DEPARTMENT OF CIVIL ENGINEERING

CE-222 STRUCTURAL MECHANICS I

Midsem 13/2/10

Problem 1

Find the **deflection (i.e., vertical and horizontal components) at *D*** in the truss-arch due to the mechanical loading shown in **Fig. 1**.

After the mechanical loads are applied the four members (***BC***, ***CD***, ***DH***, ***HG***) undergo a temperature increase of 200^0F with $\alpha = 10^{-6} / {}^0F$, and the two members (***AB***, ***FG***) are replaced by misfit members that are 0.25% shorter than the original length in **Fig. 1**, and the two members (***EC***, ***IH***) are replaced by misfit members that are 0.3% longer than the original length in **Fig. 1**. What is the additional deflection at ***D.***

Problem 2

Consider the beam-truss bridge shown in **Fig. 2.** Draw influence lines for shear at ***A***, bending moment at ***B***, and force in member ***EL***.

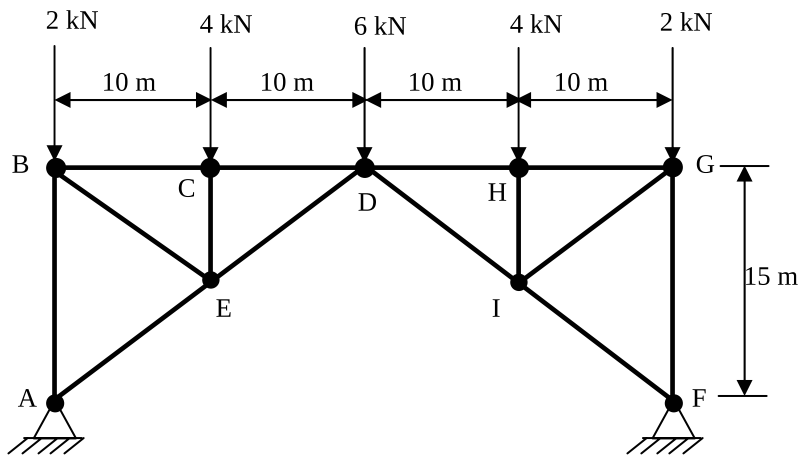


Fig. 1

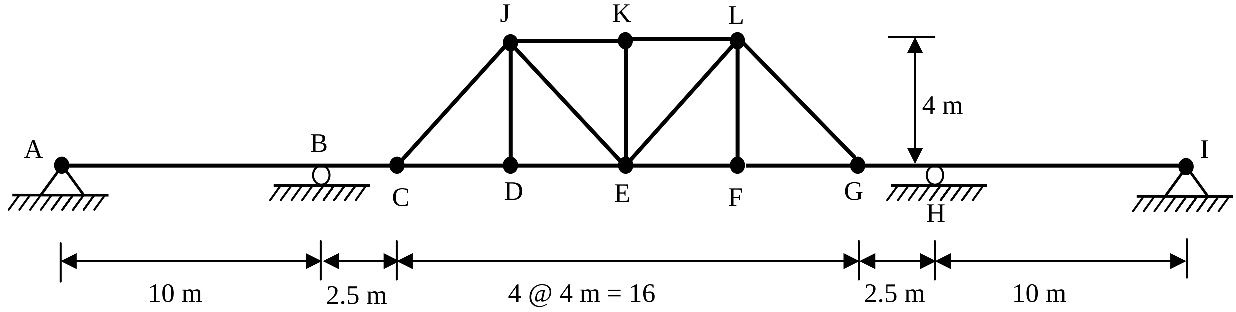


Fig. 2

Problem 3

The structure shown in **Fig. 3** comprises four members ***AB***, ***BCD***, ***DF***, and ***CE***. Members ***AB*** and ***BCD*** are connected by a pin/hinge at ***B***. Members ***BCD*** and ***CE*** are connected by a pin/hinge at ***C***. Members ***BCD*** and ***DF*** are connected by a pin/hinge at ***D***.
Find the **vertical deflection of pin/hinge point *B*** due to applied uniform load as shown. Consider axial rigidity ***AE*** and flexural rigiditiy ***EI*** to be same for all members. **Neglect shear deformations**.

Problem 4

Find the **rotation of points *A, B, C, D*** for the frame shown in ***Fig. 4***. Take flexural rigidity as ***EI*** and axial rigidity ***AE.*** **Neglect shear deformations**.

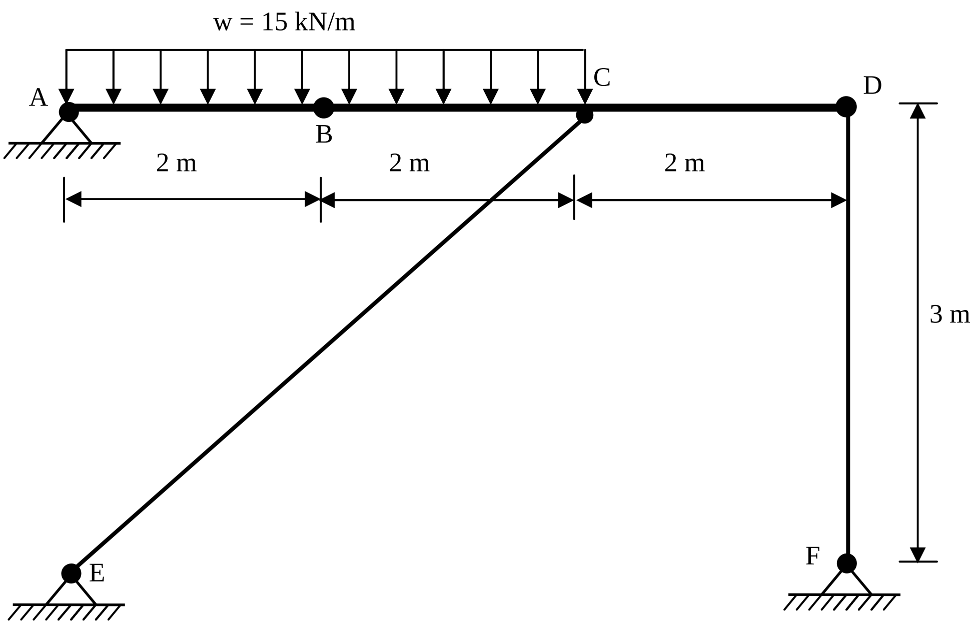


Fig. 3

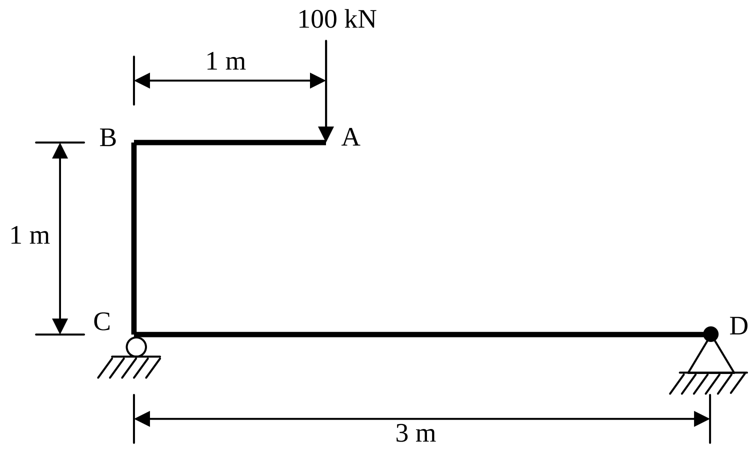
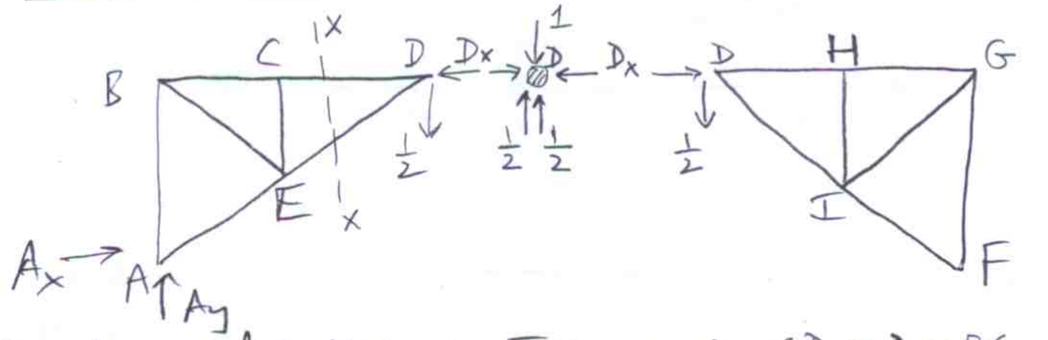


Fig. 4

P1 Unit load at D (↓). Use symmetry for half truss.



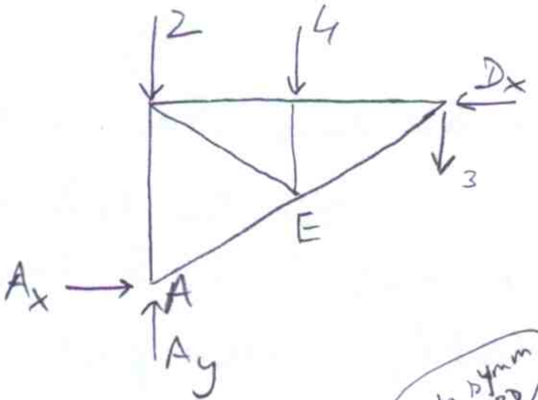
Consider section XX $\rightarrow \sum M_A = 0 \Rightarrow CD = 0 = BC$, also $CE = 0$,

jt B $\Rightarrow BE = 0 \Rightarrow BA = 0$

jt D $\Rightarrow \frac{1}{2} + DE\left(\frac{3}{5}\right) = 0 \Rightarrow DE = \frac{-5}{6} = AE$

So only AE & ED non-zero virtual member forces.
This is obvious since unit load at D gets transferred to supports thru load path DEA & DIF

Real loads (use symmetry)



jt D: $3 + DE\left(\frac{3}{5}\right) = 0$

$\Rightarrow DE = -5$

$\sum M_A = 0 \Rightarrow (4)(10) + (3)(20) = D_x(15)$

$\Rightarrow D_x = \frac{20}{3} = A_x$

jt A $\Rightarrow AE = -\left(\frac{5}{4}\right)\left(\frac{20}{3}\right) = -\frac{25}{3}$

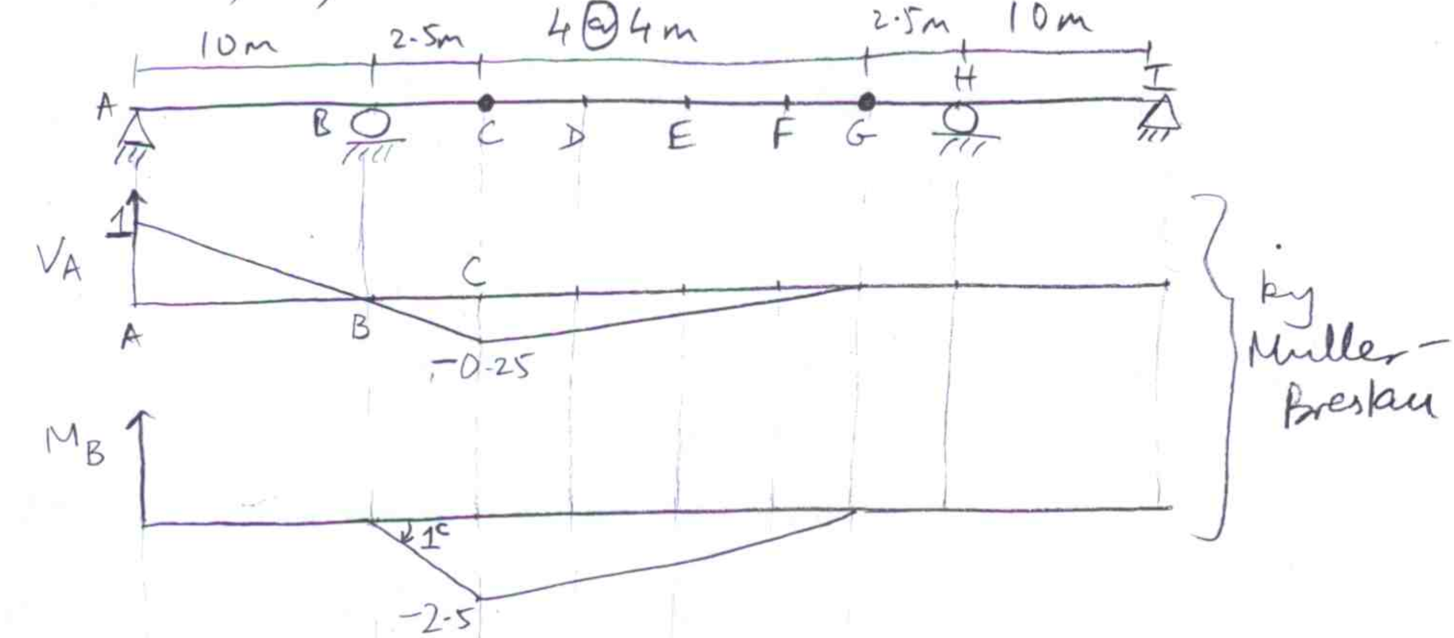
due to symm of RHS FBD

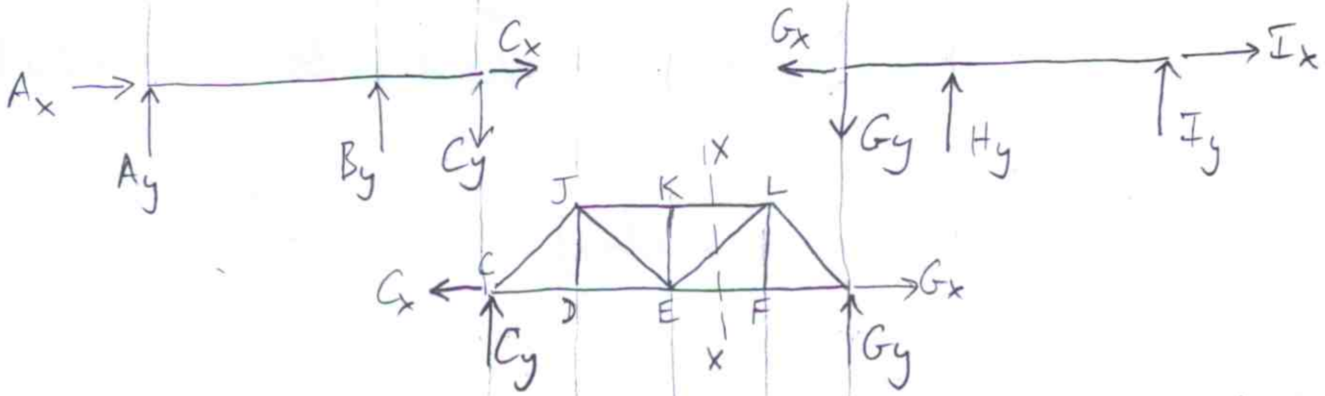
$$1.\ \Delta D_v = \left[\left(-\frac{25}{3}\right)\left(-\frac{5}{6}\right)\left(\frac{12.5}{AE}\right) + (-5)\left(-\frac{5}{6}\right)\left(\frac{12.5}{AE}\right)\right] * 2 = \frac{2500}{9AE} = \frac{277.8}{AE}$$

$\Delta D_H = 0$ (from symmetry of structure & load)

Since all members undergoing temp change and misfit have zero virtual forces, there is no additional deflection of point D

?2 Truss portion C to G can be replaced by an equivalent beam, ie,





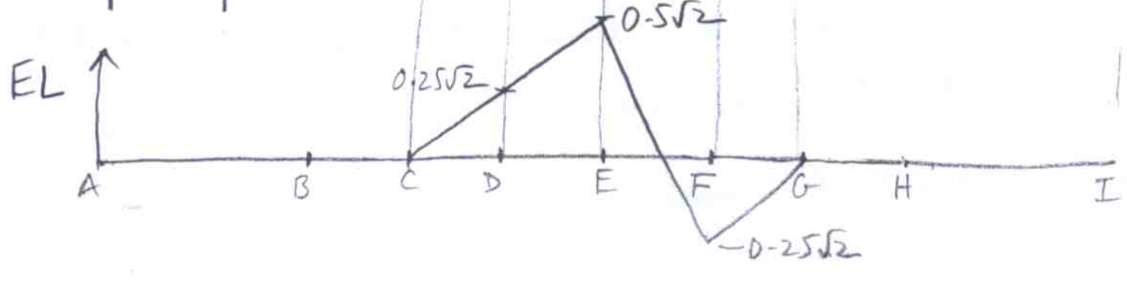
Forces in truss part are zero when unit load at A, B, H, I.

C_x, C_y, G_x, G_y are interaction between truss and beam parts at the pins C, G. So truss part can be treated independently of beam part (ie seperately).

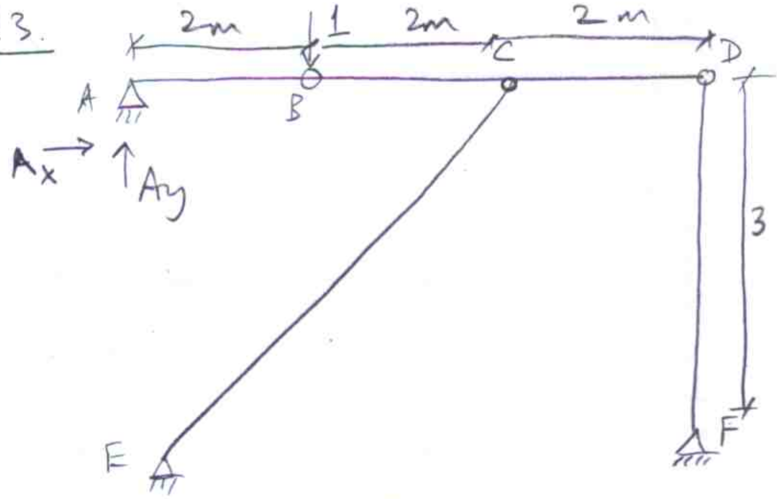
	C_y	EL
C	1	0
D	0.75	$0.25\sqrt{2}$
E	0.5	$0.5\sqrt{2}$
F	0.25	$-0.25\sqrt{2}$
G	0	0

$\frac{EL}{\sqrt{2}} + C_y - 1 = 0$, for unit load at C, D, E

$\frac{EL}{\sqrt{2}} + C_y = 0$, for unit load at F, G



P.3.

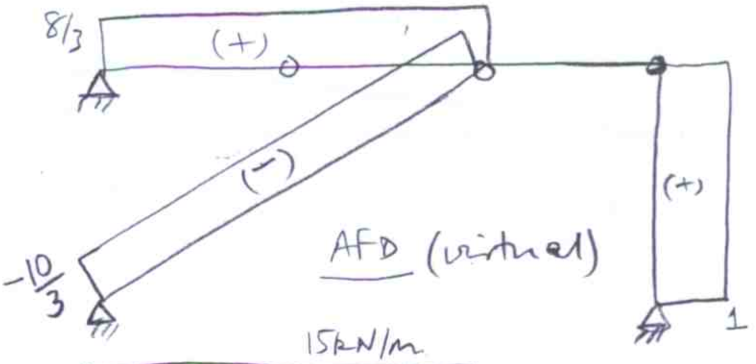


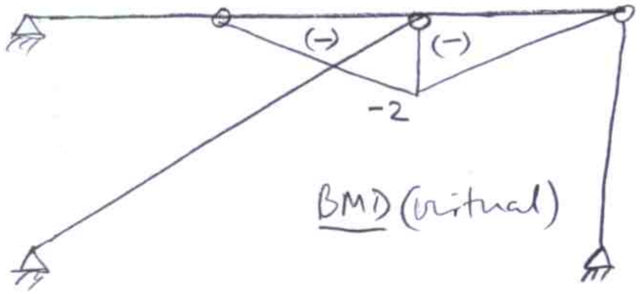
$$\Sigma M_B = 0 \Rightarrow A_y = 0$$

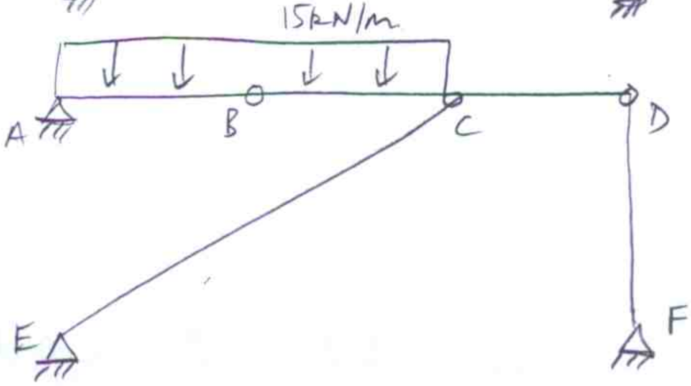
$$\Sigma M_c = 0 \Rightarrow DF = 1\,(T)$$

$$\Sigma F_y = 0 \Rightarrow CE = -(1+1)\frac{5}{3} = -\frac{10}{3}\,(C)$$

$$\Sigma F_x = 0 \Rightarrow A_x = CE\left(\frac{4}{5}\right) = -\frac{8}{3}$$







$$\Sigma M_B = 0 \Rightarrow A_y = \frac{1}{2}(15)\frac{(2^2)}{2} = 15$$

$$\Sigma M_c = 0 \Rightarrow DF = \frac{1}{2}\left[(15)\frac{(4^2)}{2} - (15)(4)\right]$$

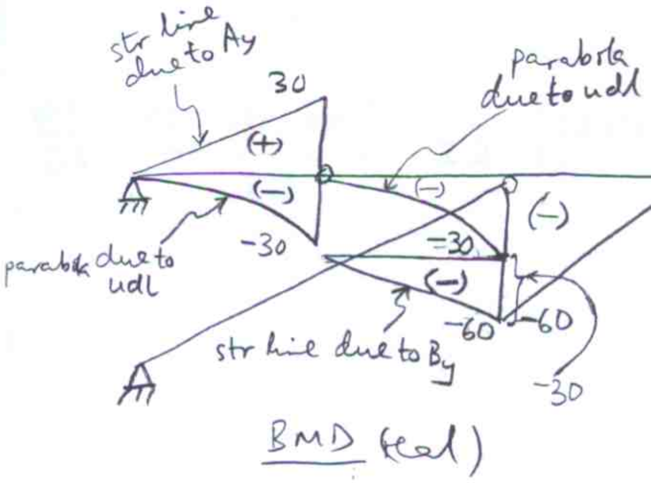
$$DF = 30\,(T)$$

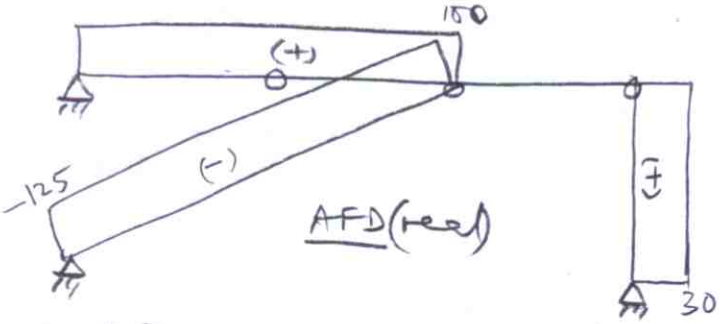
$$\Sigma F_y = 0 \Rightarrow CE = \frac{5}{3}\left[-30 - (15)(4) + 15\right]$$

$$CE = -125\,(C)$$

$$\Sigma F_x = 0 \Rightarrow A_x = CE\left(\frac{4}{5}\right) = -100$$

$$B_y = (15)(2) - A_y = 15$$





$$1.\ \Delta_{BV} = \frac{1}{AE}\left[\left(\frac{8}{3}\right)(100)(4) + \left(-\frac{10}{3}\right)(-125)(5) + (1)(30)(3)\right]$$

$$+ \frac{1}{EI}\left[\frac{1}{3}(-2)(-60)(2) + \frac{1}{3}(-30)(-2)(2) + \frac{1}{4}(30)(-2)(2) + \frac{1}{2}(-30)(-2)(2)\right]$$

$$= \frac{3240}{AE} + \frac{150}{EI}$$

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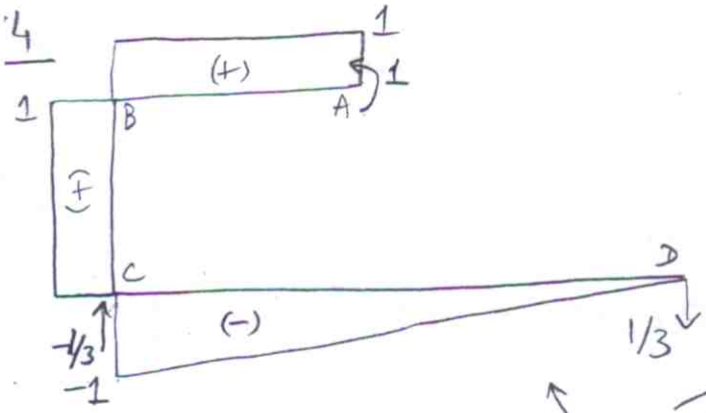
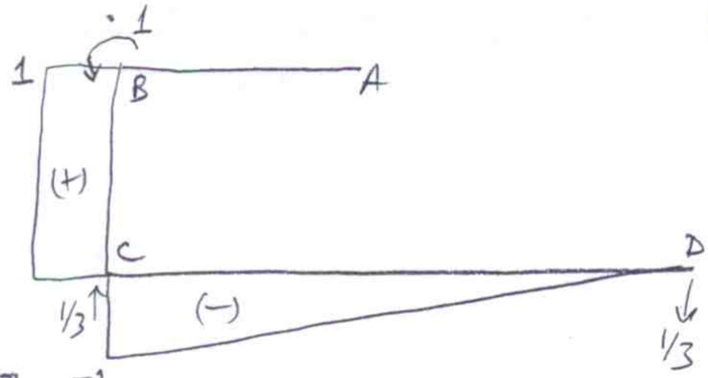
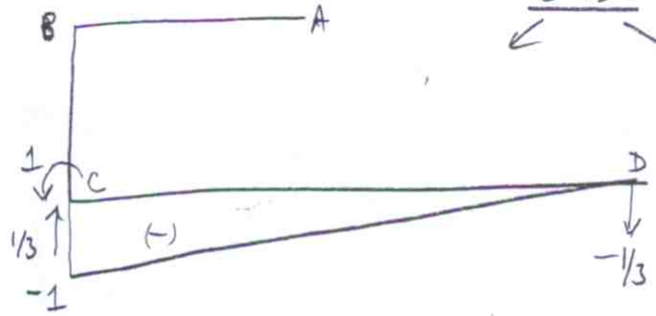
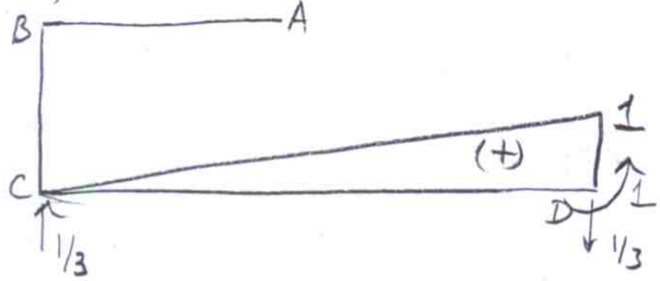
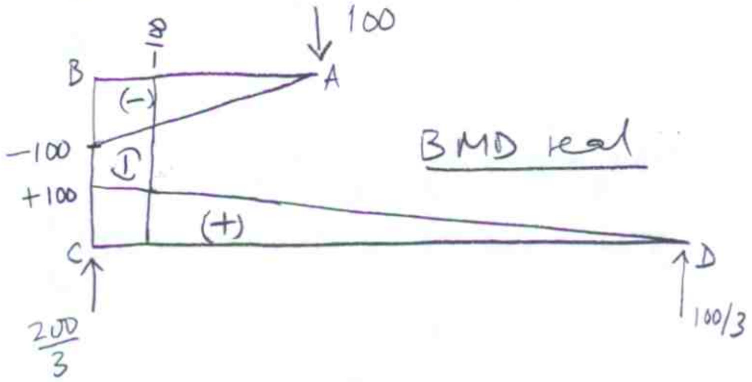




BMD's (virtual)







BMD real

Note : ∵ AFD virtual is zero, no axial deformation effects are present.

$$1 \cdot \theta_A = \left[\frac{1}{2}(1)(-100)(1) + (1)(-100)(1) + \frac{1}{3}(-1)(100)(3)\right] \cdot \frac{1}{EI} = \frac{(-50-100-100)}{EI} = \frac{-250}{EI}$$

$$1 \cdot \theta_B = \frac{-200}{EI}, \quad 1 \cdot \theta_C = -\frac{100}{EI}$$

$$1 \cdot \theta_D = \frac{1}{6}(1)(100)(3) \cdot \frac{1}{EI} = \frac{50}{EI}$$