MACHAKOS UNIVERSITY

University Examinations 2018/2019

FOURTH YEAR SECOND SEMESTER EXAMINATION FOR THE DEGREE OF BACHELOR OF SCIENCE IN MECHANICAL AND MANUFACTURING ENGINEERING

EMM 403: SOLID AND STRUCTURAL MECHANICS III

DATE: MAY 2019 TIME:2 HOURS

INSTRUCTIONS

1. This examination contains **FIVE** questions
2. You are required to attempt **THREE** questions.
3. **QUESTION ONE** is **COMPULSORY**
4. All symbols have usual meaning unless otherwise stated
5. 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. [6 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) 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:

$$\sigma_H = \rho\omega^2 r^2$$ [3 marks]

(d) How are plates classified? Give three groups of the various classifications. [4 marks]

(e) Highlight three causes of failure of a column. [3 marks]

(f) State Castigliano's first theorem of deflection. [2 marks]

(g) With the aid of a well labelled diagram, derive the equation for the Euler load of a column with both ends pinned. [6 marks]

QUESTION TWO (20 MARKS)

(a) 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 MNm^{-2}. The compound tube is then subjected to an internal pressure of 80 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]

(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 $= 500\ \text{MNm}^{-2}$. [12 marks]

QUESTION THREE (20 MARKS)

a. What is a plate? [2 marks]

b. Give two applications of plates and two applications of shells. [2 marks]

c. State four basic assumptions of the linear elastic theory for thin plates which are analogous to those of the simple bending theory of beams. [4 marks]

d. Determine the maximum deflection and bending moments of a simply supported plate as shown in Fig. Q 3 (d) due a uniformly distributed load q_o. [12 marks]

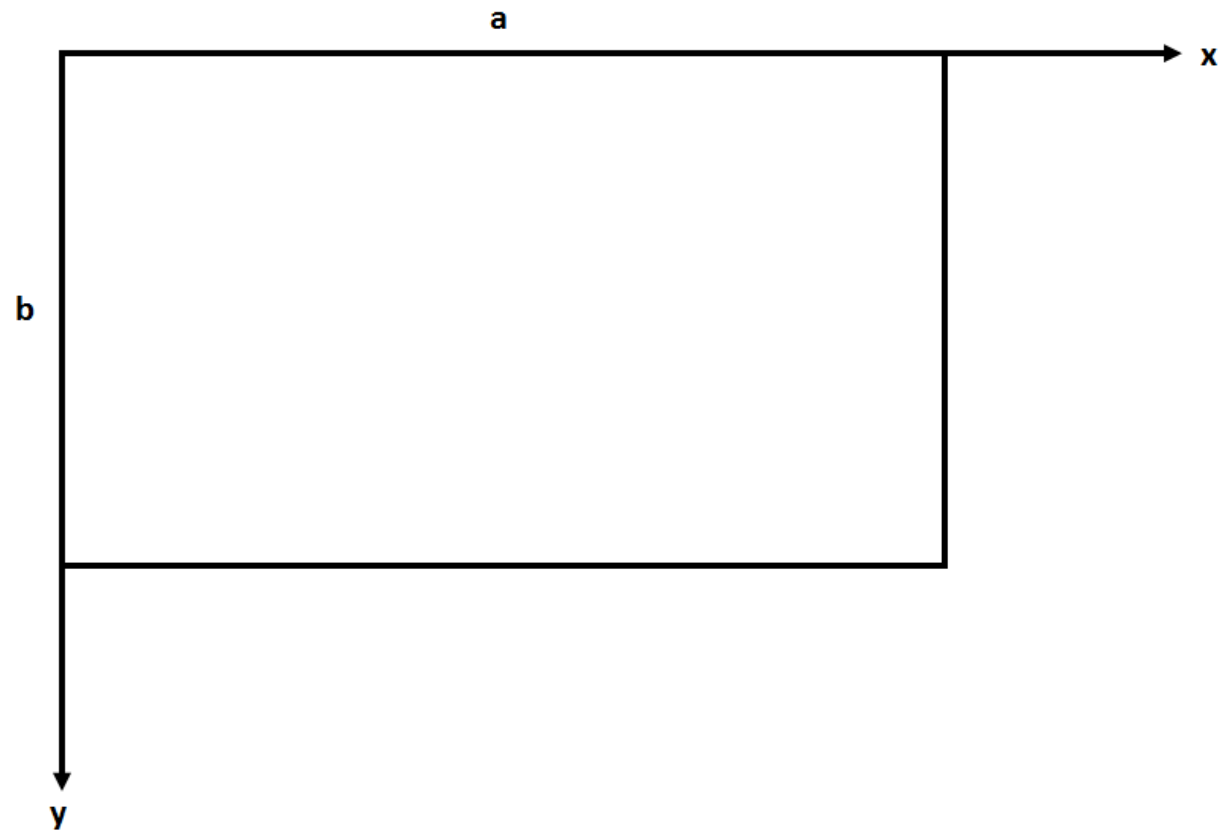

Fig. Q 3 (d)

QUESTION FOUR (20 MARKS)

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

(b) With the aid of diagrams, distinguish between determinate and indeterminate structures. Use relevant equations to support your answer. [4 marks]

(c) Use unit load method to find the deflection at the center of the beam shown in Fig. Q 4 (c). Take: $E = 0.2$ GPa and $I = 400 * 10^6$ mm^4. [14 marks]

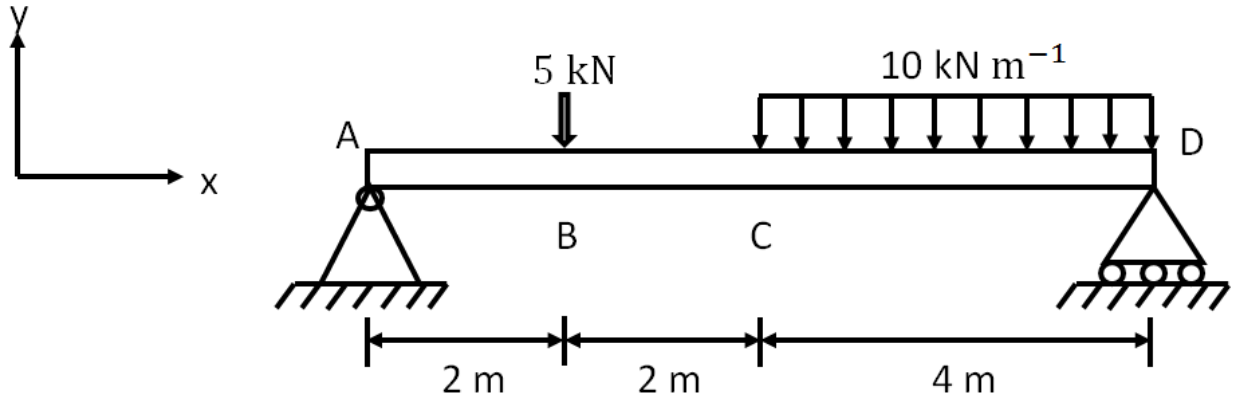

Fig. Q 4 (c)

QUESTION FIVE (20 MARKS)

a. 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. [5 marks]

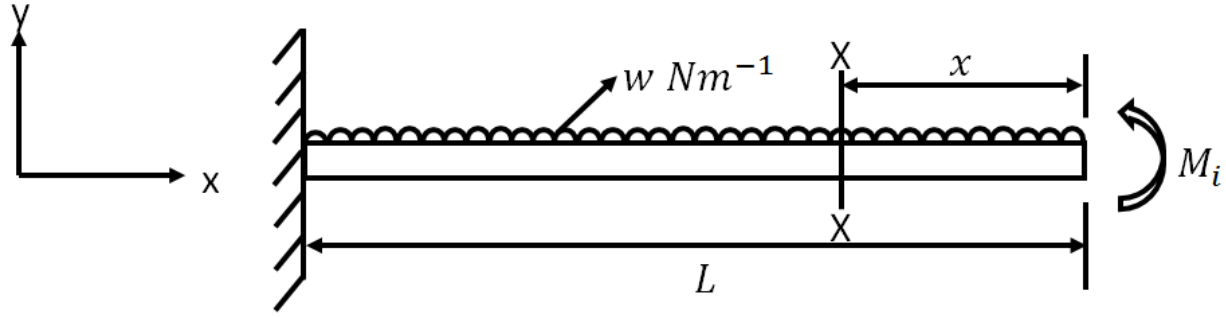

Fig. Q 5 (b)

b. Differentiate between a strut and a column. [2 marks]

c. State the three assumptions made in Euler's column theory. [3 marks]

d. With the aid of well labelled diagrams and relevant equations, distinguish between failure of a short column and that of a long column. [4 marks]

e. A column of timber section 15 cm* 20 cm is 6 m long both ends being fixed. If $E_{timber} = 17.5\ kNmm^{-2}$, determine:

   i. The crippling load. [4 marks]

   ii. The safe load for the column if factor of safety is 3.0. [1 mark]

   iii. The slenderness ratio. [1 marks]

RELEVANT EQUATIONS

i. Rotating discs and cylinders

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

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