Name : .....

Roll No. : .....

Invigilator's Signature : .....

CS/B.TECH(OLD)/SEM-1/ME-101/2011-12

2011
MECHANICAL SCIENCES

Time Allotted : 3 Hours *Full Marks :* 70

The figures in the margin indicate full marks.

Candidates are required to give their answers in their own words as far as practicable.

GROUP – A

(Multiple Choice Type Questions)

1. Choose the correct alternatives for any *ten* of the following : $10 \times 1 = 10$

   i) According to principle of transmissibility of forces, the effect of a force upon a body is

      a) maximum when it acts at the centre of gravity of a body

      b) different at different points in its line of action

      c) the same at every point in its line of action

      d) minimum when it acts at the C.G. of the body

      e) none of these.

   ii) The magnitude of two forces, which when acting at right angle produce resultant force of $\sqrt{10}$ kg and when acting at 60° produce resultant of $\sqrt{13}$ kg. These forces are

      a) 2 kg and $\sqrt{6}$ kg b) 3 kg and 1 kg

      c) $\sqrt{5}$ kg and $\sqrt{5}$ d) 2 kg and 5 kg

      e) none of these

iii) If a rigid body is in equilibrium under the action of three forces, then

a) these forces are equal

b) the lines of action of these forces meet in a point

c) the lines of action of these forces are parallel

d) both (b) and (c)

iv) The algebraic sum of moments of the forces forming couple about any point in their plane is

a) equal to the moment of the couple

b) constant

c) both (a) and (b)

d) none of these.

v) The angle which an inclined plane makes with the horizontal when a body placed on it is about to move down is known as angle of

a) friction b) limiting friction

c) repose d) kinematic friction.

e) static friction.

vi) A body is resting on a plane inclined at an angle of 30° to horizontal. What force would be required to slide it down, if the coefficient of friction between body and plane is 0.3 ?

a) Zero

b) 1 kg

c) 5 kg

d) Would depend on weight of body

e) None of these.

vii) The C. G. of a solid hemisphere lies on the central radius

a) at distance 3r/2 from the plane base

b) at distance 3r/4 from the plane base

c) at distance 3r/5 from the plane base

d) at distance 3r/8 from the plane base.

viii) M. I. of circular area whose diameter is '*d*' about an axis perpendicular to the area passing through its centre is given by

a) $n d^4/64$ b) $n d^4/32$

c) $n d^4/12$ d) $n d^4/16$

e) $n d^4/24$.

ix) Virtual work is the product of

a) displacement and virtual force

b) virtual displacement and virtual force

c) displacement and force

d) virtual displacement and force.

x) Hooke's Law is valid up to

a) yield point b) elastic limit

c) proportional limit d) none of these.

xi) The property of material which allows it to be drawn into a smaller section is called

a) elasticity b) ductility

c) malleability d) plasticity.

xii) Materials having same elastic properties in all directions are called

a) isotropic material b) ideal material

c) uniform material d) anisotropic material.

xiii) The energy absorbed by a body, when it is strained within the elastic limit, is known as

a) strain energy b) resilience

c) proof resilience d) modulus of resilience

e) toughness.

xiv) If two bodies with different masses have equal kinetic energy which one has greater linear momentum ?

a) The heavier body

b) The lighter body

c) Both have equal momentum

d) None of these.

xv) A jet engine works on the principle of conservation of

a) mass b) angular momentum

c) linear momentum d) energy.

xvi) A projectile is fired at an angle of θ is

a) 30° b) 75°

c) 60° d) 45°.

xvii) The science which deals with geometry of motion is called

a) kinematics b) kinetics

c) dynamics d) none of these.

GROUP – B

(Short Answer Type Questions)

Answer any *three* of the following. 3 × 5 = 15

2. a) State and explain *D*, alembert's principle. What are its advantages ?

   b) The velocity of a particle along the *s*-axis is given by $v = 5s^{3/2}$, where s is in millimetres and v is in millimetres per second. Determine the acceleration when s is 2 millimetres. 3 + 2

3. a) Prove that velocities are exchanged in a perfectly elastic collision between two bodies with same mass.

   b) A golf ball dropped from rest onto a cement sidewalk rebounds eight-tenths of the height through which it fell. Neglecting air resistance, determine the coefficient of restitution. 3 + 2

4. A solid uniform metal bar of diameter D and length L is hanging vertically from its upper end. Prove that the total elongation of the bar due to its own weight = $\gamma L^2/2E$, if γ is the specific weight and E the Young's modulus of the material of the bar. 5

5. a) Distinguish between particle and rigid body.

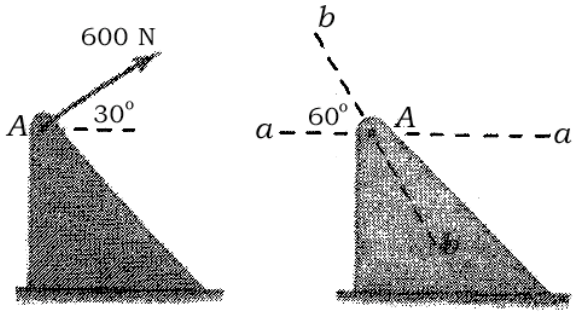
   b) State Varignon's Theorem of Moments and prove it. 2 + 3

6. a) State the laws of static friction.

   b) Define 'Angle of friction' and 'Angle of repose' and establish the relation between them. 2 + 3

7. State Pappus theorem. Using it find the centroid of a semicircular area of radius r. 5

8. The 600 N force applied to the bracket at A is to be replaced by two forces. F_a in the a-a direction and F_b in the b-b direction, which together produce the same effect on the bracket as that of the 600 N force. Determine F_a and F_b.

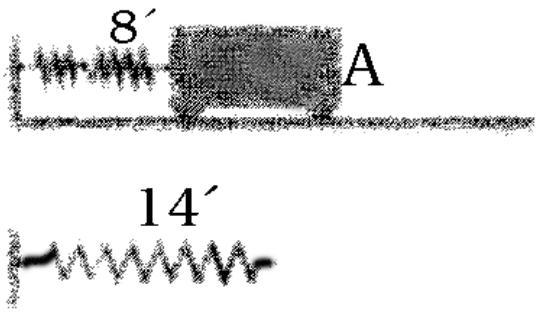


GROUP – C

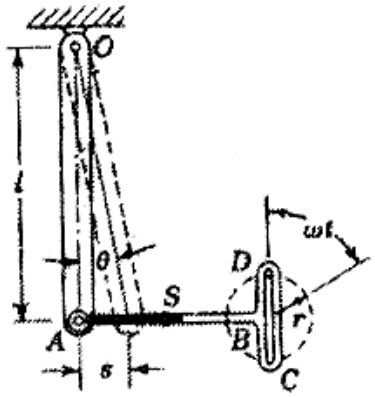
(Long Answer Type Questions)

Answer any *three* of the following. $3 \times 15 = 45$

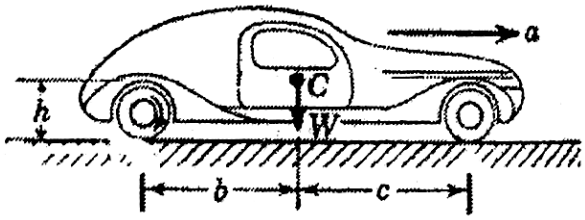
9. a) The 14 in. spring is compressed to an 8 in. length where it is released from rest and accelerates the sliding block A. The acceleration has an initial value of 400 ft/s^2 and then decreases linearly with the x-movement of the block, reaching zero when the spring regains its original 14 in. length. Calculate the time t for the block to go (i) 3 in. and (ii) 6 in. 8



b) A slender prismatic bar *OA* of weight *W* and length *l* can rotate freely about the fixed axis through *O* normal to the plane of the figure. By means of a horizontal bar *AB* and a crankshaft with crank radius *r* and crankpin *D* freely sliding in the slot *DC*, a simple harmonic motion is given to the end *A* of the bar *OA*. Determine the force *S* in the bar *AB*, assuming that its mass is negligible. 7

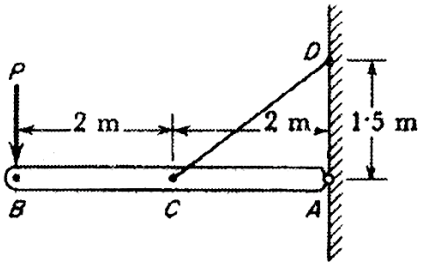


10. a) Find the maximum acceleration along a level road that the rear wheel drive automobile shown in figure can attain if the coefficient of friction between tyres and pavements is μ. 7

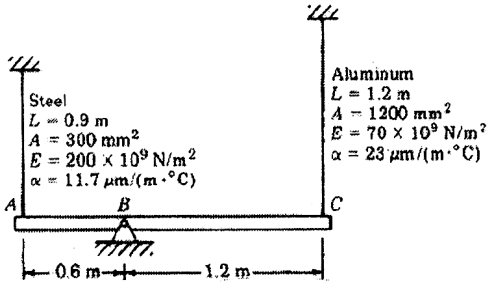


b) Two adjacent guns having the same muzzle velocity $v_0 = 300$ m/s fire simultaneously at angles of elevation α_1 and α_2 for the same target at range r = 4500 m. Calculate the time difference $t_2 - t_1$ between the two hits. 8

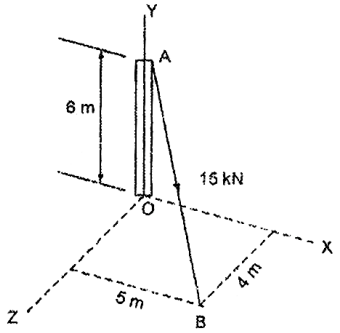
11. a) A rigid bar *AB* is hinged to a vertical wall and supported horizontally by a tie-bar *CD* as shown below. The tie-bar has cross-sectional area A = 0.5 sq. cm and its allowable stress in tension is σ_w =1500 kg/cm^2. Find the safe value of the magnitude of the load *P*. 6



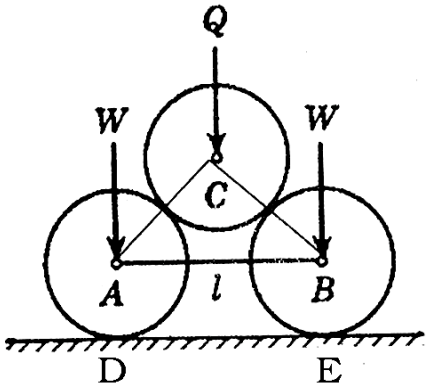
b) The rigid bar *ABC* in figure given is pinned at *B* and attached to the two vertical rods. Initially the bar is horizontal and the vertical rods are stress-free. Determine the stress in the aluminium rod, if the temperature of steel rod is decreased by 40°C. Neglect weight of the bar *ABC*. 9



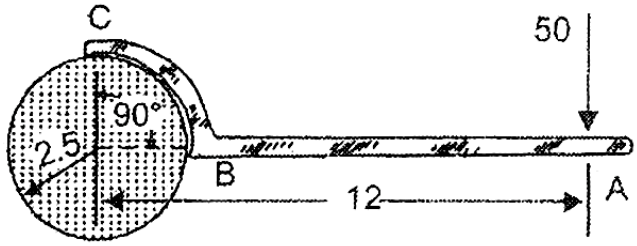
12. a) A cable supporting a 6m high vertical post. The post is anchored to the ground as shown in figure below. If the tensile force in the cable is 15 kN, find its moment about *z*-axis passing through base of the post. 7



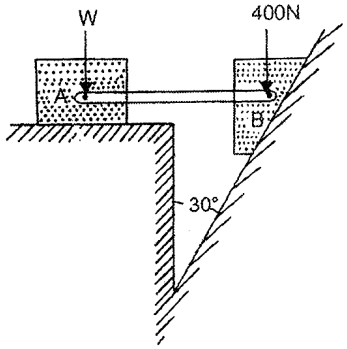
b) Two smooth circular cylinders, each of weight W=100 N and radius r = 6 cm are connected at the centres by a string AB of length l = 16 cm and rest upon a horizontal plane, supporting above them a third cylinder of weight Q = 200 N and radius r = 6 cm. Find the force S in the string AB and pressure produced on the floor at D and E. 8



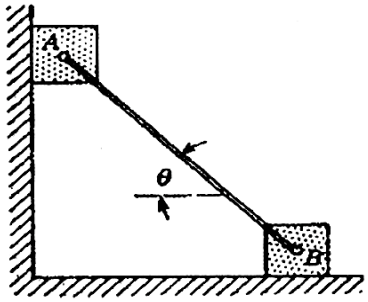
13. a) Determine the forces exerted on the cylinder at B and C by the spanner wrench due to a vertical force of 50 N applied to the handle. Neglect friction at B. 7



b) Two blocks connected by a horizontal link, *AB* are supported on two rough planes as shown below. The coefficient of friction for block *A* on the horizontal plane is $\mu = 0.4$. The angle of friction for block *B* on the inclined plane is 15°. What is the smallest weight of the block *A* for which equilibrium will exist ? 8

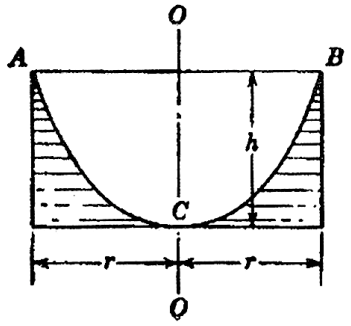


14. a) Two identical blocks *A* and *B* are connected by a rod and rest against vertical and horizontal planes respectively. If sliding impends when $\theta = 45°$, determine the coefficient of friction, μ, assuming it to be the same at both floor and wall. 8

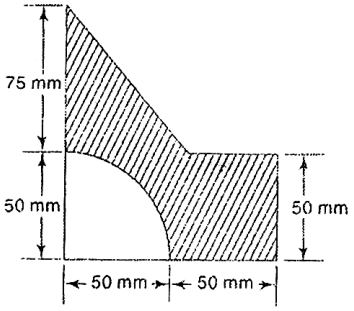


b) A uniform ladder of length l and weight w rests with its foot on a rough ground (coefficient of friction μ) and its upper end against a smooth wall, its inclination to the horizontal being α. A force *P* is applied to it horizontally at a distance, a, from the foot so as to make the foot approach the wall. Show that *P* must exceed $\frac{wl}{l-a}\left(\mu+\frac{1}{2}\cot\alpha\right)$. 7

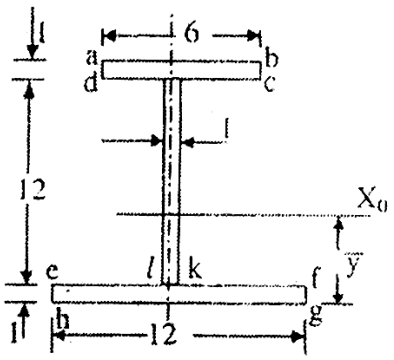
15. a) A right circular cylindrical tank containing water spins about its vertical geometric axis *OO* at such speed that the free water surface is a paraboloid *ACB*. What will be the depth of water in the tank when it comes to rest ? 8



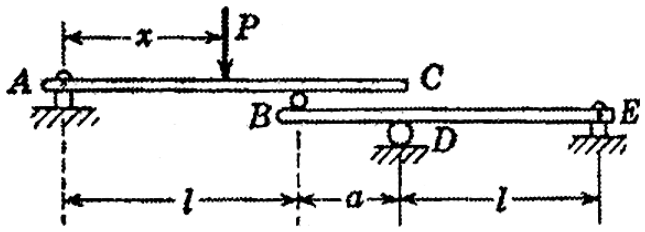
b) With respect to coordinate axes x and y, locate the centroid of the shaded area shown in figure below. 7



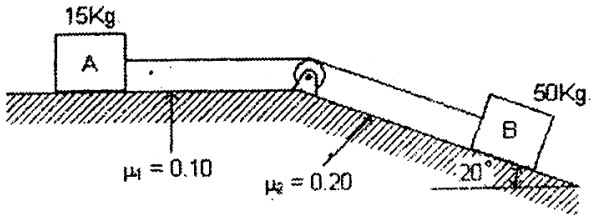
16. a) Determine the moment of inertia of the area shown in figure below with respect to its centroidal axes. (All dimensions are in cm.). 8



b) Using the principle of virtual work, find the reaction R_d for the system shown in figure below for any position of a vertical load P on the beam AC as defined by its distance x from A. 7



17. a) Two bodies A and B are connected by an inextensible string as shown. Find acceleration of the bodies and tension in the string by using D'Alembert's principle. 7



b) If the slender prismatic bar is released from rest in the horizontal position AB and allowed to fall under the influence of gravity, what angular velocity θ will it acquire by the time it reaches the vertical position AB_1 ?

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