Problems carry equal weightage

Problem 1
For the frame shown in Figure 1, calculate the horizontal deflection at C. You must use only the method of virtual work, and ignore axial and shear deformations. EI is constant for all members.
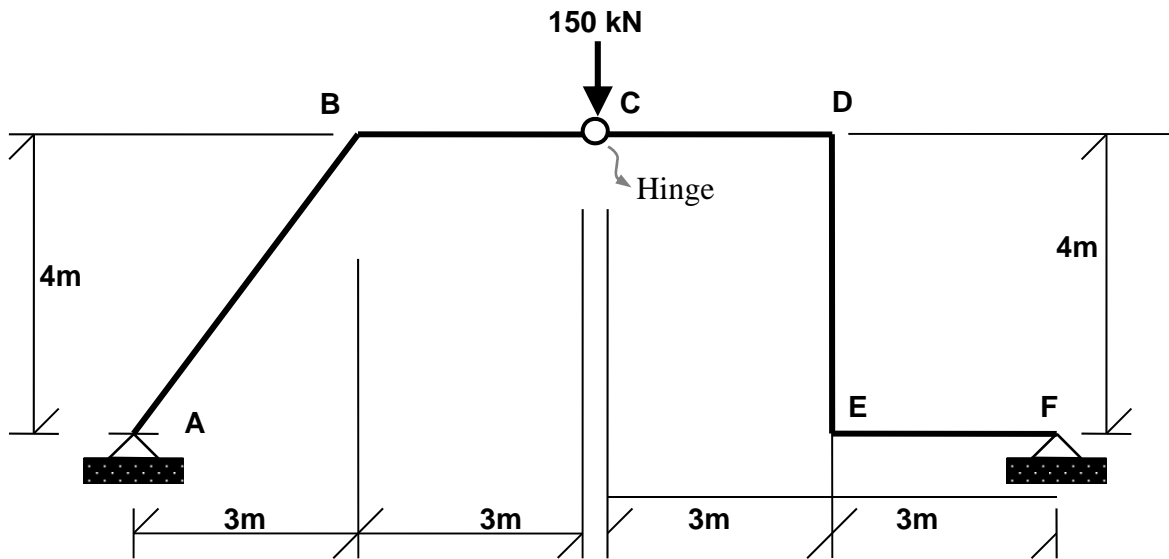

Figure 1

Problem 2
For the truss in Figure 2, calculate vertical deflection at D. In addition to the applied loading, consider that member AB is subjected to a decrease in temperature of $\Delta T = -150°C$ and member BC is short by 5mm. Take E = 200 GPa and A = 200 mm^2 for all members and thermal expansion coefficient $\alpha = 0.6(10^{-5})/°C$.
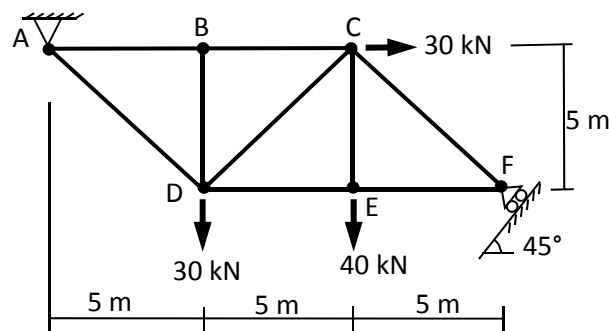

Figure 2

Problem 3

For the beam in Figure 3, calculate rotation at B in span BC. You must use only the method of virtual work and ignore axial and shear deformations. Consider that EI is constant for all members.
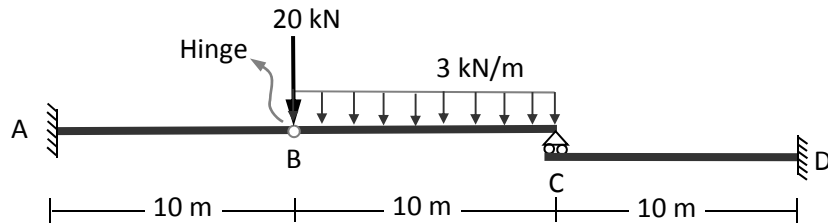

Figure 3

Problem 4

For the beam in Figure 4, draw the **influence lines** for (a) **the horizontal and vertical reactions at A** and (b) **the shear force and bending moment at G**. Unit load moves from A to E.
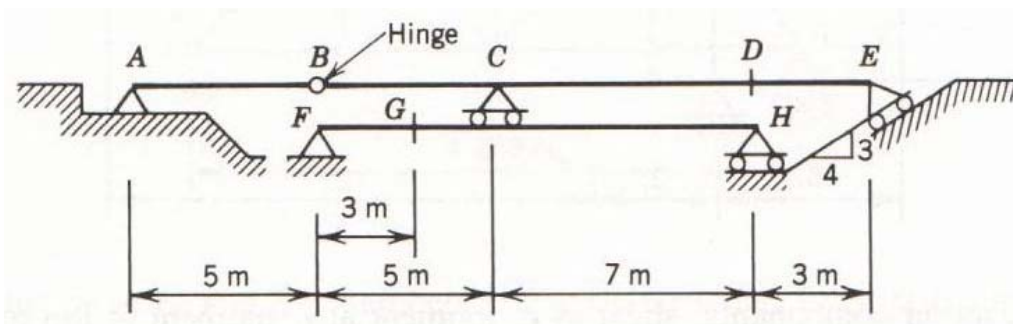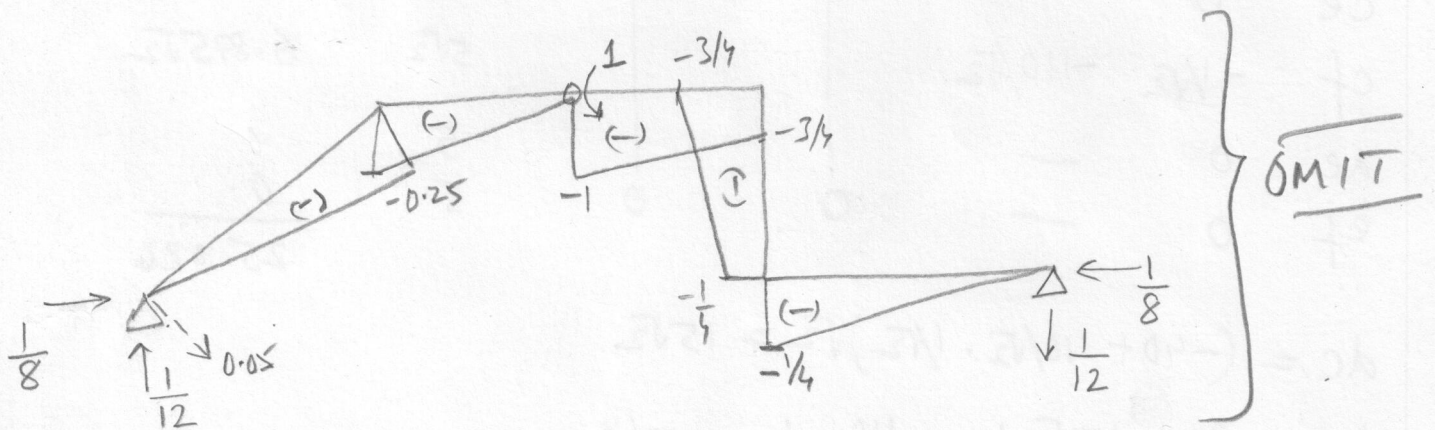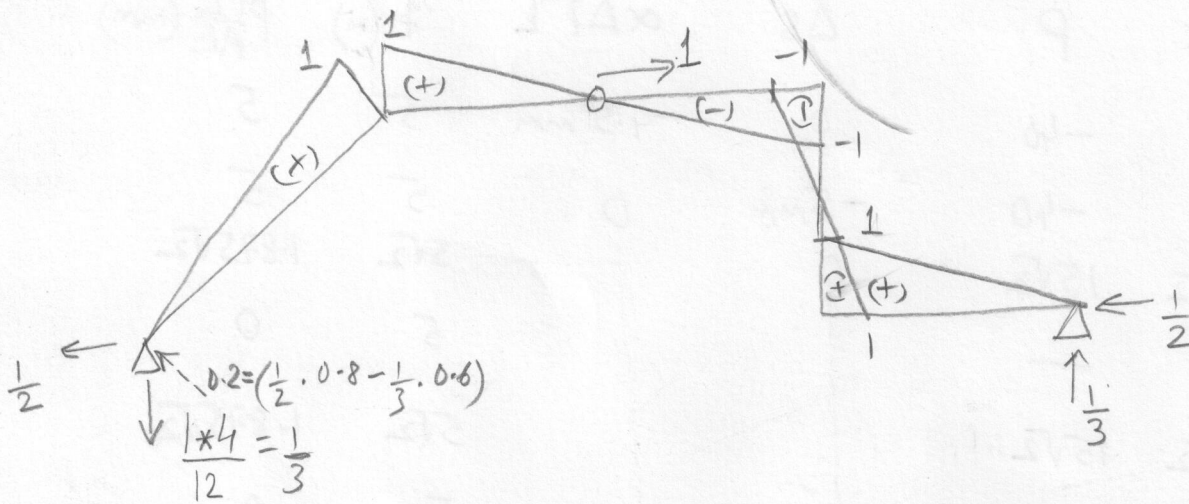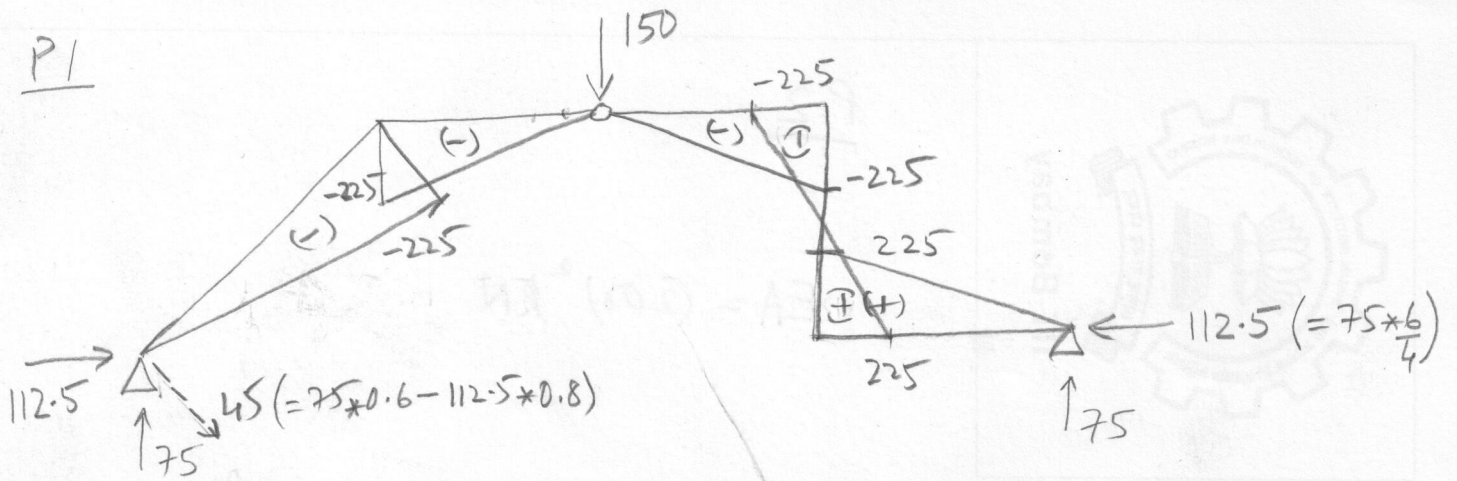

Figure 4

P1

150

−225

(−)   (−)

−225

(−)   −225

(−)   −225

112.5 →

↑ 75   45 (=75*0.6−112.5*0.8)

−225   ↑

−225

225   (+)

225

112.5 (=75*6/4) ←

↑ 75

1   1   →1   −1

(+)   (−)   ↑

(+)   −1

1

(+)   (+)

1/2 ←

↑ 1/3   1/2 ←

0.2=(1/2 · 0.8 − 1/3 · 0.6)

1*4/12 = 1/3

1   −3/4

(−)   (−)

−1   −3/4

−0.25   ↑

(−)

−1/4   (−)

−1/4

OMIT

1/8 ←   0.05

↑ 1/12   1/8 ←

↓ 1/12
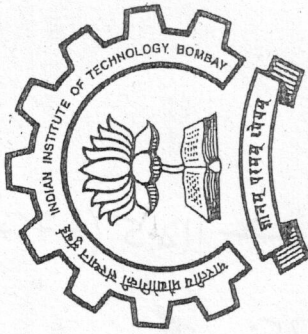
$$EI \, \Delta_{ch} = \frac{1}{3}\Big[(-225)(1)(5) + (-225)(1)(3) + (-225)(-1)(3) + (-225)(-1)(2) + (225)(1)(2) + (225)(1)(3)\Big] = 150 \text{ kN.m}^3$$

$$EA = (200)^2 \, kN$$

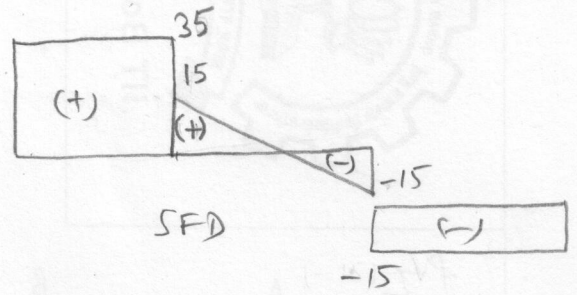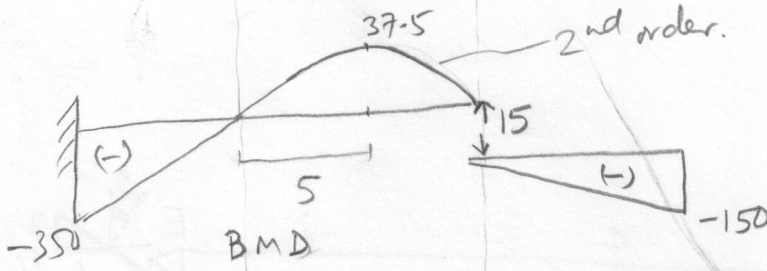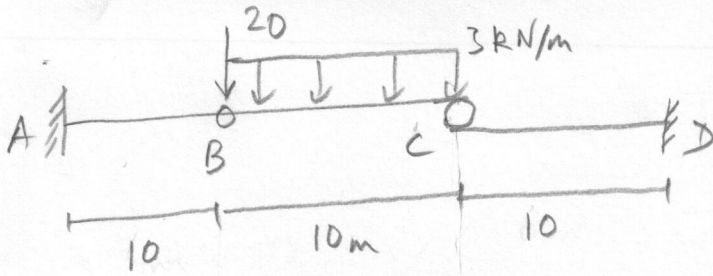|	p	P	Δs	$\alpha \Delta T L$	$L(m)$	$\frac{PL}{AE}$ (mm)
ab	-1	-40	0	-4.5 mm	5	5
bc	-1	-40	-5 mm	0	5	5
ad	$1/\sqrt{2}$	$15\sqrt{2}$	0		$5\sqrt{2}$	$1.875\sqrt{2}$
bd	0	—			5	0
cd	$1/\sqrt{2}$	$15\sqrt{2}$			$5\sqrt{2}$	$1.875\sqrt{2}$
ce	0	—			5	0
cf	$-1/\sqrt{2}$	$-110/\sqrt{2}$			$5\sqrt{2}$	$6.875\sqrt{2}$
de	0	—			5	0
ef	0	—	0	0	5	0
						25.026

$$dc = \left(-40 + \frac{110}{\sqrt{2}} \cdot \frac{1}{\sqrt{2}}\right)\sqrt{2} = 15\sqrt{2}$$

$$bc = 30 - 15\sqrt{2}\frac{1}{\sqrt{2}} - \frac{110}{\sqrt{2}} \cdot \frac{1}{\sqrt{2}} = -40$$

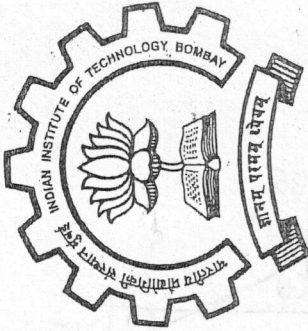$$(\alpha \Delta T L)_{AB} = 0.6 \times 10^{-5}(-150)5 = -4.5E-3 = -4.5mm$$

$$v_D = (-1)(-5) + (-1)(-4.5) + 25.026 = 34.526mm$$

P3
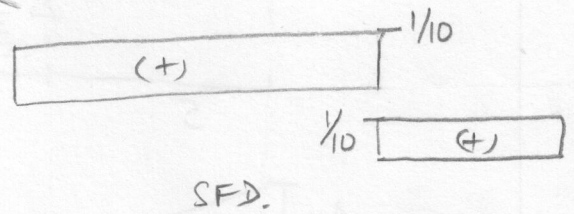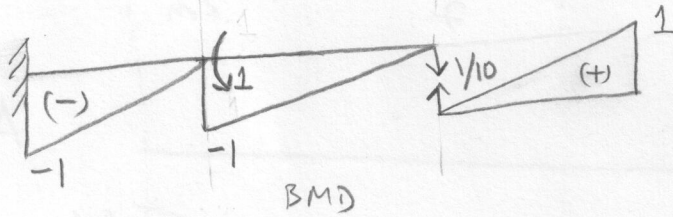
$$EI\,\theta_{B^+} = \frac{1}{3}(-350)(-1)(10) + \frac{1}{3}(-150)(1)(10) + \frac{5}{12}(37.5)(-0.5)(5)$$

$$+ \frac{1}{12}\left[(37.5)\left(3(-1) + 5(-0.5)\right)\right](5)$$

$$= \frac{1625}{3} = 541.67 \text{ kN}.$$

P4

A   B   C   D   E

F   G   H

3m   G

5   5   7   3m

3
4

1

A_V

0.75 A_H

-0.375

$\dfrac{7}{12} \cdot \dfrac{15}{10} = \dfrac{7}{8}$ $1 \cdot \dfrac{7}{12}$ V_G

$\dfrac{7}{8} \cdot 3 = \dfrac{21}{8}$ $\dfrac{7}{12} \cdot 3 = \dfrac{7}{4}$ M_G