OCD02

UNIVERSITY OF BOLTON

OFF CAMPUS DIVISION

WESTERN INTERNATIONAL COLLEGE

BENG (HONS) MECHANICAL ENGINEERING

SEMESTER ONE EXAMINATION 2023/24

MECHANICS OF MATERIALS AND MACHINES

MODULE NO: AME5012

Date: Tuesday 09 January 2024 **Time: 10:00 AM – 12:00 PM**

INSTRUCTIONS TO CANDIDATES:

There are FIVE questions on this paper.

Answer any FOUR questions

All questions carry equal marks.

Marks for parts of questions are shown in brackets.

Electronic calculators may be used provided that data and program storage memory is cleaned prior to the examination.

CANDIDATES REQUIRE:

Formula Sheet (attached)
Graph Paper

University of Bolton
Off Campus Division, Western International College
BEng(Hons) Mechanical Engineering
Semester 1 Examination 2023/2024
Mechanics of Materials and Machines
Module No. AME5012

Q1. For the simply supported overhanging beam AC of length 10m which is supported at A and B, shown in **Figure Q1**, use Macaulay's method to determine:

a) the slope and deflection equations for the beam (16 marks)

b) the slope at A and B (6 marks)

c) the deflection at D (3 marks)

Take Flexural rigidity, E= 2 x 10^5 N/mm^2 ; I = $10^8$$mm^4$

Total 25 marks

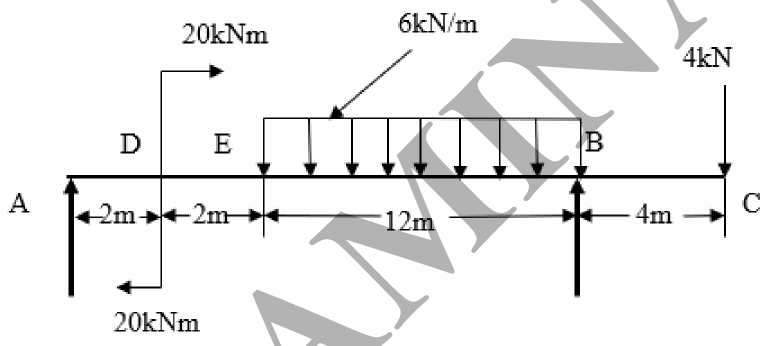

Figure Q1 simply supported overhanging beam

Q2. A damped spring-mass system with mass m = 15kg, spring stiffness k = 40 kN/m and damping ratio ξ = 0.25 is subjected to a simple harmonic disturbing force of 70 cos 25t newtons. Determine :

a) the amplitude and phase lag of the steady state vibrations (12 marks)

b) the amplitude of the steady state vibration when $\omega = \omega_n$ (4 marks)

c) the frequency of the varying force, which will give maximum amplitude and the value of this maximum amplitude. (9 marks)

Total 25 marks

Please turn the page

University of Bolton
Off Campus Division, Western International College
BEng(Hons) Mechanical Engineering
Semester 1 Examination 2023/2024
Mechanics of Materials and Machines
Module No. AME5012

Q3. An element of material is subjected to a two dimensional stress system as shown in **Figure Q3.**

a) Using a scale of 1 cm = 10 MPa, construct Mohr's stress circle (8 marks)

and hence determine :

(i) The magnitude of the principal stresses (3 marks)

(ii) The magnitude of the maximum shear stress (3 marks)

(iii) The normal and shear stresses on the plane AB (3 marks)

b) Confirm the magnitude of the principal stresses by calculation. (8 marks)

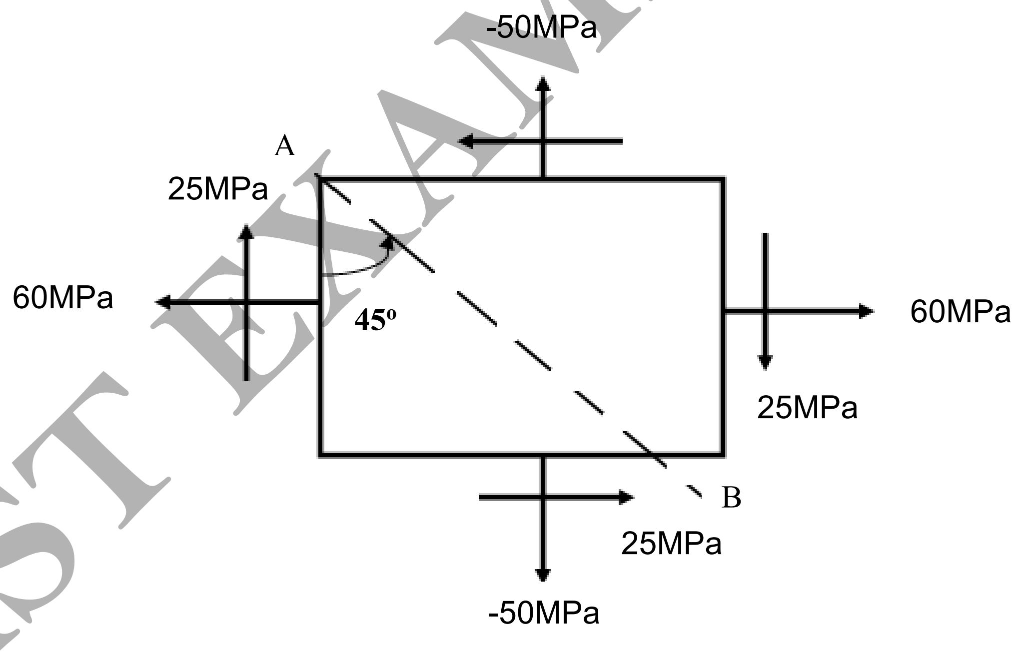

Figure Q3. Two-dimensional stress system

Total 25 marks

Please turn the page

Q4. A thick-walled cylinder is subjected to an internal pressure of 60 MPa. If the cylinder internal diameter is 11 cm and external diameter is 19 cm, determine the following:

a) the circumferential (hoop) stress at the inside and outside radii (8 marks)

b) the longitudinal stress across the wall section (3 marks)

c) the change in the internal diameter and the change in length due to the internal pressure if the original length is 4m. (6 marks)

d) Sketch the distribution of the circumferential and radial stresses across the wall section also indicating the longitudinal stress. (8 marks)

Take Modulus of elasticity, E = 200GPa & Poisson's ratio, $\nu = 0.25$

Total 25 marks

Q5. **Figure Q5** shows a 45^0 rectangular strain gauge rosette which is bonded to the surface of a steel structural member.

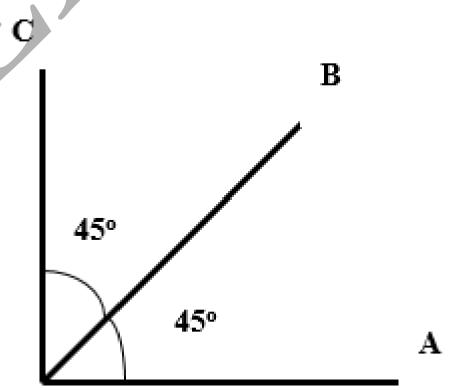

Figure Q5 45^0 rectangular strain gauge rosette

Question 5 continued over…
Please turn the page

Question 5 contd.

When the structure is loaded the strain readings are :

Gauge A : -434×10^{-6}m

Gauge B : -144×10^{-6}m

Gauge C : 538×10^{-6}m

a) Construct and label Mohr's strain circle to a scale of 1cm = 100×10^{-6} (10 marks)

b) Superimpose Mohr's stress circle onto the strain circle. (5 marks)

c) From the two circles, determine :

(i) The principal strains (2 marks)

(ii) The principal stresses (4 marks)

d) Verify the magnitudes of the principal stresses using the appropriate formula. (4 marks)

Take Modulus of elasticity, E = 200 GPa, Poisson's ratio $\nu = 0.3$

Total 25 marks

<u>END OF QUESTIONS</u>

University of Bolton
Off Campus Division, Western International College
BEng(Hons) Mechanical Engineering
Semester 1 Examination 2023/2024
Mechanics of Materials and Machines
Module No. AME5012

FORMULA SHEET

Deflection

$$EI\frac{d^2y}{dx^2} = M$$

Complex Stress

$$\sigma_\theta = \frac{\sigma_x + \sigma_y}{2} + \left(\frac{\sigma_x - \sigma_y}{2}\right)\cos 2\theta + \tau \sin 2\theta$$

$$\tau_\theta = \left(\frac{\sigma_x - \sigma_y}{2}\right)\sin 2\theta - \tau \cos 2\theta$$

$$\tan 2\theta_p = \frac{2\tau}{\sigma_x - \sigma_y}$$

Complex Strain

$$\text{Radius of stress circle} = \frac{(1-\nu)}{(1+\nu)} \text{ x Radius of strain circle}$$

$$\text{Stress circle} = \frac{E}{(1-\nu)} \text{ x strain scale}$$

$$\sigma_1 = \frac{E(\varepsilon_1 + \nu\varepsilon_2)}{1-\nu^2} \qquad \sigma_2 = \frac{E(\varepsilon_2 + \nu\varepsilon_1)}{1-\nu^2}$$

Thick Cylinder

Lame′ Equations

$$\sigma_c = A + \frac{B}{r^2}, \ \sigma_R = A - \frac{B}{r^2}$$

University of Bolton
Off Campus Division, Western International College
BEng(Hons) Mechanical Engineering
Semester 1 Examination 2023/2024
Mechanics of Materials and Machines
Module No. AME5012

Strain Format

$$\varepsilon_x = +\frac{\sigma_x}{E} - \nu\frac{\sigma_y}{E} - \nu\frac{\sigma_z}{E}$$

Strain along any angle

$$\varepsilon_\theta = \varepsilon_x sin2\theta + \varepsilon_y cos2\theta + \gamma_{xy} sin\,\theta cos\,\theta$$

<u>Vibrations</u>

$$f_n = \frac{\varpi_n}{2\pi} \qquad \omega_n = \sqrt{\frac{k}{m}}$$

Damped $$f_d = \frac{\omega_d}{2\pi} \qquad \omega_d = \omega_n\sqrt{1-\xi^2}$$

Log Decrement $$\ell_n \frac{x_1}{x_r} = \frac{2\pi(r-1)\xi}{\sqrt{1-\xi^2}}$$

Critical Damping $$C_c = 2m\,\omega_n \qquad \xi = \frac{C}{C_c}$$

Forced $$X_0 = \frac{F/K}{\sqrt{(2\xi r)^2 + (1-r^2)^2}} \qquad \phi = \tan^{-1}\frac{2\xi r}{1-r^2}, \quad r = \frac{\omega}{\omega_n}$$

$$r_{res} = \sqrt{1-2\xi^2}, \qquad r_{res} = \frac{\omega_{res}}{\omega_n}$$

Transmissibility $$F_T = \sqrt{(kX_0)^2 + (c\omega X_0)^2}$$