Indian Institute of Engineering Science and Technology, Shibpur

B.Tech. (AE, CE, CST, EE, ETC, IT, ME, MT, MN) End Semester Examination, December 2023

Mechanics (AM 1101)

Full marks: 50 Time: 3 hours

All notations have their usual meanings

(i) Take g = 9.81 m/s^2 (ii) Assume any other data not given in the question

[Group A: Statics]

(Question no. 1 is compulsory and answer any Two (02) from the rest of Group A)

1. Determine the moment of inertia of the shaded area about the y-axis (Fig. Q.1). [7]

2. Calculate the forces in members CG and CF for the truss shown (Fig. Q.2). If the 4-kN force acting on the truss were removed, identify by inspection those members in which the forces are zero. On the other hand, if the 4-kN force were applied at G instead of B, would there be any zero force members? [9]

3. A lifting device for transporting 200-kg steel drums is shown in Fig. Q.3. Calculate the magnitude of the force exerted on the drum at E and F. [9]

4. The exercise machine consists of a lightweight cart which is mounted on small rollers so that it is free to move along the inclined ramp (Fig. Q.4). Two cables are attached to the cart – one for each hand. If the hands are together so that the cables are parallel and if each cable lies essentially in a vertical plane, determine the force P which each hand must exert on its cable in order to maintain an equilibrium position. The mass of the person is 60 kg, the ramp angle is 10^0 and the angle β is 15^0. In addition, calculate the force R which the ramp exerts on the cart. [9]

[Group B: Dynamics]

(Answer any Five (5) questions from Group B)

5. A particle moves along the positive x – axis with an acceleration a_x in m/s^2 which increases linearly with x expressed in millimeters, as shown on the graph for an interval of its motion (Fig. Q.5). If the velocity of the particle at $x = 30$ mm is 0.45 m/s, determine the velocity $x = 120$ mm. [5]

6. The force $P = 30$ N is applied to the system, which is initially at rest (Fig. Q.6). Determine the speeds of A and B after A has moved 0.5 m. [5]

7. For a certain interval of motion, the pin P is forced to move in the fixed parabolic slot by the vertical slotted guide, which moves in the x- direction at the constant rate of 15 mm/s (Fig. Q.7). All measurements are in millimeters and seconds. Calculate the magnitudes of the velocity v and acceleration a of pin P when $x = 50$ mm. [5]

8. Under the action of force P, the constant acceleration of block B is 4 m/s^2 to the right (Fig. Q.8). At the instant when velocity of B is 2 m/s to the right, determine the velocity of B relative to A, the acceleration of B relative to A, and the absolute velocity of point C of the cable. [5]

9. The figure shown n spheres of equal mass m suspended in a line by wire of equal length so that the spheres are almost touching each other (Fig. Q.9). If sphere 1 is released from the dotted position and strikes sphere 2 with a velocity v_1, write an expression for the velocity v_n of the nth sphere immediately after it struck by the one adjacent to it. The common coefficient of restitution is e. [5]

10. The simple pendulum A of weight W_A and length l is suspended from the trolley B of weight W_B (Fig. Q.10). If the system is released from rest at $\theta = 0$, determine the velocity v_B of the trolley when $\theta = 90^0$. Friction is negligible. [5]

11. The system is released from rest in the position as shown in Fig. Q.11. Calculate the tension T in the cord and the acceleration a of the 20-kg block. The small pulley attached to the block has negligible mass and friction. [5]

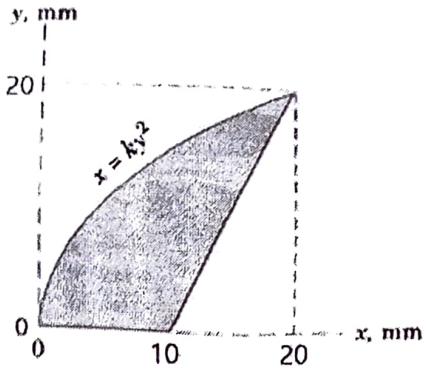

Fig. Q.1

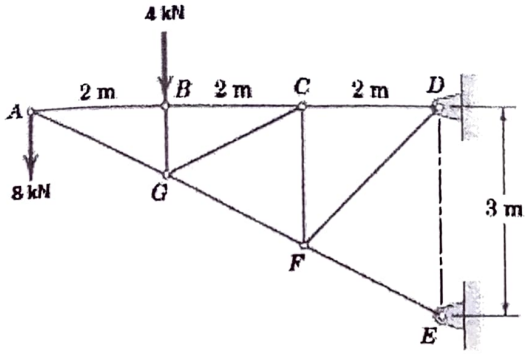

Fig. Q.2

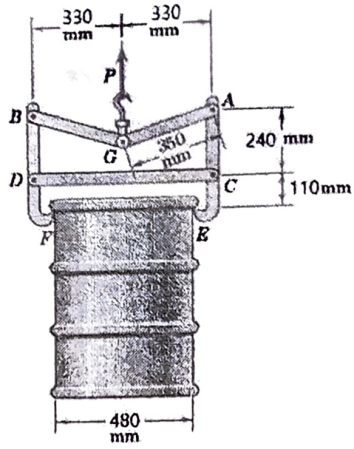

Fig. Q.3

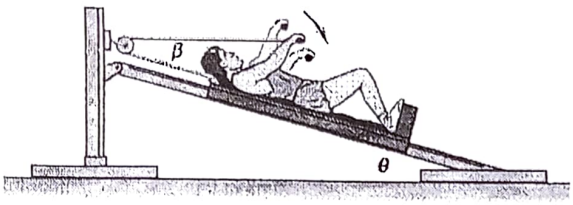

Fig. Q.4

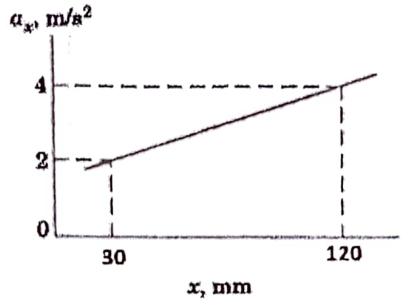

Fig. Q.5

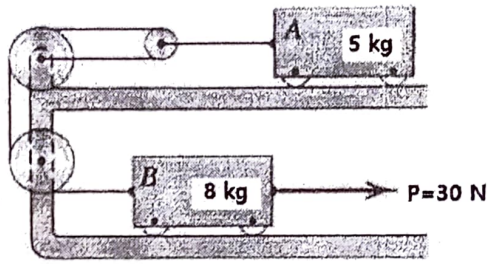

Fig. Q.6

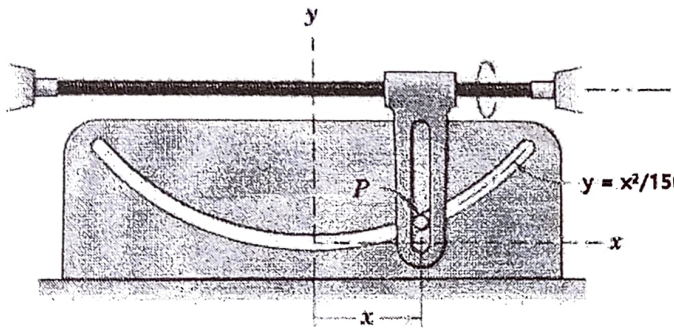

Fig. Q.7

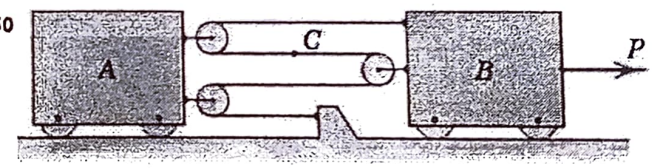

Fig. Q.8

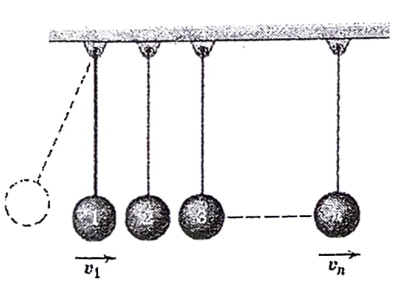

Fig. Q.9

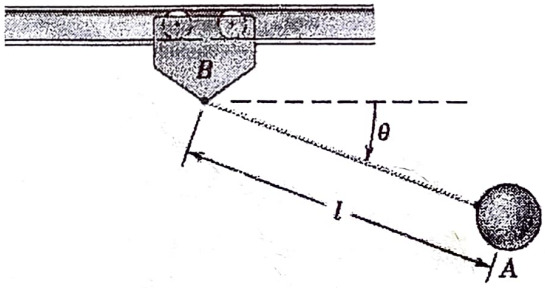

Fig. Q.10

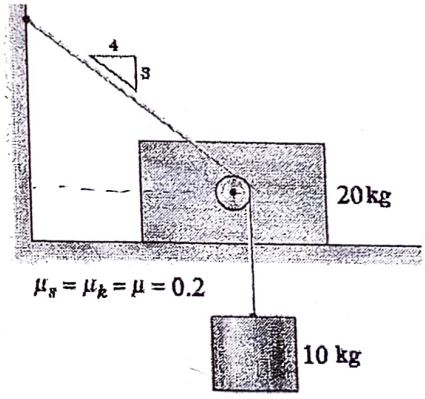

Fig. Q.11