance (Fig 1)**

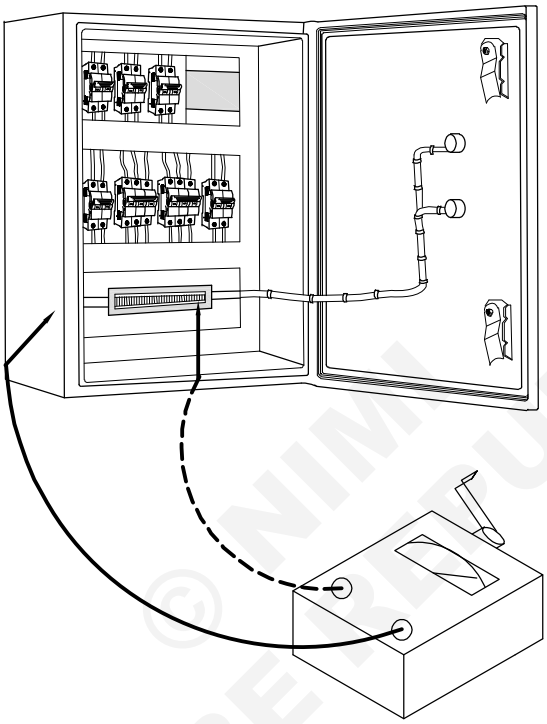
**Tools/Measuring Instruments - Service Persons Owns**

- Tool kit - 1 No.
- Megger 1000V - 1 No.

**Materials/Components**

- Connecting leads - as reqd.

Fig 1



TESTING OF PANEL BY MEGGER

WSNPD251211



1 Check the Insulation Resistance (IR) value of contactors circuit breakers etc,.

2 Check for any short circuit/open circuit fault.

3 Switch 'ON' the supply to the panel board and verify the functions of line indicator, meters etc.

4 Test the contactor, push button switch, timer for its function.

5 Switch 'on' the motor and check the functions of sensors (speed and temperature) and If any control device found faulty replace new control devices and test it.

6 Complete your testing.

**Labour charge = Rs.1,500**