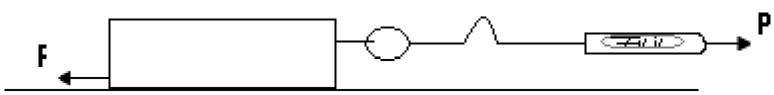
CHAPTER THREE

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.

The principles or laws of friction:

(1)The frictional force between two surfaces oppose their relative motion.
(2)The frictional force is independent of the area of contact of the given surfaces, when the normal reaction is constant.
(3)The frictional force, F, is proportional to the normal reaction R,

=> $F \propto R$ => F = UR => $U = \frac{F}{R}$, where U = the coefficient of friction.

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:

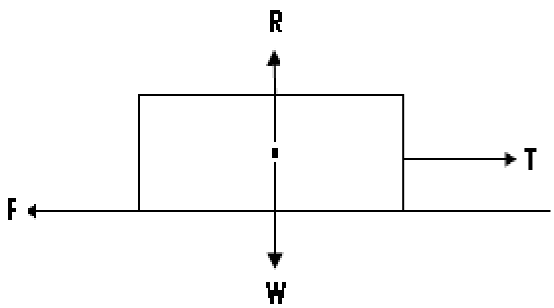
(1) It causes the soles of our shoes to wear out.
(2) Brake lining wears away because of friction.

(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.

Objects on horizontal plane:



- Let us suppose that a body of weight W, is pulled with a constant speed along a horizontal plane, by means of a string.
- If the string is parallel to the horizontal plane, then the normal reaction is equal to the weight of the body, and the effort is equal to the frictional force at work.
- This implies that R = W and F = T, but since F = UR => F = UW, where U = the coefficient of friction.

(Q1)(a) State the laws of static friction.

(b) A metal box of mass 200kg, is pulled at a constant speed along a horizontal floor. The coefficient of friction between the floor and the box is 0.5. Find the maximum effort needed to pull the box, when the effort is pulled horizontally.

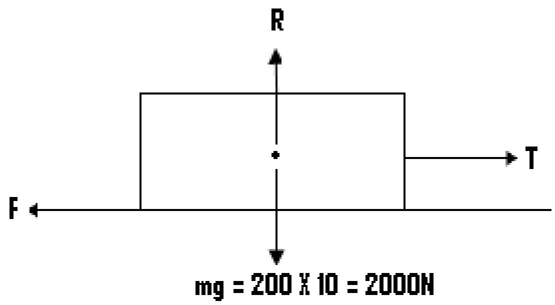
Soln:

(a) (1) The limiting frictional force between two surface in contact, is independent of the areas of the two surfaces in contact.

(2)The limiting frictional force between two surfaces in contact, is directly proportioned to the normal reaction between them i.e. F = UN, where

N = normal reactioon,
F = the limiting friction,
U = a constant referred to as the coefficient of friction

(b)



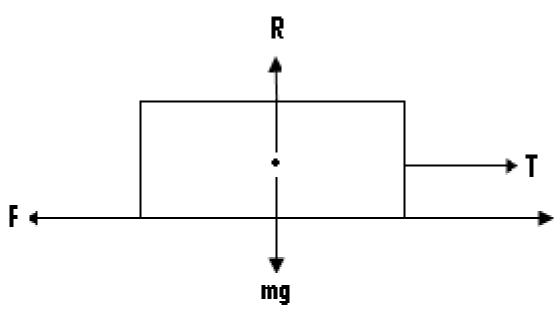
At equilibrium F = T and R = mg.

But since F = UR => F = Umg = $0.5 \times 200 \times 10 = 1000N$. Maximum effort needed = F = 1000N.

(Q2) A box of mass 36kg was pulled along a horizontal surface with a constant speed within a time period of 4 seconds. If it moved through a distance of 3m, and the coefficient of friction between the box and the surface is 0.4, calculate

(i) the effort applied in pulling the box.
(ii) the power used.

Soln:



m = mass of the box = 36kg.
g = 9.81m/s^2.
T = effort applied.
R = the normal reaction = ?
F = friction force = ?
P = power used = ?
S = distance covered = 3m.
U = coefficient of friction = 0.4.

(I) At equilibrium, R = mg, but since F = UR => F = Umg
= $0.4 \times 36 \times 9.81$ = 141.3N.

Also at equilibrium T = F
=> T = 141.3N.

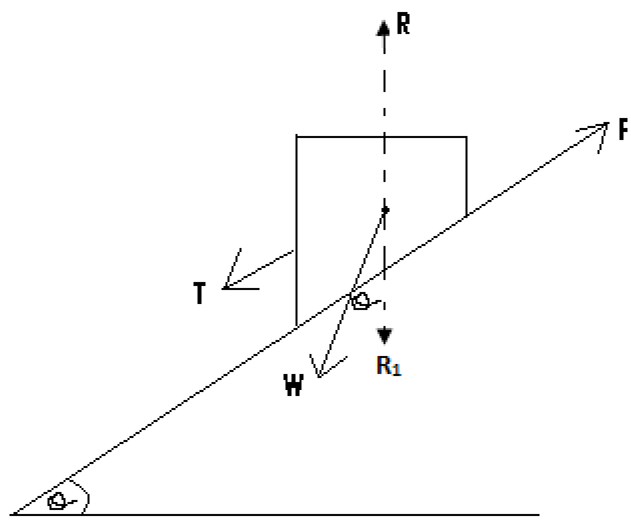
(II) P = $\frac{Force \times distance}{time}$

= $\frac{141.3 \times 3}{4 seconds} = 106W.$

N/B: Effort applied = force.

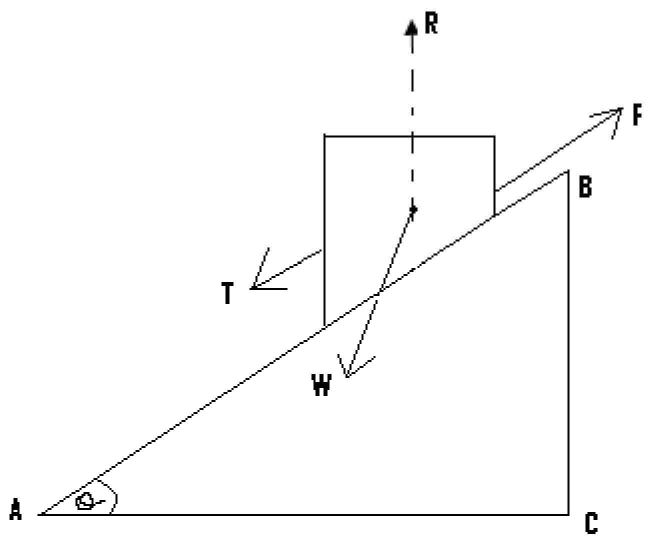
Object on inclined plane:

(1)



- A block of weight W, is placed at the top of a plane which is inclined at an angle θ to the horizontal.
- The block will slip down the plane by its own weight.
- Just at the point the block slips down the plane, the frictional force F, will be equal to the effective effort, T, of the weight which is pulling the block down the plane.
- From the resolution of forces, T = W sin θ and R_1 = W cos θ.
- But just at the point of slipping, F = T = W sin θ => R = W cos θ.
  Since U = $\frac{W sin\theta}{W\ cos\theta}$ = $\frac{sin\theta}{cos\theta}$ = tan θ,
  => U = tan θ.

(2)



- Suppose the block in the diagram moves from A to B, or from B to A, then the work done by the effort T, is given as work done = T x AB = W x BC
  => $\frac{W \times BC}{AB} = W \times \frac{BC}{AB}$, but
  $\frac{BC}{AB} = \sin\theta => T = W\sin\theta$.

Since at equilibrium, the effort, T, is equal to the frictional force => F = W$\sin\theta$

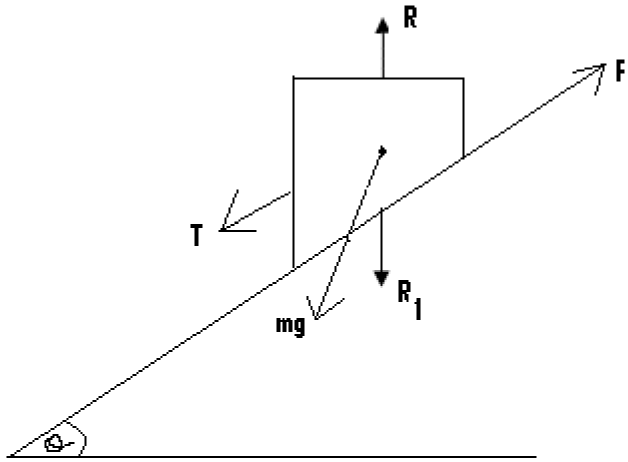
=> F = W $\times$ $\frac{BC}{AB}$.

(Q3) A body of mass 20kg uniformly rolls down a plane, which is included at an angle of 30^0 to the floor.

Calculate

(i) the frictional force.
(ii) the normal reaction.
(iii) the coefficient of friction between the plane and the body.

Soln:



m = mass of the body = 20kg,

g = 9.81m/s^2, R = normal reaction,

F = frictional force, θ = 30^0,

T = the effective part of the weight pulling the body down the plane.

(I) At equilibrium,
F = T = mg sin θ,
=> F = mg sin θ = 20 $\times 9.81 \times sin\ 30^0$
= 20 $\times$ 9.81 $\times$ 0.5 = 98.1N,
=> frictional force = 98.1N.

(II) At equilibrium, R = R_1 = mg cos θ = 20 $\times 9.81 \times cos\ 30^0$,

=> R = 20 $\times$ 9.81 $\times$ 0.866 => R = 169.9.

The normal reaction, R = 169.9N.

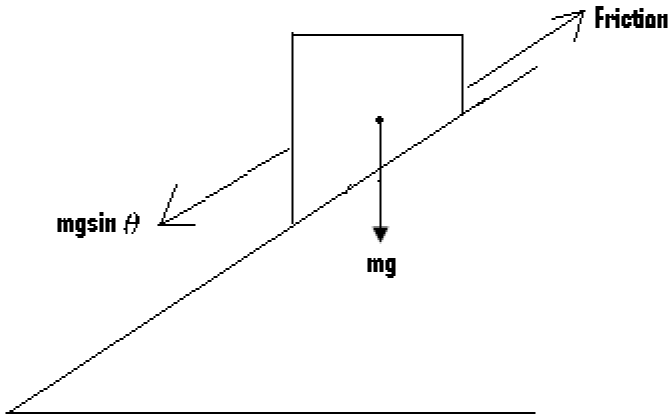
(III) U = $\frac{F}{R} = \frac{98.1}{169.9} = 0.6$,

or U = tan θ = tan 30^0 = 0.6,

=> the coefficient of friction = 0.6.

(Q4) A car of mass 1500kg, is standing on an inclined plane of 20^0 to the horizontal. What must be the frictional force acting along the slope. [Take g = 10ms^{-2}]

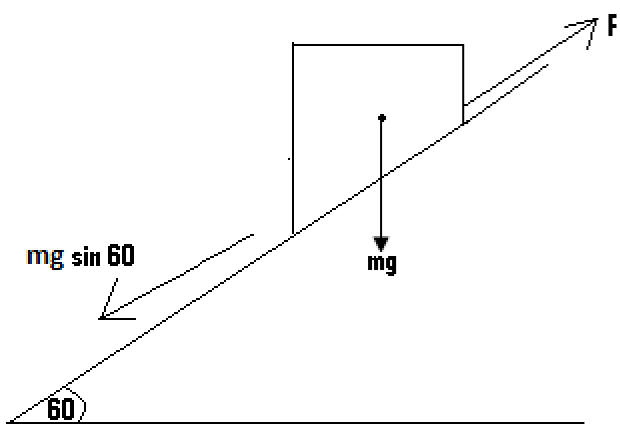
Soln:



If the car is stationary, then the component of the weight down the plane = the friction between the plane and the car.

=> friction = mg sin θ = $1500 \times 10 sin20^0$ = 5130N.

(Q5)



Determine the acceleration of the body placed on an inclined plane, which is inclined at an angle of 60^0 to the horizontal, if the coefficient of friction U = 0.5 .

Soln:

The resultant force on the body = mg sin 60^0 – F, but since F = UR => The resultant force = mg sin60 – UR.

Also R = mgcos θ => resultant force = mgsin60^0 - umgcos θ = mgsin60^0 – 0.5mgcos θ

Since force (resultant froce) = ma

Then ma = mgsin 60 – 0.5mg cos θ.

Dividing through using m

=> $\frac{ma}{m} = \frac{mgsin60}{m} - \frac{0.5mgcos\theta}{m}$,

=> a = gsin 60 – 0.5g cos 60,

=> a = $9.8 \times 0.87 - 0.5 \times 9.8 \times 0.5$

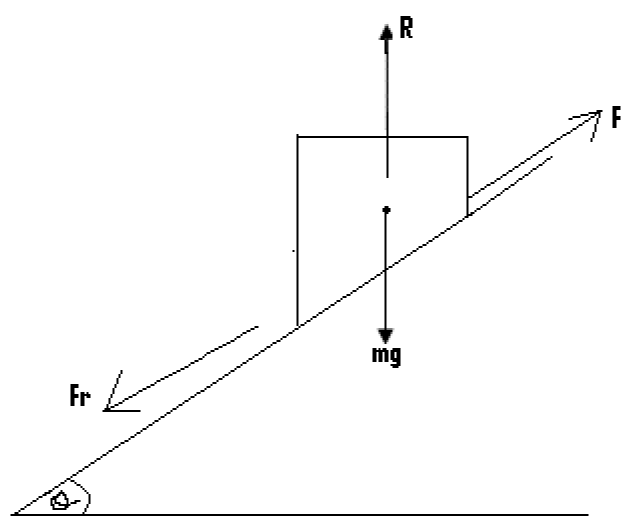
=> a = 8.5 – 2.6 = 5.9

=> the acceleration = 5.9m/s^2.

(Q6) A rectangular block of mass 10g rests on a rough plane, which is inclined to the horizontal at an angle of sin^{-1}(0.05). A force of 0.03N, acting in a direction parallel to the line of greatest slope, is applied to the block so that it moves up the plane. When the block had travelled a distance of 1.1m from its initial position, the applied force is removed. The block moves on and comes to rest again, after travelling a further 0.25m. calculate

(i) the work done by the applied force.
(ii) the gain in the potential energy of the block.
(iii) the value of the coefficient of the sliding friction, between the block and the surface of the inclined plane. [Take g = 9.8m/s^2].

Soln:



Fr = frictional force.

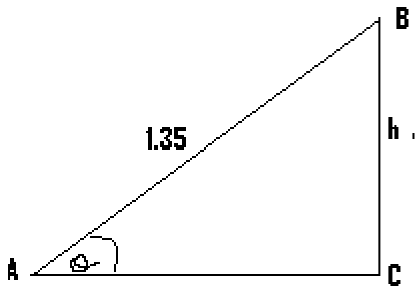
F = applied force = 0.03N.

R = normal reaction.

θ = angle of inclination.
$mass = m = 10g = 0.01kg.$

(I) Distance travelled by th block when the force of 0.03N was applied = 1.1m
Work done = Force $\times$ $distance$
= 0.03 $\times$ 1.1 = 1.033J.

(II)



The total distance travelled by the block before comingto rest = (1.1 + 0.25) = 1.35m.
This total distance travelled is along the plane, but the vertical height of the block above the earths surface = h.
h = 1.35 sin θ where
θ = sin^{-1} 0.05 = 2.9^0.
$=> h = 1.35 \times sin2.9$ = 0.0069
$=$ 0.0069J.
Gain in potential energy = mgh = 0.01$\times$ 9.8 $\times$ 0.0069 = 0.0069j

(III) Work done against friction = work done by the force – gain in potential energy
= 0.033 – 0.0069 = 0.026J.
But work done against friction = Fr $\times$ 1.35 = 1.35Fr,
=> 1.35Fr = 0.026 => Fr = $\frac{0.026}{1.35}$
=> Fr = 0.02N.
R = mg cos θ = 0.01 $\times$ 9.8
But U = $\frac{F}{R} = \frac{Fr}{R} = \frac{0.02}{0.098}$ = 0.2

<u>Viscosity:</u>

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 pascasl.

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

(Q3) A rectangular block of breadth 8m 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 aside 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 10pascals, 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:

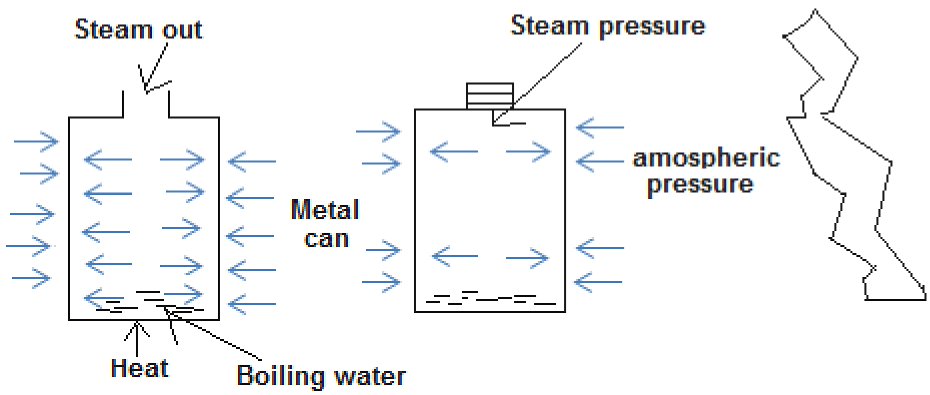
(a) Pressure = $40N/m^{2+,}$ A = $10m^2$, F = ?
From pressure = $\frac{Force}{Area}$ => 40 = $\frac{Force}{10}$,
=> Force = 40 x 10 = 400N.

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

Atmospheric Pressure:

- The atosphere exerts pressure which do not act only on the surface of the earth, but on the surface of everything on the earth`s surface. The atmospheric pressure may also be referred to as air pressure.

To demonstrate the effect of air pressure (To show that the atmsphere exerts pressure):

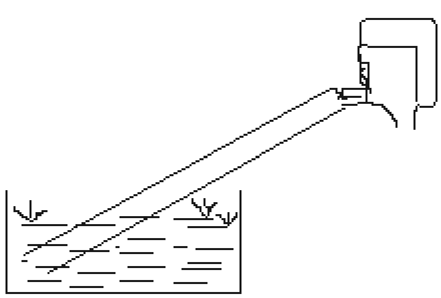


- This can be demonstrated in the crushing can experiment.
- In this, a metal can which can be fitted with an air tight stopper is used.
- The stopper is first removed and a small quantity of water is boiled in the can for a few minutes.
- The steam generated will drive out all the air from the can.
- The stopper or cork is then replaced and the flame (heater) is removed from beneath the can.
- Cold water is then poured over the can, causing the steam inside to condense into water.
- The pressure inside the can falls and the excess atmospheric pressure outside the can crushes it inward.

The application of atmospheric pressure:

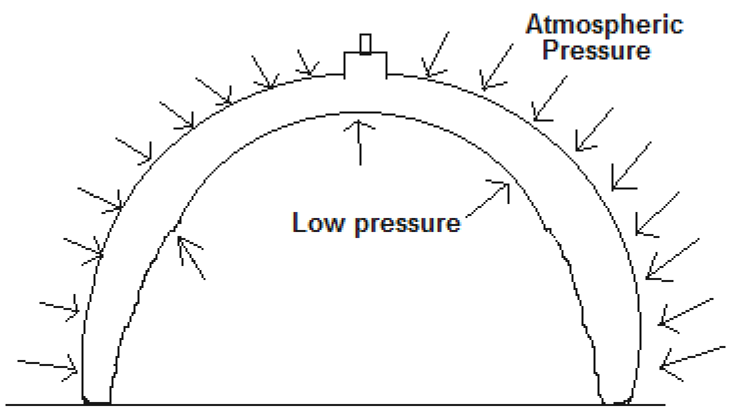
There are many applications of atmospheric pressure. It is applied in the following cases.

(1)The drinking straw:



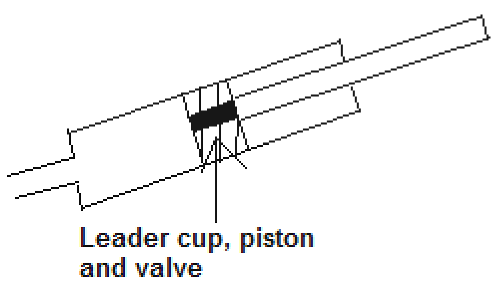
- When the air is sucked out of the straw, the air pressure inside the straw becomes lowered.
- The greater atmosphereric pressure acting on the surface of the drink or liquid, forces the liquid up the straw into our mouth.
-

(2)**The rubber sucker:**



- When the rubber sucker is pressed against a smooth surface, air is forced out and the pressure inside drops.
- The higher air pressure outside pushes the sucker against the smoooth surface.
- Any attempt to pull the sucker away from the surface will be opposed by the atmospheric pressure.
-

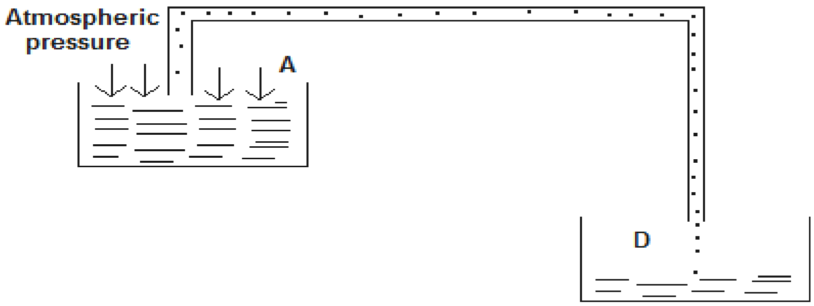
(3)**The bicycle pump:**



- When the pumps handle is pushhed in, the leadder cap at the end of the piston forces air, into the tyre.
- When the handle is pulled out, the pressure within the cylinder is lowered, for the cup acts as a valve.

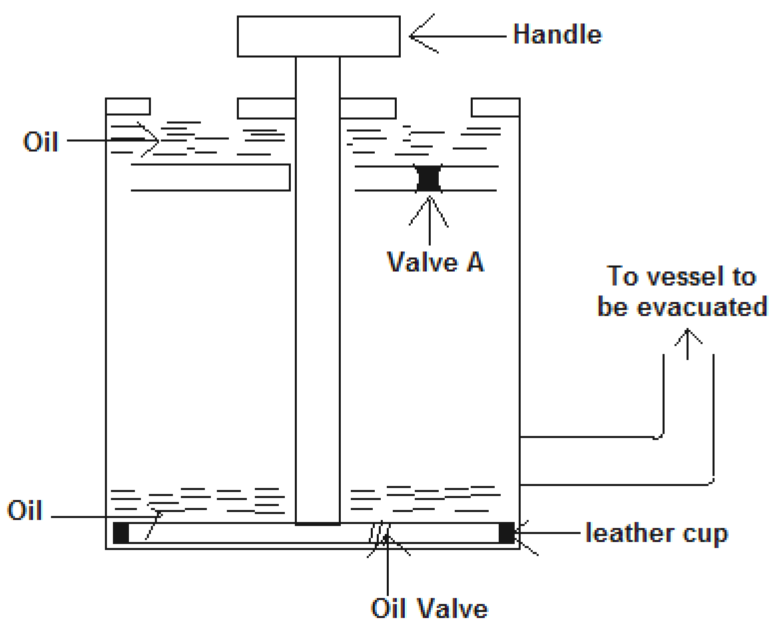
-

(4)**The Siphon:**



- The siphon which is made up of a rubber tube is used to empty containers which cannot easily be emptied, when they contain liquids.
- The shorter arm of the rubber tube is dipped into the tank, which contains the liquid, and the longer arm is outside and at a lower level.
- The pressure at the point “D” is greater thann that at A and it is this pressure, together with the atmosphhere pressure acting on the surface of the liquid within the container, which pulls the liquid from the tube.
- Also due to the cohesive force, the liquid can escape from A to D.
- To start the siphon, it must first be be filled with liquid, and when this is done, the iquid will continue to run out, so long as the end “D” is below the level of the liquid in the tank.
-

(5)**The vacuum pump:**

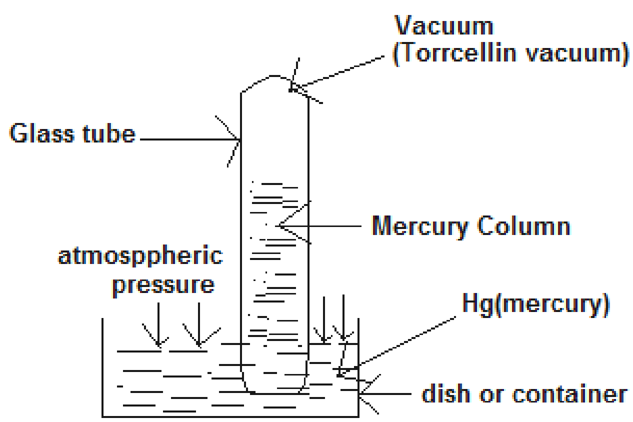


- Each time the piston is at the bottom of the cylinder,some air from the vessel to be evacuated expands into the space above the piston.
- On each upstroke, the air above the piston is carried out through value A.
- The oil on top of the piston acts not only as a lubricunt and air seal, but also fills the dead space between the piston and the valve at the top of the stroke and ensures the removal of all air trapped there.

Measurement of atmospheric or air pressure:

- It can be measured using the barometer.
- There are different types of barometers and examples are:
  (i) The simple Barometer.
  (ii) The Fortin Barometer.
  (iii) The Aneroid Barometer.
- The measurement of air pressure enables meterologists forcast the weather.
- This forecast is of great importance to sailors, farmers and pilots.

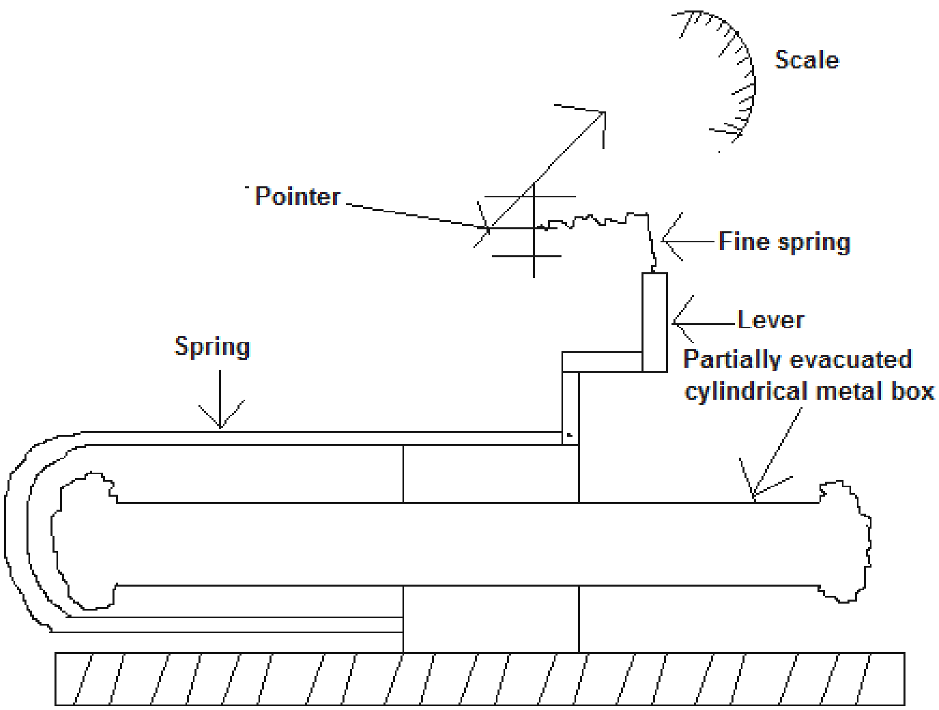
The simple Barometer:



- A simple barometer consists of a stout-walked glass tube which is a metre long and closed at one end.
- This tube is filled with mercury and then inverted over mercury within a dish, and a partial vacuum is created at the top part of the glass tube.
- The vertical height of the mercury column is roughly 760mm.
- When the pressure of the atmosphere increases, then the air pressure acting on the surface of the mercury within the dish increases, causing the mercury within the glass tube (mercury column) to rise, indicating a high atmospheric pressure.
- Also the air pressure acting on the surface of the mercury decreases, when the atmosphereric pressure decreases.

- This causes the level of mercury within the tube to fall, indicating a low atmosphereric pressure.

The Aneroid Barometer:

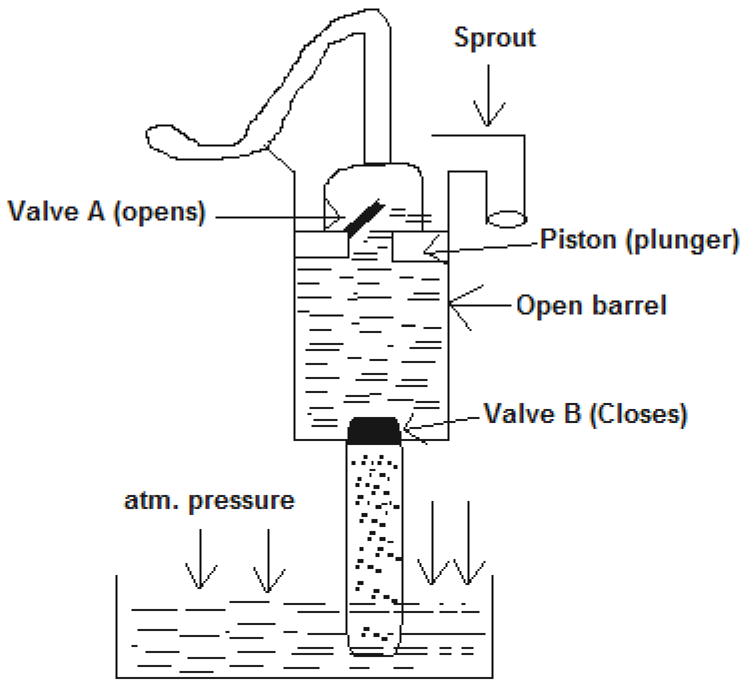


- This is a special type of barometer which does not contain liquid.
- It is made up of a metal box, which had been partially evacuated (i.e most of the air inside it had been removed).
- The top part of the box is supported by a strong spring so that it does not collapse under the pressure of the air.
- When the pressure of the atmosphere increases, the box is squeezed inward, and when the pressure decreases the box expands.
- The expansion and contraction of the evacuated box, causes the pointer to move on a scale to give the pressure of the atmosphere.
- A special type of aneroid barometer called the altimeter is used to measure the height reached as a pilot files up.

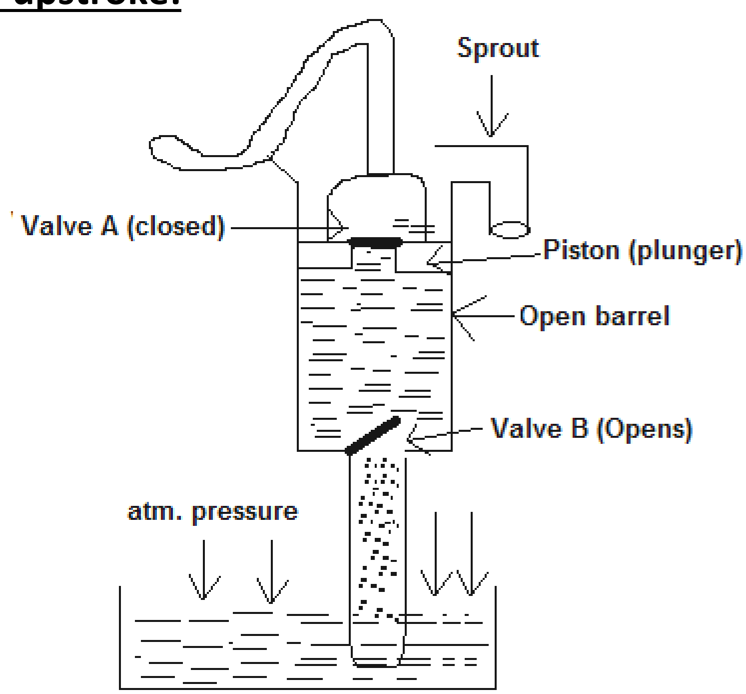
The common pump or the lift pump:

Another application or use of atmospheric pressure, can be found in the left pump or the common pump.

The downstroke:



The upstroke:



- Pumps (the lift pump can be used to draw water from a well.
- It is made up of a small metal barrel, which joins a pipe, leading to the water in a well.- This pump can draw water after a series of downwards and upward movement of the piston.

The downstroke:

When thepiston is pushed downwards, valve 'B' closes under its own weight and the weight of water in the barrel.The water in the barrel then flows upwards throgh valve A towards the sprout.

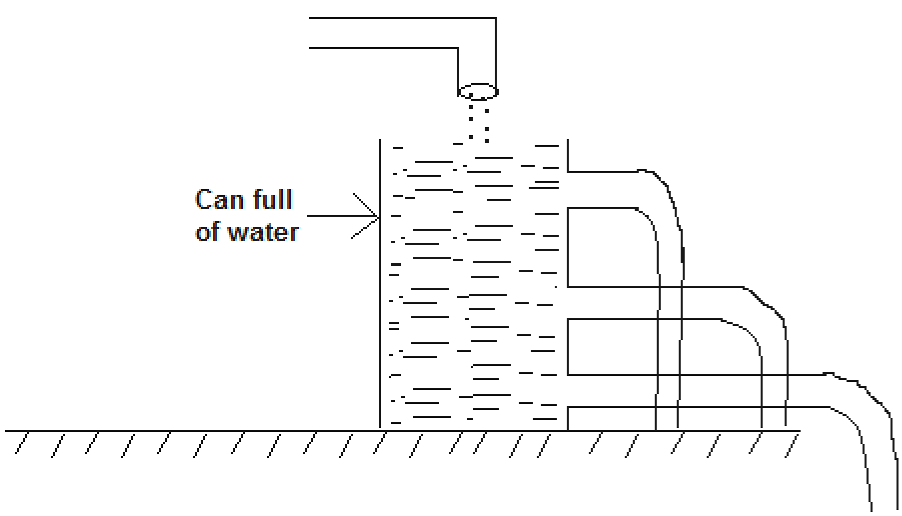
The upstroke:

During the upstroke, the piston is made to move upwards. Valve A closes and the water trapped above the piston is carried out through the sprout. At the same time, valve B opens and the atmospheric pressure acting on the surface of the water in the well, forces water up the pipe into the barrel and the whole process is repeated.

Pressure in liquids:

- Liquids also exert pressure.
- Within a liquid, the pressure increases with depth or as we move down into the lliquid,
- It also acts in all direction.

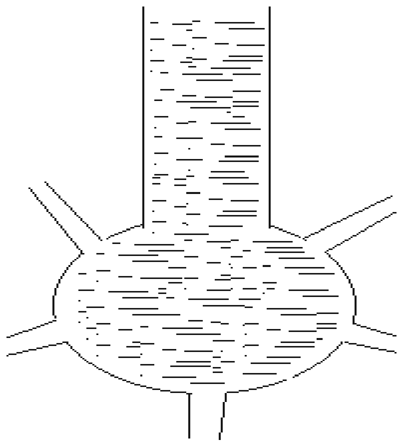
To demonstrate that water (liquid) pressure varies or increases with depth:



(1) Take a tall vessel with holes creted at different heights, and filll it with water.
(2) The speed with which the water spurts out is greatest for the lowest hole, and lowest for the highest hole.

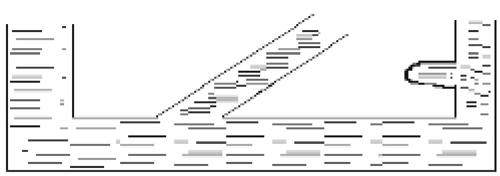
(3) This shows that within a liquid, the pressure increases or varies with depth.

To show that within a liquid, the pressure acts in all directions:



- A round bottom flask with holes all round it, is taken and filled with water.
- It will be observed that the water spurts out or comes out from every hole.
- This shows that within a liquid, the pressure acts in alll directions.

A liquid finds it own level:



- When water or any liquid is poured into communicating tubes as shown above, the level of water in each of the tubes will be the same, no matter the shape of the tube.
- We therefore say that a liquid finds its own level.

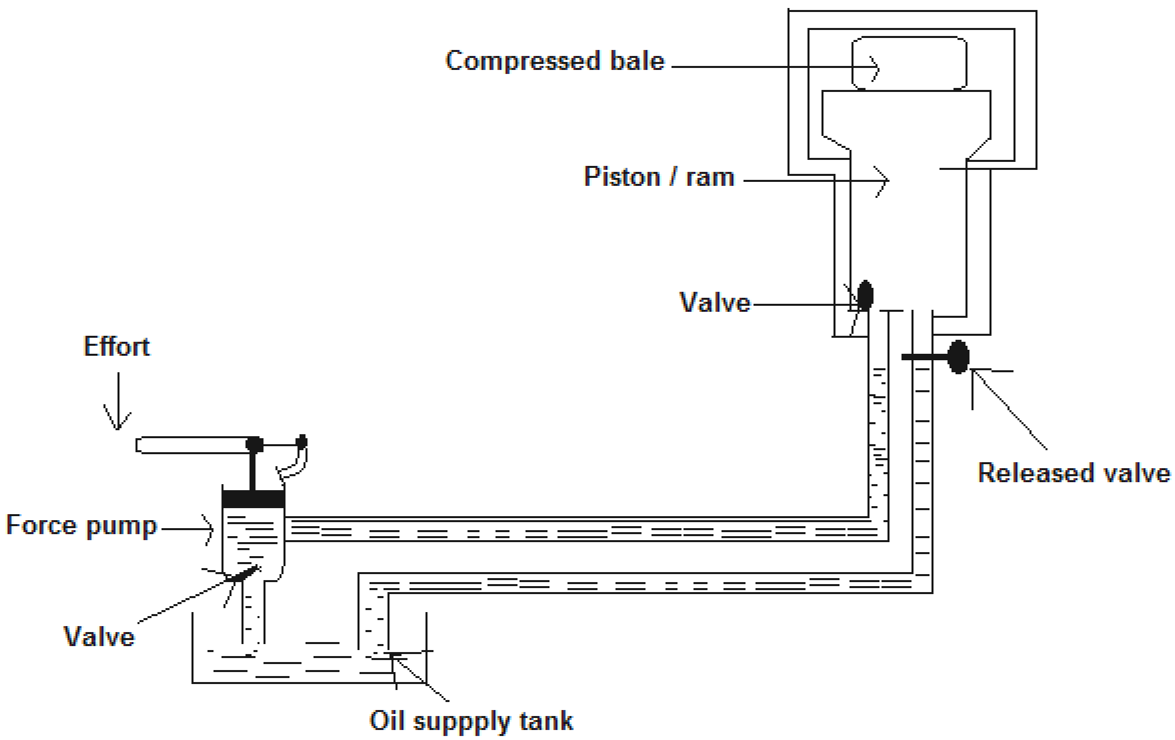
The transmission of pressure in a liquid:

- When a liquid completely fills a vessel and pressure is applied to it at any part of its surface, for example by means of a piston connected to the vessel, the pressure will be transmitted equally throughout the whole of the enclosed fluid.

The application of liquid pressure:

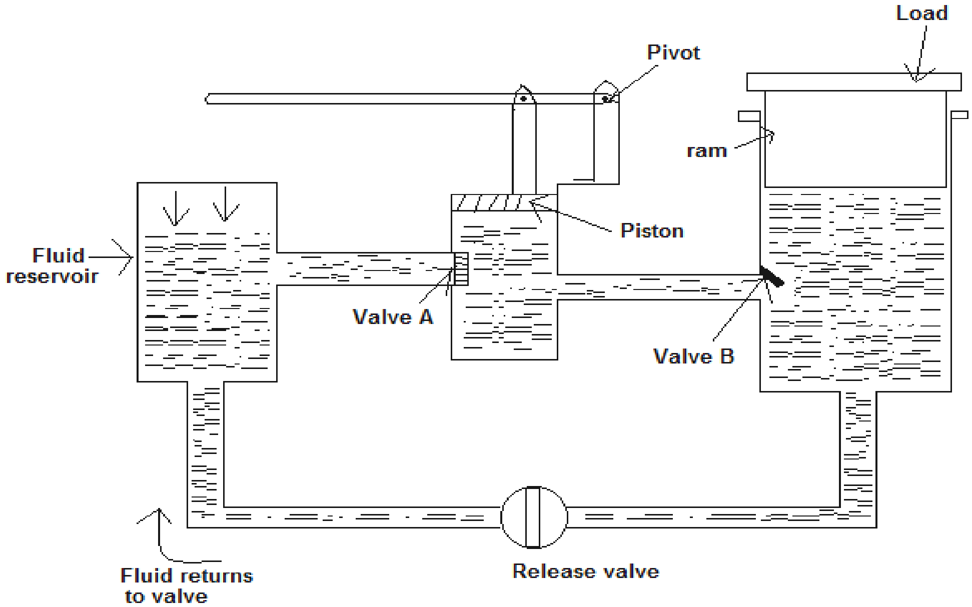
Such applications can be seen in the follqwing cases:

(1)The hydraulic press:



- This consists of a cylinder and a piston of large diameter, which is connected by a pipe to a force pump, of musch smaller diameter.
- When effort is applied by means of the force pump, oil from the supply tank is pumped into the cylinder, and the piston or ram moves out, exerting a considerable force (on let say a bale).
- A valve is provided to release the pressure and allow the oil to return to the tank, after the necessary work had been done.

(2)**<u>The hydraulic jack:</u>**



- During the downward stroke, the piston applies the effort.
- The liquid pressure becomes greater than the atmosphereic pressure, and this liquid pressure keeps valve A closed and opens valve B.
- During the upstroke, the liquid pressure is reduced and the atmospheric pressure opens valve A and liquid from the reservoir moves into the cylinder.
- At the same time, the valve B remains closed and the high pressure keeps the ram from falling.
- To lower the ram piston, the released valve is opened and this allows the liquid to return to the reservoir.
- The hydraulic press and the hyraulic jack as welll as the hydraulic brake are examples of hydraulic machines.

Questions:

(Q1) (a) Define pressure.

(b) A block lies on the ground with its surface area of dimension 10cm by 8cm in contact with the ground. Another block also lies on the ground with its area of dimension 20cm by 10cm in contact with the ground. Explain by giving reason, which of these blocks will exert a greater pressure on the ground.

Ans: - The first block will exert a greater pressure on the ground, than the second one.

- This is due to the fact it has smaller surface area, and the smaller the surface area, the greater becomes the pressure.

N/B: Take \`g\` = $10m/s^2$ when the need arises.

(Q2) A box of surface area $80m^2$ has a weight of 60kg. If it is placed on a table, determine the pressure that it will exert on the table.

Ans: $7.5Nm^{-2}$.

(Q3) A rectangular object of length 12m and breadth 10m, rests on the surface of a box. If it weighs 400g, calculate the pressure it will exert on the box.

Ans: $0.033Nm^{-2}$.

(Q4) A 54kg square box of length 8m rests on the ground. Calculate the pressure that it exert on the ground.
Ans: $8.4Nm^{-2}$.

(Q5) A 2000g square box of side 5m is positioned on the ground. Determine

(a) the force it exerts on the ground. Ans: 20N.
(b) the pressure it exerts on the ground. Ans: $0.8NM^{-2}$

(Q6) A box exerts a pressure of $16Nm^{-2}$, and a force of 400N on the surface of the ground. Calculate its surface area. Ans: $25m^2$.

(Q7) An object whose surface area is $25m^2$, exerts a pressure of $6Nm^{-2}$ on its support. Calculate the force that it exerts on its suppport. Ans: 150N.

(Q8) An object which exerts a pressure of $60N/m^2$, has a surface area of $20m^2$. Determine its weight. Ans: 120kg.

(Q9) A rectangularly shaped block has a weight of 200N, a length of 4m and a breadth of 5m. Calculate the pressure that it will exert on its suppport.

Ans: $10Nm^{-2}$.

(Q10) A rectangularly shaped of mass 20kg, has a length of 400cm and a breadth of 500cm. Calculate the force that it will exert on the ground.

Ans: $10Nm^{-2}$.

(Q11) With the aid of a labelled diagram, explain how you will prove that the atmosphere exerts pressure.

(Q12)(a) Give three applications of air pressure.

Ans:

- Siphon

- Rubber sucker

- Drinking straw.

(b) With the aid of a labelled diagram, describe and explain the mode of operation of the commmon lift pump.

(Q13) With the aid of diagrams, explain how you will prove that

(a) the pressure acting within a liquid, acts in all direction
(b) the pressure acting within a liquid increases with depth.

(Q14) With the aid of diagrams, briefly explain the mode of operation of

(a) the simple barometer.
(b) The aneroid barometer.

(15) Explain what you understand by friction and list two of its advantages.

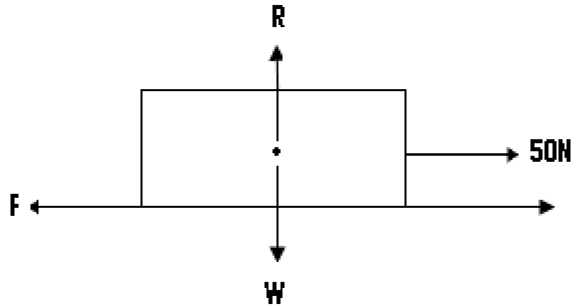
(16) Differentiate between limiting and dynamic friction.

Ans:

Limiting fraction is the value of the fractional force, just before the body begins to move, while dynamic friction is the value of the frictional force, when the body is in motion.

(17) A cement brick is being pulled alonga table with a force of 50N. If it moves with a constant speed, and the force pulling it is applied in a direction which is parallel to the horizontal, draw a diagram to show all the forces acting on the brick.

Ans:



W = theweight of the brick

R = the normal reaction from the table.

F = frictional force.

(18) A block has a mass of 6000g, and it is supposed to be pulled horizontally along the ground by the application of an horizontal effort. If the coefficient of friction betweeen the block and the ground is 0.2, what will be the maximum effort which will be needed to pull the block, if its speed is constant.

Ans: 12N.

(19) An iron box of mass 0.2kg was pulled at a constant speed along a horizontal table. If the effort was horizontally applied and the maximum effort needed to pull this box was 1.2N, determine the coefficient of friction between the box and the table.

Ans: 0.6

(20) An object whose mass is 20kg was pulled at a constant speed, along a horizontal surface. The coefficient of friction concerned was 0.2, and the distance travelled by the object within 5 seconds was 10m. Determine

(a) the effort needed in the pulling of the object.
Ans: 40N.

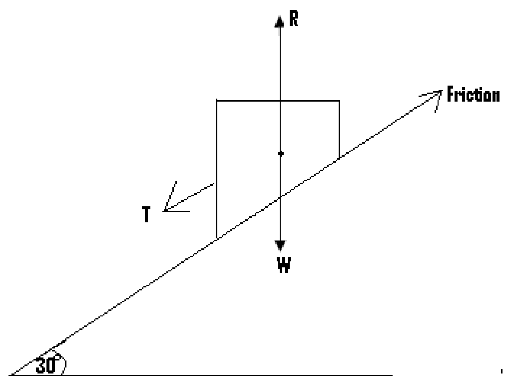
(b) the power used. Ans: 80W.

(21) The coefficient of friction between a table and a stone of mass 300g is 0.4. This stone was pulled along the horizontal surface of this table, and travelled a distance of 200m within a time period of 10minutes. Find

(a) the necessary effort which is needed in pulling the stone. Ans: 12N.

(b) the rate at which this work was done. Ans: the rate at which this work was done = the power = 240W.

(22)



The diagram shows a block of mass 2kg which is resting on an inclined plane. Determine the values of the following just before the block starts slipping down the plane.

(i) W, the weight of the block. Ans: 20N.
(ii) T, the applied effort. Ans 10N.
(iii) R, the normal reaction. Ans: 17N.
(iv) The coefficient of friction. Ans: 0.5

(22) A body of mass 2000kg, lies on an inclined plane whose angle of inclination is 60^0. What is the value of the frictional force which is acting along the slope.
Ans: 17321N.

(23) A toy car of mass 5000g is parked on top of a sloping road. If the frictional force concerned is 43N, determine the angle of inclination of the road. Ans 59.3^0

(24) A body of mass 20kg rest on a plane, which is inclined at an angle of 40^0 to the horizontal. Given the coefficient of friction to be 0.3, determine its acceleration, when it starts moving. Ans: $4.1m/s^2$.

(25) Explain how you will prove to a friend that the atmosphere exerts pressure.

(26) With the aid of diagrams, briefly explain the mode of operation of the following:
(a) the simple barometer.
(b) the aneroid barometer.
(c) the hydraulic press.

(14) What is viscosity and explain how when given two different liquids, you will determine which of them is less viscous.