[ENG19]

UNIVERSITY OF BOLTON

SCHOOL OF ENGINEERING

B.ENG (HONS) MECHANICAL ENGINEERING

SEMESTER 1 EXAMINATION - 2023/2024

ENGINEERING PRINCIPLES 1

MODULE NO: AME4062

Date: Wednesday 10th January 2024 Time: 10:00 – 12:00

INSTRUCTIONS TO CANDIDATES:

There are THREE questions in TWO sections.

Answer ANY FOUR questions only.

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 cleared prior to the examination.

CANDIDATES REQUIRE:

Formula Sheets (attached after questions).

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B.Eng (Hons) Mechanical Engineering
Semester 1 Examination 2023/2024
Engineering Principles 1
Module No. AME4062

Section 1: Mathematics

Question 1

a) **Figure Q1a** shows the symmetrical part of a rectangular bridge. Point X is the midpoint of $ABCD$. Find the size of θ angle, AB, BC and BD if $CD = 8\,m$ and $AC = 16\,m$.

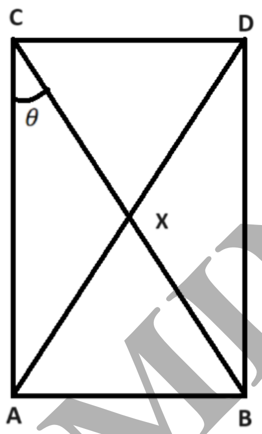

Figure Q1a: Bridge.

[10 Marks]

QUESTION 1 CONTINUES OVER THE PAGE…

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…QUESTION 1 CONTINUED

b) **Figure Q1b shows** a crank mechanism. Crank arm OA, of length $130\ mm$, rotates clockwise about O. Connecting rod AB is of length $350\ mm$.

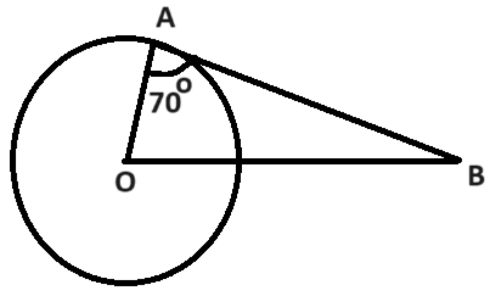

Figure Q1b: Crank mechanism.

i. If angle $OAB = 70^{\circ}$, find length OB.

[05 Marks]

ii. if OAB is changed into 60°, find length OB.

[05 Marks]

c) **Figure Q1c**, without using a calculator, evaluate i) $sin(45^{\circ})$, ii. $cos(45^{\circ})$, iii. $tan(45^{\circ})$, iv) $cosec(45^{\circ})$ and v) $sec(45^{\circ})$

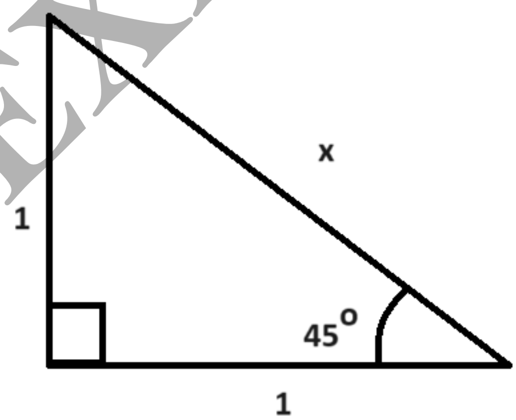

Figure Q1c: Triangle. **[05 Marks]**

Total 25 Marks

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Question 2

a) A gas in a cylinder has an initial volume of $3\ m^3$ at a pressure of $25000\ Pa$ (initial). The gas is then compressed to a volume of $1\ m^3$ according to the law

$$P(V)^{1.2} = C$$

where, P is pressure, V is velocity and C is a constant.

i. Find the final pressure of the gas based on the information above.

[05 Marks]

ii. If the initial pressure is changed into $27\ kPa$, then find the final pressure of the gas.

[05 Marks]

b) The velocity, v in m/s, of a bicycle during the application of brakes according to time t in s is given by

$$v = 10e^{-kt}$$

where, k is a friction constant of the brakes and its 0.5 and elapsed time, t is in sec.

i. At elapsed time, $t = 4\ s$, determine the velocity, v in m/s.

[05 Marks]

ii. If velocity, v is changed into $2\ m/s$, then what will be the elapsed time, t in s?

[05 Marks]

c) Determine x and y in m, using the following equations where $t = 10\ s$

i. $x = 10 + 6e^t$

[2.5 Marks]

ii. $y = 9 + 3ln\ (t)$

[2.5 Marks]

Total 25 Marks

Please turn the page…

Question 3

a) Two stresses, σ_1 and σ_2 in MPa at a certain point of a structure is defined by following equations:

$$6\sigma_1 + 8\sigma_2 = 20$$
$$4\sigma_1 + 5\sigma_2 = 10$$

Determine the values of σ_1 and σ_2 in MPa using Matrix.

[10 Marks]

b) Evaluate the following matrix multiplication:

$$\begin{bmatrix} 1 & 2 & 3 \\ 1 & 3 & 6 \end{bmatrix}\begin{bmatrix} 1 & 1 \\ 3 & 2 \\ 1 & 3 \end{bmatrix}$$

[10 Marks]

c) A force, $\vec{F}$ in N moves an object through a displacement, $\vec{s}$ in m. Find the work done, w in J by the force $\vec{F}$. Here,

$$\vec{F} = 10\hat{\imath} - 4\hat{\jmath} + 2\hat{k}$$
$$\vec{s} = 5\hat{\imath} + 2\hat{\jmath} + 3\hat{k}$$
$$w = \vec{F}.\vec{s}$$

[05 Marks]

Total 25 Marks

Please turn the page…

Section 2: Mechanics

Question 4

a) Consider a water pipeline, represented as a cylindrical structure and depicted as a beam in **Figure Q4**. Assume the pipeline is operating under steady conditions and ignore the effects of its own weight. When analysing the pipeline as a beam, complete the following tasks:

i. Draw a Free-body diagram of the beam.

[04 marks]

ii. Calculate the Support reactions at points A and B.

[04 marks]

iii. Construct the Shear Force diagram for the beam.

[04 marks]

iv. Construct the Bending diagram for the beam.

[04 marks]

v. Identify the locations on the beam where maximum and minimum bending moments occur.

[04 marks]

b) In Figure Q4, replace the existing $6\ kN$ load with a new point load of $2\ kN$ that is applied vertically downwards. This new load is positioned $2.5\ m$ away from point A on the beam. Based on this configuration, calculate the moment generated by this load.

[05 marks]

Total 25 marks

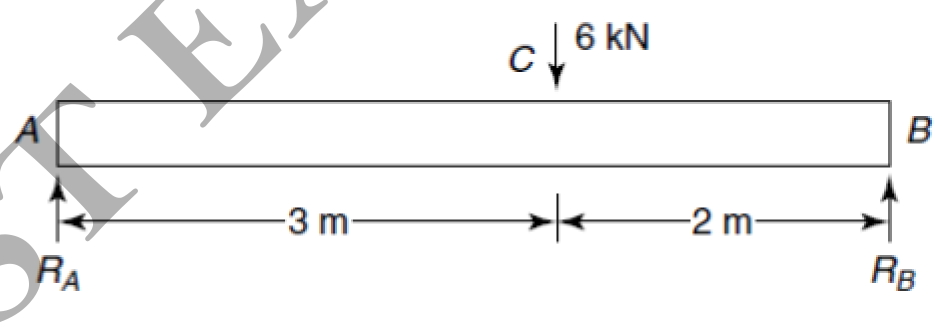

Figure Q4: Simply supported beam.

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Question 5

a) Address the following concepts in mechanics of material:

i. Define **Hooke's Law** in straightforward terms. Include in your explanation how Hooke's Law relates to the behaviour of materials under elastic deformation, emphasising its importance in understanding how materials respond to applied forces within their elastic limits.

[04 marks]

ii. Explain the concept of **'stress'** in material science. Provide a clear definition of stress and discuss its significance in assessing how materials withstand external forces, focusing on its role in determining material strength and failure points.

[04 marks]

iii. Describe what is meant by **'strain'** in the context of materials. Offer a concise explanation of strain, illustrating its relevance in measuring the extent of deformation in materials when they are subjected to stress.

[04 marks]

b) Consider a scenario where a crane uses a special cable, referred to as 'cable X', to lift bricks weighing $89000\ N$, as depicted in **Figure Q5** (shown over the page). The cable, made from a strong material, has a diameter of $0.0254\ m$ and an initial length of $15.24\ m$ before lifting. The material of the cable has a modulus of elasticity, E of $2.41361\ x\ 10^{11} Pa$. Based on this information, calculate the following:

i. The normal stress experienced by the cable.

[04 marks]

ii. The normal strain in the cable.

[04 marks]

iii. The elongation of the cable under the given load.

[05 marks]

Please demonstrate your calculations step-by-step and ensure to use the provided units in your answers.

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…QUESTION 5 CONTINUED

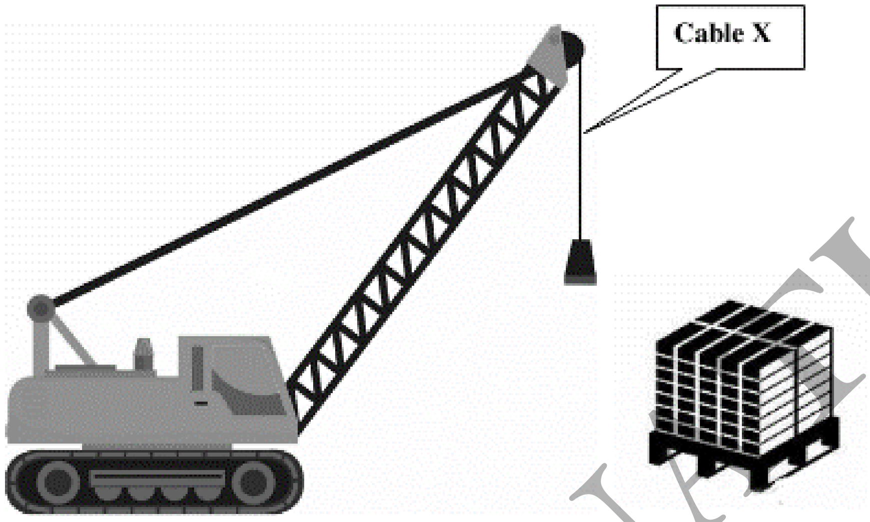

Figure Q5: A Crane.

Total 25 marks

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Question 6

Consider a small bridge modeled as a truss structure, as shown in Figure **Q6**. Using the provided geometry and load details, complete the following tasks:

i. Draw a Free Body Diagram (FBD) for the truss.

[04 marks]

ii. Determine the reaction forces at supports A and D.

[04 marks]

iii. Calculate the internal forces in all members of the truss using the Method of Joints. Consider the joins A, B, C, and D for this analysis.

[12 marks]

iv. Verify your results by applying the Method of Joints at joint E.

[5 marks]

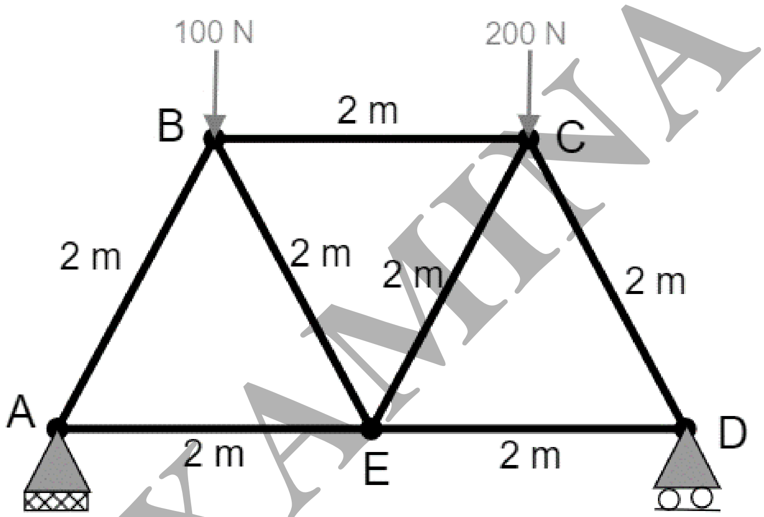

Figure Q6: Truss structure.

Total 25 marks

END OF QUESTIONS

Formula sheets follow over the page

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<u>Formula Sheets</u>

Mathematics Equations

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Trigonometry:

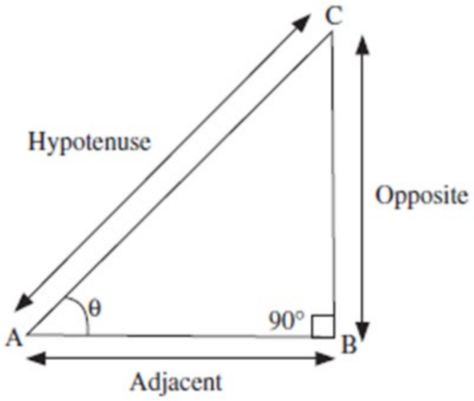

Figure E1

In **Figure E1**,

$$sin(\theta) = \frac{opposite\ length}{hypotenuse\ length}$$

$$cos(\theta) = \frac{adjacent\ length}{hypotenuse\ length}$$

$$tan(\theta) = \frac{opposite\ length}{adjacent\ length}$$

$$cosec(\theta) = \frac{1}{sin(\theta)}$$

$$sec(\theta) = \frac{1}{cos(\theta)}$$

$$cot(\theta) = \frac{1}{tan(\theta)}$$

Please turn the page…

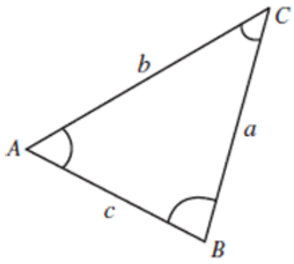

Figure E2

According to cos rule in **Figure E2**,

$$a^2 = b^2 + c^2 - 2bc.cos(A)$$

Matrix:

$$A^{-1} = \frac{1}{detA} \times adj(A)$$

where,

$$A = \begin{pmatrix} a & b \\ c & d \end{pmatrix}$$

$$detA = ad - bc$$

$$Adj(A) = \begin{pmatrix} d & -b \\ -c & a \end{pmatrix}$$

Vector:

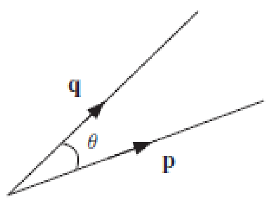

Figure E3

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In **Figure E3**, scaler product can be defined as

$$\boldsymbol{p}.\boldsymbol{q} = |\boldsymbol{p}||\boldsymbol{q}|cos\theta$$

If $\boldsymbol{p} = a\boldsymbol{i} + b\boldsymbol{j} + c\boldsymbol{k}$ and $\boldsymbol{q} = d\boldsymbol{i} + e\boldsymbol{j} + f\boldsymbol{k}$, then $\boldsymbol{p}.\boldsymbol{q} = ad + be + cf$

$$\boldsymbol{p} = a\boldsymbol{i} + b\boldsymbol{j} + c\boldsymbol{k}$$

$$\boldsymbol{q} = d\boldsymbol{i} + e\boldsymbol{j} + f\boldsymbol{k}$$

Mechanics Equations

Tensile Properties:

Normal Stress,

$$\sigma = \frac{F}{A}$$

where A is cross-sectional area and F is force normal to the A.

Strain,

$$\varepsilon = \frac{\Delta L}{L}$$

where L is initial length and ΔL is change in length.

Elastic Modulus,

$$E = \frac{\sigma}{\varepsilon}$$

Beam &Truss:

At any node of a truss,

Summation of all the vertical loads,

$$\Sigma F_y = 0$$

Summation of all the horizontal loads,

$$\Sigma F_x = 0$$

Please turn the page…

Summation of Moments,

$$\Sigma M = \Sigma M_{clockwise} - \Sigma M_{anticlockwise} = 0$$

Moment,

$$M = r \times F$$

where, F is applied load and r is perpendicular distance to F

End of Formula Sheets

END OF PAPER