WORKSHOP CALCULATION & SCIENCE

(NSQF)

2nd YEAR

(As per Revised Syllabus July 2022)

Instrument Mechanic

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

Instrument Mechanic - 2nd Year NSQF

As per Revised Syllabus July 2022

Developed & Published by

National Instructional Media Institute
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Guindy, Chennai - 600032
INDIA
Email: chennai-nimi@nic.in
Website: www.nimi.gov.in

First Edition : November 2023 Copies: 1000

Rs: 85/-

FOREWORD

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

The National Instructional Media Institute (NIMI), Chennai, has now come up with instructional material to suit the revised curriculum for **Workshop Calculation & Science - Instrument Mechanic 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,
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November 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 -** Instrument Mechanic 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 -** Instrument Mechanic 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 - Instrument Mechanic 2nd Year** as per NSQF Revised 2022.

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Shri. G. Michael Johny	-	Manager, NIMI, Chennai - 32.

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

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

INTRODUCTION

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

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

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

Time allotment - 2nd Year : 18 Hrs

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

S.No	Title	Exercise No.	Time in Hrs
1	Friction	2.1.01 - 2.1.03	2
3	Algebra	2.2.04 & 2.2.05	6
4	Estimation and Costing	2.3.06 - 2.3.19	10
		Total	**18 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 - Instrument Mechanic
Revised syllabus July 2022 under CTS

S.no.	Syllabus	Time in Hrs
I	**Friction** 1 Advantages and disadvantages, Laws of friction, co- efficient of friction, angle of friction, simple problems related to friction 2 Friction – Lubrication 3 Co- efficient of friction, application and effects of friction in workshop practice	2
II	**Algebra** 1 Addition, Subtraction, Multiplication & Divisions 2 Algebra – Theory of indices, Algebraic formula, related problems	6
III	**Estimation and Costing** 1 Simple estimation of the requirement of material etc., as applicable to the trade 2 Problems on estimation and costing	10
	Total	18

Friction - Advantages and disadvantages, Laws of friction, co-efficient of friction, angle of friction, simple problems related to friction

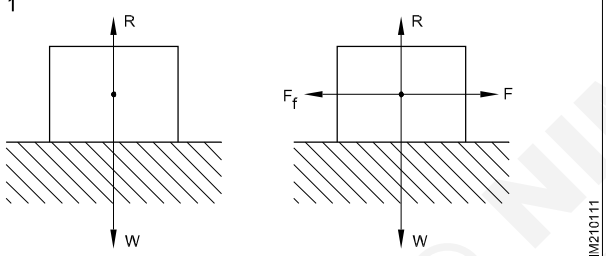
Introduction

When on a solid surface, another solid is rubbed a force is created between the two solids which acts in the opposite direction of motion or tries to obstruct the motion of the object, this force is called frictional force. This phenomenon is called friction. This happens due to roughness of the two surfaces.

In other words, It is the force of resistance offered to motion, experienced by bodies which are in contact. It depends upon the normal reaction between the contacting surfaces and the nature of the surfaces. No surface is absolutely friction less.

Friction plays an important role in our daily life. It would not be possible to walk without friction between our foot and floor. Vehicles are able to run on roads because of the friction between the wheels and road.

Fig 1



Types of friction

1 Static friction

2 Dynamic friction

1 Static friction

The friction between two solid objects when at rest is called static friction.

Eg. Static friction can prevent an object from sliding down on a sloped surface.

Limiting friction

When the frictional force (F) is equal to the applied pulling force (P) then the friction between two surfaces is known as limiting friction. (i.e F=P)

2 Dynamic friction

It is the friction between two objects, when are in motion is called dynamic friction. It is also called kinetic friction.

Sliding friction

It is the friction experienced by an object when its slides over another object. Sliding friction is always less than limiting friction.

Rolling friction

It is the friction that occurs when a circular object such as a ball or roller rolls on a flat surface. Rolling friction is less than sliding friction. (ball or roller bearing)

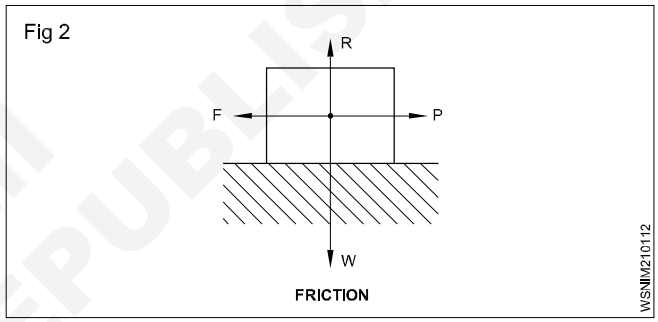
Forces acting on a body when a pulling force is applied to move (Fig 2)

- Weight of the block acting vertically downward (W)
- The normal reaction which acts upwards (R)
- The applied pulling force (F)
- The frictional force (F_f)

When the body is about to move W=R, F=P

When pulling force is increased the body starts to move.

Fig 2



Advantages of friction

1 Helps us to walk without slipping.

2 Used to stop vehicles when brakes are applied.

3 Movement of vehicles due to friction between revolving wheels with tyres and the road.

4 Power transmission using gear drive or belt pulley drive.

5 Using friction we can sharp any object and also to hold it.

6 Nails and screws are held in wood by friction.

7 Heat is produced when two rough surfaces are rubbed against each other.

Disadvantages of friction

1 It causes wear and tear of the machine parts.

2 It produces heat and may cause melting of machine parts. To avoid production of heat using of coolant is necessary.

3 It reduces efficiency of a machine.

4 It reduces speed of the moving object. eg. spindle, shaft, piston etc.

Friction can be reduced

1 By using suitable lubricants (oil, grease) between the moving parts.

2 By polishing the surface to make them smooth.

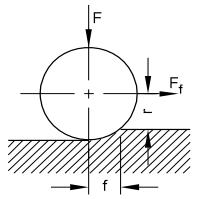
3 By using ball bearings and roller bearings.

4 By the use of wheel.

Laws of friction (Fig 3 & 4)

- Frictional force is directly proportional to the normal reaction between contacting surfaces.
- Frictional force acts opposite to the direction of motion.
- Frictional force depends on the nature of contacting surfaces.
- Frictional force is independent over the area and shape of contacting surfaces.

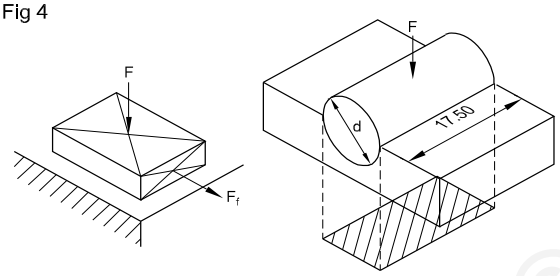
Fig 3



FRICTION

WSNIM210113

Fig 4



FRICTION

WSNIM210114

Coefficient of friction

The ratio between the limiting friction force and the normal reactions is called the co-efficient of friction.

Suppose, by applying a force P kg, the object is just fit to move, then limiting friction force will be produced in between the two surfaces. The limiting friction force will be equal to external force applied and will work in the opposite direction.

$\therefore \quad F = P$ kg

According to the second law of limiting friction force, the friction force will be proportional to normal reaction.

$F \propto R$ ($\propto$ sign is proportional to)

$F = R \times$ constant

or $\frac{F}{R} =$ constant

This constant between objects is called Co-efficient of Friction. This is represented by μ.

$$\mu = \frac{F}{R} \text{ or } F = \mu.R$$

$$\text{Co-efficient of Friction} = \frac{\text{Limiting friction force}}{\text{Normal reaction}}$$

Co-efficient of friction is always constant for any two objects and it has no units.

Angle of friction (Fig 5)

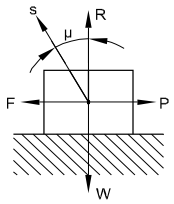
The forces acting on a body when it is just about to move by the application of a pulling force are W, R, P and F. The forces 'R' and 'F' are compounded and we get the resultant force 'S'. The angle formed by 'S' with 'R' is the angle of friction.

Therefore

$$\tan \theta = \frac{F}{W}$$

$$\tan \theta = \mu$$

Fig 5



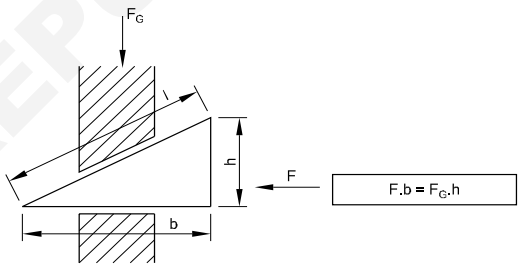
FRICTION

WSNIM210115

Angle of repose (Fig 6)

A body placed on an inclined surface remains at rest till the angle of inclination equals the angle of friction. When it exceeds the body starts sliding down. This is known as angle of repose.

Fig 6



ANGLE OF REPOSE

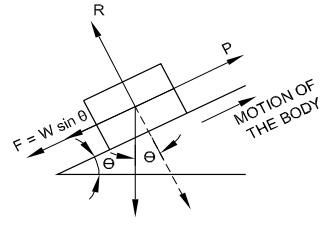
WSNIM210116

Inclined Plane (Fig 7)

According to the figure, given below plane AB is inclined $\theta°$ to the horizontal. On this, the vertical line working at W kg weight will make an angle with normal line of the inclined plane equal to the degree of inclination of the base at the horizontal.

The first component of weight 'W' of the object acts on the normal line and is equal to W cos $\theta°$. The second component acts parallel to base and downward and is equal to sin $\theta°$.

Fig 7



MOTION UP THE PLANE

WSNIM210117

$\therefore$ Normal Reaction 'R' = W cos θ°

Limiting Friction Force 'F' = W sin θ°

$\therefore$ Co-efficient of friction 'μ' $= \frac{F}{R}$

$= \frac{W \sin\theta}{W \cos\theta}$

$= \tan\theta$

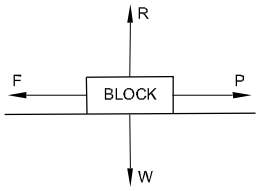
$\therefore$ $\mu = \tan\theta$

It may also be mentioned as:

In an inclined plane, some object without any external force applied only due to W sin 0 is about to come right downwards, then the plane makes an angle equal to the angle of friction with the horizontal.

Force of Friction When the Force is Horizontal (Fig 8)

Fig 8



Let,

P = Force required to pull the block

F = Force of friction

R = Normal reaction

W = Weight of block

μ = Co-efficient of friction between block and surface.

As per observation from the figure 8:

The block will move forward, if it has been overcome by the force of friction.

$\therefore$ P = F (it is horizontal)

Normal reaction of block is opposite to the direction of weight. $\therefore$ R= W

$\therefore$ Force of friction = μ . R

$\therefore$ Force required to move the block = μ . R

Force of Friction When the Force is Inclined at an Angle θ with the Horizontal (Fig 9)

Let,

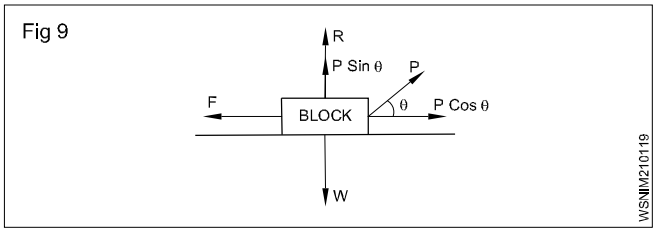
θ = Angle of pull 'P' to move the block with the horizontal

W = Weight of block

R = Normal reaction

P = Pull at an angle 'θ' with the horizontal

Fig 9



As per observations: from the geometry of figure 9, it is obvious:

Horizontal component of 'P' = P cos θ

Vertical component of 'P' = P sin θ

The horizontal component P cosθ will be the effective pull, while the vertical component P sinθ will go on for reducing the normal reaction.

As per condition of equilibrium :

Algebraic sum of horizontal components = 0

$F - P \cos\theta = 0$

$F = P \cos\theta$

Algebraic sum of vertical components = 0

$R + P \sin\theta - W = 0$

$R = W - P \sin\theta$

We know $F = \mu . R$

$P \cos\theta = \mu [W - P . \sin\theta]$

$= \mu . W - \mu . P . \sin\theta$

$P \cos\theta = \mu . W + \mu . P . \sin\theta = 0$

$P [\cos\theta + \mu . \sin\theta] = \mu . W$

$$P = \frac{\mu . W}{\cos\theta + \mu . \sin\theta}$$

Force of pull required at an angle of θ with the horizontal is given by:

$$P = \frac{\mu . W}{\cos\theta + \mu . \sin\theta}$$

Example

1 A force of 40 kg is required to pull a weight of 400 kg on a horizontal plane. Determine the coefficient of friction.

$$\text{Coefficient of friction} = \frac{\text{Force}}{\text{Weight}} = \frac{F}{W}$$

But F = P and R = W

$$\mu = \frac{F}{W} = \frac{F_f}{R} = \frac{40}{400}$$

μ = 0.1

2 A force for 30N is required to move a body of mass 35 kg on a flat surface horizontally at a constant velocity. Find the coefficient of friction.

Mass of the body = 35 kg. = W (By taking
The weight force=35 x 10 = 350 N 1kg = 10N)

(By taking g = 10 metre/sec^2)

$$\therefore \mu = \frac{F}{W} = \frac{F_f}{R} = \frac{30}{350} = \frac{3}{35} = 0.086$$

μ = 0.09

3 A solid weights 20 kg. This is placed on a solid surface. How much force does it require to come in motion when co-efficient of friction is 0.24.

Co-efficient of friction (μ) = 0.24
Weight (W) = 20 kg
Force required (F) = ?

$$\mu = \frac{F}{W}$$

$$0.24 = \frac{F}{20}$$

$$F = 20 \times 0.24$$

F = 4.8 kg

4 A tanker with loaded weight of 14500 kg is running on the road. If the co-efficient friction between tyres and road surface is 0.28. Find out its force of friction.

Co-efficient of friction (μ) = 0.28
Weight (W) = 14500 kg
Force friction (F) = ?

$$\mu = \frac{F}{W}$$

$$0.28 = \frac{F}{14500}$$

$$F = 0.28 \times 14500$$

F = 4060 kg.

5 A force of 800 gram weight is needed to pull a block weighing 3200 gram. What is the co-efficient of friction.

Force (F) = 800 gm
Weight (W) = 3200 gm
Co-efficient of friction (μ) = ?

$$\text{Co-efficient of friction } (\mu) = \frac{F}{W}$$

$$= \frac{800}{3200}$$

μ = 0.25

6 A force of 40 kg is required to move a mass of 80 kg on a flat surface horizontally at a constant velocity. Calculate its co-efficient of friction?

Force (F) = 40 kg
Weight (W) = 80 kg
Co-efficient of friction (μ) = ?

$$\text{Co-efficient of friction } (\mu) = \frac{F}{W}$$

$$\mu = \frac{40}{80}$$

μ = 0.5

7 A weight of 10 kg is resting on a horizontal table and can just moved by a force of 2 kg. Find the co-efficient of friction?

Weight (W) = 10 kg
Force (F) = 2 kg
Co-efficient of friction (μ) = ?

$$\text{Co-efficient of friction } (\mu) = \frac{F}{W}$$

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

μ = 0.2

8 A body weighing 100kg is resting on a table. Find the co-efficient of friction if a force of 30 kg makes its just to move?

Weight (W) = 100 kg
Force (F) = 30 kg
Co-efficient of friction (μ) = ?

$$\text{Co-efficient of friction } (\mu) = \frac{F}{W}$$

$$= \frac{30}{100}$$

μ = 0.3

9 A metal block weighing 10 kg rests on a horizontal table. A horizontal force of 2.5 kg can just slide the block. Find the normal reaction, limiting friction and co-efficient of friction?

Weight (W) = 10 kg
Force (F) = 2.5 kg
R = ?
Normal reaction = W
Limiting friction = ?
μ = ?
Normal reaction (R) = 10 kg

Limiting friction (F) = 2.5 kg

$$\mu = \frac{F}{W}$$

$$= \frac{2.5}{10}$$

$$\mu = \mathbf{0.25}$$

10 A wooden block weights 100 kg. If the co-efficient of friction is 0.3, find out force required to move the block.

Weight (W) = 10 kg

Co-efficient of friction (μ) = 0.3

Force (F) = ?

$$\mu = \frac{F}{W}$$

$$0.3 = \frac{F}{100}$$

$$F = 100 \times 0.3$$

$$\mathbf{F = 30\ kg}$$

11 Calculate the angle of inclination, if a weight of 150 kg is in equilibrium, co-efficient of friction is 0.25. Calculate the force of normal reaction also.

Work done (W) = 150 kg

Co-efficient of friction (μ) = 0.25

θ = ?

Force F = ?

$\mu = \tan\theta = 0.25$

$= 14^\circ\ 2'\ 20''$

$$\mu = \frac{F}{W}$$

$$0.25 = \frac{F}{150}$$

$$F = 0.25 \times 150$$

$$\mathbf{F = 37.5\ Kg.}$$

12 A body of mass 60kg rests on a horizontal plane. The value of co-efficient of friction between it and the plane being 0.2. Find the work done in moving the body through a distance of 5 meters along the plane.

Co-efficient of friction (μ) = 0.2

Weight (W) = 60 kg

Distance (S) = 5 m

Work done (W) = ?

$$\mu = \frac{F}{W}$$

$$0.2 = \frac{F}{60}$$

$$F = 60 \times 0.2$$

$$= 12\ kg$$

Work done = Force x distance = F x S

$= 12 \times 5$

$= 60$ Kg.m

(ie) Work done (or) Applied force = 60 Kg.m

13 If a force of 30N is required to move a mass of 35kg on a flat surface horizontally at constant velocity, what will be the co-efficient of friction?

Force (F) = 30 N

Weight (W) = 35 kg

1 kg = 9.8 N

35 Kg = 9.8 x 35 = 343 N

Co-efficient of friction = $\mu = \frac{F}{W}$

$$= \frac{30\ N}{35\ kg}$$

$$= \frac{30\ N}{35 \times 9.8\ N}$$

$$\mu = \mathbf{0.087}$$

14 A block of ice weighing one quintal rests in equilibrium on a wooden plank inclined at 30º. Find the coefficient of friction between the ice and wood.

W = 1 quintal = 100 kg = Weight

θ = 30º $\qquad \frac{F}{W} = \mu = \tan\theta$

$\mu = \tan\theta = \tan 30^\circ$

μ **= 0.5774**

15 Calculate the force that is required to slide a mass of 980 kg on a guide, when the coefficient of friction between the surfaces is 0.09.

Weight (W) = 980 kg

Co-efficient of friction (μ) = 0.09

Force (F) = ?

Co-efficient of friction = $\mu = \frac{F}{W}$

$$0.09 = \frac{F}{980\ kg}$$

$$F = 0.09 \times 980\ kg$$

Required force(F) = 88.2 kg

16 A metal block weighing 10kg rests on a horizontal board and the coefficient of friction between the surfaces is 0.22. Find (a) the horizontal force which will just move the block and (b) the force acting at an angle of 30° with the horizontal, which will just move the block.

Weight (W) = 10 kg

Co-efficient of friction (μ) = 0.22

(a) F = ?

(b) Force acting at an angle of 30º with the horizontal?

(a) $\mu = \frac{F}{W}$

$0.22 = \frac{F}{10\ kg}$

F = 2.2 Kg.

(b) Force acting at an angle of 30º $= \frac{F}{\cos \theta}$

= 2.2/cos 30º

= 2.2/0.8660

Force acting at an angle of 30º **= 2.54 kg**

17 Calculate the angle of inclination, if a weight of 250 kg is in equilibrium. Coefficient of friction is 0.36. Calculate the force of normal reaction also.

Angle of inclination (θ) = ?

Weight (W) = 250kg

μ = 0.36

Force (F) = ?

$\tan \theta = \mu$

$\tan \theta = 0.36$

$\theta = 19º\ 48'$

$\mu = \frac{F}{W}$

$0.36 = \frac{F}{250\ kg}$

F = 0.36 x 250 kg

F = 90 kg.

18 A body of mass 10 kg rests on a horizontal plane. The co-efficient of friction between the body and plane is 0.15. Find the work done in moving the body through a distance of 10 metre.

Weight (W) = 10kg

Co-efficient of friction (μ) = 0.15

Distance (S) = 10 metre

Work done (W) = ?

$\mu = \frac{F}{W}$

$0.15 = \frac{F}{10\ Kg}$

F = 0.15 x 10 kg

F = 1.5 kg

Work done = W = F x S

= 1.5 kg x 10 m

Work done **= 15 kg.m**

Assignment A

1 A force 50N is required to move a mass of 40kg on a flat surface horizontally at a constant velocity. Find the coefficient of friction. (9.8N = 1kg)

2 A vehicle having a weight of 800kg is moving on the road. If the coefficient of friction between the tyres and road surface is 0.3, then calculate the force of friction.

3 A solid weighing 50kg is placed on a solid surface. How much force is required to move the block when coefficient of friction is 0.25 between the block and the surface.

4 A railway wagon weighs 1250 tonnes. If the coefficient of friction between it and the rails is 0.003, find the force required to move the wagon.

5 A body of mass 100kg rests on a horizontal plane. The angle of friction between the body and the plane being 0.025. Find the work done in moving the body through a distance of 16m along the plane.

6 A body of mass 20kg rests on a horizontal plane, the co-efficient of friction between the body and plane is 0.3. Find the work done in moving the body through a distance of 10 metres.

7 A body of mass 2000 kg moves a distance of 10 meters in 5 sec. If the co-efficient of friction between the body and floor is 0.3 find the horizontal force required to move the body and horsepower absorbed against friction.

8 A vehicle is moving at 50kmph and the load on the vehicle is 5000 kg. Find the H.P. required to move the vehicle if $\mu = 0.2$.

9 Find out the power lost due to friction by a planer under the following conditions.

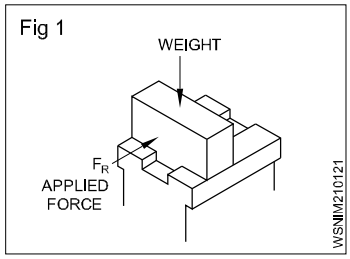
Mass of the planer table = 3500 kg

Rate of moment of the table=0.5 m/sec

Co-efficient of friction between the table and the ways=0.06

10 A truck having weight 12000 kg is moving on the road. If the co-efficient of friction between the tyres and the road surface is 0.3, then calculate the force of friction.

Assignment B

1 

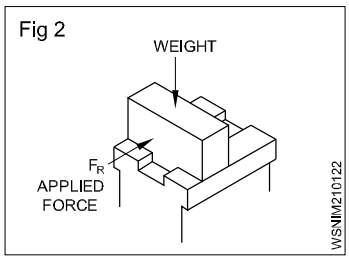
F = 1800 N

μ (static) = 0.16

μ (dynamic) = 0.012

F_R to overcome static friction = _____ N

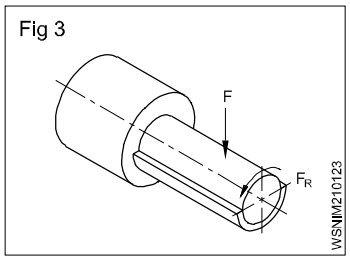
F_R to overcome dynamic friction = _____ N

2 

mass = 250 kg

F_R = 160 N

μ = _____

3 

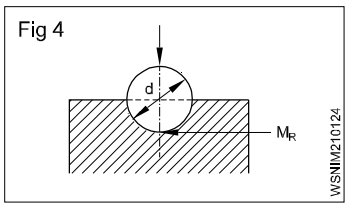
F = 5000 N

μ (dry) = 0.03

μ (fluid friction) = 0.01

F_R when dry = _____ N

F_R when lubricated = _____ N

4 

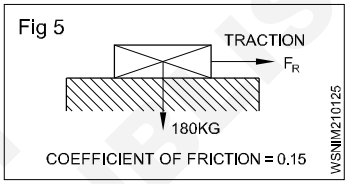
F = 1.2 kN

d = 60 mm

μ = 0.03

Frictional torque M_R = _____ Nm

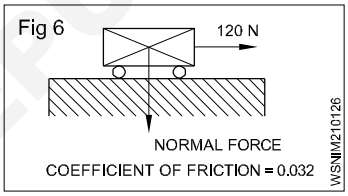
(Frictional torque = Frictional force x radius)

5 

mass = 180 kg

μ = 0.15

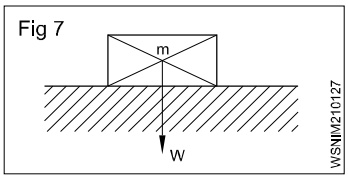
F_R = _____ N

6 

F_R = 120 N

μ = 0.032

Normal force F = _____ N

7 

m = 1000 kg

μ = 0.4

Force required to move F_R = _____ N

C MCQ

1 Which one of the following is useful friction

A Rings in cylinders B Crankshaft bearings

C Brake shoe linings D Wheel hole bearings

2 Which is in between the wheels and road, if vehicles are able to run on roads.

A erosion B motion

C corrosion D friction

3 Which direction of motion frictional force acts.

A equal B opposite

C inclined D forward

4 What is the formula of angle of friction, if 'F' is the frictional force, R is the normal reaction and θ is the angle of friction.

A $\text{Tan } \theta = \frac{F}{R}$ B $\text{Cot } \theta = \frac{F}{R}$

C $\text{Sin } \theta = \frac{F}{R}$ D $\text{Cos } \theta = \frac{F}{R}$

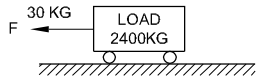
5 What is the formula for Co-efficient of friction (m).

A $\mu = \frac{R}{F}$ B $\mu = \frac{F}{R}$

C $\mu = F \times R$ D $\mu = F + R$

6 A loaded truck weighs 2400 kg and it can be moved by a force of 30 kg. Determine the co-efficient of rolling friction

Fig 1



FRICTION

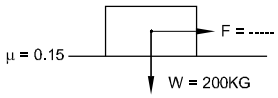
WSNIM210131

A 0.0215 B 0.0152

C 0.0125 D 0.0251

7 Calculate the pulling force required for the figure shown.

Fig 2



FRICTION

WSNIM210132

A 27 Kg B 28 Kg

C 29 Kg D 30 Kg

8 Determine the co-efficient of friction (μ) between brass and steel when a brass slider was placed on the horizontal steel surface until it is just moving, if brass slides (W) = 3 Kgf and required force is 0.7 Kgf.

Brass slides (W) = 3 Kgf

Force (F) required = 0.7 kgf

A 0.033 B 0.133

C 0.233 D 0.333

9 Which is necessary to avoid production of heat.

A sand B coolant

C lubricant D salt

10 Which is used to reduce the friction.

A lubricants B sand

C coal D coolant

Friction - Lubrication

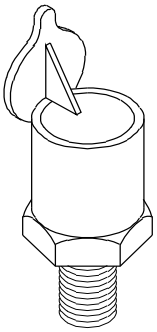
There are 3 systems of lubrication.

- 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)

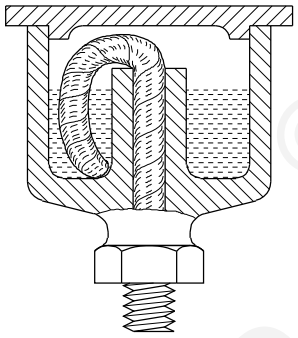
Fig 1



OIL CUP

WSNIM210211

Fig 2



WICK FEED

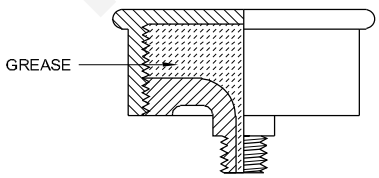
WSNIM210212

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

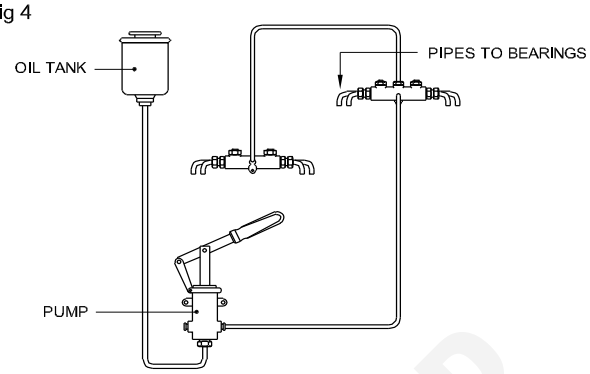


MANUAL SCREW DOWN GREASER

WSNIM210213

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)

WSNIM210214

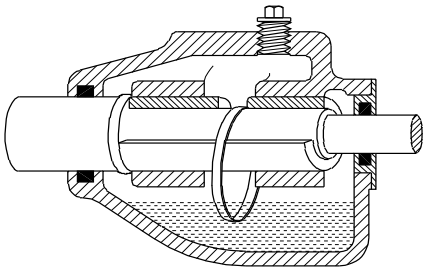
Oil pump method

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

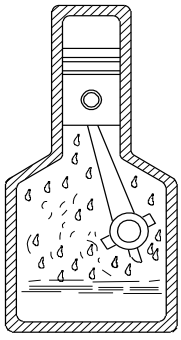


RING OILING

WSNIM210215

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

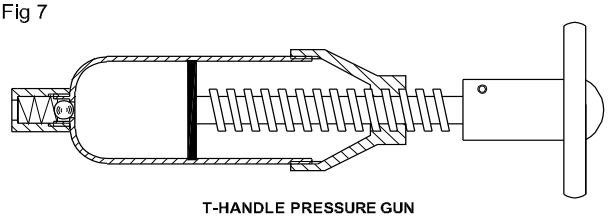
WSNIM210216

Types of grease guns

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

- 'T' handle pressure gun (Fig 7)

Fig 7

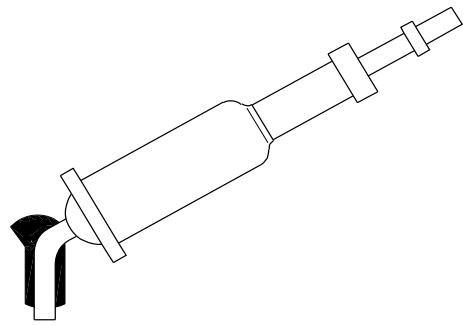


T-HANDLE PRESSURE GUN

WSNIM210217

- Automatic and hydraulic type pressure gun (Fig 8)

Fig 8

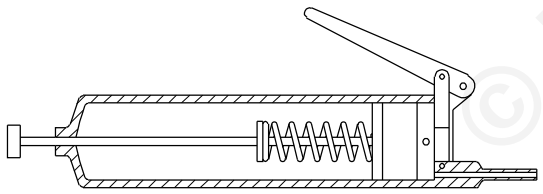


AUTOMATIC HYDRAULIC-TYPE PRESSURE GUN

WSNIM210218

- Lever-type pressure gun (Fig 9)

Fig 9



PRESSURE GREASE GUN

WSNIM210219

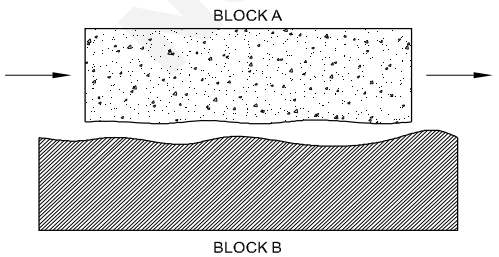
Lubrication to exposed slideways

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)

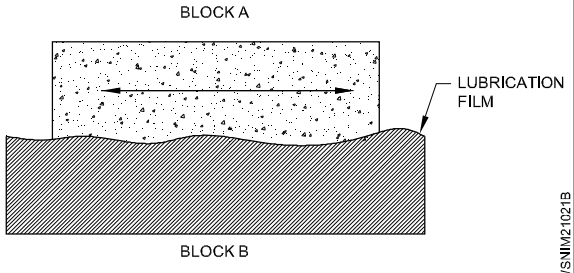
Fig 10



WSNIM21021A

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)

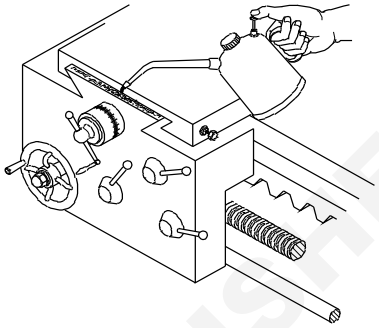
Fig 11



WSNIM21021B

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

Fig 12

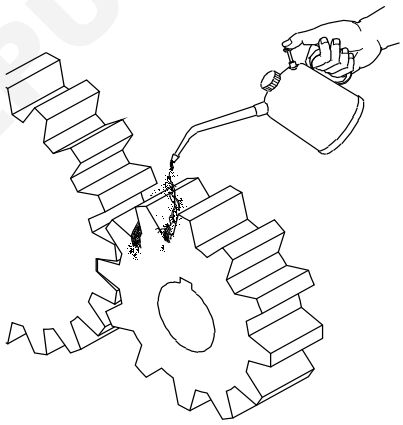


OIL THE SLIDES FREQUENTLY

WSNIM21021C

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

Fig 13



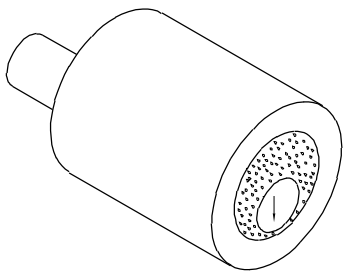
WSNIM21021D

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)

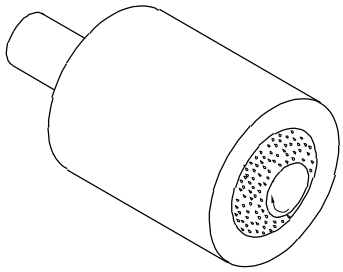
Fig 14



WSNIM21021E

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)

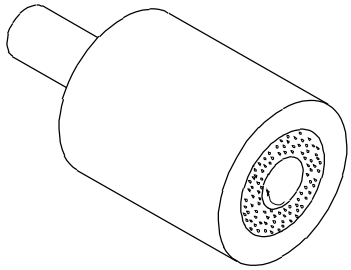
Fig 15



WSNIM21021F

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

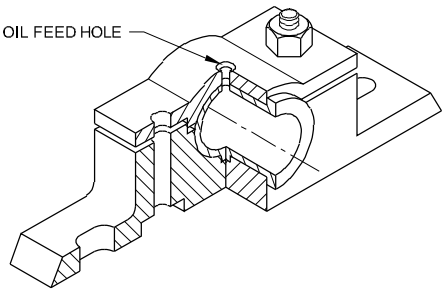


WSNIM21021G

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



WSNIM21021H

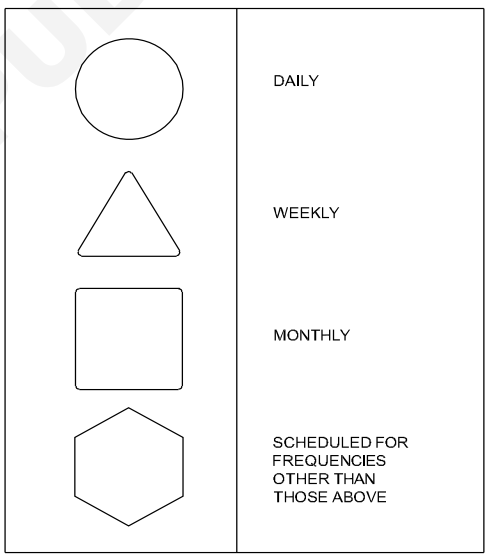
Hints for lubricating machines:

- 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



WSNIM21021I

Friction - Co -efficient of friction, application and effects of friction in workshop practice

Co-efficient of friction

The ratio between the limiting frictional force and the normal reaction is called co-efficient of friction.

Suppose, by applying a force 'P' kg, the object is just fit to move, then limiting frictional force will be produced in between the two surfaces. The limiting frictional force will be equal to external force applied and will work in the opposite direction.

$\therefore \quad F = P$ kg

According to the second law of limiting frictional force, the frictional force will be proportional to normal reaction.

$F \propto R$ ($\propto$ sign is proportional to)

$F = R \times$ constant

or $\frac{F}{R}$ = constant

This constant between objects is called co-efficient of friction. This is represented by μ.

$$\mu = \frac{F}{R} \text{ or } F = \mu.R$$

$$\text{Co-efficient of friction} = \frac{\text{Limiting frictional force}}{\text{Normal reaction}}$$

Co-efficient of friction is always constant for any two objects and it has no unit.

Example

1 The sliding valve of a steam engine has dimensions 25cm by 45 cm and the steam pressure on the back of the valve is 25 kg/cm^2. If the co-efficient of friction is 0.13. Calculate the force required to move the valve?

Dimension of steam valve = 25 cm x 45 cm.

Steam pressure = 25 kg/cm^2

Co-efficient of friction = 0.13

Force required to move the valve = ?

F = ?

Force of the steam = Pressure x Area

= 25 x 25 x 45

$\frac{25\text{kg}}{\text{cm}^2} \times 25\text{cm} \times 45\text{cm}$ = 28125 kg.

Force acts on the valve = 28125 kg

$$\mu = \frac{F}{W}$$

$$0.13 = \frac{F}{28125}$$

$F = 0.13 \times 2812$

Force required to move the valves = 3656.25 Kg

2 An empty drum weighing 50kg is resting on a shop floor. Find the coefficient of friction if a force of 15kg makes it just move.

Weight (W) = 50 kg

Force (F) = 15

Co-efficient of friction $\mu = \frac{F}{W}$

$= \frac{15\text{ kg}}{50\text{ kg}}$

μ **= 0.3**

3 **A machine crate weighing 1000kg moves distance of 5m in 5 sec. If the coefficient of friction between the crate and floor is 0.3, calculate the horizontal force required to move the crate and horse power absorbed against friction.**

Weight (W) = 1000 kg

Distance (S) = 5 meter

Time (t) = 5 second

i) Co-efficient of friction (μ) = 0.3

ii) Force (F) = ?

Horse power (H.P.) = ?

i) $\mu = \frac{F}{W}$

$0.3 = \frac{F}{1000\text{ Kg}}$

$F = 0.3 \times 1000$ kg

$F = 300$ kg

(1 HP = 75 m.kg/sec)

ii) $H.P = \frac{F \times S}{t} \times \frac{1}{75}$

$$H.P = \frac{300 \times 5}{5} \times \frac{1}{75} = 4 \text{ H.P}$$

Horse power absorbed against friction = 4.H.P.

4 A weight of 600 kg is kept on the inclined plane at 30^0. Calculated the normal reaction and force rolling downwards.

Solution:

Weight kept on the inclined plane (W) = 600kg

Angle of the inclined plane (θ) = 30^0

$\therefore$ Normal reaction (R) = W . cos θ

= 600 x cos 30^0

= 600 (0.8660)

= 519.6 kg

Force rolling downwards = W . sin θ

= 600 x sin 30^0

= 600 (0.5000)

= 300 kg

$\therefore$ **Normal reaction = 519.6 kg**

Force rolling downwards = 300 kg

5 Find out the power lost due to friction by a planner under the following conditions.

Mass of the planer table = 3500 kg

Rate of movement of the table = 0.5m/sec

Co-efficient of friction between the table and the ways = 0.06

Solution:

Weight of planer (W) = 3500 kg

Distance moved (d) = 0.5 m/sec

Co-efficient of friction (μ) = 0.06

Co-efficient of friction $= \mu = \frac{F}{W}$

$0.06 = \frac{F}{3500}$

$F = 0.06 \times 3500 = 210$ kg

Workdone = F x distance moved

= 210 x 0.5 = 105 kgm/sec

75 kgm/sec = 1 H.P

105 kgm/sec $= \frac{105 \times 1}{75} = 1.4$ H.P

Power lost due to friction = 1.4 H.P

6 A planner table weighing 800 kg moves a distance of 2 metres in seconds on its bed. If co-efficient of friction between bed and table is 0.30 find the power required to move the table against the friction.

7 On a milling machine table a component of 20 kgf is clamped with the help of three equidistant clamps. What force must be exerted by each clamp to avoid slipping of the component when the horizontal cutting force is 60 kgf and the coefficient of friction is equal to 0.2.

8 A machine weight of 14500 kg moving on the floor. If the co-efficient of friction between the machine and floor surface is 0.28 then calculate the force of friction.

9 A tail stock of a lathe has a mass of 21.5 kg and co-efficient of friction at the slides is 0.122. What horizontal force will be required to slide the tail stock?

10 An inclined surface makes an angle of 30 degrees with the horizontal. An object weighting 5 tons is placed on the surface. Find out the normal reaction at the object and also the effective force required to bring the object downwards.

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 $5xy$, $11xy$, $-xy$, $-14xy$

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

2 Unlike terms

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

b $2xy$, y^2, a^2b, xz, 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 $25xy$, $+ 2xy$, $- 6xy$, $- 3xy$

$25xy + 2xy + (- 6xy) + (- 3xy)$

$= 27xy - 9xy$

$= 18xy$

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

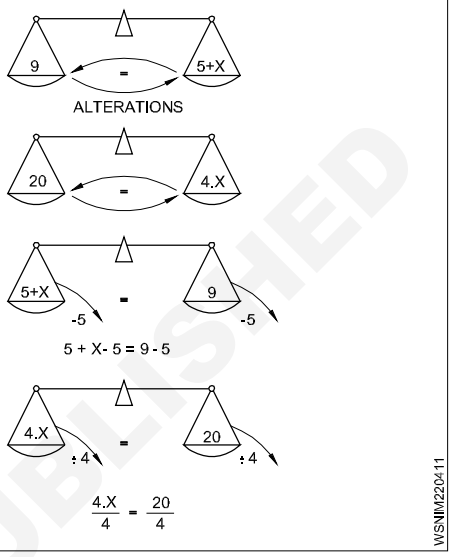
– minus

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 $\frac{-5m \times -6n - 7p}{-28mn}$

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 x 2 x 2) x (2 x 2) = 2 x 2 x 2 x 2 x 2 = 2^5

8 x 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 x 2 x 3 x 3 = 6 x 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 x 2) x (2 x 2) x (2 x 2) = (2 x 2 x 2) (2 x 2 x 2)

4 x 4 x 4 = 64

8 x 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

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

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

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

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

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

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

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

$4xy = 2$

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

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

$= 4 \times 4 = 16$

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

Estimation and Costing - Simple estimation of the requirement of material etc., as applicable to the trade - Fault and rectification of pressure gauge in pipeline with safety valve and pig tail / siphon etc.

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: Fault and rectification of pressure gauge in pipeline with safety valve and pig tail / siphon etc. (Fig 1)

Tools - Service Persons - Owns

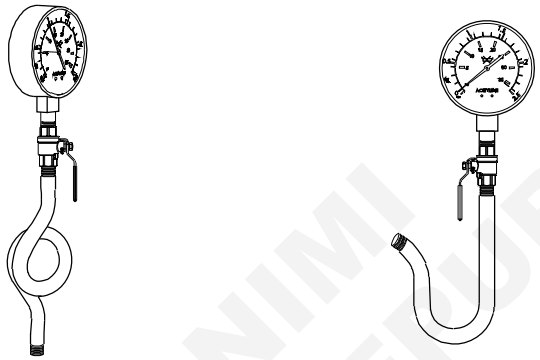
Tools/Instruments

- Pressure gauge (0-5) kg /cm^2 - 1 No.
- Siphon/Digital 12" – q tube 10 kg/cm^2/300°C - 1 No.
- Safety valve 1/2" - 3 Nos.
- Pump ½ HP/ 230V - 1 No.
- Resistor tank 20 lit - 1 No.
- Temperature Trainer setup - 1 No.
- Adjustable spanner - 1 No.

Materials

- Adaptors - as reqd.
- Teflon tape - 1 No.
- Mulmul cloth - as reqd.

Fig 1



WSNIM230611

1 Fill water inside Pigtail /siphon as shown in figure.
2 Fit pressure gauge, Pigtail /siphon, safety valve using suitable adopter.
3 Check the leakage in the Fitting.
4 Switch ON the pump.
5 Open HV2 valve and Fill tank 2.
6 Switch ON the heater.
7 Observe the water is heated in tank 2.
8 Open the safety valve, observe and measure the pressure through the Pigtail /siphon.
9 Check the work done by the instructor.

1	Cost of Pressure gauge (0-5) kg /cm^2	=	Rs. 2390
2	Siphon cost	=	Rs. 200
3	Safety valve cost	=	Rs. 1500
4	Materials cost	=	Rs. 300
	Total cost	**=**	**Rs. 4390**

Estimation and Costing - Simple estimation of the requirement of material etc., as applicable to the trade - Fault and rectification of valve actuator (pneumatic) with control valve

Fault and rectification of valve actuator (pneumatic) with control valve. (Fig 1)

Tools - Service Persons - Owns

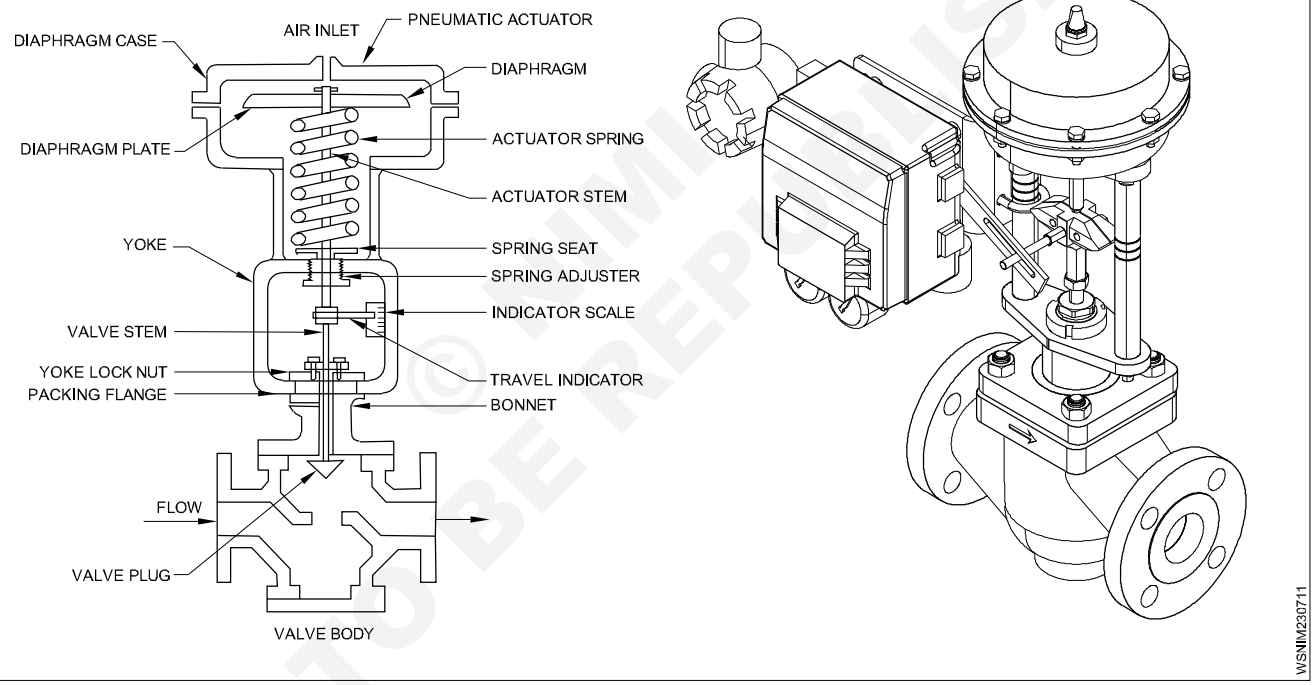
Tools/Instruments

- Control valve - 1 No.
- Ring Spanner - 1 No.
- Adjustable spanner - 1 No.
- Screw driver - 1 No.
- Air regulator (FRL) - 1 No.

Materials

- Cotton waste - 1 No.
- Cleaning solution - 1 No.
- Poly urethane tube - 1 No.

Fig 1



1 Properly clean the given control value using cotton waste in cleaning solution.

2 Note down the specification of the given control valve.

3 Correct the PU tube to the actuator.

4 Connect the PU tube to the compressor.

5 Open the valve and check whether air is pushed the diaphragm.

6 Test the valve actuator after giving required air supply.

1	Valve actuator cost	= Rs.3250
2	Materials cost	= Rs. 650
	Total cost	**= Rs.3900**

Estimation and Costing - Simple estimation of the requirement of material etc., as applicable to the trade - Fault and rectification of pressure switch and pressure relief valve with compressor

Fault and rectification of pressure switch and pressure relief valve with compressor. (Fig 1)

Tools - Service Persons - Owns

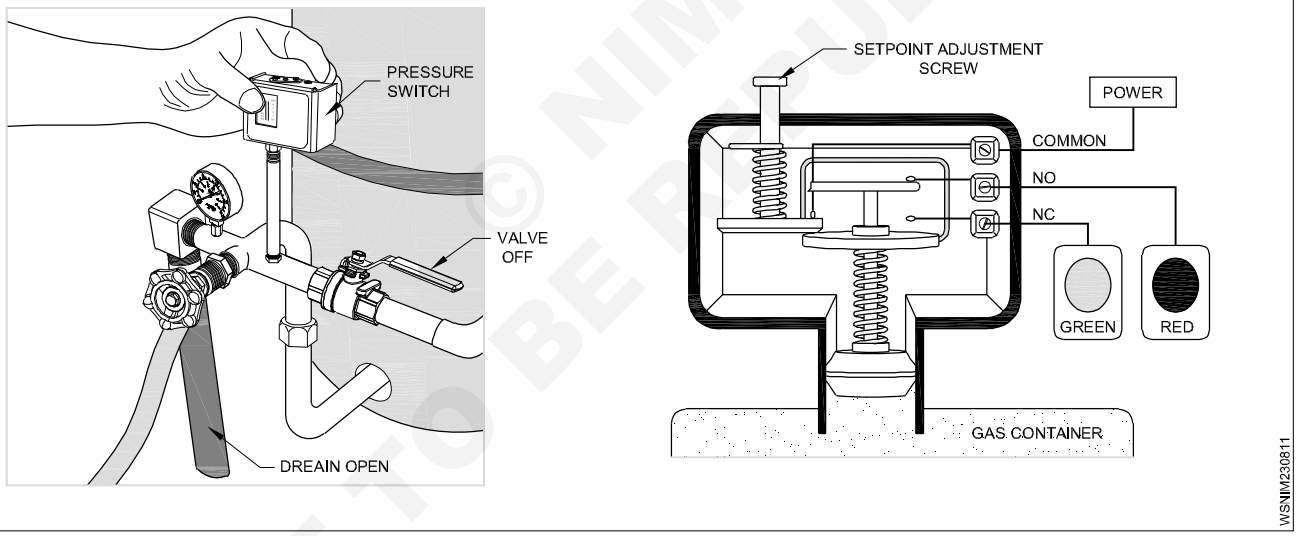
Tools/Instruments

- Compressor (0- 10) kg/cm^2 - 1 No.
- Pressure switch psi mechanical - 1 No.
- Ball valve - 1 No.
- Solenoid valve 230 V AC - 1 No.
- Foot pump (0-5) Kt / cm² - 1 No.
- Pressure gauge (0- 30) psi - 1 No.
- Spanner - 1 No.
- Foot pump outlet needle valve - 1 No.

Materials

- Nylon PVC tube 6 mm - 10 meters.
- Pneumatic Fittings – Linear elbow, T connector - each 2 Nos.
- Teflon tape - 1 Roll
- Connecting wires - as reqd.
- Insulation tape - 1 No.

Fig 1



1 Fix all the Flow transmitters in vertical position as shown in figure.

2 Connect red and green bulb with compressor.

3 Apply pressure from compressor to pressure switch.

4 Check whether the pressure switch is working or not.

NO --> Normally opened

NC --> Normally closed

5 Note: Red bulb is connected to normally closed contact when 230V supply is given; Red bulb will glow. If we increase the pressure to set point normally close contact is changed to normally open, then the green bulb will glow.

Be careful with AC supply

6 Connect starter in compressor, pressure switch, AC supply and motor as shown in figure and check with instructor.

7 observe air supply from the compressor to switch and relief valve.

8 Confirm the pressure switch is connected in AC normally close contact by giving 230V supply.

9 Observe when set point reaches 60 psi normally close contact in pressure switch is changed to normally open and compressor is switched off.

10 Observe when set point reaches 40 psi the compressor is switched on, check the work done by instructor.

1	Cost of Pressure switch	=	Rs. 200
2	Cost of Pressure relief valve	=	Rs. 700
3	Materials cost	=	Rs. 800
	Total cost	**=**	**Rs.1700**

Estimation and Costing - Simple estimation of the requirement of material etc., as applicable to the trade - Fault and rectification of calibration of ultrasonic flow meter

Fault and rectification of calibration of ultrasonic flow meter. (Fig 1)

Tools - Service Persons - Owns

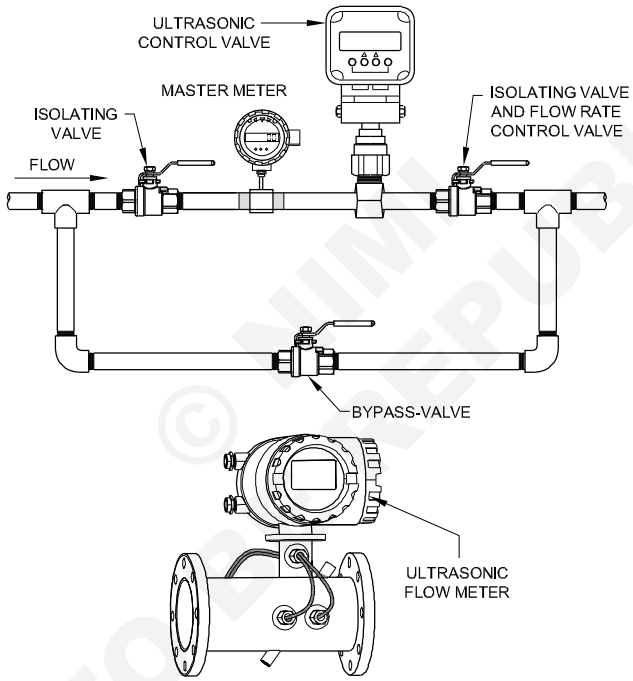
Tools/Instruments

- Tool kit - 1 set.
- Flow meter - 1 No.
- Water tank 500 litre - 2 nos.
- Pipe tank - as reqd.
- Isolation valve required - 2 Nos.

Materials

- Teflon tape - 1 No.
- Cleaning cloth - 1 No.

Fig 1



1 Fix the Flow transmitters in vertical position as shown in figure.

2 Place the valves, and regulators far away from the beams of ultrasonic flow meter.

3 Fix the isolating valves in upstream and down stream side.

4 Connect ultrasonic flow meter in the bypass line as shown in figure and check the leaks.

5 Connect ultrasonic flow meter with master flow meter as shown in figure and check the leakage in the setup.

1	Cost of Ultrasonic flow meter	=	Rs.1500
2	Material cost	=	Rs. 200
	Total cost	**=**	**Rs.1700**

Estimation and Costing - Simple estimation of the requirement of material etc., as applicable to the trade - Fault and rectification of calibrating quantitative flow meter

Fault and rectification of calibrating quantitative flow meter. (Fig 1)

Tools - Service Persons - Owns

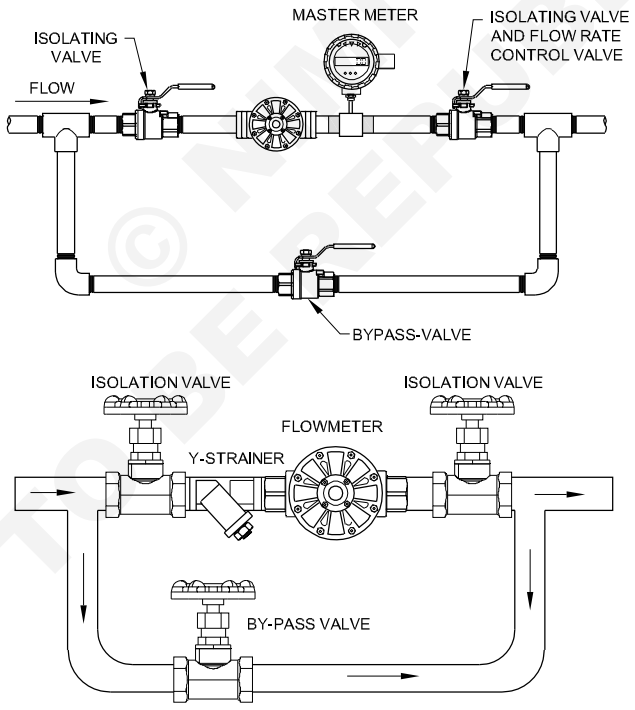
Tools/Instruments

- Tool Kit - 1 No.
- Oscillating piston type flowmeter 0 - 1000lph - 1 No.
- Lobed impeller type flowmeter 0 - 200lph - 1 No.
- Rotating vane type flowmeter 0 - 500 lph - 1 No.
- Oval type flowmeter 0 - 400lph - 1 No.
- Pointer puller - 1 No.
- Pipe wrench Adjustable - 1 No.

Materials

- Teflon tape - 1 No.
- Mulmul cloth - as reqd.
- CTC (Carbon Tetra Chloride) Solution - as reqd.

Fig 1



1 Fix the positive displacement flow meter in horizontal or vertical position as shown in figure.

2 Ensure that the flowmeter is always filled with water by applying 2-3 psi back pressure.

3 Fit the meter by seeing the arrow on the meter.

4 Verify that the gears are Rotating freely before installing flowmeter.

5 Remove the dusts inside the pipeline.

6 Check the flowmeter is fully filled with water.

7 Maintain the flowmeter by applying 2 to 5 psi back pressure.

8 Connect flowmeter Via by pass valve and pipeline to water.

9 Easy to install Sensor after installation of flow meter.

10 Connect the tested flowmeter as shown in figure with master for calibration.

11 Switch ON the pump.

12 Open v1 valve and close v2 valve.

13 Record the readings of test flow meter and master flowmeter.

14 Close v1 valve, open v2 valve and switch 'OFF' the pump.

1	Cost of Flow meter	=	Rs. 4500
2	Material cost	=	Rs. 300
	Total cost	**=**	**Rs. 4800**

Estimation and Costing - Problems on estimation and costing - Servicing and maintenance of mechanical tachometer

Servicing and maintenance of mechanical tachometer. (Fig 1)

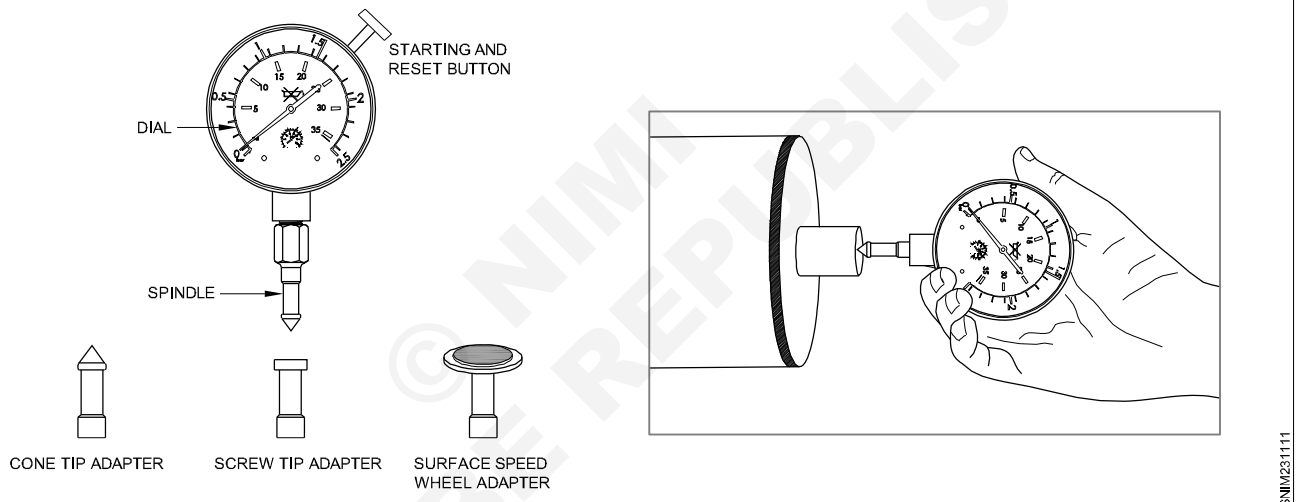
Tools/Measuring Instruments - Service Persons Owns

- Tester - 1 No.
- Drag cup tachometer (0-600) rpm - 1 No.
- Motor (single phase) (1400) rpm - 1 No.
- Variable transformer - 1 No.
- Electrical tachometer (0-1500) rpm - 1 No.
- Screwdriver - 1 Set.
- Multimeter - 1 No.

Materials

- Cleaning cloth - as reqd.
- Cleaning brush - 1 No.
- Carbon tetrachloride - as reqd.

Fig 1



1 Clean the given mechanical tachometer.

2 Keep it on the working table.

3 Dismantle the mechanical tachometer.

4 Identify its parts and list the parts.

5 Clean the defective parts of the tachometer using carbon tetrachloride solution.

6 Replace starting and reset button.

7 Reassemble the parts and check all the parts.

8 Connect mechanical tachometer.

9 Switch on the motor.

10 Vary the speed of motor using variable transformer.

11 Note down different reading of tachometer.

Service Charge = Rs.800

Estimation and Costing - Problems on estimation and costing - Servicing and maintenance of electrical tachometer

Servicing and maintenance of electrical tachometer. (Fig 1)

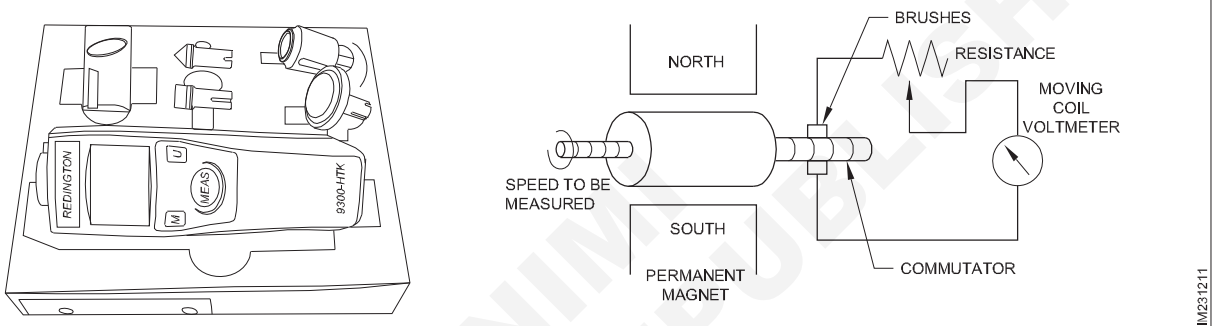
Tools/Measuring Instruments - Service Persons Owns

- Tester - 1 No.
- Drag cup tachometer (0-600) rpm - 1 No.
- Motor (single phase) (1400) rpm - 1 No.
- Variable transformer - 1 No.
- Electrical tachometer (0-1500) rpm - 1 No.
- Screwdriver - 1 Set.
- Multimeter - 1 No.

Materials

- Cleaning cloth - as reqd.
- Cleaning brush - 1 No.
- Carbon tetrachloride - as reqd.

Fig 1



1 Ensure that the tachometer is disconnected from any power source.

2 Opening the tachometer - Using the appropriate screwdriver, carefully remove the screws holding the tachometer casing together.

3 Inspection - Inspect the internal components for any signs of damage, loose connections, or dirt accumulation.

4 Cleaning - Using the cleaning solution and a soft cloth or a cotton swab, clean the internal components of the tachometer. Pay extra attention to any areas that seem dirty or contaminated.

5 Lubrication - Apply a small amount of appropriate lubricating oil to any moving parts or rotating components. This will ensure smooth and reliable operation.

6 Testing - Put on your safety gloves and goggles. Connect the tachometer to a power source and use a multimeter to test its functionality. Look for any abnormal readings or malfunctions.

7 Reassembly - Once you're satisfied with the tachometer's performance, carefully reassemble the casing using the screws. Make sure everything is snug and secure.

8 Calibration - Periodically calibrate the tachometer to ensure its accuracy. The calibration frequency will depend on the manufacturer's recommendations and the level of accuracy required for your specific application.

Service Charge = Rs.800

Estimation and Costing - Problems on estimation and costing - Dismantling, checking overhauling and calibration of DP

Dismantling, checking overhauling and calibration of DP (Fig 1)

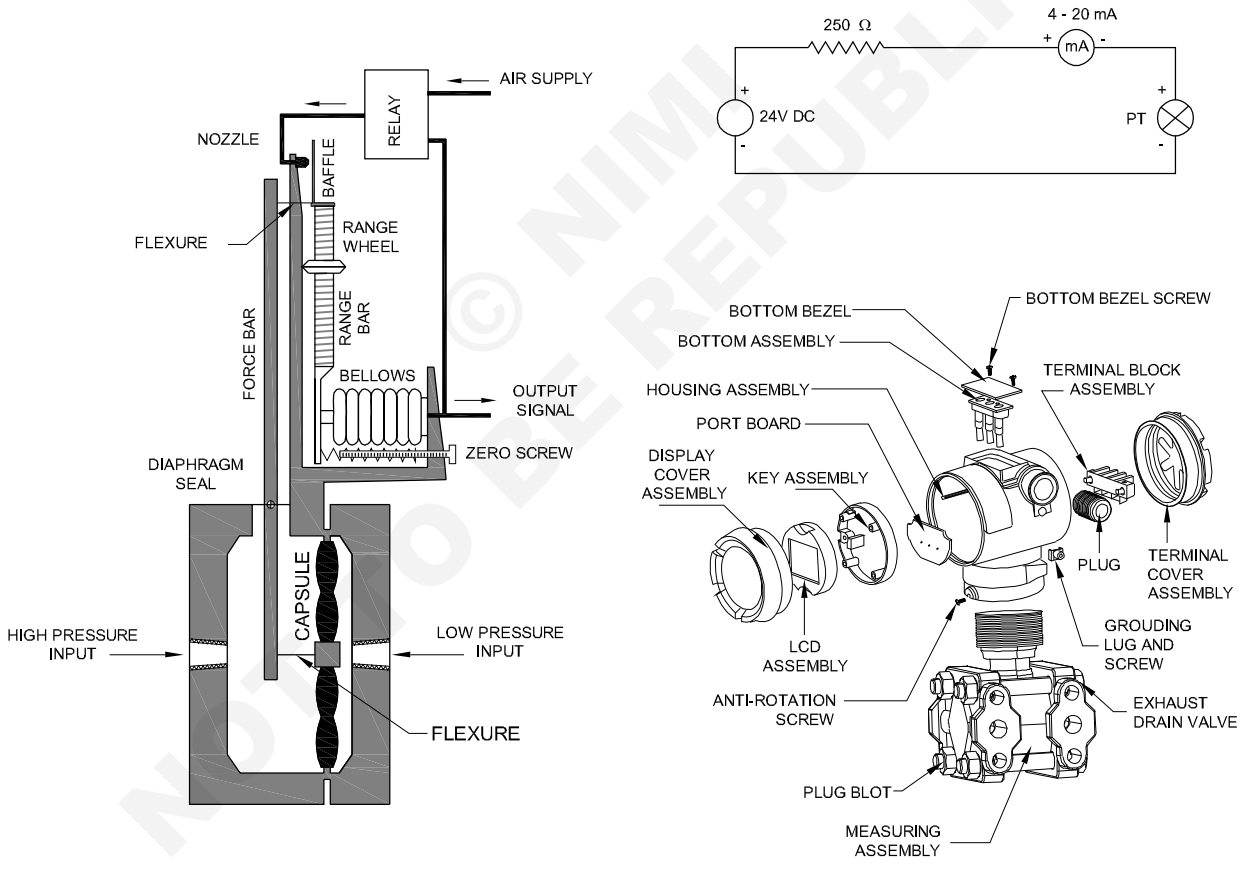
Tools/Instruments - Service persons owns

- Tool Kit - 1 No.
- Electronic DPT - 1 No.
- Pneumatic DPT - 1 No.
- RPS (0-30) VDC - 1 No.
- Foot pump (0.5) kg/cm^2 - 1 No.
- Pressure gauge (0-2)kg/cm^2 - 1 No.
- Multi meter with probe - 1 No.

Materials

- PVC tubes 8 mm - 2 mts.
- Connecting wires - 2 Meters.
- Pneumatic Fittings - as reqd.

Fig 1



Dismantling, checking and calibrating pneumatic DPT pneumatic and electronic transmitter

1 Remove DPT Transmitter from the service line.

2 Close the air supply valves.

3 Dismantle the DP transmitter and observe the parts ie Link, air tubes, flapper nozzle, diaphragm condition.

4 Replace the dejected parts with the help of instructor.

5 Clean the input parts and output parts of DPT and then assemble.

6 Give air supply 20 psi from foot pump to DPT.

7 Adjust the zero and span parts of DPT and verify that the minimum pressure is in 3 psi & maximum pressure is in 15 psi.

Electronic DPT

8 Remove the Electronic DPT from the supply.

9 Remove front and back cover of DPT using proper tools.

10 Dismantle the electronic DP transmitter and observe the dejected parts.

11 Replace the dejected parts.

12 Clean the input parts and output parts of Electronic DPT and then assemble it.

13 Connect the DPT.

14 Give 24v /DC supply to DP transmitter.

15 Adjust zero and span in DPT and then verify that the minimum output is in 4 mA and maximum output is in 20mA.

Service Charge = Rs.1000

Estimation and Costing - Problems on estimation and costing - Identify and carry out maintenance & preventive maintenance of solid flow measuring system

Identify and carry out maintenance & preventive maintenance of solid flow measuring system. (Fig 1)

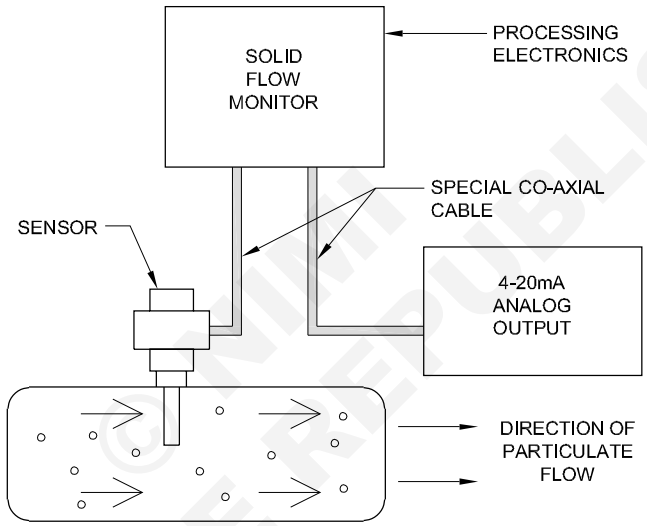
Tools/Measuring Instruments - Service Persons Owns

- Microwave solid flow meter - 1 No.
- Solid trainer - 1 No.
- Trainees tool kit - 1 No.
- Multi meter with probe - 1 No.

Materials

- Teflon tape - 1 No.
- Solid - as reqd

Fig 1



Service microwave solid flowmeter

1 Clean the given microwave solid flow meter and keep it on the working table.
2 Note down the defects physically present in the meter
3 Remove the outer cover using suitable tool.
4 Check the continuity of microwave solid flow meter using multi meter.
5 Change the probe of flow meter if it is not working.
6 Change the defect parts.
7 Reassemble the flow meter and check
8 Connect assembled flow meter in solid flow.
9 Note down the readings in table.
10 Do calibration if the readings are not within accuracy.

Cost for Replace flow meter	=	Rs.1500
Service charge	=	Rs.1000
Total cost	**=**	**Rs.2500**

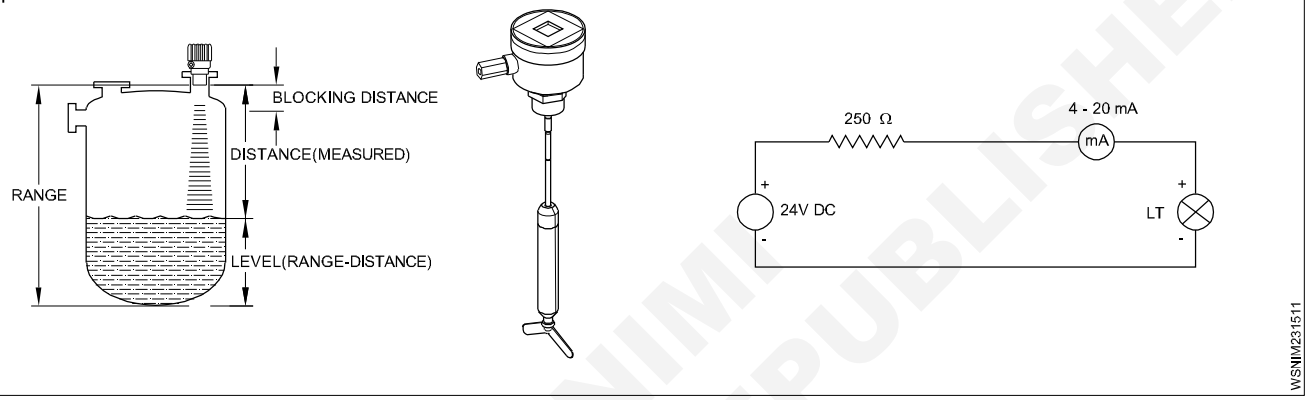
Estimation and Costing - Problems on estimation and costing - Service and calibrate various types of solid level indicating transmitters and sonic level detector

Service and calibrate various types of solid level indicating transmitters and sonic level detector. (Fig 1)

Tools/Measuring Instruments - Service Persons Owns

- Tool kit - 1 No.
- Tank - 1 No.
- Radar instrument transmitter - 1 No.
- Different types of solid indicator transmitter - 1 No.
- Solid state trainer - 1 No.

Fig 1



Fix the radar transmitter on the top of the tank

1 Follow the instructions below to install the radar transmitter.

i Install the conical shape tank at a distance of one meter as shown in figure.

Note:During measuring if there is any disturbance the sensitivity of the radar transmitter will be affected.

ii To ensure are butt joint flange spray and washer to keep radar transmitter stationary.

iii Fix the radar transmitter on the top of the tank.

iv Align the conveyor system horizontally.

2 Check any leakage in the transmitter.

3 Give the 24v DC supply to transmitter.

4 Note the transmitter output (4mA) when the tank is empty.

5 Turn on the conveyor system and fill the tank with 25% solids.

6 Switch on the transmitter and note the output.

7 Fill the tank 50%,60%,70%,80%,100% and record the transmitter output.

8 Repair Method

- Note any damages on the outside of the transmitter.
- Use the suitable tools to remove the transmitter.
- If any parts are damaged replace them and assemble using proper tools.

9 Calibration method

- Connect transmitter input with 24 volt DC supply and output with current meter (mA).
- Set the transmitter output 4 mA (zero) when the tank is empty (0%).
- Set the transmitter output 20mA (SPAN) by filling the solids in the tank fully (100%).
- Repeat the above steps 4 or 5 times and calibrate it.
- Check the work.

Service and calibrate of solid level indicating transmitter and sonic level detector = **Rs.2000**

Estimation and Costing - Problems on estimation and costing - Service and calibrate various types of thermometers and switches

Service and calibrate various types of thermometers and switches. (Fig 1)

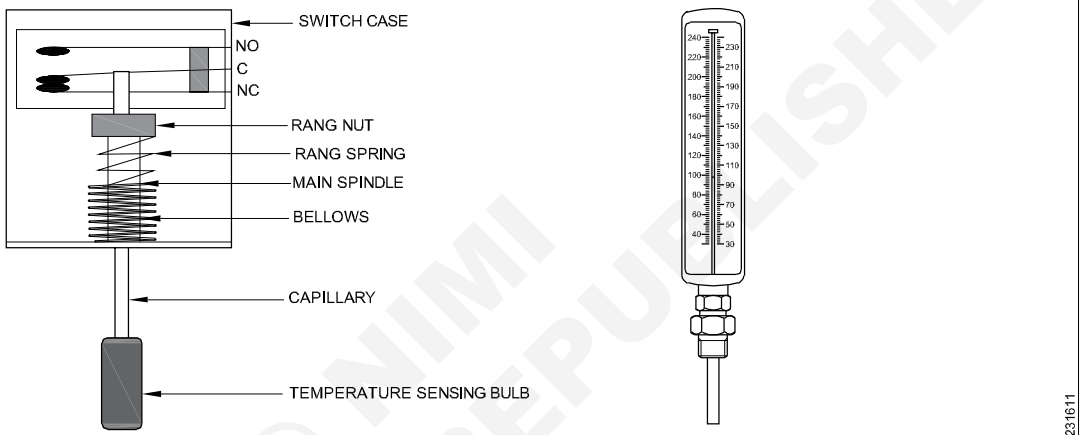
Tools/Measuring Instruments - Service Persons Owns

- Mercury filled thermometer - 1 No.
- Thermal switch - 1 No.
- Oil bath - 1 No.
- Multimeter - 1 No.

Materials:

- Cotton waste - as reqd.
- Radar instrument transmitter - 1 No.

Fig 1



1 Clean the working table.

2 Clean the given thermo switch and keep it on the table.

3 Note down the defects on thermo switch by physical visual inspection.

4 Dismantle thermo switch using proper tools.

5 Replace the dejected Parts and check.

6 Reassemble the thermo switch.

7 Fill up the parts of thermo switch in the blocks as shown in figure.

8 Follow the points below to install thermo switch.

- Select suitable thread/adoptor to fix thermo switch with the medium.
- Seal all the joints with sealing components.
- Use pressure relief / safety valve arrangement.

9 Connect red, green bulb, and temperature switch and then insert the switch into the furnace/water bath.

10 Connect 230v AC supply to bulbs.

11 Switch ON furnace / water bath and AC supply .

12 Red bulb is connected to NC Contact, when 230 v/AC supply is given Red bulb will glow.

- When furnace reaches maximum set temperature NC Contact changed to NO so green bulb will glow.
- Precaution: Becareful when working in AC supply.

13 Insert thermo switch in the furnace/water bath and do calibration.

14 Adjust the knob and set 60°C in thermo switch.

15 Fill 3/4th of water in the kettle.

16 Insert thermo switch and bimetallic thermometer into the kettle.

17 Connect bulb to NO contact of thermo switch and give 230v AC supply to bulb.

Service and calibration charges for thermometer and switches } = Rs.1500

Estimation and Costing - Problems on estimation and costing - Service and calibrate various types of RTD transmitters using temperature calibrator or resistors

Service and calibrate various types of RTD transmitters using temperature calibrator or resistors. (Fig 1)

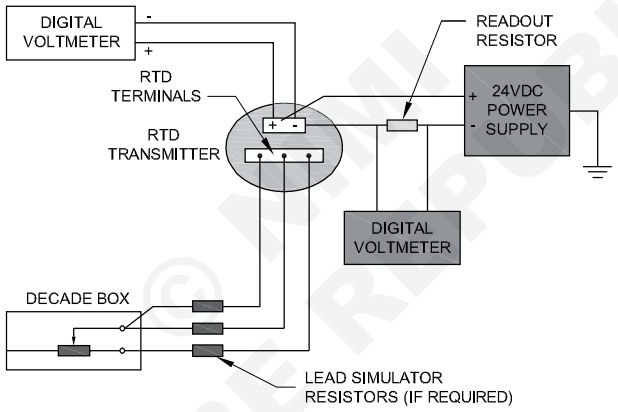
Tools/Measuring Instruments - Service Persons Owns

- PT 100 Ω RTD - 1 No.
- Copper RTD - 1 No.
- Multi meter with probe - 1 No.
- Temperature transmitter - 1 No.
- Screw driver 150mm - 1 No.
- Digital voltmeter - 1 No.
- 24 V DC Power source - 1 No.
- 5 Dial resistance decade box 100Ω steps - 1 No.

Materials

- Cleaning cloth - as reqd.
- White petrol - as reqd.
- Wires - as reqd.

Fig 1



Calibrate various types of RTD transmitter using resistor.

1 Locate the RTD transmitter terminal by removing the housing cover.

2 Remove all the RTD lead connection if RTD is already connected.

3 Determine the RTD resistance at base (0°) and full scale temperatures.

4 Turn the power supply ON.

5 Set the resistance decade box to the resistance that corresponds to the base temperature.

6 Adjust the zero pot (potentiometer) of transmitter until the output is 4 mA.

7 Set the resistance decade box to the resistance that corresponds to the full scale temperature.

8 Adjust the span pot (potentiometer) of transmitter until the output is 20 mA.

9 Repeat the above steps until 4 mA and 20mA reading are obtained without read just span and zero potentiometers.

Service and calibration of RTD Transmitter = Rs.1000

Estimation and Costing - Problems on estimation and costing - Service & test and use electromechanical and solid state relay

Service & test and use electromechanical and solid state relay. (Fig 1)

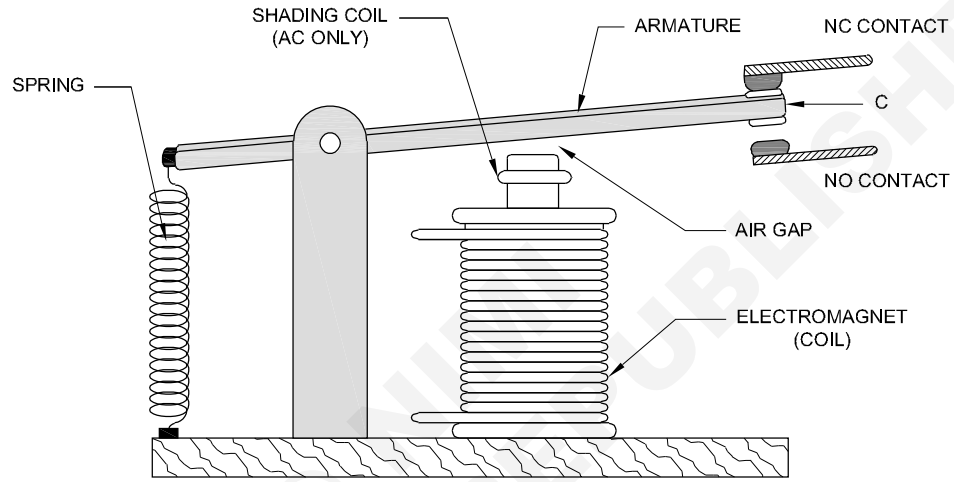
Tools/Measuring Instruments - Service Persons Owns

- Electro mechanical Relay - 1 No.
- Screw driver - 1 No.
- Multimeter - 1 No.

Materials

- Cotton waste - 1 No.
- Cleaning solution for electrical contacts - 1 No.

Fig 1



1 Remove the relay cover.

2 Inspect for cracks or frame tightness.

3 Check the covers and glass.

4 Check for loose contacts.

5 Check the resistance of the coil.

6 Check the NO / NC contact charge over where the relay energized.

Service and test Electromechanical solid state relay charges } = Rs.1000

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Estimation and Costing - Problems on estimation and costing - Service and test different types of valves

Service and test different types of valves. (Fig 1)

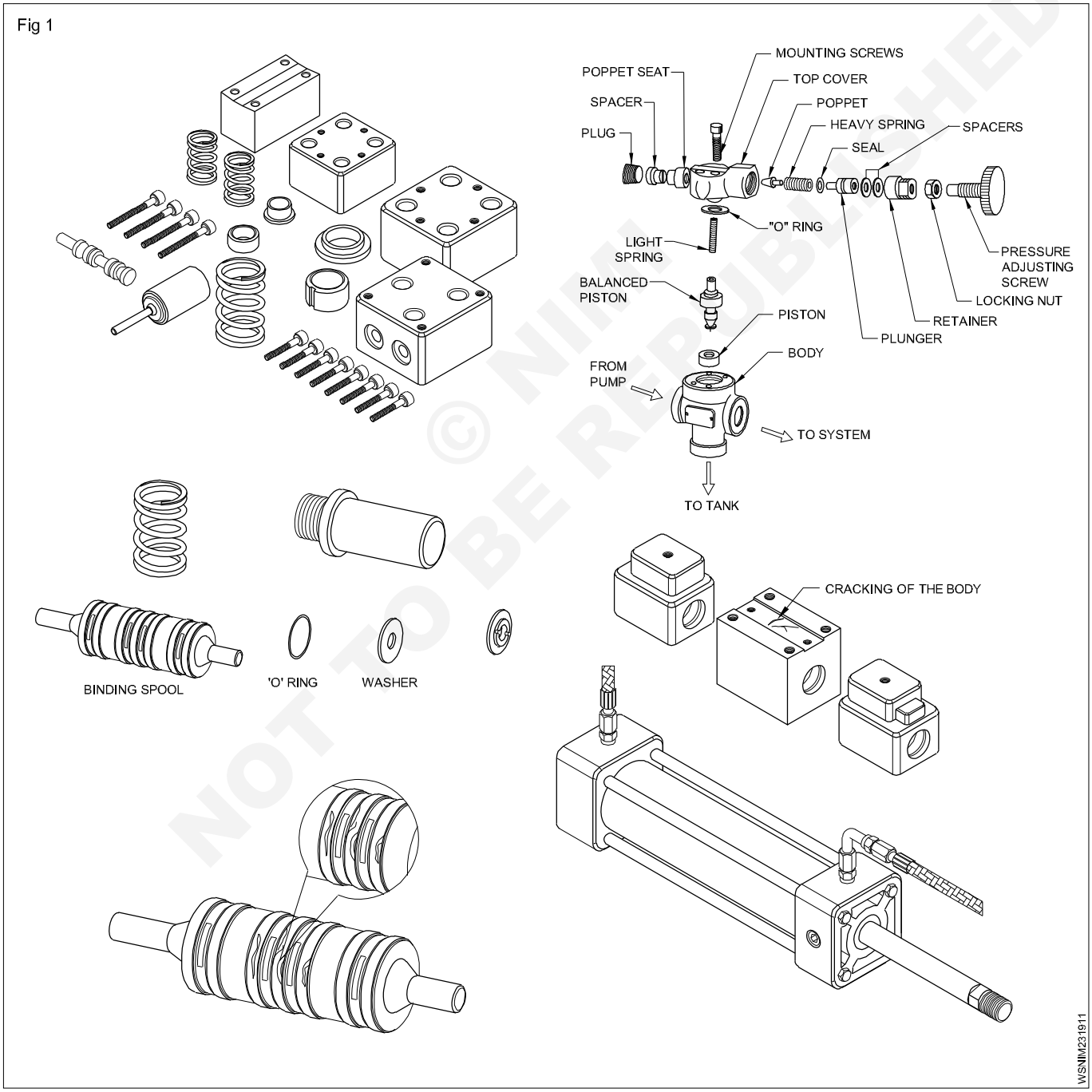
Tools/Measuring Instruments - Service Persons Owns

- Direction Control Valve
- Different types of control Valve - 1No.
- Hydraulic Kit - as reqd.
- Hydraulic Source

Materials

- PVC Tube - as reqd.
- Muslin Cloth - as reqd.

Fig 1



Servicing different types of hydraulic valves

1 Clean the working table.

2 Clean the given valves with a cloth and place it on the table.

3 Check the valves for any defects, if any defects are present then note the defects.

4 Arrange the dismantled parts in order.

5 Understand and study the parts of given valve.

6 Following are the defects that could occur in valves Damage of spool.

- Damage of "O" ring
- Binding of spool
- Cracking of Body
- Wearing of washer

7 Note down the defects.

8 Replace the defected parts.

9 Assemble the valves in reverse order.

10 Do the same procedure for different valves available in your lab.

11 Check the work done.

1	Cost of 'O' ring	=	Rs. 100
2	Cost of Binding spool	=	Rs. 500
3	Cost for Cracking body replaced	=	Rs. 1000
4	Cost of Washer	=	Rs. 100
5	Service charge	=	Rs. 1000
	Total cost	**=**	**Rs. 2700**

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