University of Nottingham
Department of Mechanical Engineering

MM2MS3 Mechanics of Solids 3
Exercise Sheet 6 – Strain Energy Methods

1. Using strain energy, derive an expression for the end deflection of the cantilever beam shown in Fig Q1. I = Second Moment of Area of cross-section and E = Young's Modulus of the beam.

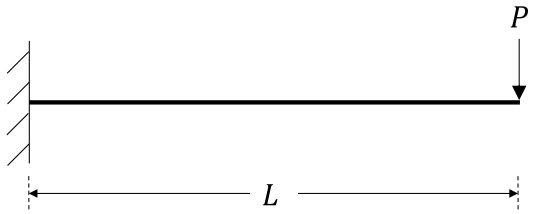
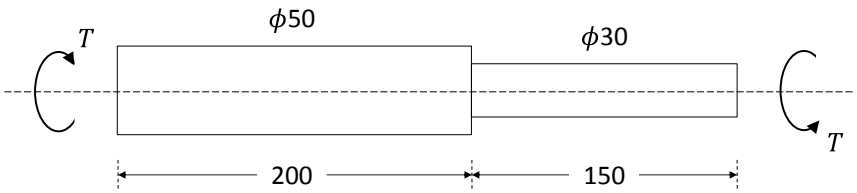


Fig Q1

[Ans: $\boldsymbol{u_v = \frac{PL^3}{3EI}}$***]***

2. The stepped steel shaft shown in Fig Q2 carries a uniform torque of 500Nm. Determine the total torsional strain energy stored in the shaft. Assume G_{steel} = 70GPa.



All dimensions in mm

Fig Q2

[Ans: 3.95J]

University of Nottingham
Department of Mechanical Engineering

MM2MS3 Mechanics of Solids 3
Exercise Sheet 6 – Strain Energy Methods

3. Using strain energy, derive an expression for the deflection at the load point of the beam shown in Fig Q3.

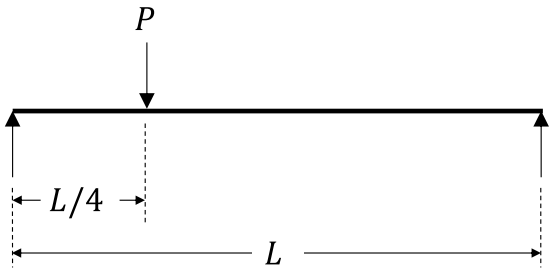
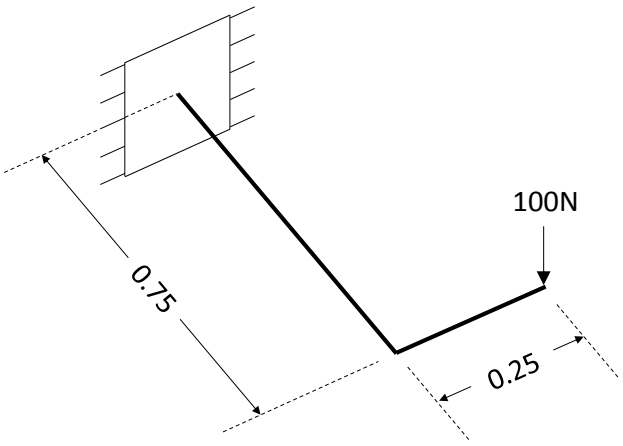


Fig Q3

[Ans: $\frac{9PL^3}{768EI}$***]***

4. Calculate the deflection beneath the force for the cantilevered bracket shown in Fig Q4. The bar is circular in cross section with a diameter, ϕ of 20mm, a Young's Modulus, E of 200GPa and a Shear Modulus, G of 80GPa.



All dimensions in meters

Fig Q4

[Ans: 13mm]

University of Nottingham
Department of Mechanical Engineering

MM2MS3 Mechanics of Solids 3
Exercise Sheet 6 – Strain Energy Methods

5. Derive an expression for the increase in distance between the ends A and D of a thin bar of uniform cross-section consisting of a semi-circular portion BC and two straight portions AB and CD as shown in Fig Q5.

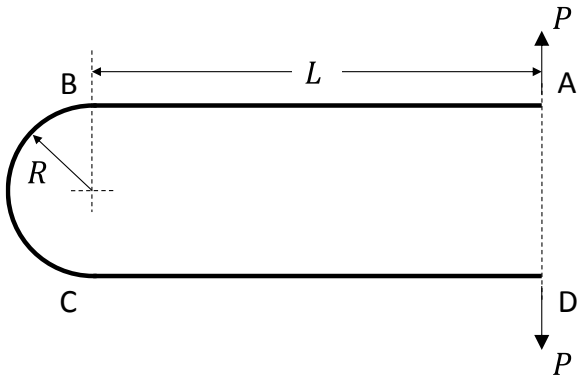


Fig Q5

If the bar is of diameter 6mm, R is 40mm and is to have a spring stiffness, P/δ of 100kg/m, show that the necessary length for L, is approximately 210mm. The bar is made from mild steel with Young's modulus, E = 210GPa.

6. Considering the effect of the bending only, determine the horizontal deflection of the point A of the frame shown in Fig Q6 due to the force P.

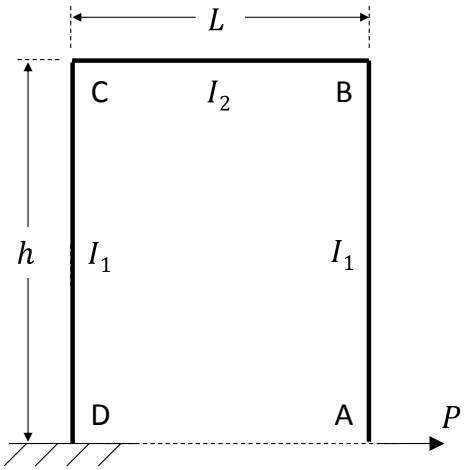


Fig Q6

[Ans: $\frac{Ph^2}{E}\left(\frac{2h}{3I_1}+\frac{L}{I_2}\right)$***]***

University of Nottingham
Department of Mechanical Engineering

MM2MS3 Mechanics of Solids 3
Exercise Sheet 6 – Strain Energy Methods

7. The cranked rod ABCD in Fig Q7 is built-in at end A and carries a transverse force P, perpendicular to the plane ABCD at D. Assuming that the rod is made from round bar of uniform section, obtain (a) the deflection of D in the direction of P and (b) the angular rotation of the end D about axis CD.

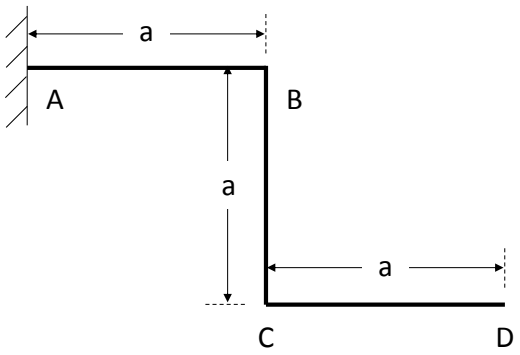


Fig Q7

[Ans: $\frac{Pa^3\left(3+\frac{E}{G}\right)}{EI}$, $\frac{Pa^2\left(1+\frac{E}{G}\right)}{2EI}$***]***