# UNIVERSITY OF BOLTON

# OFF CAMPUS DIVISION

# WESTERN INTERNATIONAL COLLEGE

# BENG (HONS) MECHANICAL ENGINEERING

# SEMESTER ONE EXAMINATION 2024/2025

# ENGINEERING PRINCIPLES 1

# MODULE NO: AME4062

**Date: Saturday, 04 January 2025** **Time: 2:00 pm – 4:00 pm**

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**INSTRUCTIONS TO CANDIDATES:** **There are SIX (6) questions.**

**Answer TWO (2) Questions from Part A and TWO (2) Questions from Part B.**

**All questions carry equal marks.**

**Marks for parts of questions are shown in brackets.**

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

**CANDIDATES REQUIRE:** **Formula Sheet (attached)**

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## PART A

### QUESTION 1

a) Solve the following

(i) If $[A] = \begin{bmatrix} 2 & 3 \\ 1 & 0 \end{bmatrix}$ and $[B] = \begin{bmatrix} 2 & 3 \\ 0 & 1 \end{bmatrix}$ show that $(A \times B) \neq (B \times A)$

**(4 marks)**

(ii) Evaluate $\begin{vmatrix} 1 & 4 & -3 \\ -5 & 2 & 6 \\ -1 & -4 & 2 \end{vmatrix}$

**(5 marks)**

b) A force of 5N is inclined at an angle of $45^0$ to a second force of 8N, both forces acting at a point. Calculate the magnitude of the resultant of these two forces and the direction of the resultant with respect to the 8N force. The two forces are shown in **Figure Q1**.

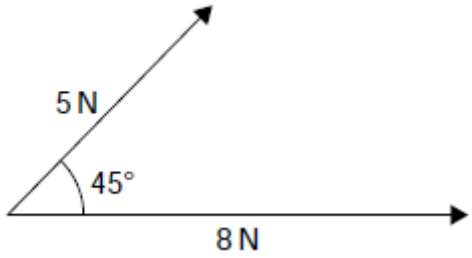


**Figure Q1**

**(10 marks)**

c) Solve the complex equations:

(i) $(2 - j3) = \sqrt{(a + jb)}$

(ii) $(x - j2y) + (y - j3x) = (2 + j3)$

**(6 marks)**

**[TOTAL 25 MARKS]**

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**QUESTION 2**

a) Consider a system where the transfer function of a control system is given by:

$$Y(s) = \frac{2x^2 - 9x - 35}{(x+1)(x-2)(x+3)}$$

To analyse the system response in the time domain, you need to decompose the transfer function $Y(s)$ into partial fractions. Find the partial fraction decomposition of the transfer function

**(10 marks)**

b) Consider stacking the washers on a bolt, and each washer is slightly thicker than the previous one. The thickness of the first washer is 3.5 mm, the second washer is 4.1 mm, the third washer is 4.7 mm, and so on, increasing by 0.6 mm each time. What is the total thickness of the stack after adding 21 washers?

**(4 marks)**

c) If £100 is invested at compound interest of 8% per annum, determine (a) the value after ten years, (b) the time, correct to the nearest year, it takes to reach more than £300.

**(5 marks)**

d) Solve the logarithmic equations

(i) $\text{Log}_5(x) = -2$ (ii) $\log_3(1/81) = x$ (iii) $\log(x^2 - 3) - \log(x) = \log(2)$

**(6 marks)**

**[TOTAL 25 MARKS]**

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**QUESTION 3**

a) A d.c. circuit comprises three closed loops. Applying Kirchhoff's laws to the closed loops give the following equations for current flow in milliamperes:

$2I_1 + 3I_2 - 4I_3 = 26$

$I_1 - 5I_2 - 3I_3 = -87$

$-7I_1 + 2I_2 + 6I_3 = 12$

Use determinants to solve for $I_1$, $I_2$ and $I_3$

**(13 marks)**

(b) Determine the partial fraction decomposition of the following expression.

$$\frac{5x^2 - 2x - 19}{(x+3)(x-1)^2}$$

**(8 marks)**

(c) In **Figure Q3**, *PR* represents the inclined jib of a crane and is 10.0 long. *PQ* is 4.0m long. Determine the inclination of the jib to the vertical and the length of tie *QR*.

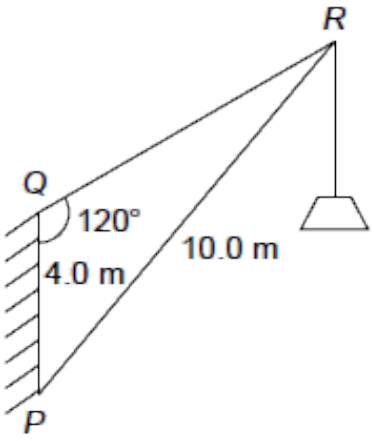


**Figure Q3**

**(4 marks)**

**[TOTAL 25 MARKS]**

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## PART B

### QUESTION 4

a) A tensile test was conducted on a mild steel bar to determine the properties of the material. The results of the tensile test are as follows.

| | | |
|---|---|---|
| Diameter of the steel bar | = | 30mm |
| Gauge length of the bar | = | 200mm |
| Load at elastic limit | = | 250kN |
| Extension at the load of 150kN | = | 0.21mm |
| Maximum load | = | 380kN |
| Total Extension | = | 60mm |
| Diameter of the rod at failure | = | 22.5mm |

Determine:

(i) The Young's Modulus **(4 mark)**
(ii) The stress at elastic limit **(3 mark)**
(iii) The percentage elongation **(4 mark)**
(iv) The percentage decrease in area **(4 mark)**

b) An axial pull of 25000 N is acting on a circular bar consisting of 3 lengths as shown in **Figure Q4**. If the Young's Modulus is 2.1 x $10^5$ N/mm$^2$, determine:

(i) Stresses in each section and **(5 mark)**

(ii) Total extension of the bar **(5 mark)**

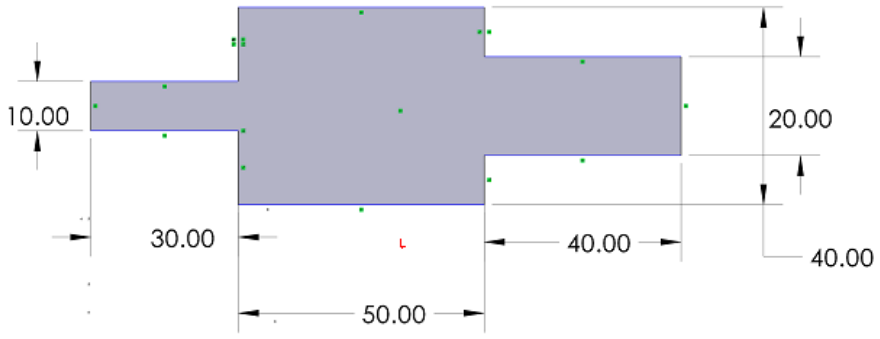


**Figure Q4**: Stepped Bar

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**QUESTION 5**

Consider a small bridge modeled as a truss structure, as shown in **Figure Q5**
Using the provided geometry and load details, complete the following tasks:

i. Briefly describe the nature of support reactions for hinged, roller and fixed support **(4 marks)**

ii. Determine the reaction forces at supports A and F. **(6 marks)**

iii. Calculate the internal forces in all members of the truss using the Method of Joints. **(15 marks)**

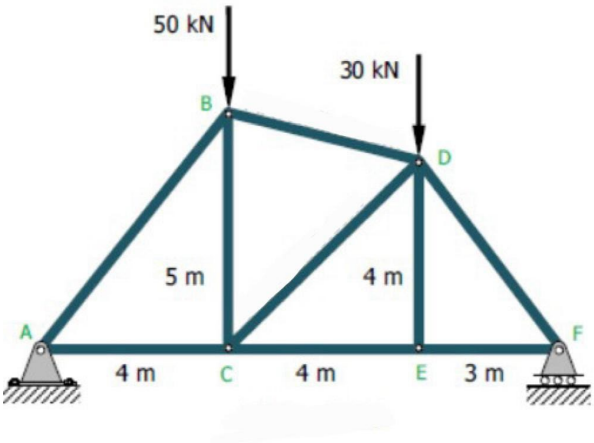


**Figure Q5**: Truss

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**QUESTION 6**

A simply supported beam carries concentrated lateral loads at C and D, and a uniformly distributed lateral load over the length CD as shown in **Figure Q6**. Determine:

i. Reaction loads at the support **(5 marks)**

ii. Construct the shear force diagram for the beam **(8 marks)**

iii. Construct the bending moment diagram for the beam **(8 marks)**

iv. Find the position of maximum bending moment. **(4 marks)**

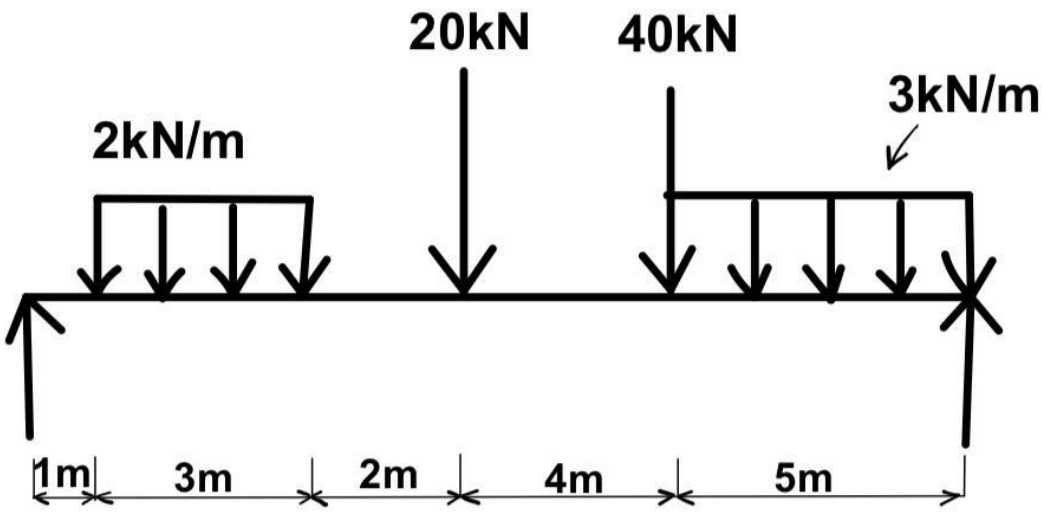


**Figure Q6:** Simply supported beam

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**END OF QUESTIONS**

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# FORMULA SHEET

Determinants

$$\frac{x}{D_x} = \frac{-y}{D_y} = \frac{z}{D_z} = \frac{-1}{D}$$

Matrices

$$A^{-1} = \frac{adjA}{D} X = A^{-1}B$$

Series

$U_n = a + (n - 1)\, d$

$S_n = \frac{n}{2}[2a + (n - 1)\, d]$

$U_n = ar^{n-1}$

$S_n = \frac{a(1-r^n)}{1-r}$

$$S_\infty = \frac{a}{1-r}$$

Binomial

$$\frac{n(n-1)}{2!}x^2 + \ldots\ldots\ldots\ldots\ldots..$$

$(1 + x)^n = 1 + nx +$

Validity $|x| < 1$ Partial Fractions

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$$\frac{F(x)}{(x+a)(x+b)} = \frac{A}{(x+a)} + \frac{B}{(x+b)}$$

$$\frac{F(x)}{(x+a)(x+b)(x+c)} = \frac{A}{(x+a)} + \frac{B}{(x+b)} + \frac{C}{(x+c)}$$

Stress

Normal $\sigma = \frac{P}{A}$ A = x-sectional area

Shear $\tau = \frac{P}{A}$ A = shear area

Strain

Normal $\varepsilon = \frac{\delta\ell}{\ell}$

Shear $\gamma = \frac{x}{y}$ (Angular Displacement in rads in direction of F)

Compound Bars

$P = P_1 + P_2$

$P = \sigma_1 A_1 + \sigma_2 A_2$

$$\frac{\sigma_1}{E_1} = \frac{\sigma_2}{E_2},$$

Elastic Constants

$$E = \frac{\sigma}{\varepsilon}, \qquad G = \frac{\tau}{\gamma}$$

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

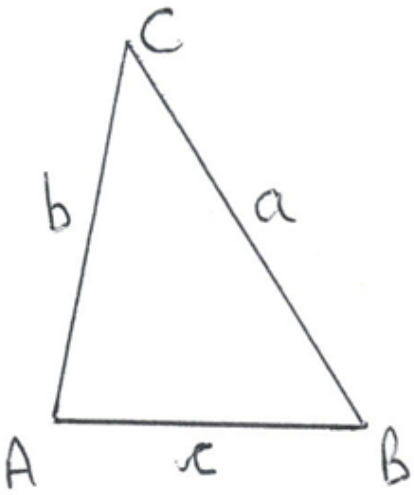
$$\varepsilon_y = \frac{\sigma_y}{E} - \upsilon\frac{\sigma_x}{E} - \upsilon\frac{\sigma_z}{E}$$

$$\varepsilon_z = \frac{\sigma_z}{E} - \upsilon\frac{\sigma_x}{E} - \upsilon\frac{\sigma_y}{E}$$

$$\varepsilon_v = \varepsilon_x + \varepsilon_y + \varepsilon_z$$

$$\varepsilon_v = \frac{1-2\upsilon}{E}(\sigma_x + \sigma_y + \sigma_z)$$

$$\varepsilon_v = \frac{\delta V}{V}$$




Compressibility

$$K = \frac{\sigma}{\varepsilon_V}$$

$$\varepsilon_V = \frac{3\sigma(1-2\upsilon)}{E}$$

$$E = 3K(1-2\upsilon)$$

$$E = 2G(1+\upsilon)$$

$$e_\upsilon = \frac{\delta L}{L}(1-2\mu)$$

Trigonometry

Sine Rule: $\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}$

Cosine Rule: $a^2 = b^2 + c^2 - 2bc \cos A$

**END OF PAPER**