**Ref. No. : Ex/ET/AM/ME/T/1B/125/2017**

**B.E. ELECTRONICS AND TELE-COMMUNICATION ENGINEERING**

**FIRST YEAR 2ND SEMESTER EXAMINATION-2017**

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

***Answer Question No. 1 (compulsory) and any seven from the rest.***

***Value of ' g ' (acceleration due to gravity) may be taken as 10 $m/s^2$, if it is not specified.***

***Any missing data may be suitably assumed.***

1. (a) Write the expression of moment of the force $F$ about point '$O$' and '$A$' respectively as shown in the **Fig. Q1a**. [2]

(b) If a general three-dimensional force system is reduced to a wrench resultant at a point, the angle between the direction of the resultant moment vector and that of the resultant force vector is ____________. (Fill up the blank with appropriate answer.) [1]

(c) A power screw has a lead of **5 mm** and mean diameter of the thread **25 mm**. The coefficient of static friction in the thread is **0.20**. What is the helix angle for the screw? State if the screw is self-locking or overhauling. [2]

(d) A triangle with a base of length $b$ and height $h$, has a second moment of area about its base equal to ____________ and that about an axis parallel to the base and passing through its centroid equal to ____________. (Fill up the blank with appropriate answer.) [2]

(e) In polar ( $r-\theta$ ) coordinate system the expression of radial and transverse components of acceleration are ____________ and ____________ respectively. (Fill up the blank with appropriate answer.) [2]

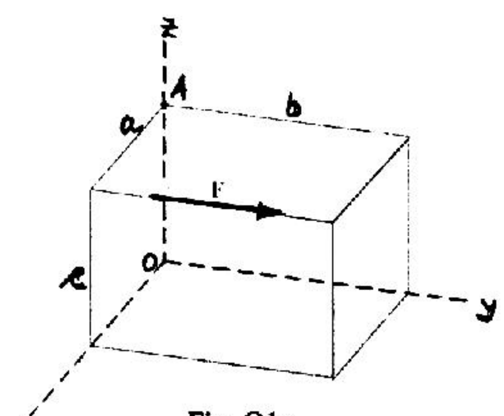


**Fig. Q1a**

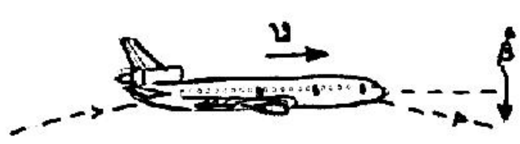


**Fig. Q1f**

(f) An airplane travelling at a speed $v$ negotiates a curved path in the vertical plane, where the acceleration due to gravity is $g$ as shown in **Fig. Q1f**. At what rate $\dot{\beta}$ should the pilot drop the longitudinal line of sight to achieve the condition of weightlessness at the top of the curve? [2]

[ Turn over

(g) The ball is released from position $A$ with a velocity of **3 m/s** and swings in a vertical plane as shown in **Fig. Q1g**. At the bottommost position of the ball, the cord wraps around a fixed bar at $B$, and the ball continues to swing in the dotted arc. What will be the velocity of the ball as it passes through the position $C$? **[2]**

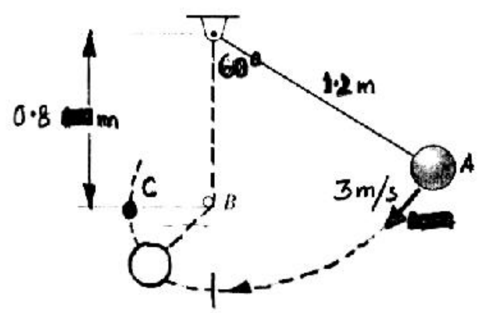


**Fig. Q1g**

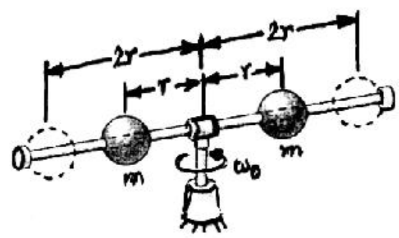


**Fig. Q1h**

(h) The two spheres of equal mass $m$ are able to slide along the horizontal rotating rod as shown in **Fig. Q1h**. If they are initially latched in position at a distance $r$ from the axis of rotation with the assembly rotating freely with an angular velocity $\omega_0$, what will be the new angular velocity $\omega$ after the spheres are released and finally assumes positions at the ends of the rod at a radial distance of $2r$. What will be the percentage of kinetic energy of the system lost in this process? **[3]**

2. For the loading shown in the **Fig. Q2**, determine the equivalent force and the moment about the point $A$. Also, determine the point on the $x$-axis through which the **equivalent single resultant force** will act. **[12]**

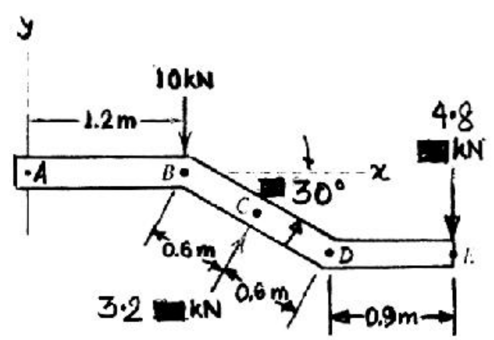


**Fig. Q2**

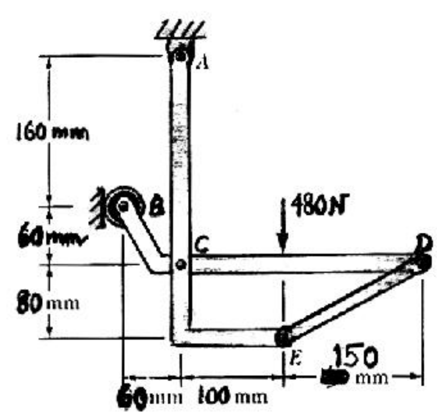


**Fig. Q3**

3. Two rigid members $ACE$ and $BCD$ of the frame in **Fig. Q3** are connected by a pin at $C$ and by the link $DE$. For the loading shown, find out the reactions at supports $A$ and $B$, determine the force in link $DE$ and the components of the force exerted at $C$ on member $BCD$. **Draw the necessary free-body diagram(s).** **[12]**

4. For the boom shown in **Fig. Q4** self-weight is negligible compared to the applied **30-kN** load. Determine the tensions $T_1$ and $T_2$ in the cables and the components of the reaction force acting at the ball and socket joint at $A$. **Draw the necessary free-body diagram(s).** **[12]**

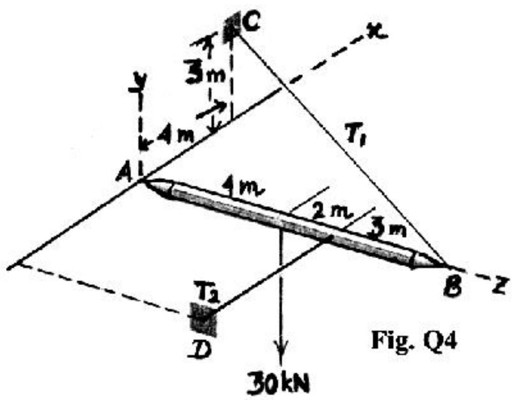


Fig. Q4

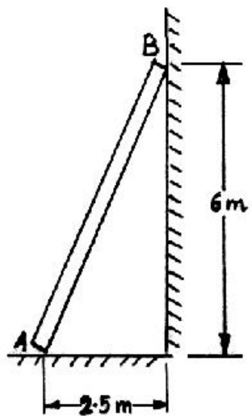


Fig. Q5

5. A **6.5-m** ladder $AB$ of mass **10 kg** leans against a vertical wall as shown in **Fig. Q5**. Assuming that the coefficient of static friction $\mu_S$ is same at both surfaces of contact, determine the smallest value of $\mu_S$ for which equilibrium can be maintained. **Draw the necessary free-body diagram.** **[12]**

6. Determine the moments of inertia of the shaded area shown in **Fig. Q6** about $x$- and $y$-axes. **[12]**

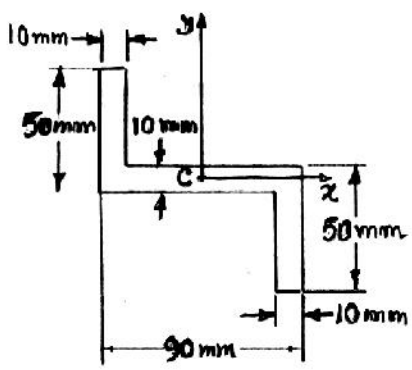


Fig. Q6

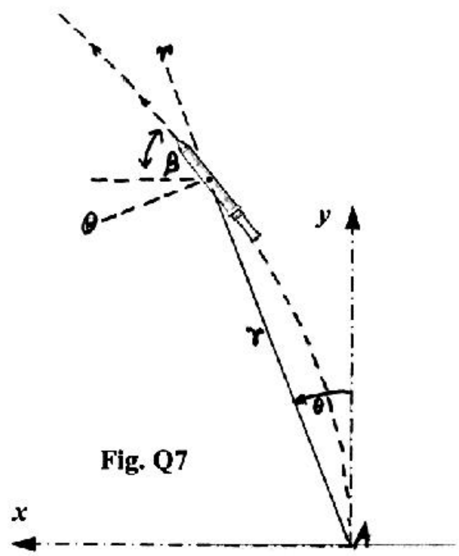


Fig. Q7

7. A rocket is tracked by radar from its launching point at $A$ as shown in **Fig. Q7**. When it is **10 seconds** into its flight, the following radar measurements are recorded: $\boldsymbol{r}$ = **2200 m**, $\dot{r}$ = **500 m/s**, $\ddot{r}$ = **4.66 m/s²**, $\theta$ = **22°**, $\dot{\theta}$ = **0.0788 rad/s** and $\ddot{\theta}$ = **-0.0341 rad/s²**. For this instant determine the angle $\beta$ between the horizontal and the direction of the trajectory of the rocket. Also determine the magnitudes of velocity and acceleration. Also find the unit vector along the direction of the resultant acceleration vector in terms of unit vectors along $x$ and $y$- directions as shown. **[12]**

8. The $x$- and $y$-motions of guides $A$ and $B$ with right-angle slots control the curvilinear motion of the connecting pin $P$, which slides in both slots as shown in **Fig. Q8**. For a short interval, the motions are governed by $x = 20 + \frac{t^2}{4}$ and $y = 15 - \frac{t^3}{6}$, where $x$ and $y$ are in **mm** and $t$ is in **second**.

(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.

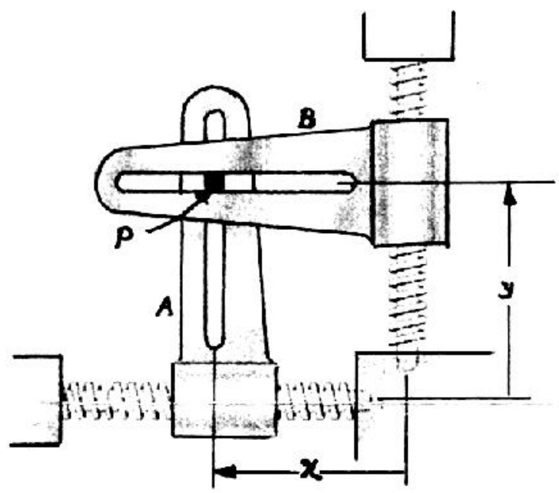

**Fig. Q8**

(d) Determine the radius of curvature for the path of the pin at that instant of time. **[4+2+4+2]**

9. For the system shown in **Fig. Q9**, determine the acceleration of bodies $A$ and $B$ if they are released from rest. Also find out the tension in the connecting cable. Neglect friction and mass of the pulleys. **Draw the necessary free-body diagram(s).** **[12]**

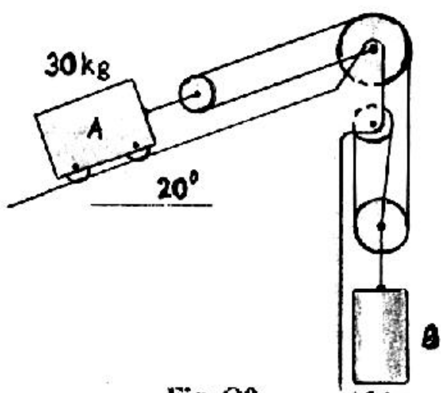

**Fig. Q9**

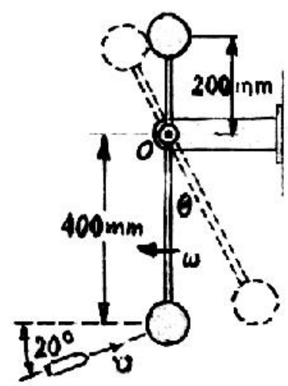

**Fig. Q10**

10. A pendulum consists of two **3.2-kg** concentrated masses on a light but rigid rod as shown in **Fig. Q10**. The pendulum is swinging through the vertical position with a clockwise angular velocity $\omega = 6$ **rad/s** when a **0.05-kg** bullet, travelling with velocity $v = 300$ **m/s** in the direction shown strikes the lower mass and becomes embedded on it. Calculate the angular velocity of the pendulum immediately after the impact and find the maximum angular deflection of the pendulum from the vertical position.

**[12]**