ENGINEERING MECHANICS
(MECH 2101)

Time Allotted : 2½ hrs **Full Marks : 60**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 4 (four) from Group B to E, taking one from each group.

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

Group – A

1. Answer any twelve: **12 × 1 = 12**

Choose the correct alternative for the following

(i) If **i** and **j** are two Cartesian unit vectors than
(a) $i \times j = 1$ (b) $i \times j = 0$ (c) $i \times j = 2$ (d) $i \times j = -1$

(ii) Couple is a
(a) bound vector (b) free vector
(c) sliding vector (d) equivalent vector.

(iii) Angle between the vectors (**i + j**) and (**i - j**) is
(a) 90° (b) 45° (c) 0° (d) 180°.

(iv) If φ is angle of friction, then coefficient of friction (μ) is
(a) cos φ (b) sin φ (c) tan φ (d) sec φ.

(v) Free body diagram of a body is drawn
(a) by isolating the body from its surrounding
(b) by indicating the forces acting on it
(c) both (a) and (b)
(d) none of the above.

(vi) The maximum frictional force between two surfaces, is
(a) kinetic friction (b) sliding friction
(c) rolling friction (d) limiting friction.

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

(viii) The centre of gravity of solid hemisphere of radius R is
(a) R/2 (b) 3R/8 (c) 3R/4 (d) none of these.

(ix) Moment of inertia of a triangle of base b and height h about the centroidal axis parallel to base is
(a) $bh^3/36$ (b) $bh^3/12$ (c) $bh^3/6$ (d) $bh^3/3$.

(x) If the velocity of projection is u m/s and the angle of projection is α, 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) $\frac{u^2 \sin^2 \alpha}{g}$

Fill in the blanks with the correct word

(xi) Work done on motion between any two points is equal to change in _____ energy.

(xii) Any straight line in the body always retains an orientation parallel to its original direction during such a motion is known as_____.

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

(xiv) D' Alembert's principle is applied to solve problems related to _____.

(xv) If a momentum of a body is doubled, its kinetic energy will increase by _____ times.

Group - B

2. (a) Define direction cosines.
Prove that $\vec{e_v} = l\vec{i} + m\vec{j} + n\vec{k}$ where the symbols have their usual meanings.
[(CO1)(Remember/LOCQ)]

(b) The line of action of the 500 N force runs through the points A(–7, –2) and B(8, 6) as shown in Fig. 1. Find the 'x' and 'y' scalar components of force F. *[(CO1)(Apply/IOCQ)]*

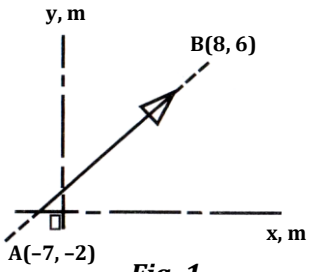

Fig. 1

(2 + 4) + 6 = 12

3. (a) State and proof the Varignon's theorem for a system of concurrent forces.
[(CO1)(Remember/LOCQ)]

(b) A force of 200 N is directed along the line drawn from the point P(5, 2, 4) to the point Q(3, -5, 6). Determine the moment of this force about a point A(4, 3, 2). The distances are in meters. *[(CO1)(Apply/IOCQ)]*

6 + 6 = 12

Group - C

4. (a) A horizontal bar AB is hinged to a vertical wall at A and supported at its mid-point C by a cable CD as shown in Fig. 2. The bar is subjected to a vertical load P applied at the free end B. The bar maintains horizontal position. Find the tension in the cable and reaction at A. Neglect the weight of the bar. *[(CO2)(Apply/IOCQ)]*

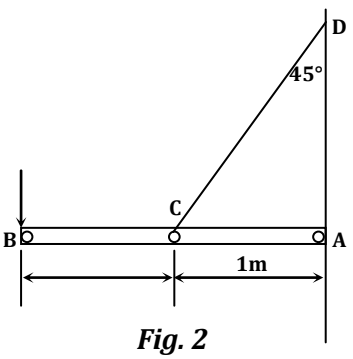

Fig. 2

(b) A ball of weight Q = 120 N rests in trough ABC, as shown in Fig. 3. Determine the forces exerted on the sides, on the vertical face at D and on the inclined face at E, if all the surfaces are perfectly smooth.

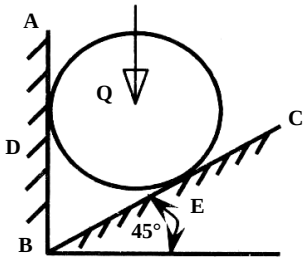

Fig. 3

[(CO2)(Analyze/HOCQ)]

6 + 6 = 12

5. (a) A 150 kg man stands on the mid-point of a 50 kg ladder as shown in Fig. 4. Assuming that floor and the wall are perfectly smooth, find the reactions at points A and B. *[(CO2)(Evaluate/HOCQ)]*

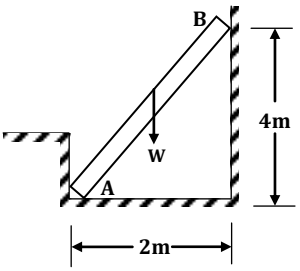

Fig. 4

(b) A roller of radius 'r' and weight 'W' is to be rolled over a curb of height 'h' by a horizontal force 'P' applied to the end of a string wound around the circumference of the roller as shown in Fig. 5. Find the magnitude of P required to start the roller over the curb. Assume that contact at B is frictionless, but there is sufficient friction between the roller surface and the edge of the curb to present slip at A. Given r = 2h.

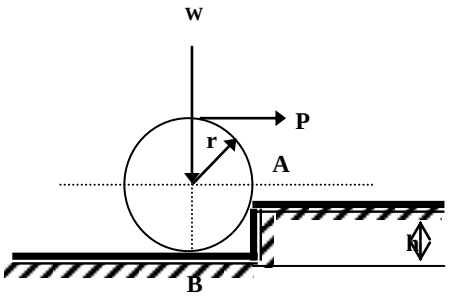

Fig. 5

[(CO2)(Evaluate/HOCQ)]

6 + 6 = 12

Group - D

6. (a) Define the angle of friction and angle of repose with neat sketch. *[(CO3)(Remember/LOCQ)]*

(b) A block A weighing 1000 N rests on a rough inclined plane as shown in Fig. 6 whose inclination to horizontal is 45°. The block is connected to another block B weighing 3000 N resting on a rough horizontal plane, by a weightless rigid bar inclined at an angle of 30° to the horizontal. Find the horizontal force required to be applied to the block B, to just move the block A in upward direction. Assume angle of limiting friction is 15° at all surfaces where is sliding.

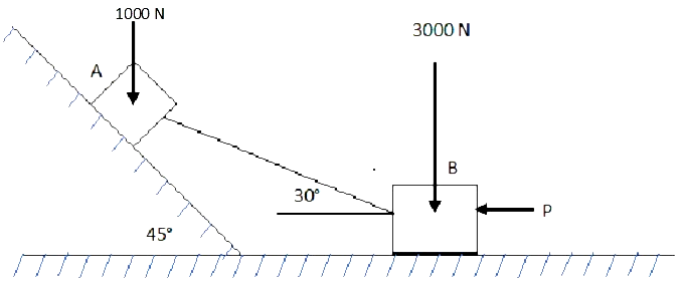

Fig. 6

[(CO4)(Apply/HOCQ)]

(2 + 2) + 8 = 12

7. (a) State and explain the parallel axis theorem of area moment of inertia. *[(CO5)(Remember/LOCQ)]*

(b) Determine the polar moment of inertia of the section shown in Fig. 7 about itscentroidal axis. *[(CO5)(Apply/IOCQ)]*

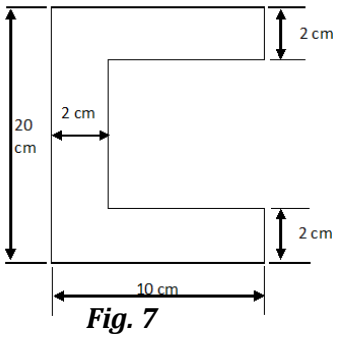

Fig. 7

(2 + 2) + 8 = 12

Group - E

8. (a) A projectile is launched with an initial speed of 200 m/s at an angle of 60° with respect to the horizontal as shown in Fig. 8. Compute the range R as measured up the incline. *[(CO4)(Apply/HOCQ)]*

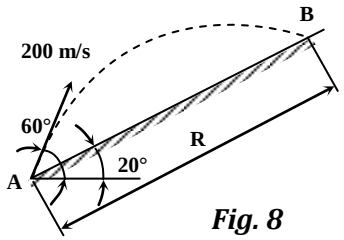

Fig. 8

(b) Prove that work done on motion between any two points is equal to the change in kinetic energy. *[(CO6)(Remember/LOCQ)]*

6 + 6 = 12

9. (a) The 3 kg slider is released from rest at point A and slides with negligible friction in a vertical plane along the circular rod. The attached spring has a stiffness of 350 N/m and has an unstretched length of 0.6 m as shown in Fig. 9. Determine the velocity of the slider as it passes position B. *[(CO6)(Solve/HOCQ)]*

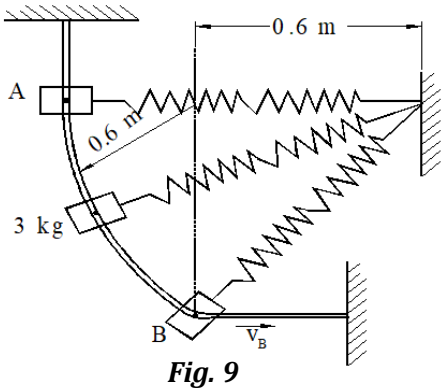

Fig. 9

(b) Determine the tension in the strings and accelerations of two blocks of masses 150 kg and 50 kg connected by a string and a frictionless, weightless pulley as shown in Fig. 10. *[(CO4)(Apply/HOCQ)]*

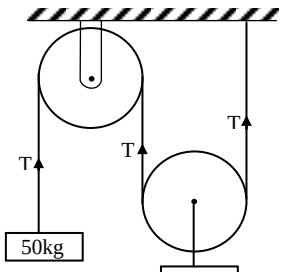

Fig. 10

6 + 6 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	27	27	46

Course Outcomes (CO):

After going through the course, the students will be able to

CO1: Describe basic concepts of vector algebra as applied to engineering mechanics.
CO2: Construct a free body diagram of a system under equilibrium.
CO3: Interpret friction phenomenon and calculate friction force.
CO4: Execute dynamics of members/links in a mechanism and inertia force with the help of D'Alembert's principle.
CO5: Develop the steps to calculate the centroid and MI values required for designing structures.
CO6: 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.*