ENG147

UNIVERSITY OF GREATER MANCHESTER

SCHOOL OF ENGINEERING AND BUILT ENVIRONMENT

BEng (HONS) CIVIL ENGINEERING

SEMESTER ONE EXAMINATION 2025/2026

STRUCTURAL ANALYSIS & DETAILED DESIGN

MODULE NO: CIE5016

Date: Thursday 15th January 2026 **Time: 2pm – 4pm**

INSTRUCTIONS TO CANDIDATES:

There are THREE Questions.

Answer ALL questions.

Marks for parts of questions are shown in brackets.

This examination paper carries a total of 75 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 1(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 1(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.

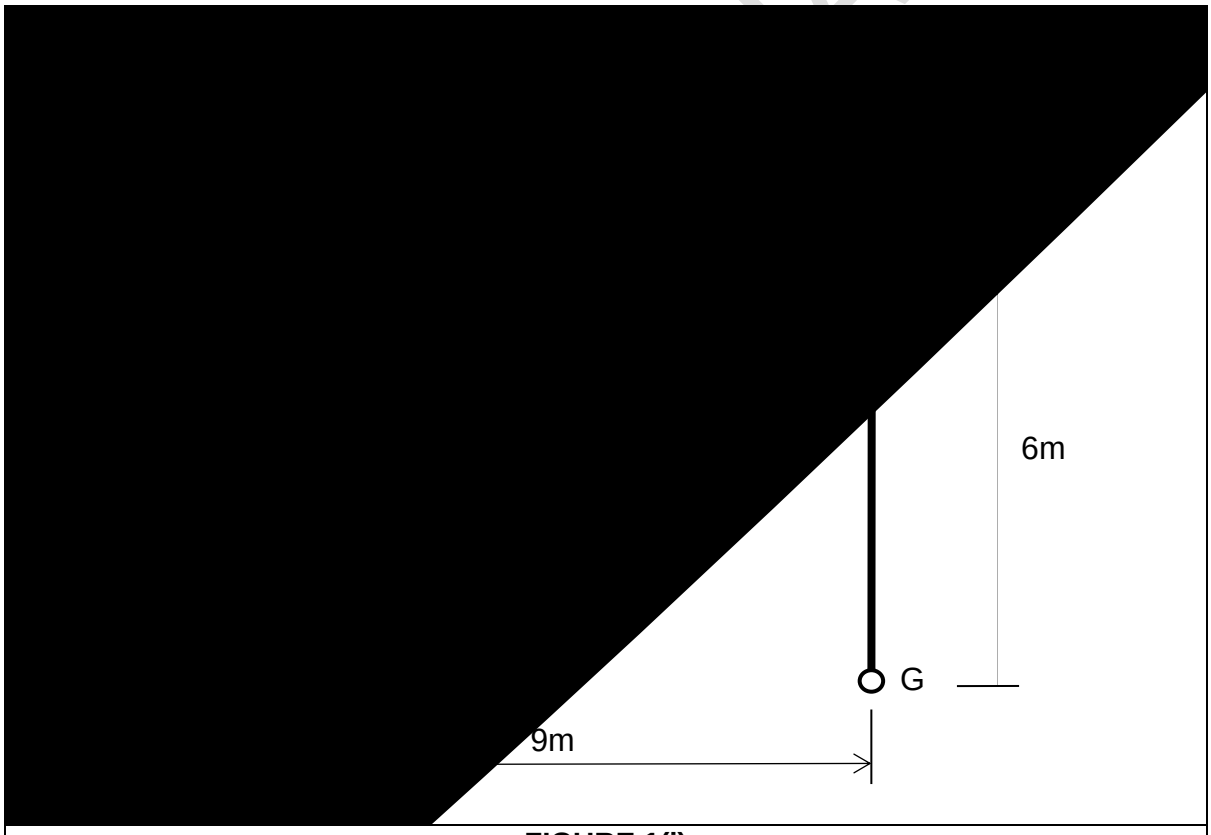

FIGURE 1(i)

Figure 1(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 1 continued over page 3

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Question 1 continued

e) Without doing any further calculations, sketch the Bending Moment Diagram (BMD) for the three pin frame shown in Figure 1(ii). Do not attempt to calculate the values of the bending moments in the frame. **(6 marks)**

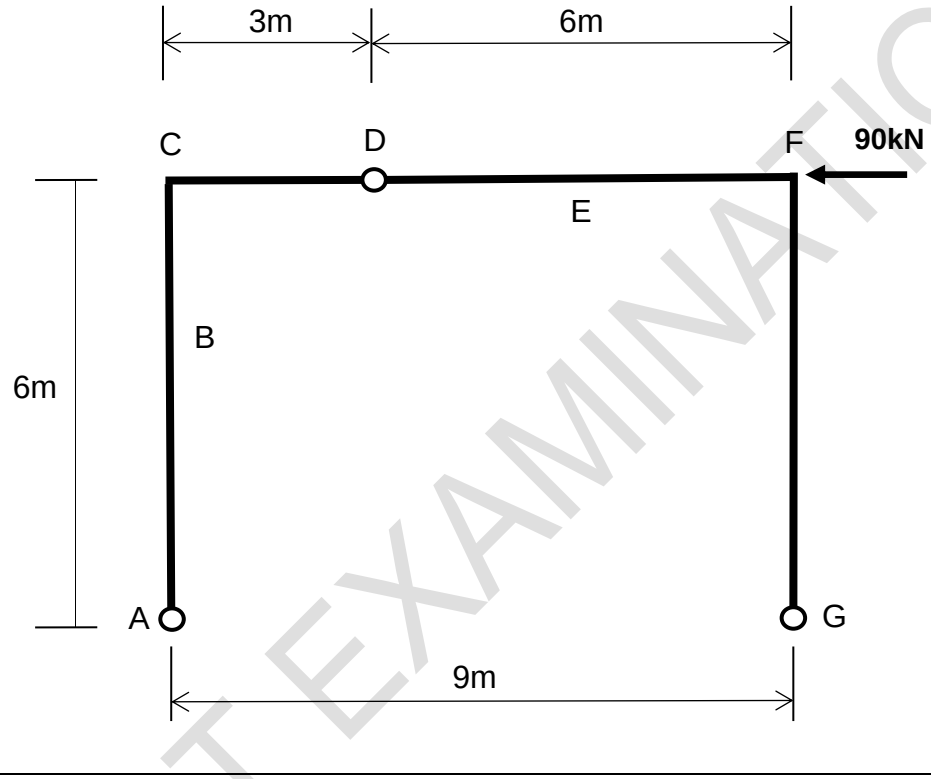

FIGURE 1(ii)

(Total 25 marks)

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Question 2

Figure Q2 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 **95m^3**

Total volume of the concrete used in beams is **8m^3**

Total volume of the concrete used in columns is **6m^3**

Total volume of the concrete used in footings is **40m^3**

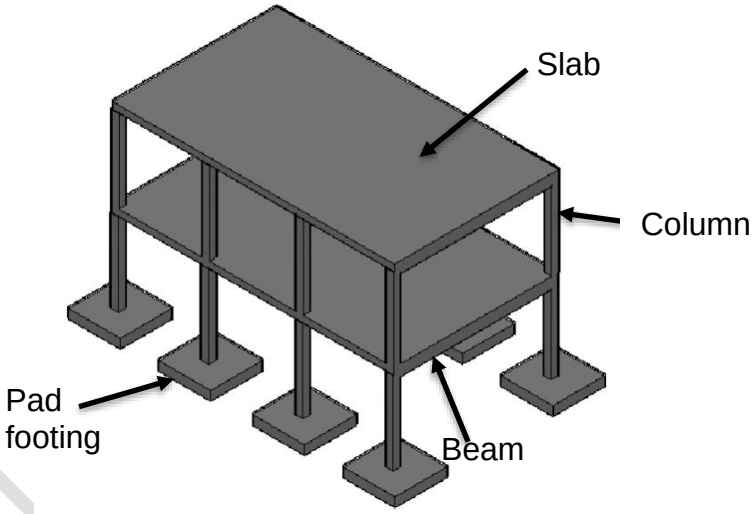

Figure Q2

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: 120 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: 90 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)

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Question 3 – Moment Distribution Method

Figure Q3 shows a 3-span continuous beam ABCD which is fixed to supports at A and D and simply supported at B and C. The I values of the members are shown, and all members have the same E value.

a. Using Moment Distribution method, calculate the bending moments at A, B, C and D.

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

Opposite end pinned: $K = 0.75EI / L$

(17 marks)

b. Sketch the bending moment diagram for the whole beam, showing values at supports and mid-spans. Indicate on your diagram where the beam is in hogging.

The maximum bending moment for a simply supported beam carrying a full length **UDL** is $\mathbf{wL^2 / 8}$

The approximate maximum bending moment for a simply supported beam carrying an **off-set point** load is **Pab / L**

The approximate maximum bending moment for a simply supported beam carrying **mid-point** load is **PL / 4**

(8 marks)

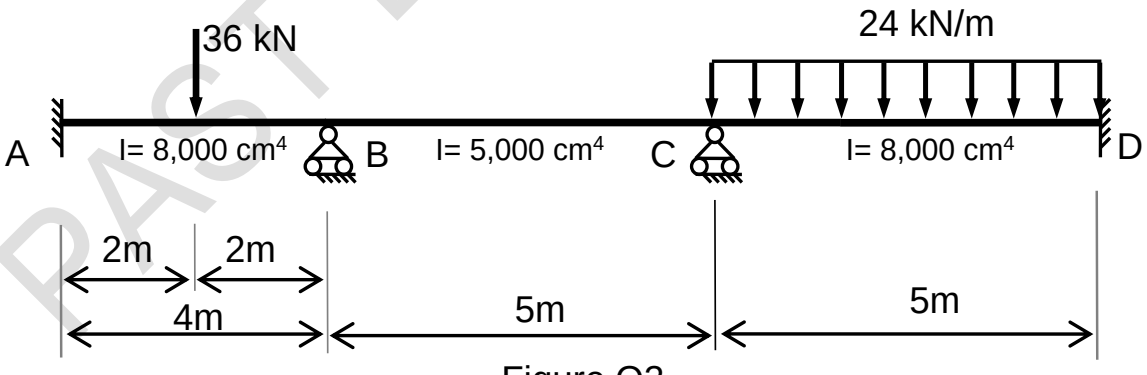

Figure Q3

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

Question 3 continued over page 6

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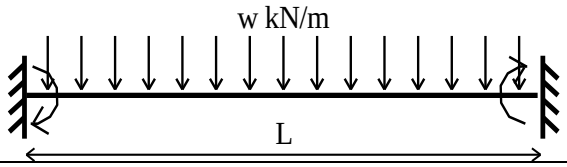
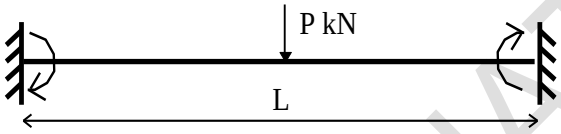
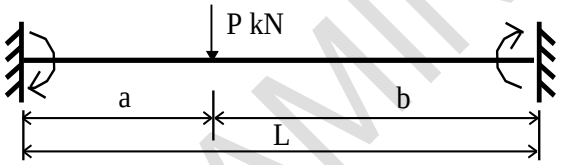
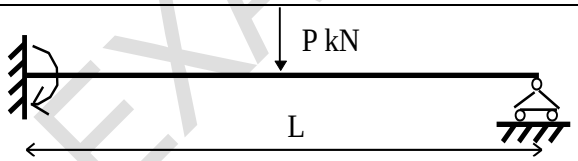
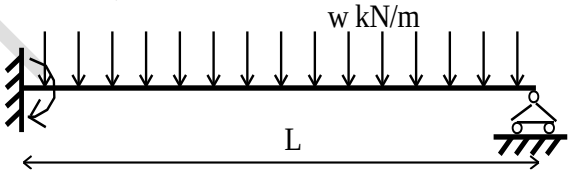
Question 3 continued

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** $\text{Reaction} = \frac{3wL}{8}$

(Total 25 marks)

END OF QUESTIONS

END OF PAPER