[ENG34]

UNIVERSITY OF BOLTON

SCHOOL OF ENGINEERING

B.Eng (Hons) MECHANICAL ENGINEERING

SEMESTER TWO EXAMINATIONS 2021/22

ENGINEERING PRINCIPLES 2

MODULE No: AME4063

Date: Wednesday 18th May 2022 **Time: 10:00 -12:00**

INSTRUCTIONS TO CANDIDATES:

There are SIX questions.

Answer ANY FOUR questions.

All questions carry equal marks.

Marks for parts of questions are shown in brackets.

This examination paper carries a total of 100 marks.

All working must be shown. A numerical solution to a question obtained by programming an electronic calculator will not be accepted.

Candidates require:

Formuls sheet (provided following questions from page 7)

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Question 1

Determine the location of the stationary points and classify them for the following two functions.

a) $f(\mathrm{x}) = \mathrm{x}^3 - \frac{21}{2}\,\mathrm{x}^2 + 30\mathrm{x} + 22$ on the interval [1,6].

[13 marks]

b) $f(\mathrm{x}) = \frac{1}{4}\,\mathrm{x}^4 - 2\,\mathrm{x}^3 + 8$ on the interval [-4,10].

[12 marks]

Total 25 marks

Question 2

(a) Calculate the following definite integral.

$$\int_{x=-3}^{x=3} (2x^5 + 4x^3 - 5x)\,dx$$

[8 marks]

(b) Use integration to find the area of the blue shaded region in **Figure Q1** up to three decimal places. **[17 marks]**

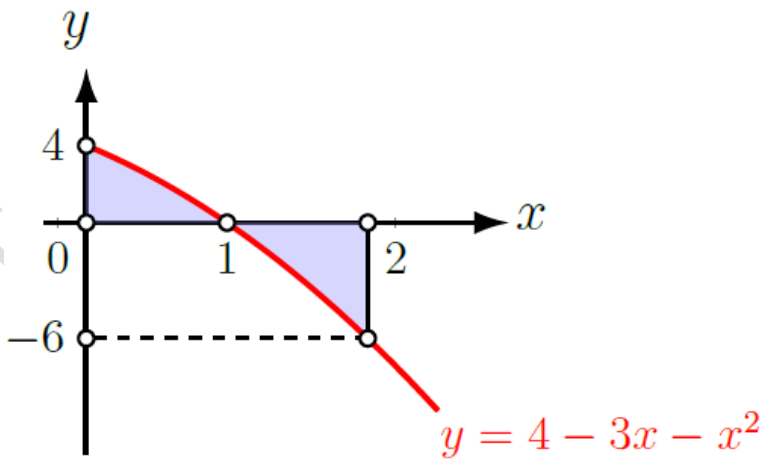

Figure Q1: Area under curve

Total 25 marks

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Question 3

a) What are section properties and write down four important section properties.

[5 marks]

b) Calculate the total area and the area moment of inertia (or second moment of area) about the horizontal axis passing through the centrioid for the following I section (**Figure Q2**).

You first need to compute the centroid and then prove that the section is symmetric with respect to the horizontal axis passing through the centroid.

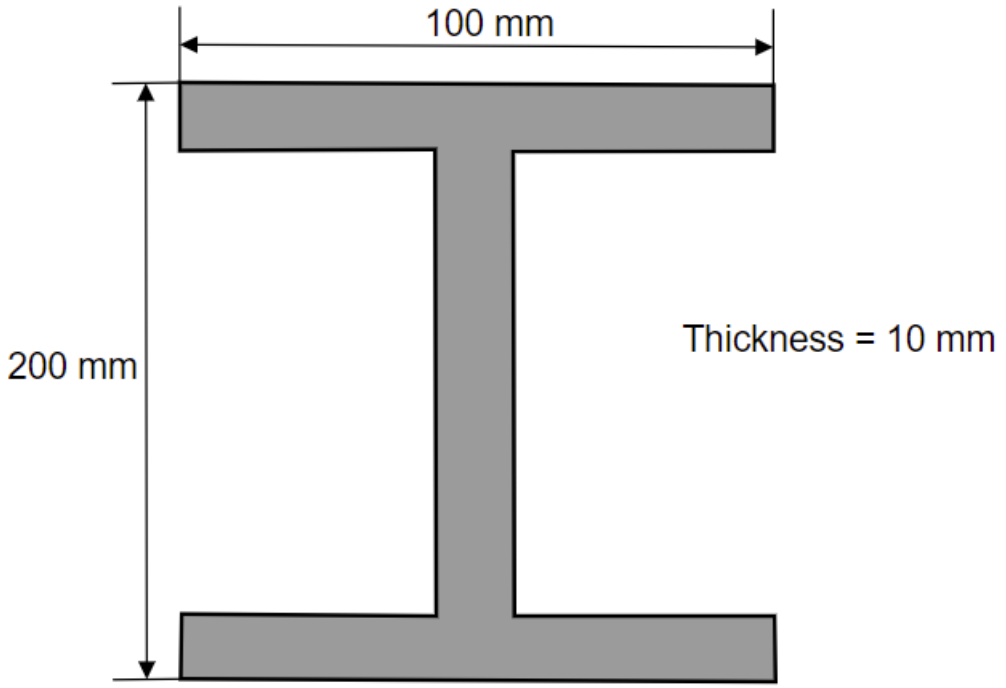

Figure Q2: I-section

[20 marks]

Total 25 marks

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Question 4

(a) Briefly answer the following questions on Torque.

(i) What is Torque?

(ii) What is the SI unit of Torque?

(iii) What are the practical applications of Torque?

[5 marks]

(b) A hollow propellor shaft transmits a torque of 1.76 kN m. The outer and inner diameters of the shaft are 70 mm and 45 mm, respectively.
Assume that the modulus of rigidity is 90 GPa.

(i) If the speed of rotation of the shaft is 100 rpm, find the power transmitted.

[4 marks]

(ii) Calculate the polar moment of inertia of the shaft.

[4 marks]

(iii) Find the shear stress at both the outer and inner surfaces.

[8 marks]

(iv) Calculate the angle of twist if the length of the shaft is 2 m.

[4 marks]

Total 25 marks

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Question 5

(a) A ball is thrown vertically upwards from point A. The ball reaches a point B which is at a height of 50 m from point A. Calculate the time between the instant that the ball is projected and the instant it returns to A.

[13 marks]

(b) A flywheel of diameter 1 m has its initial angular velocity of 8 rad/s increased by an acceleration of 15 rad/s^2 whilst making 150 revolutions. Calculate

i. the final angular velocity of the flywheel, and

ii. the time taken for the 100 revolutions.

[12 marks]

Total 25 marks

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Question 6

A simply supported beam with solid rectangular cross-section is used to support a storage attic. The weight acting on the beam can be modelled as a uniformly distributed load as shown in **Figure Q6a**. The dimensions of rectangular cross-section are shown in **Figure Q6b**. For this beam, answer the the following:

a) Find the reactions at the supports A and B. **[4 marks]**

b) The bending moment is given by $M = 2x(3 - x)\ kNm$, where x is the distance from the left end, point A. Draw the bending moment diagram. Find the location and the value of the maximum. **[7 marks]**

c) Calculate the second moment of area of the cross-section with respect to horizontal axis passing through the centroid. **[5 marks]**

d) Calculate the maximum tensile and compressive stresses in the beam, and draw the distribution of stress along the thickness of the beam.

[9 marks]

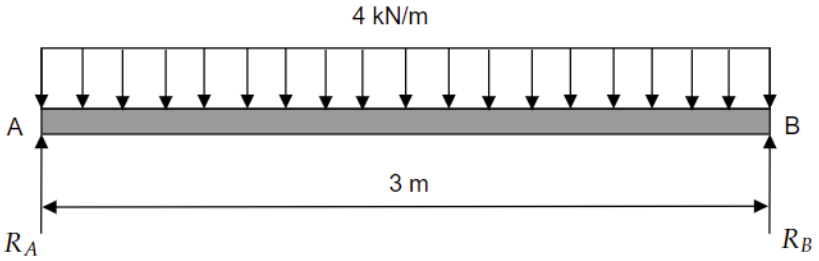

Figure Q6a: Simply supported beam with UDL.

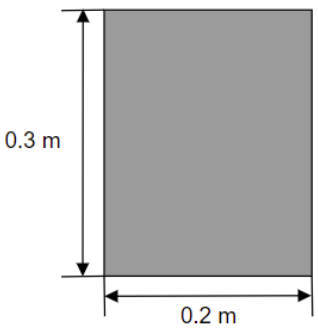

Figure Q6b: Solid rectangular cross-section.

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END OF QUESTIONS

Formula Sheet follows on the next page….
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FORMULAE SHEET

Table of derivatices

$f(x)$	$\frac{df}{dx}$
c	0
x	1
x^2	$2x$
x^n	$n\,x^{n-1}$

Note: c is a constant.

Table of integrals

$f(x)$	$\int f\,dx$
1	$x + C$
k	$kx + C$
x	$\frac{x^2}{2} + C$
x^2	$\frac{x^3}{3} + C$
$x^n, n \neq -1$	$\frac{x^{n+1}}{n+1} + C$
$\frac{1}{x}$	$\ln(x) + C$

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Note: C and k are constants.

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Torsion formula

$$\frac{T}{J} = \frac{\tau}{r} = \frac{G\,\theta}{L}$$

τ – Shear stress (Pa or MPa)
T – Torque (N m)
J – Polar moment of inertia ($m^{4)}$
r – Distance from centre (m)
G – Shear modulus (Pa or GPa)
θ – Angle or twist (radians)
L – Length of the shaft (m)

Flexure formula

$$\frac{M}{I} = \frac{\sigma}{y} = \frac{E}{R}$$

σ – Bending stress
M – Bending moment
I – Second moment or area
y – Distance from neutral axis
E – Young's modulus
R – Radius of curvature

SUVAT equations for linear motion

$$v = u + at$$
$$s = \frac{1}{2}(u + v)t$$
$$s = ut + \frac{1}{2}at^2$$
$$s = vt - \frac{1}{2}at^2$$
$$v^2 - u^2 = 2as$$

s - displacement,
u - initial velocity,
v - final velocity,

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t - time,
a - acceleration.

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