

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

1201-(O)

[Turn over



- 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
- at distance $3r/2$ from the plane base
 - at distance $3r/4$ from the plane base
 - at distance $3r/5$ from the plane base
 - 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
- $\pi d^4/64$
 - $\pi d^4/32$
 - $\pi d^4/12$
 - $\pi d^4/16$
 - $\pi d^4/24$.
- ix) Virtual work is the product of
- displacement and virtual force
 - virtual displacement and virtual force
 - displacement and force
 - virtual displacement and force.
- x) Hooke's Law is valid up to
- yield point
 - elastic limit
 - proportional limit
 - none of these.
- xi) The property of material which allows it to be drawn into a smaller section is called
- elasticity
 - ductility
 - malleability
 - 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

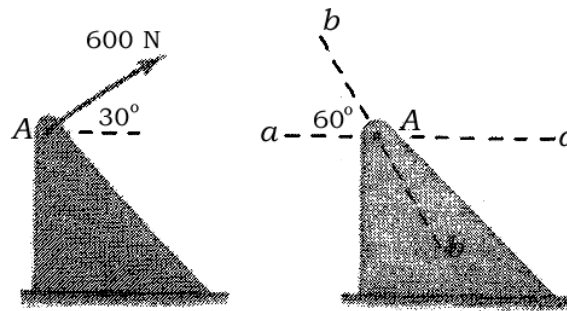
(Short Answer Type Questions)

Answer any *three* of the following. $3 \times 5 = 15$

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 .

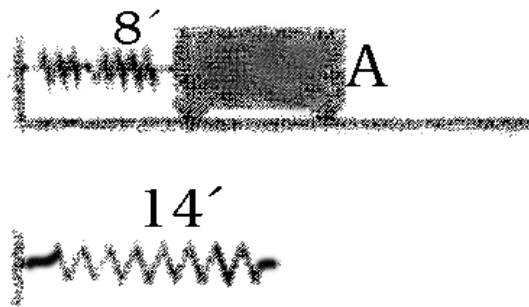


GROUP – C

(Long Answer Type Questions)

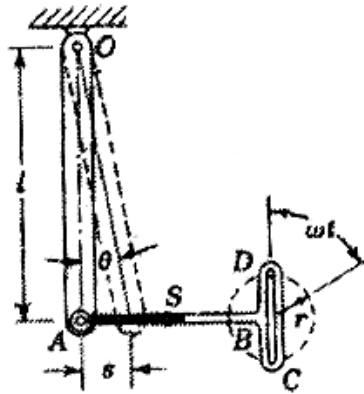
Answer any *three* of the following. $3 \times 15 = 45$

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

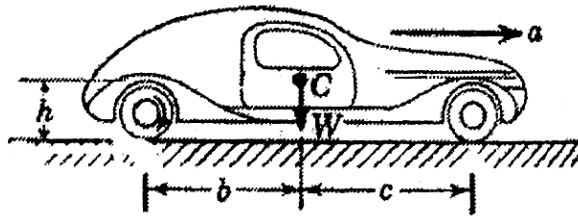




- b) A slender prismatic bar OA of weight W and length l can rotate freely about the fixed axis through O normal to the plane of the figure. By means of a horizontal bar AB and a crankshaft with crank radius r and crankpin D freely sliding in the slot DC , a simple harmonic motion is given to the end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



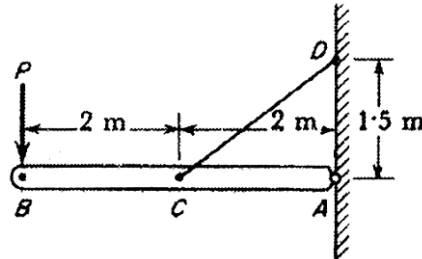
10. a) Find the maximum acceleration along a level road that the rear wheel drive automobile shown in figure can attain if the coefficient of friction between tyres and pavements is μ . 7



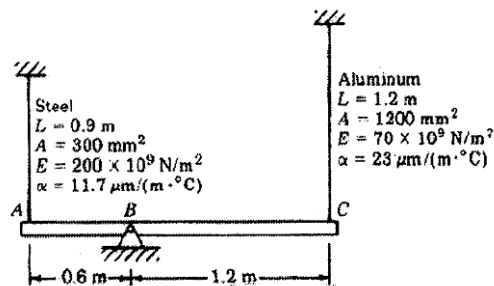
- b) Two adjacent guns having the same muzzle velocity $v_0 = 300$ m/s fire simultaneously at angles of elevation α_1 and α_2 for the same target at range $r = 4500$ m. Calculate the time difference $t_2 - t_1$ between the two hits. 8



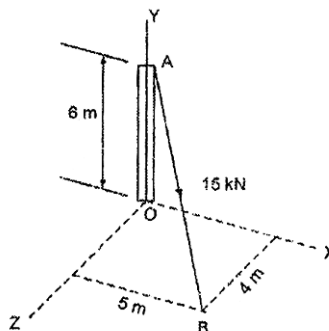
11. a) A rigid bar AB is hinged to a vertical wall and supported horizontally by a tie-bar CD as shown below. The tie-bar has cross-sectional area $A = 0.5 \text{ sq. cm}$ and its allowable stress in tension is $\sigma_w = 1500 \text{ kg/cm}^2$. Find the safe value of the magnitude of the load P . 6



- 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

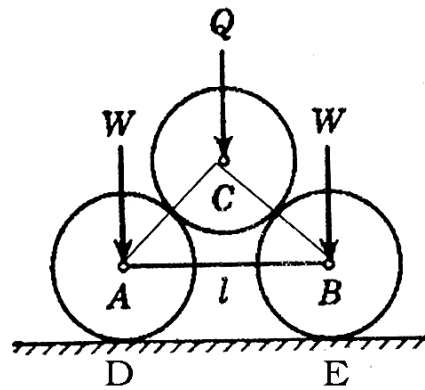


12. a) A cable supporting a 6m high vertical post. The post is anchored to the ground as shown in figure below. If the tensile force in the cable is 15 kN, find its moment about z-axis passing through base of the post. 7

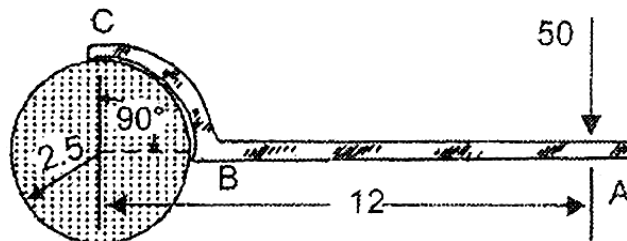


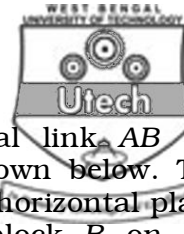


- b) Two smooth circular cylinders, each of weight $W=100\text{ N}$ and radius $r = 6\text{ cm}$ are connected at the centres by a string AB of length $l = 16\text{ cm}$ and rest upon a horizontal plane, supporting above them a third cylinder of weight $Q = 200\text{ N}$ and radius $r = 6\text{ cm}$.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

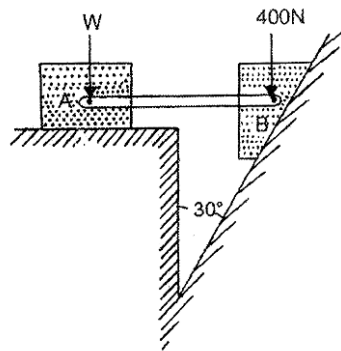


13. a) Determine the forces exerted on the cylinder at B and C by the spanner wrench due to a vertical force of 50 N applied to the handle. Neglect friction at B .

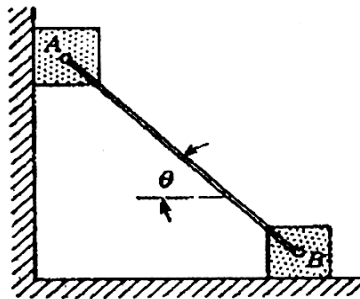




- b) Two blocks connected by a horizontal link AB are supported on two rough planes as shown below. The coefficient of friction for block A on the horizontal plane is $\mu = 0.4$. The angle of friction for block B on the inclined plane is 15° . What is the smallest weight of the block A for which equilibrium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



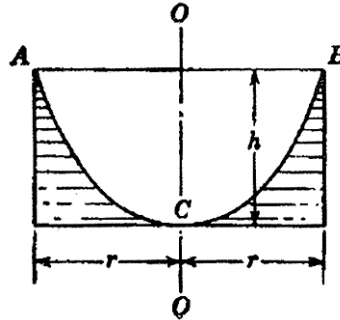
14. a) Two identical blocks A and B are connected by a rod and rest against vertical and horizontal planes respectively. If sliding impends when $\theta = 45^\circ$, determine the coefficient of friction, μ , assuming it to be the same at both floor and wall. 8



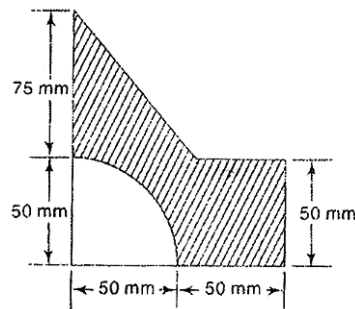
- b) A uniform ladder of length l and weight w rests with its foot on a rough ground (coefficient of friction μ) and its upper end against a smooth wall, its inclination to the horizontal being α . A force P is applied to it horizontally at a distance, a , from the foot so as to make the foot approach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



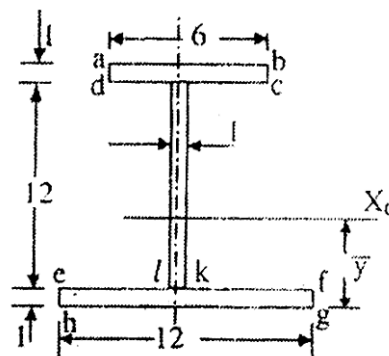
15. a) A right circular cylindrical tank containing water spins about its vertical geometric axis OO at such speed that the free water surface is a paraboloid ACB . What will be the depth of water in the tank when it comes to rest ? 8

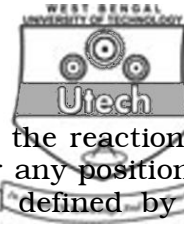


- b) With respect to coordinate axes x and y , locate the centroid of the shaded area shown in figure below. 7

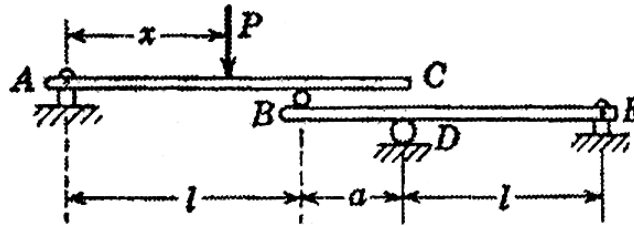


16. a) Determine the moment of inertia of the area shown in figure below with respect to its centroidal axes. (All dimensions are in cm.). 8

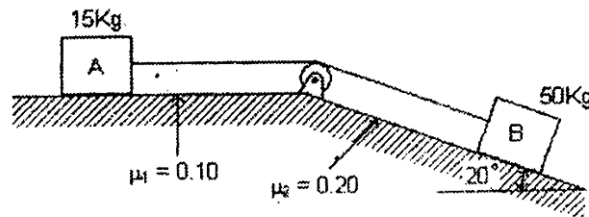




- b) Using the principle of virtual work, find the reaction R_d for the system shown in figure below for any position of a vertical load P on the beam AC as defined by its distance x from A . 7



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 ? 8

