MACHAKOS UNIVERSITY

University Examinations 2018/2019

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF MECHANICAL AND MANUFACTURING ENGINEERING

THIRD YEAR SPECIAL/SUPPLEMENTARY EXAMINATION FOR

BACHELOR OF SCIENCE IN MECHANICAL ENGINEERING

EMM 303: SOLID AND STRUCTURAL MECHANICS II

DATE: 23/7/2019 **TIME: 11.00-1.00 pm**

INSTRUCTIONS:

Answer Question One and Any Other Two Questions

All symbols have usual meaning unless otherwise stated

Use **CLEAR**, **NEAT** and **WELL-LABELLED** sketches

QUESTION ONE (30 MARKS)

a) The method of solution for compound cylinders constructed from similar materials involves breaking down the problem into three separate effects. Using well labelled diagrams, illustrate the three effects then show how each boundary condition can be obtained. (10 marks)

b) A thick cylinder of 100 mm internal radius and 150 mm external radius is subjected to an internal pressure of 60 MNm^{-2} and an external pressure of 30 MNm^{-2}.

i. Sketch the cylinder (1 mark)

ii. Determine the hoop and radial stresses at the inside and outside of the cylinder and calculate the longitudinal stress acting on the cylinder. Assume the cylinder has closed ends. (5 marks)

c) A compound cylinder is formed by shrinking a tube of 250 mm internal diameter and 25 mm wall thickness onto another tube of 250 mm external diameter and 25 mm wall thickness, both tubes being made of the same material. The stress set up at the junction

owing to shrinkage is $10\ \text{MNm}^{-2}$. The compound tube is then subjected to an internal pressure of $80\ \text{MNm}^{-2}$.Compare the hoop stress distribution now obtained with that of a single cylinder of 300 mm external diameter and 50 mm thickness subjected to the same internal pressure. (8 marks)

d) The beam shown in Fig. Q 1 (d) is loaded with a combination of concentrated and uniformly distributed loads. Suppose the point of inflection occurs between C and D, find its location from point C. (6 marks)

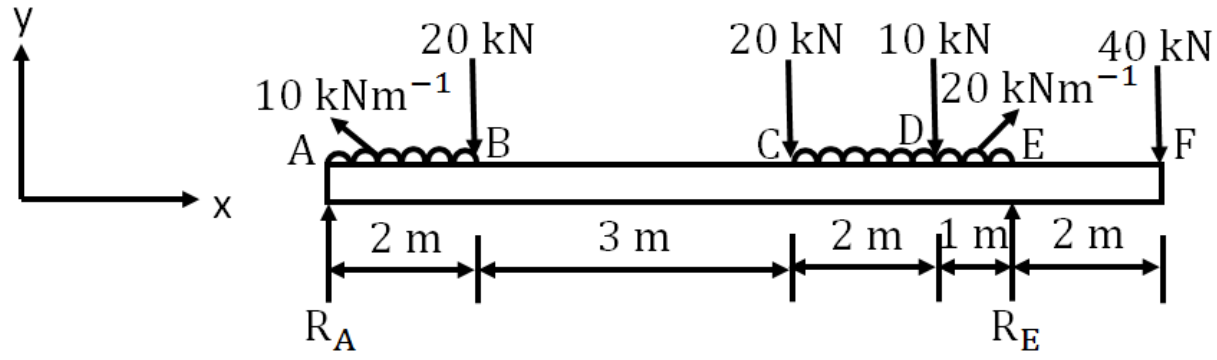


Fig. Q 1 (d)

QUESTION TWO (20 MARKS)

a) With the aid of a well labelled diagram, show that the tensile hoop stress set up in a thin rotating ring or cylinder is given by:

$$\sigma_H = \rho\omega^2 r^2$$ (5 marks)

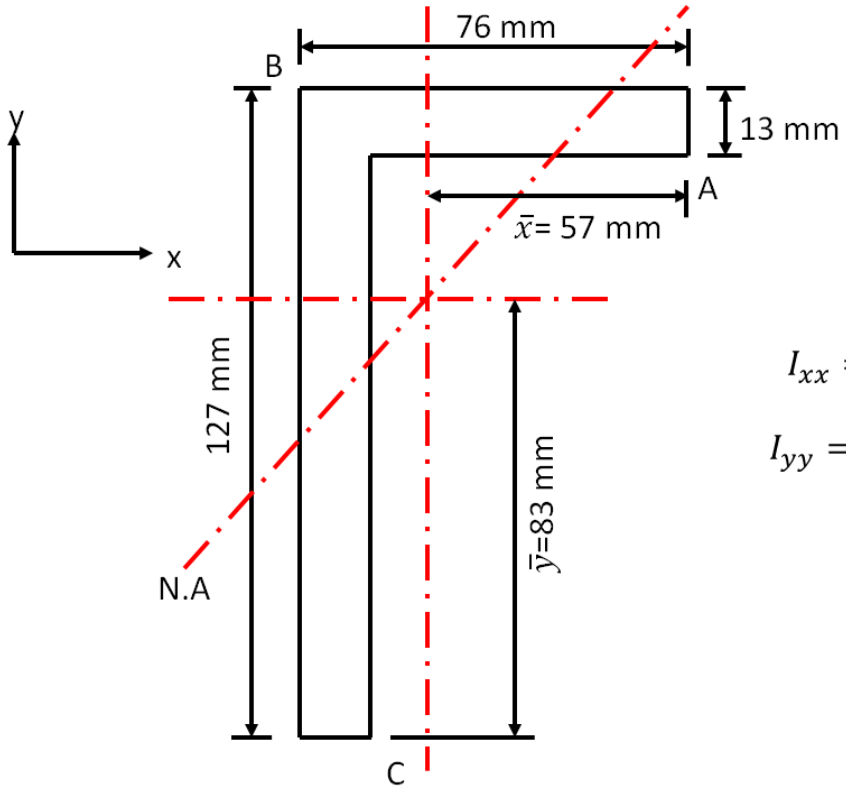
b) A steel rotor disc which is part of a turbine assembly has a uniform thickness of 40 mm. The disc has an outer diameter of 600 mm and a central hole of 100 mm diameter. If there are 200 blades each of mass 0.153 kg pitched evenly around the periphery of the disc at an effective radius of 320 mm, determine the rotational speed at which yielding of the disc first occurs according to the maximum shear stress criterion of elastic failure. State any necessary assumptions made. For steel, $\text{E} = 200\ \text{GNm}^{-2}$, $\nu = 0.3$, $\rho = 7470\ \text{kgm}^{-3}$ and the yield stress σ_y in simple tension $= 500\ \text{MNm}^{-2}$. (15 marks)

QUESTION THREE (20 MARKS)

a) A cantilever of length 1.2 m and of the cross section shown in Fig. Q 3 carries a vertical load of 10 kN at its outer end, the line of action being parallel with the longer leg and arranged to pass through the shear center of the section i.e. there is no twisting of the section. I_{xx} and I_{yy} are as shown in the figure.

i. Working from first principles, find the stress set up in the section at points **A, B** and **C**, given that the centroid is located as shown in figure. Also, comment on the nature of these stresses. (17 marks)

ii. Determine also the angle of inclination of the N.A. (3 marks)



$$I_{xx} = 4 * 10^{-6}\ m^4$$

$$I_{yy} = 1.08 * 10^{-6}\ m^4$$

Fig. Q 3

QUESTION FOUR (20 MARKS)

a) State the principle of virtual work. (2 marks)

b) With the aid of well labelled diagrams, differentiate between determinate and indeterminate structures. (4 marks)

c) Use unit load method to find the deflection at the center of the beam shown in Fig. Q 4 (c). Take: $E = 200$ GPa and $I = 400 * 10^6$ mm^4. (14 marks)

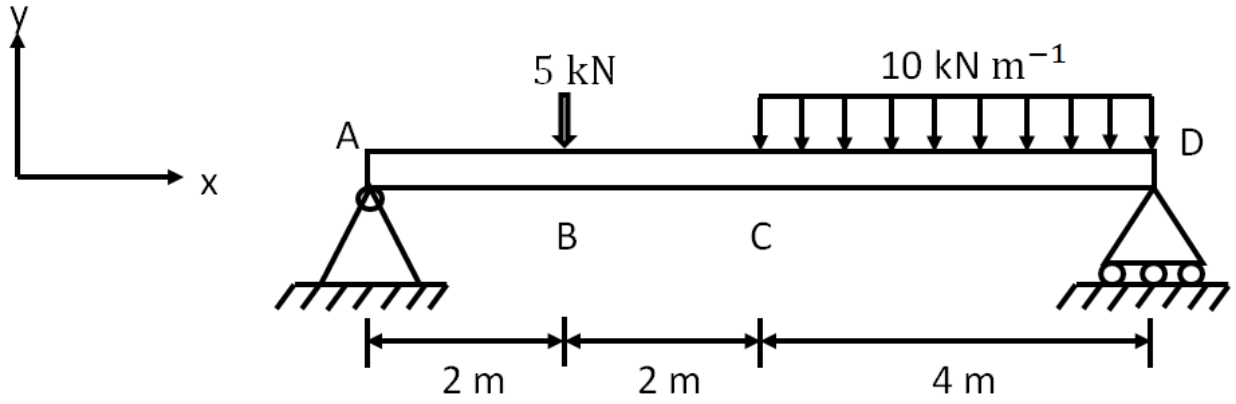


Fig. Q 4 (c)

QUESTION FIVE (20 MARKS)

a) State Castigliano's first theorem of deflection. (1 mark)

b) Derive the equation for the slope at the free end of a cantilever carrying a uniformly distributed load over its full length as shown in Fig. Q 5 (b) using Castigliano's theorem. (6 marks)

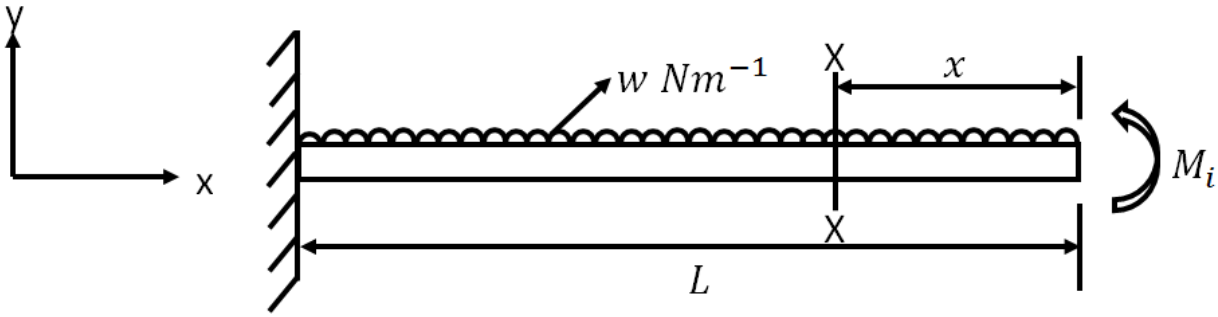


Fig. Q 5 (b)

c) State the assumptions made in the analysis of curved beams. (3 marks)

d) The curved member shown in Fig. 5.1 has a circular cross-section 0.10 m in diameter. If the maximum tensile and compressive stresses in the member are not to exceed 150 MPa and 200 MPa respectively, determine the value of load P that can be safely be carried by the member. (10 marks)

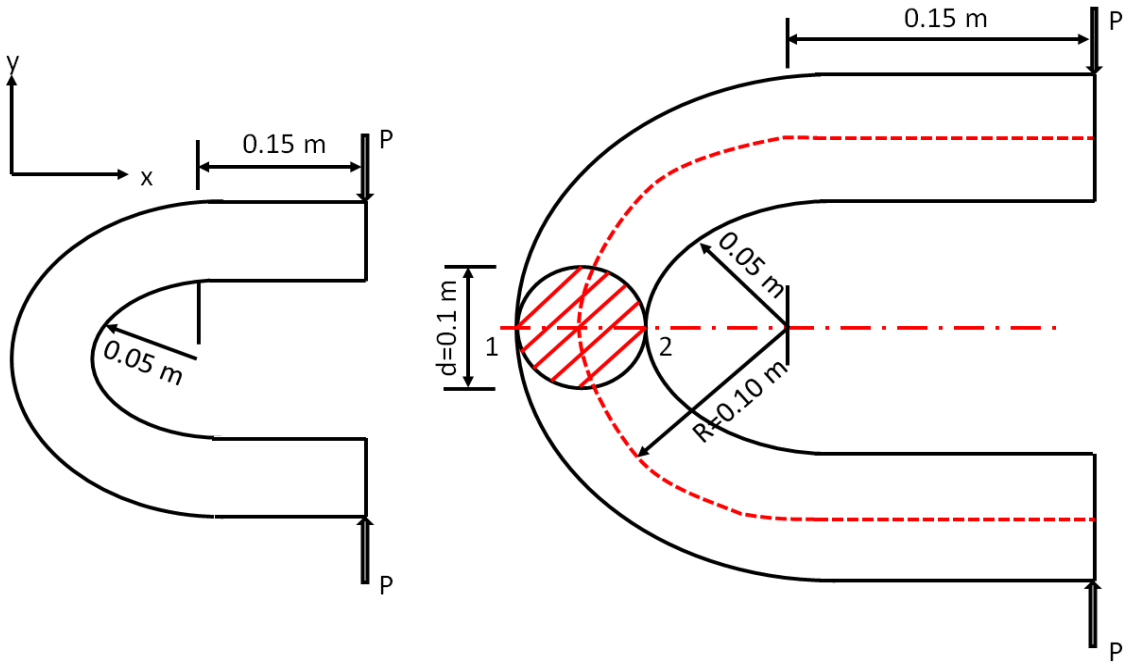


Fig. Q 5 (d)

EQUATIONS

i. Curved bars

$$\sigma_{tensile} = \frac{-P}{A} + \frac{M}{AR}\left[1 + \frac{R^2}{h^2} * \frac{y}{R+y}\right]$$

$$\sigma_{compressive} = \frac{P}{A} + \frac{M}{AR}\left[1 + \frac{R^2}{h^2} * \frac{y}{R-y} - 1\right]$$

$$h^2 = \frac{d^2}{16} + \frac{1}{128} * \frac{d^4}{R^2}$$

ii. Rotating discs and cylinders

$$\sigma_r = A - \frac{B}{r^2} - (3+\nu)\frac{\rho\omega^2 r^2}{8}$$

$$\sigma_H = A + \frac{B}{r^2} - (1+3\nu)\frac{\rho\omega^2 r^2}{8}$$