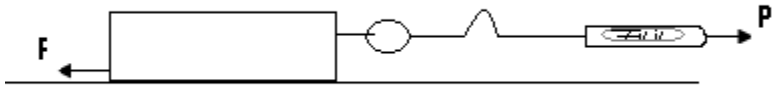
CHAPTER FIVE

FRICTION, ATMOSPHERIC AND LIQUID PRESSURE:

Friction:

- This is the force, which opposes the relative sliding motion between two surfaces in contact with each other.
- Friction occurs because the surfaces of objects are never perfectly smooth, for microscopic “hills and hallows” or ups and downs on the surface catch into each other and as such oppose the sliding motion, between the two surfaces in contact.

Limiting or static friction:



- A rectangular block of wood placed on a flat surface has a spring dynamometer attached to it, so that a horizontal force, P, can be be applied to it.
- If a gradually increasing force is applied to the block, it will at first continue to remain at rest, since an equally increasing but oppositely directed force of friction F, comes into action at the under surface of the block.
- At this stage, the pull P and the opposing force F are in equilibrium.
- If we continue to increase the pull P, a stage will be reached when the block just begins to slip.
- At this stage or point, the friction brought into play has reached its maximum value for the two surfaces concerned, and it is called the limiting or the static friction.
- In short, the limiting friction is the value of the frictional force, just before the body starts to move.
- Frictional force can be measured using a dynamometer.

Sliding, dynamic or kinetic friction:

- This is the value of the frictional force when the object starts moving or is in motion, and it is always less than the limiting friction.
- In short dynamic friction is the frictional force, acting between two surfaces which have relative motion.

Coefficient of friction:

- Both limiting and dynamic friction are increased roughly in simple proportion to the force, which is perpendicular to the surface pressing them together.
- The ratio of the static and the dynamic friction to the force pressing the surfaces together, are called the coefficient of static and dynamic friction respectively.

- $U = \frac{F}{R}$.

where U = coefficient of friction, F = friction and R = the force pressing the surfaces together i.e. the normal reaction.

- The coefficient of dynamic friction = $\frac{F}{R}$, where F = dynamic friction and R = normal reaction.
- Also, the coefficient of static friction = $\frac{F}{R}$, where F = the static friction and R= the normal reaction.
- The coefficient of static friction has no unit.
- The normal reaction is the force which keeps the two surfaces in contact together, and acts at right angle to the surface.

Advantages or uses of friction:

(1) It enables us to walk.
(2)The operation of most brakes depend on friction.
(3)May frictional devices depend on frictional forces. E.g. nails, bolts and nuts.

Disadvantages of Friction:

(1) It causes the soles of our shoes to wear out.
(2) Brake lining wears away because of friction.
(3) Friction in machinery causes the loss of useful energy, and possible damage through over heating if care is not take.

Reducing friction:

- By using lubricants such as oil or grease.
- By making the rough surface smooth.
- By the use of small ball bearings.

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Viscosity:

This is the study of the frictional forces in moving liquids, and viscosity in liquids helps in lubrication. In order to determine which of two different liquids (e.g kerosene and gas oil) has more viscosity, two cylindrically shaped containers of the same size are taken. The first one is filled with kerosene while the other one is filled with the gas oil.Two small identical balls are then dropped at the same time into these two liquids, and the liquid in which the ball falls more slowly, has greater viscosity than the other. Capillarity tubes can also be used to determine which of these two liquids has greater or the lesser viscosity. Two capillary tubes are put separately into these two liquids, and the liquid which rises faster in the tube has the lesser viscosity than the other one, or in other words, it is less viscous than the other one.

Atmospheric and liquid pressure:

- Pressure is defined as the force acting per unit area.
- Its standard unit is Nm^{-2} or the pascal.
- Pressure = $\frac{Force}{Area}$.

- From this formula, it can be seen that pessure is directly proportional to the force.
- This implies that when the pressure increases, the force also increases.

- Also, an increase in force will cause an increae in the pressure.
- From this same formula, it becomes clear that the smaller the area becomes, the greater the pressure becomes, and the greater the area, the smaller becomes the pressure.
- For this reason, if a person wearing a shoe with a big sole steps on our foot, we do not feel much pain since the large area of the sole, will make the pressure small.
- However, if the same person steps on our foot, wearing a shoe with a small sole, this pain will be great since the small area of the sole will generate a great pressure.

(Q1) Calculate the pressure exerted by a block of surface area $100m^2$, if it has a weight of 40kg. [Take `g` or the acceleration due to gravity = $10m/s^2$].

N/B: To get the force, we must multiply the weight or the mass which must be in kg (kilogram), by `g` i.e. $10m/s^2$ or $9.8m/s^2$.

Soln:

Weight = 40kg => Force

= 40 x 10 = 400N.

Area = $100m^2$

Since Pressure = $\frac{Force}{Area}$,

then Pressure = $\frac{400}{100}$ = 4NM^{-2}.

(Q2) The area of a box which is resting on a table is 50m^2. If it has a mass of 20kg, calculate the pressure it will exert onto the surface of the table. [Take g = 10m/s^2].

Soln:

Mass = 20kg => force = 20 x 10 = 200N.

Area = 50m^2.

Pressure = $\frac{Force}{Area}$ = $\frac{200}{50}$ = 4 pascal.

N/B: If the mass or the weight is given in grams, it must be converted into kilogram by using 1000 to divide.

(Q3) A rectangular block of breadth 8 m and length 10m, lies on the surface of the floor. Calculae the pressure that it will exert on the surface of the floor, if it has a mass of 4000g. [Take `g` = 10m/s^2].

Soln:

Mass = 4000g = $\frac{4000}{1000} = 4kg$.

Force = 4 x 10 = 40N.

Area of the rectangular block = length x breadth

= 10 x 8 = 80m^2

Pressure = $\frac{Force}{Area}$ = $\frac{40}{80}$ = 0.5p.

(Q4) A rectangular box of length 20m and breadth 10m, rests on a table. If it has a weight of 8000g, determine the pressure it will exert on the table. [Take `g` = 10ms^{-2}].

Soln:

Weight = 8000g = $\frac{8000}{1000} = 8kg$.

Area of box = L x B = 20 x 10 = 200m^2

Force = 8 x 10 = 80N.

Pressure = $\frac{Force}{Area} = \frac{80}{200} = 0.4$

=> Pressure = o.4NM^{-2}.

(Q5) A square box of side or length 5m, lies on a table. If it has a mass of 25kg, find the pressure it will exert on the surface of the table.

N/B: The area of a square is given by S^2 or l^2, where S = the side, and l = the length.

Soln:

Length of box = 5m.

Area of the square box= length squared = $5^2 = 25m^2$.

Mass = 25kg => force = 25 x 10 = 250N.

Pressure = $\frac{Force}{Area} = \frac{250}{25} = 10Nm^{-2}$.

(Q6) A square block has a breadth or a side of 2m. If it has a mass of 800g, determine the force it will exert when it is placed on the ground.

Soln:

Breadth or side of block = 2m.

Area of square block = B^2 or S = side => Area of block = $2^2 = 4m^2$.

Mass = 8000g = $\frac{8000}{1000}$ = 8kg,

Force = 8 x 10 = 80N.

Pressure = $\frac{Force}{Area} = \frac{80}{4}$ = 2p.

N/B: If the mass or the weight is given in Newtons(N), then it is force and as such there must be no convertion.

(Q7) The weight of a box is 40m^2, calculate the pressure it will exert on a table on which it lies.

Soln:

Weight = Force = 40N.

Area = $20m^2$.

Pressure = $\frac{Force}{Area} = \frac{40}{20}$ = 2N/m^2.

(Q8) A rectangular box has a length of 14m and a breadth of 5m. If it has a mass of 80N and it is placed on a table, determine the force it will exert on the table.

Soln:

Area of the rectangular block = L x B = 14 x 5 = 70m^2.

Weight = Force = 80N.

Pressure = $\frac{Force}{Area} = \frac{80}{70}$ = 1.14p.

(Q9) A chalk box of dimension 5m by 4m, exerts a force of 200N. Determine the pressure it will exert on a chair, if it is placed on it.

Soln:

L = 5m, B = 4m.

Area = L x B = 5 x 4 = 20m^2.

Force = 200N.

Pressure = $\frac{Force}{Area} = \frac{200}{20}$ = 10Nm^{-2}.

(Q10) The pressure exerted by an object is 4Nm^{-2}. If the force it exerts is 80N, calculate the area of this object.

Soln:

Pressure = 4Nm^{-2}

Force = 80N.

Area = ?.

Since pressure = $\frac{Force}{Area}$, => 4 = $\frac{80}{Area}$ => 4 x area = 80

=> area = $\frac{80}{4}$ = 20m^2.

(Q11) The pressure exerted by an object is 5NM^{-2}. If its surface area is 20m^2, calculate the force it will exert on its support.

Soln:

Pressure = $5Nm^{-2}$

Area = $20m^2$

Force = ?

From Pressure = $\frac{Force}{Area}$, => 5 = $\frac{Force}{Area}$ => 5 = $\frac{Force}{20}$

=> 5 x 20 = Force

=> Force = 100N.

(Q12) If the pressure exerted by a block of length 10m, and breadth 8m is 10 pascal, calculate the force exerted by this block.

Soln:

Pressure = 10p.

Area = L x B = 10 x 8 = $80m^2$

Force = ?

From Pressure = $\frac{Force}{Area}$ => 10 = $\frac{Force}{8}$

=> Force = 10 x 8 = 80N.

N/B: Weight (in kg) = $\frac{Force}{`g`}$, where g = acceleration due to gravity.

(Q13) An object exerts a pressure of $40N/m^2$. If it has an area of $10m^2$, calculate

(a) the force it exerts.
(b) its weight.

Soln:

(a) Pressure = $40N/m^{2+,}$ A = $10m^2$, F = ?
From pressure = $\frac{Force}{Area}$ => 40 = $\frac{Force}{10}$,
=> Force = 40 x 10 = 400N.

(b) Weight = $\frac{Force}{`g`}$ = $\frac{400}{10}$ = 40kg.

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