

Short Questions & Answers.

Q.1. Define Force & Write its Units.

Ans. Force is defined as an external agent which changes either the state of rest or state of motion of a body.

It is denoted by F :

Mathematically, $F = M.a$ Where M = Mass of a body, a = acceleration due to gravity.

Units : In S.I .. M.K.S \Rightarrow Kg \times m/sec² = Newton (N)

In C.G.S \Rightarrow gm \times Cm/sec² = Dyne

$$1N = 10^5 \text{ dyne}$$

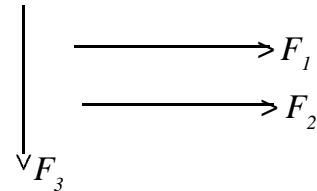
Q.2. Define co-planar forces and concurrent forces.

Ans. Co-planer forces :

It is defined as lines of action of forces lie on the same plane, known as co-planer force.

e.g : The lines of action of forces F_1 , F_2 and F_3 lie on the same plane.

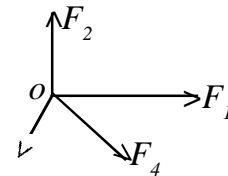
Hence these forces are called co-planar forces.



Concurrent forces :

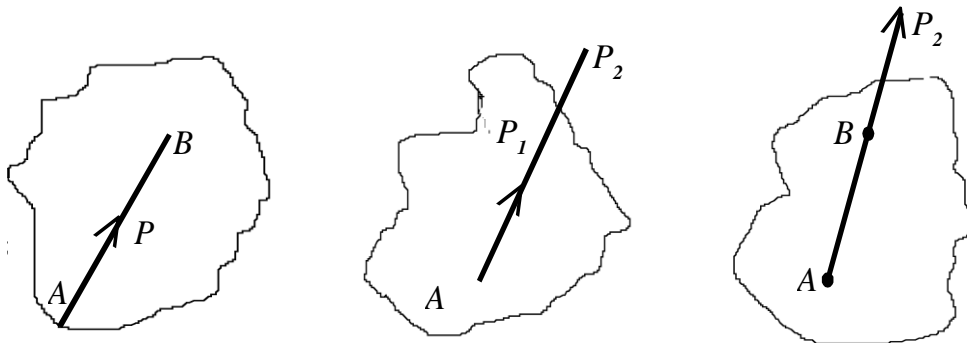
It is defined as lines of action of forces pass through the common point, known as concurrent forces.

e.g. : The lines of action of forces F_1 , F_2 , F_3 , F_4 pass through the common point 'o'. Hence they are called con-current forces.



Q.3. State Principle of Transmissibility of a force ?

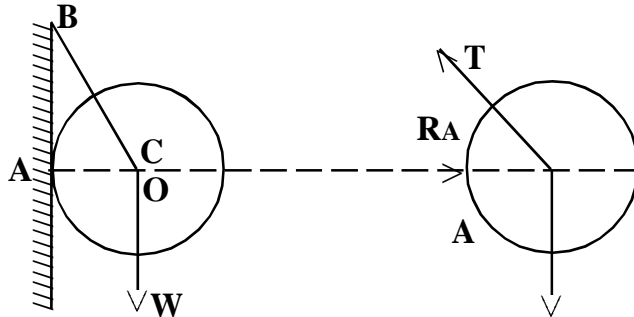
Ans. The principle states that "The condition of equilibrium or motion of a rigid body will not be changed if a force acting on a body at a certain point is replaced by a force of same magnitude and same direction but applied at a different point provided the two forces act along the same straight line".



$$P = P_1 = P_2$$

Q.4. What do you mean by free body diagram ?

Ans. Free Body Diagram may be drawn for the single body or for a sub system or for whose structure irrespective of whether the system is in equilibrium or not. All the internal as well as external forces must be taken into consideration.



Q.5. What do you mean by Resolution of a Force

Ans. The process of finding the components of a given force in two given directions is called resolution.

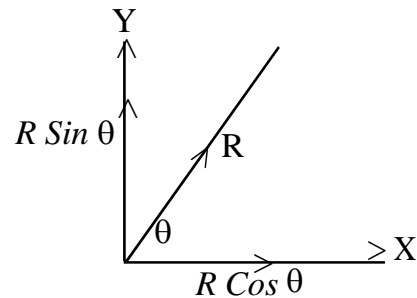
A force is generally resolved along two mutually perpendicular direction.

Horizontal Component = $R \cos \theta$

Vertical Component = $R \sin \theta$

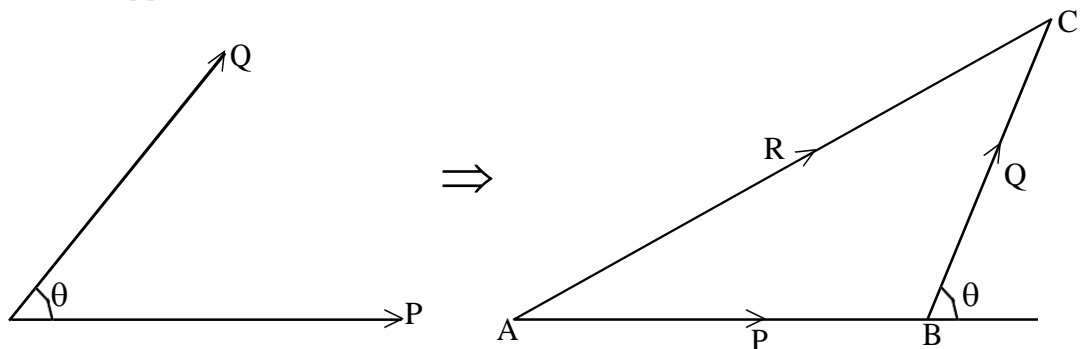
Resultant, $R = \sqrt{(R \cos \theta)^2 + (R \sin \theta)^2}$

Direction, $\tan \theta =$



Q.6. State Triangle Law of Forces.

Ans. Statement : "If two forces acting simultaneously on a body, be represented in magnitude and direction by two sides of a triangle take in order their resultant may be represented in magnitude and direction by the third of side of the triangle taken in opposite order."



$$\vec{R} = \vec{P} + \vec{Q}$$

Q.10. Two forces are acting at an angle of 120° . The greater force is 40N and the resultant is acting at 90° to the smaller force. Find the magnitude of the smaller force ?

Ans. Here, $\theta = 120^\circ$

$$\alpha = 90^\circ$$

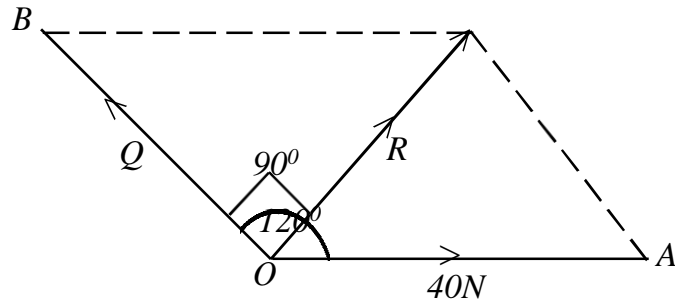
$$\alpha = 120^\circ - 90^\circ = 30^\circ$$

$$P = 40\text{N}$$

$$Q = ?$$

$$\therefore \tan \alpha = \frac{Q \cdot \sin \theta}{P + Q \cdot \cos \theta}$$

$$\Rightarrow \tan 30^\circ = \frac{Q \cdot \sin 120^\circ}{40 + Q \cdot \cos 120^\circ} \Rightarrow \boxed{Q = 20\text{N}}$$



Q.11. The resultant of two equal forces acting at a point also equal to 'P'. Determine the angle between the two forces.

Ans. When the two forces are equal and θ is the angle between them.

$$\text{We know, } R = \sqrt{P^2 + Q^2 + 2P \cdot Q \cos \theta} \quad (\because R = P = Q)$$

$$\Rightarrow P = 2P \cdot \cos \frac{\theta}{2} \Rightarrow \boxed{Q = 120^\circ}$$

Q.12. Define moment of a force and write its units.

Ans. Moment of a force about a point may be defined as the turning effect of the force about that point.

Moment of the force is expressed as the product of the force and the perpendicular distance of the point, about which the moment is to be found.

$$\text{Mathematically, } \boxed{M = F \times L}$$

Where, F = Force acting on the body

L = Perpendicular distance between the point, about which the moment is to be found out.

Units : In SI $\Rightarrow \text{N} \cdot \text{m}$ or $\text{N} \cdot \text{mm}$

In C.G.S $\Rightarrow \text{dyne} \cdot \text{cm}$

Q.13. State Varignon's Theorem.

Ans. Statement : "The algebraic sum of moments of a number of co-planar forces about any point in their plane is equal to the moment of their resultant about the same point."

- ✦ When all the forces are concurrent.
- ✦ When all the forces are parallel.

Q.14. Define Couple and Arm of Couple.

Ans. Couple : A couple is defined as a pair of two equal and unlike parallel forces, separated by a finite distance.

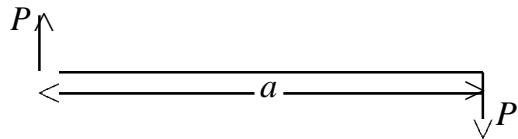
Arm couple : The perpendicular distance between the lines of action of the couple, is called Arm of Couple.

The product of either force of the couple with the arms of the couple is called **Moment of Couple.**

$$M = P \times a$$

Where, P = magnitude of the force.

a = Arm of Couple.



Q.15. A rectangular PQRS has sides $PQ = RS = 100\text{mm}$ and $QR = 5P = 80\text{mm}$. Forces of 200N each act along PQ and RS and forces 150N each act along QR and SP. Find out the resultant moment of the system of forces.

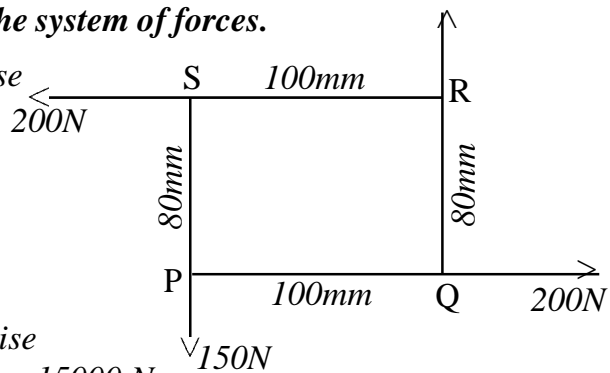
Ans. The force of 200N each will give rise to a couple of moment.

$$\begin{aligned} &= 200 \times 80 \\ &= 16000 \text{ N-mm} \\ &= 16 \text{ N-m} \end{aligned}$$

The forces of 150N each will give rise to a couple of moment = $150 \times 100 = 15000 \text{ N-mm}$
= 15 N-m

Resultant moment of the system = $16 + 15 = 31 \text{ N-m}$

This will be an anti-clock wise moment.



LONG QUESTIONS :

Q.1. State and proves parallelogram law of force.

Q.2. State and proves Varignon's Theorem.

Q.3. Three forces of $4P$, $5P$ and $6P$ are acting along three edges of an equilateral triangle of 100mm side taken in order.

Determine the magnitude and position of the resultant force. Ans: $3.6P$ & 433.012mm .



CHAPTER -2 EQUILIBRIUM

Short Questions & Answers :

Q.1. What do you mean by Equilibrium ?

Ans. When two or more forces act on a body in such way that the body remain in a state of rest or of uniform motion, then the system of forces is said to be in equilibrium.

Q.2. What do you mean by Equilibrant ?

Ans. When a number of forces act on a body, they may not be in equilibrium. The resultant of these forces may change the state of rest or of uniform motion. Hence a single force is applied is called on equilibrant. An equilibrant is equal and opposite to the resultant of disturbing forces.

Q.3. Write the General Conditions for equilibrium.

Ans. The following conditions are :

Displacement parallel to X-axis due to component 'Fx' of the resultant force.

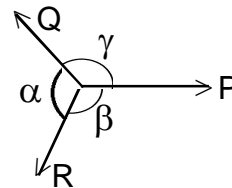
Displacement parallel to Y-axis due to component 'Fy' of the resultant force.

Rotation due to resultant couple.

Q.4. State Lami's Theorem ?

Ans. Statement or if three forces acting at a point be in equilibrium, then each force is proportional to the sine of the angle between the other two.

$$\therefore \boxed{\frac{P}{\sin\alpha} = \frac{Q}{\sin\beta} = \frac{R}{\sin\gamma}}$$



Q.5. Write the Analytical Conditions of equilibrium of a coplanar concurrent force system ?

Ans. The following conditions are :

- ❖ Algebraic sum of the resolved parts of the forces in an assigned direction is equal to zero.
- ❖ Algebraic sum of the resolved parts of the forces in a direction at right angles to the assigned direction is equal to zero.

$$\text{i.e. } \Sigma H = 0 \ \& \ \Sigma V = 0$$

Long Questions :

Q.1. A ball of weight $W = 50\text{N}$ rests in a right-angled trough as shown in fig.(1). Determine the forces exerted on sides through D and E, if all forces are perfectly smooth.

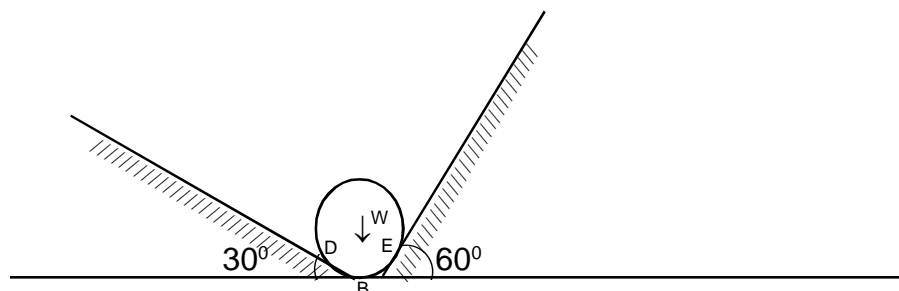
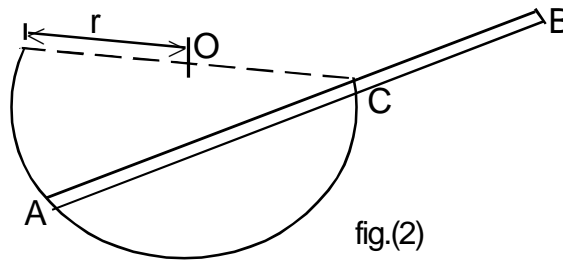
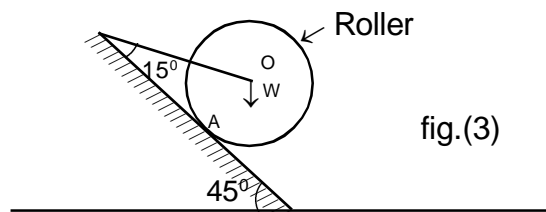


fig.(1)

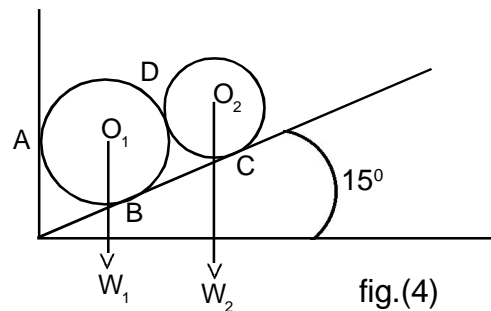
- Q.2. An uniform rod AB of length $3r$ remains in equilibrium on a hemispherical bowl of radius r as shown in fig.(2) Ignoring friction find the inclination of rod with the horizontal.



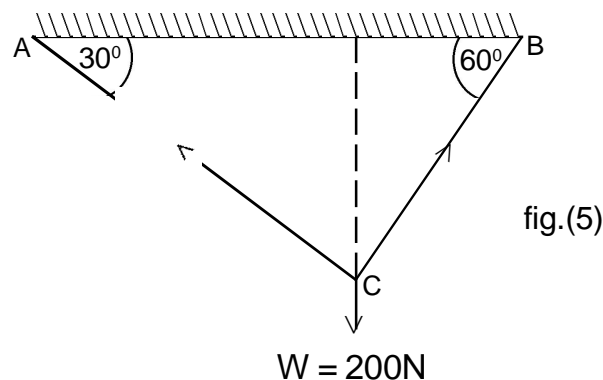
- Q.3. A roller of weight 1000N is kept on a smooth inclined plane and is prevented from moving down by a rope as shown in fig.(3). Find the tension in the rope and the reaction at point of contact 'A'.



- Q.4. Given : $W_1 = 400\text{N}$, $W_2 = 300\text{N}$. Find the reaction at point of contact A, B, C, D. Assume all the surface to be smooth fig.(4).



- Q.5. A weight of 200N is supported by two chains AC and BC as shown in fig.(5). Find out the tension in each chain.



CHAPTER -3 FRICION

Short Questions & Answers :

Q.1. Define Friction.

Ans. When a body is made to slide over another body the stationary body offers force of resistance to the motion of the sliding body over it. This force of resistance is known as (force of friction or friction).

Q.2. Define Limiting Friction.

Ans. The limiting friction is the maximum value upto which the static friction can reach and balance the external force applied for motion.

Q.3. Define co-efficient of friction.

Ans. It is the ratio of limiting friction to the normal reaction between two bodies and is generally denoted by

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

Where ϕ = Angle of Friction
F = Limiting Friction
R = Normal Reaction

Q.4. What is the angle of Friction ?

Ans. It is the angle which the resultant of normal reaction and limiting friction makes with the normal reaction.

Q.5. What do you mean by Ladder Friction ?

Ans. The ladder is a device for climbing or scaling on the roofs or wall. It consists of two long up rights of wood iron connected by a number of cross pieces called rungs.

Q.6. Define Sliding Friction and Rolling Friction.

Ans. Sliding Friction : It is the friction experienced by a body when it slide over another body.

Rolling Friction : It is the friction experienced by a body when it rolls over another body.

Long Questions :

Q.1. Briefly explain laws of Friction.

Q.2. A body resting on a rough horizontal plane, required pull of 180N inclined at 30° to the plane just to move it. It was found that a push of 220N inclined at 30° to the plane just moved the body. Determine the weight of the body and the co-efficient of friction.

Q.3. Equilibrium of a Body on a Rough inclined plane subjected to force acting along the inclined plane :

Calculate : (a) Minimum force (P_1) which will keep the body in equilibrium, when it is at the point of sliding downward.

(b) Minimum force (P_2), which will keep the body in equilibrium, when it is at the point of sliding upwards.

Q.4. A uniform ladder of length 3.25M and weighing 250N is placed against a smooth vertical wall with its lower end 1.25M from the wall. The co-efficient of friction between the ladder and floor is 0.3. What is the frictional force acting on the ladder and floor. Show that the ladder will remain in equilibrium in this position ?

Q.5. A ladder 5m long rests on a horizontal ground and leans against a smooth vertical wall at an angle of 70° with the horizontal. The weight of ladder is 900N and acts at its middle. The ladder is at the point of sliding, when a man weighing 750N stands on the rung 1.5M from the bottom of ladder. Calculate the co-efficient of friction between the ladder and the floor ?

CHAPTER -4

CENTRE OF GRAVITY & MOMENT OF INERTIA

Short Questions & Answers :

Q.1. Define Centre of Gravity and Centroid.

Ans. A body consists of a number of particles. Each particle is attracted towards the centre of earth by the earth. As the body is negligible in comparison with the earth, all the forces of attraction are considered to be parallel with each other. The resultant of all these forces acting at the point is known as Centre of Gravity (C.G). Every body has one and only one C.G.

The plane figures triangles quadrilateral etc have no mass but have only area. The centre of area of such figures is known as centroid.

Q.2. Define Moment of Inertia (M.I) and write its units.

Ans. The moment of a force (P) about a point, is the product of the force and perpendicular distance (x) between the point and the line of action of the force (i.e. P.x). This moment is also called first moment of force. If this moment is again multiplied by the perpendicular distance (x) between the point and the line of action of the force i.e. p.x.x - p.x². Then this quantity is called moment of the moment of a force or second Moment of a force of inertia i.e. M.I.

Units : In S.I. \Rightarrow m⁴ mm⁴

In C.h.s \Rightarrow Cm⁴

Q.3. What is Perpendicular Axis Theorem ?

Ans. It states that if 'I'_{xx} and 'I'_{yy} be the moment of inertia of a plane section about two perpendicular axes meeting at 'O' the moment of inertia 'I'_{zz} about the axis z - z perpendicular to the plane and passing through x-x and y-y is given by

$$I_{zz} = I_{xx} + I_{yy}$$

Q.4. What is parallel axis theorem ?

Ans. It states that "If the moment of inertia of a plane area about an axis through its centre of gravity is denoted by I_a, then the moment of inertia of the area about any other axis 'AB' parallel to the first and at a distance 'h' from the center of gravity is given by

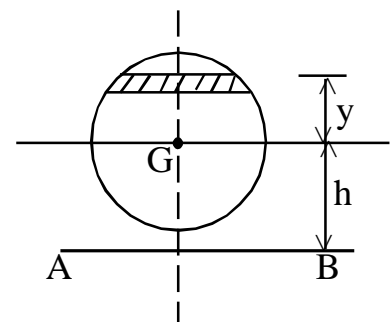
$$I_{AB} = I_G + ah^2$$

where, I_{AB} = M.O.I about an axis AB

I_G = M.O.I. about its Centre of gravity.

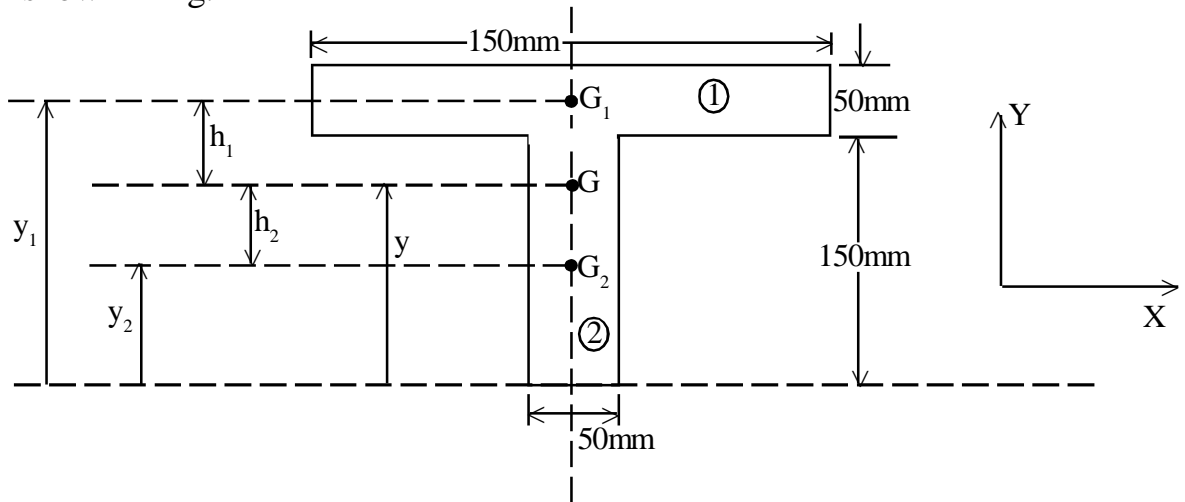
a = area of section.

h = distance between C.G and axis AB

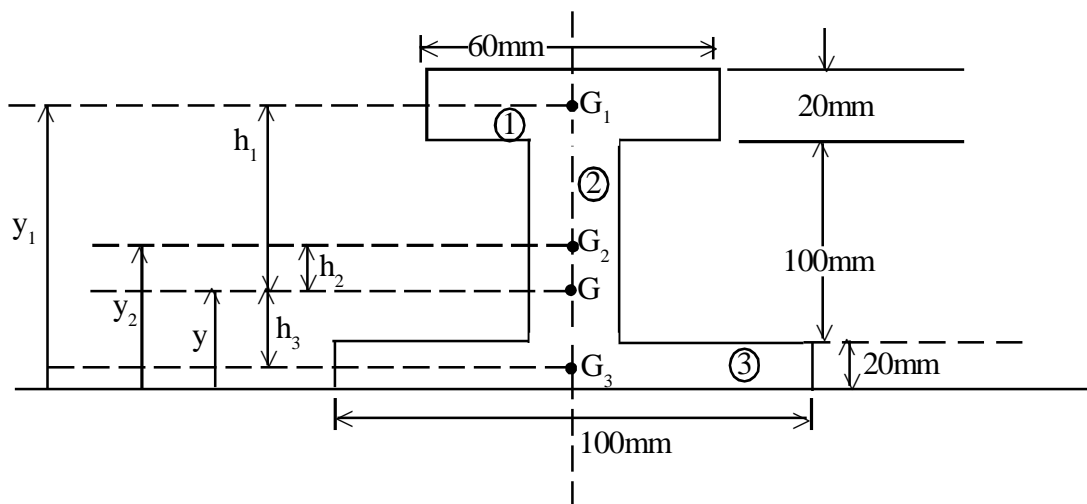


Long questions :

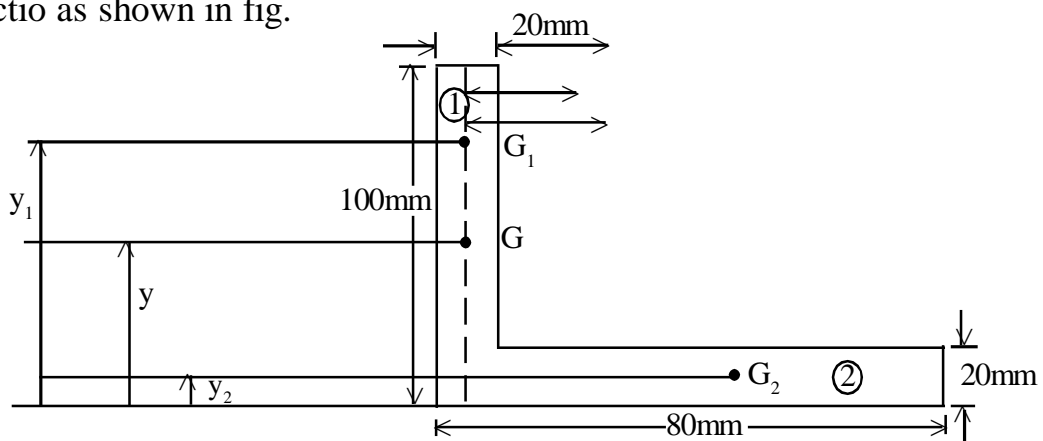
Q.1. Find MOI about x-x and y-y axis through centre of Gravity of section as shown in fig.



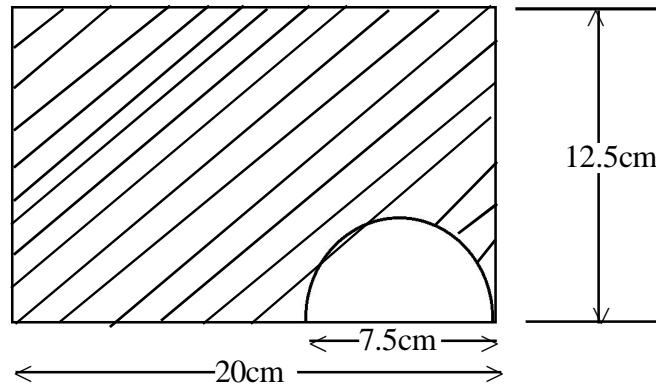
Q.2. An I-section is made up of three rectangles as shown in fig. Find the moment of inertia of the section about the horizontal axis passing through the centre of Gravity of the Section.



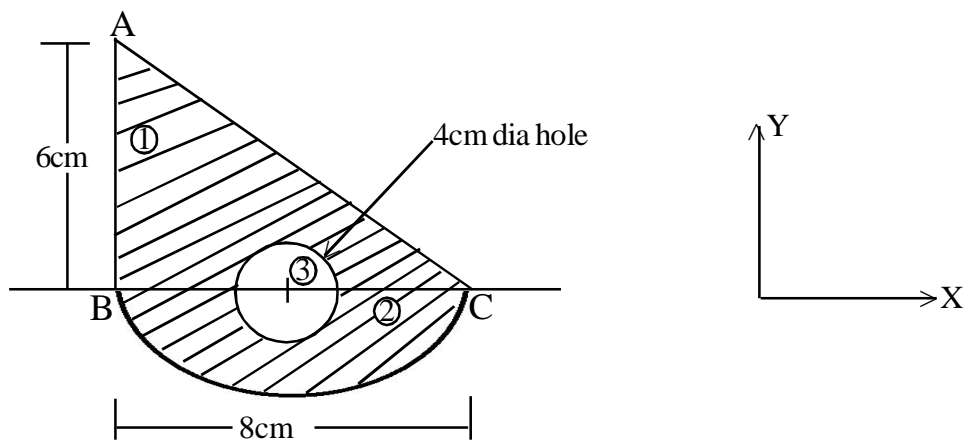
Q.3. Find the moment of inertia about the centroidal x-x and y-y axis of the angle section as shown in fig.



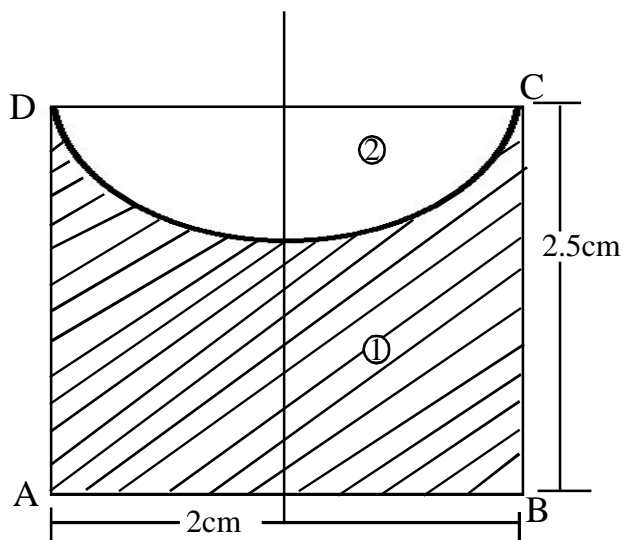
Q.4. Find the location of the C.G of the shaded area shown in fig. and its moment of inertia about the centroidal axis.



Q.5. Find moment of inertia about the centroidal axis of area shown shaded in fig. The section consists of triangle ABC, Semi-Circle on BC as diameter and a circular hole of diameter '4cm' with its centre on BC.



Q.6. Determine the moment of matrix of area shown shaded in fig. about x-axis that coincides with the base 'AB'.



CHAPTER -5
SIMPLE LIFTING MACHINES

Short Questions & Answers :

Q.1. What is Simple Machine ?

Ans. A Simple Machine may be defined as a device, which enables us to do some useful work or to overcome some resistance when an effort or force is applied, is known as simple machine.

Q.2. What is Compound Machine ?

Ans. A Compound Machine may be defined as a device consisting of a number of simple machines, which enables us to do some useful work at a faster speed or with a much less effort as compared to simple machines, is known as Compound Machine.

Q.3. What is Lifting Machine ?

Ans. It is a device which enables us to lift a heavy load (W) by applying a comparatively smaller effort (P).

Q.4. What is Input of Machine ?

Ans. The input of a machine is the work done on the machine. In lifting machine, it is measured by the product of effort and the distance through which it has moved.

Let, P = effort required to lift the load.

y = distance moved by the effort.

$$\therefore \boxed{\text{Input of a Machine} = P \times y}$$

Q.5. What is output of a machine ?

Ans. The output of a machine is the actual work done by the machine. In lifting machine, it is measured by the product of weight lifted and the distance through which it has been lifted.

Let, W = load lifted by the machine.

x = distance moved by the load.

$$\therefore \boxed{\text{Output of a machine} = W \times x}$$

Q.6. Define Mechanical Advantage.

Ans. It is the ratio of weight lifted (W) to the effort (P) applied and is always expressed in pure number.

$$\text{Mathematically} \quad \text{Mechanical Advantage} = \frac{W}{P}$$

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Q.7. Define efficiency of machine.

Ans. It is the ratio of output to the input of a machine and is generally expressed as a percentage.

$$\text{Mathematically, Efficiency, } \eta = \frac{\text{output of machine}}{\text{input of machine}} \times 100$$

$$\text{or } \boxed{\eta = \frac{W \times x}{P \times y} \times 100}$$

Q.8. What is ideal machine ?

Ans. If the efficiency of machine is 100%, i.e. if the output is equal to input, the machine is called as a perfect or an ideal machine.

Q.9. Define Velocity Ratio.

Ans. It is ratio of distance moved by the effort (y) to the distance moved by the load (x) and is always expressed in pure number.

$$\text{Mathematically, } \boxed{\text{Velocity Ratio (VR)} = \frac{y}{x}}$$

Q.10. What do you mean by Reversibility of a machine ?

Ans. Sometimes, a machine is also capable of doing some work in the reversed direction after the effort is removed. Such a machine is called a reversible machine and its action is known as reversibility of a machine i.e. efficiency should be more than 50%.

Q.11. What do you mean by self locking machine ?

Ans. Sometimes, a machine is not capable of doing any work in the reversed direction, after the effort is removed such a machine is called a non-reversible or self locking machine.

i.e. efficiency should not be more than 50%.

Q.12. What do you mean by Friction in a Machine ?

Ans. The machine friction may be expressed either on the effort side or on the load side. If expressed on the effort side, the friction may be defined as an additional effort required to overcome the friction force. But if expressed on load side, the friction may be defined as the additional load that can be lifted to overcome friction.

Q.13. What do you mean by law of machine ?

Ans. The term law of machine may be defined as relationship between the effort applied and the load lifted.

$$\text{Mathematically, } \boxed{P = M.W + C}$$

Where, P = effort applied to lift the load.

M = Constant, called co-efficient of friction which is equal to the slope of line.

W = load lifted.

C = Another constant, which represents the machine friction.

Q.14. What do you mean by maximum mechanical advantage of a lifting machine ?

Ans. Maximum mechanical advantage of a lifting machine.

$$\boxed{(M.A)_{\max} = \frac{1}{M}}$$

Where, M = Constant, called co-efficient of friction which is equal to the slope of line.

Q.15. What do you mean by maximum efficiency of a lifting machine.

Ans. Efficiency of a lifting machine.

$$\eta = \frac{M.A}{V.R}$$

Maximum efficiency of a lifting machine.

$$\boxed{(\eta)_{\max} = \frac{1}{M \times VR}} \quad \text{VR = Velocity Ratio}$$

Long Questions :

Q.1. In a lifting machine whose velocity ratio is 50 and an effort of 100N is required to lift a load of 4KN. Is the machine reversible ? If so, what effort should be applied, so that the machine is at the point of reversing.

- Q.2. In a certain machine, an effort of 100N is just able to lift a load of 840N. Calculate the efficiency and friction both an effort and load side, if the velocity ratio of machine is 10.
- Q.3. What load can be lifted by an effort of 120N, if the velocity ratio is 18 and efficiency of the machine at this load is 60%. Determine the law of machine, if it is observed that an effort of 200N is required to lift a load of 2600N and find the effort required to run the machine at a load of 3.5KN.
- Q.4. What load will be lifted by an effort of 12N, if the velocity ratio is 18 and efficiency of the machine at this load is 60%. If the machine has a constant friction resistance. determine the law of the machine and find the effort required to run this machine at (i) no load (ii) a load of 900N
- Q.5. The velocity ratio of the machine is 100. Find the maximum possible mechanical advantage and the maximum possible efficiency of machine. Determine the effort required to overcome the machine friction, while lifting a load of 600N. Also calculate the efficiency of the machine at this load.

CHAPTER -6 DYNAMICS

Short Questions & Answers :

Q.1. State D'Alembert's Principle.

Ans. If a rigid body is acted upon by a system of forces, the system of forces is in dynamic equilibrium with the inertia force of the body.

Let P = resultant of a number of forces acting on the rigid body of mass m.

Then this resultant (P) will move the body with an acceleration (a) in its own direction.

We have $P = m \cdot a$ (1)

The body will be at rest if a force equal to (m.a) is applied in reverse direction, hence for dynamic equilibrium of the body sum of resultant force and the reversed force will be equal to zero.

We have $P - ma = 0$ (2)

The force (-ma) is known as inertia force or reversed effective force.

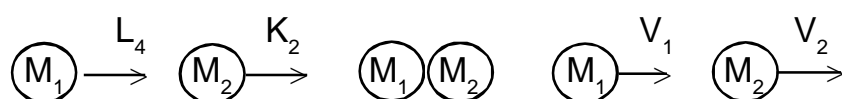
Eqn(1) is the equation of dynamics and Eqn(2) is the equation of statics. The

Eqn(2) is known as the equation of dynamic equilibrium under the action of 'P'.

This is known as 'D'Alembert's Principle

Q.2. State Law of Conservation of Linear Momentum.

Ans. It states that total momentum of any system always remains constant and no external force acts on it.



It may also be stated as for an isolated system, total momentum of the system is constant.

i.e. Momentum before collision = Momentum after collision

$$\boxed{M_1 L_1 + M_2 K_2 = M_1 V_1 + M_2 V_2}$$

Q.3. State Law of Conservation of Energy.

Ans. It states on energy can not be created nor can it be destroyed, but it can be transformed from one form to the other.

Or, the total energy possessed by an object remains constant provided no energy is added to or subtracted from it.

Q.4. State Newton's Law of Collision of Elastic Bodies.

Ans. It states when two moving bodies collide with each other their velocity of separation bears a constant ratio to their velocity of approach.

Mathematically $(V_2 - V_1) = e(K_1 - K_2)$

Where $e =$ Co-efficient of restitution.

if $e = 0 \Rightarrow$ two bodies are in elastic

if $e = 1 \Rightarrow$ two bodies are perfectly elastic.

Q.5. Define co-efficient of restitution.

Ans. It is defined as the ratio of velocity of separation to velocity of approach.

Mathematically, $e = \frac{\text{Velocity of separation}}{\text{Velocity of approach}}$

$$\text{i.e. } e = \frac{V_2 - V_1}{u_1 - u_2}$$

Where, $u_1 =$ initial velocity of body A, $V_1 =$ Final velocity of body A after collision.

$u_2 =$ initial velocity of body B, $V_2 =$ final velocity of body B after collision.

Long Questions :

Q.1. A body of mass 7.5kg is moving with a velocity of 1.2m/6sec. If a force of 15N is applied on the body determine its velocity after 2 sec.

Q.2. A constant retarding force of 50N is applied to a body of mass 20kg moving initially with velocity of 15m/sec. How long the body will take to stop ?

Q.3. A bullet of mass 20g is fired horizontally with a velocity of 300m/s, from a gun carried in a carriage which together with the gun has mass of 100kg. The resistance to sliding of the carriage over the ice on which it rest is 20N. Find

(a) Velocity with which the gun will recede.

(b) Distance in which it comes to rest.

(c) Time taken to do so.

Q.4. A ball of mass 1kg moving with a velocity of 2m/s impinges directly on a ball of mass 2kg at rest. The first ball, after impinging, comes to rest.

Find the velocity of the second ball after the impact and the co-efficient of restitution.

Q.5. A ball impinges directly on a similar ball at rest. The first ball is reduced to rest by the impact. Find the co-efficient of restitution, if half of the initial kinetic energy is lost by impact.