ENGINEERING MECHANICS
(MECH 2101)

Time Allotted : 3 hrs **Full Marks : 70**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

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

Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**

(i) Five equal forces of 10 N are applied at a point. If the angle between them is equal, what is the resultant force?
(a) 10 N (b) $10\sqrt{2}$ N (c) 20 N (d) 0.

(ii) The value of constant p, for which the vectors $\vec{a} = 3\hat{\imath} - 4\hat{\jmath} + 2\hat{k}$ and $\vec{b} = 2\hat{\imath} - 3\hat{\jmath} + p\hat{k}$ are mutually perpendicular
(a) - 4 (b) 3 (c) - 3 (d) - 9

(iii) Varignon's theorem is related with
(a) moment of forces (b) friction
(c) deformation of rigid bodies (d) none of these.

(iv) For a semi-circular arc of radius r, centre of mass lies at a distance
(a) $\frac{r}{\pi}$ from its centre (b) $\frac{2r}{\pi}$ from its centre (c) $\frac{3r}{\pi}$ from its centre (d) $\frac{4r}{\pi}$ from its centre.

(v) Pappus and Guldinus Theorem is relevant with
(a) friction (b) moment of inertia
(c) centre of gravity (d) moment of force about a point.

(vi) A block of 70 N is placed on a horizontal plane. A pull force of P is applied at an angle θ with the horizontal. The magnitude of P will be minimum when
(a) $\theta < \varphi$ (b) $\theta = \varphi$ (c) $\theta > \varphi$ (d) $\theta = 0$.

(vii) Equation of motion of a particle is $s = 2t^3 - t^2 - 2$ where s is displacement in meters and t is time in seconds. Acceleration of the particle after 1 second will be
(a) 5 m/s^2 (b) 8 m/s^2 (c) 8 m/s^2 (d) 8 m/s^2

(viii) Moment of inertia of a circular area of diameter d about an axis perpendicular to the area and passing through its center is given by
(a) $\frac{\pi d^4}{16}$ (b) $\frac{\pi d^4}{32}$ (c) $\frac{\pi d^4}{64}$ (d) $\frac{\pi d^4}{128}$

(ix) Two particles with masses in the ratio 1:4 are moving with equal kinetic energies. The magnitude of their linear momentums will conform to the ratio
(a) 1 : 8 (b) 1 : 2 (c) $\sqrt{2}$: 1 (d) 4 : 1

(x) A jet engine works on the principle of conservation of
(a) energy (b) mass (c) angular momentum (d) linear momentum.

Group - B

2. (a) A force acts at a point A whose coordinates are (1, –2, 3) m. Compute (i) moment of force about origin. (ii) moment of force about the point B (2, 1, 2) m. [(CO1) (Analyse/IOCQ)]

   (b) Explain the principle of Transmissibility of forces and Equivalent vectors. [(CO2)(Understand/LOCQ)]

8 + 4 = 12

3. (a) A force of $(3\vec{i}+4\vec{j}+5\vec{k})$N acts on a particle and displaces it from origin to a point (2, 0, 3). Find the work done. (Length is in m) [(CO1)(Understand/LOCQ)]

   (b) The y-component of the force F which a person exerts on the handle of the box wrench shown in Fig.1 is known to be 70 N. Determine the $x-$component and the magnitude of F. [(CO2)(Analyse/IOCQ)]

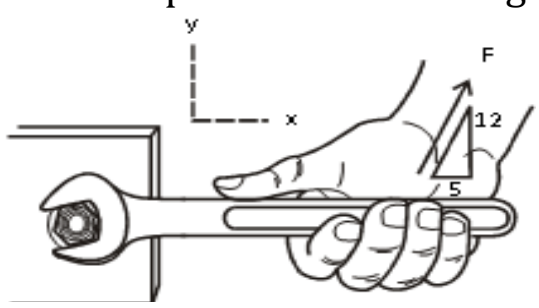

Fig.1

6 + 6 = 12

Group - C

4. (a) A block, shown in Fig.2, is acted on by its weight $W = 400$ N, a horizontal force $F = 600$ N and the pressure P exerted by the inclined plane. The resultant R of these forces is parallel to the incline. Determine P and R. Does the block move up or down the incline? [(CO2)(Evaluate/HOCQ)]

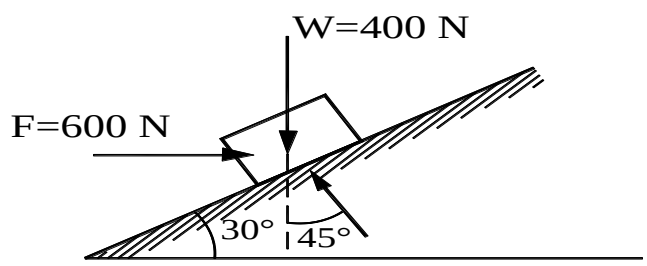

Fig.2

   (b) The wheel loads on a small tractor crossing on 18 m span are given in Fig.3. Determine the distance x at which the support reaction at A is twice that of B. [(CO1)(Evaluate/HOCQ)]

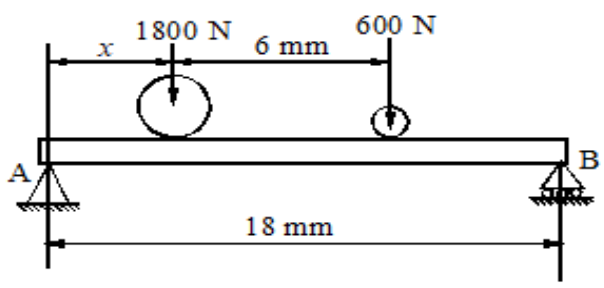

Fig.3

6 + 6 = 12

5. (a) Two smooth spheres, each of radius 50 cm and weight 500 kN rests in a horizontal channel having two vertical walls shown in Fig.4, the distance between the walls being 175 cm. Find the force exerted on the walls and the floor at the points of contact. [(CO2)(Evaluate/HOCQ)]

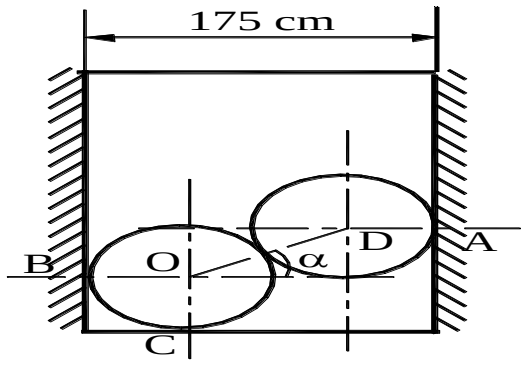

Fig.4

   (b) As shown in Fig.5 the intensity of loading on a simply supported beam 10 m long is given by $\mathbf{y = 10\ x^3}$, where, y is in N/m and x is in m, measured from A. Find the reactions at A and B.

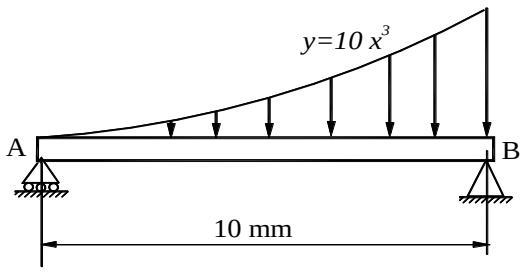

Fig.5

[(CO2)(Evaluate/HOCQ)]

6 + 6 = 12

Group - D

6. (a) Determine the coordinate of the centroid of the enclosed area shown in Fig.6.

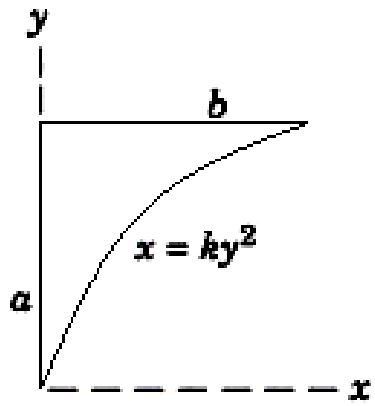

Fig.6

[(CO5)(Analyze/IOCQ)]

(b) The uniform pole of length l and mass m is placed against the supporting surface shown in Fig.7. If the coefficient of static friction is $\mu_s = 0.25$ at both A and B, determine the maximum angle θ at which the pole can be placed before it begins to slip.

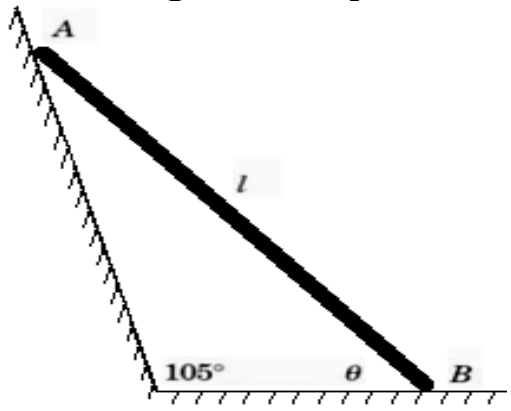

Fig.7

[(CO3)(Evaluate/HOCQ)]

6 + 6 = 12

7. (a) Determine the moment of inertia about x-axis of the square area without the central circular hole, shown in Fig.8.

[(CO5)(Analyze/IOCQ)]

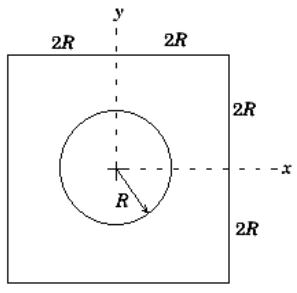

Fig.8

(b) The system of two blocks, cable and fixed pulley is initially at rest as shown in Fig.9. Determine the horizontal force P necessary to cause motion when P is applied to 5 kg block. Also determine the tension T in the cable.

[(CO3)(Evaluate/HOCQ)]

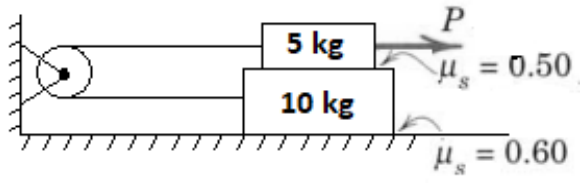

Fig.9

6 + 6 = 12

Group - E

8. (a) The car is travelling at a constant speed $v_0 = 100$ km/hr on the level portion of the road as shown in Fig.10. When the 6 percent $(\tan\theta = 6/100)$ incline is encountered, the driver does not change the

throttle setting and consequently the car decelerates at the constant rate $g \sin\theta$. Determine the speed of the car (i) 10 seconds after passing point A and (ii) when S = 100 m.

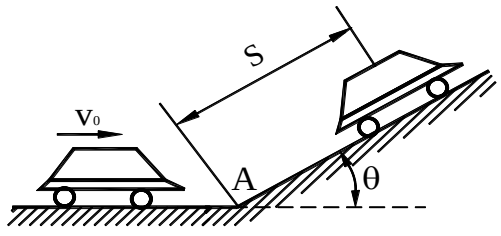

Fig.10 [(CO4)(Analyze/IOCQ)]

(b) The driver of the truck has an acceleration of 0.4 g as the truck passes over the top A of the hump in the road at constant speed as shown in the Fig.11. The radius of curvature of the road at the top of the hump is 98 m, and the center of mass G of the driver (considered a particle) is 2 m above the road. Calculate the speed v of the truck. [(CO6) (Analyze/IOCQ)]

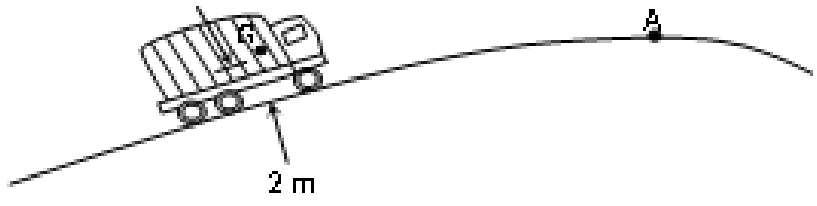

Fig.11

6 + 6 = 12

9. (a) Find the tension S in the string during motion of the system shown in Fig.12. If W_1 = 200 N and W_2 = 100 N. The system is in a vertical plane, and the coefficient of friction between the inclined plane and the block W_1 is μ= 0.2. Assume the pulleys to be without mass.

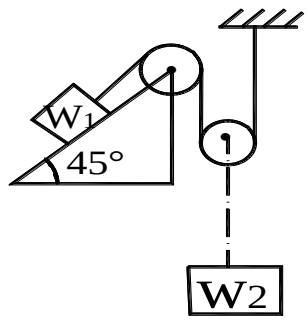

Fig.12 [(CO3)(Analyze/IOCQ)]

(b) The 3 kg slider is released from rest at point A and slides with negligible friction in a vertical plane along the circular rod as shown in Fig.13. The attached spring has a stiffness of 350 N/m and has an unstretched length of 0.6 m. Determine the velocity of the slider as it passes position B.

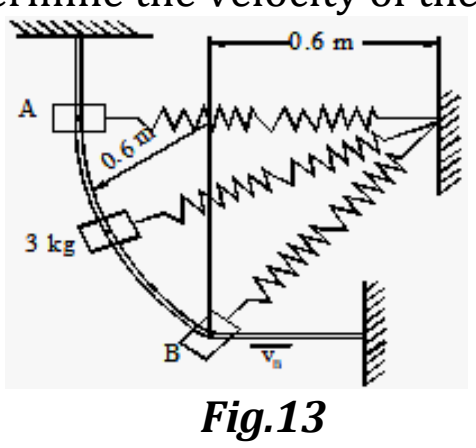

Fig.13 [(CO6)(Evaluate/HOCQ)]

6 + 6 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	10.42	45.83	43.75

Course Outcome (CO):

After the completion of the course students will be able to
1. Describe basic concepts of vector algebra as applied to engineering mechanics.
2. Construct a free body diagram of a system under equilibrium.
3. Interpret the friction phenomenon and calculate friction force.
4. Execute dynamics of members/links in a mechanism and inertia force with the help of D'Alembert's principle.
5. Develop the steps to calculate the centroid and MI values required for designing structures.
6. Implement the principles of work-energy and impulse-momentum for analysis of dynamic systems.

*LOCQ: Lower Order Cognitive Question; IOCQ: Intermediate Order Cognitive Question; HOCQ: Higher Order Cognitive Question