Ref No.Ex/PG/ME/T/116J/2025

M.E. MECHANICAL ENGINEERING FIRST YEAR FIRST SEMESTER EXAM 2025

Subject: Advanced Dynamics

Full Marks – 100

Answer all questions

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1) Prove that - $\frac{d\hat{\varepsilon}}{du} = \frac{d\theta}{du}\,\hat{n}$ (10)

   Hence obtain $\dot{\hat{\varepsilon}}_\theta$

2) Prove that - $a_\theta = r\ddot{\theta} + 2\dot{r}\dot{\theta}$ (10)

3) Define Conservative force.
   What is the test of whether a force is conservative. Prove the validity of the test.
   Prove that for conservative force, Work is independent of the path. (10)

4) Prove that $\bar{a}_B = \bar{a}_A + \bar{\omega} \times (\bar{\omega} \times \bar{\rho}) + \bar{\alpha} \times \bar{\rho}$ (10)

5) The 4-kg slider is released from rest at *A* and slides with negligible friction down the circular rod in the vertical plane. Determine (*a*) the velocity *v* of the slider as it reaches the bottom at *B* and (*b*) the maximum deformation *x* of the spring. (10)

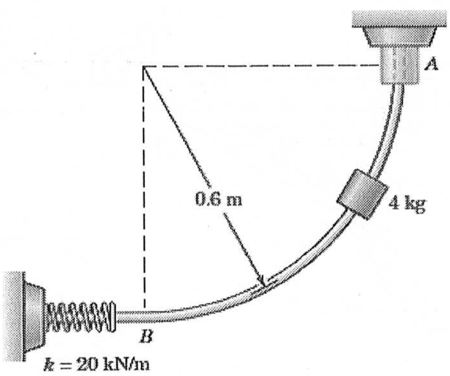

Figure Q5

[Turn over

Q6. Figure Q6 shows a block of mass m_1 moving on a frictionless surface. A particle of mass m_2 is connected to the block by a mass-less rigid link. The pin joint between the block and the link is frictionless.

Using the shown generalized coordinates derive the equations of motion using virtual work principle. (10)

Construct the partial velocity table, active force table and inertia force table (10)

Derive the equations of motion using Kane's method (5)

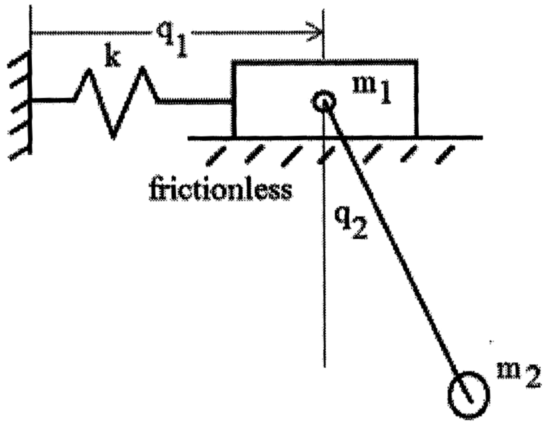

Figure Q6

Q7. Figure Q7 shows 2 rigid uniform links executing plane motion. The first link is hinged to the ground. The second link is joined to the first one using a revolute joint. Starting from the shifter matrix, derive the equations of motion in the following form:-

$$[M]\{\ddot{q}\} = \{f\}$$

Write down the constraint equation. How can you augment the equations of motion for incorporating the constraint using Lagrange multiplier? (25)