ENGINEERING & MANAGEMENT EXAMINATIONS, DECEMBER - 2006

MECHANICAL SCIENCES

SEMESTER - 1

Time : 3 Hours] [Full Marks : 70

Group - A

(Multiple Choice Questions)

1. Choose the correct answer from the given alternatives in each of the following questions : $10 \times 1 = 10$

a) Centre of gravity of a solid cone lies on the axis at the height,

i) one-fourth of the total height above base

ii) one-third of the total height above base

iii) one-half of the total height above base

iv) three-eighth of the total height above base

v) none of these.

b) In the equation of virtual work, which of the following forces is (are) neglected ?

i) Reaction of any smooth surface with which the body is in contact

ii) Reaction of a rough surface of a body which rolls on it without slipping

iii) Reaction at a point or an axis, fixed in space, around which a body is constrained to turn

iv) All of these

v) None of these.

c) M.I. of rectangular area of base b and height d about z-axis is given by

i) $bd^3 / 3$

ii) $bd^3 / 4$

iii) $bd^3 / 6$

iv) $bd^3 / 12$

v) $bd^3 / 8$.

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

i) $\pi d^4 / 64$

ii) $\pi d^4 / 32$

iii) $\pi d^4 / 12$

iv) $\pi d^4 / 16$

v) $\pi d^4 / 24$.

e) The acceleration due to gravity of a particle falling towards earth is

$$a = -g\frac{R^2}{r^2}$$

where r is the distance from centre of the earth to the particle, g = acceleration due to gravity.

If the particle is projected from a tower of height h, its escape velocity (V_e) will be

i) $V_e = \left(\frac{2gR}{R+h}\right)^{1/2}$

ii) $V_e = 2g\left(\frac{R}{R+h}\right)^2$

iii) $V_e = \left(\frac{2g}{R+h}\right)^{1/2} R$.

f) In order to avoid overturning for a vehicle moving on a level curved path, the maximum permissible velocity must be

i) $V_{max} \leq [\, gra / h \,]^{1/2}$

ii) $V_{max} \geq [\, gra / h \,]^{1/2}$

iii) $V_{max} \leq [\, hra / g \,]^{1/2}$

iv) $V_{max} \leq [\, hg / (ra) \,]^{1/2}$,

where V = velocity of the vehicle moving along a circular path

r = radius of the path

h = height of c.g. of the vehicle from the track.

$2a$ = wheel to wheel distance.

g) 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 co-efficient of friction between body and plane is 0·3 ?

i) zero

ii) 1 kg

iii) 5 kg

iv) would depend on weight of the body

v) none of these. ☐

h) On a plane resultant stress is inclined at an angle of 30° to the plane. If the normal stress on the plane is 50 N/mm^2, the shear stress on the plane will be

i) 43·3 N/mm^2 ii) 86·6 N/mm^2

iii) 100 N/mm^2 iv) None of these. ☐

i) Equation of motion of a particle is $s = 2t^3 - t^2 - 2$, where s is displacement in metres and t is time in seconds. Acceleration of the particle after 1 second will be

i) 8 m/sec^2 ii) 9 m/sec^2

iii) 10 m/sec^2 iv) 5 m/sec^2. ☐

j) The ratio of lateral strain to the linear strain within elastic limit is known as

i) Young's modulus ii) Bulk modulus

iii) Modulus of elasticity iv) Poisson's ratio. ☐

Group - B

(Short Answer Questions)

Answer any *three* questions. $3 \times 5 = 15$

2. A ball is dropped onto a fixed horizontal surface from height h_0. The co-efficient of restitution is e. Show that the total vertical distance D, travelled by the ball before it comes to rest is

$$D = h_0\left(\frac{1+e^2}{1-e^2}\right).$$

3. A bullet of mass m, moving with a horizontal velocity v, hits a stationary block of mass M, suspended by a massless string of length L. The bullet gets embedded in the block after impact and the two together swings up. Show that the maximum angle of swing (*i.e.* angle made by the string with the vertical) is

$$\theta = \cos^{-1}\left(1 - \frac{M^2 v^2}{2gL(M+m)^2}\right)$$

4. State and prove Varignon's theorem. What is meant by a free-body diagram ?

5. With a neat sketch, explain stress-strain diagram for a ductile material.

6. What is D'Alembert's principle ? What is the advantage of using the principle ? How does it differ from Newton's second law of motion ?

Group - C
(Long Answer Questions)

Answer any *three* questions. $3 \times 15 = 45$

7. a) Determine the axial moment of inertia of the *T*-section shown in Fig. 1 about the centroidal axis parallel to base. 7

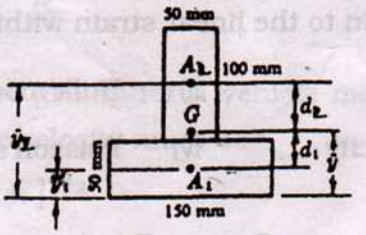

Fig. 1

b) A steel tube 4·5 cm external diameter and 3 mm thick encloses centrally a solid copper bar of 3 cm dia. The bar and the tube are rigidly connected together at the ends at a temperature of 30°C. Find the stress in each metal when heated to 180°C. Also find the increase in length if original length of assembly is 30 cm. Given, $\alpha_{st} = 1{\cdot}08 \times 10^{-5}$ per °C, $\alpha_{copper} = 1{\cdot}7 \times 10^{-5}$ per °C, $E_{steel} = 2{\cdot}1 \times 10^{-6}$ kg/cm^2, $E_{copper} = 1{\cdot}1 \times 10^{-6}$ kg / cm^2. 8

a) A ball of weight W rests upon a smooth horizontal plane and has attached to its centre two strings AB and AC which pass over frictionless pulleys at B and C and carry loads P and Q respectively, as shown in Fig. 2. If the string AB is horizontal, find the angle α that the string AC makes with the horizontal when the ball is in a position of equilibrium. Also find the pressure R between the ball and the plane. 8

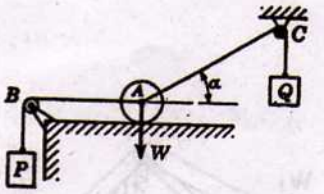

Fig. 2

b) Find the acceleration of a falling weight P hanging over a pulley by a string connecting a block Q as shown in the Fig. 3, the co-efficient of friction between block Q and the horizontal plane if slides is μ. Neglect inertia of the pulley and friction on its axle. Given, $P = 10$ kgf, $Q = 12$ kgf, $\mu = \frac{1}{2}$. 7

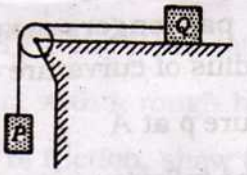

Fig. 3

9. a) Determine the maximum ratio h/b for which the homogeneous block will slide without tipping under the action of force P as shown in the Fig. 4. The co-efficient of static friction between the block and the incline is μ_s. 8

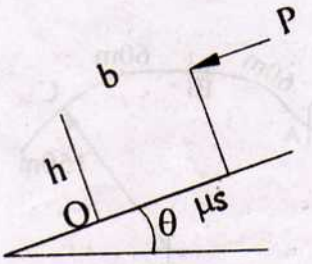

Fig. 4

b) Two blocks of weight W_1 and W_2 are located on two inclined planes as shown in Fig. 5. Assuming the contact surfaces to be frictionless, W_1 = 200 N, W_2 = 300 N, determine the angle θ for equilibrium. 7

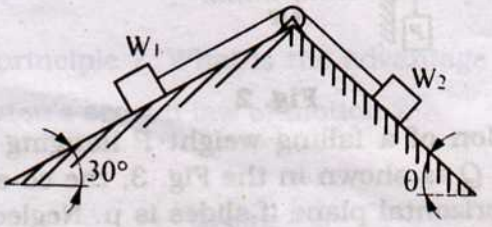

Fig. 5

10. a) To anticipate the dip and hump in the road, the driver of a car applies his brakes to produce a uniform deceleration. his speed is 100 km/hr at the bottom *A* of the dip and 50 km/hr at the top *C* of the hump, which is 120 m along the road from *A*. If the passengers experience a total acceleration of 3 m/s^2 at *A* and if the radius of curvature of the hump at *C* is 150 m, calculate

i) the radius of curvature ρ at *A*

ii) the acceleration at the inflexion point *B*, and

iii) the total acceleration at *C*. 8

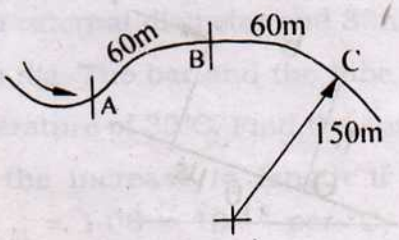

Fig. 6

b) A broad jumper approaches his take-off board A with a horizontal velocity of 10 m/s. Determine the vertical component v_y of the velocity of his centre of gravity at take-off for him to make the jump shown in Fig. 7. What is the vertical rise h of his centre of gravity ? 7

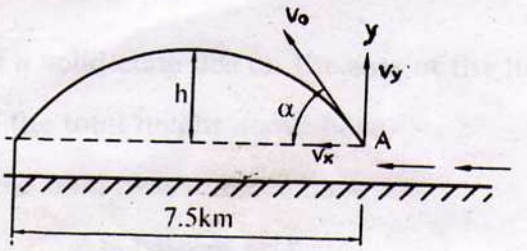

Fig. 7

11. Two equal uniform rods AC and CB are freely jointed at C and rest in a vertical plane with the ends A and B in contact with a rough horizontal plane. If the equilibrium be limiting and μ is the co-efficient of friction, show that

$$\sin \angle ACB = \frac{4\mu}{1 + 4\mu^2}$$ 15