EX/ME(M2)/PC/B/T/212/2024

BME-Second Year, First Semester Examination, 2024

Engineering Dynamics

Full Marks: 100 **Time: 3.0 Hours**

[*Assume any missing data with proper justifications*]

Group A [Answer any Six (6) Questions] **6×10=60**

1) Find the time derivatives of unit vectors in radial and cross-radial directions and hence deduce the expression of acceleration in polar co-ordinates.

2) Refer **Fig Q2**. The slotted arm **OA** oscillates about **O** within the limits shown and drives the crank **CP** through the pin **P**. For an interval of the motion, $\dot{\theta} = K$ a constant. For this interval, show that the magnitude of the velocity of **P** is a constant. Also determine the acceleration of the particle. Use polar co-ordinates.

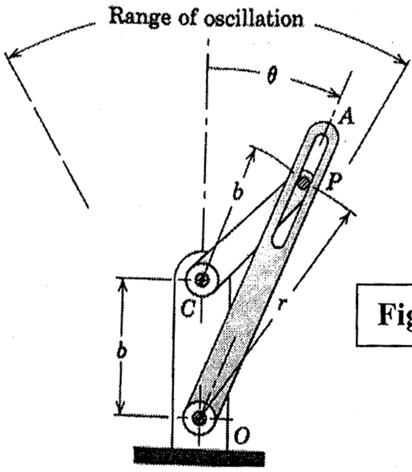


Fig Q2

3) Refer **Fig Q3**. A particle **P** moving in plane curvilinear motion is located by the polar co-ordinates shown. At a particular instant, following data are noted:

$r = 2m, \theta = 60^0, v_r = 3m/s, v_\theta = 4m/s, a_r = -10m/s^2, a_\theta = -5m/s^2$. For this instant calculate the radius of curvature of the particle. Use path co-ordinates.

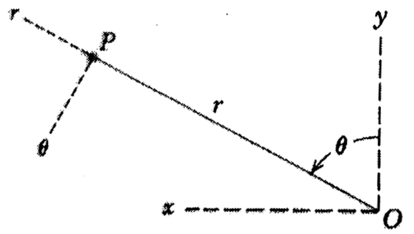
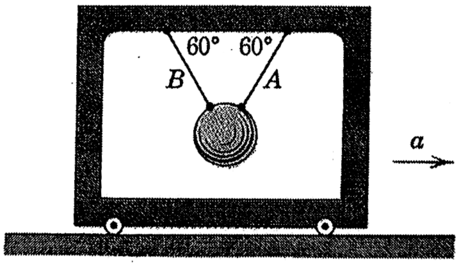


Fig Q3

[Turn over

4) Define inertial frame in the light of Newton's law. Write equation of motion in non-inertial frame and hence solve the following problem. Refer **Fig Q4**. The steel ball is suspended from the accelerating frame by two cords **A** and **B**. Determine the acceleration of the frame which will cause the tension in **A** to be **twice** that in **B**.

Fig Q4



5) A stretch of highway includes a succession of evenly spaced dips and humps, the contour of which may be represented by the relation $y = b\sin\left(\frac{2\pi x}{L}\right)$. What is the maximum speed at which the car **A** (of mass m) can go over a hump and still maintain contact with the road? It the car maintains this critical speed, what is the total normal reaction under its wheels at the bottom of the dip? Use path c

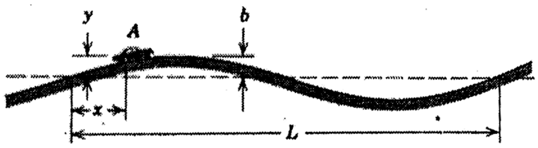


Fig Q5

6) The mechanism consists of three small cylinders each of mass M connected by the light hinged bars. Each of the two springs has a stiffness K and is unstretched in the initial position shown. If the mechanism is released from rest at this position, determine the expression for the maximum downward movement y of the lower cylinder. Refer **FigQ6**.

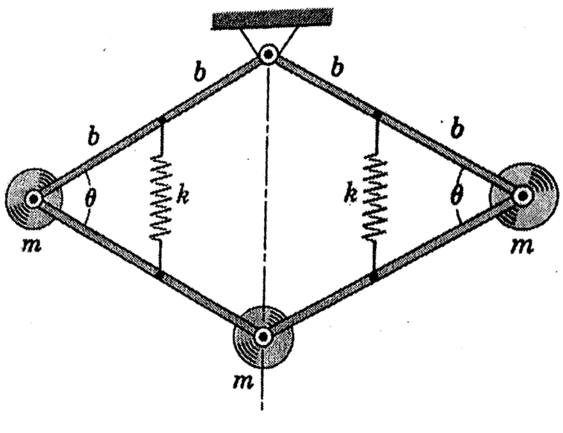


Fig Q6

7) For a system of particles, prove the angular momentum theorem in relative form –

$$\sum \vec{M}_A = \frac{d\left(\vec{H}_{rel}\right)_A}{dt} + m\vec{\rho}_{G/A} \times \vec{a}_A . \text{ When is } \frac{d\left(\vec{H}_{rel}\right)_A}{dt} = \sum \vec{M}_A \text{ ?}$$

Here **G** denotes the center of mass of the system and other notations are used in their common senses.

8) Refer **FigQ8**. Determine the angular velocity of the link **AB** in terms of the angle θ and angular velocity ω_0 of the link **OA** assumed constant. Use **absolute motion** method.

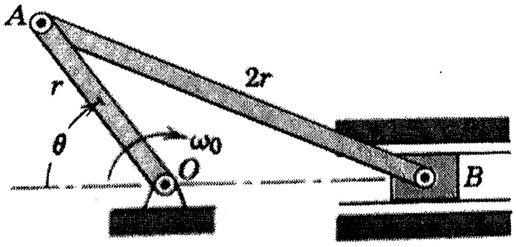


Fig Q8

Group B [Answer any Two (2) Questions] **2×20=40**

9) Fig shows a quick return mechanism. If the driving crank **OA** has a constant angular velocity of **3 rad/s**, determine the velocity of point **B** for the instant θ=**30⁰**. Refer **FigQ9**

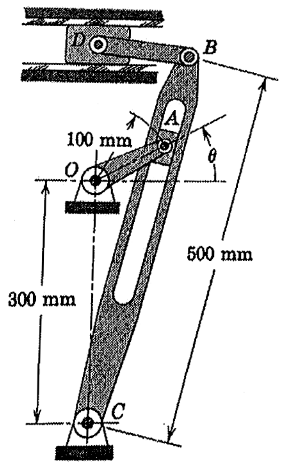


Fig Q9

10) Refer **FigQ10**. The parallel links **OE** and **CD** are given a constant counter clockwise angular acceleration of **10** rad/s^2 by the torque M. As the angle θ reaches 60^0, the angular velocity of the links is $\dot{\theta} = 4\, rad\,/\,s$. Specify the nature of motion of the vertical bar. For this instant calculate the moment at the weld **A**. The vertical bar has a mass of **2.4 kg**.

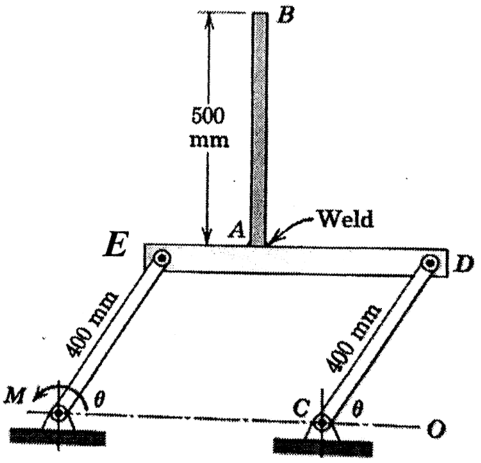
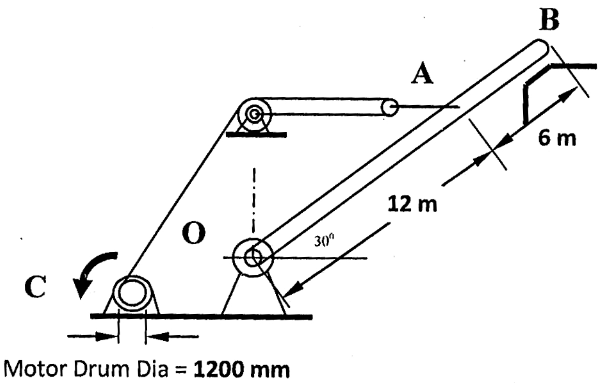


Fig Q10

11) The uniform **18 m** mast has a mass of **300 kg** and is hinged at its lower end to a fixed support at **O**. If the winch **C** develops a starting torque of **1300 Nm,** calculate the total force supported by the pin at **O** as the mast begins to lift off its support at **B**. Also find the corresponding angular acceleration of the mast. The cable at A is horizontal, and the mass of the pulleys and winch is negligible. Refer **FigQ11**

Fig Q11



12) Refer **FigQ12**. The circular disk of **200 mm** radius has a mass of **25 kg** and centroidal radius of gyration of **175 mm** and has a concentric circular groove of **75 mm** radius cut into it. If a steady horizontal force of **20 N** is applied to a cord wrapped around the groove as shown, find the angular acceleration of the disk and the acceleration of the center of the disk as it starts from rest. The coefficient of friction between the disk and the horizontal surface is **0.10**.

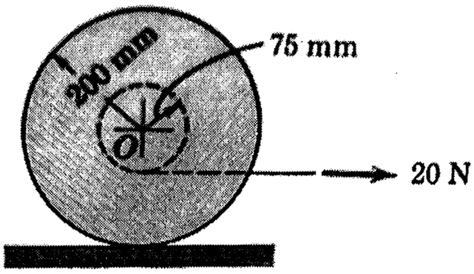


Fig Q12

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