NANYANG TECHNOLOGICAL UNIVERSITY

SEMESTER 2 EXAMINATION 2013-2014

CV2012 – STRUCTURAL ANALYSIS II

April – May 2014 **Time Allowed: 2½ hours**

INSTRUCTIONS

1. This paper contains **FOUR (4)** questions and comprises **SEVEN (7)** pages.
2. Answer **ALL FOUR (4)** questions.
3. All questions carry equal marks.
4. An Appendix of **ONE (1)** page is attached together with this paper.
5. This is a Restricted Open Book Examination. Only **ONE (1) Sheet** of A4-size paper containing any reference materials is allowed.

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

- Vertical reaction support B
- Shear force at point C
- Shear force to the right of point D
- Bending moment in the beam at point D
- Reaction at support F

If the beam is subjected to a uniform dead load of 16 kN/m, a uniform live load of 24 kN/m, and a concentrated live load of 40 kN, determine the maximum vertical reaction at support B.

(13 Marks)

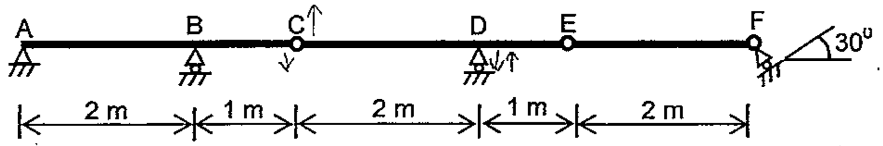


Figure Q1(a)

Note: Question No. 1 continues on page 2

(b) A bridge truss shown in Figure Q1(b) is subjected to a vertical unit load moving from points D to L. Draw the influence lines for forces in members BE, BC and HK.

A truck having wheel loads 20 kN and 15 kN with 1 m distance apart from each other travels on the bridge deck. The wheel loads are transferred to the bridge truss at its bottom panel points D to L. Determine the maximum forces (tension or compression) in member BE.

(12 Marks)

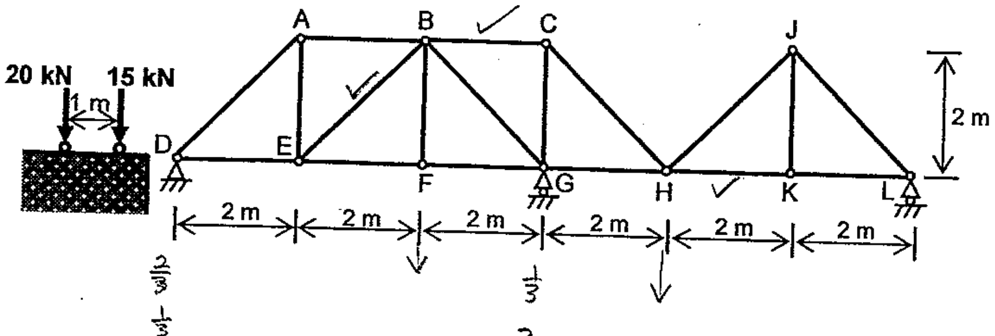


Figure Q1(b)

2. (a) The continuous beam ABCD shown in Figure Q2(a) has a flexural rigidity EI. The beam is subjected to a concentrated load at point B and a uniform load from points C to D.

(i) Using the Force Method (Flexibility Method), determine the reaction at support C.

(ii) Draw the shear force and bending moment diagrams for the beam.

(19 Marks)

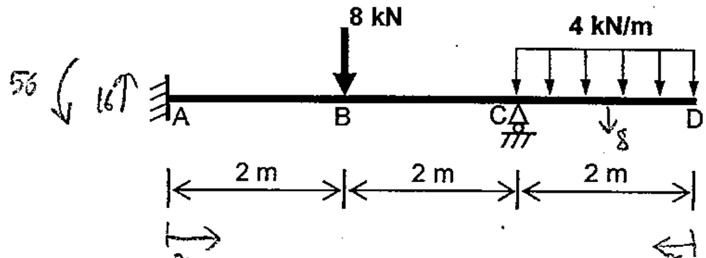


Figure Q2(a)

(b) The beam ABCD shown in Figure Q2(b) is identical to that in Figure Q2(a), except that the roller support at point C is replaced by a spring with stiffness 400 kN/m. If point C settles (downwards) by 2 cm, given EI = 1000 kNm^2, calculate the reaction at point C using the Force Method (Flexibility Method).

(6 Marks)

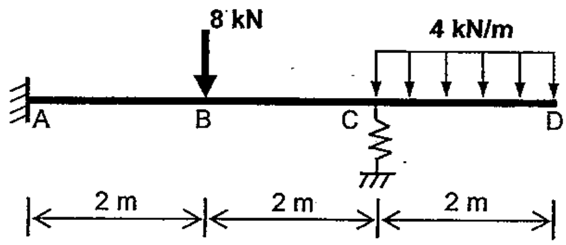


Figure Q2(b)

3. (a) Figure Q3(a) shows a rigid frame with its loading arrangement. Support A is hinged, Support C is on roller and Supports E and F are fixed. The flexural rigidity for each member is shown in the figure. Neglect axial deformation.

(i) Show that only **ONE** degree of freedom is required to solve this problem using the Slope Deflection Method. Identify the unknown degree of freedom.

(ii) Calculate all the member end moments using the Slope Deflection Method.

(iii) Draw the bending moment diagram for the beam ABC.

(15 Marks)

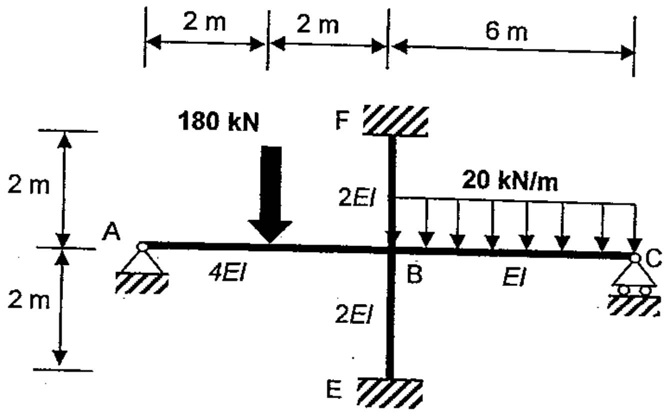


Figure Q3(a)

Note: Question No. 3 continues on page 5

(b) The frame shown in Figure Q3(a) is modified by adding a beam member CD as shown in Figure Q3(b). The original roller support at C is removed and members BC and CD are connected by a hinge at C. Support D is fixed.

(i) Show that this problem can be solved by using **TWO** degrees of freedom using the Slope Deflection Method. Identify the unknown degrees of freedom.

(ii) Establish the equilibrium equations that can be used to solve for the two unknowns. (Note: There is no need to solve the equations.)

(10 Marks)

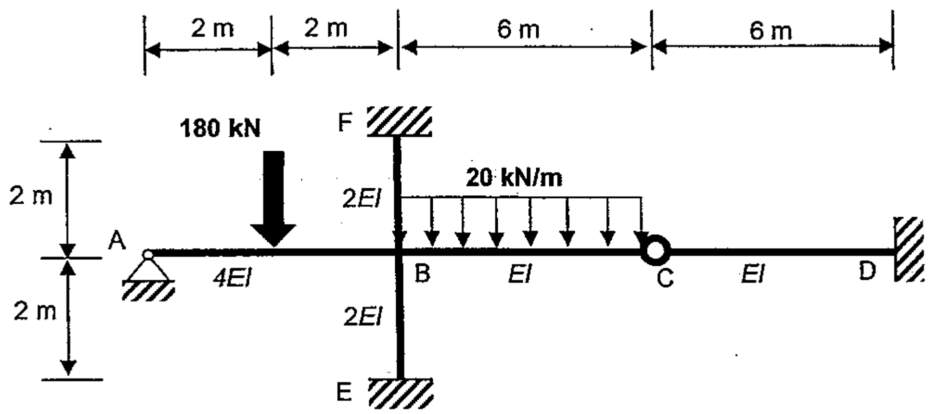


Figure Q3(b)

4. (a) Figure Q4(a) shows a rigid frame with its loading. Support A is hinged and the supports at C and D are on roller while the supports at E and F are fixed. The flexural rigidity for each member is shown in the figure. Note that the flexural rigidity for member BF is 0.1*EI* only (i.e. one-tenth of the beam's).

(i) Calculate all the member end moments using the Moment Distribution Method.

(ii) Calculate the horizontal reaction at A.

(15 Marks)

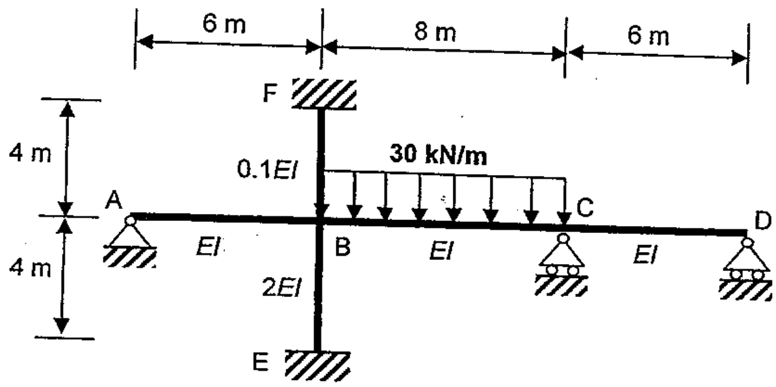


Figure Q4(a)

Note: Question No. 4 continues on page 7

(b) Suppose Support A in Figure Q4(a) is now modified from a hinge to a roller (i.e. same as Support D), as shown in Figure Q4(b).

(i) Evaluate the fixed end moments for members BE and BF if there is a horizontal displacement of 1600 $kNm^3/(6EI)$ to the right at B only (i.e. without any loading on member BC or other joint rotations).

(ii) If the member end moments (in kNm) with the horizontal displacement specified in Q4(b)(i) are found by the Moment Distribution Method as M_{BA} = 31.28, M_{BE} = -74.90, M_{BF} = 16.26, M_{BC} = 27.37, M_{CB} = 7.82, M_{CD} = -7.82, M_{EB} = -137.47, M_{FB} = 13.13, re-calculate all the member end moments for the frame in Figure Q4(b).

(10 Marks)

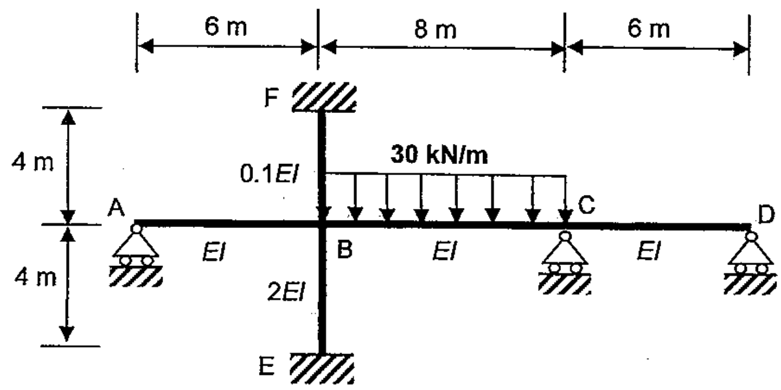


Figure Q4(b)

END OF PAPER

Slope Deflection Equations:

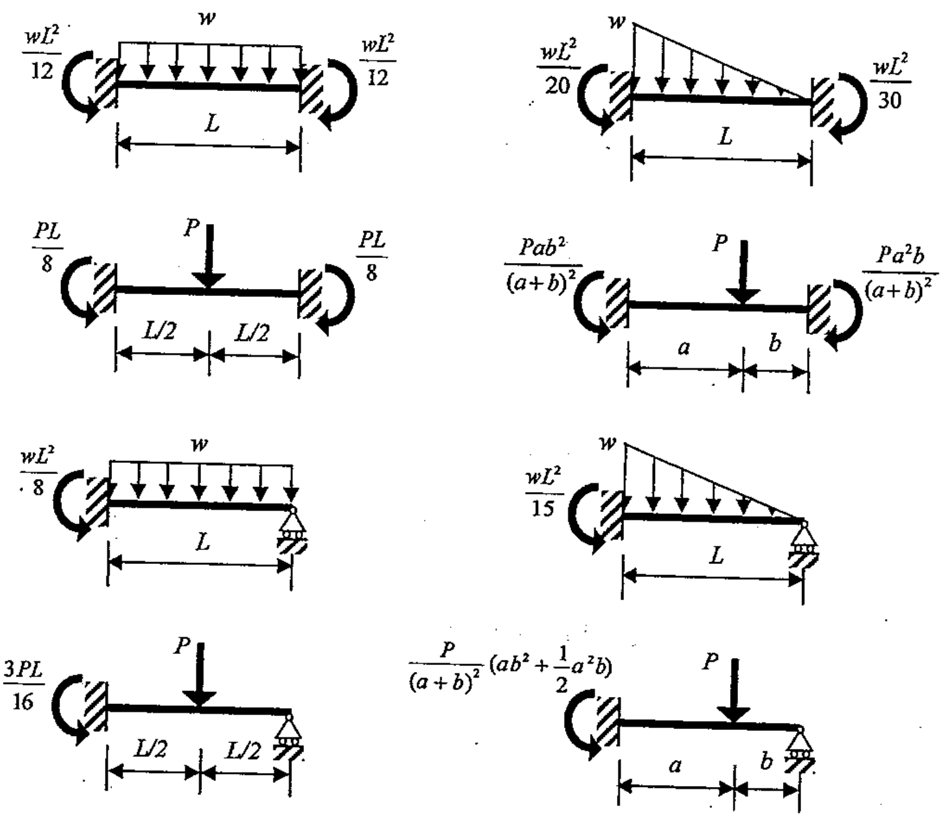
$$M_N = \frac{2EI}{L}[2\theta_N + \theta_F - 3\psi] + FEM_N \text{, or}$$

$$M_N = \frac{3EI}{L}[\theta_N - \psi] + FEM_N$$ .... for member pinned at the far end

where

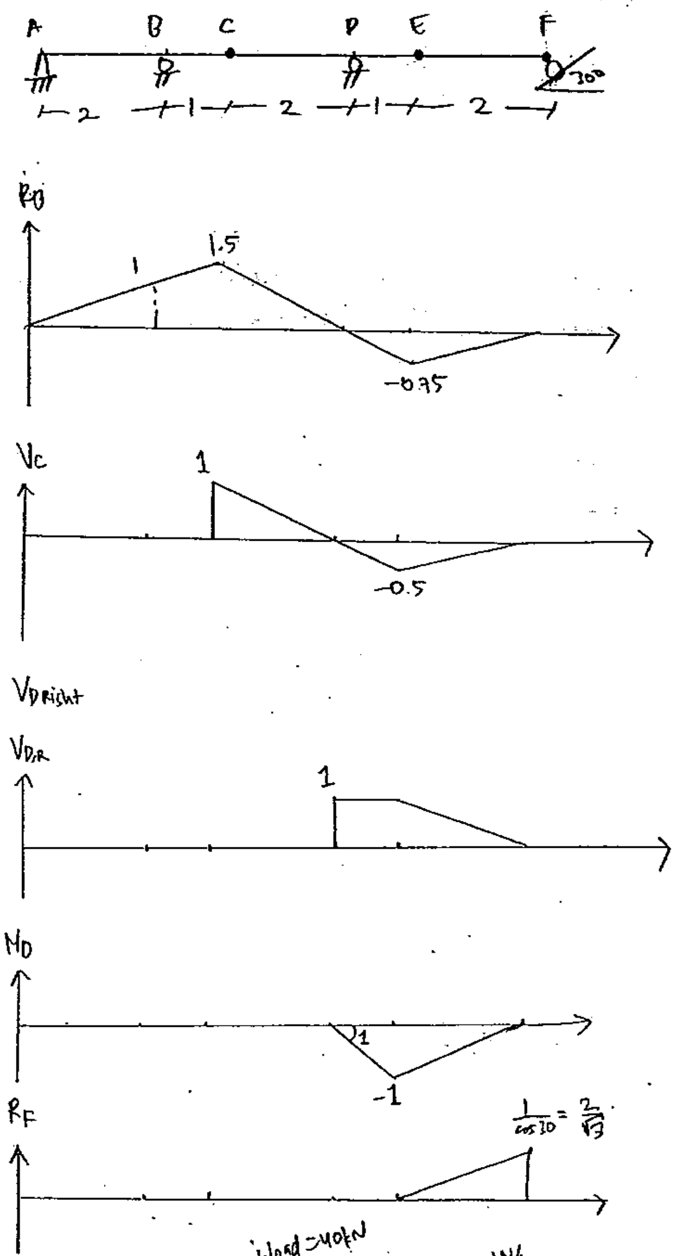
M_N	=	internal moment at the near end of the span
EI	=	flexural rigidity
L	=	beam length
θ_N, θ_F	=	near and far end slope or angle of the span at the supports
Δ	=	relative lateral displacement at the ends
ψ	=	Δ/L = span rotation of its cord due to a linear displacement
FEM_N	=	fixed end moment at the near end support

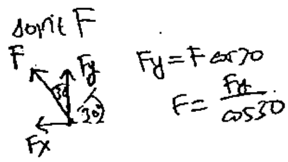
Fixed End Moments:



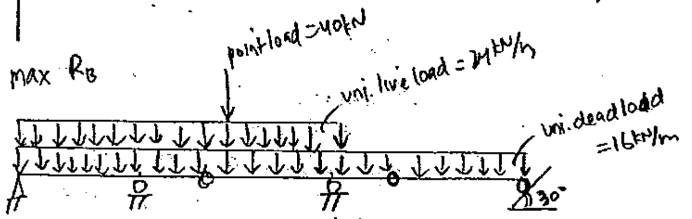
1a)

PYP CV2012 2013/2014
STRUCTURE ANALYSIS II





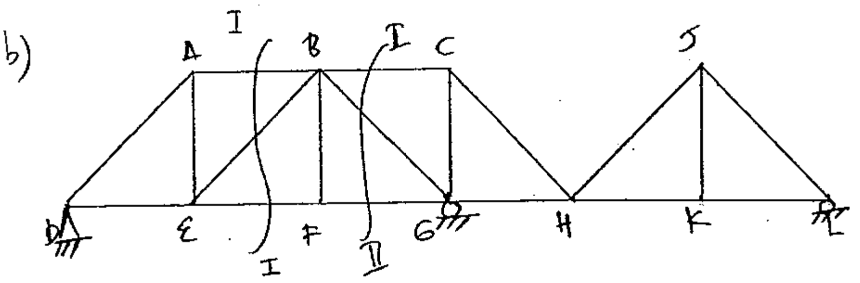
max R_B



$$\text{Max } R_b = \underbrace{\left[\frac{5\times1.5}{2} - \frac{0.75\times3}{2}\right]\times 16}_{\text{dead load}} + \underbrace{\left[\frac{5\times1.5}{2}\times 24\right]}_{\text{live load}} + \underbrace{40\times1.5}_{\text{point load}}$$

$\boxed{R_b = 192\text{ kN}}$

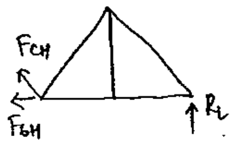
b)



F_{BE}, cut at I-I

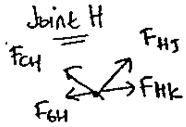
load at E

Truss HJLK



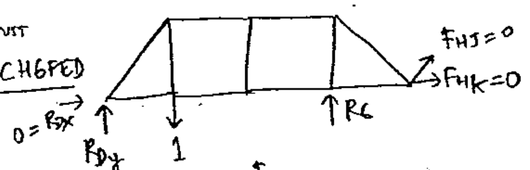
$\Sigma M_H = 0$ $R_L = 0$ $\Sigma F_y = 0$ $F_{CH} = 0$ $\Sigma F_x = 0$ $F_{GH} = 0$

Joint H



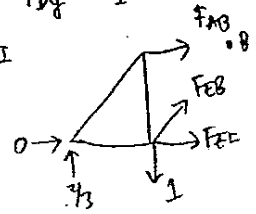
$\Sigma F_x = 0$ $F_{HJ} = 0$ $F_{HK} = 0$

Truss ABCHGFED



$\Sigma M_G = 0$ $R_{Dy} = \frac{2}{3}$ $\Sigma F_x = 0$ $R_{Dx} = 0$

Section I-I left,



$\Sigma F_y = 0$

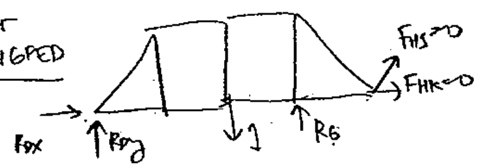
$-\frac{2}{3} + \frac{1}{\sqrt{2}} F_{EB} - 1 = 0$

$F_{EB} = \frac{5}{3}\sqrt{2}$

load at F

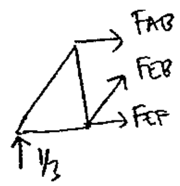
Truss HJLK $R_L = 0$ $F_{CH} = 0$ $F_{GH} = 0$ (same as load at E) $F_{HJ} = 0$ $F_{HK} = 0$

Truss ABCHGFED



$\Sigma M_G = 0$ $R_{Dy} = \frac{1}{3}$ $\Sigma F_x = 0$ $R_{Dx} = 0$

Section I-I left,

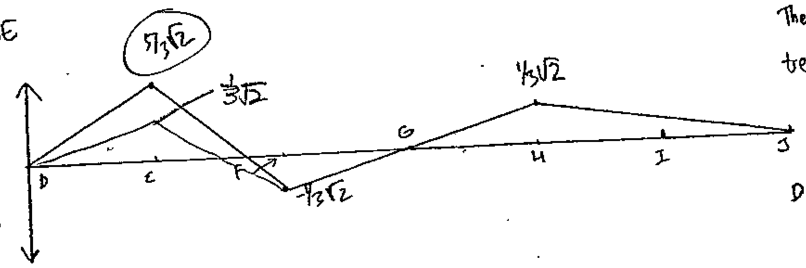


$\Sigma F_y = 0$

$\frac{1}{3} + \frac{1}{\sqrt{2}} F_{EB} = 0$

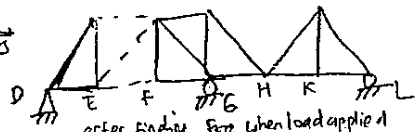
$F_{EB} = -\frac{1}{3}\sqrt{2}$

F_{BE}



TIPS:

we only need to find F_{EB} when the load is applied at E and F.
Then, we follow the Muller-Breslau principle treating the other section as beam.



after finding F_{EB} when load applied at E and F,
contreat DE as one section of beam and FGH as one beam and HKL as one beam with pin joint at H.

F_{BC}

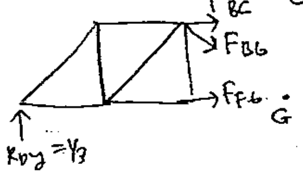
load at F

Truss HJLK $R_L = 0$ $F_{GH} = 0$ $F_{HK} = 0$

$F_{CH} = 0$ $F_{HJ} = 0$

Truss ABCHGFED $R_{Dy} = \frac{1}{3}$ $R_{Dx} = 0$ (same as above)

Section II − II left,



@↺ $\Sigma M_G = 0$

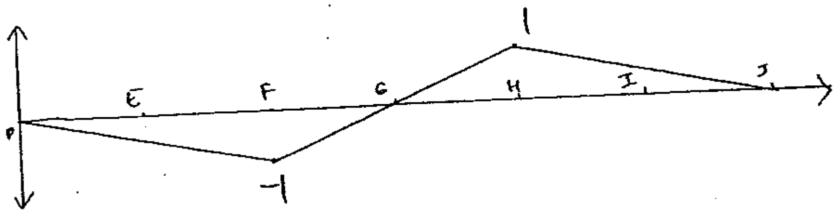
$-R_{Dy} \times 3 - F_{BC} \times 1 = 0$

$F_{BC} = -R_{Dy} \times 3$

$= -1$

TIPS: same as before, only we need find F_{BC} when load is applied at F and G. (But if load is applied at G, $F_{BC} = 0$ because there is support at G in this case).

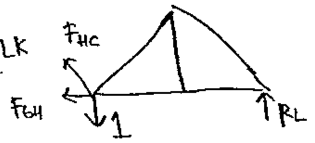
F_{BC}



F_{HK}

load at H

Truss HJLK

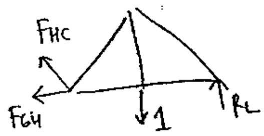


$\Sigma M_H = 0$

$R_L = 0$, $F_{JL} = 0$, $F_{KL} = 0$, $F_{JK} = 0$, $\boxed{F_{HK} = 0}$

load at K

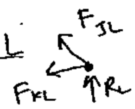
Truss HJLK



$\Sigma M_H = 0$

$R_L = \frac{1}{2}$

Joint L



$\Sigma F_y = 0$

$\frac{1}{\sqrt{2}} F_{JL} + R_L = 0$

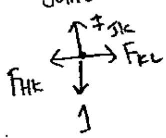
$F_{JL} = -\frac{1}{2}\sqrt{2}$

$\Sigma F_x = 0$

$F_{KL} + \frac{1}{\sqrt{2}} F_{JL} = 0$

$F_{KL} = -\frac{1}{\sqrt{2}}\left(-\frac{1}{2}\sqrt{2}\right) = \frac{1}{2}$

Joint K

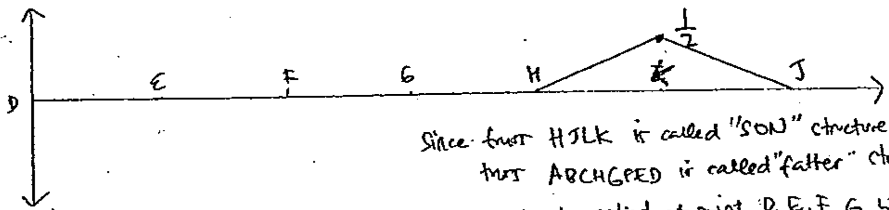


$\Sigma F_x = 0$

$F_{HK} = F_{KL}$

$F_{HK} = \frac{1}{2}$

F_{HK}



Since truss HJLK is called "SON" structure and truss ABCHGFED is called "father" structure, any vertical load applied at point D, E, F, G will be carried by reaction at D and G only without being transferred to truss HJLK

Maximum forces in member BE:

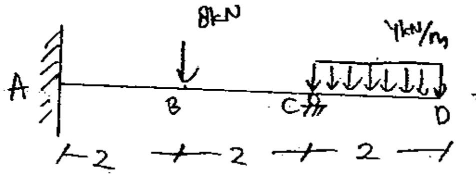
① by load 20kN at E, load 15kN between E & F

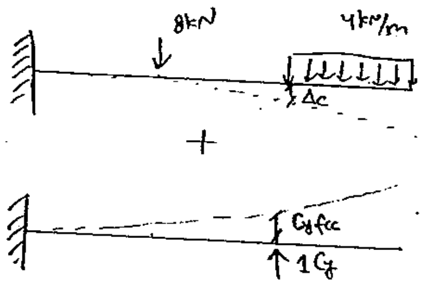
∴ $F_{BE} = 20 \times \frac{5}{3}\sqrt{2} + 15 \times \frac{4}{3}\sqrt{2} = \boxed{\frac{130}{3}\sqrt{2}\,kN \rightarrow larger}$ ∴ Max $F_{BE} = \frac{130}{3}\sqrt{2}$ kN (in tension)

② by load 15kN at E, load 20kN between D & E

∴ $F_{BE} = 20 \times \frac{2.5}{3}\sqrt{2} + 15 \times \frac{5}{3}\sqrt{2} = \frac{125}{3}\sqrt{2}\,kN$

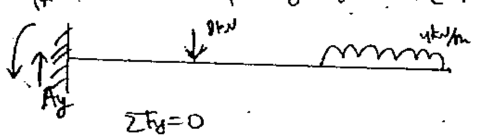
2 a)





[The system is statistically indeterminate to degree of one take Cy as redundant force.]

Compatibility Eq: $\Delta_c + C_y f_{cc} = 0$



$\Sigma F_y = 0$

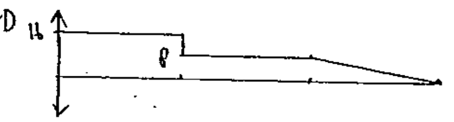
$A_y = 8 + 4 \times 2 = 16kN$

$\Sigma M_A = 0$

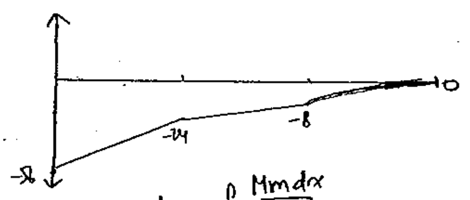
$M_A = 8 \times 2 + 4 \times 2 \times 5$

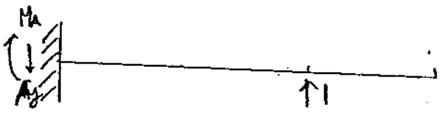
$= 56$ kNm

SFD



BMD

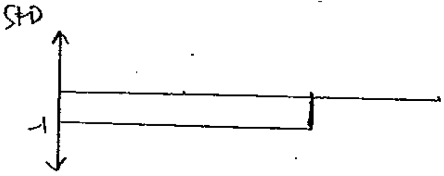




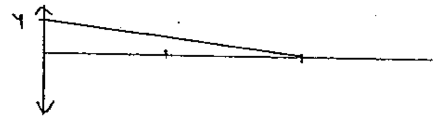
$\Sigma F_y = 0$ $A_y = 1$

$\Sigma M_A = 0$ $M_A = 4$

SFD



BMD



$\Delta_c = \int \frac{Mm\,dx}{EI}$

using table formula

Span AB

		m_1 4			m_2 2	L/L³ 2	Product sum
M_1	-56	-224	1/3	1/6	-112	2	$-\frac{580}{3}$
M_2	-24	-96	1/6	1/3	-48	2	$-\frac{384}{6}$

$\int Mm\,dx = -\frac{752}{3}$

Span BC

		m_1 4			m_2 2	L/L³ 2	Product sum
M_1	-24	-96	1/3	1/6	-48	2	-80
M_2	-8	-32	1/6	1/3	-16	2	-64/3

$\int Mm\,dx = -\frac{304}{3}$

$f_{cc} = \frac{\int m^2 dx}{EI}$

Span AC

		m_1 4			m_2 0	L/L³ 4	Pro sum
m_1	4	16	1/3	1/6	0	4	64/3
m_2	0	0	1/6	1/3	0	4	0

$\int m^2 dx = 64/3$

$\Delta_c = \left[-\frac{752}{3} + -\frac{304}{3}\right] \times \frac{1}{EI}$

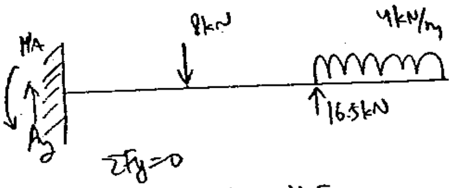
$\Delta_c = -\frac{352}{EI}$

$f_{cc} = \frac{64}{3EI}$

$\Delta_c = -C_y f_{cc}$

$C_y = -\frac{\Delta_c}{f_{cc}} = -\frac{-352/EI}{64/3EI}$

$C_y = 16.5\,kN$ //



$\Sigma F_y = 0$

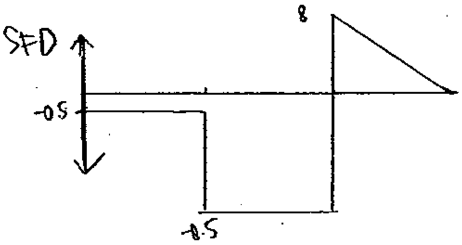
$A_y = 8 + 4\times2 - 16.5$

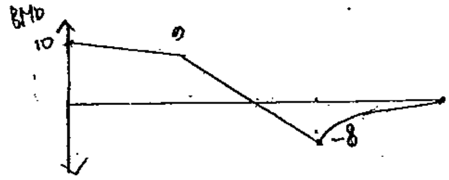
$= -0.5\text{kN}$

$\Sigma M_A = 0$

$M_A = 8\times2 - 16.5\times4 + 4\times2\times5$

$= -10\text{kNm}$





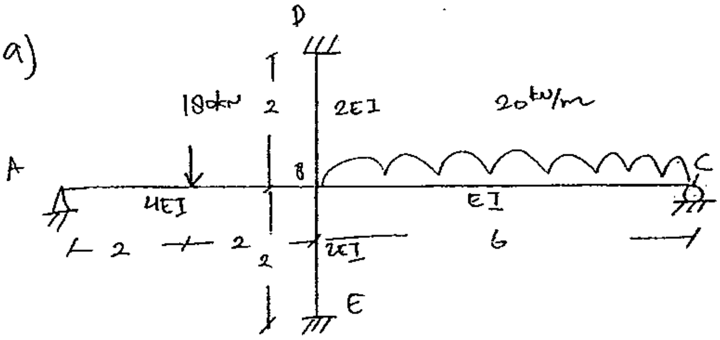
2b) Compatibility equation becomes

$$\Delta_c + C_y f_{cc} = -\frac{C_y}{K} - 2$$

$$-\frac{352}{1000} + \frac{64}{3\times1000} C_y = -\frac{C_y}{400} - 0.02$$

$$\boxed{C_y = 13.93\text{kN}}$$

3a)



- D & E fixed support, $\theta_D = \theta_E = 0$
- no open rotation allowed, $\psi_{AB} = \psi_{BA} = \psi_{DB} = \psi_{BD} = \psi_{BE} = \psi_{EB} = \psi_{BC} = \psi_{CB} = 0$
- left are : $\theta_A, \theta_B, \theta_C$
- θ_A and θ_C can be eliminated → no need for calculation

Proof: $M_N = 2\frac{EI}{L}(2\theta_N + \theta_F - 3\psi) + FEM_N$

$M_{AB} = 2\frac{EI}{L}(2\theta_A + \theta_B) + FEM_{AB} = 0$ → since A is a pinned support

$M_F = 2\frac{EI}{L}(2\theta_N + \theta_F - 3\psi) + FEM_F$

$M_{BA} = 2\frac{EI}{L}(2\theta_B + \theta_A) + FEM_{BA}$

$M_{BA} = M_{BA} - \frac{1}{2}M_{AB}$

$= 2\left(\frac{EI}{L}\right)2\theta_B + 2\left(\frac{EI}{L}\right)\theta_A + FEM_{BA} - \frac{1}{2}\left(2\frac{EI}{L}(2\theta_A) + 2\frac{EI}{L}(\theta_B) + FEM_{AB}\right)$

$= 3\left(\frac{EI}{L}\right)\theta_B + \boxed{FEM_{BA} - \frac{1}{2}FEM_{AB}}$ → modified FEM

∴ only θ_B

The same principle also applies to θ_C

The DOF is one, which is θ_B

(ii) $FEM_{BA} = \frac{3PL}{16} = \frac{3(180)4}{16} = 135$

$FEM_{BC} = -\frac{wl^2}{8} = -\frac{(20)(6)^2}{8} = 90$

Endmoments

$M_{BA} = \frac{3EI}{L}(\theta_B - \psi) + FEM_{BA}$

$= \frac{12EI}{4}(\theta_B) + 135$

$= 3EI\theta_B + 135$

$M_{BC} = \frac{3(EI)}{6}(\theta_B) - 90$

$= \frac{1}{2}EI\theta_B - 90$

$M_{BF} = \frac{2(2EI)}{2}(\theta_B) = 4EI\theta_B$

$M_{FB} = \frac{2(2EI)}{2}(\theta_B) = 2EI\theta_B$

$M_{BE} = \frac{2(2EI)}{2}(2\theta_B) = 4EI\theta_B$

$M_{EB} = \frac{2(EI)}{2}(\theta_B) = 2EI\theta_B$

Equilibrium at joint B

$M_{BA} + M_{BF} + M_{BC} + M_{BE} = 0$

$3EI\theta_B + 135 + \frac{1}{2}EI\theta_B - 90 + 4EI\theta_B + 4EI\theta_B = 0$

$\frac{23}{2}EI\theta_B = -45$

$EI\theta_B = -\frac{90}{23}$

Substitution

$M_{BA} = 3(-\frac{90}{23}) + 135 = 123.26 kNm$

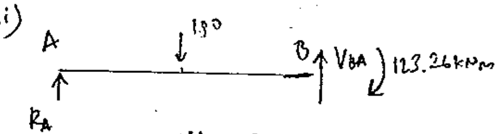
$M_{BC} = \frac{1}{2}(-\frac{90}{23}) - 90 = -91.96 kNm$

$M_{BF} = 4(-\frac{90}{23}) = -15.65 kNm$

$M_{BE} = 4(-\frac{90}{23}) = -15.65 kNm$

$M_{FB} = M_{EB} = 2(-\frac{90}{23}) = -7.83 kNm$

(iii)



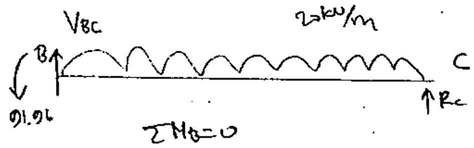
$\Sigma M_B = 0$

$-R_A \times 4 + 180 \times 2 - 123.26 = 0$

$R_A = 59.185 kN$

$\Sigma F_y = 0$

$V_{BA} = 120.815 kN$



$\Sigma M_B = 0$

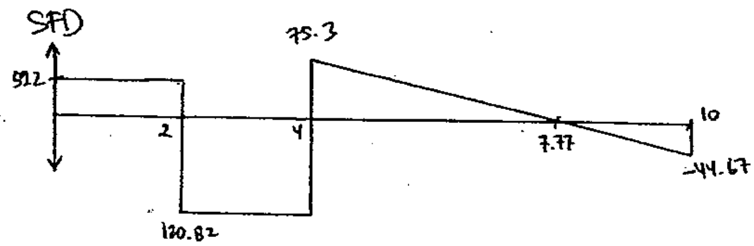
$91.96 - 20 \times 6 \times 3 + R_C \times 6 = 0$

$R_C = 44.673 kN$

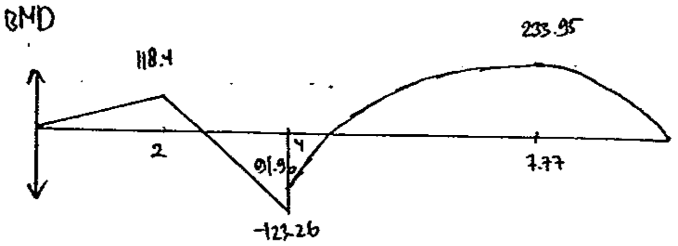
$\Sigma F_y = 0$

$V_{BC} = 75.327 kN$

SFD



BMD



b) (i) DOF should be θ_B and Δ_C

- D, E & F fixed moments, $\theta_D = \theta_E = \theta_F = 0$
- C & A is pinned support, have θ_A & θ_C but can be eliminated (proven through 2a(i))
- the allowed displacement is only in joint C vertically

Hence, the DOF is θ_B and Δ_C

(ii) Fixed End Moments is the same as (i)

, since we assume Δ_C moves downward,

$\psi_{BC} = \frac{\Delta_C}{L_{BC}} = \frac{\Delta_C}{6}$

$\psi_{CD} = -\frac{\Delta_C}{L_{CD}} = -\frac{\Delta_C}{6}$

End moments

- $M_{BA} = \frac{3EI}{L}(\theta_B - \psi) + FEM_{BA}$

$= \frac{3(4EI)}{4}\theta_B + 135$

$M_{BA} = 3EI\theta_B + 135$

- $M_{BC} = \frac{3EI}{L}(\theta_B - \psi_{BC}) + FEM_{BC}$

$= \frac{1}{2}EI\theta_B - \frac{1}{2}EI\frac{\Delta_C}{6} - 90$

$M_{BC} = \frac{1}{2}EI\theta_B - \frac{1}{12}EI\Delta_C - 90$

- $M_{DC} = \frac{3EI}{L}(\theta_D - \psi_{CD}) + FEM_{CD}$

$= \frac{1}{2}EI\left(0 - \left(-\frac{\Delta_C}{6}\right)\right) + 0$

$M_{DC} = \frac{1}{12}EI\Delta_C$

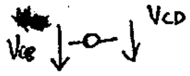
- $M_{BF} = 4EI\theta_B$
- $M_{FB} = 2EI\theta_B$
- $M_{BE} = 4EI\theta_B$
- $M_{EB} = 2EI\theta_B$

Equilibrium

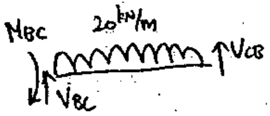
Joint B, $\Sigma M_B = 0$

(1) $M_{BA} + M_{BF} + M_{BC} + M_{BE} = 0$

(2) Joint C, $\Sigma F_y = 0$ $V_{CB} + V_{CD} = 0$



Beam BC

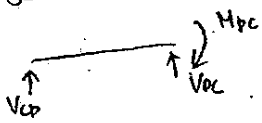


$\Sigma M_B = 0$

$-M_{BC} - 20 \times 6 \times 3 + V_{CB} \times 6 = 0$

$V_{CB} = \frac{1}{6}M_{BC} + 60$

Beam CD



$\Sigma M_D = 0$

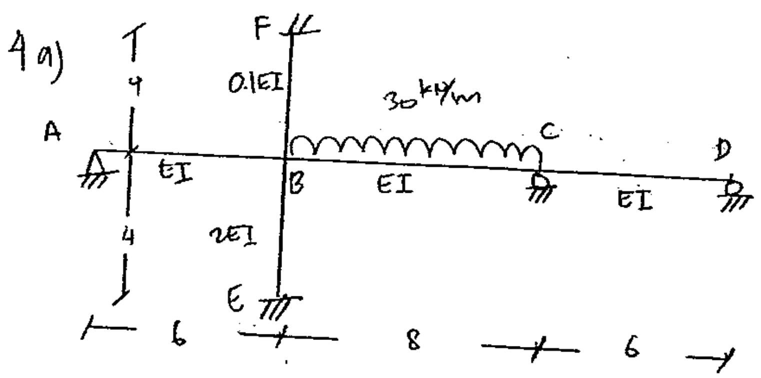
$-M_{DC} - V_{CD} \times 6 = 0$

$V_{CD} = -\frac{1}{6}M_{DC}$

$\therefore \frac{1}{6}M_{BC} + 60 - \frac{1}{6}M_{DC} = 0$

Using the equilibrium equations, we can obtain θ_B and Δ_C

4 a)



* Fixed End Moments

$FEM_{BC} = -\frac{wL^2}{12} = -\frac{30 \times 8^2}{12} = -160\ kNm$

$FEM_{CB} = \frac{wL^2}{12} = 160\ kNm$

* Stiffness Factor

$K_{AB} = \frac{3EI}{6} = \frac{EI}{2}$

$K_{BF} = \frac{4(0.1EI)}{4} = 0.1EI$

$K_{BE} = \frac{4(2EI)}{4} = 2EI$

$K_{BC} = \frac{4EI}{8} = \frac{EI}{2}$

$K_{CD} = \frac{3EI}{6} = \frac{EI}{2}$

* Distribution Factor

$DF_{AB} = 1$

$DF_{BA} = \frac{EI/2}{EI/2 + 0.1EI + 2EI + EI/2} = 0.1613$

$DF_{BE} = \frac{2EI}{EI/2 + 0.1EI + 2EI + EI/2} = 0.6452$

$DF_{BF} = \frac{0.1EI}{EI/2 + 0.1EI + 2EI + EI/2} = 0.0323$

$DF_{BC} = \frac{EI/2}{EI/2 + 0.1EI + 2EI + EI/2} = 0.1613$

$DF_{CB} = \frac{EI/2}{EI/2 + EI/2} = 0.5$

$DF_{CD} = \frac{EI/2}{EI/2 + EI/2} = 0.5$

$DF_{DC} = 1$

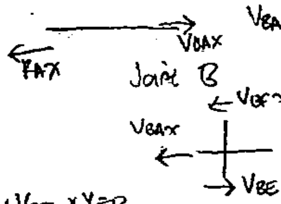
$DF_{FB} = 0$

$DF_{EB} = 0$

* Moment Distribution Method

Joint	A	B				E	F	C		D
	AB	BA	BE	BF	BC	EB	FB	CB	CD	DC
DF	1	0.1613	0.6452	0.0323	0.1613	0	0	0.5	0.5	1
FEM					-160			160		
Dist		25.81	103.23	5.168	25.81			-80	-80	
C.O					-40	51.62	2.58	12.91		
Dist		6.45	25.81	1.29	6.45	0	0	-6.46	-6.46	
C.O					-3.23	12.91	0.65	3.23		
Dist		0.52	2.08	0.10	0.52	0	0	-1.62	-1.62	
C.O					-0.81	1.04	0.05	0.26		
Dist		0.13	0.52	0.03	0.13	0	0	-0.13	-0.13	
ΣM	0	32.91	131.64	6.59	-171.13	65.57	3.28	88.19	-88.19	0

Beam AB

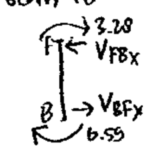


$\Sigma F_x = 0$

$V_{BAX} = R_A$

* Horizontal reaction at A

Beam FB

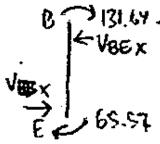


$\Sigma M_F = 0$

$-3.28 - 6.59 + V_{BFX} \times 4 = 0$

$V_{BFX} = 2.47\ kN$

Beam BE



$\Sigma M_E = 0$

$-131.64 - 65.57 + V_{BEX} \times 4 = 0$

$V_{BEX} = 49.30\ kN$

$\Sigma F_x = 0$

$V_{BAX} = R_{AX} = V_{BFX} + V_{B}$

$R_{AX} = 46.83\ kN$

b) (i) $FEM_{BE} = -\frac{6EI\Delta_B}{L^2} = -\frac{6(2EI)\left(\frac{1600}{6EI}\right)}{4^2} = -200\ kNm$

FEM for Δ,

$M_A = \frac{6EI\Delta}{L^2}$

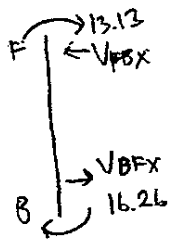
$M_B = \frac{6EI\Delta}{L^2}$

$FEM_{EB} = -200\ kN/m$

$FEM_{BF} = +\frac{6(0.1EI)\left(\frac{1600}{6EI}\right)}{4^2} = +10\ kNm$

$FEM_{FB} = +10\ kNm$

(ii) Beam FB

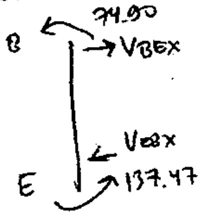


$\Sigma M_F = 0$

$-13.13 - 16.26 + V_{BFX} \times 4 = 0$

$V_{BFX} = 7.35\ kN$

Beam BE

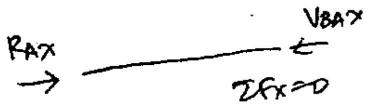


$\Sigma M_E = 0$

$74.90 + 137.47 - V_{BEX} \times 4 = 0$

$V_{BEX} = 53.09\ kN$

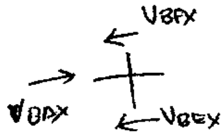
Beam AB



$\Sigma F_x = 0$

$V_{BAX} = R_A$

Joint B



$\Sigma F_x = 0$

$V_{BAX} = R_{AX} = V_{BFX} + V_{BEX} = 60.44\ kN$

$\therefore$

$M_{BA} = 32.91 + \frac{46.83}{60.44}(31.28) = 57.15\ kNm$

$M_{BE} = 131.64 + \frac{46.83}{60.44}(-74.90) = 73.61\ kNm$

$M_{BF} = 6.59 + \frac{46.83}{60.44}(16.26) = 19.19\ kNm$

$M_{BC} = -171.13 + \frac{46.83}{60.44}(27.37) = -149.92\ kNm$

$M_{CB} = 88.19 + \frac{46.83}{60.44}(7.82) = 94.25\ kNm$

$M_{CD} = -88.19 + \frac{46.83}{60.44}(-7.82) = -94.25\ kNm$

$M_{EB} = 65.57 + \frac{46.83}{60.44}(-137.47) = -40.94\ kNm$

$M_{FB} = 7.28 + \frac{46.83}{60.44}(13.13) = 13.45\ kNm$

#

[signature]

GOOD LUCK! ☺