UNIVERSITY OF BOLTON

SCHOOL OF THE BUILT ENVIRONMENT & ENGINEERING

BSc (HONS) CIVIL ENGINEERING

SEMESTER ONE EXAMINATION 2009/2010

STRUCTURES

MODULE NO: BLT2018

Date: Tuesday 19 January 2010 **Time: 10.00 am – 12.00 noon**

INSTRUCTIONS TO CANDIDATES:

There are FOUR questions.

Answer ANY THREE questions.

All questions carry equal marks.

Marks for parts of questions are shown in brackets.

This examination paper carries a total of 75 marks.

Tables of fixed-end moments are provided.

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Question 1.

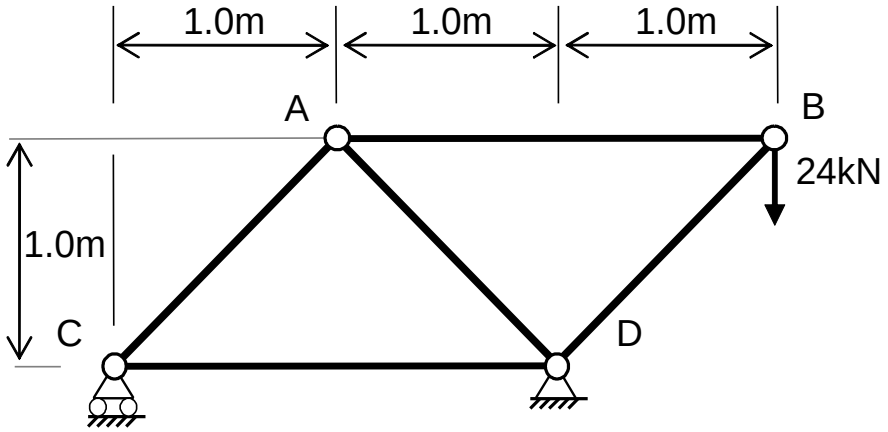

Figure Q1

Figure Q1 shows a pin-jointed frame ABCD which has a roller support at C, a pinned support at D and carries a single point load of 24 kN at B. The members are timber, E = 7 kN/mm^2, and are all 80mm x 80mm square.
The member axial forces, P_0, due to the load shown in Figure Q1 are shown in Table 1 provided separately.

Use the principle of virtual work to find the horizontal and vertical displacements of joint B.
Use the Worksheet shown in Table 1 for your solution.

Formula for the deflection of a joint in a pin-jointed truss: $\delta = \sum \frac{P_o P_1 L}{EA}$

Total 25 marks

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Question 2

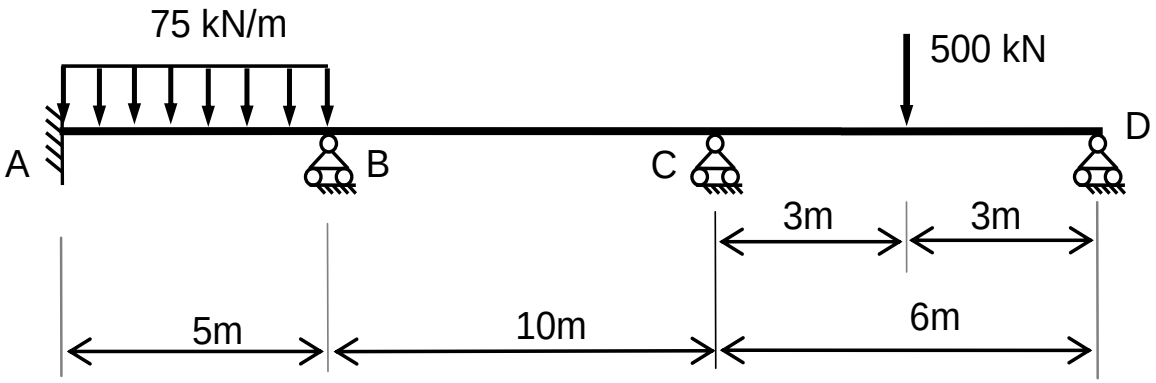

Figure Q2

Figure Q2 shows a 3-span continuous beam ABCD which is fixed to the support at A and simply supported at B, C and D. All the members have the same E value and I value. The beam carries a point load of 500kN on span CD and a distributed load of 75 kN/m on span AB.

a. Using moment distribution, calculate the bending moments at A, B, C and D.

(17 marks)

b. Sketch the bending moment diagram for the whole beam, showing values at supports and at maximum span moments.

(4 marks)

c. Without carrying out any further structural calculations, sketch the bending moment diagram for the beam for the following two cases. Indicate where bending moments have been increased or decreased following the changes described below:

(i) The fixed end support at A is removed entirely (leaving a cantilever)
(ii) With the fixed end support in place at A, the simple support at D is changed to also be a fixed end support

(4 marks)

Flexural stiffnesses of beams:
Opposite end fixed K = EI / L
Opposite end pinned K = 0.75EI / L
Tables of Fixed-End Moments are provided separately.

Total 25 marks

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Question 3

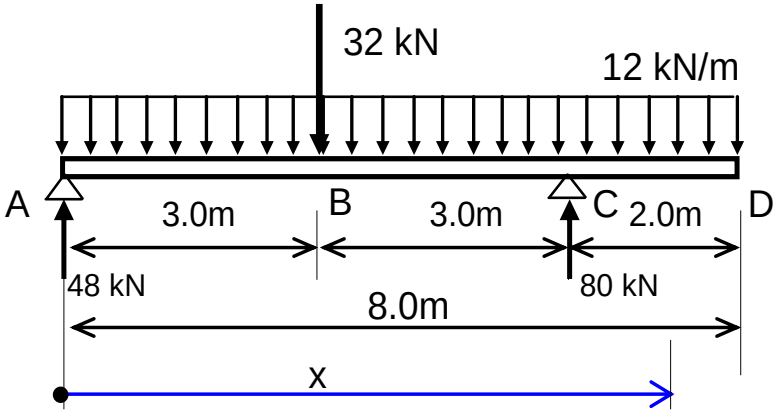

Figure Q3

Figure Q3 shows a beam ABCD which is simply supported over a span AC of 6.0 metres with a 2m cantilever CD. The beam carries a point load and a full-length distributed load as shown. The vertical reactions at supports A and C are shown in Figure Q3.
The beam has uniform rigidity EI.

a Use Macaulay's method to calculate, in terms of EI, downward deflection of the beam at B and at D.

(17 marks)

b What is the rotation of the beam, in terms of EI, at points B and D.

(5 marks)

c Draw the bending moment diagram for the beam showing values at the points of maximum sagging BM and maximum hogging BM.

(3 marks)

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

Total 25 marks

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Question 4

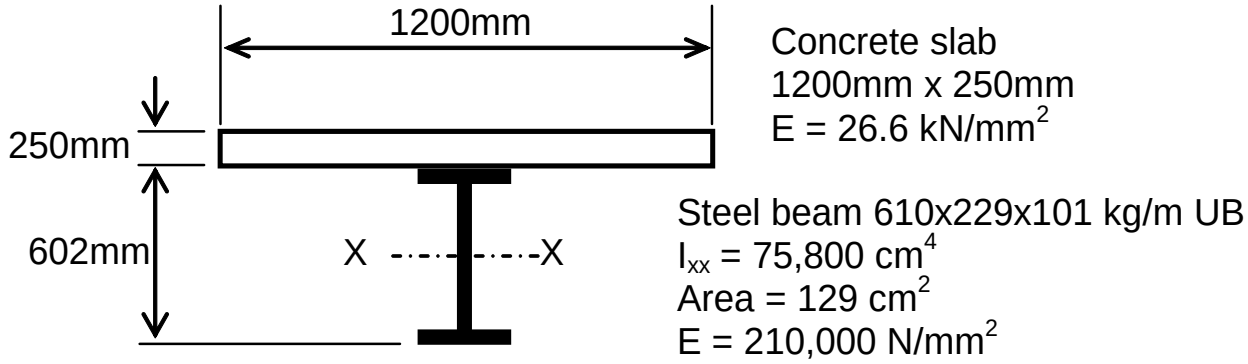

Figure Q4

Figure Q4 shows the section of a composite steel/concrete beam. The E value of the steel is 210,000 N/mm^2 and the E value of the concrete is 26.6 kN/mm^2.

The beam is simply supported over a span of 12.0m and carries a total working load of 60 kN/m which includes dead loading. In the following questions there is no need to factor the working load:

(a) Transform the composite section to an equivalent steel beam. Find the position of the neutral axis and the I value of the transformed beam.

(12 marks)

(b) Find the maximum stress in the steel, the maximum stress in the concrete and the maximum deflection of the composite beam under the working loading

(6 marks)

(c) If the UB section carried the load without composite action, find the maximum stress and maximum deflection of the beam.

(4 marks)

Question 4 continued over the page…

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Question 4 continued

(d) Without doing any further structural calculations, answer the following question (giving only brief explanations for your comments):
The 1200mm wide x 250mm deep concrete is to be replaced with a cross section of concrete of equal area but of different proportions, being 548mm wide x 548mm deep . What effect, if any, will this have on the stresses in the steel and in the concrete in the composite section?

(3 marks)

DATA
The central deflection of a simply supported beam carrying a uniformly distributed load w per unit length is given by $\delta = 5wL^4/384EI$

Total 25 marks

END OF QUESTIONS

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Table 1: Worksheet for Question Q1

P_0 are the truss member axial forced due to the load shown in Figure Q1.

	P0 kN	P1 kN	P2 kN	L mm	E kN/mm2	A mm2	P0P1L/EA mm	P0P2L/EA mm
AB	+24							
AC	+17							
AD	-17							
BD	-34							
CD	-12							

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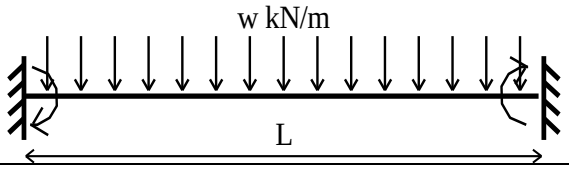
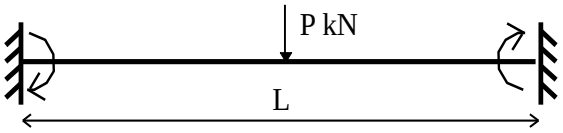
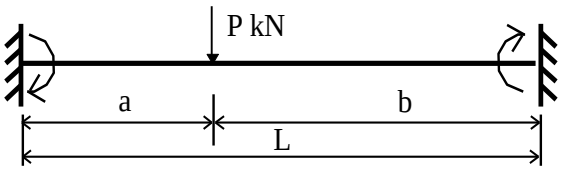
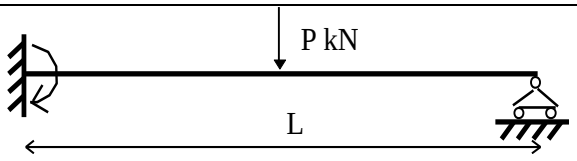
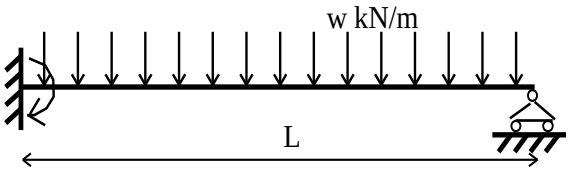
Table of Fixed-End Moments for Question 2.

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