MACHAKOS UNIVERSITY

University Examinations 2018/2019

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF MECHANICAL AND MANUFACTURING ENGINEERING

FOURTH YEAR SPECIAL/SUPPLEMENTARY EXAMINATION FOR

BACHELOR OF SCIENCE IN MECHANICAL ENGINEERING

EMM 403: SOLID AND STRUCTURAL MECHANICS III

DATE: 1/8/2019 **TIME: 8.30-10.30 AM**

INSTRUCTIONS:

Answer Question One and Any Other Two Questions

QUESTION ONE (30 MARKS)

a) Define the term shear flow and show how it is calculated. (2 marks)

b) With the aid of well labelled diagrams and equations, describe the behaviour of a beam loaded in a vertical plane of symmetry. (4 marks)

c) The method of solution for compound cylinders made from similar materials involves breaking down the problem into three separate effects. Using well labelled diagrams, illustrate the three effects. Show how each boundary condition is obtained. (10 marks)

d) A simply supported 20 m long beam is subjected to a load of 50 kN acting downward at its center as shown in Fig. Q 1 (c). The beam used is a rectangular $3\ \text{m} * 5\ \text{m}$ steel beam. Determine:

i. The horizontal shear stress which develops in the beam due to the loading. (3 marks)

ii. The horizontal shear stress 3.5 m above the bottom of the beam. (3 marks)

iii. What conclusion can you draw from (i) and (ii) above? (1 mark)

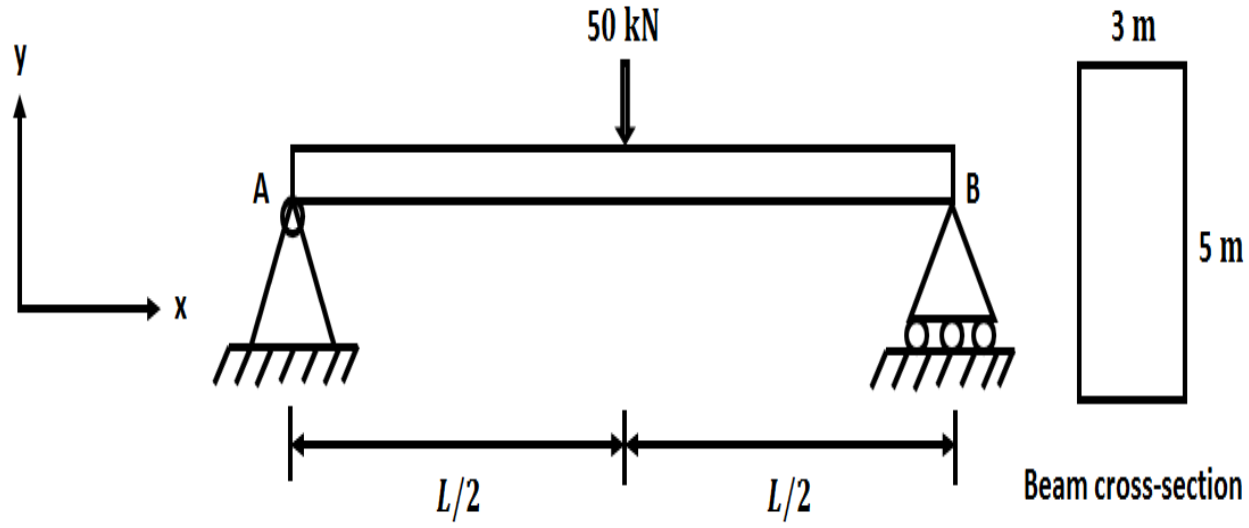

Fig. Q 1 (c)

e) Figure Q 1 (d) shows a square aluminium tube subjected to a torque of 85 Nm. Taking $G_{Al} = 26$ GPa, Compute:

i. The average shear stress in the tube at point *A*. (3 marks)

ii. The angle twist due to this loading. (4 marks)

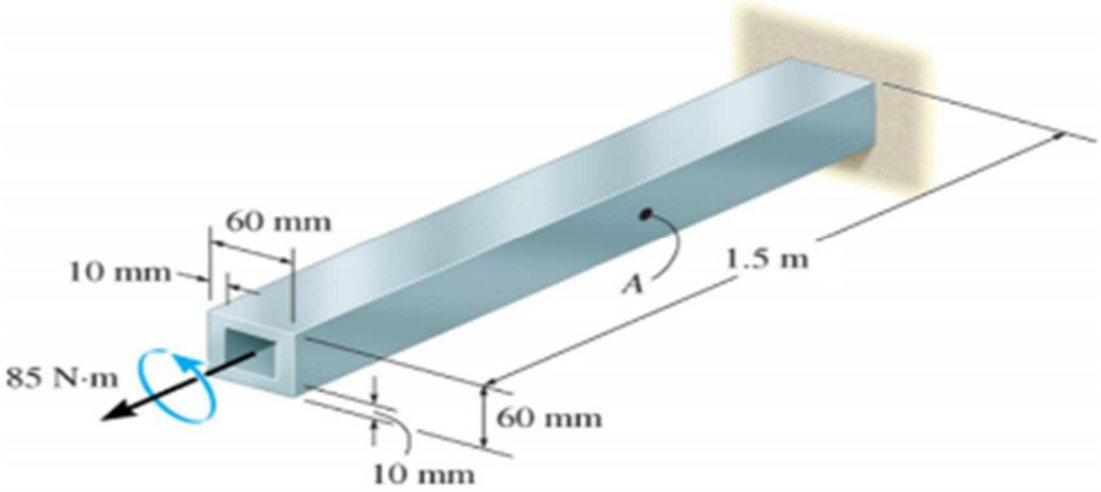

Fig. Q 1 (d)

QUESTION TWO (20 MARKS)

a) The simply supported beam shown in Fig Q 2 (a) is subjected to a uniform load of intensity q acting throughout the span of the beam. The beam has length L and constant flexural rigidity. Determine:

i. The equation of the deflection curve. (12 marks)

ii. The maximum deflection ∂_{max} at the midpoint of the beam. (2 marks)

iii. The angle of rotation θ_A at the support A and θ_B at the support B. (2 marks)

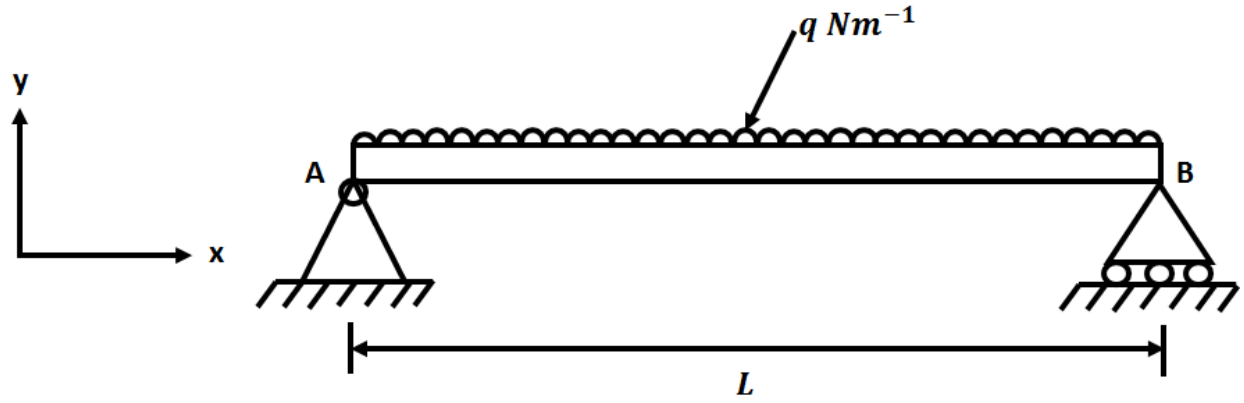

Fig. Q 2 (a)

b) Suppose $q = 5000\ \text{Nm}^{-1}$, calculate the flexural stiffness which limits the deflection to 2 mm at the mid span of the beam. (4 marks)

QUESTION THREE (20 MARKS)

a) Differentiate between a strut and a column. (2 marks)

b) State the three assumptions made in Euler's column theory. (3 marks)

c) With the aid of well labelled diagrams and relevant equations, distinguish between failure of a short column and that of a long column. (6 marks)

d) A solid bar 3 m long and 5 cm in diameter is used a s a strut with both ends hinged. The Elastic modulus of the bar may be taken as $2.0 * 10^5\ \text{Nmm}^{-2}$. Determine:

i. The crippling or collapse load. (2 marks)

ii. The safe load for the column given a safety factor of 3. (1 mark)

e) For the problem (d) above, determine the crippling load when the given strut is used with the following conditions:

i. One end of the strut is fixed and the other end is free. (2 marks)

ii. Both ends of the strut is fixed. (2 marks)

iii. One end is fixed and the other hinged. (2 marks)

QUESTION FOUR (20 MARKS)

a) State the principle of superposition. (2 marks)

b) Define the term statically indeterminate. (1 mark)

c) For the uniform beam and loading shown in Fig Q 4 (c), determine the reaction at each support and the slope at end *A* using the principle of superposition. (10 marks)

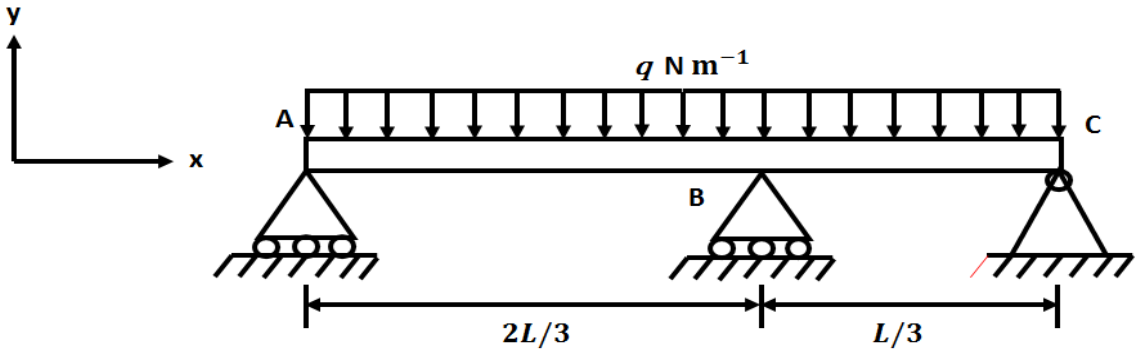

Fig. Q 4 (c)

d) Using the beam shown in Fig. Q 4 (d), derive the Clapeyron's theorem (Theorem of three moments) given by equation 4.2 below. The beam is continuous and has two adjacent spans AB and BC. The settlement of the supports may be taken as ΔA, ΔB and ΔC respectively. Assume the beam section is homogeneous i.e. the flexural rigidity (EI) is constant.

(7 marks)

$$M_A l_1 + 2M_B(l_1 + l_2) + (M_C l_2 = -6\left(\frac{A_1\bar{x}_1}{l_1} + \frac{A_2\bar{x}_2}{l_2}\right) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 4.2$$

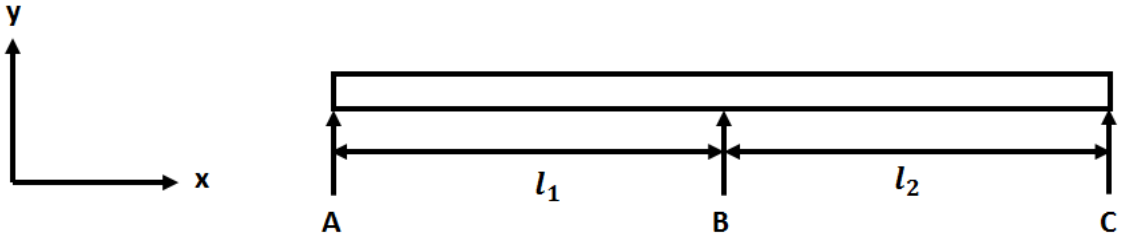

Fig. Q 4 (d)

QUESTION FIVE (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 5 (d) due a uniformly distributed load q_o. (12 marks)

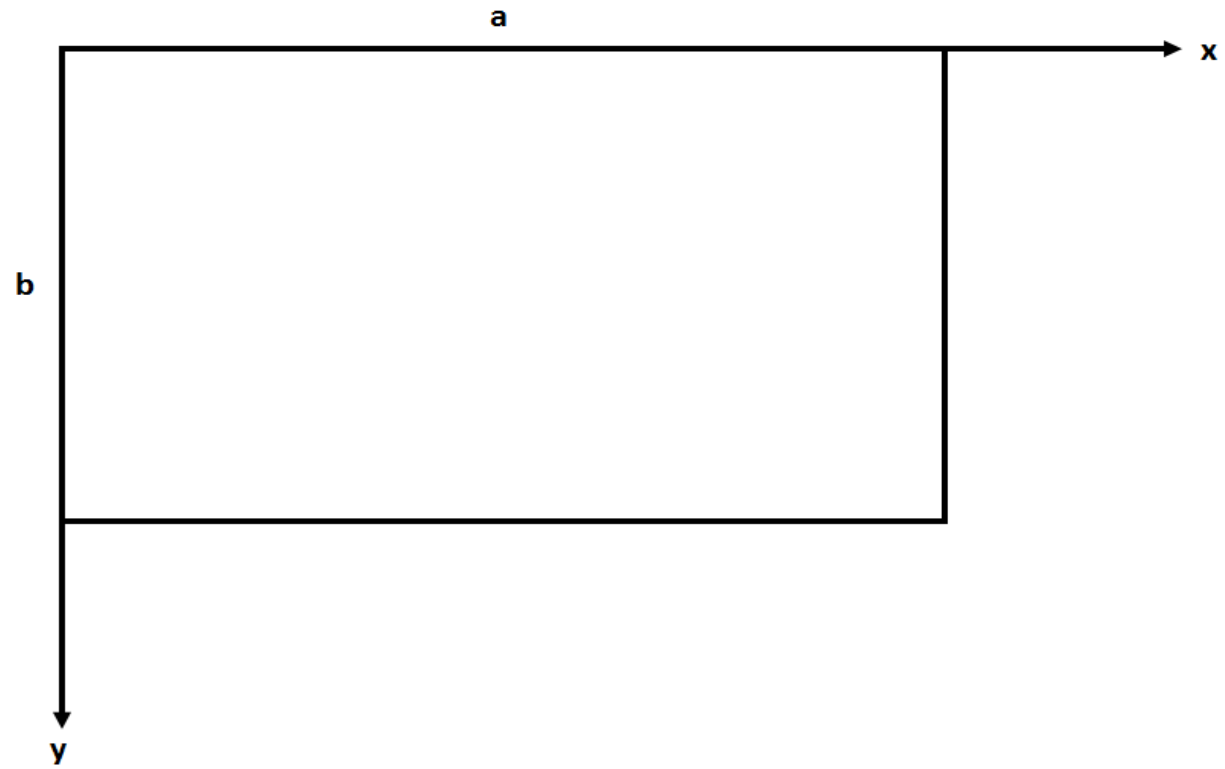

Fig. Q 5 (d)