ENGINEERING MECHANICS
(MEC2101)

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

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

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

(iv) A rigid truss with 6 joints must contain following number of members
(a) 7 (b) 6 (c) 9 (d) 11

(v) The ratio of the moment of inertia of a circular plane about its x-axis to that about the y-axis is
(a) 0.5 (b) 1.0 (c) 1.5 (d) 2.0

(vi) Pappus and Guldinus Theorem is relevant with
(a) Friction (b) Moment of inertia
(c) Centre of gravity (d) Moment of force about a point.

(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/s² (b) 8 m/s² (c) 8 m/s² (d) 8 m/s².

(viii) If a momentum of a body is doubled, its kinetic energy will
(a) increase by two times (b) increase by four times
(c) remain same (d) get halved.

(ix) Dimension of impulse is
(a) MLT^{-1} (b) MLT^{-2} (c) $ML^{-2}T^{-3}$ (d) $ML^{-2}T^{-1}$

(x) The work done against any conservative force is stored in the body in the form of
(a) Energy (b) Potential energy (c) Elastic energy (d) Strain energy.

Fill in the blanks with the correct word

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

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

(xiii) Zero-force members are the members those do not carry any _____.

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

(xv) Moment of Inertia of a triangle of height h and base b about its base is _____.

Group - B

2. (a) (i) Define direction cosines. *[(CO1)(Remember/LOCQ)]*
(ii) Prove that $\vec{e_v} = l\vec{\imath} + m\vec{\jmath} + n\vec{k}$ where the symbols have their usual meanings. *[(CO2)(Understand/LOCQ)]*
(b) A ball of weight Q = 120 N rests in trough ABC, as shown in Fig. 1. 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. *[(CO3)(Apply/IOCQ)]*

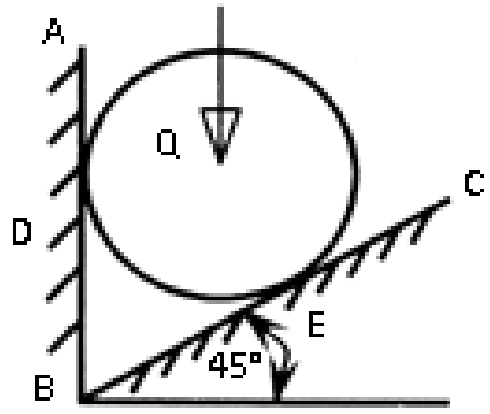

Fig. 1

(2 + 4) + 6 = 12

3. (a) A 150 kg man stands on the mid-point of a 50 kg ladder as shown in Fig. 2. Assuming that floor and the wall are perfectly smooth, find the reactions at points A and B. *[(CO3)(Apply/IOCQ)]*

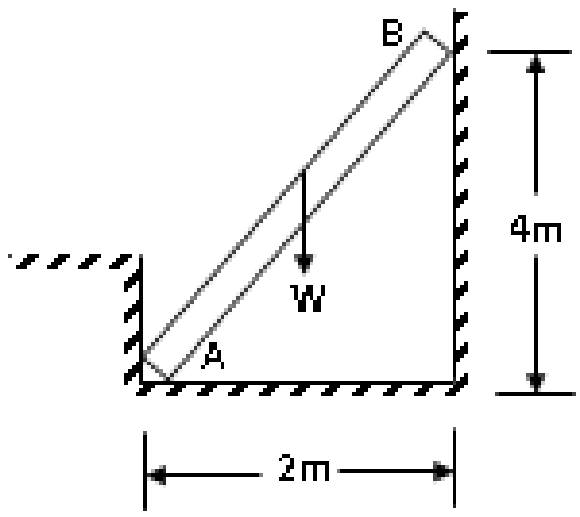

Fig. 2

(b) A ball of weight W is resting upon a smooth plane and is attached at its centre to the strings which pass over a smooth pulley and carry load P and Q as shown in Fig. 3. Find the angle θ and pressure between the ball and the plane.

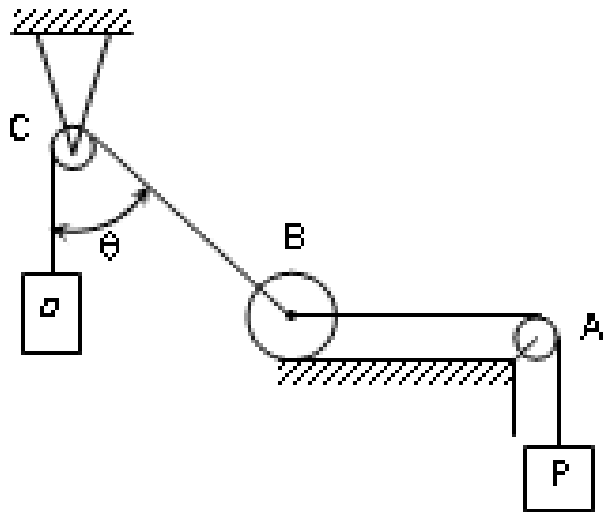

Fig. 3

[(CO3) (Apply/IOCQ)]

6 + 6 = 12

Group - C

4. (a) Explain coefficient of static friction and kinetic friction. *[(CO2)(Understand /LOCQ)]*

(b) Using the principle of virtual work, find the value of the angle θ defining the configuration of equilibrium of the system shown in Fig. 4. The ball D and E can slide freely along the bars AC and BC, but the string DE connecting the balls is inextensible. *[(CO3)(Apply/HOCQ)]*

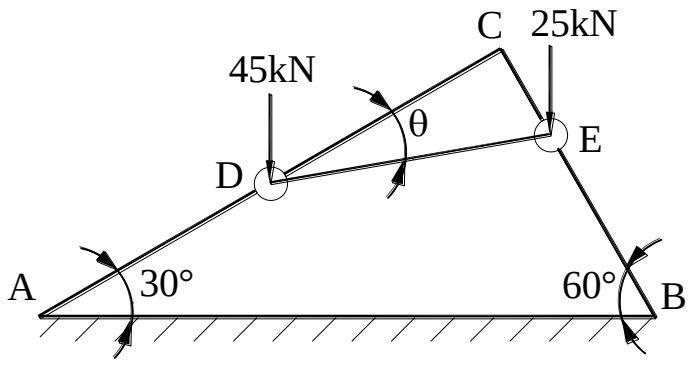

Fig. 4

(2 + 2) + 8 = 12

5. (a) Two blocks of weight W1 and W2 are located on two inclined planes as shown in Fig. 5. Assuming the contact surfaces to be frictionless, W1 = 200 N, W2 = 300 N, determine the angle θ for equilibrium. *[(CO3)(Apply/IOCQ)]*

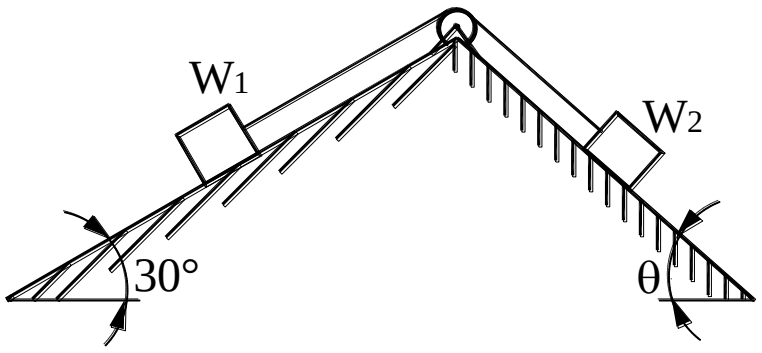

Fig. 5

(b) The uniform pole of length l and mass m is placed against the supporting surface shown in Fig. 6. 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.

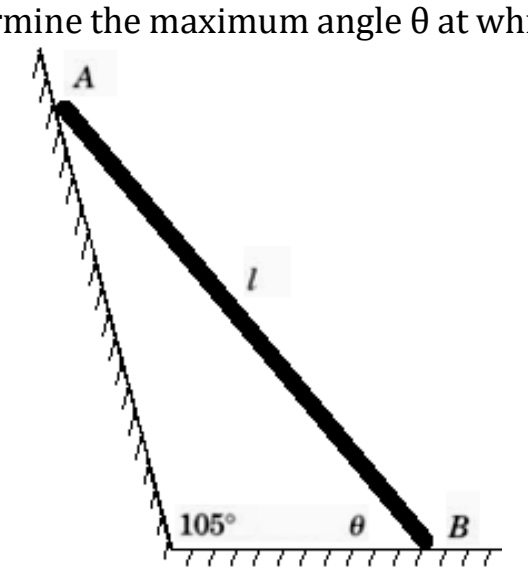

Fig. 6 *[(CO3)(Apply/IOCQ)]*

6 + 6 = 12

Group - D

6. (a) State and explain the parallel axis theorem of area moment of inertia. *[(CO1)(Remember/LOCQ)]*

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

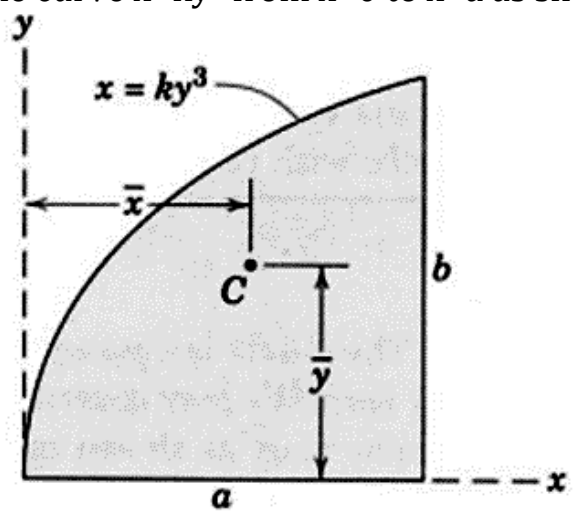

Fig. 7

4 + 8 = 12

7. (a) Determine the moment of inertia of the shaded figure about x-axis as shown in Fig. 8. *[(CO5)(Analyse/IOCQ)]*

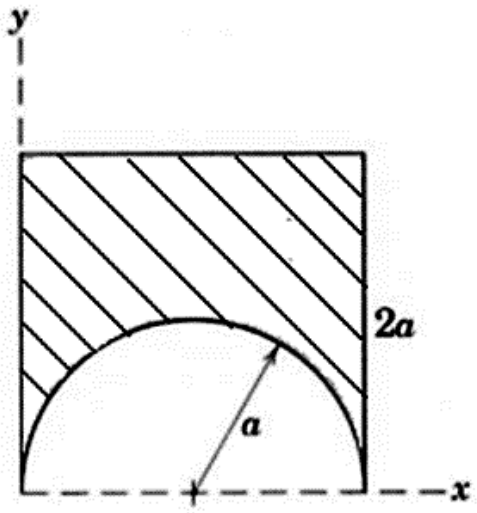

Fig. 8

(b) Find out the CG of the hatched area formed by eliminating the square with 40 mm sides from that of a quarter of a circle with an 80 mm radius as shown in Fig. 9. *[(CO5) (Analyse/IOCQ)]*

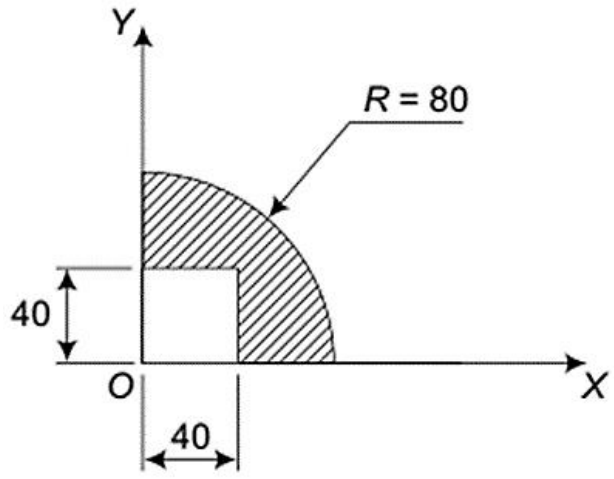

Fig. 9

6 + 6 = 12

Group - E

8. (a) Neglecting friction and inertia of the two step pulley as shown in Fig. 10, find the acceleration of the falling weight P. Assume P=10N, Q=15 N and $r_2=2r_1$. *[(CO4)(Apply/IOCQ)]*

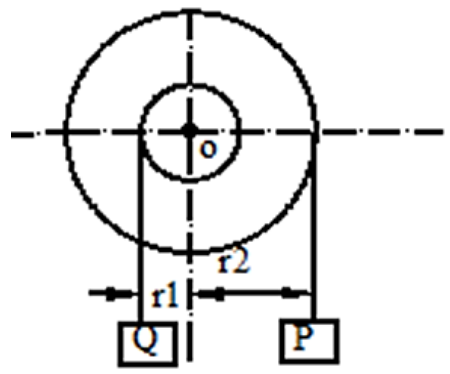

Fig. 10

(b) The system is released from rest with the spring initially stretched 75 mm as shown in Fig. 11. Calculate the velocity v of the cylinder after it has dropped 12 mm. The spring has a stiffness of 1050 N/m. Neglect the mass of the small pulley.

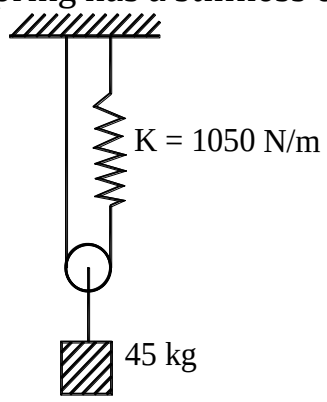

Fig. 11

[(CO6)(Analyse/HOCQ)]

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. 12. Determine the velocity of the slider as it passes position B. *[(CO6)(Analyse/HOCQ)]*

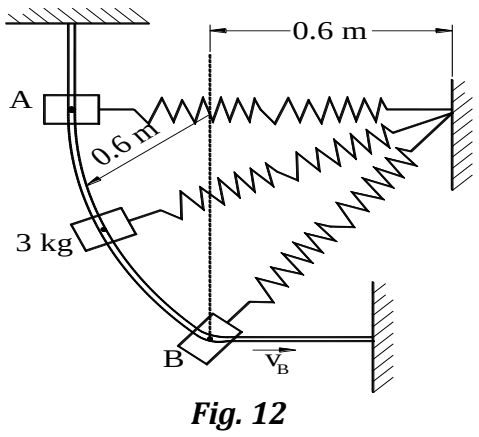

Fig. 12

(b) A particle A of mass m is attached to a fixed point O by a string of length l whirls in a horizontal circular path of radius r with a uniform speed v as shown in Fig 13. Determine the tensile force in the string during such motion. *[(CO6)(Analyse/HOCQ)]*

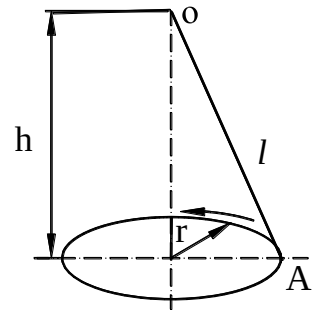

Fig. 13

6 + 6 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	14.60	58.33	27.07