ENGINEERING & MANAGEMENT EXAMINATIONS, DECEMBER – 2007

MECHANICAL SCIENCE

SEMESTER – 1

Time : 3 Hours] [Full Marks : 70

GROUP – A

(Multiple Choice Type Questions)

1. Choose the correct alternatives for the following : $10 \times 1 = 10$

i) Two non-collinear parallel equal forces in opposite direction

a) balance each other b) constitute a moment

c) constitute a couple d) constitute a moment of couple

e) constitute a resultant couple. ☐

ii) The centre of gravity of a uniform lamina lies at

a) the centre of heavy portion b) the bottom surface

c) the mid-point of its axes d) all of these

e) none of these. ☐

iii) The ratio of limiting friction and reaction is known as

a) coefficient friction b) angle of friction

c) angle of repose d) sliding friction

e) friction resistance. ☐

iv) D' Alembert's principle is applied to solve problems related to

a) Statics b) Stress of a structure

c) Dynamics d) none of these. ☐

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

a) Ideal material b) Isotropic material

c) Elastic material d) Uniform material. ☐

vi) The energy absorbed in the body when it is strained within the elastic limit is

a) strain energy b) resilience

c) toughness d) modulus of resilience. ☐

vii) For stable equilibrium the potential energy will be

a) maximum b) minimum

c) zero d) none of these. ☐

viii) If the velocity of projection is u m/sec and the angle of projection is $\alpha°$, the maximum height of the projectile on a horizontal plane is

a) $\frac{u^2 \cos^2 \alpha}{(2g)}$ b) $\frac{u^2 \sin^2 \alpha}{(2g)}$

c) $\frac{u^2 \tan^2 \alpha}{2g}$ d) $\frac{u^2 \sin^2 \alpha}{g}$

e) $\frac{u \sin \alpha}{g}$. ☐

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

a) energy b) mass

c) angular momentum d) linear momentum

e) none of these. ☐

x) When a body slides down an inclined surface (angle of inclination = θ), the acceleration f of the body is given by

a) $f = g$ b) $f = g \sin \theta$

c) $f = g \cos \theta$ d) $f = \tan \theta$

e) $f = g / \sin \theta$. ☐

GROUP – B

(Short Answer Type Questions)

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

2. a) State Varignon's Principle. 2

b) Determine the tension in the tie rod AC = 300 mm when a circular roller of weight Q = 450 N and radius r = 150 mm is rest against a vertical wall at B as shown in Fig. 1. 3

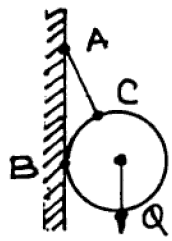

Fig. 1

3. a) State and prove Lami's theorem. 3

b) State the principle of Transmissibility of forces. 2

4. Define clearly :

a) Malleability

b) Resilience

c) Toughness and

d) Poisson's ratio. 5

5. a) State D' Alembert principle. 2

b) The position of a particle is given by, $S = 4t^3 + 3t^2 - 18t + 5$, when S is in metre, t in second. Determine the velocity and acceleration at $t = 3$ seconds. 3

6. A force given by $F = 3i + 2j - 4k$ is applied at the point P (1, – 1, 2). Find the moment of the force F about the point O (2, – 1, 3). 5

GROUP – C

(Long Answer Type Questions)

Answer any *three* questions. 3 × 15 = 45

7. a) The tension in the supporting cable AB (Fig. 2) is 10 kN. Write the force which the cable exerts on the boom BC as a vector T. Determine the angle θ_x, θ_y and θ_z which the line of action of T forms with the positive x-, y- and z-axes. 7

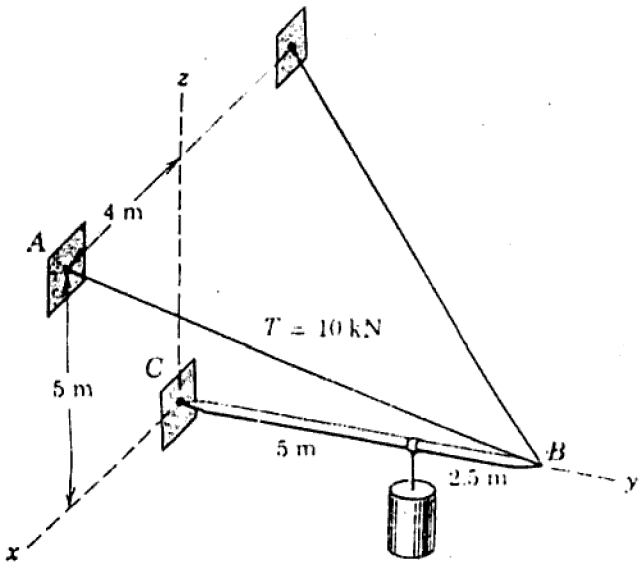

Fig. 2

b) A roller of radius r = 12 cm and weight Q = 5 kN is to be rolled over a curb of height h = 6 cm by a horizontal force P applied to the end of a string wound around the circumference of the roller as shown in Fig. 3. Find the magnitude of P required to start the roller over the curb. There is sufficient friction between the roller surface and the edge of the curb to prevent slip at A. 8

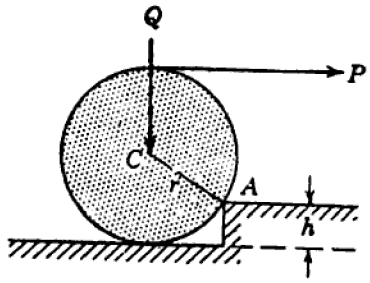

Fig. 3

8. a) A slender prismatic bar AB of length l and weight Q stands in a vertical plane and is supported by smooth surfaces at A and B as shown in Fig. 4. Using the principle of virtual work, find the magnitude of the horizontal force P applied at A if the bar is in equilibrium. 7

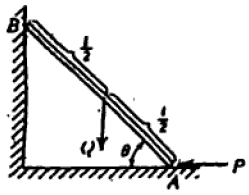

Fig. 4

b) A projectile is launched with an initial speed of 200 m/s at an angle of 60° (Fig. 5) with respect to the horizontal. Compute the range R as measured up the incline. 8

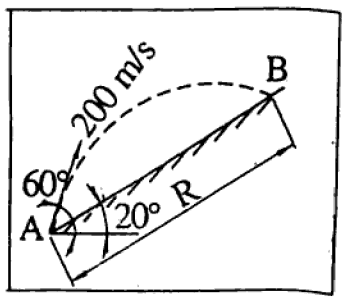

Fig. 5

a) Two rectangular blocks of weights W_1 and W_2 are connected by a flexible cord and rest upon a horizontal and an inclined plane, respectively, with the cord passing over a pulley as shown in Fig. 6. In the particular case where $W_1 = W_2$ and the coefficient of static friction μ is the same for all contiguous surfaces, then find the angle α of inclination of the inclined plane at which motion of the system will impend. Neglect friction in the pulley. 10

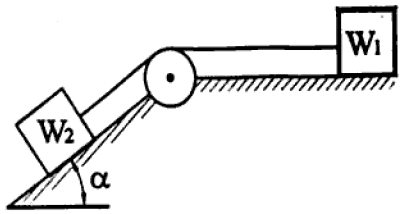

Fig. 6

b) A particle is moving along a circular path having a radius of 4 m such that its position as a function of time is given by $\theta = \cos 2t$, where θ is in radians and t is in seconds. Determine the magnitude of the velocity of the particle when $\theta = 30°$. 5

10. a) A slender bar AB of length l which remains always in the same vertical plane has its ends A and B constrained to remain in contact with a horizontal floor and a vertical wall, respectively as shown in Fig. 7. The bar starts from a vertical position and the end A is moved along the floor with constant velocity v_0 so that its displacement $OA = v_0 t$. Find the displacement time and acceleration time equations for the vertical motion of the end B of the bar. 8

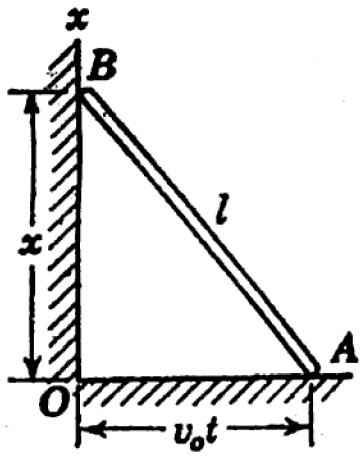

Fig. 7

b) A 20 tonnes goods train is travelling at a constant speed of 100 km/hr while total resistance against the motion due to ground friction and air pressure is 50 N per tonne weight. Suddenly the last wagon weighing 20 tonnes gets decoupled and falls behind the main train. Determine :

i) the acceleration and deceleration of the main train and decoupled wagon respectively

ii) the distance between the two after 20 seconds. 7

11. a) Referring to Fig. 8 determine the coordinates of the centre of the circular hole cut in a thin plate so that this point will be the centre of gravity of the remaining shaded area. 8

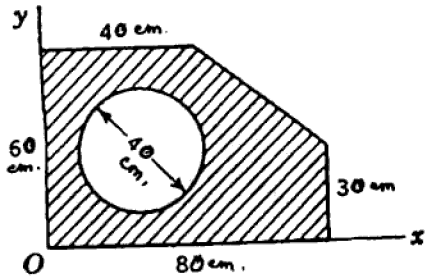

Fig. 8

b) In Fig. 9 a lever is attached to a spindle by means of a square key 6 mm × 6 mm by 2·5 cm long. If the average shear stress in the key not to exceed 700 kg/cm^2 , what is the safe value of the load P applied to the end of the lever ? 7

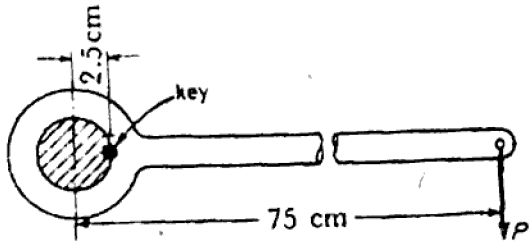

Fig. 9

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