UNIVERSITY OF BOLTON

OFF CAMPUS DIVISION

WESTERN INTERNATIONAL COLLEGE

BENG (HONS) MECHANICAL ENGINEERING

SEMESTER ONE EXAMINATION 2023/24

ENGINEERING PRINCIPLES 1

MODULE NO: AME4062

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

INSTRUCTIONS TO CANDIDATES: **There are SIX questions.**

Answer TWO Questions from Part A and TWO 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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BEng(Hons) Mechanical Engineering
Semester 1 Examination 2023/24
Engineering Principles I
Module No. AME4062

PART A

Question 1

a) Determine the inverse of the following matrix

$$\begin{pmatrix} 1 & 5 & -2 \\ 3 & -1 & 4 \\ -3 & 6 & -7 \end{pmatrix}$$

(10 marks

b) Two alternating voltages are given by

$$V_1 = 10 \sin \omega t \ volts \quad ; \qquad V_2 = 14 \sin\left(\omega t + \frac{\pi}{3}\right) volts$$

Determine a sinusoidal expression for the resultant $\mathbf{V_R = V_1 + V_2}$, using both sine and cosine rules and compare the answer of both rules graphically.

(10 marks)

c) Use De Moivre's Theorem to find the 5th power of the complex number z = 2(cos 24° + i sin 24°). Express the answer in the rectangular form a + bi

(5 marks)

(Total 25 marks)

Question 2

a) Use partial Fractions to expand:

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

(10 marks)

Question 2 continued over…

Please turn the page

Question 2 continued…

b) 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

(9 marks)

c) Solve the logarithmic equation

$$\log x^4 - \log x^3 = \log 5x - \log 2x$$ (3 marks)

$$2.68 = \ln (4.87 / x)$$ (3 marks)

(Total 25 marks)

Question 3

a) The law connecting friction F and load L for an experiment is given by

F = aL- Mb,

where a, b & M are constants. Given that when F=6.84N., L= 2.3N, M= 4.4 and when F= 1.23N, L=8.5N, M = 6.7. Find the following:

i) the value of a & b using ***determinant method*** (8 marks)

ii) find the value of F when L = 6.0 and M = 0 (2 marks)

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

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

(9 marks)

Question 3 continued over…

Please turn the page

Question 3 continued…

c) Solve, the following

$\log(x - 1) + \log(x + 8) = 2\log(x + 2)$ (3 marks)

$\log(x^2 - 3) - \log(x) = \log(2)$ (3 marks)

(Total 25 marks)

PART B

Question 4

A metallic bar 300 mm x 100 mm x 40 mm is subjected to a force of 5 kN (tensile),6 kN (tensile) and 4 kN (tensile) along x, y, and z directions respectively.

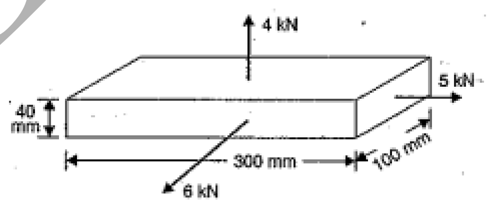

Figure Q4. Steel cube block

Question 4 continued over…

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Question 4 continued…

Determine the following:

a) Stresses in x, y and z directions (6 marks)

b) Assuming Poisson's ratio as 0.25, find in terms of modulus of elasticity of the material E, the strains in the direction of each force. (6 marks)

c) If modulus of elasticity E=200kN/mm^2, find the values of the modulus of rigidity and bulk modulus for the material of the block. (8 marks)

d) The change in volume of the block due to loading specified above. (5 marks)

Total 25 marks

Question 5

a) Two brass rods and one steel rod together support a load of 250kN denoted as P. Take *E* for steel as 2×10^5 N/mm^2 and for brass 1×10^5 N/mm^2. The cross-sectional area of steel rod is 1600 mm² and of each brass rod is 1000 mm².

I. Stress developed in steel rod (5 marks)

II. Stress developed in brass rod (5 marks)

III. Define compound bar and its rules of calculation (5 marks)

Question 5 continued over…

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Question 5 continued…

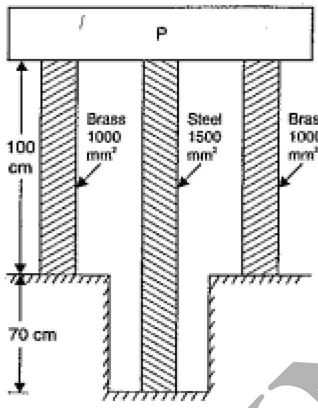

Figure Q5a. A Compound bar

b) The following forces act at a point as shown in Figure Q5b:

(i) 20 N inclined at 30° towards North of East,

(ii) 25 N towards North,

(iii) 30 N towards North-West, and

(iv) 35 N inclined at 40° towards the South of West.

Find the magnitude and direction of the resultant force.

(10 marks)

Question 5 continued over…

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Question 5 continued…

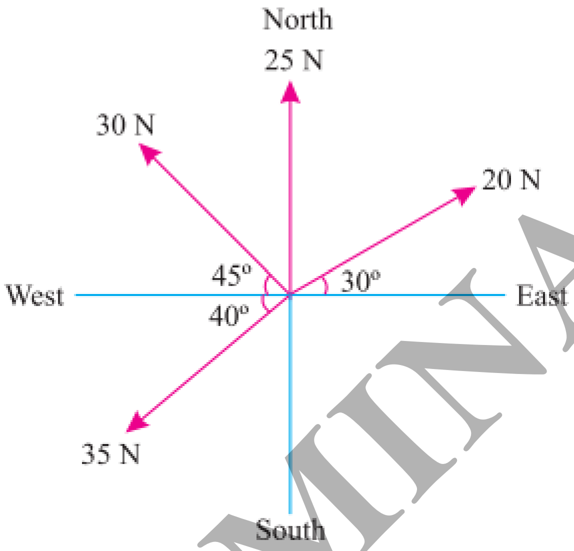

Figure Q5b. Concurrent force system

Total 25 marks

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)

Question 6 continued over…
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Question 6 continued…

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

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

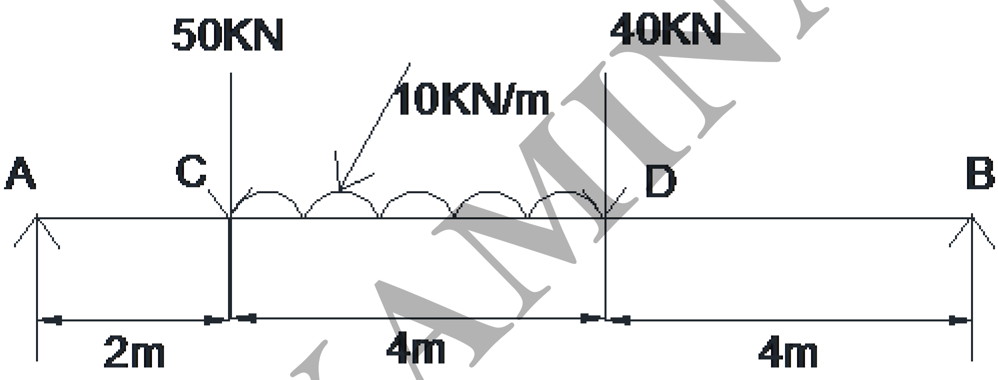

Figure Q6. Simply supported beam

Total 25 marks

END OF QUESTIONS

Please turn the page for formulae

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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

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

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

Please turn the page

Validity $|x| < 1$ Partial Fractions

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

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

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

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

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

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

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

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

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

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

<u>Compressibility</u>

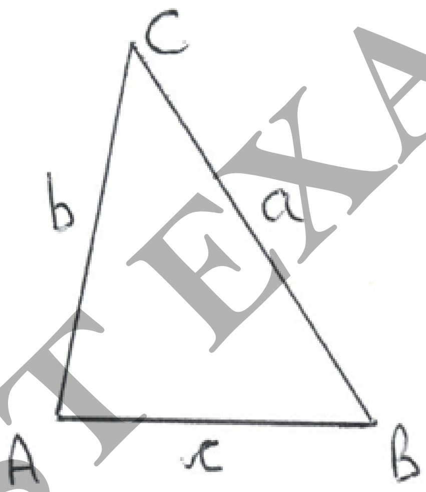
$$K = \frac{\sigma}{\varepsilon_V}$$

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

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

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

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



<u>Trigonometry</u>

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