B.E. ELECTRONICS AND TELE-COMMUNICATION ENGINEERING

FIRST YEAR SECOND SEMESTER-2018

Subject: ENGINEERING MECHANICS **Time: Three Hours** **Full Marks: 100**

Attempt all the sections.

The value of the acceleration due to gravity (g) can be taken as 10 m/s^2, if it is not specified.

Any missing information can be assumed suitably with appropriate justification.

Section A *(Answer any two questions from this section)*

1. Replace the two forces acting on the bent pipe as show in **Fig. Q1** by an equivalent force-couple system at the point ***A***. Find the distance from the point ***A*** to the point on y-axis through which the single resultant force (with zero moment) will pass. **[10]**

2. For the right-angle pipe shown in **Fig. Q2**, it is known that the tension in the cable ***BC*** is **750 N**. Replace this tension by an equivalent force-couple system at the point ***O***. **[10]**

3. The **800-N** force applied at point ***A*** of the bracket as shown in **Fig. Q3**. Determine the moment of this force about (i) the point ***B*** and (ii) the line ***BC***. **[10]**

Section B (*Answer any two questions from this section*)

4. The vertical mast as shown in **Fig. Q4** supports **4 kN** force and is constrained by the two fixed cables ***BC*** and ***BD*** and by a ball-and-socket connection at A. Calculate the tension T_1 and T_2 in ***BD*** and in ***BC***. **Draw the necessary free body diagram(s).** **[10]**

5. The coefficient of static friction is **0.40** for all surfaces of contact (as shown in **Fig. Q5**). Determine the smallest force ***P*** needed to start the **30-kg** block moving. Find the corresponding friction forces between two blocks. **Draw the necessary free body diagram(s).** **[10]**

6. For which value of the clockwise couple acting on the member ***BC*** of the frame shown in **Fig. Q6** will the horizontal component of the pin reaction at ***A*** be zero? If the couple of same magnitude were applied in counter clockwise sense, what will the corresponding value of horizontal component of the pin reaction at ***A***? **Draw the necessary free body diagram(s).** **[10]**

Section C. (*Answer any one question from this section*)

7. Find the x- and y-coordinate of the shaded area shown in the **Fig. Q7**. Also find the 2nd moments of the shaded area about x- and y-axes. **[20]**

8. Determine the y-coordinate of the centroid of the shaded area shown in **Fig. Q8**. Also find the 2nd moment of the shaded area about x-axis. **[20]**

Section D. (*Answer any two questions from this section*)

9. A test projectile is fired horizontally into a viscous liquid with a velocity v_0 as shown in **Fig. Q9**. The acceleration of the particle due to drag of the liquid becomes $a = -kv^2$ where v is the instantaneous velocity of the projectile. Derive an expression for the distance D travelled by the projectile in the liquid and the corresponding time required to reduce the velocity to $v_0/2$. Neglect any vertical motion. **[10]**

10. The piston of the hydraulic cylinder gives pin 'A' a constant velocity v = **15 m/s** in the direction shown in **Fig. Q10**, for an interval of its motion. For the instant when θ = **60°**, determine $\dot{r}$, $\ddot{r}$, $\dot{\theta}$ and $\ddot{\theta}$ where $|\bar{r}| = OA$. **[10]**

11. A small particle moving in the x-y plane has a position vector given by $\bar{\mathbf{r}} = \frac{3}{2}t^2\hat{\mathbf{i}} + \frac{2}{3}t^3\hat{\mathbf{j}}$, where $\bar{\mathbf{r}}$ and t are measured in meter and in second, respectively.

(a) Find the magnitudes of the velocity and acceleration of the pin for t = **2 s**.

(b) From the expression of velocity vector at t = **2 s**, determine the unit tangential vector at that instant of time.

(c) Find out the magnitudes of tangential and normal components of acceleration at that instant of time.

(d) Determine the radius of curvature for the path of the pin at that instant of time.

[10]

Section E. (*Answer any one question from this section*)

12. (a) The system shown in **Fig. Q12a** is released from rest with the cable taut. The coefficients of static and kinetic friction between the **60-kg** block and the inclined plane are μ_S = **0.25** and μ_k = **0.20** respectively. Calculate the acceleration of each block and the tension in the cable. **Draw the necessary free body diagram(s).** **[12]**

(b) The **0.8-kg** collar slides freely on the fixed circular rod as shown in **Fig. Q12b**. Calculate the velocity of the collar as it hits the stop ***B*** if it is elevated from rest at ***A*** by the action of the **40-N** force applied in the cord. The cord is guided by small fixed pulley as shown in the figure and the force at its free end maintains a fixed direction. **[8]**

13. (a) The slotted arm as shown in **Fig. Q13a** revolves **in the horizontal plane about the fixed vertical axis through point *O***. The **2-kg** slider ***P*** is drawn towards ***O*** at the constant rate of **50 mm/s** by pulling the cord ***S***. At the instant for which r = **225 mm**, the arm rotates at a rate **6 rad/s** in **counterclockwise** direction, which is slowing down at a rate **2 rad/s^2**. For this instant of time determine the tension in the cord and the magnitude of the reaction force exerted on the slider by the smooth walls of the radial slot. **Draw the necessary free-body diagram(s).** **[10]**

(b) The **9-kg** block is moving to the right with a velocity of v_0 = **0.6 m/s** on a horizontal surface when a force P is applied to it at time t = 0 as shown in **Fig. Q13b**. Calculate the velocity v of the block when t = **0.4 s**. The coefficient of kinetic friction is μ_k = **0.30**. **Draw the necessary free-body diagram(s). [10]**

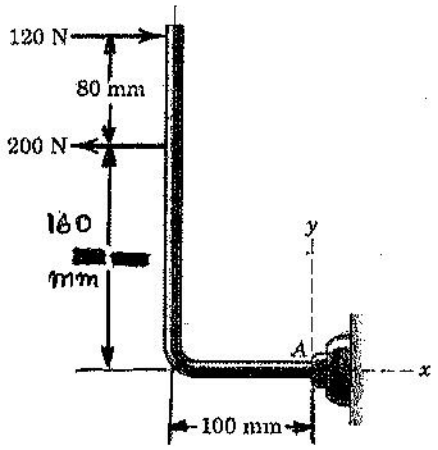


Fig. Q1

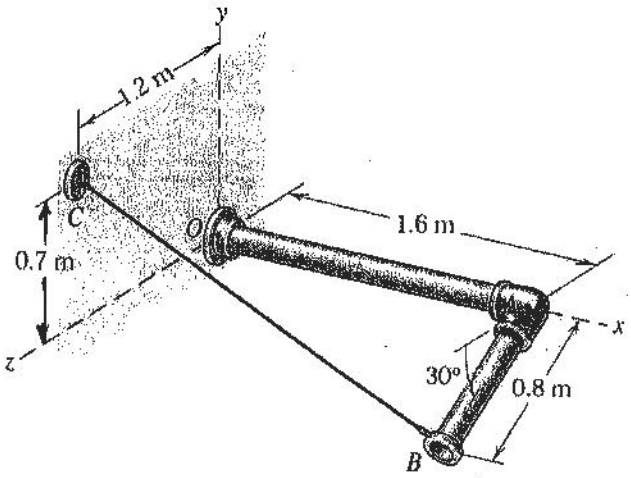


Fig. Q2

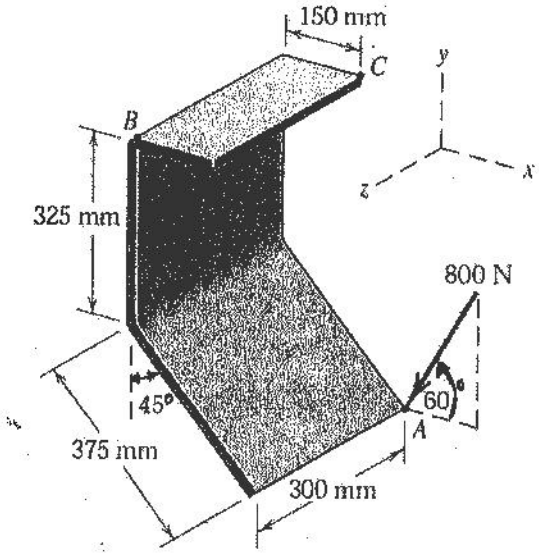


Fig. Q3

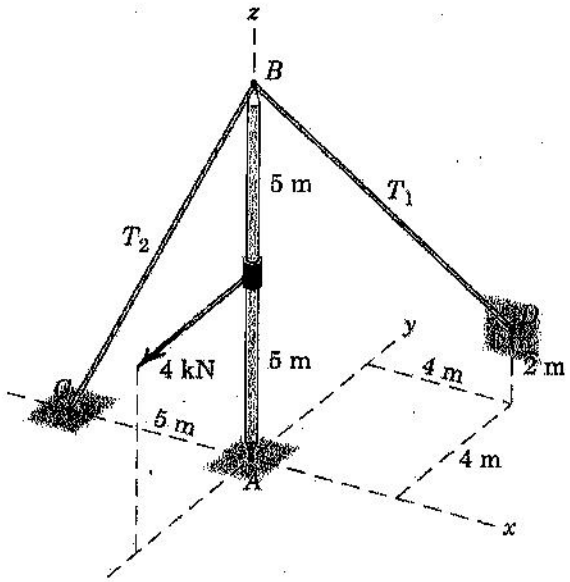


Fig. Q4

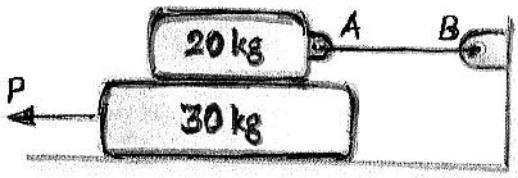


Fig. Q5

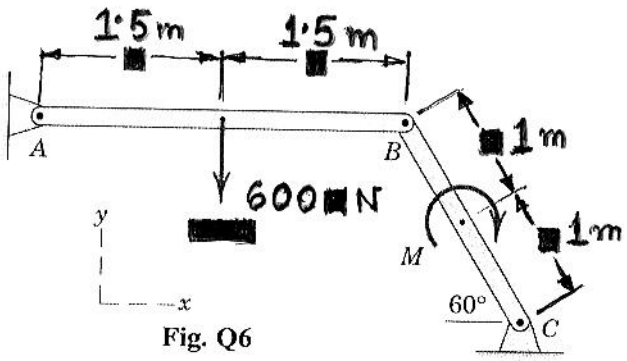


Fig. Q6

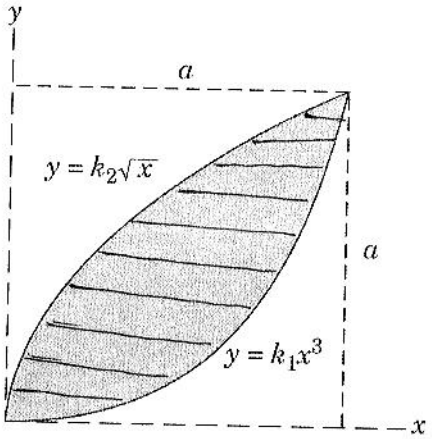


Fig. Q7

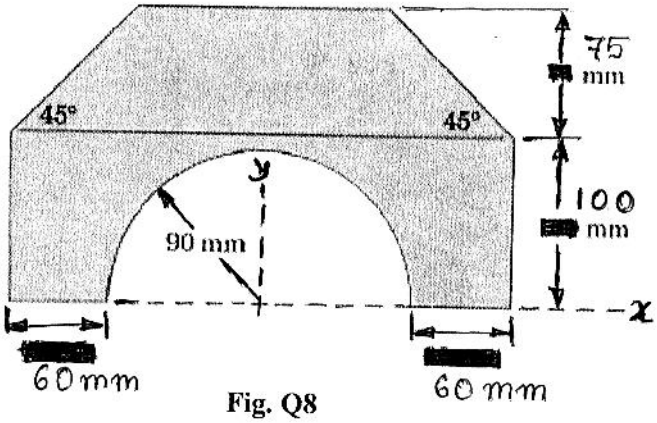


Fig. Q8

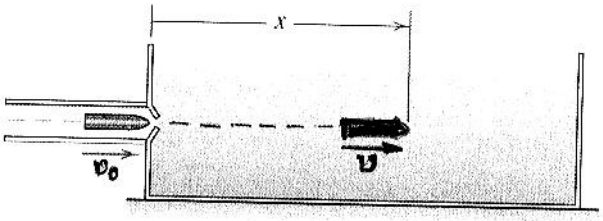


Fig. Q9

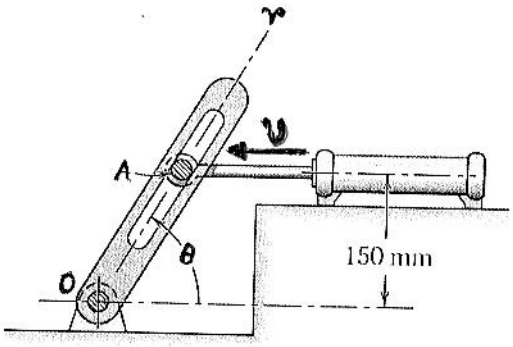


Fig. Q10

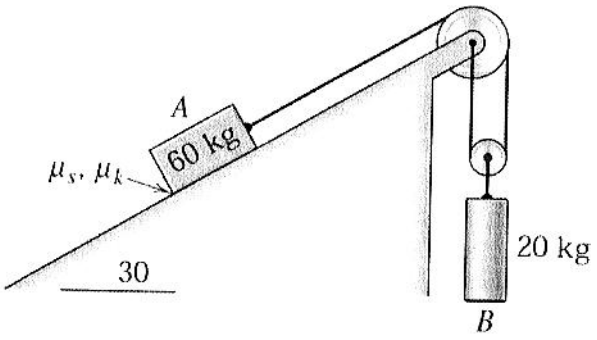


Fig. Q12a

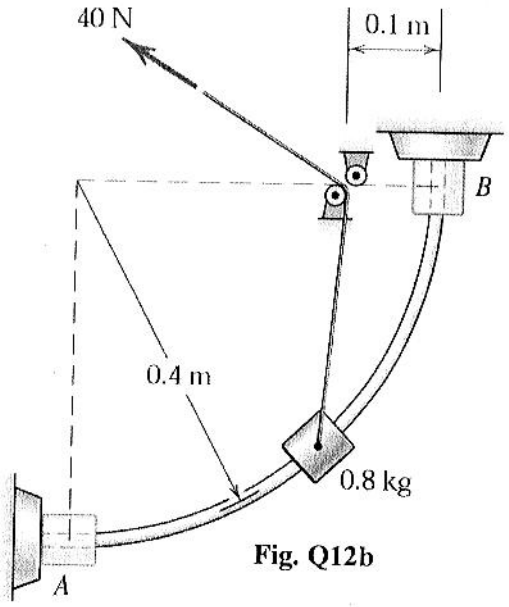


Fig. Q12b

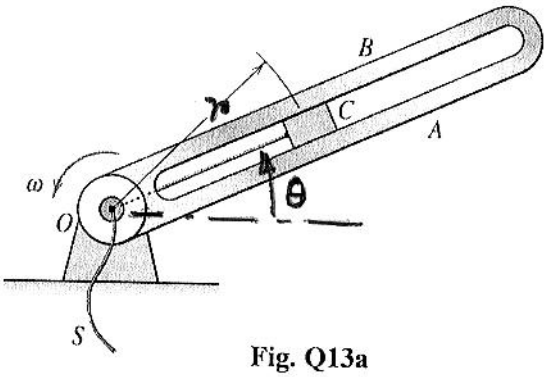
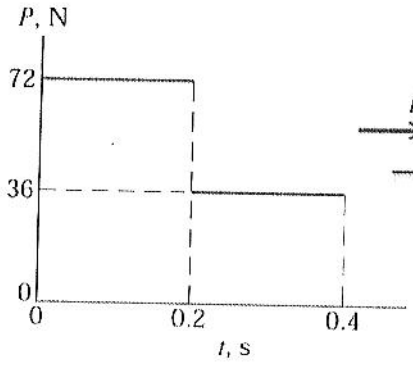


Fig. Q13a



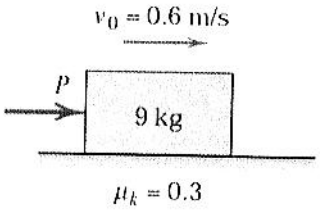


Fig. Q13b