



ENGINEERING &amp; 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 × 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  $30^\circ$  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  $30^\circ$  to the plane. If the normal stress on the plane is  $50 \text{ N/mm}^2$ , the shear stress on the plane will be

- i)  $43.3 \text{ N/mm}^2$
- ii)  $86.6 \text{ N/mm}^2$
- iii)  $100 \text{ N/mm}^2$
- 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)  $8 \text{ m/sec}^2$
- ii)  $9 \text{ m/sec}^2$
- iii)  $10 \text{ m/sec}^2$
- iv)  $5 \text{ m/sec}^2$ .

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 × 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

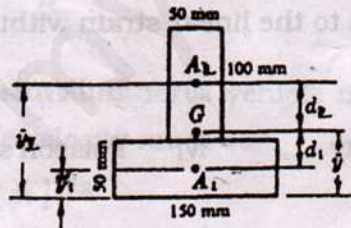


Fig. 1

- 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,  $\alpha_{st} = 1.08 \times 10^{-5}$  per °C,  $\alpha_{copper} = 1.7 \times 10^{-5}$  per °C,  $E_{steel} = 2.1 \times 10^{-6}$  kg/cm<sup>2</sup>,  $E_{copper} = 1.1 \times 10^{-6}$  kg/cm<sup>2</sup>. 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  $\alpha$  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

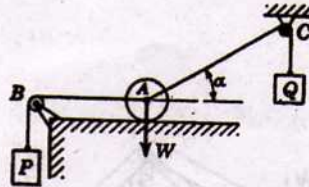


Fig. 2

- 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  $\mu$ . Neglect inertia of the pulley and friction on its axle. Given,  $P = 10 \text{ kgf}$ ,  $Q = 12 \text{ kgf}$ ,  $\mu = \frac{1}{2}$ . 7

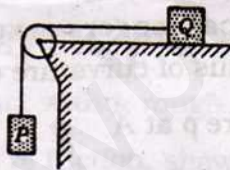


Fig. 3

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  $\mu_s$ . 8

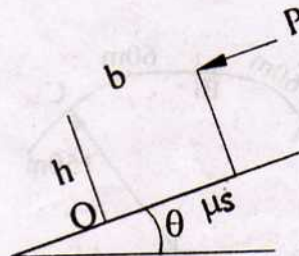


Fig. 4

- 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  $\theta$  for equilibrium. 7

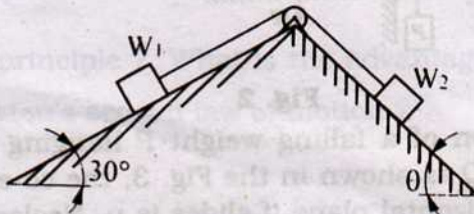


Fig. 5

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  $3 \text{ m/s}^2$  at A and if the radius of curvature of the hump at C is 150 m, calculate
- the radius of curvature  $\rho$  at A
  - the acceleration at the inflexion point B, and
  - the total acceleration at C.

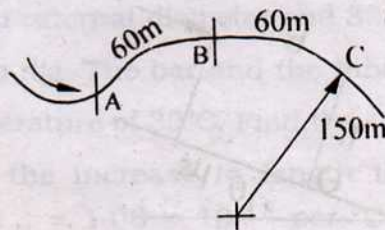


Fig. 6



- 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?

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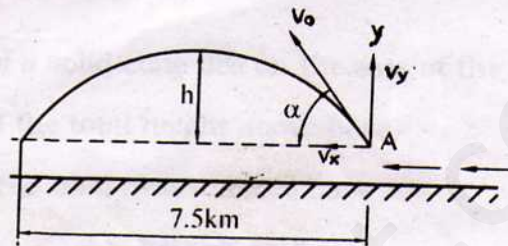


Fig. 7

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  $\mu$  is the co-efficient of friction, show that

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

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