UNIVERSITY OF BOLTON

SCHOOL OF ENGINEERING

B.ENG (HONS) MECHANICAL ENGINEERING

SEMISTER ONE EXAMINATION - 2021/2022

ENGINEERING PRINCIPLES 1

MODULE NO: AME4062

Date: Tuesday 11th January 2022 **Time: 10:00 – 12:00**

INSTRUCTIONS TO CANDIDATES:

There are SIX questions.

Answer FOUR questions, TWO from each section.

All questions carry equal marks.

Marks for parts of questions are shown in brackets.

Formula and equation sheets have been provided at the back of the examination paper.

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

Total Marks: 100

School of Engineering
B.Eng (Hons) Mechanical Engineering
Semester One Examination 2021/2022
Engineering Principles 1
Module No. AME4062

Section 1: Mathematics – Answer TWO questions

Question 1

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

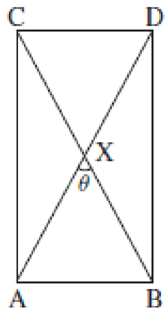

Figure Q1a: Bridge.

[8 Marks]

b) **Figure Q1b** shows a crank mechanism. Crank arm OA, of length 140 mm, rotates clockwise about O. Connecting rod AB is of length 340 mm. If angle OAB=60^{o}, find length OB.

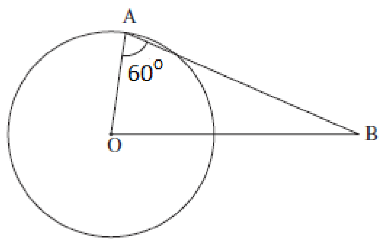

Figure Q1b: Crank mechanism.

[7 Marks]

Question 1 continued over the page….

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Question 1 continued…

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

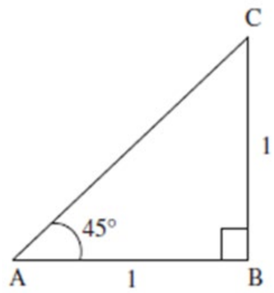

Figure Q1c: Triangle.

[5 Marks]

d) From **Figure Q1d**, without using a calculator, evaluate i) $sin(30^{\circ})$, ii) $cos(30^{\circ})$, iii) $cos(60^{\circ})$, iv) $tan(60^{\circ})$ and v) $cosec(30^{\circ})$

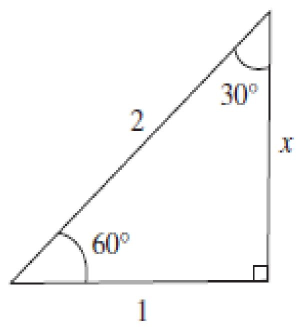

Figure Q1d: Triangle.

[5 Marks]

[Total 25 Marks]

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Question 2

a) The velocity, v, of a vehicle during the application of brakes according to time t is given by $v = 8e^{-kt}$, where k is a friction constant of the brakes. At t= 25 s, the velocity is reduced to 2 m/s. Determine k.

[8 Marks]

b) A gas in a piston has an initial volume of 0.02 m^3 at a pressure of 240 kPa. The gas is then compressed to a pressure of 700 kPa according to the law $P(V)^{1.2} = C$, where, P is pressure, V is velocity and C is a constant. Find the final volume.

[7 Marks]

c) The current gain, G, in neper of a system is defined as $G = ln(\frac{I_{out}}{I_{in}})$, where I_{out} and I_{in} are the output and input current, respectively. Evaluate G for I_{out}=0.4 mA and I_{in}=0.0001 A.

[5 Marks]

d) Evaluate the following:

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

[5 Marks]

[Total 25 Marks]

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Question 3

a) By applying Kirchoff's law to a circuit we obtain the following equations:

$$6i_1 + 8i_2 = 2$$
$$5i_1 + 6i_2 = 1$$

Where, i_1 and i_2 represent current in Ampere (A). Find the values of i_1 and i_2 using Matrix.

[10 Marks]

b) **Figure Q3b** shows an object O subject to forces. Find the resultant force $\boldsymbol{R}$ in terms of magnitude and angle.

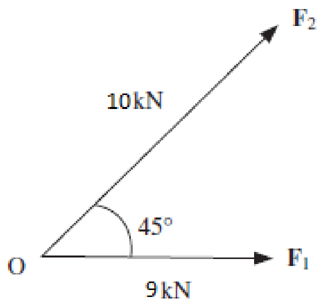

Figure Q3b: Object O subject to forces.

[5 Marks]

c) The velocity, $\boldsymbol{v}$, and acceleration, $\boldsymbol{a}$, of a particle are given by

$$\boldsymbol{v} = 16\boldsymbol{i} - 6\boldsymbol{j} + \boldsymbol{k}$$
$$\boldsymbol{a} = 6\boldsymbol{i} + 4\boldsymbol{j} + \boldsymbol{k}$$

Determine the angle between the velocity, $\boldsymbol{v}$, and acceleration, $\boldsymbol{a}$.

[5 Marks]

d) Determine the moment vector (**Figure Q3d**), M, about the origin, O, of a force, $F = 10\boldsymbol{i} - \boldsymbol{j} + 2\boldsymbol{k}$ passing through the point with position vector, $\boldsymbol{r} = 2\boldsymbol{i} - 3\boldsymbol{j} + 5\boldsymbol{k}$.

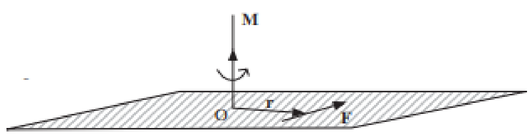

Figure Q3d: Moment vector.

[5 Marks]

[Total 25 Marks]

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<u>Section 2: Mechanics</u> – Answer <u>TWO</u> questions

Question 4

a) You have conducted a tensile test to determine the properties of a material. The results of a tensile test are as follows:
Diameter of specimen 15 mm;
Gauge length 40 mm;
Load at limit of proportionality 85 kN;
Extension at limit of proportionality 0.075 mm;
Maximum load 120 kN;
Final length at point of fracture 55 mm.

Determine

i. Young's modulus of elasticity,

[6 marks]

ii. the ultimate tensile strength,

[3 marks]

iii. the stress at the limit of proportionality,

[3 marks]

iv. the percentage elongation.

[3 marks]

b) A hollow cast iron cylinder of outside diameter D and wall thickness of 10 mm (**Figure Q4**) is to carry a compressive load of 100 kN. Compute the required outside diameter D, if the working stress in compression is 80 N/mm^2.

[10 marks]

[Total 25 marks]

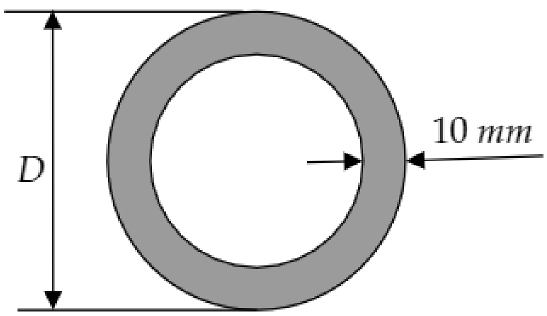

Figure Q4: Hollow circular cross-section.

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Question 5

a) Describe the roller, pinned and fixed supports and also state the types of reactions at each of the supports.

[6 marks]

b) A truss structure for a small bridge is shown in **Figure Q5.** For the given geometry and loads,

c)

i. Find the reactions at supports A and D.

[4 marks]

ii. Calculate forces in all truss members using the Method of Joints. Consider the joints A, B, C and D only.

[12 marks]

iii. Check your results by applying the method of joints at joint E.

[3 marks]

[Total 25 marks]

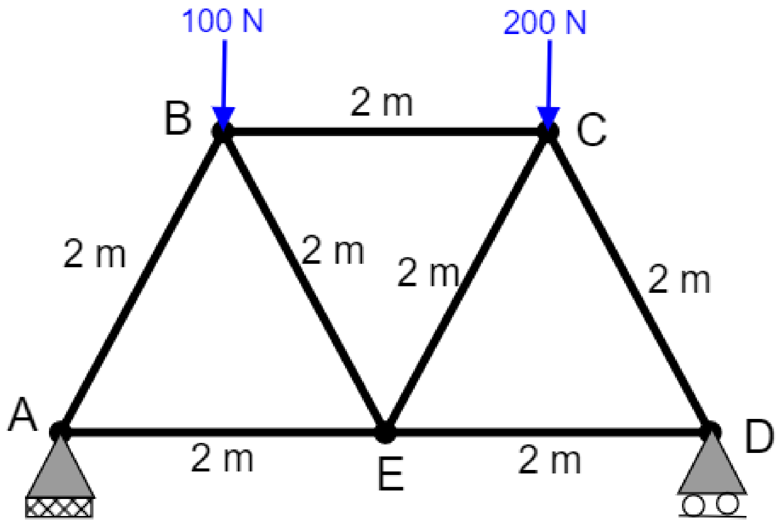

Figure Q5: Truss structure.

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Question 6

a) A cantilever beam supports three point loads as shown in **Figure Q6a**. For this beam configuration

i. Find the reaction forces and moments at the fixed end.

[4 marks]

ii. Construct the shear force diagram.

[5 marks]

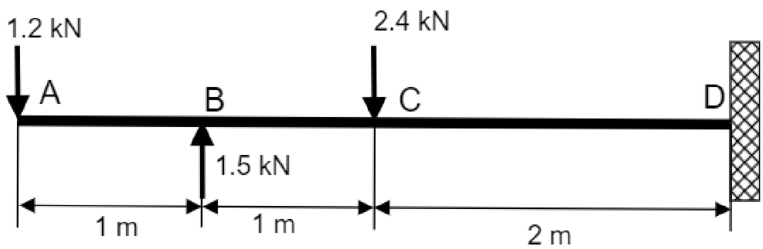

Figure Q6a: Cantilever beam.

b) A hollow rectangular beam is used to support an industrial motor in machining plant. The beam is simply supported, and the weight acting on the beam can be modelled as a uniformly distributed load as shown in **Figure Q6b**. For this beam:

i. Determine the reactions at the supports A and B. **[4 Marks]**

ii. Draw the shear force and bending moment diagrams with appropriate annotations. **[8 Marks]**

iii. Find the maximum bending moment and the location on the beam that experiences maximum bending moment. **[4 Marks]**

[Total 25 marks]

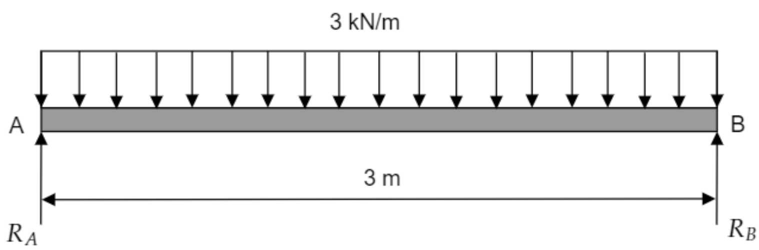

Figure Q6b: Simply supported beam with UDL.

END OF QUESTIONS

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Mathematics Equations

Trigonometry:

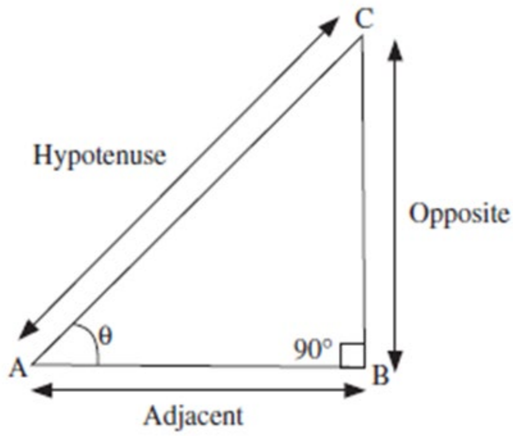

Figure 7

In Figure 7,

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

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

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

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

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

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

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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:

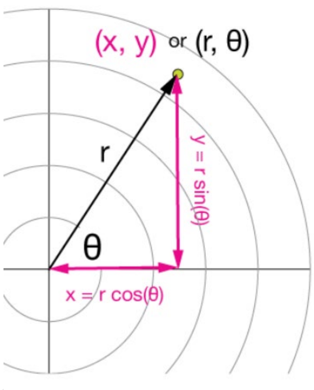

Figure 8

In Figure 8

$$x = rcos\theta$$

$$y = rsin\theta$$

$$\boldsymbol{r} = |\boldsymbol{r}|cos\theta\boldsymbol{i} + |\boldsymbol{r}|sin\theta\boldsymbol{j}$$

Where, $\boldsymbol{i}$ and $\boldsymbol{j}$ are unit vectors in the x (horizontal) and y (vertical) directions.

$$|\boldsymbol{r}| = \sqrt{x^2 + y^2}$$

$$\theta = \tan^{-1}\left(\frac{y}{x}\right)$$

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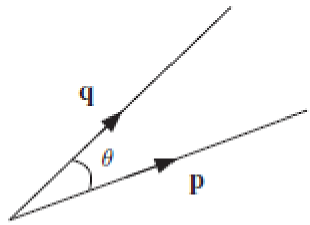

Figure 9

In Figure 9, scaler product can be defined as

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

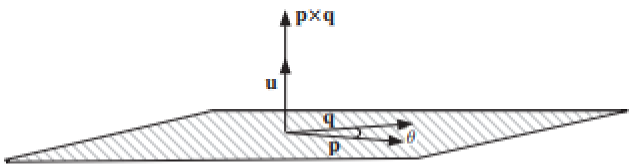

Figure 10

In Figure 10, vector product can be defined as

$$\boldsymbol{p} \times \boldsymbol{q} = |\boldsymbol{p}||\boldsymbol{q}|sin(\theta)\boldsymbol{u}$$

If

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

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

Then,

$$\boldsymbol{p} \times \boldsymbol{q} = det\begin{pmatrix} \boldsymbol{i} & \boldsymbol{j} & \boldsymbol{k} \\ a & b & c \\ d & e & f \end{pmatrix} = (bf - ce)\boldsymbol{i} + (af - dc)\boldsymbol{j} + (ae - bd)\boldsymbol{k}$$

End of the Formula Sheet

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