SYLLABUS

2nd Year **Common for All Engineering Trades under CTS (For All 2 year Trades)** **Duration: One Year**

S.no.	Syllabus	Time	Marks
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	14	7
II	**Centre of Gravity** 1 Centre of gravity and its practical application	6	4
III	**Area of cut – out regular surfaces and area of irregular surfaces** 1 Area of cut – out regular surfaces – circle, segment and sector of circle 2 Related problems of area of cut – out regular surfaces – circle, segment and sector of circle 3 Area of irregular surfaces and application related to shop problems	16	9
IV	**Algebra** 1 Addition, Subtraction, Multiplication & Divisions 2 Algebra – Theory of indices, Algebraic formula, related problems	12	8
V	**Elasticity** 1 Elastic, plastic materials, stress, strain and their units and young's modulus 2 Ultimate stress and working stress	9	4
VI	**Heat Treatment** 1 Heat treatment and advantages 2 Different heat treatment process – Hardening, Tempering, Annealing, Normalising, Case Hardening	3	3
VII	**Profit and Loss** 1 Simple problems on profit & loss 2 Simple and compound interest	12	8
VIII	**Estimation and Costing** 1 Simple estimation of the requirement of material etc., as applicable to the trade 2 Problems on estimation and costing	12	7
	Total	84	50

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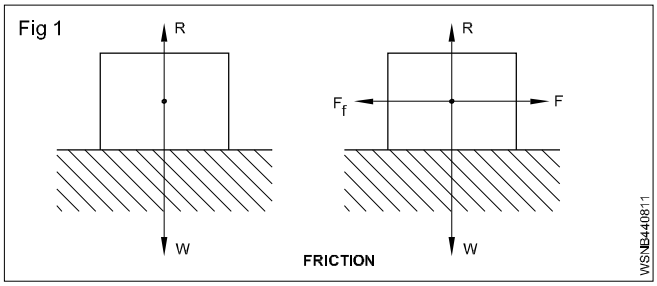
Friction - Advantages and disadvantages, Laws of friction, co-efficient of friction, angle of friction, simple problems related to friction Exercise 2.1.01

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.



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

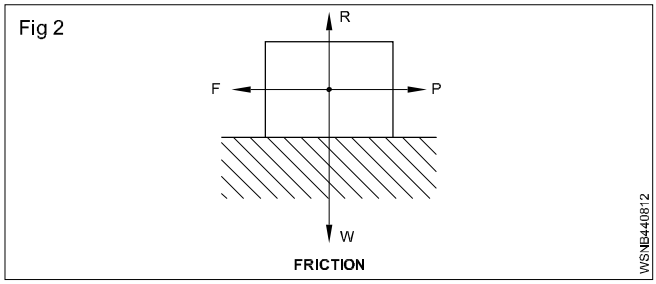
It is the friction that occurs when a circular object such as a ball or roller rolls on a flat surface. Rolling friction is less than sliding friction. (ball or roller bearing)

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)

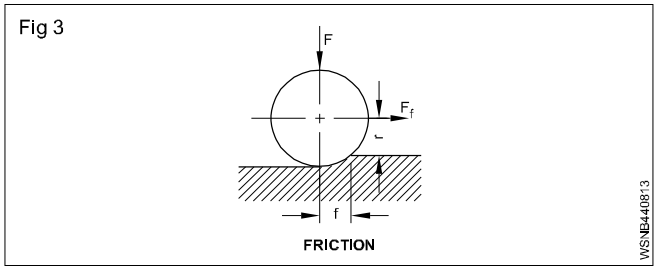
When the body is about to move W=R, F=P

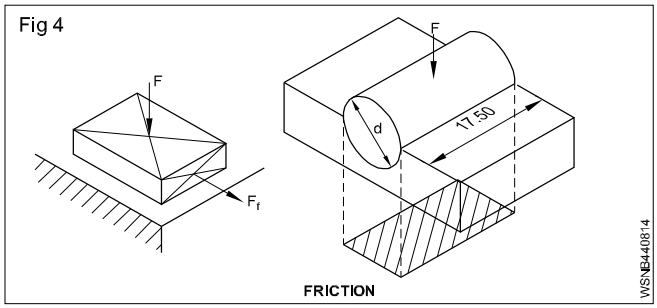
When pulling force is increased the body starts to move.



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.





Coefficient of friction

It is a ratio between the frictional force to the normal reaction when the body is just about to move but at equilibrium. It is represented by symbol μ. (read as 'meu')

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Therefore

$$\text{Co - efficient of friction} = \frac{\text{Limiting friction(or)force}}{\text{normal reaction(or) weight}}$$

$$\mu = \frac{F}{W} (\text{or}) \frac{F_f}{R}$$

Angle of friction (Fig 5)

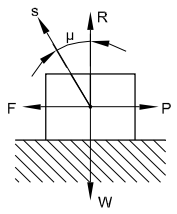
The forces acting on a body when it is just about to move by the application of a pulling force are W, R, P and F. The forces 'R' and 'F' are compounded and we get the resultant force 'S'. The angle formed by 'S' with 'R' is the angle of friction.

Therefore

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

$$\tan \theta = \mu$$

Fig 5



FRICTION

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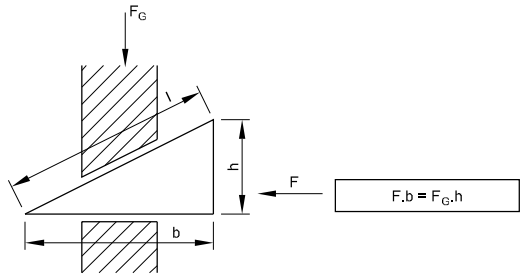
Angle of repose (Fig 6)

Fig 6



ANGLE OF REPOSE

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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.

Motion up the plane

When $\theta > \phi$ a force must be applied to keep the body in equilibrium. The applied force may be parallel to the plane, horizontal or at an angle to the plane itself.

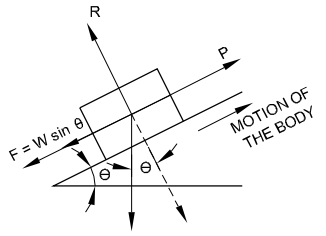
When the body is at the point of motion up the plane the frictional force 'F' acts down the plane.

Forces acting are W,R,P and F. The weight force 'W' is resolved into two components of W cos θ perpendicular to the plane acting downwards and W sin θ acting parallel to the plane downwards.

$$\frac{F}{R} = \mu = \tan \phi$$

Where ϕ is the angle of friction.

Fig 7



MOTION UP THE PLANE

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$\therefore$ P = F + W sin θ and R = W cos θ

$\therefore$ P = uR + W sin θ = u(W cos θ) + W sin θ

$\therefore$ P = W x tan ϕ cos θ + W cos θ

$$= W \times \frac{\sin \phi}{\cos \phi} \times \cos \theta + W \cos \theta$$

$$= W \times \frac{\sin \phi + \cos \theta + W \cos \phi \times \cos \theta}{\cos \phi}$$

$$= W \frac{[\sin (\theta + \phi)]}{\cos \phi}$$

Similarly when the body is about to slide down the plane the applied force P must be equal to

$$= W \frac{[\sin (\theta + \phi)]}{\cos \phi}$$

To keep the body under equilibrium when the body is about to move up the plane by the action of an applied force the applied force $P = W \frac{[\sin (\theta + \phi)]}{\cos \phi}$ and the force necessary to be applied to the body to prevent it from sliding down the plane will be $P = W \frac{[\sin (\theta + \phi)]}{\cos \phi}$

Note : Under all circumstances

$$= W \frac{[\sin (\theta + \phi)]}{\cos \phi} < P < = W \frac{[\sin (\theta + \phi)]}{\cos \phi}$$

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.

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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.

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 meter/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.

μ = 0.24 = Co-efficient of friction

W = 20 kg = Weight

F = ? = Force required

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

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

F = 20 x 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.

μ = 0.28 = Co-efficient of friction

W = 14500 kg = Weight

F = ? = Force friction

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

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

F = 0.28 x 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.

F = 800 gm = Force

W = 3200 gm = Weight

μ = ?

Co-efficient of friction = ?

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

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

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?

F = 40 kg = Force

W = 80 kg = Weight

μ = ?

Co-efficient of friction = ?

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

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

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?

W = 10 kg = Weight

F = 2 kg = Force

μ = ?

Co-efficient of friction = ?

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

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

μ = 0.2

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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?

W = 100 kg = Weight

F = 30 kg = Force

μ = ?

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?

W = 10 kg = Weight

F = 2.5 kg = Force

R = ?

Normal reaction = W

Limiting friction = ?

μ = ?

R = Normal reaction = 10 kg

Limiting friction = F = 2.5 kg

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

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

μ = 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.

W = 10 kg = Weight

μ = 0.3 = Co-efficient of friction

F = ? = Force

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

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

F = 100 x 0.3

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.

W = 150 kg = Work done

μ = 0.25 = Co-efficient of friction

θ = ?

F = ? = Force

μ = tan θ = 0.25

θ = $\tan^{-1}$ 0.25

= 14° 2'

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

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

F = 0.25 x 150

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.

μ = 0.2 = Co-efficient of friction

W = 60 kg = Weight

S = 5 m = Distance

W = ? = Work done

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

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

F = 60 x 0.2

= 12 kg

Work done = Force x distance = F x S

= 12 x 5

= 60 m - Kg.

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

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?

F = 30 N = Force

W = 35 kg = Weight

1 kg = 9.8 N

35 Kg = 9.8 x 35 = 343 N

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

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

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

μ **= 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 $\qquad \frac{F}{W} = \mu = \tan\theta$

μ = tan θ = tan 30º

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.

W = 980 kg = Weight

μ = 0.09 = Co-efficient of friction

F = Force = ?

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

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

F = 0.09 x 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.

W = 10 kg = Weight

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

= 2.54 kg

17 Calculate the angle of inclination, if a weight of 150 kg is in equilibrium. Coefficient of friction is 0.25. Calculate the force of normal reaction also.

θ = ? = angle of inclination

W = 150kg = Weight

μ = 0.25

F = ? = Force

tan θ = μ

tan θ = 0.25

θ = 14º 2'20"

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

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

F = 0.25 x 150 kg

F = 37.5 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 meter.

W = 10kg = Weight

μ = 0.15 = Co-efficient of friction

S = 10 meter = distance

W = Work done = ?

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

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

F = 0.15 x 10 kg

F = 1.5 kg

Work done = W = F x S

= 1.5 kg x 10 m

= 15 m - kg

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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 place 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 is 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 meters.

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

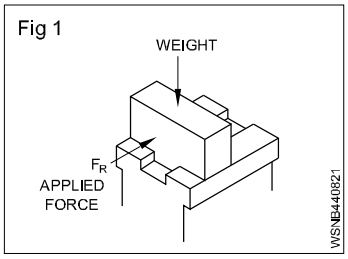
Rate of moment of the table=0.5 m/sec

Co-efficient 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

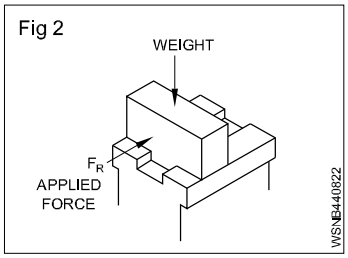
μ (static) = 0.16

μ (dynamic) = 0.012

F_R to overcome static friction = _____ N

F_R to overcome dynamic friction = _____ N

2

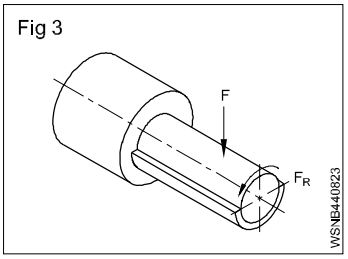


mass = 250 kg

F_R = 160 N

μ = _____

3



F = 5000 N

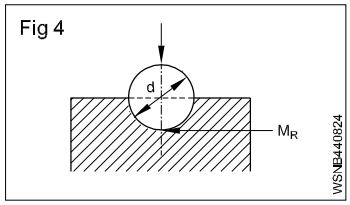
μ (dry) = 0.03

μ (fluid friction) = 0.01

F_R when dry = _____ N

F_R when lubricated = _____N

4



F = 1.2 kN

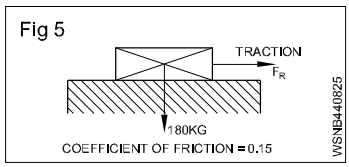
d = 60 mm

μ = 0.03

Frictional torque M_R = _____ Nm

(Frictional torque = Frictional force x radius)

5

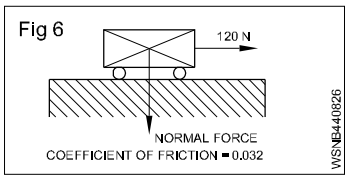


mass = 180 kg

μ = 0.15

F_R = _____ N

6

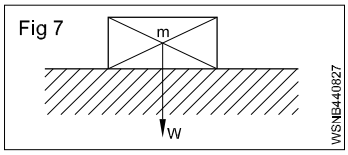


F_R = 120 N

μ = 0.032

Normal force F = _____ N

7



m = 1000 kg

μ = 0.4

Force required to move F_R = _____ N

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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 q is the angle of friction.

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

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

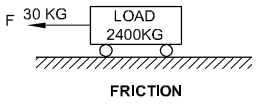
5 What is the formula for Co-efficient of friction (m).

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

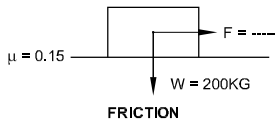


A 0.0215 B 0.0152

C 0.0125 D 0.0251

7 Calculate the pulling force required for the figure shown.

Fig 2



A 27 Kg B 28 Kg

C 29 Kg D 30 Kg

8 Determine the co-efficient of friction() 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

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 using for reduce the friction.

A lubricants B sand

C coal D coolant

Key Answers

A

1 0.1275
2 240 Kg
3 12.5 Kg
4 3.75 Tonne
5 40 m-kg
6 60 m-kg
7 F = 600 Kg
P = 16 HP
8 185.2 HP
9 1.4 HP
10 3600 Kg

B

1 288N, 21.6 N
2 0.065
3 150 N, 50 N
4 36 N, 1.08 Nm
5 264.6 N
6 3750 N
7 3920 N

C MCQ

1 C
2 D
3 B
4 A
5 B
6 C
7 D
8 C
9 B
10 A

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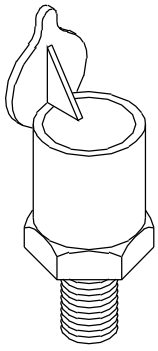
There are 3 systems of lubrication.

- 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

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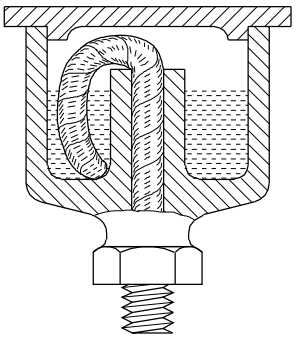
Fig 2



WICK FEED

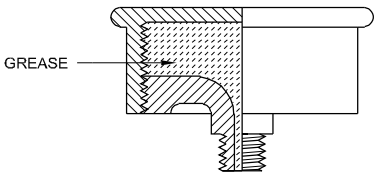
WSNB440912

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

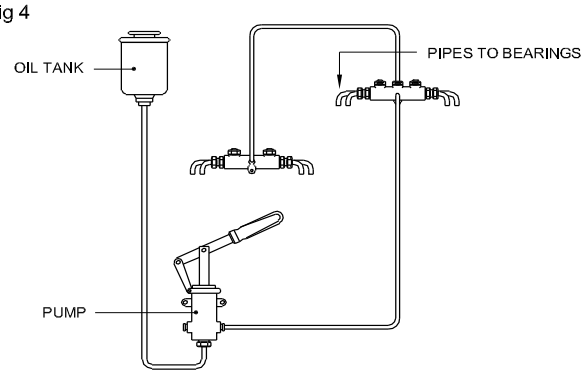


MANUAL SCREW DOWN GREASER

WSNB440913

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)

WSNB440914

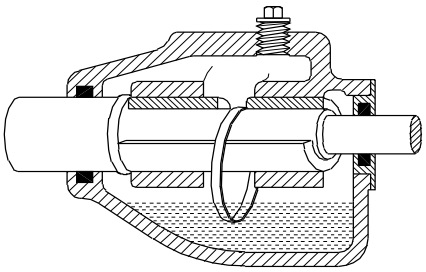
Oil pump method

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

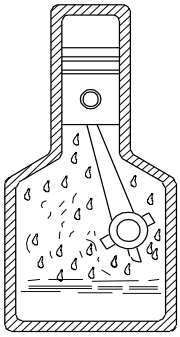


RING OILING

WSNB440915

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

WSNB440916

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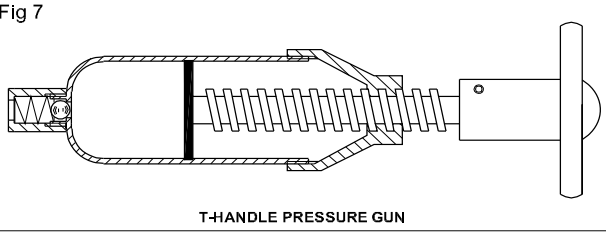
Types of grease guns

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

- 'T' handle pressure gun (Fig 7)

Fig 7

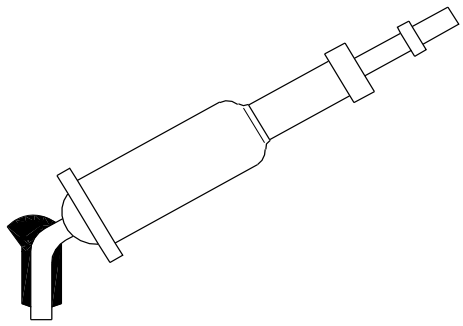


T-HANDLE PRESSURE GUN

WSNB440917

- Automatic and hydraulic type pressure gun (Fig 8)

Fig 8

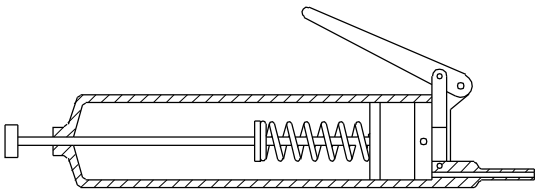


AUTOMATIC HYDRAULIC-TYPE PRESSURE GUN

WSNB440918

- Lever-type pressure gun (Fig 9)

Fig 9



PRESSURE GREASE GUN

WSNB440919

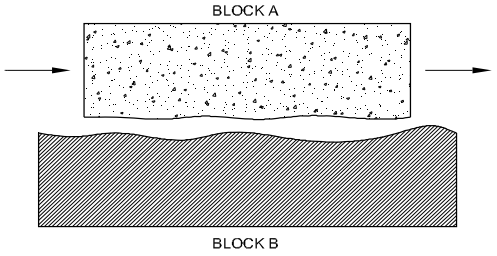
Lubrication to exposed slideways

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

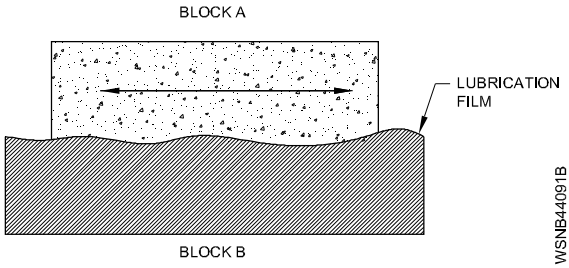


WSNB44091A

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

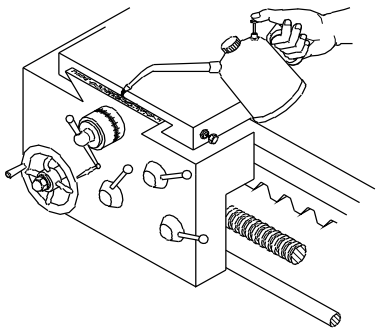
The slideways are lubricated frequently by an oilcan. (Fig 12)

Fig 11



WSNB44091B

Fig 12

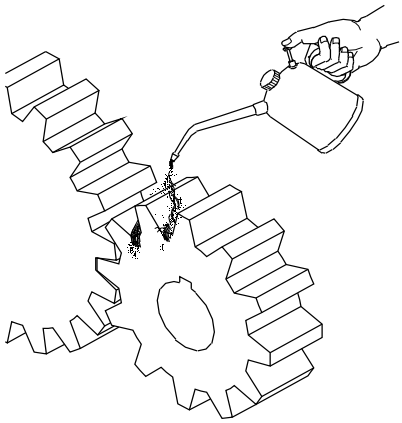


OIL THE SLIDES FREQUENTLY

WSNB44091C

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

Fig 13



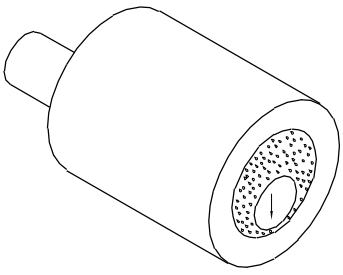
WSNB44091D

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



WSNB44091E

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)

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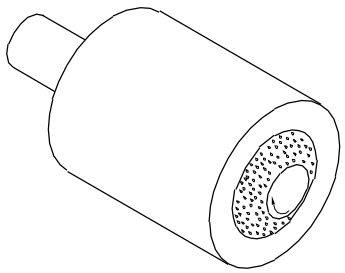
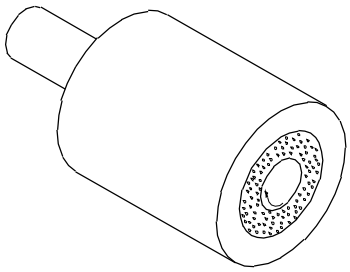
Fig 15



WSNB44091F

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

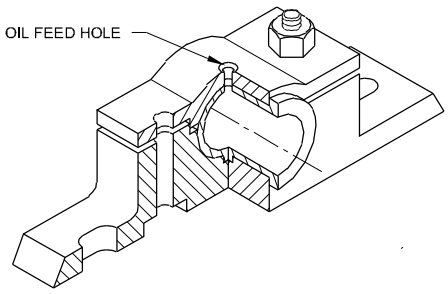


WSNB44091G

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



WSNB44091H

Hints for lubricating machines:

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

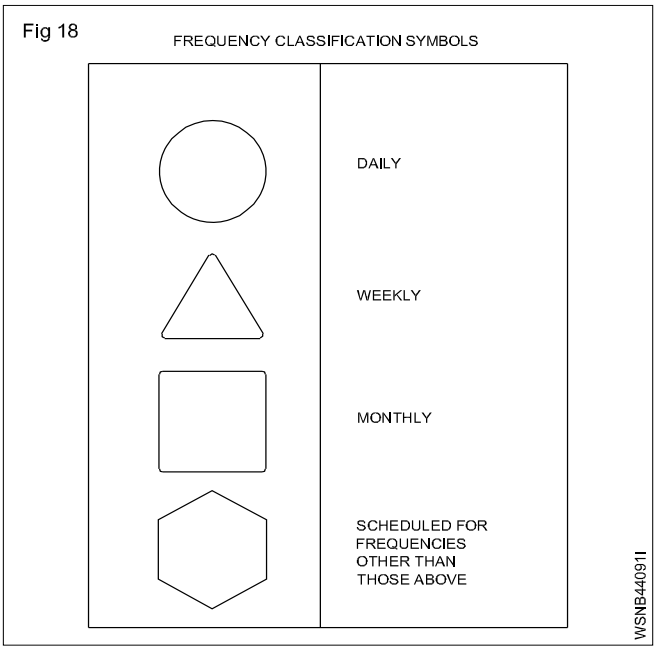
The manufacturer's manual contains all the necessary details for lubrication of parts in machine tools. Lubricants are to be applied daily, weekly, monthly or at regular intervals at different points or parts as stipulated in the manufacturer's manual.

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

Cutting Fluids

Cutting fluids and compounds are the substances used for efficient cutting while cutting operations take place.

Fig 18



WSNB44091I

Functions

The functions of cutting fluids are:

- to cool the tool as well as the workpiece
- to reduce the friction between the chip and the tool face by lubricating
- to prevent the chip from getting welded to the tool cutting edge
- to flush away the chips
- to prevent corrosion of the work and the machine.

Advantages

As the cutting fluid cools the tool, the tool will retain its hardness for a longer period; so the tool life is more.

Because of the lubricating function, the friction is reduced and the heat generated is less. A higher cutting speed can be selected.

As the coolant avoids the welding action of the chip to the tool-cutting edge, the built up edge is not formed. The tool is kept sharp and a good surface finish is obtained.

As the chips are flushed away, the cutting zone will be neat.

The machine or job will not get rusted because the coolant prevents corrosion.

Properties of a good cutting fluid

A good cutting fluid should be sufficiently viscous.

At cutting temperature, the coolant should not catch fire.

It should have a low evaporation rate.

It should not corrode the workpiece or machine.

It must be stable and should not foam or fume.

It should not create any skin problems to the operator.

Should not give off bad smell or cause itching etc. which are likely to irritate the operator, thus reducing his efficiency.

Should be transparent.

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Types of cutting fluids

The following are the common cutting fluids.

- Straight mineral oil
- Chemical solution (synthetic fluids)
- Compounded or blended oil
- Fatty oils
- Soluble oil (Emulsified oil-suds)

Straight mineral oil

Straight mineral oils are the coolants which can be used undiluted. Use of straight mineral oil as a coolant has the following disadvantages.

It gives off a cloud of smoke.

It has little effect as a cutting fluid.

Hence straight mineral oils are poor coolants. But kerosene which is a straight mineral oil is widely used as a coolant for machining aluminium and its alloys.

Chemical solution (Synthetic oil)

These consist of carefully chosen chemicals in dilute solution with water. They possess a good flushing and a good cooling action, and are non-corrosive and non-clogging. Hence they are widely used for grinding and sawing. They do not cause infection and skin trouble. They are artificially coloured.

Compounded or blended oil

These oils are used in automatic lathes. These oils are much cheaper and have more fluidity than fatty oil.

Fatty oil

Lard oil and vegetable oil are fatty oils. They are used on heavy duty machines with less cutting speed. They are also used on bench-works for cutting threads by taps and dies.

Soluble oil (Emulsified oil)

Water is the cheapest coolant but it is not suitable because it causes rust to ferrous metals. An oil called soluble oil is added to water which gets a non-corrosive effect with water in the ratio of about 1: 20. It dissolves in water giving a white milky solution. Soluble oil is an oil blend mixed with an emulsifier.

Other ingredients are mixed with the oil to give better protection against corrosion, and help in the prevention of skin irritations.

Soluble oil is generally used as a cutting fluid for centre lathes, drilling, milling and sawing.

Soft soap and caustic soda serve as emulsifying agents.

A chart showing coolants for different metals is given below.

Recommended cutting fluids for various metals and different operations

Material	Drilling	Reaming	Threading	Turning	Milling
Aluminium	Soluble oil Kerosene Kerosene and lard oil	Soluble oil Kerosene Mineral oil	Soluble oil Kerosene Lard oil	Soluble oil	Soluble oil Lard oil Mineral oil Dry
Brass	Dry soluble oil Mineral oil Lard oil	Dry soluble oil	Soluble oil Lard oil	Soluble oil	Dry soluble oil
Bronze	Dry soluble oil Mineral oil Lard oil	Dry soluble oil Mineral oil Lard oil	Soluble oil Lard oil	Soluble oil	Dry soluble oil Mineral oil Lard oil
Cast iron	Dry Air jet Soluble oil	Dry soluble oil Mineral lard oil	Dry sulphurized oil Mineral lard oil	Dry soluble oil	Dry soluble oil
Copper	Dry soluble oil Mineral lard oil Kerosene	Soluble oil Lard oil	Soluble oil Lard oil	Soluble oil	Dry soluble oil
Steel alloys	Soluble oil Sulphurized oil Mineral lard oil	Soluble oil Sulphurized oil Mineral lard oil	Sulphurized oil Lard oil	Soluble oil	Soluble oil Mineral
General purpose steel	Soluble oil Sulphurized oil Lard oil Mineral lard oil	Soluble oil Sulphurized oil Lard oil	Sulphurized oil Lard oil	Soluble oil	Soluble oil Lard oil

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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.

$\therefore$ 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 x 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

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

Force acts on the valve = 28125 kg

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

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

F = 0.13 x 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.

W = 50 kg = Weight

F = 15 kg = Force

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

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

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

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

F = 0.3 x 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

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= 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 x 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 = 104 H.P

6 A planner table weighting 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 aganist 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 weigting 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.

11 A glass block of 400 grams has been placed on the table. The glass is commuted by a string to a 40 grams scale pan. The string passes over pulley. When a weight of 60 grams is placed on the scale pan, the block starts sliding. Find out the co-effiecient of friction between wood and glass.

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