MECHANICS FOR ENGINEERS
(MECH 2106)

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) The resultant of two equal forces P making an angle θ, is given by
(a) $2P \sin\frac{\theta}{2}$ (b) $2P \cos\frac{\theta}{2}$ (c) $2P \tan\frac{\theta}{2}$ (d) $2P \cot\frac{\theta}{2}$

(ii) Two equal vectors have their resultant equal to three fourth of either of them. The angle between them is
(a) 44^0 (b) 53.1^0 (c) 136^0 (d) 128.7^0

(iii) A free body diagram is considered for analysing a problem of a body in
(a) equilibrium only (b) non-equilibrium only
(c) both equilibrium and non-equilibrium (d) neither equilibrium nor non-equilibrium.

(iv) The centroid of an equilateral triangle with each side (a) is _____ from any of thethree sides.
(a) $\frac{a\sqrt{3}}{2}$ (b) $\frac{a\sqrt{2}}{3}$ (c) $\frac{a}{2\sqrt{3}}$ (d) $\frac{a}{3\sqrt{2}}$

(v) The materials having same' elastic properties in alldirections are called
(a) isotropic materials (b) elastic materials
(c) ideal materials (d) homogeneous materials.

(vi) 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

(vii) For a body thrown vertically upwards with velocity u, the total time taken by the body to fall back to ground is
(a) $\frac{2u}{g}$ (b) $\frac{u}{g}$ (c) $\frac{u^2}{g}$ (d) $\frac{u}{g^2}$

(viii) The stress at which extension of a ductile material takes place more quickly as compared to the increase in load is called _____
(a) elastic point (b) plastic point (c) breaking point (d) yielding point.

(ix) The ratio of limiting friction and normal reaction is known as
(a) coefficient friction (b) angle of friction (c) angle of repose (d) sliding friction.

(x) The stress produced in the members so to prevent sliding of a section over other is called
(a) nominal stress (b) bearing stress (c) shear stress (d) none of the above.

Group - B

2. (a) A force with a magnitude of 100 N is applied at the origin O of the x, y, z axes. The line of action F passes through a point A whose coordinates are 3 m, 4 m, and 5 m. Determine the x, y and z scalar components of F.
[(CO1)(Understand/LOCQ)]

(b) The tension in the supporting cable is 800 N as shown in Fig.1. Determine the force which this cable exerts on the boom OAB as a vector. Determine the angles made by the line of action of T with positive x, y and z axes. [(CO1)(Understand/LOCQ)]

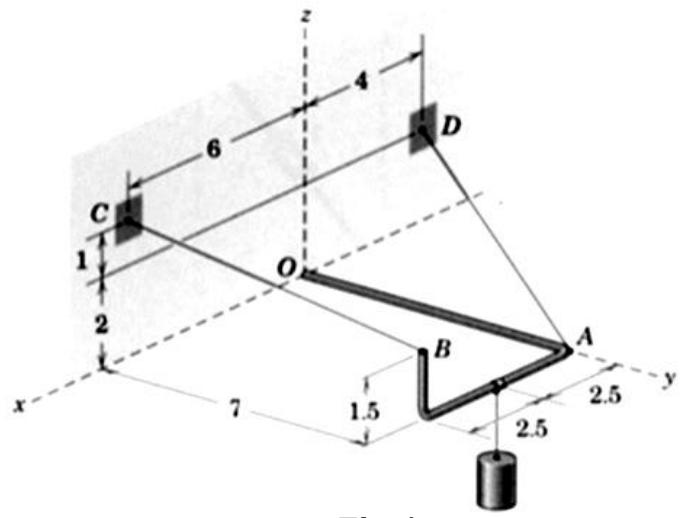

Fig.1

4 + 8 = 12

3. (a) Calculate the moment of the 90 N force about point O for the condition $\theta = 15^0$ as shown in Fig.2. Also, determine the value of θ for which the moment about O is zero and maximum. [(CO1)(Analyse/IOCQ)]

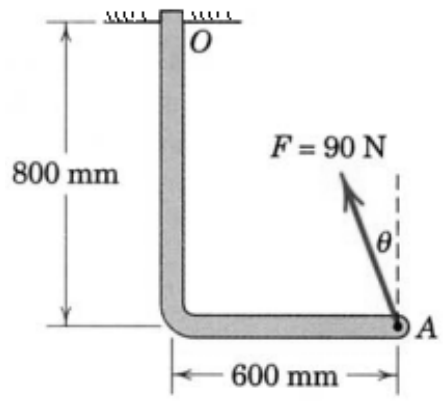

Fig.2

(b) The initial point of a vector is A (3, 1, -2) and terminal point is B (4, -7, 10). Determine the angles made by the vector with the coordinate axes. [(CO1)(Analyse/IOCQ)]

6 + 6 = 12

Group - C

4. (a) Two smooth cylinders as shown in Fig.3, each of weight W = 200 N and 15 cm diameter are connected by a string AB of length 20 cm and rest upon a horizontal plane supporting a third smooth cylinder of weight Q = 600 N having 8 cm in diameter above them. Find the tension along the string AB and the reaction produced by the ground at points of contact D and E. [(CO2)(Evaluate/HOCQ)]

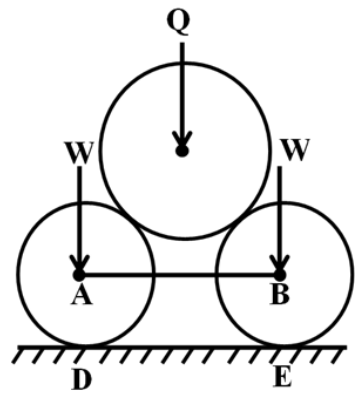

Fig.3

(b) The uniform pole of length l and mass m is placed against the supporting surface shown in Fig.4. 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. [(CO2)(Evaluate/HOCQ)]

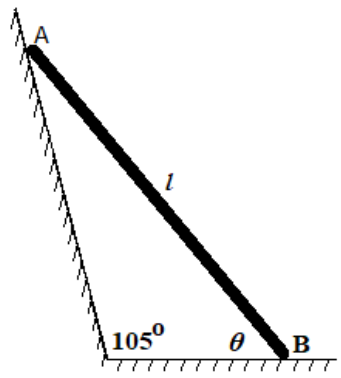

Fig.4

6 + 6 = 12

5. (a) A rope AB as shown in Fig.5 is 4.75 m long and is connected at two points A and B at the same level 4 m apart. A load on 2000 N is suspended from a point C on the rope at 1.5 m from A. What load connected at point D on the rope, 1 m from B will be necessary to keep the position CB level. [(CO3)(Evaluate/HOCQ)]

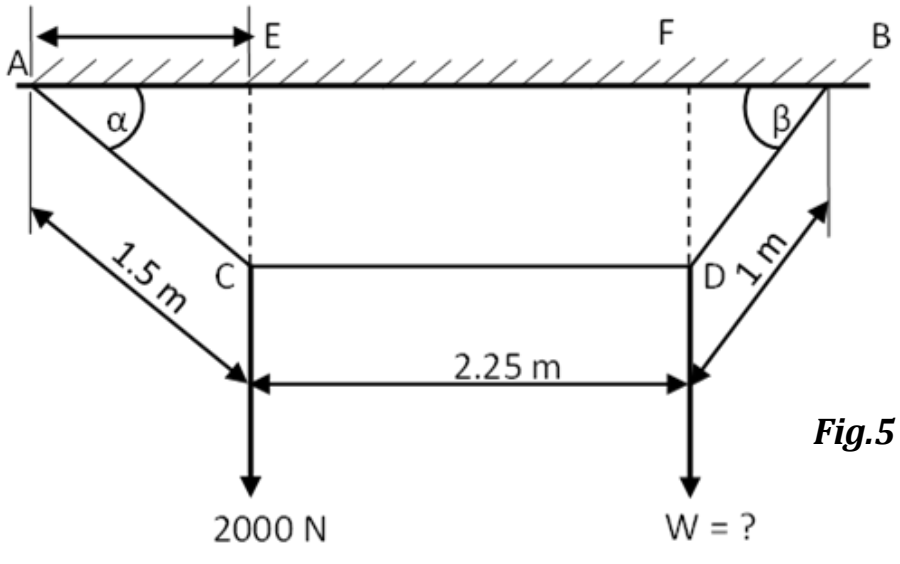

Fig.5

(b) A wedge *A* having weight 50 N is to be driven between an inclined support and a block *B* of weight 1500 N as shown in Fig.6. Determine the magnitude of the vertically applied force *P* on the wedge so as to initiate movement of the blocks. Assume that the coefficient of friction between all the contiguous surfaces to be $\mu = 0.3$. [(CO3)(Evaluate/HOCQ)]

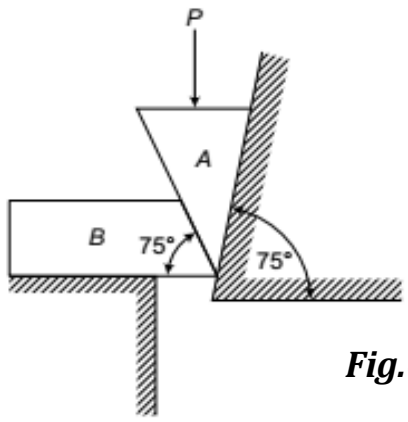

Fig.6

6 + 6 = 12

Group - D

6. (a) Locate the centroid of the given area as shown in Fig.7. All the dimensions are in mm. [(CO5)(Analyze/IOCQ)]

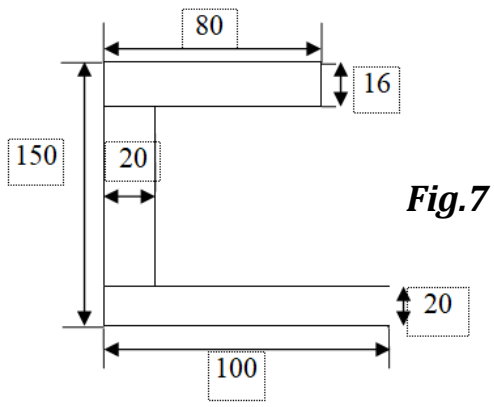

Fig.7

(b) A bar of brass 20 mm is enclosed in a steel tube of 40 mm external diameter and 20 mm internal diameter. The bar and the tubes are initially 1.2 m long and are rigidly fastened at both ends using 20 mm diameter pins. If the temperature is raised by 60 °, find the stresses induced in the bar, tube, and pins.
Given –
$E_s = 2.1 \times 10^5$ N/mm^2 $E_b = 1.1 \times 10^5$ N/mm^2
$\alpha_S = 11.6 \times 10^{-6}$/ °C $\alpha_b = 18.7 \times 10^{-6}$ /°C. [(CO5)(Analyze/IOCQ)]

6 + 6 = 12

7. (a) Locate the centroid of the area under the curve $x = ky^3$ from x = 0 to x = a, shown in Fig.8. [(CO5) (Analyze/IOCQ)]

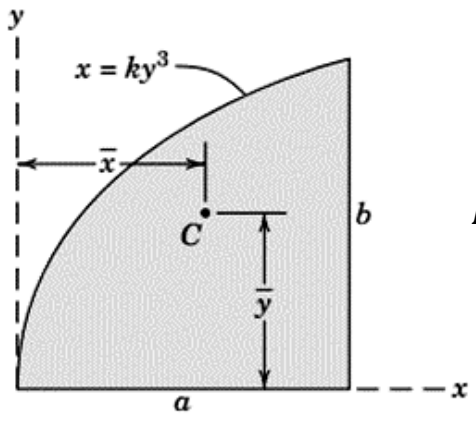

Fig.8

(b) The brass rods and one steel rod together support a load P as shown in Fig.9. If the stresses in brass and steel are not to exceed 60 N/mm^2 and 120 N/mm^2, find the safe load that can be supported. Take E of steel = 2×10^5 N/mm^2 and for brass = 1×10^5 N/mm^2. The cross-sectional area of steel rod is 1500 mm^2 and of each brass rod is 1000 mm^2. [(CO4)(Analyze/IOCQ)]

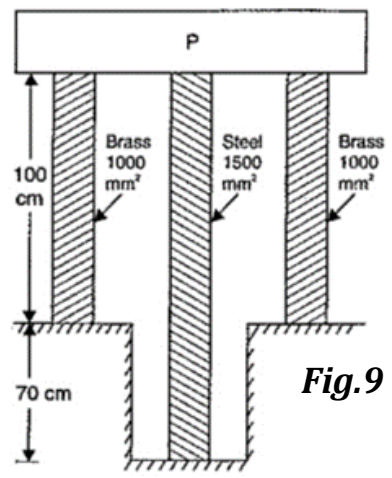

Fig.9

6 + 6 = 12

Group - E

8. (a) A soldier fires a bullet with a velocity of 31.32 m/sec at an angle α upwards from the horizontal from his position on a hill to strike a target which is 100 m away and 50 m below his position as shown in Fig.10. Find the angle of projection α. Also find the velocity with which the bullet strikes the target. [(CO6)(Analyze/IOCQ)]

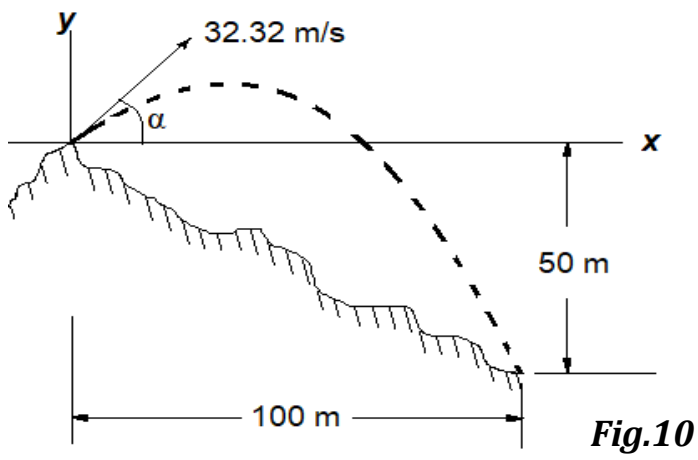

Fig.10

(b) A body moves along a straight line and its acceleration "a" which varies with time is given by a = 2 – 3t. Five seconds after the start of observation, its velocity is found to be 20 m/sec. Ten seconds after the start of observation, the body is at 90 m from the origin. Determine, (i) its acceleration, velocity and distance from the origin, and (ii) the time in which the velocity becomes zero and the corresponding distance from the origin. [(CO6)(Analyze/IOCQ)]

6 + 6 = 12

9. (a) A small cart has a speed v_A = 4 m/s as it passes point A (shown in Fig.11). It moves without appreciable friction and passes over the top hump of the track. Determine the cart speed as it passes point B. [(CO6)(Evaluate/HOCQ)]

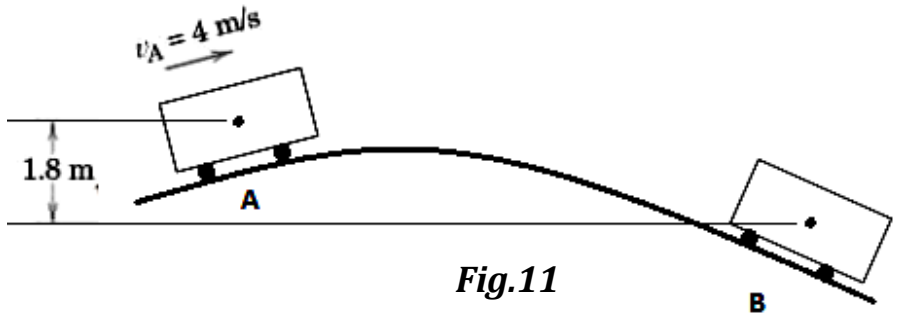

Fig.11

(b) The solid homogeneous cylinder released from rest on the ramp shown in Fig.12. If θ=40°, μ_s= 0.30, and μ_k= 0.20, determine the acceleration of the mass centre G and the friction force exerted by the ramp on the cylinder. [(CO6)(Evaluate/HOCQ)]

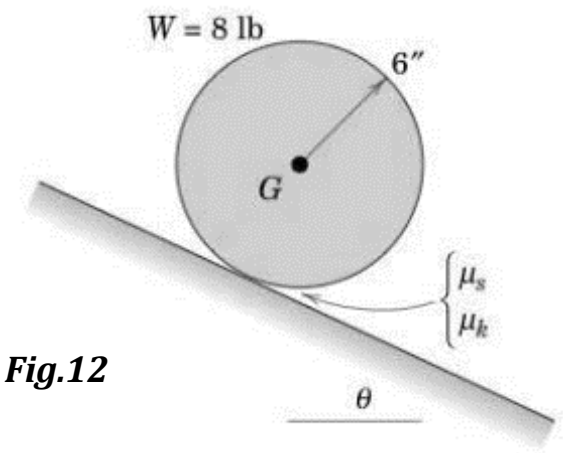

Fig.12

6 + 6 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	12.5	50	37.5

Course Outcome (CO):

After the completion of the course, students will be able to

1. Understand basic concepts of vector algebra as applied to engineering mechanics.
2. Draw free body diagram of a system under equilibrium.
3. Understand friction phenomenon and calculate friction loss.
4. Understand and quantify elastic behaviour of deformable bodies.
5. Know how to calculate CG location required for design of structures.
6. Apply the principles of work-energy for analysis of dynamic systems.

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