2024 SECOND SEMESTER FINAL EXAMINATIONS

Faculty	:	Engineering and the Environment
Department	:	Metallurgical Engineering
Paper Code/Title	:	EMG 2202/Solid Mechanics
Duration	:	3 Hours
Examiner	:	P. Garanowako
Authorized material	:	calculator, list of formulae

INSTRUCTIONS

1. This paper contains **one** section with **six** questions.
2. Answer any **four** questions.
3. Where the question contains subdivisions, the mark of each subdivision is shown in brackets.
4. Each question carries **25 marks**.
5. Start each question on a new page.

NB: DO NOT TURN OVER THE QUESTION PAPER OR COMMENCE WRITING UNTIL INSTRUCTED TO DO SO.

QUESTION 1

a. Define the following terms

i. Normal stress **[2 marks]**

ii. Shearing stress **[2 marks]**

iii. Bearing stress **[2 marks]**

iv. Eccentric loading **[2 marks]**

v. Centric loading **[2 marks]**

b. In Figure 1, each of the four vertical links has an 8 x 36-mm uniform rectangular cross section and each of the four pins has a 16-mm diameter. Determine

(i) The average shearing stress in the pin at C. **[5 marks]**

(ii) The average bearing stress at C in link CE **[5 marks]**

(iii) The average bearing stress at C in member ABC, given that this member has 10 x 50 mm uniform rectangular cross section**.** **[5 marks]**

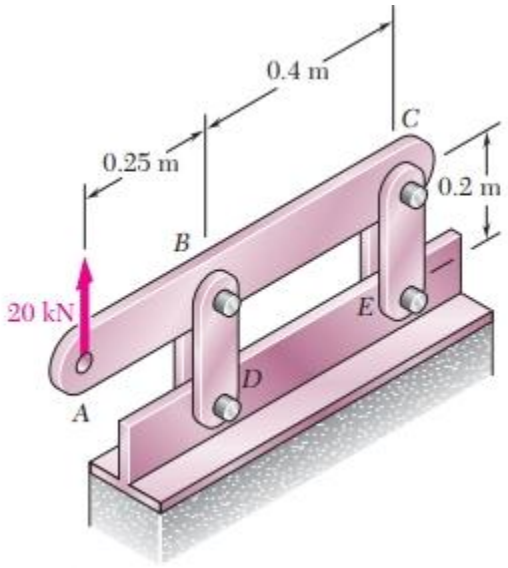

Figure 1

QUESTION 2

a. A steel rod has a diameter of 10mm and length of 2mm. it is stretched with a force of 20 kN and extends 0.2mm. calculate the

   i. nominal stress **[2 marks]**

   ii. nominal strain **[2 marks]**

   iii. true stress **[4 marks]**

   iv. true strain **[4 marks]**

b. Comment on the differences between the nominal and true values of the above calculated values if any. **[3 marks]**

c. Figure 2. Shows stress *vs* strain diagram for the typical mild steel specimen. State and explain the following salient points(A,B,C,D,E) which are observed on stress-strain curve: **[10 marks]**

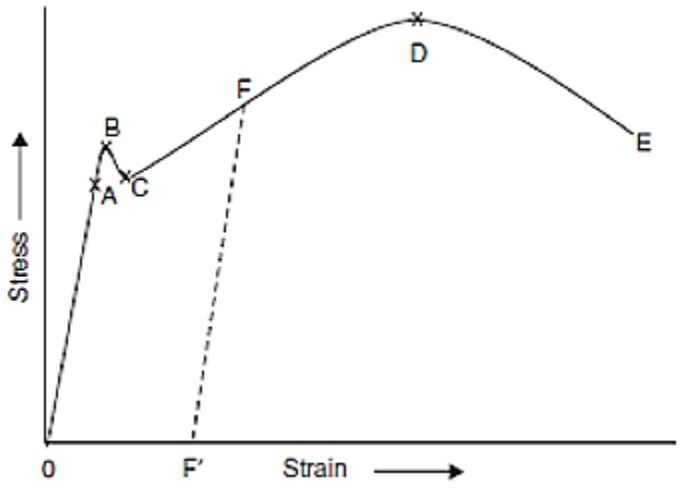

Figure 2

QUESTION 3

a. What are the differences between failure by creep and failure by fatigue? Can you provide examples of real-world scenarios where these types of failures may occur? **[5 marks]**

b. A 500-mm-long, 16-mm-diameter rod made of a homogenous, isotropic material is observed to increase in length by300 μm and to decrease in diameter by 24 μm when subjected to an axial 12-kN load. Determine the modulus of elasticity and Poisson's ratio of the material. **[10marks]**

c. Figure 3 shows a 1.8 m concrete post reinforced by six steel bars, each of 22 mm diameter. Given that the modulus of elasticity of steel, E_S = 200GPa and the coefficient of expansion of steel, $\alpha_S = 11.7 \times 10^{-6}/^{O}C$.

Determine the normal stresses induced in the steel and in the concrete by a temperature rise of 35 ^{O}C. **[10 marks]**

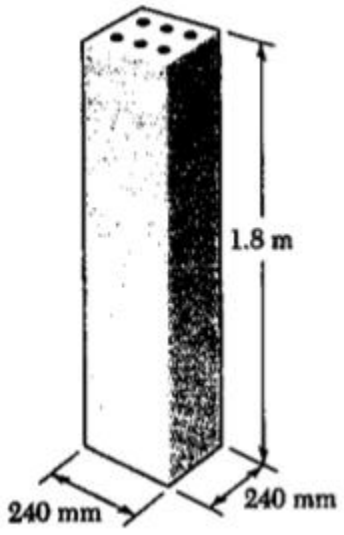

Figure 3

Question 4

a. What are the fundamental equations and assumptions used to describe torsional behavior in solid materials? **[5 marks]**

b. (i) Determine the torque which may be applied to a solid shaft 90 mm outer diameter without exceeding the allowable shearing stress of 75 MPa**.[5 marks]**
(ii) Solve part (i) assuming that the solid shaft is replaced by a hollow shaft of the same mass and of 90 mm inner diameter. **[5 marks]**

c. (i)Determine the torque T which causes a maximum shear stress of 70 MPa in the steel cylindrical shaft shown in Figure 4 **[5 marks]**
(ii) with reference to Figure 4 determine the maximum shearing stress caused by a toque T = 800N-m. **[5 marks]**

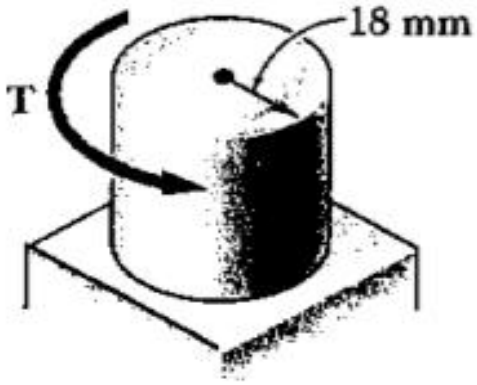

Figure 4

Question 5

a. Write the assumptions in the theory of simple bending **[5 marks]**

b. Write the theory of simple bending equation **[5 marks]**

c. A W200 x 31.3 rolled-steel beam is subjected to a couple M of moment 45 kN m as shown in Figure 5.1. Given that E = 200 GPa and v = 0.29, determine the radius of curvature ρ, **[5 marks]**

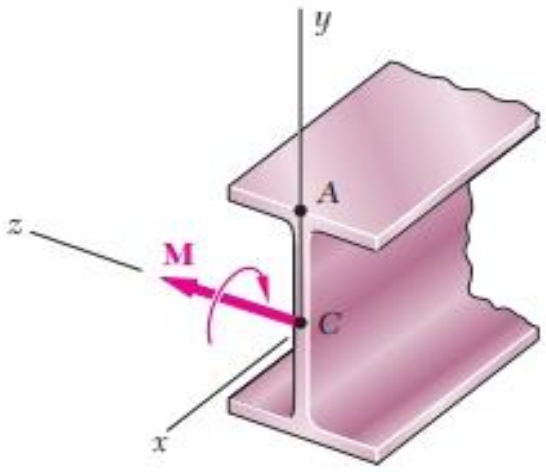

Figure 5.1

d. Given that a beam of the cross section shown in Figure 5.2 is bend about the horizontal axis and that the bending moment is 8 kNm , determine the force acting on the top flange **[10 marks]**

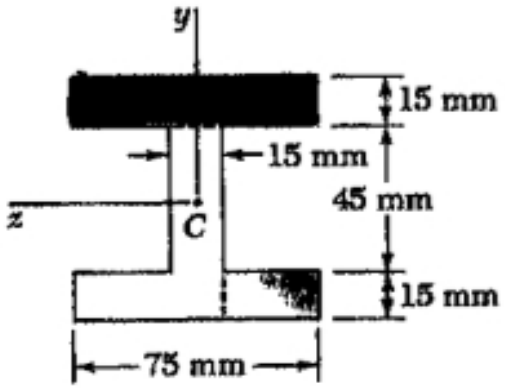

Figure 5.2

Question 6

a. What is the purpose of beam design and analysis in engineering? 5 marks

b. What are the key factors to consider when selecting a beam shape or cross-section? 5 marks

c. A 5-m-long, simply supported steel beam AD is to carry the distributed and concentrated loads shown in Figure 6. Given that the allowable normal stress for the grade of steel to be used is 160 MPa, select the wide-flange shape that should be used (use table 1 for selection of the flange shape). (15 marks)

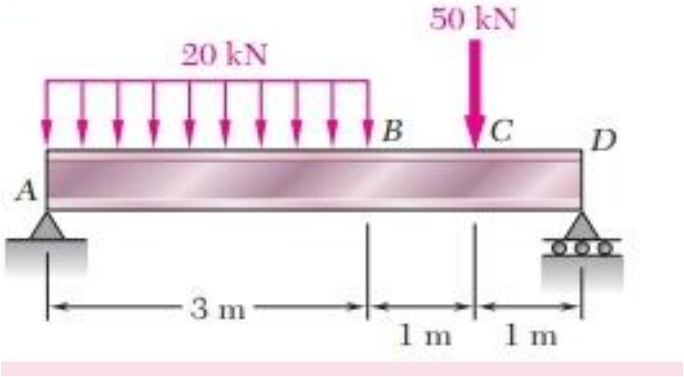

Figure 6

Shape	**S, mm^3**
W410 X 38.8	637
W 360 X 32.9	474
W310 X 38.7	549
W250 X 44.8	535
W 200 X 46.1	448

Table 1