

UNIVERSITY OF GREATER MANCHESTER

OFF CAMPUS DEVISION

WESTERN INTERNATIONAL COLLEGE, RAS AL

KHAIMAH

BENG(HONS) MECHANICAL ENGINEERING

SEMESTER ONE (AND RESIT) EXAMINATION
2025/2026

MECHANICS OF MATERIALS AND MACHINES

MODULE NO:AME5012

Date: Saturday, 24th January 2026

Time: 10:00am – 12:00pm

INSTRUCTIONS TO CANDIDATES:

There are **FIVE (5)** questions on this paper.

Answer any **FOUR (4)** 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

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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:

- the slope and deflection equations for the beam (16 marks)
- the slope at A and B (6 marks)
- the deflection at D (3 marks)

Take Flexural rigidity, $EI = 20 \times 10^6 \text{ N/m}^2$

Total 25 marks

Given Length; AD=1m; DE=1m; EB=6m; BC=2m

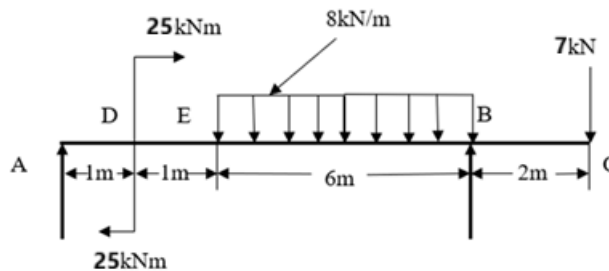


Figure Q1 simply supported overhanging beam

Q2. A damped spring-mass system with mass $m = 25\text{kg}$, spring stiffness $k = 50 \text{ kN/m}$ and damping ratio $\xi = 0.25$ is subjected to a simple harmonic disturbing force of $75 \cos 25t$ newtons. Determine :

- the amplitude and phase lag of the steady state vibrations (12 marks)
- the amplitude of the steady state vibration when $\omega = \omega_n$ (4 marks)
- the frequency of the varying force, which will give maximum amplitude and the value of this maximum amplitude. (9 marks)

Total 25 marks

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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 = 5 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)

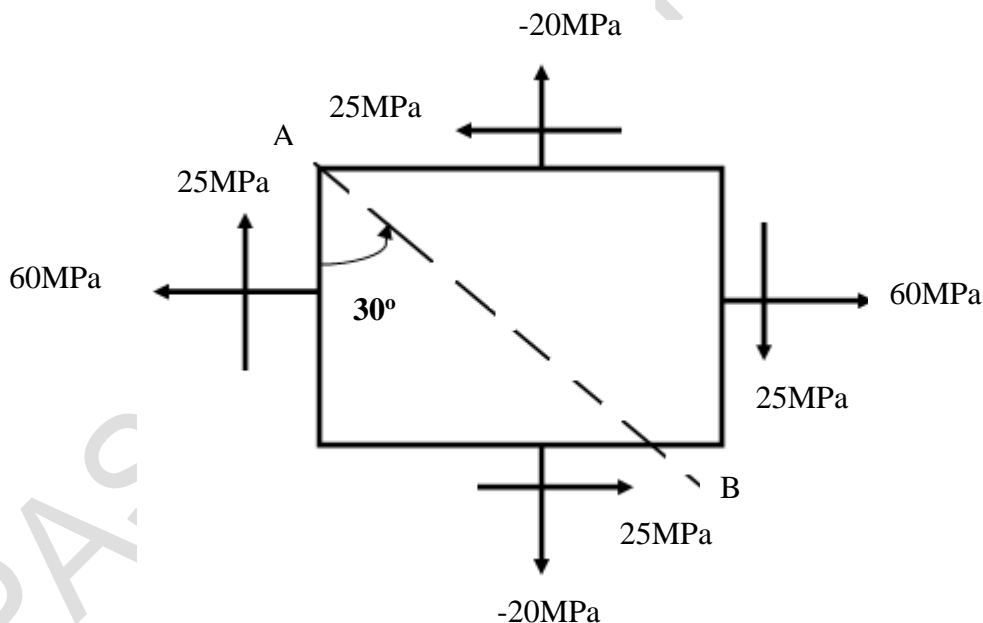


Figure Q3. Two dimensional stress system

Total 25 marks

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- Q4 A thick-walled cylinder is subjected to an internal pressure of 75 MPa. If the cylinder internal diameter is 10 cm and external diameter is 18 cm, determine the following:
- the circumferential (hoop) stress at the inside and outside radii (8 marks)
 - the longitudinal stress across the wall section (3 marks)
 - the change in the internal diameter and the change in length due to the internal pressure if the original length is 6m. (6 marks)
 - Sketch the distribution of the circumferential and radial stresses across the wall section also indicating the longitudinal stress. (8 marks)

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

Total 25 marks

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

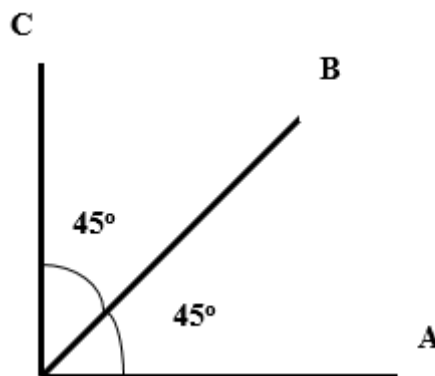


Figure Q5 45° rectangular strain gauge rosette

Question 5 continues over the page

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Question 5 continued.

When the structure is loaded the strain readings are:

Gauge A : 500×10^{-6}

Gauge B : -120×10^{-6}

Gauge C : 200×10^{-6}

- a) Construct and label Mohr's strain circle to a scale of $1\text{cm} = 100 \times 10^{-6}$ (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, $E = 200 \text{ GPa}$, Poisson's ratio $\nu = 0.3$

Total 25 marks

END OF QUESTIONS

Please turn the page for formula sheet

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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

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

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

$$\sigma_1 = \frac{E(\epsilon_1 + \nu\epsilon_2)}{1-\nu^2} \quad \sigma_2 = \frac{E(\epsilon_2 + \nu\epsilon_1)}{1-\nu^2}$$

Thick Cylinder

Lame' Equations

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

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Strain Format

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

Strain along any angle

$$\varepsilon_\theta = \varepsilon_x \sin 2\theta + \varepsilon_y \cos 2\theta + \gamma_{xy} \sin \theta \cos \theta$$

Vibrations

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

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

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

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

End of Paper