UNIVERSITY OF BOLTON

WESTERN INTERNATIONAL COLLEGE FZE

BENG (HONS) MECHANICAL ENGINEERING

SEMESTER ONE EXAMINATION 2019/2020

ENGINEERING PRINCIPLES 1

MODULE NO: AME4062

Date: Thursday 16th January 2020 **Time: 1:00pm – 3:00pm**

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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Engineering Principles 1
Module No. AME4062

PART A

Q1.

a) The complex number z can be expressed as $\mathbf{z} = -\frac{1}{2} + \frac{1}{2}\mathbf{j}$

Evaluate $z^{1/2}$ and display the roots in an argand diagram.

(6 marks)

b) Resolve into partial fractions:

$$\frac{x^2 + 1}{x^2 - 3x + 2}$$

(9 marks)

c) Two alternating voltages are given by

$$V_1 = 7\sin\omega t \ volts \quad ; \qquad V_2 = 5\sin\left(\omega t + \frac{\pi}{4}\right) volts$$

Determine a sinusoidal expression for the resultant $\mathbf{V_R = V_1 + V_2}$, using sine and cosine rule and compare your results graphically.

(10 marks)

(Total 25 marks)

Q2.

a) The energy **W** stored in a flywheel is given by: $W = kr^5 N^2$, where **k** is a constant, **r** is the radius and **N** the number of revolutions. Determine the approximate percentage change in the energy stored **W** when the radius **r** is increased by 1.3% and the number of revolution **N** is decreased by 2%.

(5 marks)

Q2 continued over the page

Q2 continued…

b) In a mass-spring-damper system, the acceleration $\ddot{x}\,\frac{m}{s^2}$, velocity $\dot{x}\ m/s$ and displacement **x** m are related by the following simultaneous equations:

$$6.2\ddot{x} + 7.9\dot{x} + 12.6x = 18.0$$

$$7.5\ddot{x} + 4.8\dot{x} + 4.8x = 6.39$$

$$13.0\ddot{x} + 3.5\dot{x} \pm 13.0x = -17.4$$

By using ***Determinant method***, determine the acceleration, velocity and displacement for the mass – damper system, correct to 2 decimal places.

(12 marks)

c) The temperature **θ^0C** of an electrical conductor at time **t** seconds is given by: **$\theta = \theta_0\,(1 - e^{-t/T})$**, where **$\theta_0$** is the initial temperature and **T** seconds is a constant. Determine:

(i) θ when $\theta_0 = 159.9^0$C, t =30s and T = 80s,

(4 marks)

(ii) the time t for θ to fall to half the value of θ_0 if T remains at 80 s.

(4 marks)

(Total 25 mark)

Q3.

a) In two closed loops of an electrical circuit, the currents flowing (**I**) in Amperes are given by the simultaneous equations:

$$I_1 + 2I_2 + 4 = 0$$

$$5I_1 + 3I_2 - 1 = 0$$

Use matrices method to solve for I_1 and I_2 respectively from the equations

(10 marks)

Q3 continued over the page

Q3 continued…

b) A ship heads in a direction of E20^{0}S at a speed of 27 km/hr while the current is 6 km/hr in a direction of N30^{0}E. Determine the speed and actual direction of the ship.

(7 marks)

c) Solve the logarithmic equations:

(i) $\log(x^2+8) - \log(2x) = \log 3$

(4 marks)

(ii) $\ln x + \ln(x-3) = \ln 6x - \ln(x-2)$

(4 marks)

(Total 25 marks)

END OF PART A

PLEASE TURN THE PAGE FOR PART B

PART B

Q4.

a) A compound bar consists of a circular rod of steel of diameter 20mm rigidly fitted into a copper tube of internal diameter 20mm and thickness 5mm as shown in **Figure Q4**. If the bar is subjected to a load of 100kN,determine the following:

(i) Stress developed in steel rod

(7 marks)

(ii) Stress developed in copper tube

(7 marks)

Take modulus of elasticity, E of steel as 200GPa and E of copper as 120GPa

(iii) Define compound bar and its rules of calculation

(3 marks)

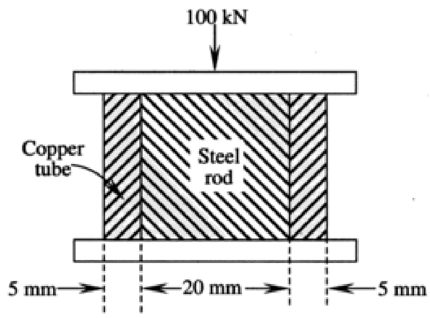

Figure Q4. A Compound bar

b) A bar 24mm in diameter and 400mm in length is acted upon by an axial load of 38kN.the elongation of the bar and the change in diameter are measured as 0.165mm and 0.0031mm respectively. Determine the following:

(i) Poisson’s ratio

(3 marks)

(ii) The values of modulus of elasticity, bulk modulus and rigidity modulus.

(5 marks)

Total 25 marks

Please turn the page

Q5.

a) A steel bar of 20mm diameter is loaded as shown in **Figure Q5a**.The loads applied are axially which include axial and compressive loads. Using superposition determine the following:

(i) Stresses in each part

(6 marks)

(ii) Total elongation

(6 marks)

Take E = 210 GPa

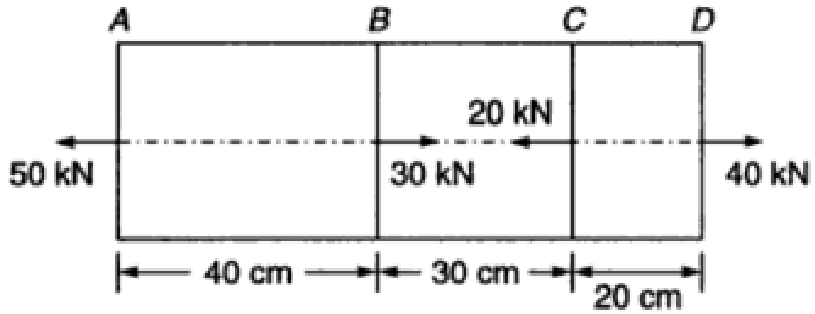

Figure Q5a.

b) A Square plate with non-concurrent coplanar forces acting on a hook is shown in the free body diagram in **Figure Q5b**.

Determine the following forces for the static equilibrium of the square plate:

I. The force F_D

(4 marks)

II. The force F_C

(4 marks)

III. The angle Θ

(5 marks)

Q5 continued over the page

Q5 continued…

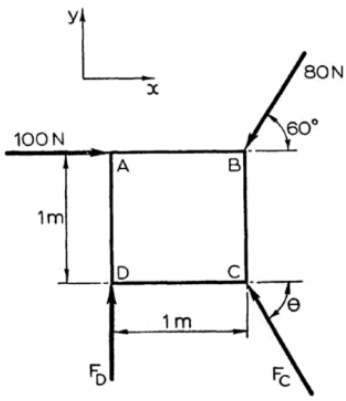

Figure Q5b. Square plate with non-concurrent coplanar forces acting on a hook

Total 25 marks

Q6.

A simply supported beam carries concentrated lateral loads at C and E, and a uniformly distributed lateral load over the length DC 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)

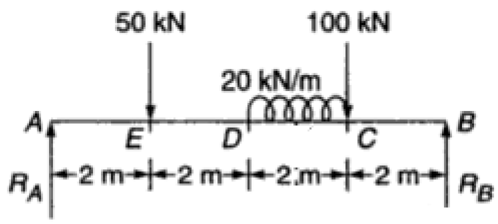

Figure Q6. Simply supported beam

Total 25 marks

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

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

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

$U_n = ar^{n-1}$

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

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

$U_n = a + (n - 1)d + \frac{1}{2}(n - 1)(n - 2)C$

Binomial

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

Validity $|x| < 1$

Partial Fractions

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

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

Formula sheet continued over the page

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Formula sheet Continued…

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

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

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

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

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

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

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

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

Formula sheet continued over the page

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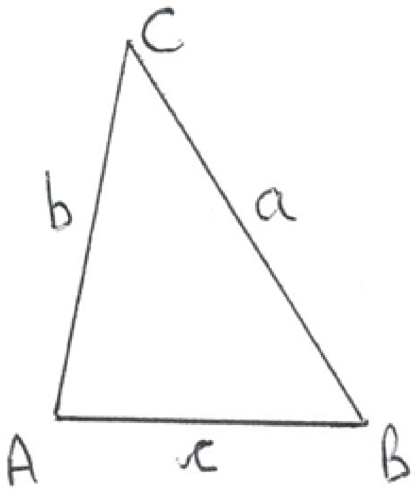

Compressibility

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

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

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

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

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

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 FORMULA SHEET