NANYANG TECHNOLOGICAL UNIVERSITY

SEMESTER 1 EXAMINATION 2010-2011

CV3101 – STRUCTURES II

December 2010 **Time Allowed: 2½ hours**

INSTRUCTIONS

1. This paper contains **FOUR (4)** questions and comprises **FOUR (4)** pages.
2. Answer **ALL FOUR (4)** questions.
3. All questions carry equal marks.
4. This is an Open Book Examination with restriction to only **ONE (1)** sheet of A4-size paper with notes.

---

1. The beam shown in Figure Q1 is subjected to a vertical unit load moving from Point A to F. Draw the influence lines for:

   - Vertical reactions at Supports A and E
   - Shear force and bending moment at Point 1
   - Shear force and bending moment at Point C
   - Bending moment at Support E
   - Shear forces to the left and right of Support E
   - Shear force and bending moment at Point 2

   If the beam is subjected to a uniform dead load of 10 kN/m, a uniform live load of 5 kN/m, and a concentrated live load of 40 kN, determine the maximum vertical reaction at A and the maximum negative moment at Point 1.

   (25 marks)

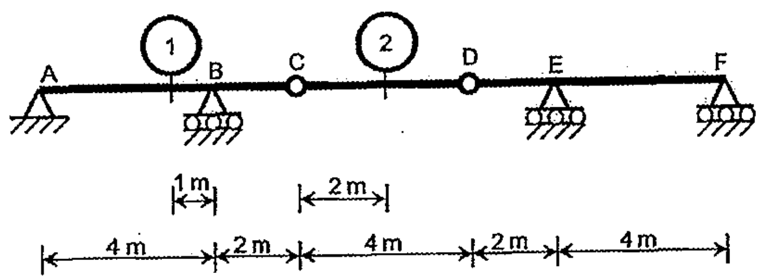


Figure Q1

2. (a) The cantilever beam AC, shown in Figure Q2(a), is additionally supported using a tie rod at Point B. The beam and rod are made of steel with a modulus of elasticity of 200 GPa. The beam has constant moment of inertia $I = 200 \times 10^6$ mm^4. The cross sectional area of the rod is 100 mm^2.

Using the force method (flexibility method), compute the force in the tie rod BD. Subsequently, compute the reactions at support A and the deflection at point B.

Draw the shear force and bending moment diagrams for the beam. Compute all the important values and the maximum positive moment of the beam.

(18 marks)

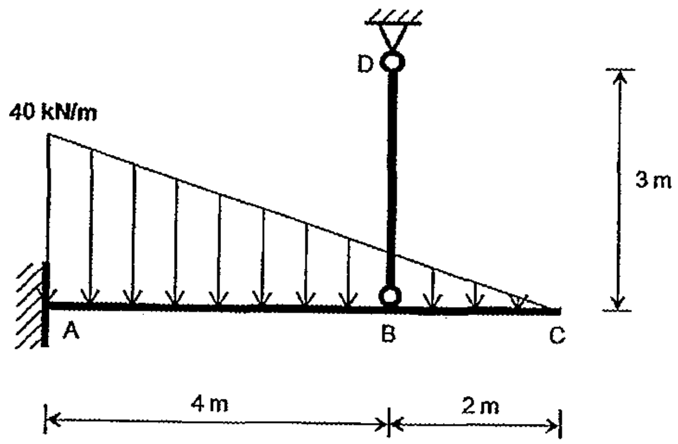


Figure Q2(a)

(b) The beam shown is Figure Q2(b) is identical to that in Figure Q2(a), except that the rod BD has been replaced by a roller. Using the results obtained in part (a), compute the reactions at A and B.

(7 marks)

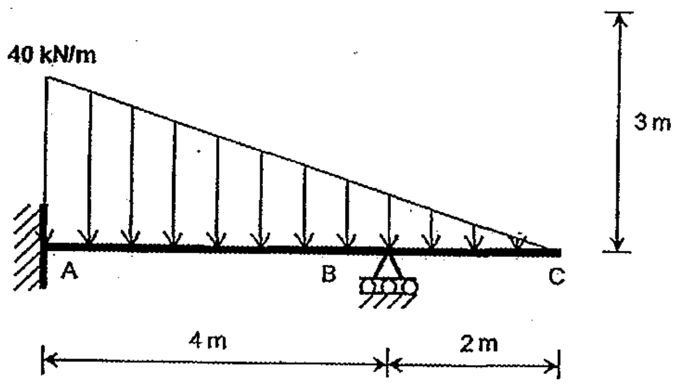


Figure Q2(b)

3. (a) For the two frame structures shown in Figures Q3(a) and Q3(b), draw their deflected shapes under the given loading and determine the degree of kinematic indeterminacy of each frame. Indicate the corresponding joint rotations and translations.

(6 marks)

(b) Figure Q3(c) shows a rigid frame with its loading arrangement. Supports A is fixed while supports C and D are pinned. EI is constant throughout.

(i) Calculate all the end moments by using the Slope Deflection Method.

(ii) Construct the bending moment diagram for the frame.

(19 marks)

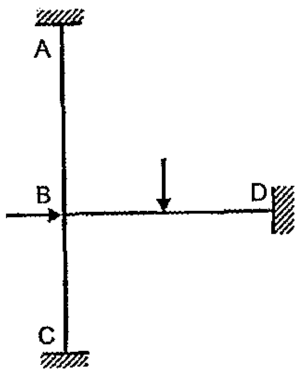


Figure Q3(a)

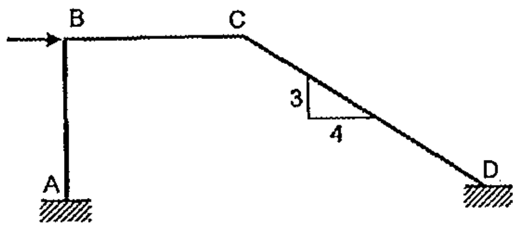


Figure Q3(b)

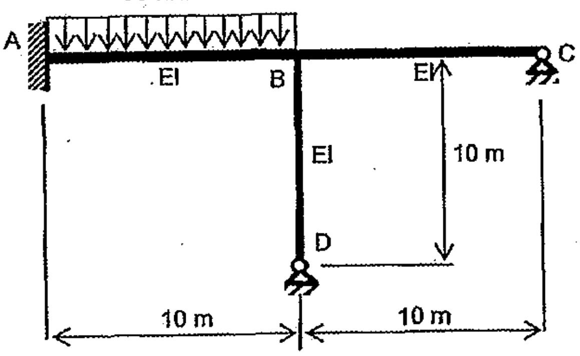
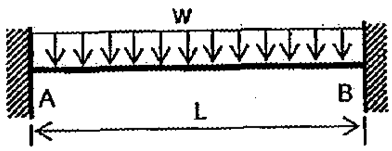


Figure Q3(c)

Note:

Fixed End Moments:



$-(1/12)\ w L^2$ $+(1/12)\ w L^2$

Slope Deflection Equation:

$M_{nf} = (2EI/L)\ \{2\theta_n + \theta_f - 3\Delta_{nf}/L\} + FEM_{nf}$

4 A rigid frame is shown in Figure Q4. Member BC carries 24 kN/m uniform load while member CD is subjected to a horizontal point load of 80 kN at a point 2.5 m from support D. Supports E and D are pinned while support A is fixed. EI is constant throughout.

(a) Calculate all the member end moments using the moment distribution method.

(17 marks)

(b) Draw the bending moment diagram for the frame.

(8 marks)

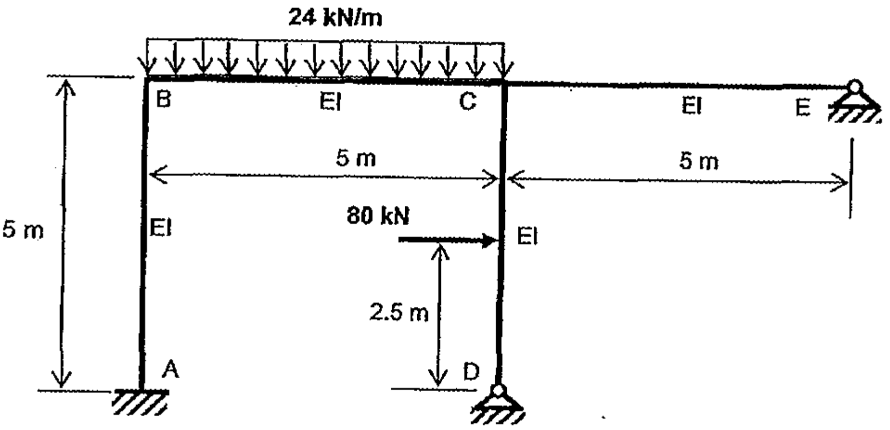
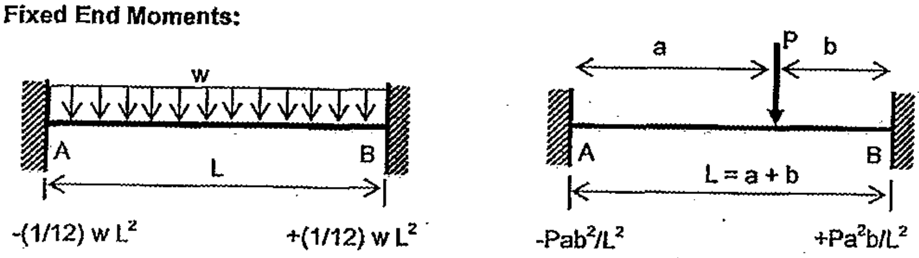


Figure Q4

Note:

Fixed End Moments:

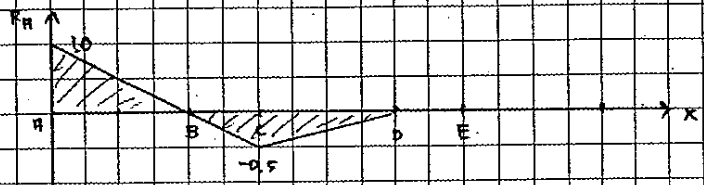


END OF PAPER

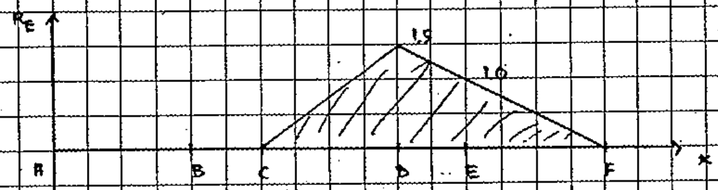
10|11 S1

CV3101. STRUCTURES II. ~~09/10~~ Sem 2.

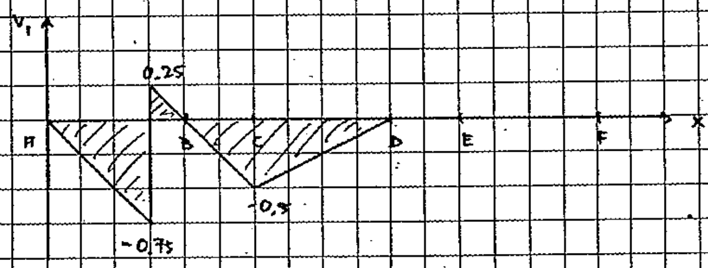
(Q1). a. Vertical reaction at support A.

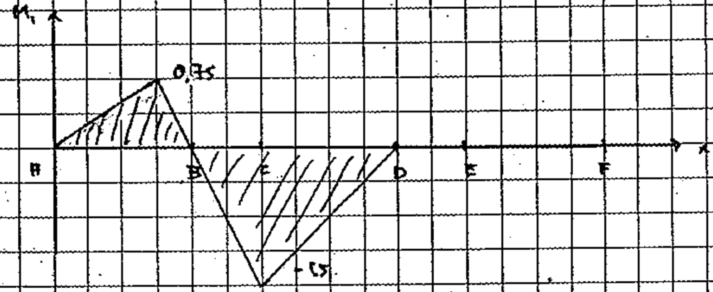


a. vertical reaction at support E.

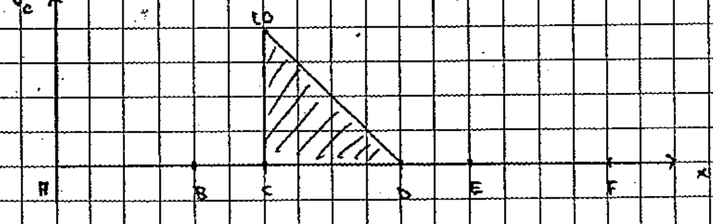


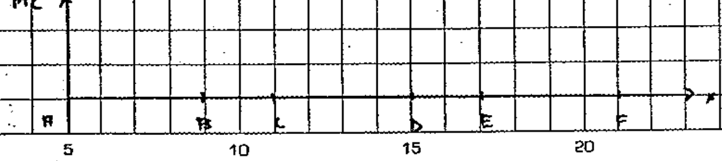
a. shear force and bending moment at point 1.





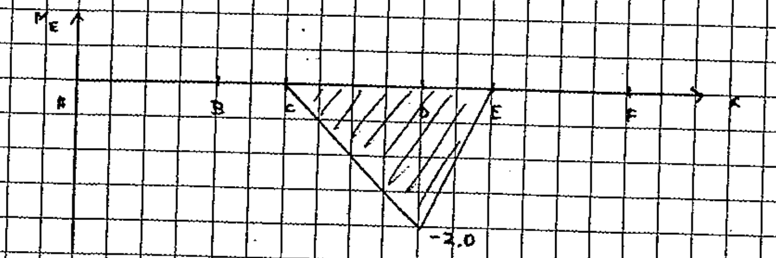
a. shear force and bending moment at point C.



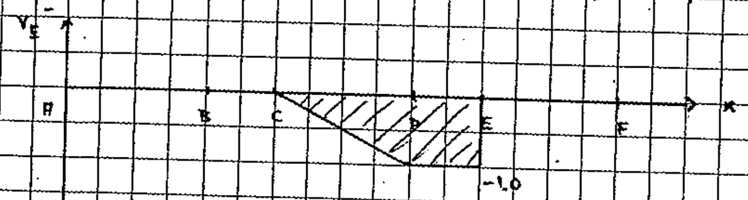


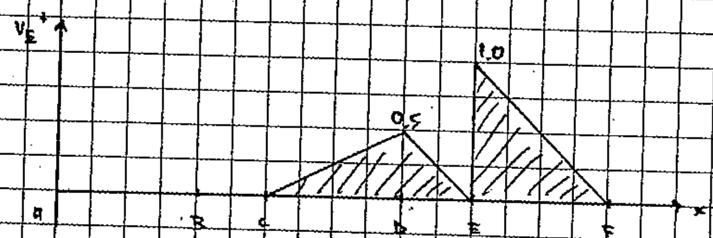
(M_c is 0 from point A to point F).

a. Bending moment at support E.

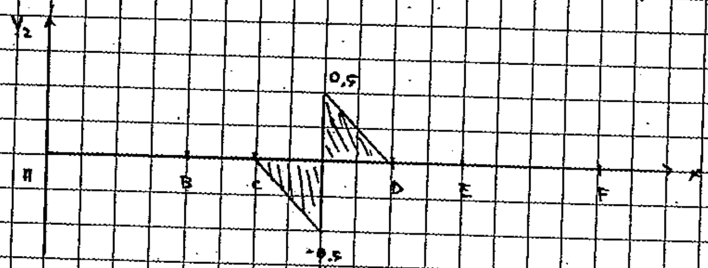


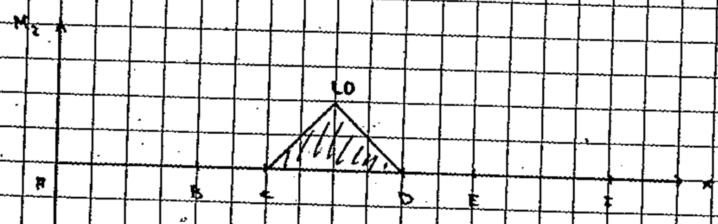
b. Shear force to the left and right of support E.





c. Shear force & bending moment at point 2.





Uniform DL = 10 kN/m
Uniform LL = 5 kN/m } Total UDL = 15 kN/m

Concentrated LL = 40 kN.

Maximum vertical reaction at A :

$$V_A = \left[\frac{1}{2}(1)(4) - \frac{1}{2}(0.5)(6) \right] \times 15 + (1.0) \times 40.$$

$$= \underline{\underline{47.5}} \text{ kN}$$

Maximum negative moment at point 1 :

$$M_1 = \left[\frac{1}{2}(0.75)(4) - \frac{1}{2}(1.5)(6) \right] \times 15 + (-1.5) \times 40.$$

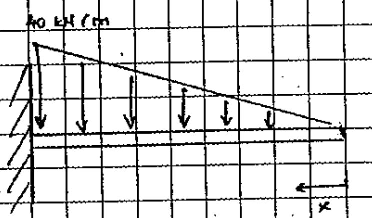
$$= \underline{\underline{-105}} \text{ kN.m}$$

(Q2) 7. a) $E = 200$ GPa

$I = 200 \cdot 10^{6}$ mm^4. $= 200 \cdot 10^{-6}$ m^4.

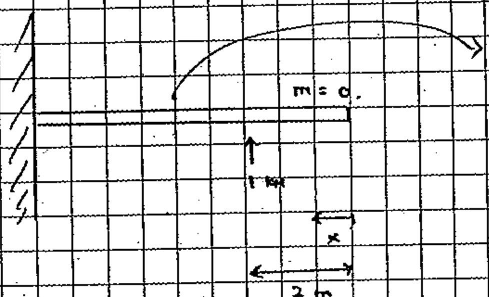
$A = 100$ mm^2, $= 100 \cdot 10^{-6}$ m^2

Consider tie rod BD as redundant.

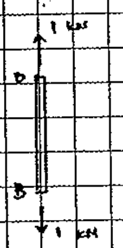


$$M = -\frac{1}{2}(x)\left(\frac{40}{6}x\right)\left(\frac{1}{3}x\right).$$

$$= -\frac{10}{9}x^3$$



$$m = (1)(x-2).$$



$$\Delta_{BD} = \int \frac{Mm\,dx}{EI} + \sum \frac{N \cdot n\,L}{AE} \nearrow 0.$$

$$= \int_2^6 \frac{\left(-\frac{10}{9}x^3\right)(x-2) \cdot dx}{EI}$$

$$= -\frac{10}{9EI} \cdot \int_2^6 (x^4 - 2x^3)\,dx$$

$$= -\frac{10}{9EI} \cdot \left[\frac{1}{5}x^5 - \frac{2}{4}x^4 \right]_2^6.$$

$$= -\frac{10}{9EI} (907.2 - (-1.6)).$$

$$= -\frac{9088}{9EI} //$$

$$f_{BD,BD} = \int \frac{m^2 \cdot dx}{EI} + \sum \frac{n^2 \cdot L}{EA}$$

$$= \int_2^6 \frac{(x-2)^2 \cdot dx}{EI} + \frac{(1)^2 \cdot (3)}{EA}$$

$$= \int_0^4 \frac{x^2 \cdot dx}{EI} + \frac{3}{EA}$$

$$= \frac{1}{EI} \cdot \frac{1}{3} x^3 \Big|_0^4 + \frac{3}{EA}$$

$$= \frac{64}{3EI} + \frac{3}{EA}$$

The compatibility equation :

$$\Delta_{BD} + f_{BD,BD} \times F_{BD} = 0.$$

$$-\frac{9088}{9EI} + \left[\frac{64}{3EI} + \frac{3}{EA} \right] F_{BD} = 0.$$

$$-\frac{9088}{9 \cdot 200 \cdot 10^{-6}} + \left[\frac{64}{3 \cdot 200 \cdot 10^{-6}} + \frac{3}{100 \cdot 10^{-6}} \right] F_{BD} = 0.$$

$$F_{BD} = 36.94 \text{ kN}.$$

Reaction of support A :

$$\Sigma F_y = 0.$$

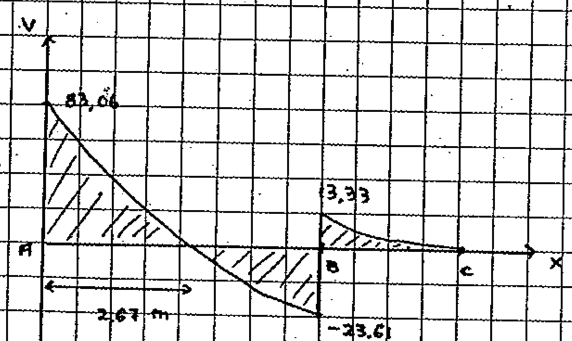
$$R_A + F_{BD} - \frac{1}{2}(6)(40) = 0.$$

$$R_A + 36.94 - 120 = 0.$$

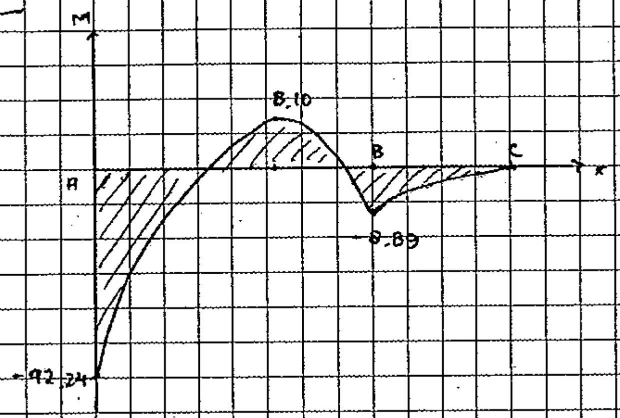
$$R_A = 83.06 \text{ kN}$$

Deflection at point B = 0 → since A is supported by the rod BD.

SFD :



BMD :



b>. By changing the rod to roller support → r = 0.

Hence, our compatibility equation :

$\Delta_{BD} + f_{BD,BD} \cdot F_{BD} = 0.$

$-\frac{9088}{9EI} + \frac{64}{3EI} \cdot F_{BD} = 0.$

$F_{BD} = 47.33$ kN

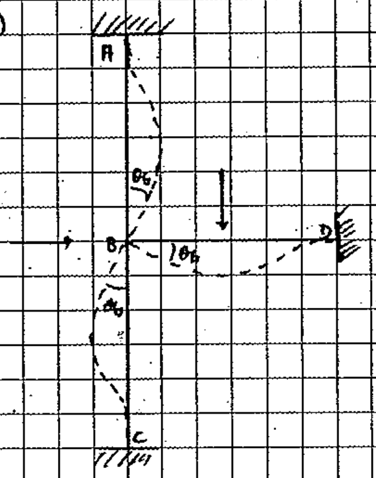
• Reaction at B = F_{BD} = 47.33 kN.

• Reaction at A : $\Sigma F_y = 0.$

$R_A + F_{BD} - 120 = 0.$

$R_A = 72.67$ kN

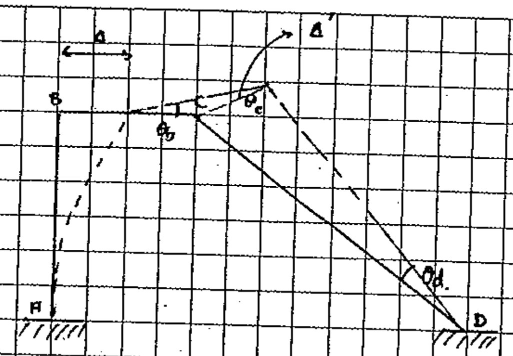
03>. (a)



Degree of kinematic indeterminacy = 1. (θ_b).

5 mm Square 275 mm x 200 mm

U-GRADE



Degree of Kinematic Indeterminacy = 4.

$(\theta_b, \theta_c, \theta_d, \Delta)$.

$\frac{\Delta}{\Delta'} = \frac{3}{5}$

$\Delta' = \frac{5}{3}\Delta$.

<6>. (i) $FEM_{AB} = -\frac{(30)(10)^2}{12} = -250$ kN-m.

$FEM_{BA} = +250$ kN-m.

$M_{AB} = \frac{2EI\theta_b}{10} - 250$

$M_{BA} = \frac{4EI\theta_b}{10} + 250$

$M_{BC} = \frac{4EI\theta_b}{10} + \frac{2EI\theta_c}{10}$

$M_{CB} = \frac{2EI\theta_b}{10} + \frac{4EI\theta_c}{10}$

$M_{BD} = \frac{4EI\theta_b}{10} + \frac{2EI\theta_d}{10}$

$M_{DB} = \frac{2EI\theta_b}{10} + \frac{4EI\theta_d}{10}$.

$\Sigma M_b = 0$.

$M_{BA} + M_{BC} + M_{BD} = 0$.

$0.4EI\theta_b + 250 + 0.4EI\theta_b + 0.2EI\theta_c + 0.4EI\theta_b + 0.2EI\theta_d = 0$.

$1.2EI\theta_b + 0.2EI\theta_c + 0.2EI\theta_d + 250 = 0$ — (1)

$\Sigma M_c = 0$.

$M_{CB} = 0$.

$0.2EI\theta_b + 0.4EI\theta_c = 0$. — (2)

$\Sigma M_D = 0$.

$0.2EI\theta_b + 0.4EI\theta_d = 0$ — (3)

From solving (1), (2) & (3) : $EI\theta_b = -250$, $EI\theta_c = 125$, $EI\theta_d = 125$.

Hence; $M_{AB} = -300$ kN-m

$M_{BA} = 150$ kN-m

$M_{BC} = -75$ kN-m

$M_{CB} = 0$.

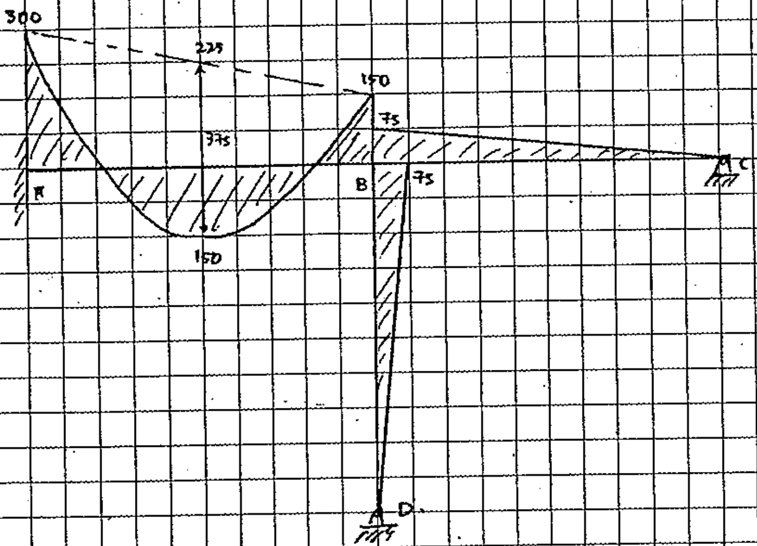
$M_{BD} = -75$ kN-m

$M_{DB} = 0$.

mm Square 275 mm x 200 mm

U-GRADS

c(ii).



$\frac{1}{8}wL^2 = \frac{1}{8}(30)(10)^2$

$= \underline{375}$ kN·m.

(Q4) (a). $FEM_{bc} = -\frac{1}{12}(24)(5)^2 = -50$ kN·m

$FEM_{cB} = +50$ kN·m.

$FEM_{cD} = +\frac{80(2.5)^3}{(5)^2} = +50$ kN·m.

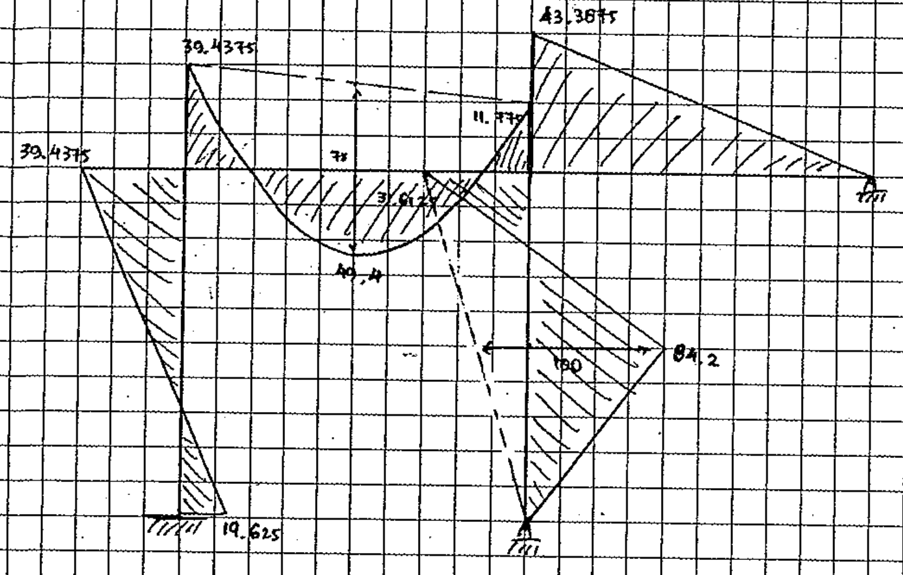
$FEM_{Dc} = +50$ kN·m.

Joint	a	b		c			d	e
Member end	ab	ba	bc	cb	cd	ce	dc	ec
Rel. stiffness	4EI/5	4EI/5	4EI/5	4EI/5	3EI/5	3EI/5	3EI/5	3EI/5
D.F.	0	0.5	0.5	0.4	0.3	0.3	1	1
FEM	0	0	-50	50	50	0	-50	0
DM	0	25	25	-40	-30	-30	50	0
COM	12.5		-20	12.5	25			
DM	0	10	10	-15	-11.25	-11.25		
COM	5		-7.5	5				
DM	0	3.75	3.75	-2	-1.5	-1.5		
COM	1.875		-1	1.875				
DM	0	0.5	0.5	-0.75	-0.5625	-0.5625		
COM	0.25		-0.375	0.25				
DM	0	0.1875	0.1875	-0.1	-0.075	-0.075		
ΣM	19.625	39.4375	-39.4375	11.775	31.6125	-43.3875	0	0

5 mm Square 275 mm x 200 mm

U-GRADE

<b7.



5 10 15 20 25 30 35 40

5 mm Square 275 mm x 200 mm

U-GRAD5