THE UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING
DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING

UNIVERSITY EXAMINATIONS

FINAL EXAMINATIONS

29ᵗʰ NOVEMBER 2021

TIME: 14:00 – 17:00

CEE 3211– MECHANICS OF MATERIALS

Candidates are advised to read the following instructions carefully

1. *This examination is closed book*
2. *Time allowed is three (3) hours*
3. *Attempt ANY FIVE (5) questions **clearly underlining your answers***
4. *All questions carry equal marks*
5. *This question paper has **FIVE** printed pages including this cover*

Q1. The beam BCDE is connected to a link AB at point B. The loading is as shown in Figure Q1. The link AB is made of steel for which the ultimate normal stress is 450 MPa. Determine the cross-sectional area for AB for which the factor of safety will be 3.5. Assume that the link will be adequately reinforced around the pins at A and B.
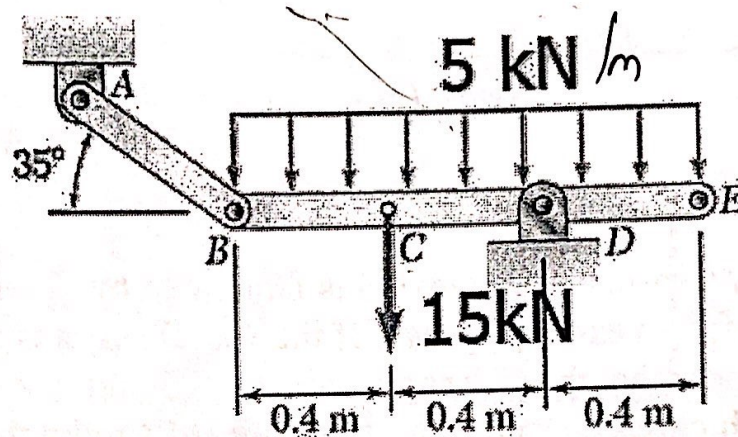

Figure Q 1

[20 Marks]

Q2 A torque of $T = 5000$ kN·m is applied to a torsion member whose cross-section is shown in Figure Q2. The dimensions of the cross-section are $a = 600$ mm, $b = 1,080$ mm, $d = 1,660$ mm, $t_1 = 18$ mm, $t_2 = 9$ mm, and $t_3 = 15$ mm. The dimensions given for a, b, and d are measured to the wall centerline. Determine the following:

a. The cross-section mean area
b. The average shear stress acting at point A
c. The average shear stress acting at point B
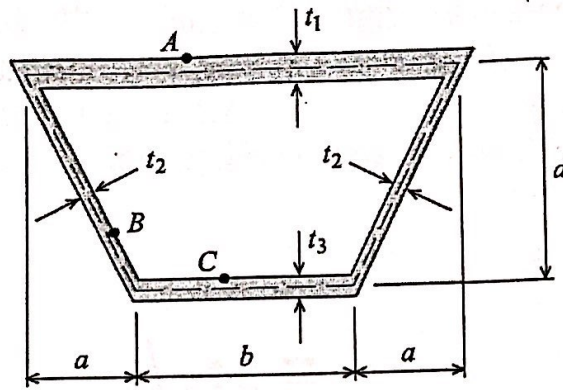d. The average shear stress acting at point C.

Figure Q2

[5+5+5+5 Marks]

Q3. A pressure-vessel head shown in Figure Q3 is fabricated by glueing the circular plate to the end of the vessel as shown. If the vessel sustains an internal pressure of 450 kPa. Assume that the Poisson's ratio $v = 0.3$ and $E = 200$ GPa. Glue is applied over the thickness of the plate. Determine the following:

a. The average shear stress in the glue
b. The state of stress in the wall of the vessel (hoop and longitudinal stresses)
c. The hoop strain
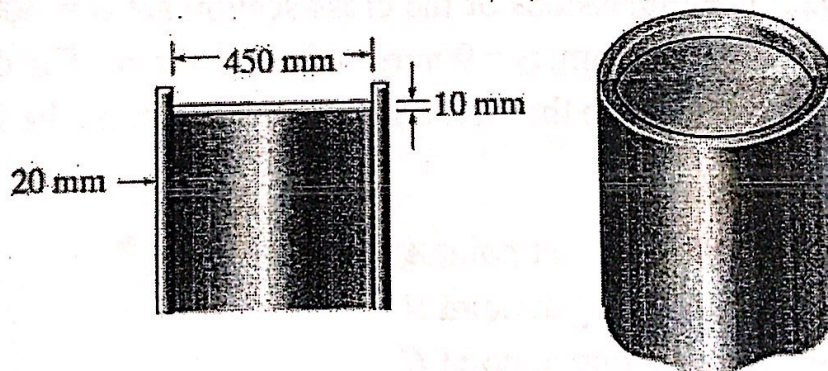d. The increase in the diameter due to the internal pressure.

Figure Q3

[5+5+5+5 Marks]

Q4. Figure Q4 shows a composite beam consisting of a bronze [$E = 105$ GPa] bar (2) attached rigidly to an aluminium alloy [$E = 70$ GPa] bar (1). The dimensions of the cross-section are 60 mm (bar 1 width), 25 mm (bar 2 width), and 40 mm depth. The allowable stress of the aluminium alloy is 165 MPa, and the allowable stress of the bronze is 210 MPa. What is the magnitude of the allowable bending moment M_z that may be applied to the composite cross-section?
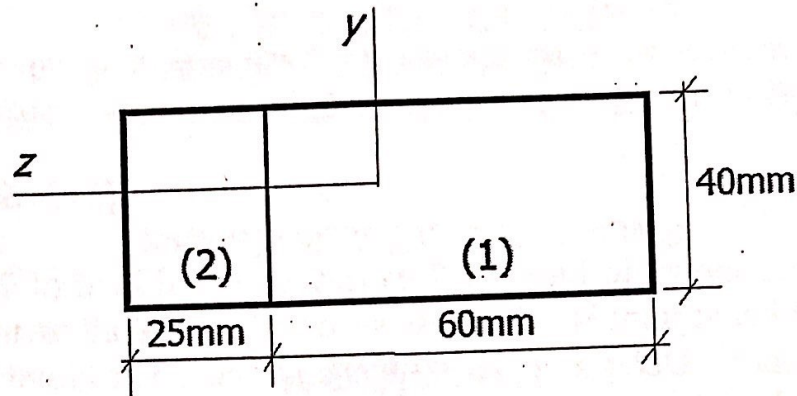

Figure Q4

[20 Marks]

Q5. The steel cantilevered beam AB has a triangular distributed loading shown in Figure Q5. A pointed load of magnitude 25kN is imposed on the beam's mid-point. Using the parameters; L = 3 m, E = 200 GPa; I = 130×10^6 mm^4, determine the following by the use of **integration method:**
   a. The elastic curve
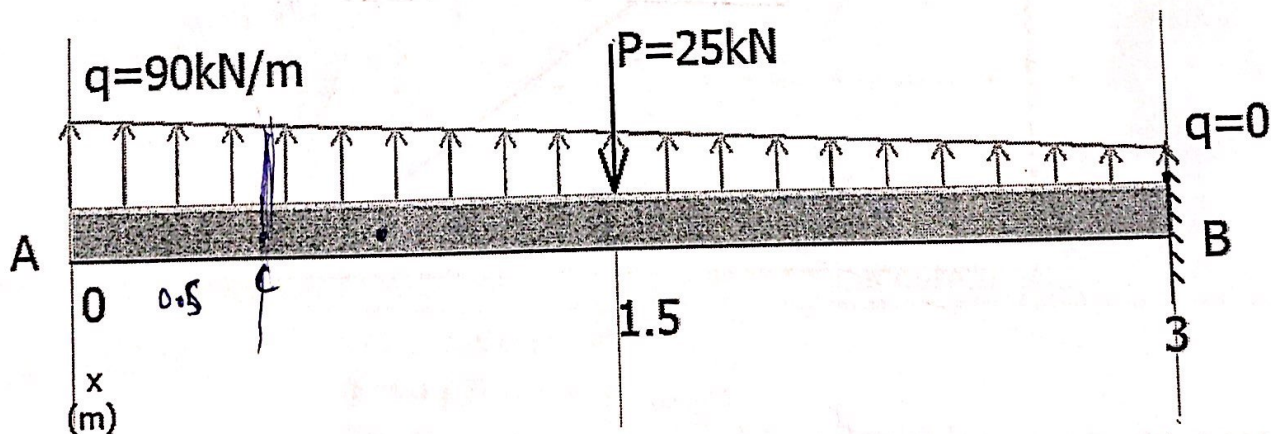   b. The deflection at a distance 0.5m from point A.

Figure Q5

[10+10 Marks]

Q6. A structural steel is used as a column with an actual length of 6 m. The column is supported only at its ends and it may buckle in any direction. If a factor of safety of 2 with respect to failure by buckling is specified, determine the maximum safe (allowable) load for the column for the following end conditions:

(a) pinned-pinned
(b) fixed-free
(c) fixed-pinned
(d) fixed-fixed

$$\sigma A = \frac{\pi^2 E R}{(cl)^2}$$

$$P = \frac{\pi^2 EI}{(cl)^2}$$

Use the following cross-sectional properties: $A = 2{,}770 \text{ mm}^2$, $I_x = 8.70 \times 10^6 \text{ mm}^4$, $I_y = 4.62 \times 10^6 \text{ mm}^4$, $E = 200\text{GPa}$

[5+5+5+5 Marks]

Q7. A 3-member truss shown in Figure Q7 carries a vertical load of 75 kN and a horizontal load of 25 kN at joint B. The cross-sectional area of all members is 150 mm^2 and $E = 210\text{kN/mm}^2$. Determine the vertical displacement of joint **B** using the method of virtual work. Take the lengths AB and AC as 3m and 4m respectively.
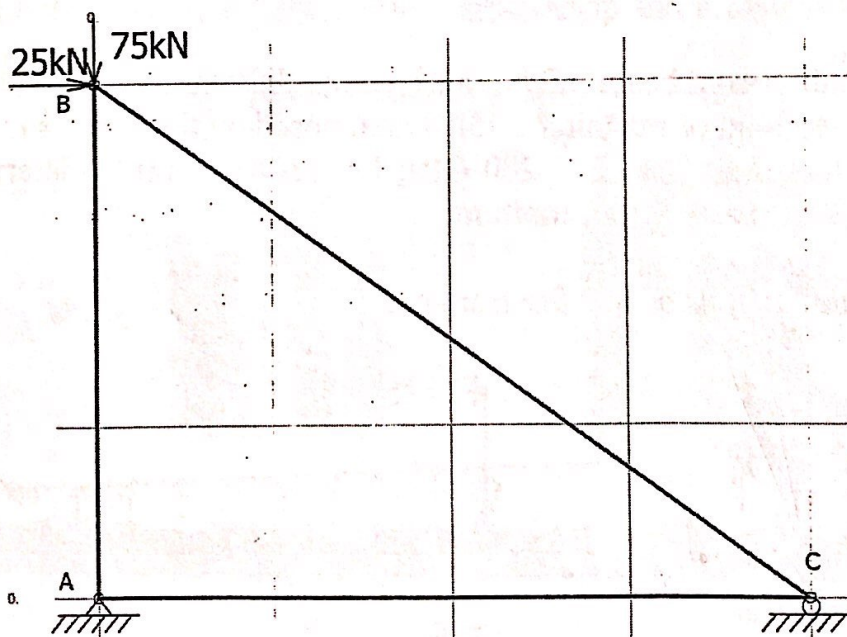
[20 Marks]

Figure Q7

END OF CEE 3211 EXAMINATIONS