[ENG04]

UNIVERSITY OF BOLTON

SCHOOL OF ENGINEERING

BEng (HONS) CIVIL ENGINEERING

SEMESTER ONE EXAMINATION 2022/2023

ENGINEERING MATHEMATICS & STRUCTURES

MODULE NO: CIE5004

Date: Wednesday 11th January 2023 Time: 10:00 – 13:00

INSTRUCTIONS TO CANDIDATES:

There are FOUR Questions.

Answer ALL 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.

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Question 1

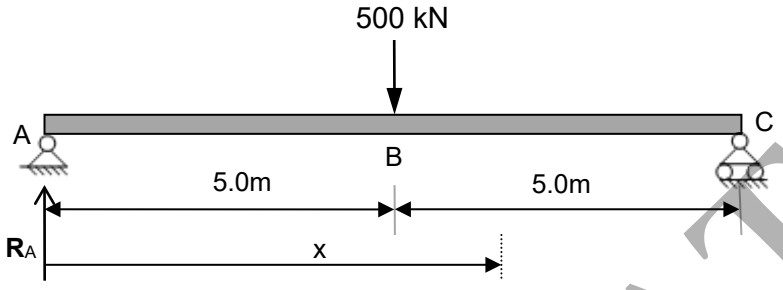

Figure Q1

Figure Q1 shows a beam ABC which is simply supported with a span of 10 m. The beam carries one point load at the centre of the span as shown in Figure Q1. The beam has uniform rigidity EI = 20,000kNm^2.

a. Use the method of Macaulay to calculate

i. The rotation (slope) at A.

ii. The vertical deflection at B.

(20 marks)

b. Estimate the value of x at which the rotation (slope) will be zero.

(5 marks)

Formula for the deflection of a beam: $M = -EI\frac{d^2v}{dx^2}$

Total 25 marks

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Question 2

Figure 2(i) shows a three pin frame, pinned to supports at A and G, with a third pin at D. There is a horizontal point load of **90kN** at position **B**, and a vertical point load of **30kN** at position **E** as shown in Figure 2(i).

a) Calculate the value of the support reactions at A and G. (5 marks)

b) Draw the axial force diagram (AFD) (4 marks)

c) Draw the shear force diagram (SFD) (4 marks)

d) Draw the bending moment diagram (BMD) (6 marks)

For b), c) and d), show all important values on the diagrams and produce accompanying calculations to show how these values have been derived.

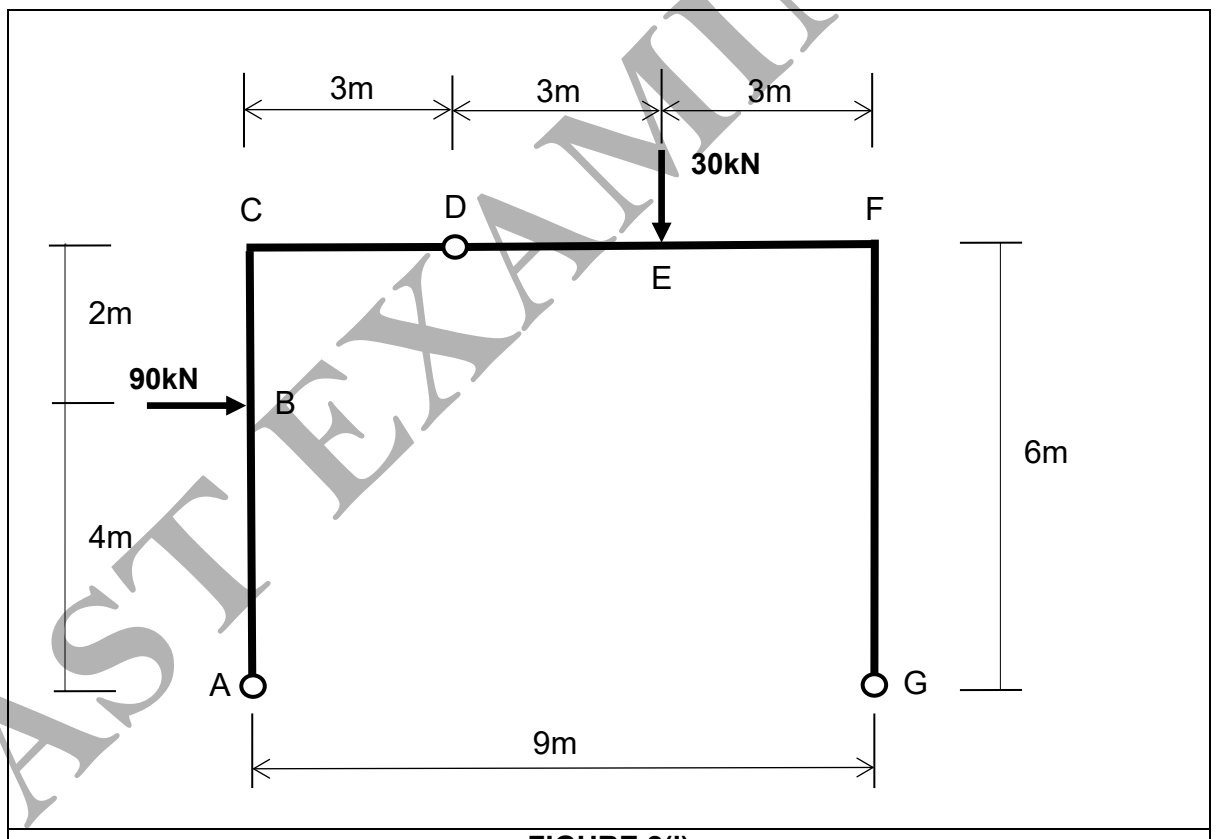

FIGURE 2(i)

Figure 2(ii) (on the next page) shows a very similar three pin frame, pinned to supports at A and G, with the third pin at D. The horizontal point load remains the same value but is now applied at Point F.

Question 2 continues over the page….
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Question 2 continued….

e) Without doing any further calculations, sketch the Bending Moment Diagram (BMD) for the three pin frame shown in Figure 2(ii). Do not attempt to calculate the values of the bending moments in the frame. (6 marks)

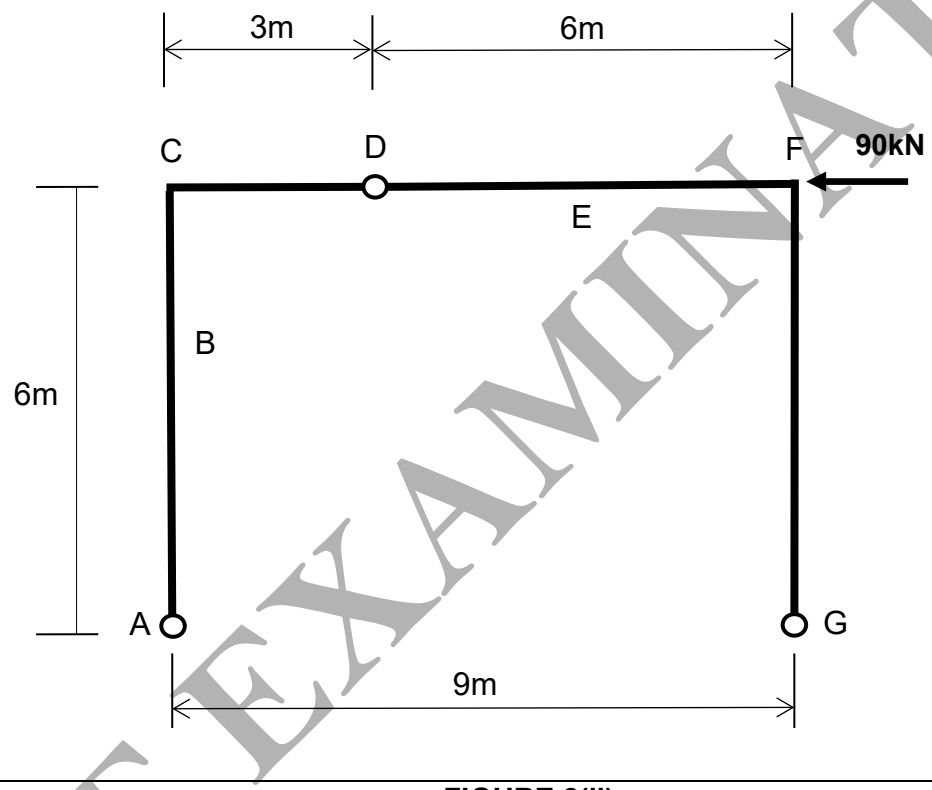

FIGURE 2(ii)

Total 25 marks

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Question 3 – Moment Distribution Method

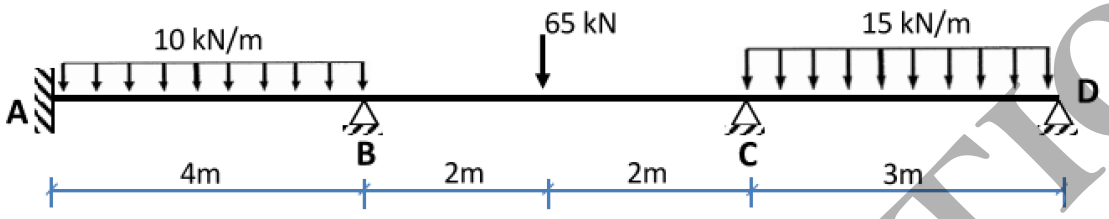

Figure Q3

Figure **Q3** shows a 3-span continuous beam ABCD which is simply supported at B, C and D and fixed to a support at A. Assume that all the spans have the same stiffness EI value.

Flexural stiffnesses of beams: Opposite end fixed: K = EI / L

Opposite end pinned: K = 0.75EI / L

a. Using the Method of Moment Distribution, calculate the bending moments at A, B, C and D. **(20 marks)**

b. Sketch the bending moment diagram for the whole beam, showing values at supports and approximate values around mid-spans. **(5 marks)**

Table of Fixed-End Moments is shown in **Table 1** on page 6.

Total 25 marks

Question 3 Table 1 – Table of Fixed-End Moments over the page….

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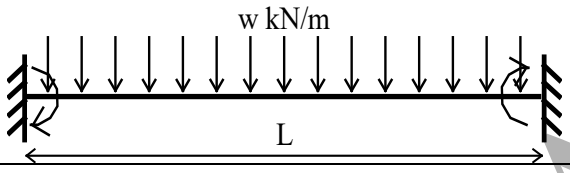
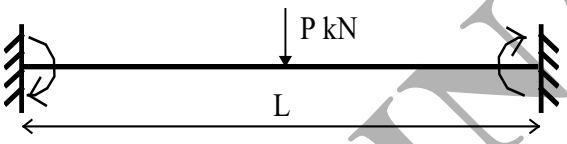
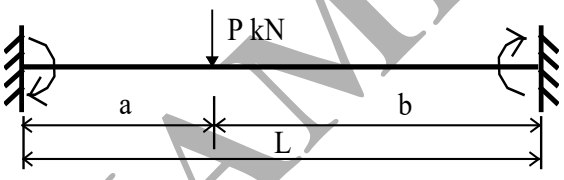
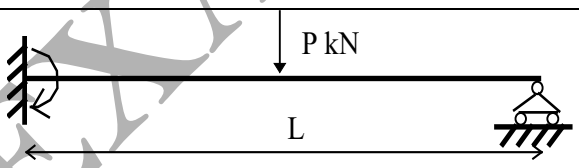
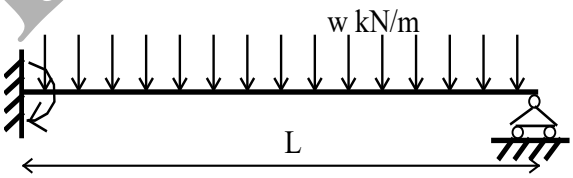
Question 3 continued….

Table 1: Fixed End Moments to be used with Question 3

FIXED-END MOMENTS		
FEM_{AB}	**A** **B**	FEM_{BA}
$-\frac{wL^2}{12}$		$\frac{wL^2}{12}$
$-\frac{PL}{8}$		$\frac{PL}{8}$
$-\frac{Pab^2}{L^2}$		$\frac{Pa^2b}{L^2}$
$-\frac{3PL}{16}$ $\text{Reaction} = \frac{11P}{16}$		**0** $\text{Reaction} = \frac{5P}{16}$
$-\frac{wL^2}{8}$ $\text{Reaction} = \frac{5wL}{8}$		**0** $\text{Reaction} = \frac{3wL}{8}$

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Question 4

Figure Q4 shows a reinforced concrete frame structure that includes slabs, beams, columns and pad footings.

Calculate the mass of carbon emissions for the whole structure including the footings.

If you know:

Total volume of the concrete used in slabs is **70m^3**

Total volume of the concrete used in beams is **3.4m^3**

Total volume of the concrete used in columns is **4m^3**

Total volume of the concrete used in footings is **20m^3**

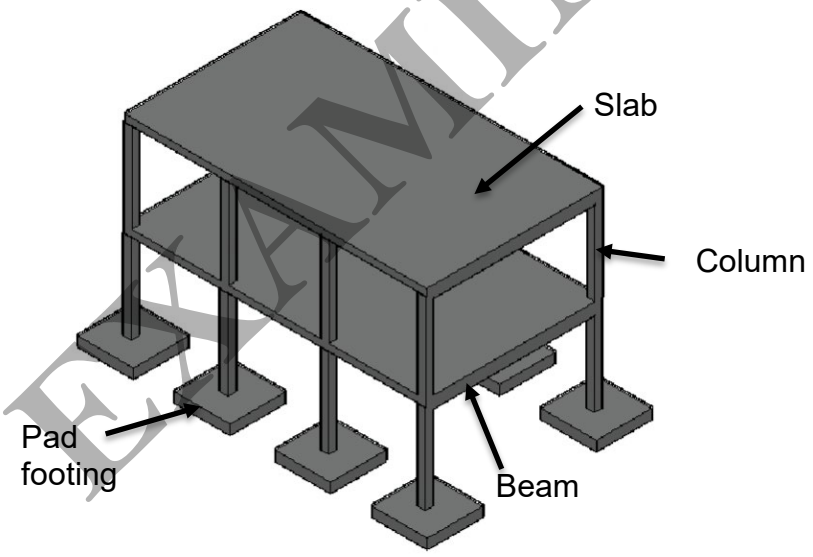

Figure Q4

Use the following data:

Density of concrete is 2400 kg/m^3
Estimated amount of reinforcement for slabs is: 75 kg/m^3 of concrete
Estimated amount of reinforcement for beams is: 100 kg/m^3 of concrete
Estimated amount of reinforcement for columns is: 200 kg/m^3 of concrete
Estimated amount of reinforcement for footings is: 80 kg/m^3 of concrete
Apply the wastage rate as 4%
Rate of embodied carbon for concrete is 0.126 kg CO2e/kg
Rate of embodied carbon for steel is 1.4 kg CO2e/kg

Total 25 marks

END OF PAPER