QUESTION BANK

ON

ENGINEERING MECHANICS

(Th- 4a) 1st & 2nd Semester, all branches.

Under SCTE & VT, Odisha

GOVERNMENT POLYTECHNIC JAJPUR

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LECT. IN MECHANICAL

MODULE 1

FUNDAMENTALS OF ENGINEERING MECHANICS

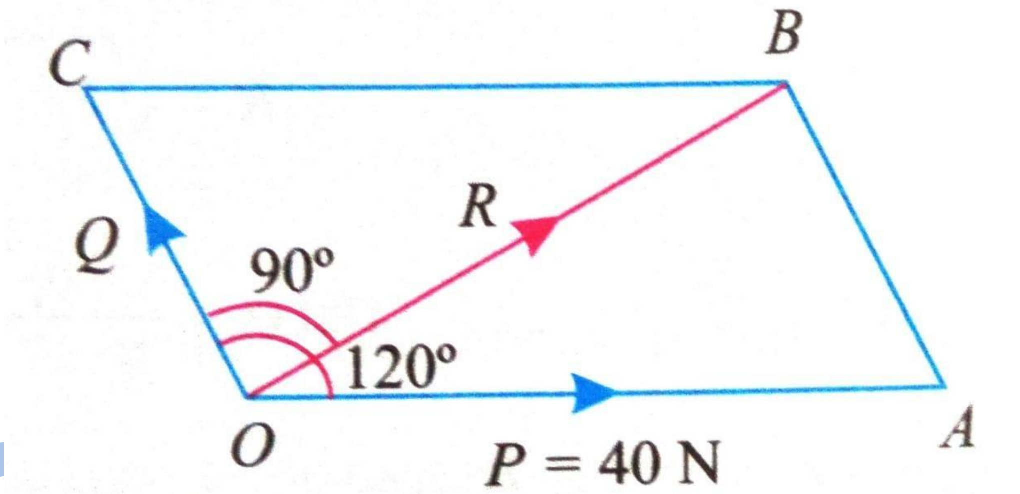
SHORT ANSWER TYPE QUESTIONS (2 MARKS)

1. Define force and its units in S.I. System.
2. What is a rigid body?
3. What is free body diagram?
4. What is a resultant force?
5. What is co-planer forces?
6. What is concurrent forces?
7. What is co-linear forces?
8. What is co-planer concurrent forces?
9. Define triangle law of forces.
10. State the law of Parallelogram of forces.
11. State Polygon's law of forces.
12. Define Moment of a Force and state its unit in S.I. system.
13. State law of moment.
14. Define couple.
15. State Varignon's theorem.

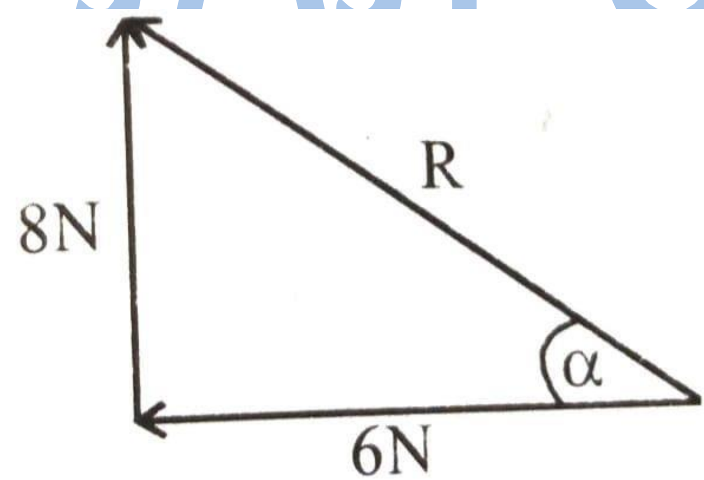
SHORT ANSWER TYPE QUESTIONS (5 MARKS)

1. A particle is acted on by three forces 2, $2\sqrt{2}$ and 1 KN. The first force is horizontal and towards the right, the second acts at 45^0 to the horizontal and inclined right upward and the third is vertical. Determine the resultant of the given forces.
2. State and prove triangle law of forces.

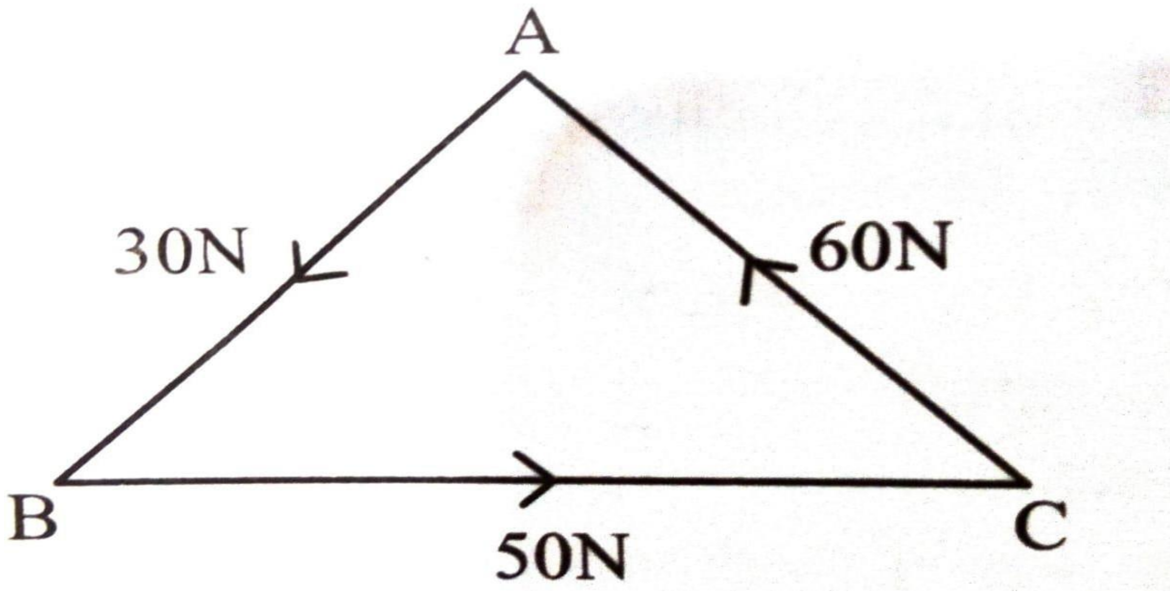
3. State and explain Parallelogram law of forces.
4. The resultant of two forces P and 15N is 50N inclined at 60^0 to the 15N force. Find the magnitude and direction of P.
5. Two forces act at an angle of 120^0. The bigger force is 40N and the resultant is perpendicular to the smaller one. Find the smaller force.



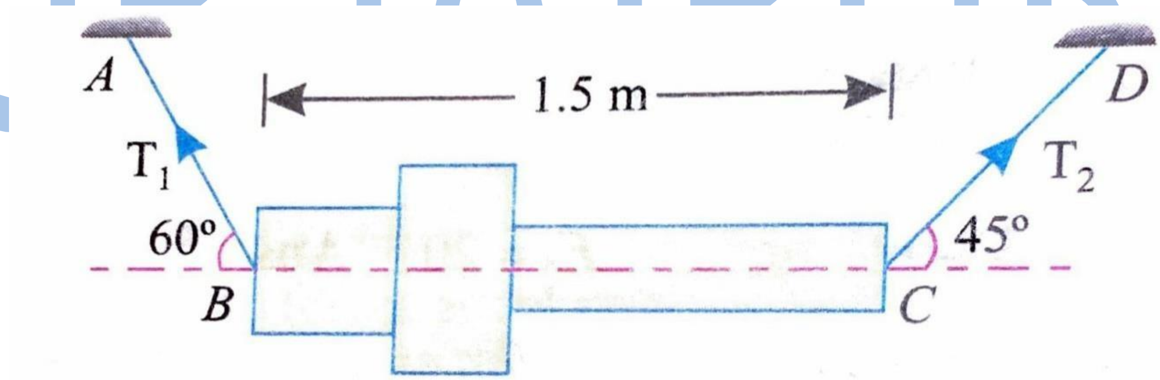
6. Find the angle between two equal forces of magnitude P, when their resultant is
   (i) P (ii) P/2
7. Find the magnitude and direction of force, which when combines with a 8N vertical force, will give 6N horizontal force.



8. Force of 30N, 50N and 60N are acting along the sides of an equilateral triangle ABC of side 50cm as shown in figure. Find the magnitude, direction and position of resultant force.

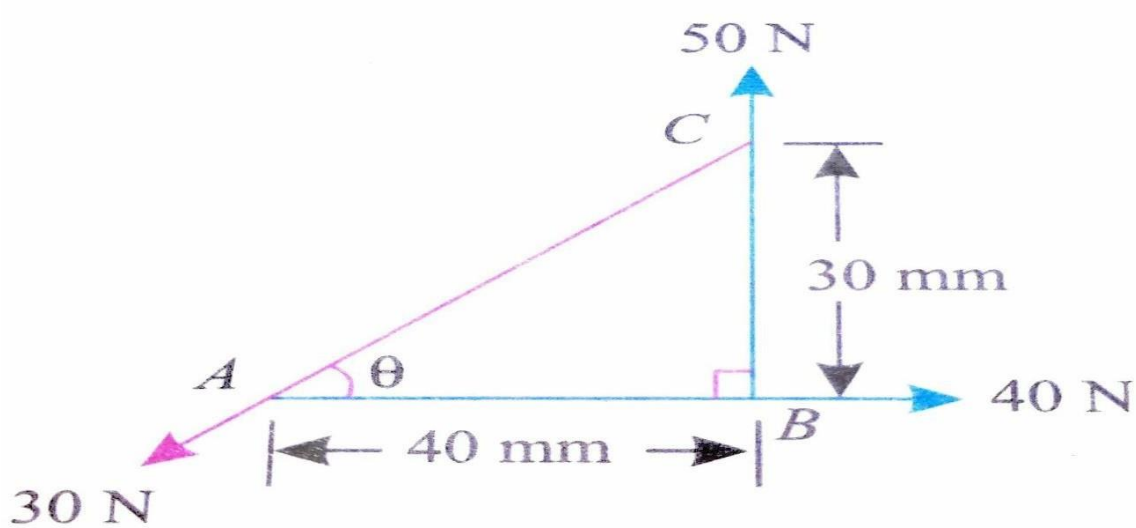


9. Two forces one of which is double the other, has resultant of 260N. If the direction of the larger force is reversed and the other remain unaltered, the resultant reduces to 180N. Determine the magnitude of the forces and the angle between them.
10. A machine component 1.5m long and weight 1000N is supported by two ropes AB and CD as shown in figure given below.

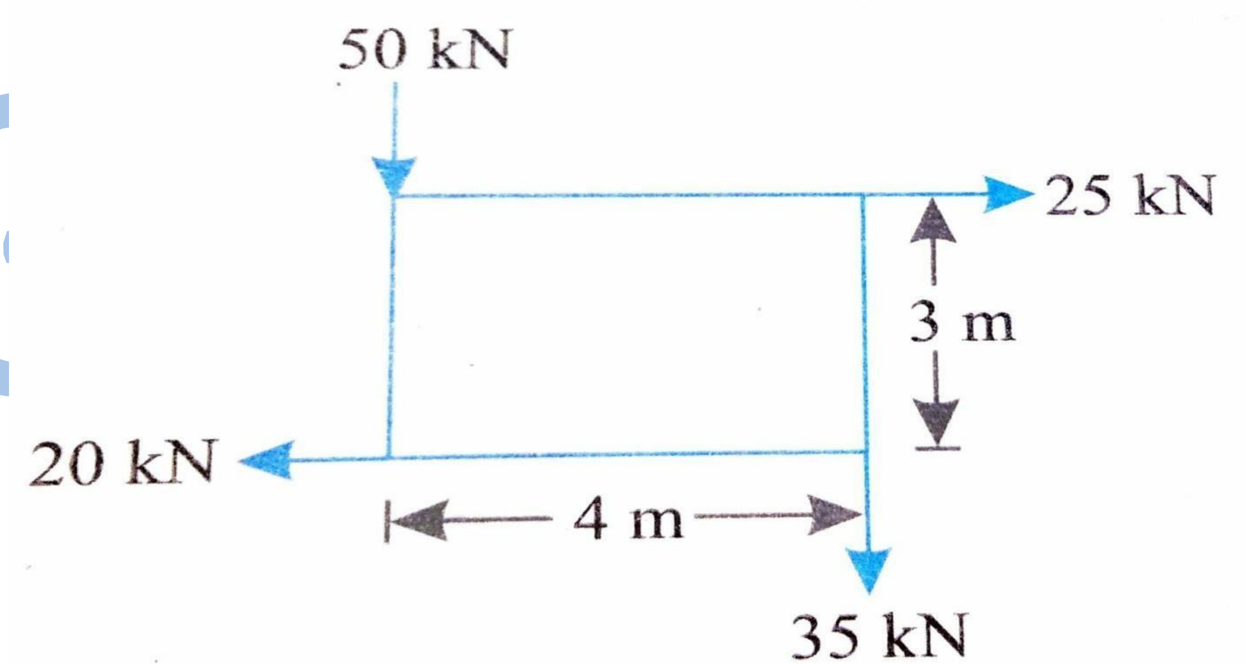


Calculate the tensions T_1 and T_2 in the ropes AB and CD.

11. A triangle ABC has its side AB=40mm along positive x-axis and side BC=30mm along positive y-axis. Three forces of 40N, 50N and 30N act along the sides AB, BC and CA respectively. Determine magnitude of the resultant of such a system of forces.

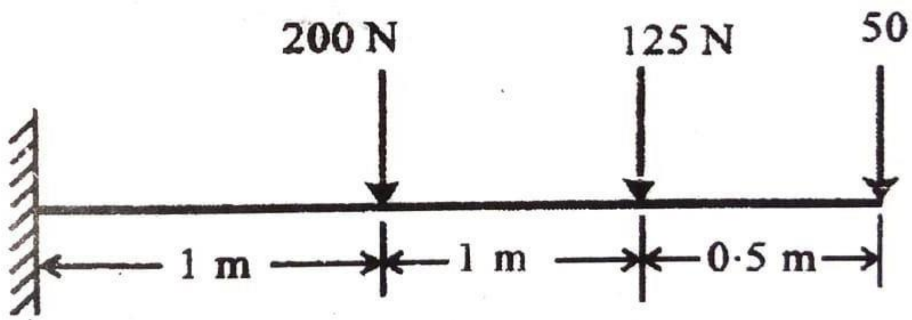


12. A system of forces are acting at the corners of a rectangular block as shown in figure.

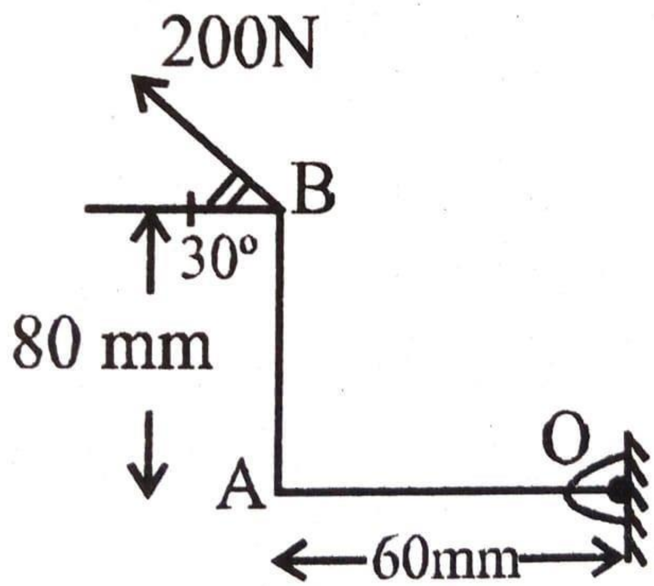


Determine the magnitude and direction of the resultant force.

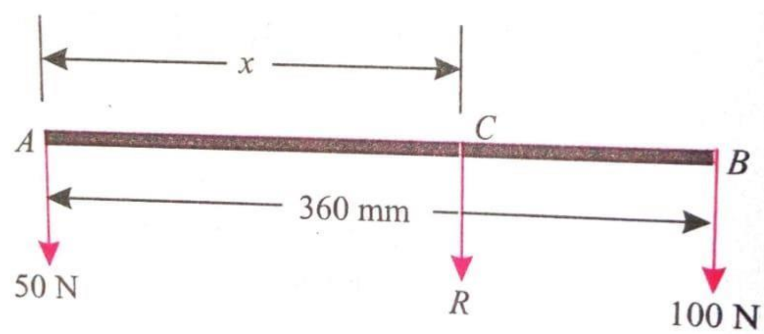
13. State and explain Varignon's theorem.
14. A system of parallel forces acting on a lever is shown in figure. Determine the magnitude, direction and position of the resultant.



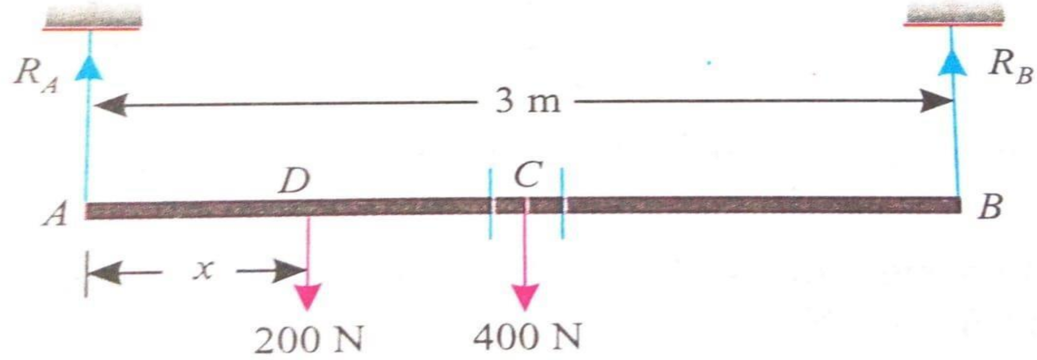
15. A force of 200N is acting on a bracket OAB hinged at ‘O’ as shown in figure. Find the moment of the force about ‘O’.



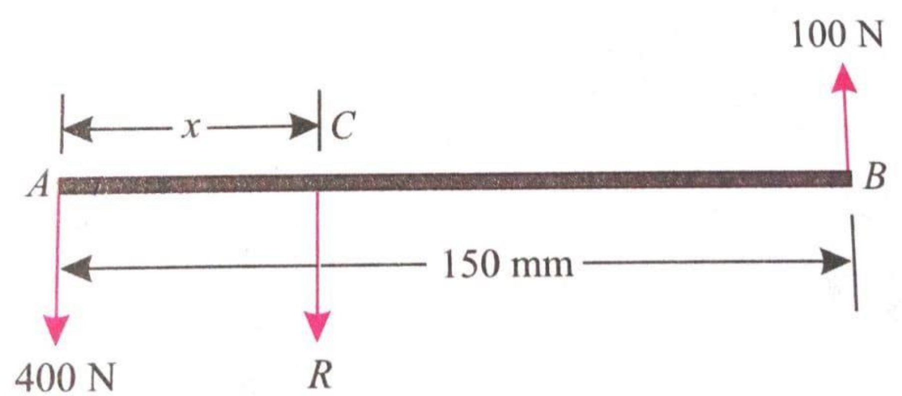
16. ABCD is a rectangle, in which AB=CD=25cm and BC=DA=45cm. Forces of 150N each act along AB and CD and forces of 200N each act along BC and DA. Find the resultant moment of two couple.
17. Two like parallel forces of 50N and 100N act at the ends of a rod 360mm long. Find the magnitude of the resultant force and the point where it acts.



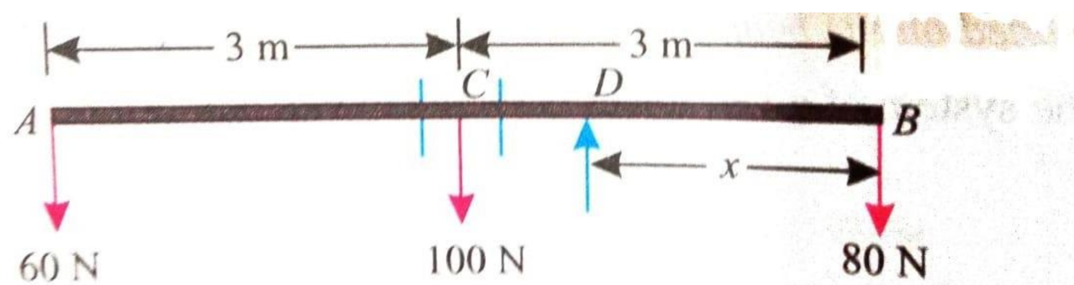
18. A beam 3m long weighing 400N is suspended in a horizontal position by two vertical strings, each of which can withstand a maximum tension of 350N only. How far a body of 200N weight be placed on the beam, so that one of the strings may just break?



19. Two unlike parallel forces of magnitude 400N and 100N are acting in such a way that their lines of action are 150mm apart. Determine the magnitude of the resultant force and the point at which it acts.

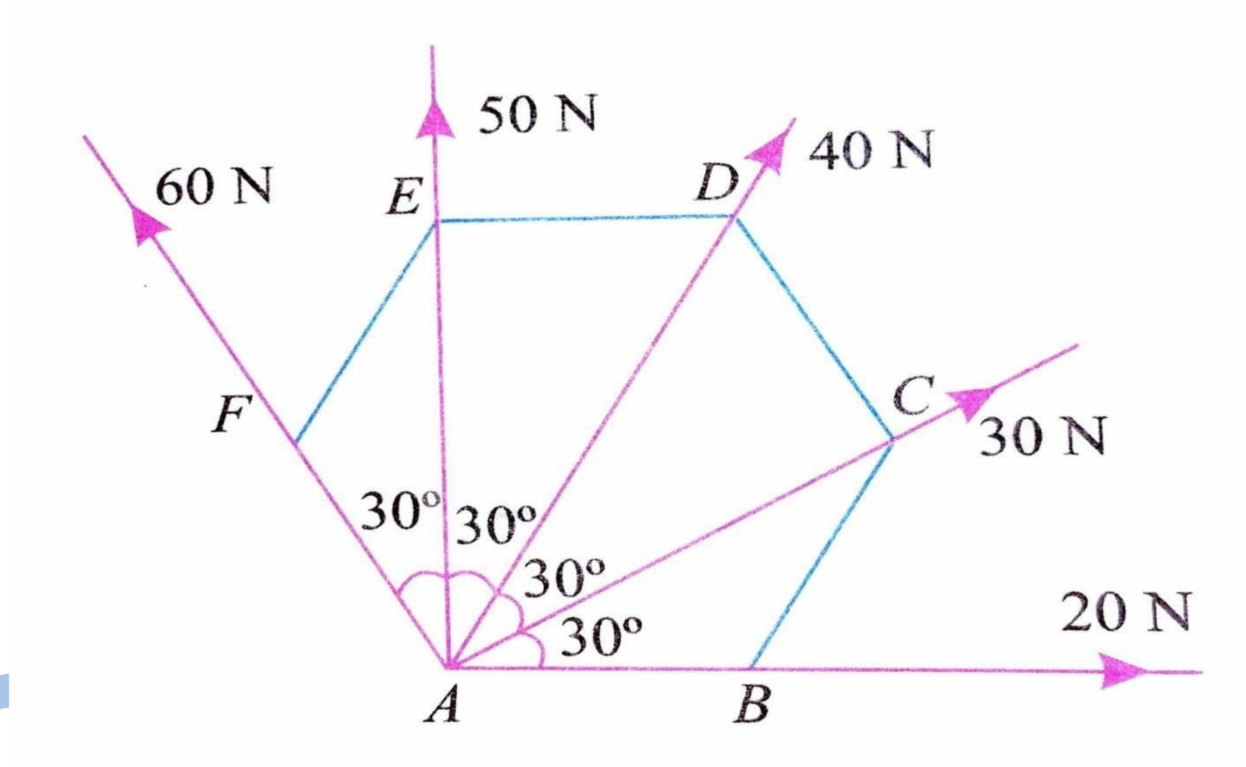


20. A uniform beam AB of weight 100N and 6m long had two bodies of weights 60N and 80N suspended from its two ends as shown in figure.
Find analytically at what point the beam should be supported, so that it may rest horizontally.



LONG ANSWER TYPE QUESTIONS (8 MARKS)

1. The forces 20 N, 30 N, 40 N, 50 N and 60 N are acting at one of the angular points of a regular hexagon, towards the other five angular points, taken in order. Find the magnitude and direction of the resultant force.



2. The following forces act at a point :

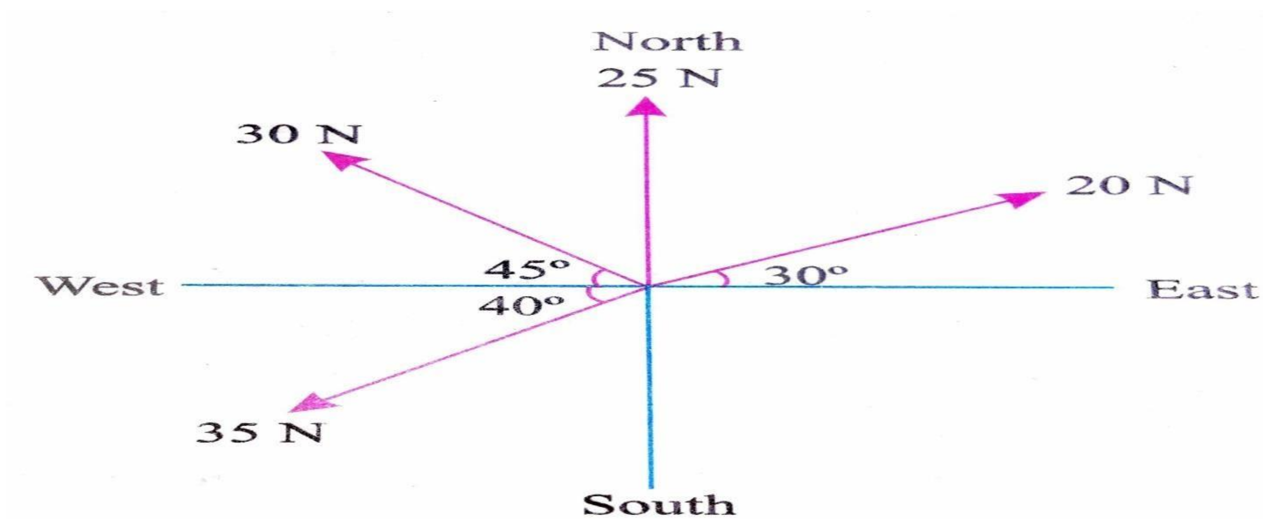
   (i) 20N inclined at 30^0 towards North of East

   (ii) 25N towards North

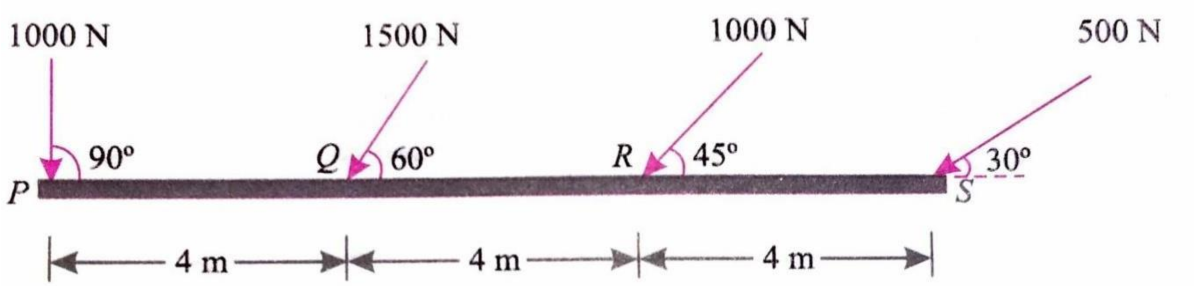
   (iii) 30N towards North West, and

   (iv) 35N inclined at 40^0 towards South of West

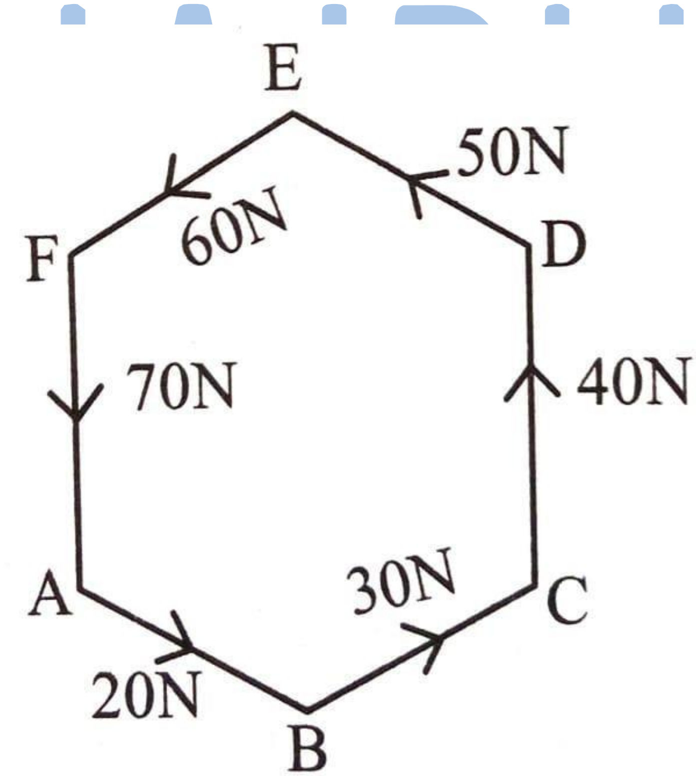
   Find the magnitude and direction of the resultant force.



3. A horizontal line PQRS is 12 m long, where PQ = QR = RS = 4 m. Forces of 1000 N, 1500 N, 1000 N and 500 N act at P, Q, R and S respectively with downward direction. The lines of action of these forces make angles of 90°, 60°, 45° and 30° respectively with PS. Find the magnitude, direction and position of the resultant force.

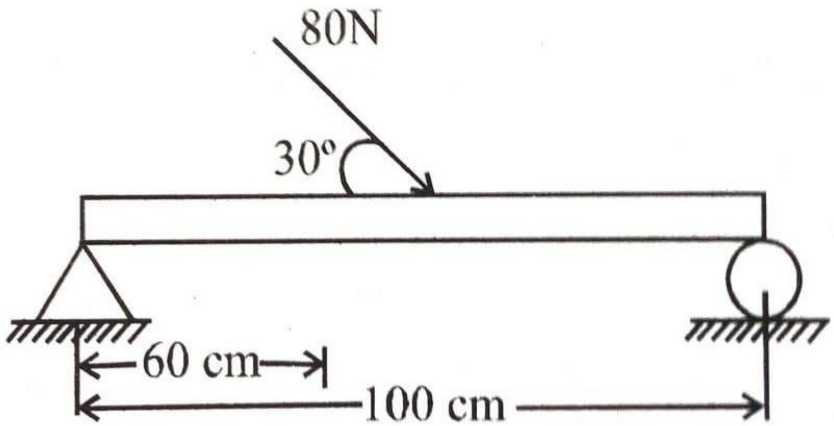


4. ABCDEF is a regular hexagon. Forces are 20N, 30N, 40N, 50N, 60N and 70N are acting along the sides AB, BC, CD, DE, EF and FA respectively as shown in Fig.-1. Find the magnitude and direction of resultant force.

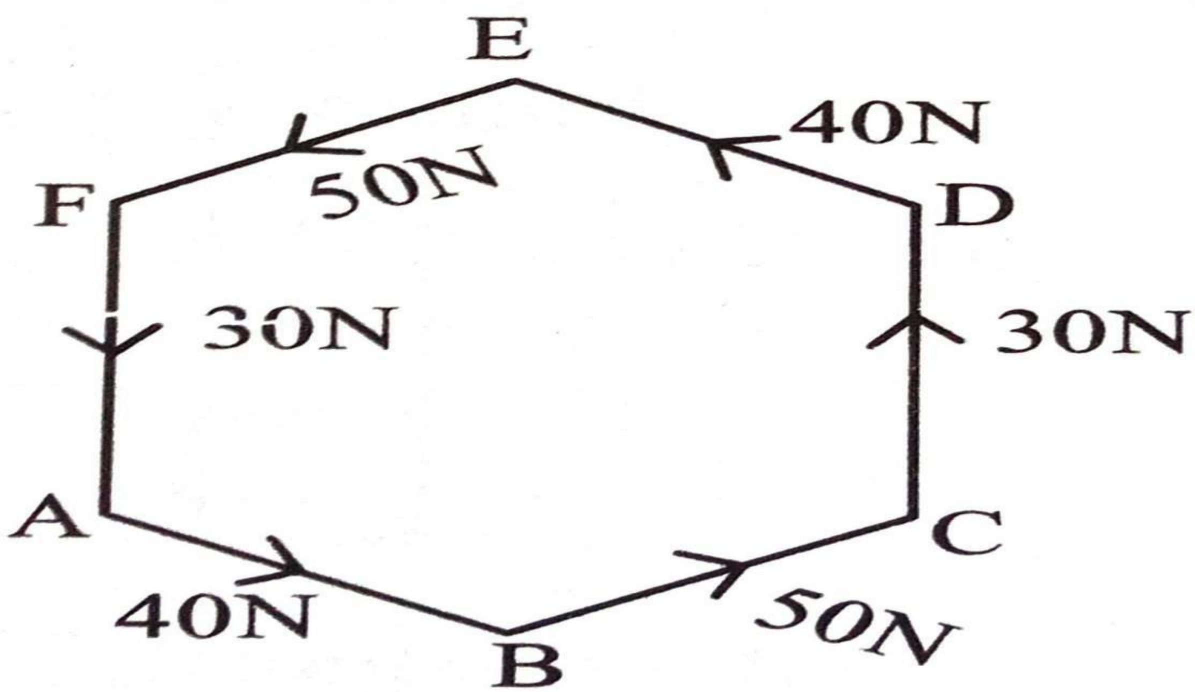


5. A beam AB of length 5m supported horizontally at A and B carries point loads of 5KN, 8KN and 3KN at a distance of 1m, 2m and 4m from the support A respectively. Find the reactions at A and B.

6. A beam of length 1m is hinged at one end A and rests on a roller support at other end B as shown in figure. The beam is acted upon by an inclined force of 80N at a distance of 60cm from A. Find the reaction at A and B.

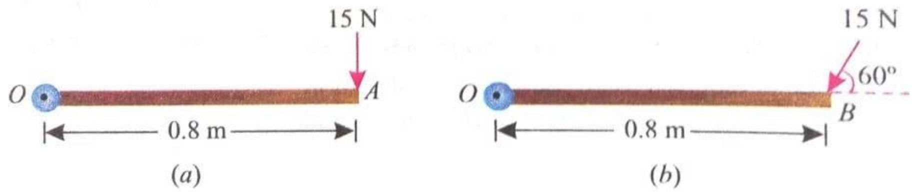


7. A regular hexagon has sides equal to 20cm. Forces of 30N each act along AF and DC, 40N each along AB and DE, 50N each along BC and EF as shown in figure. Find the moment of the couple required to keep the system in equilibrium.

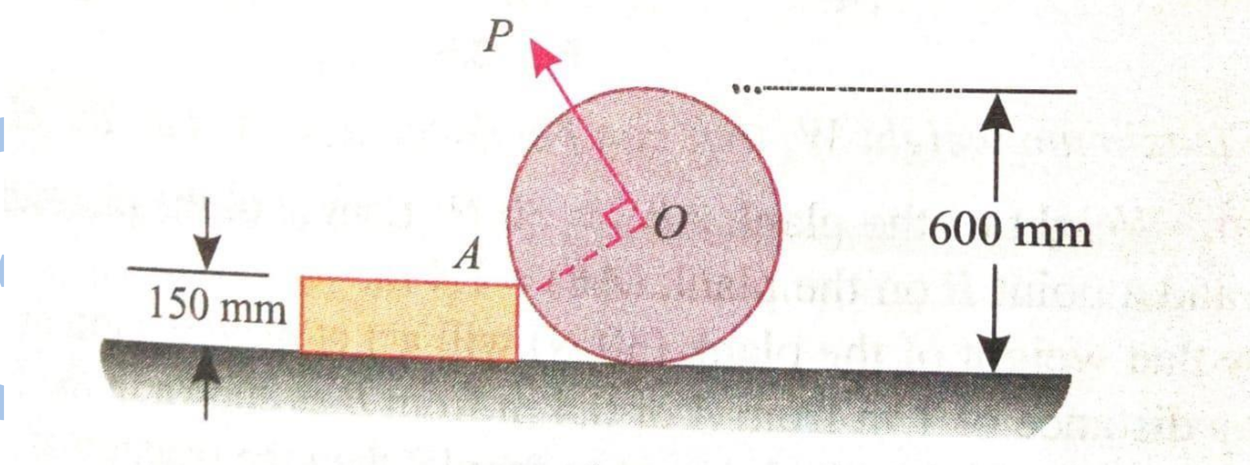


8. A force of 15N is applied perpendicular to the edge of a door 0.8m wide as shown in figure (a). Find the moment of the force about the hinge.

If this force is applied at an angle of 60^0 to the edge of the same door, as shown in figure (b), then find the moment of this force.



9. A uniform wheel of 600mm diameter, weighing 10KN rests against a rigid rectangular block of 150mm height as shown in figure. Find the least pull required at the top of the wheel just to turn the wheel over the corner 'A' of the block. Also find the reaction at 'A'. (Assume all the surfaces to be smooth.)



MODULE 2

EQUILIBRIUM

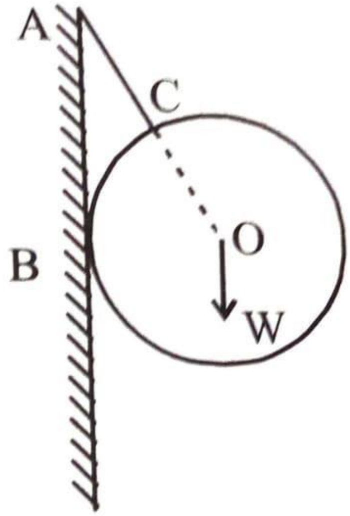
SHORT ANSWER TYPE QUESTIONS (2 MARKS)

1. What are the conditions for equilibrium?
2. State the condition of equilibrium for non-concurrent forces.
3. State the condition of equilibrium for a free body diagram.
4. State Lami's theorem.

SHORT ANSWER TYPE QUESTIONS (5 MARKS)

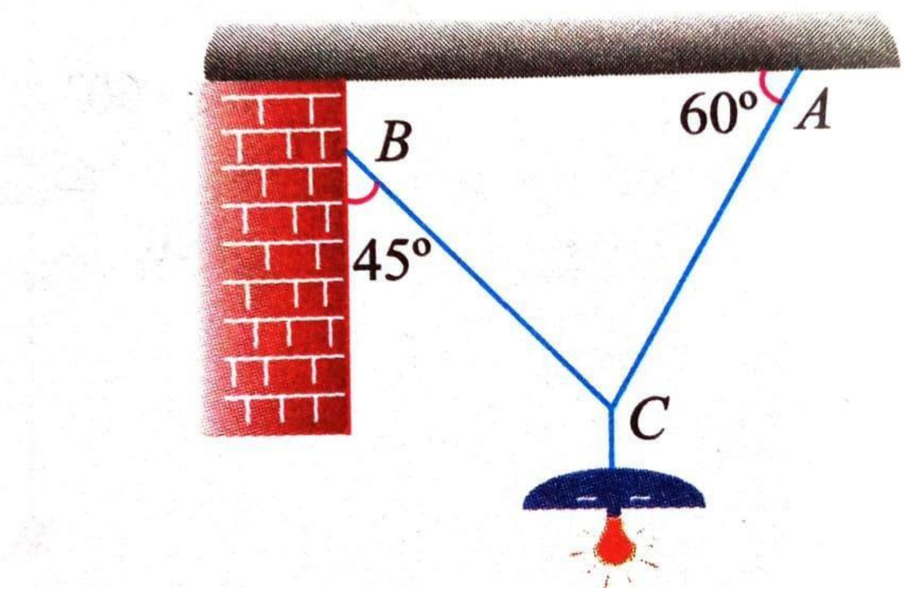
1. State and Proof Lami's theorem.

2. A smooth sphere of weight 1000N is supported by a string fastened to a point A on the smooth vertical wall, the other end is in contact with point B on the wall as shown in figure. If the length of the string AC is equal to the radius of the sphere, find the tension in the string and reaction of the wall.



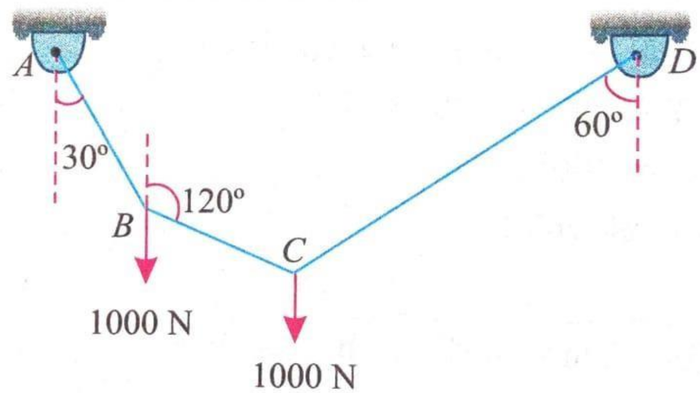
LONG ANSWER TYPE QUESTIONS (8 MARKS)

1. An electric light fixture weighs 15N hangs from a point 'C' by two strings AC and BC. The string is inclined at 60^0 to the horizontal and BC is at 45^0 to the horizontal as shown in figure below.



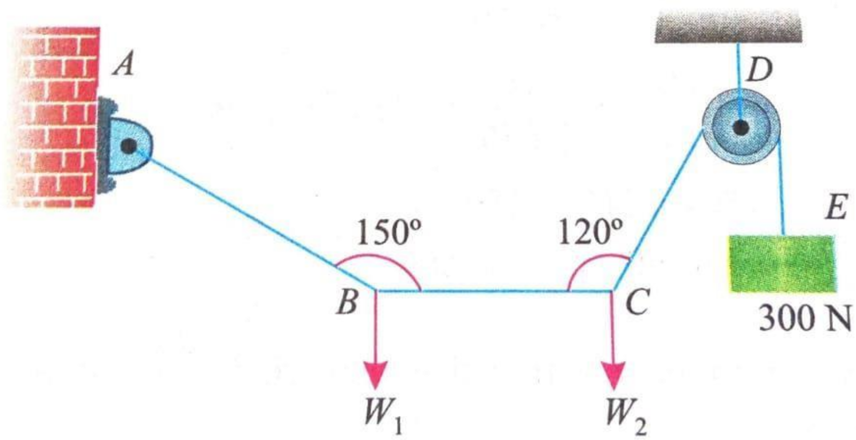
Determine the forces on string AC and BC using Lami's theorem.

2. A string ABCD, attached to fixed points A and D has two equal weights of 1000N attached to it at B and C. The weight rest with the portions AB and CD inclined at angles as shown in figure.



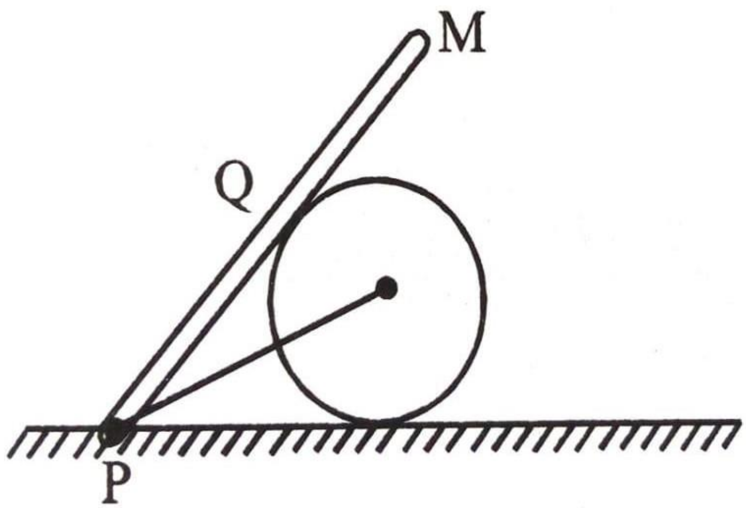
Find the tensions in the portions AB, BC and CD of the string, if the inclination of the portion BC with the vertical is 120^0.

3. A light string ABCDE whose extremity A is fixed, has weights W_1 and W_2 attached to it at B and C. It passes round a small smooth peg at D carrying a weight of 300N at the free end E as shown in figure.

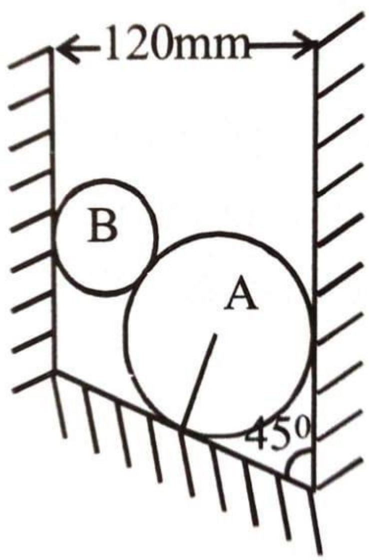


If in the equilibrium position, BC is horizontal and AB and CD make 150^0 and 120^0 with BC, find (i) Tension in the portion AB, BC and CD of the string and (ii) Magnitude of W_1 and W_2.

4. A smooth right circular cylinder of radius 16cm rests on horizontal plane and is prevented from rolling by an inclined string PC of length 32cm as shown in figure. A prismatic bar PQM of length 48cm and weight 530N is hinged at P and leans against the cylinder. Find the tension in the string.



5. A spherical ball of weight 100 kgf rests on two smooth inclined planes whose sides are inclined at 30^0 and 60^0 to the horizontal. Find the reaction of each inclined plane on the ball.
6. Two cylinders A and B of diameter 100mm and 50mm respectively are placed in through as shown in figure. Weight of A is 200N and that of B is 50N. Neglecting friction find the reactions at the contact surfaces.



MODULE 3

FRICTION

SHORT ANSWER TYPE QUESTIONS (2 MARKS)

1. Define friction and co-efficient of friction.
2. Define coefficient of friction.

3. Define limiting angle of friction.
4. Write any two advantages of friction.

SHORT ANSWER TYPE QUESTIONS (5 MARKS)

1. Explain laws of friction.
2. A body of weight 50N is pulled along a rough horizontal plane by a force of 18N acting at an angle of 14^0 with the horizontal. Find the coefficient of friction.
3. Derive the relation between angle of friction and angle of repose.
4. Show that angle of friction is equal to angle of repose of an inclined plane.

LONG ANSWER TYPE QUESTIONS (8 MARKS)

1. A body resting on a rough horizontal plane required a pull of 18KN inclined at 30^0 to the plane just to move it. It was found that a push of 22KN inclined at 30^0 to the plane just moved the body. Determine the weight of the body and coefficient of friction.
2. Two blocks 'A' and 'B' of weight 1KN and 2KN are in equilibrium position as shown below.

   If the coefficient of friction μ between two blocks and block 'B' and floor is 0.3. Find force 'P' required to move the block.
3. The block 'A' as shown in figure weighs 2000N. The cord attached to 'A' passes over a frictionless pulley and supports a weight equal to 800N. The value of the coefficient of friction between 'A' and the horizontal plane is 0.35. Find the value of P, if motion is impending towards left.
4. A body of weight 500N is lying on a plane inclined at an angle of 30^0 with the horizontal. It is supported by an effort P parallel to the plane as shown in figure. Determine the minimum and maximum value of P for which equilibrium can exist, if the coefficient of friction is 0.35.
5. A rectangular block weighing 150N is lying on an inclined plane, whose inclination with horizontal is 45^0. The block is tied up by a horizontal string, as shown in figure, which has a tension of 50N. Find.

   (i) The frictional force on the block

   (ii) Normal reaction of the inclined plane

   (iii) Coefficient of friction between the surfaces of contact

6. Find the force acting parallel to the inclined plane required to move a weight of 400N up to plane the inclination of the plane being such that a force of 100N applied to the body at an angle of 30^0 could support it if the plane were smooth. Assume μ=0.25.
7. A ladder 5m long rests on a horizontal ground and leans against a smooth vertical wall at an angle 70^0 with ladder is 900N and acts at its middle. The ladder is at the point of sliding, when a man weighing 750N stands on a rung 1.5m from the bottom of the ladder. Calculate the coefficient of friction between ladder and the floor.
8. A 4m ladder weighing 250N is placed against a smooth vertical wall its lower end 1.5m away from the wall. If the coefficient of friction between the ladder and the floor is 0.3, show that the ladder will remain in equilibrium in this position.
9. A block weighing 3000KN is to be raised by means of a 10^0 wedge as shown in figure. Assuming μ=0.3 for all surfaces of contact, what minimum horizontal force P should be applied to raise the block?

MODULE 4

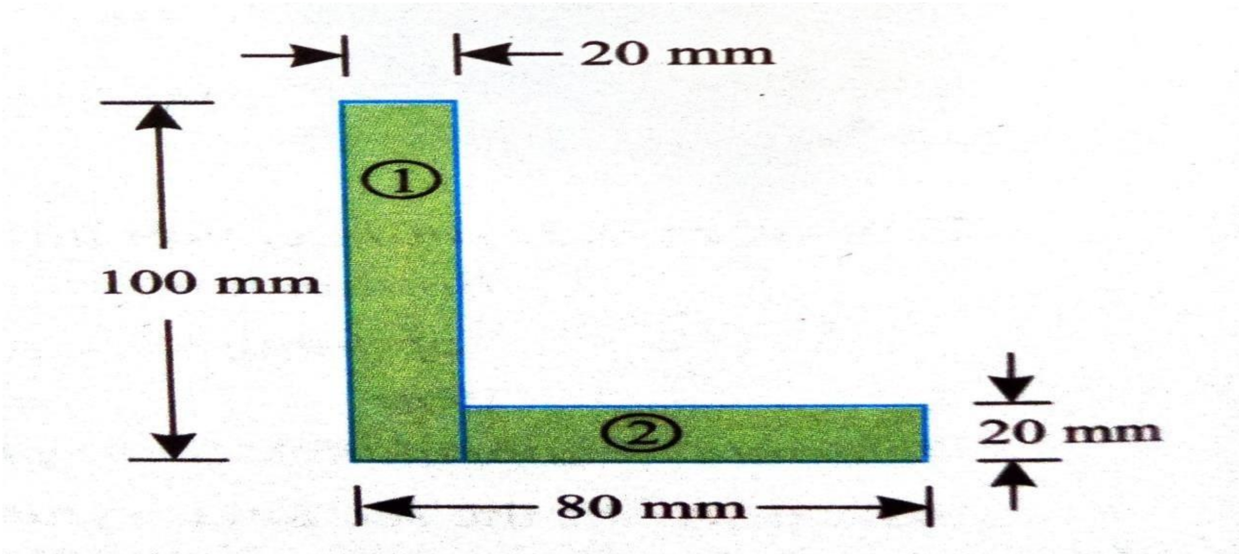
CENTROID & MOMENT OF INERTIA

SHORT ANSWER TYPE QUESTIONS (2 MARKS)

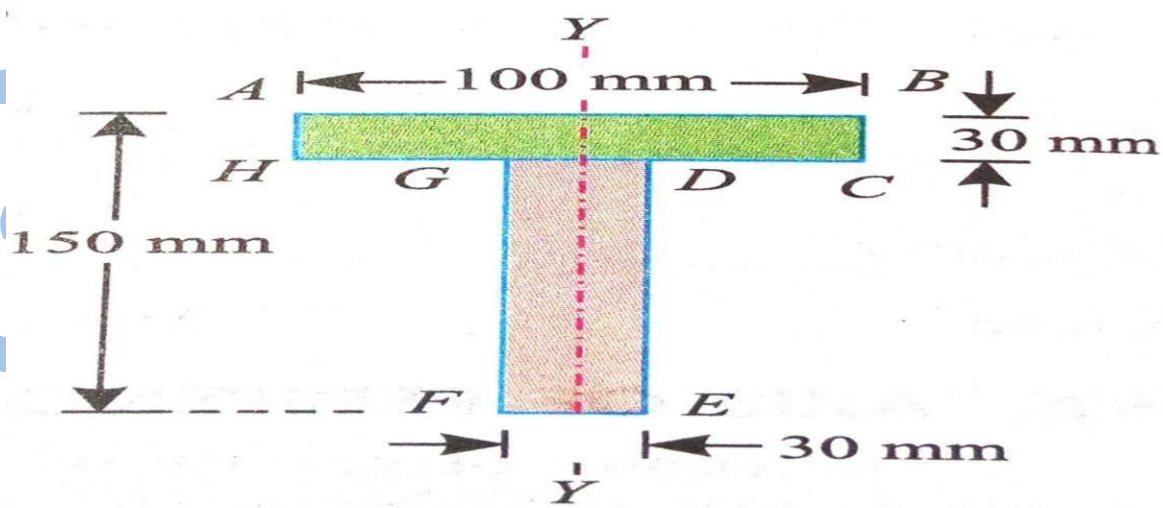
1. Define centroid of a plane figure.
2. What is the distance of centroid of a semicircular area from the base?
3. Define center of gravity.
4. Distinguish between centroid and center of gravity.
5. State perpendicular axis theorem.
6. State parallel axis theorem.

SHORT ANSWER TYPE QUESTIONS (5 MARKS)

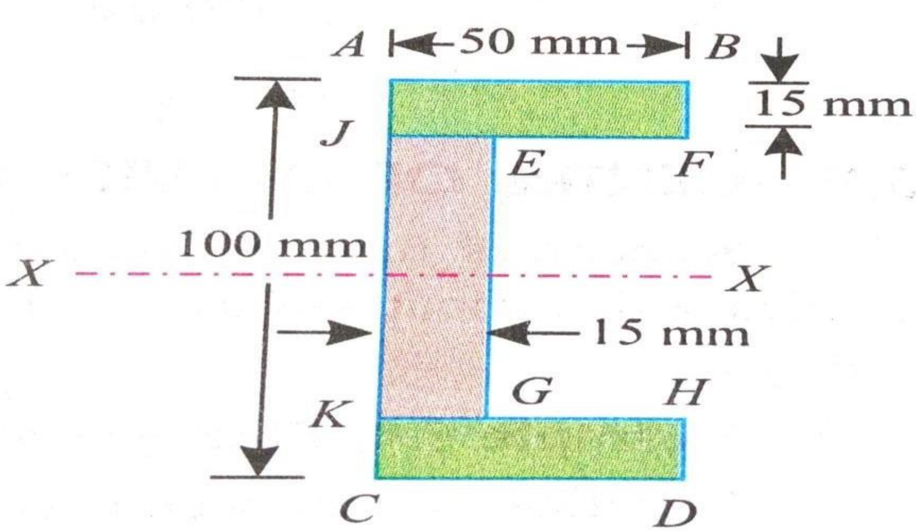
1. Find the position of centroid of a L-section as shown in the figure below :



2. Find the C.G. of a 100mm×150mm×30mm T-section.



3. Find the C.G. of a channel section 100mm×50mm×15mm.



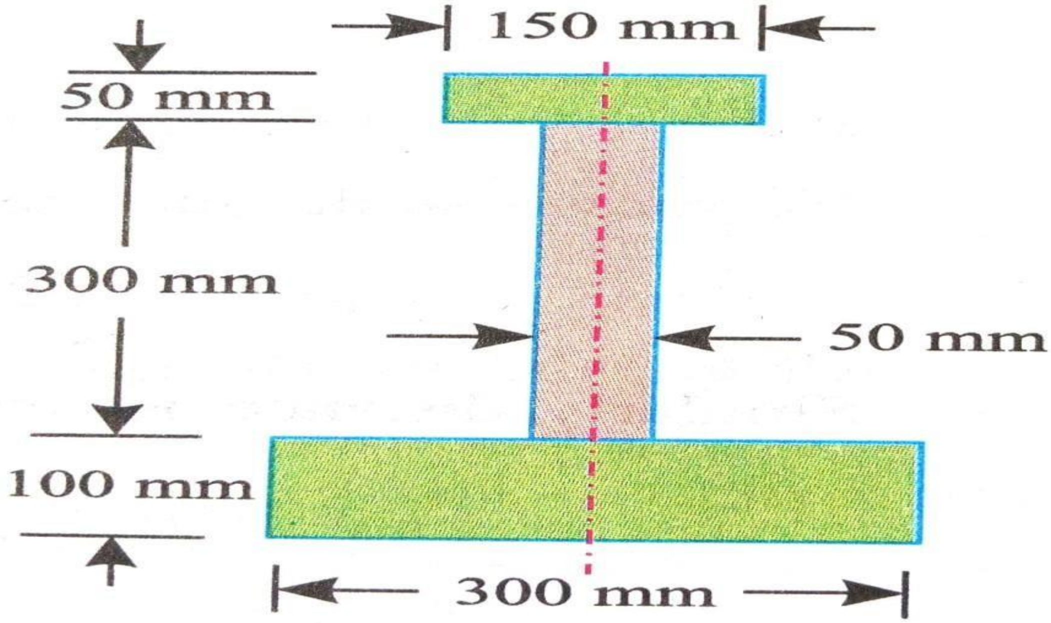
4. An I-section has the following dimensions in mm units:

   Bottom flange=300×100

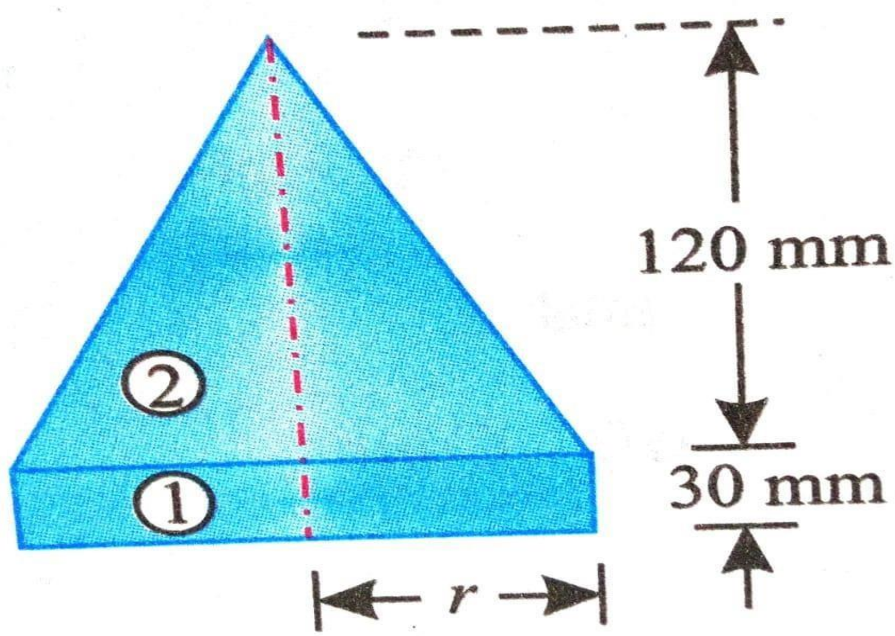
   Top flange=150×50

   Web=300×50

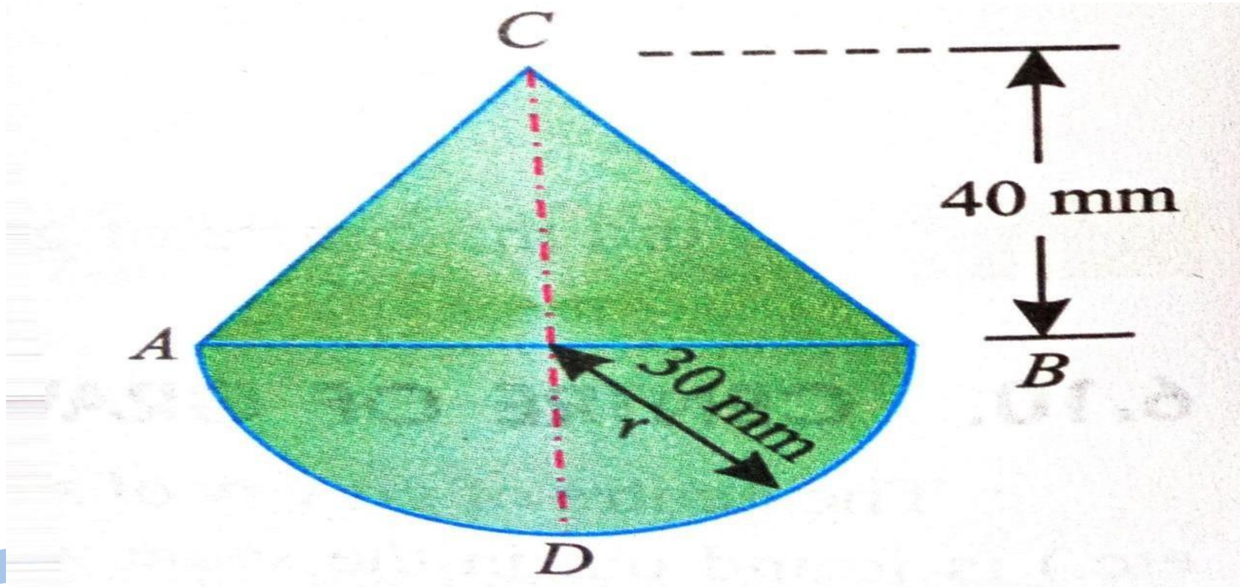
   Determine mathematically the position of C.G. of the section.



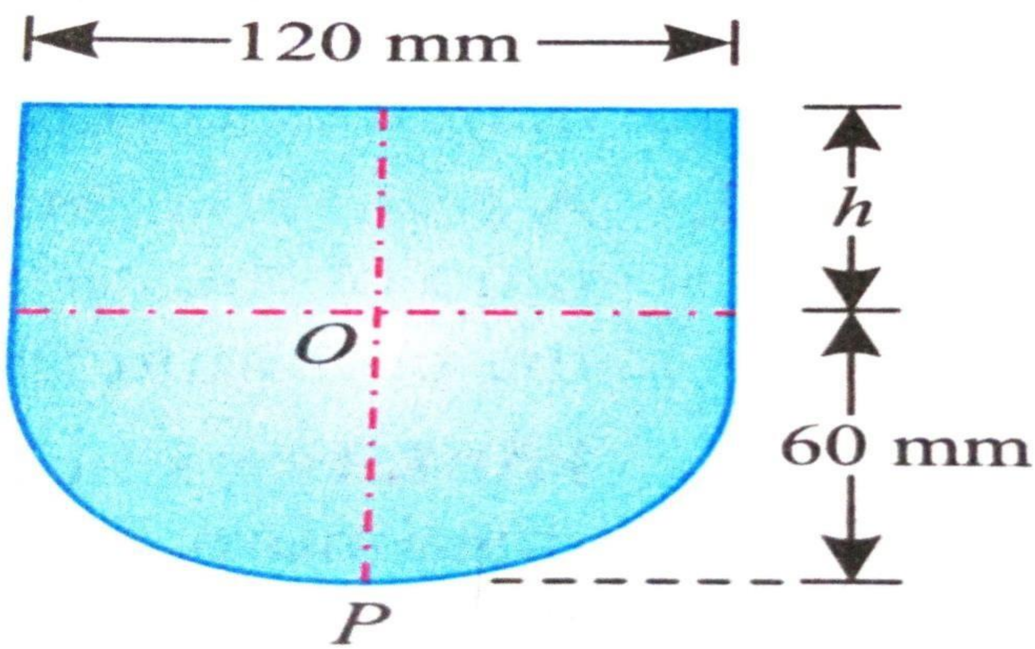
5. A solid body formed by joining the base of a right circular cone of height H to the equal base of a right circular cylinder of height h. Calculate the distance of the centre of mass of the solid from its plane face, when H=120mm and h=30mm.



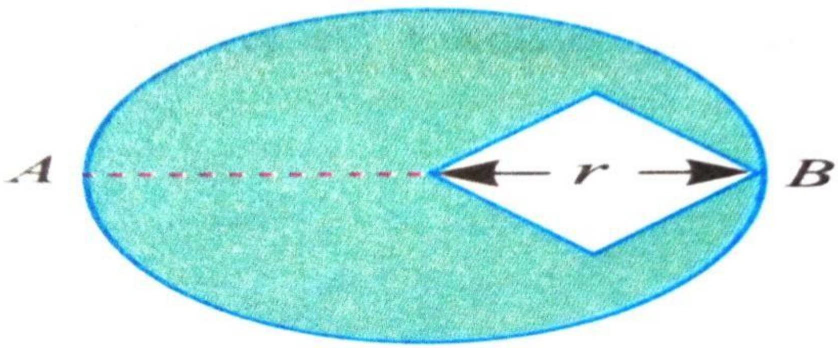
6. A body consists of a right circular solid cone of height 40mm and radius 30mm placed on a solid hemisphere of radius 30mm of the same material. Find the position of C.G. of the body.



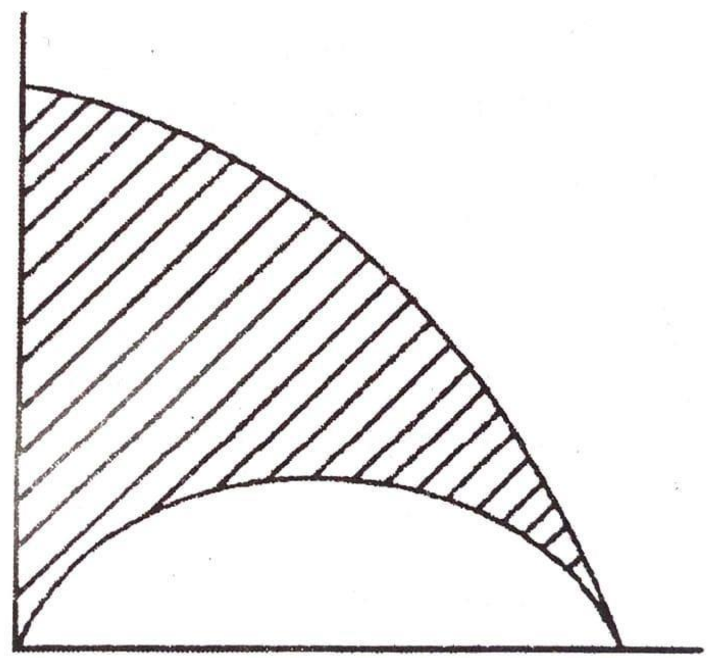
7. A right circular cylinder of 12cm diameter is joined with a hemisphere of the same diameter face to face. Find the greatest height of the cylinder, so that C.G. of the composite section coincides with the plane of joining the two sections. The density of the material of hemisphere is twice that the material of cylinder.



8. A semicircle of 90mm radius is cut out from a trapezium as shown in figure. Find the position of the C.G. of the figure.



9. Locate the centroid of the shaded area shown in figure, created by cutting a semicircle of dia. 12cm from a quarter circle of radius 12cm.

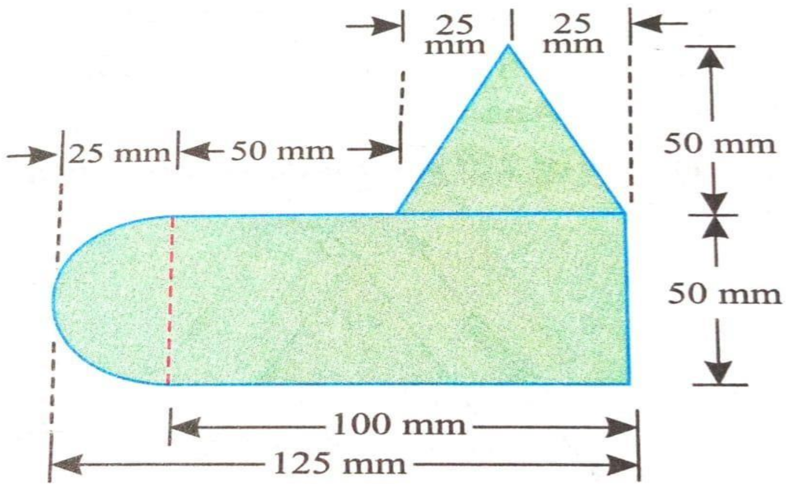


10. Derive the expression to find out the C.G. of a semi-circular lamina of radius ‘r’.
11. State and prove perpendicular axis theorem.
12. State and prove parallel axis theorem.
13. Find the moment of inertia of a square section of side 80mm about its diagonal.
14. Find the moment of inertia of a rectangular section 40mm wide and 60mm deep about X-X axis and Y-Y axis.

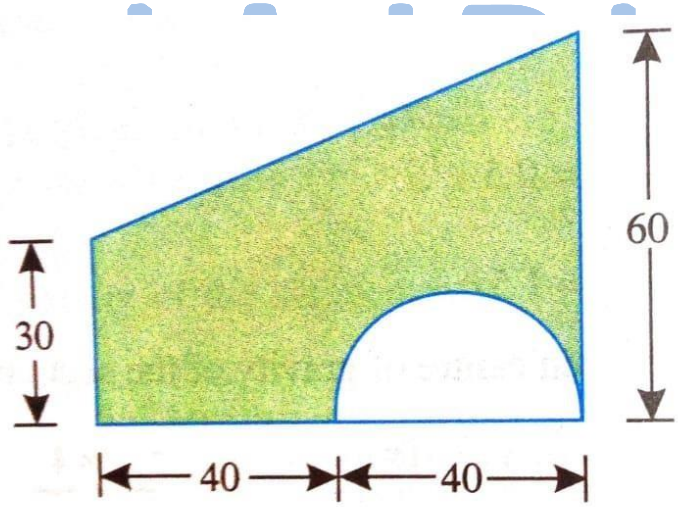
<u>LONG ANSWER TYPE QUESTIONS (8 MARKS)</u>

1. A uniform lamina shown in figure consists of a rectangle, a circle and a triangle.

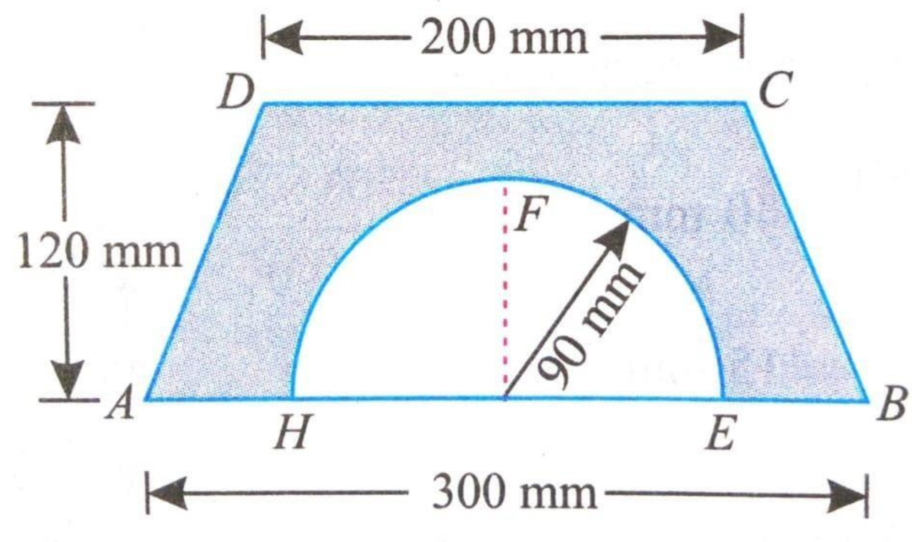
   Determine the C.G. of the lamina. All dimensions are in mm.



2. A semicircular area is removed from a trapezium as shown in figure.(dimensions in mm) Determine the centroid of the remaining area (shown hatched).

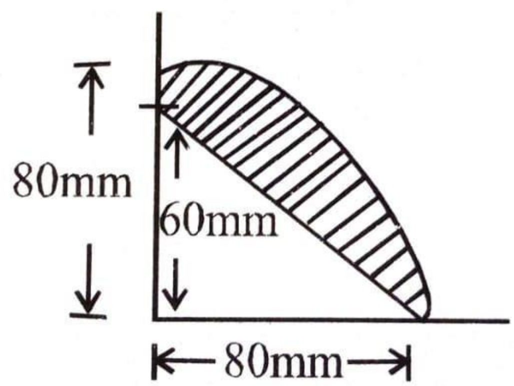


3. A semicircle of 90mm radius is cut out from a trapezium as shown in figure.

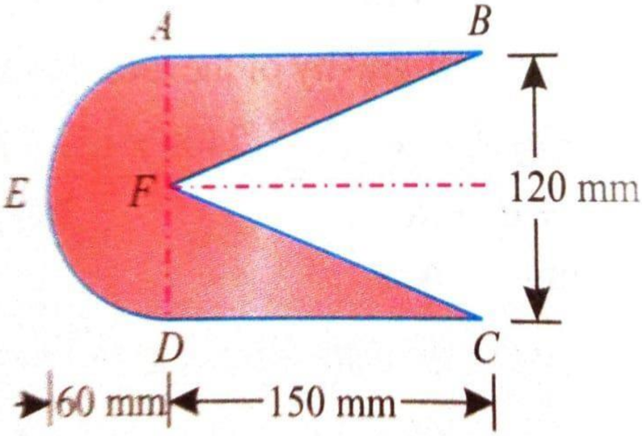


Find the position of C.G. of the figure.

4. A triangular section is cut out from a quarter circular section as shown in figure. Find the position of the centroid of the cut out section.

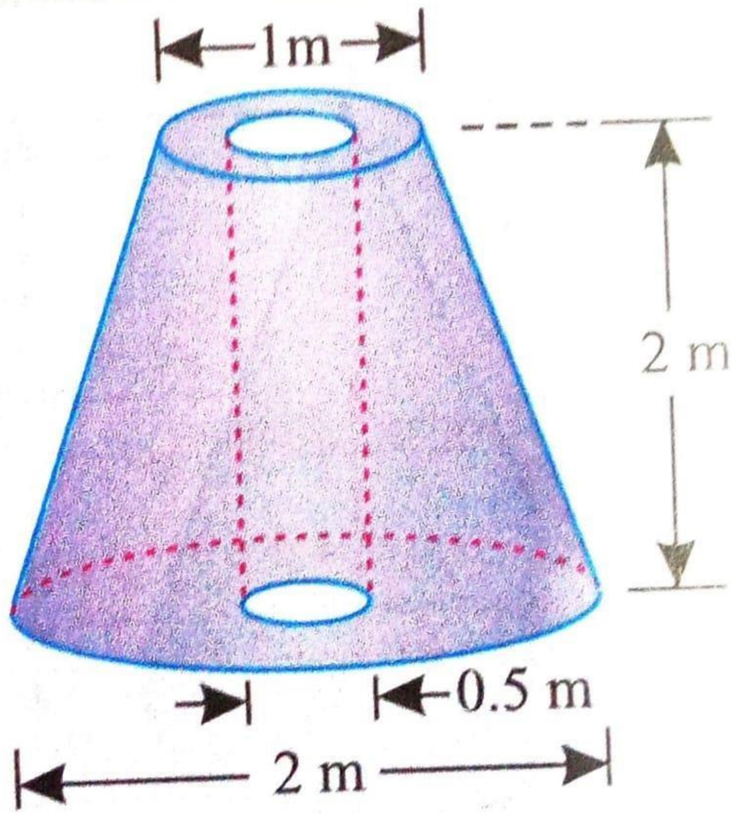


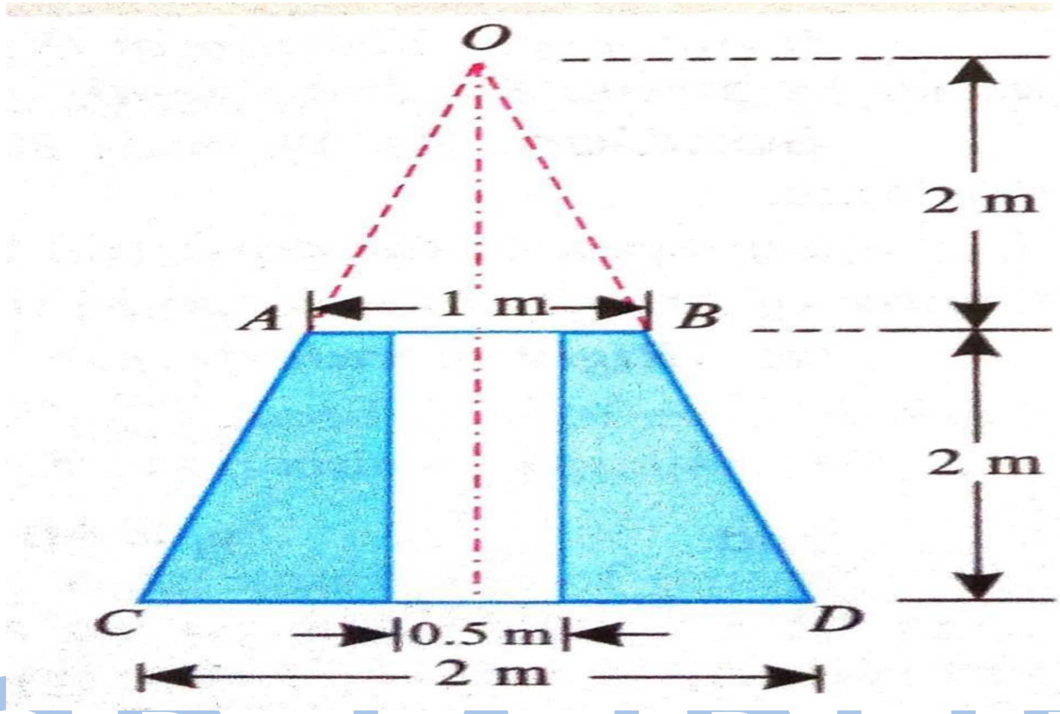
5. A solid consists of a right circular cylinder and a hemisphere with a cone cut out from the cylinder as shown in figure.



Find the C.G. of the body.

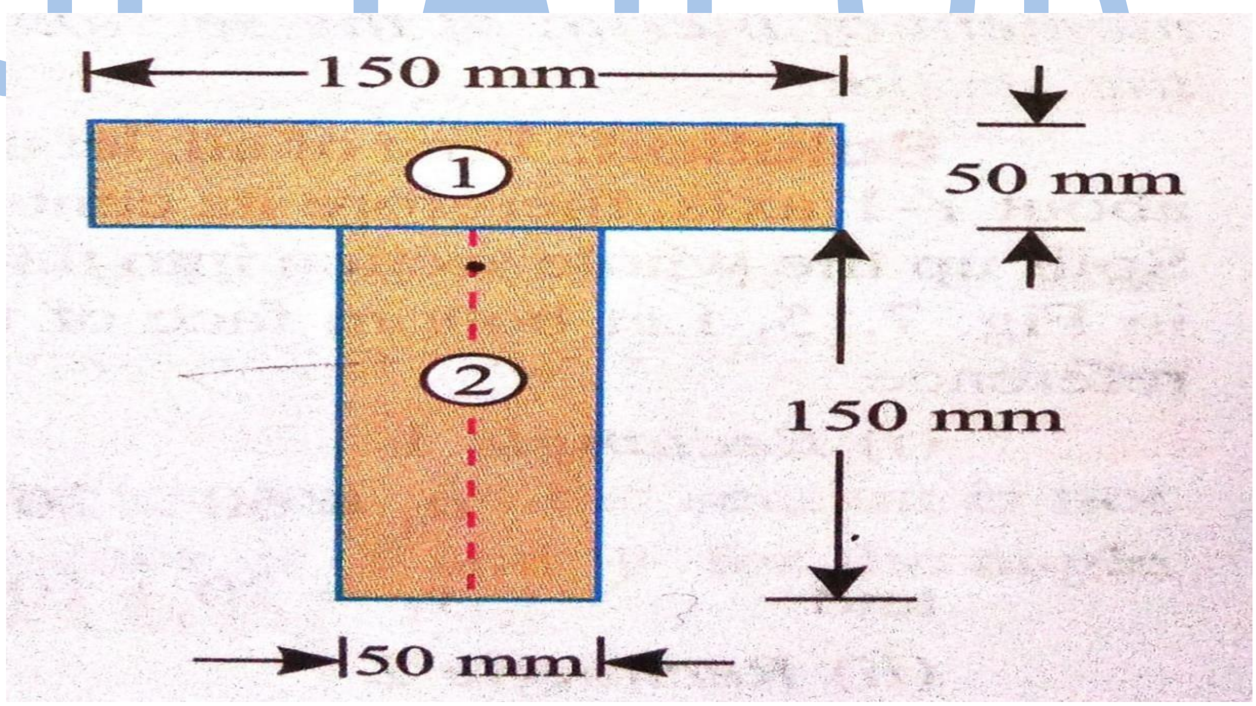
6. A frustum of a solid right circular cone has an axial hole of 50cm diameter as shown in figure.



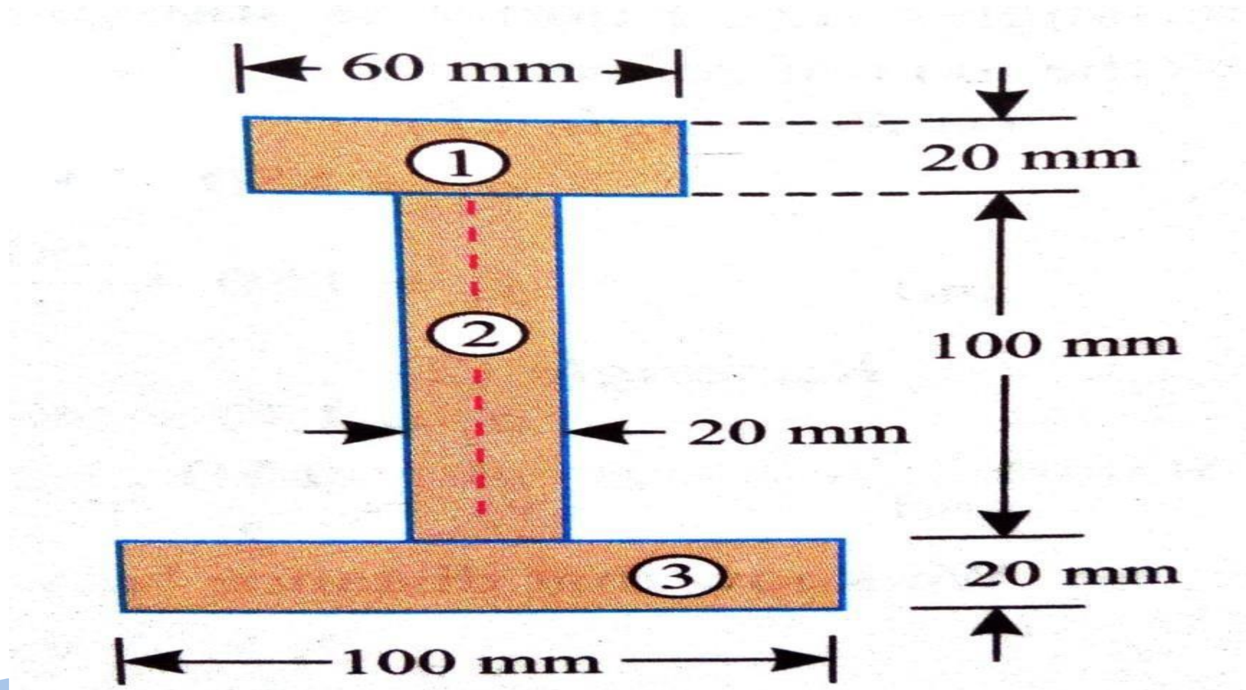


Determine the C.G. of the body.

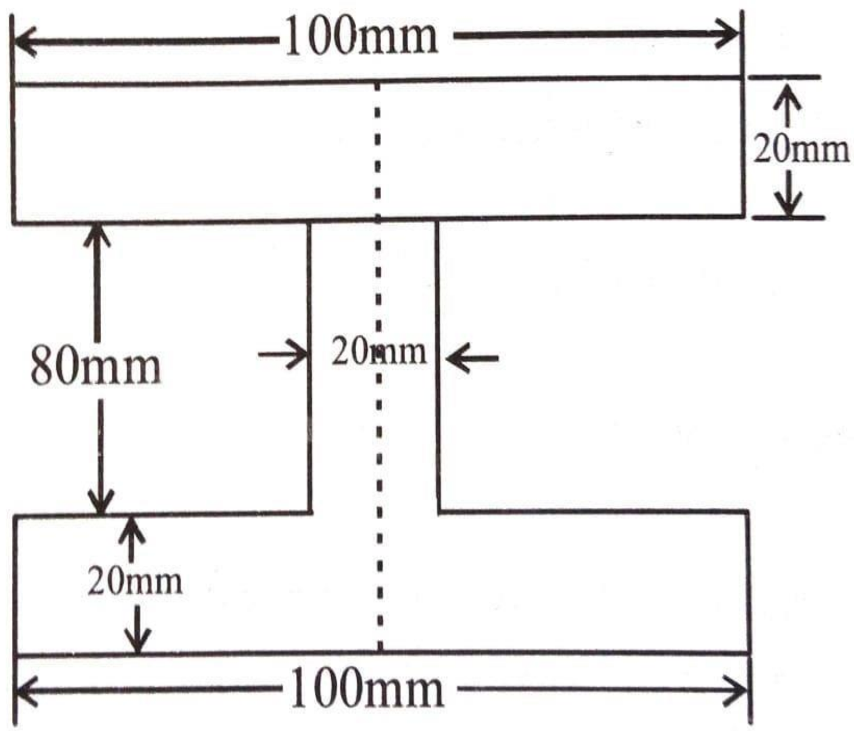
7. Find the M.I. of a T-section with flange as 150mm×50mm and web as 150mm×50mm about X-X and Y-Y axes through the C.G. of the section.



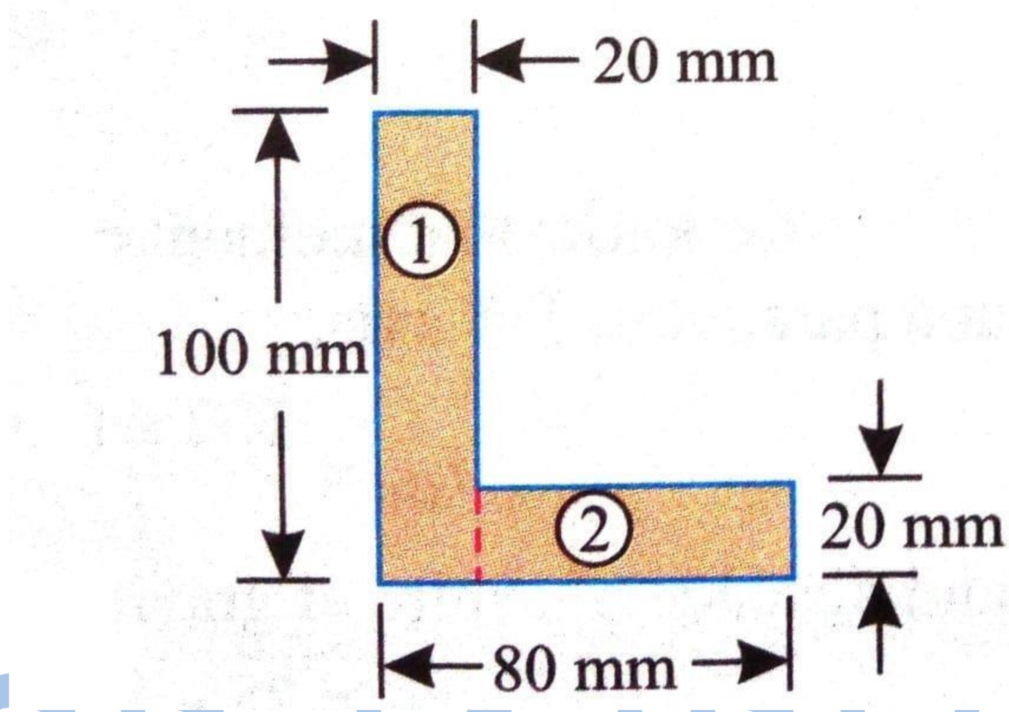
8. Find the M.I. of an I-section as shown in figure about the centroidal axis parallel to the base and perpendicular to the base.



9. Find the M.I. of an I-section as shown in figure about the centroidal X-X and Y-Y axes.



10. Find the M.I. of a L-section as shown in figure about the centroidal X-X and Y-Y axes.



MODULE 5

SIMPLE MACHINES

SHORT ANSWER TYPE QUESTIONS (2 MARKS)

1. Define a simple lifting machine.
2. Define M.A. of a lifting machine.
3. Define V.R. of a lifting machine.
4. Mention the expression for velocity ratio of worm and worm wheel.
5. Mention the expression for velocity ratio of a double purchase crab winch.
6. State expression for velocity ratio of a screw jack.
7. State the relation between M.A., V.R. and efficiency of a simple lifting machine.
8. What is an ideal machine?
9. What is reversible machine? What is the condition of reversibility of a lifting machine?
10. What is self-locking machine? What is the condition of self-locking of a lifting machine?
11. What is law of machine?

12. What is maximum M.A. of a lifting machine?
13. What is maximum efficiency of a lifting machine?
14. What is gear train?
15. State expression for velocity ratio of a simple gear train.
16. State expression for velocity ratio of a compound gear train.

<u>SHORT ANSWER TYPE QUESTIONS (5 MARKS)</u>

1. Define M.A., V.R. and efficiency and derive the relationship between them.
2. What do you mean by reversibility of a lifting machine? Derive the condition of reversible machine.
3. In a certain lifting machine, a weight of 1 KN is lifted by an effort of 25 N. While the weight moves up by 100 mm, the point of application of effort moves by 8 m. Find mechanical advantage, velocity ratio and efficiency of the machine.
4. In a lifting machine, whose velocity ratio is 50, an effort of 100 N is required to lift a load of 4 KN. Is the machine reversible? If so, what effort should be applied, so that the machine is at the point of reversing?
5. In a lifting machine, an effort of 50 N is required to lift a load W. The distance moved by the load and effort are 20 mm and 500 mm respectively. Determine the magnitude of the load W if the efficiency of the machine is 80%.
6. Derive velocity ratio of a compound gear train.
7. Explain worm and worm wheel. Derive its velocity ratio.
8. In a differential wheel and axle, the dia. of the wheel is 2m and the dia. of axles are 30cm and 20cm respectively. Find the V.R. If a load of 800N be lifted at an efficiency of 70%, what effort will be required to lift this load?

<u>LONG ANSWER TYPE QUESTIONS (8 MARKS)</u>

1. In a certain weight lifting machine, an effort of 15N can lift a load of 300N and an effort of 20N can lift a load of 500N. Find the law of the machine. Also find the effort required to lift a load of 880N.

2. In a lifting machine, an effort of 40N raised a load of 1KN. If efficiency of the machine is 0.5, what is its V.R.? If on this machine, an effort of 74N raised a load of 2KN, what is now the efficiency? What will be the effort required to raise a load of 5KN?
3. What load can be lifted by an effort of 120N, if the V.R. is 18 and efficiency of the machine at this load is 60%?

   Determine the law of the 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.
4. In a lifting machine an effort of 50kgf raised a load of 2500kgf. What is the M.A.? If the V.R. of the machine is 100, determine the efficiency of the machine at this load. If on the same machine an effort of 75kgf raised a load of 400kgf, what is the law of the machine?
5. In a weight lifting machine, an effort of 40N can lift a load of 1000N and an effort of 55N can lift a load of 1500N. Find the law of machine. Also find maximum M.A. and maximum efficiency of the machine. Take V.R. of the machine is 48.
6. The law of a machine is given by the relation:

   $$P=0.04W+7.5$$

   Where (P) is the effort required to lift a load (W), both expressed in newtons. What is the M.A. and efficiency of the machine, when the load 2KN and V.R. is 40? What is the maximum efficiency of the machine?

   If (F) is the effort lost in friction, find the relation between F and W. Also find the value of F, when W is 2KN.
7. The law of a certain lifting machine is:

   $$P=\frac{W}{50}+8$$

   The V.R. of the machine is 100. Find the maximum possible M.A. and the maximum possible efficiency of the 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.
8. In a worm and worm wheel, the number of teeth in the worm wheel is 25. The effort handle is 300 mm long and the load drum is 150 mm diameter. Find the efficiency of the machine, if an effort of 30 N can lift a load of 345 N and the worm is double threaded.

9. A single purchase crab winch has 300mm long handle and 120mm diameter drum. Number of teeth on the pinion are 25 and that on wheel 130. If an effort of 20N lifts a load of 300N, find the M.A., V.R. and efficiency of the crab winch.

MODULE 6

DYNAMICS

SHORT ANSWER TYPE QUESTIONS (2 MARKS)

1. Define Newton's first law of motion.
2. Define Newton's second law of motion.
3. State law of conservation of linear momentum.
4. State Newton's law of collision of two bodies.
5. State D'Alembert's principle.
6. Define work and write down its S.I. unit.
7. Define power and write down its S.I. unit.
8. Define energy and write down its S.I. unit.
9. Define impulse.
10. Define momentum.
11. Define coefficient of restitution.
12. State law of conservation of energy.

SHORT ANSWER TYPE QUESTIONS (5 MARKS)

1. A constant force acting on a body of mass 20kg changes its speed from 2.5m/sec to 10m/sec in 15 seconds. What is the magnitude of the force?
2. State and explain D'Alembert's principle.
3. A body of mass 200kg, is found to move with a velocity of 20m/s when a force of 100N acts on it for 90sec. Determine the velocity of the body:

   (i) when the force acts in the direction of motion.

   (ii) when the force acts in the opposite direction on motion.

4. A bullet weighs 0.5N and moving with a velocity of 400m/sec hits centrally a 30N block of wood moving away at 25m/sec and gets embedded in it. Find the velocity of the bullet and block after impact.
5. A motorist travelling at a speed of 70km per hour suddenly applies brakes and comes to a stop after skidding 50m. Determine:

   (i) time required to stop the car.

   (ii) the coefficient of friction between the tyres and the road.
6. An elevator is moving upward with an acceleration of 1m/sec^2. Find the pressure exerted by the man of mass.
7. A body starting from rest attain a velocity of 40cm/sec in 8 seconds. Determine the velocity of the body moving under uniform acceleration at the end of 14 seconds.
8. Derive the expression for Kinetic Energy?
9. A body was thrown vertically down from a tower and traversed a distance of 45 meter during the 4th second of its fall. Find the initial velocity of the body.
10. Find the amplitude and time period of a particle moving with simple harmonic motion, which has a velocity of 9m/sec and 4m/sec at a distance of 2m and 3m respectively from the center.
11. State and explain law of conservation of energy.

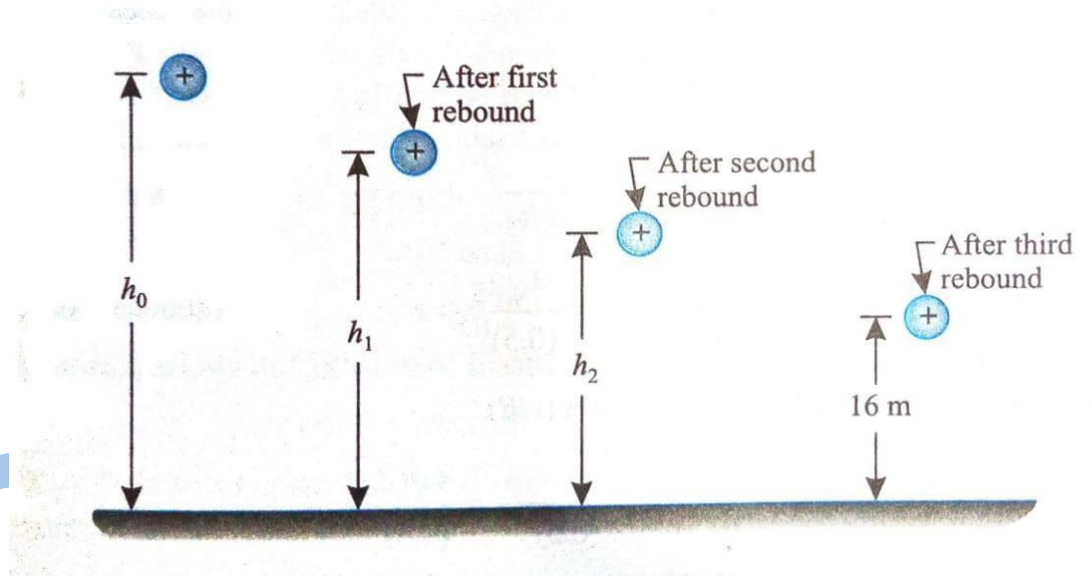
__LONG ANSWER TYPE QUESTIONS (8 MARKS)__

1. A ball of mass 8kg moving with a velocity of 10m/sec, impinges directly on another of mass 10m/sec, impinges directly on another of mass 24kg moving at a speed of 2m/sec in the opposite direction. If e=$\frac{1}{2}$, find the velocity of the balls after impact.
2. A ball of mass '1kg' moves with a velocity of 2m/sec impinges directly on a ball of mass '2kg' at rest. The 1st ball after impinging comes to rest. Find the velocity of the second ball after impact and coefficient of restitution.
3. Two balls of masses 2kg and 3kg are moving with velocities 2m/sec and 3m/sec towards each other. If the coefficient of restitution is 0.5, find the velocity of the two balls after impact.
4. A ball is dropped from a height h_0=1m on a smooth floor. Knowing that the height of the first bounce is h_1=81cm, determine:

(a) coefficient of restitution

(b) expected height h_2 after the second bounce

5. From what height, must a heavy elastic ball be dropped on a floor, so that after rebounding thrice it will reach a height of 16 metres? Take e = $(0.5)^{1/3}$.



6. Derive the expression for conservation of energy and conservation of linear momentum.