B.E. MECHANICAL ENGINEERING SECOND YEAR SECOND SEMESTER EXAM 2025

SUBJECT: ADVANCED ENGINEERING MECHANICS

FULL MARKS 100

ANSWER ANY FIVE QUESTIONS. ALL QUESTIONS CARRY EQUAL MARKS

Assume appropriate value for any missing data

Question 1

The 100 mm-radius wheel has a mass of 3kg and turns about the Y'axis with and angular velocity $p = 40\pi\ rad/s$ in the direction shown. Simultaneously the fork rotates about inertial X axis with an angular velocity $\omega = 10\pi\ rad/s$ as indicated in Figure Q1. A point A is fixed to the disc.

The $X'Y'Z'$ frame is fixed to the fork.

Find velocity and acceleration of point A using the generalized kinematic equations and the frames XYZ (inertial) and $X'Y'Z'$

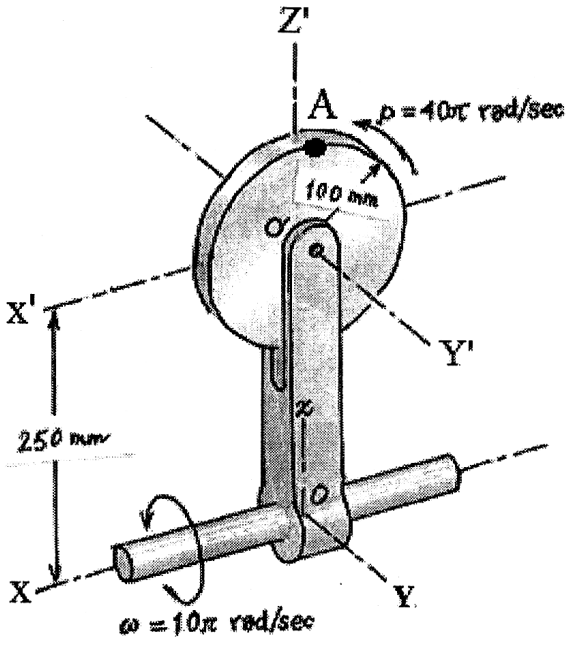

Figure Q1

Question 2

Sketch Euler angles and show their derivatives in a neatly drawn figure.

Treating the derivatives of Euler angles as vectors find out their components in the body-fixed frame

The spacecraft shown in Figure Q2 has a mass m with mass centre G. Its radius of gyration about it's z-axis of rotational symmetry is k and that about either the x −axis or y −axis is k'. In space, the spacecraft spins about z-axis at the rate p. Simultaneously, a point C on the z-axis precesses in a circle about the z_0-axis, fixed in space, with a frequency f (rotations per second). Determine the angular momentum $\bar{H}_G$ of the spacecraft with respect to xyz axes.

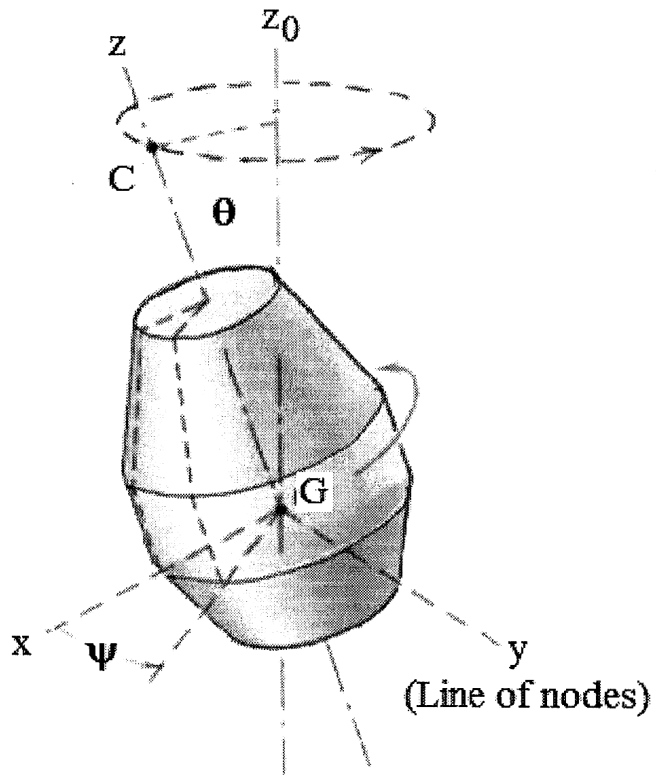

Figure Q2

Question 3

Refer Figure Q3. The thin solid circular disc of radius 'r' and mass 'm' rolls on the horizontal plane without slipping in a circle of radius 'b'. The centre line OC of the disc rotates about OZ with angular velocity 'ω'. Determine the angular momentum about point O.

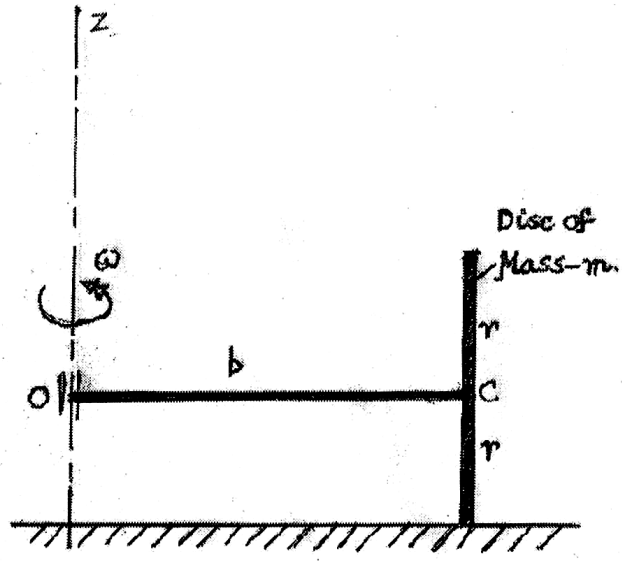

Fig-Q3

Question 4

a. A two- element steel truss is shown in Figure Q4a. The cross-sectional area of the two elements is identical. Find out the vertical and horizontal deflection at A. **Use Castigliano's theorem.**

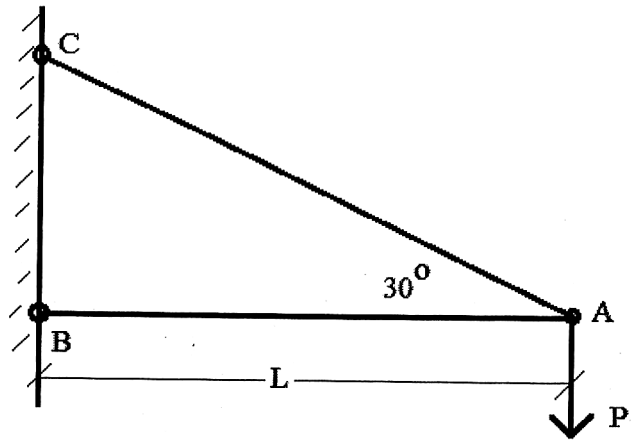

Figure Q4a

b. A thin semi-circular arch ring of mean radius R (Figure Q4b) is loaded by a concentrated force P at it's crown C. The arch is supported by pin joints at two unyielding supports at A and B. Find out the support reactions. **Use Castigliano's theorem.**

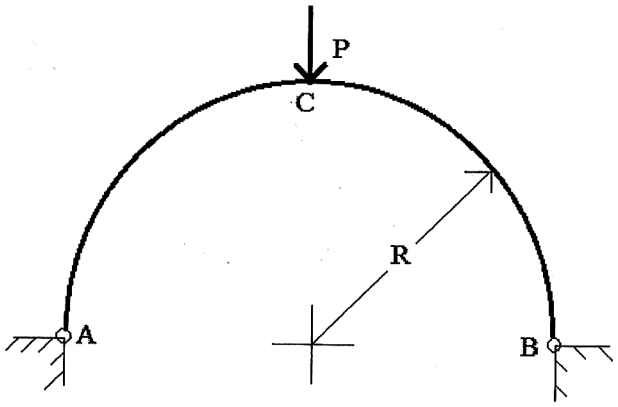

Figure Q4b

Question 5

a. Figure Q5a shows a propped cantilever loaded by two concentrated loads P and 2P at B and C respectively. Calculate the support reaction at D in terms of P. Take bending rigidity of the beam EI. **Use method of superposition.**
(For a cantilever loaded by a concentrated load at the free end, the deflection and slope at the free end are $(Pl\text{^}3)/3EI$ and $(Pl\text{^}2)/2EI$ respectively)

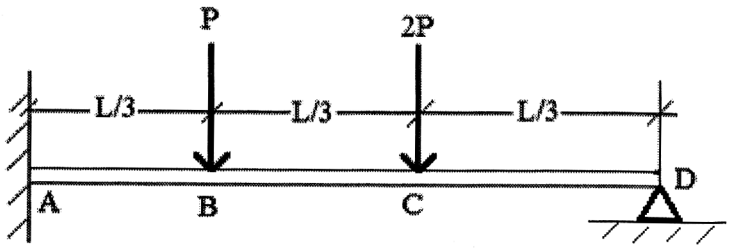

Figure Q5a

b. A cantilever steel beam is built-in at A and is supported at B by a vertical steel tie-rod BC as shown in Figure Q5b. The tie-rod is just taut but without any initial tension. Find the tension in the tie-rod after a load P is applied at B. The bending rigidity of the beam is EI and the tension rigidity of the tie-rod is AE. **Use method of superposition.**

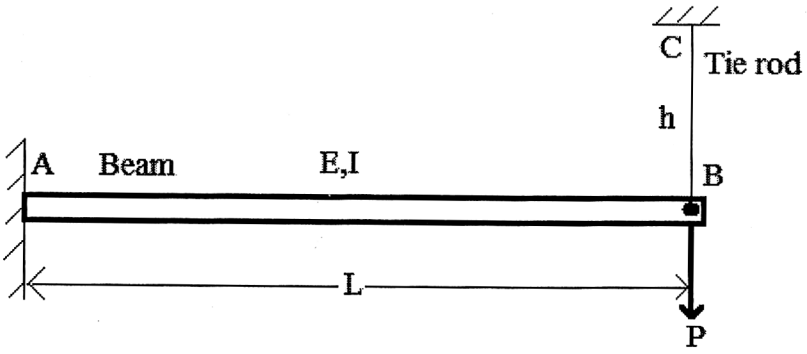

Figure Q5b

Question 6

A state of plain strain in a steel plate is defined by the following data

$\epsilon_x = 500\ \mu\epsilon, \epsilon_x = 100\ \mu\epsilon,\ \gamma_{xy} = 350\ \mu\epsilon,$

Find out the magnitudes and directions of principal strains. Draw Mohr's circle in a graph paper.