DEPARTMENT OF CIVIL ENGINEERING

CE-222 STRUCTURAL MECHANICS I

Midsem 14/2/09

Problem 1

Find the **maximum tension in the parabolic cable** shown in **Fig. 1** due to the uniformly distributed load applied on the girder. The girder has an internal hinge at ***B*** which lies directly below the lowest point on the cable as shown in **Fig. 1**. Support at ***A*** is pinned and support at ***C*** is roller.

Problem 2

Each member of the truss in **Fig. 2** has cross-section area 400 mm^2 and Young's modulus 200 GPa. In the first case the truss is loaded as shown in the figure, for which point ***A*** has vertical and horizontal displacements v_A and h_A, respectively. Then, the loads are removed, member ***AE*** is replaced by a defective member that is shorter by 20 mm, and member ***HJ*** is replaced by a member with cross-section area 200 mm^2. The loads in **Fig. 2** are applied again and member ***AB*** further undergoes a temperature increase of 200^0 F, with $\alpha = 10^{-6} / {}^0F$. Let the new vertical and horizontal displacements of point ***A*** be $\bar{v}_A$ and $\bar{h}_A$, respectively. Find the differences $v_A - \bar{v}_A$ and $h_A - \bar{h}_A$. Clearly indicate the direction that point ***A*** moves when going from the first loading case to the second loading case.

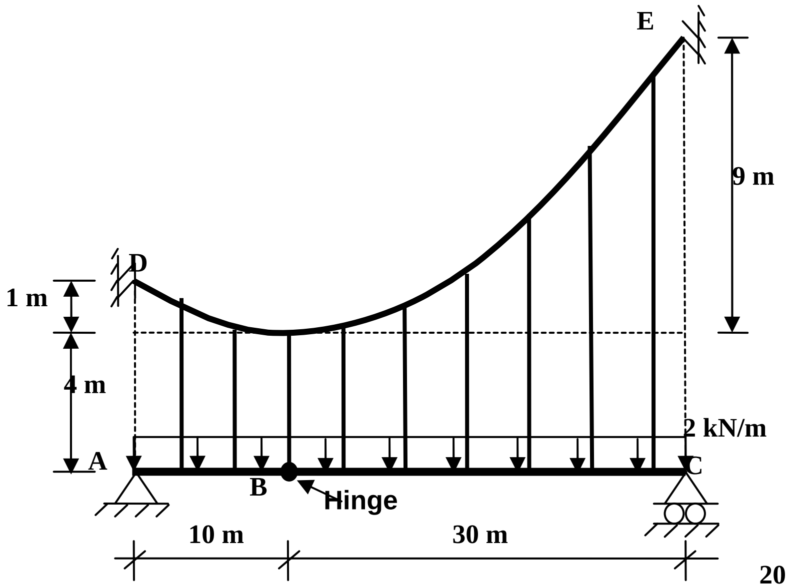

Fig. 1

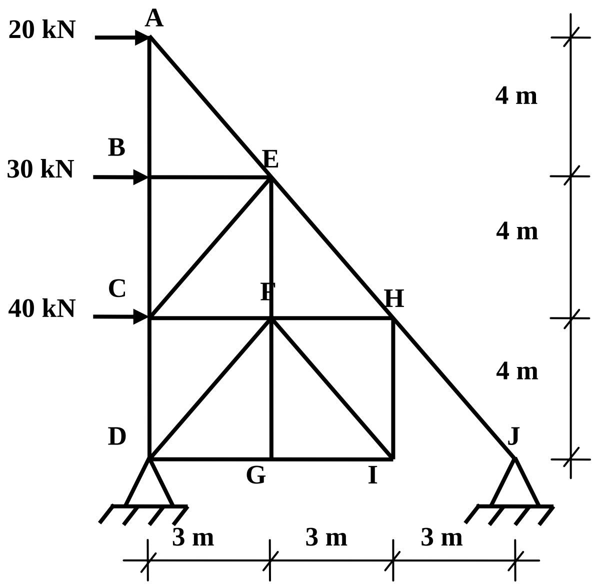

Fig. 2

Problem 3

Find the **<u>vertical deflection of point *B*</u>** for the continuously supported beam ***AB*** which has an internal hinge ***F*** (***Fig. 3***). The beam ***AB*** has flexural rigidity ***EI*** and is supported by a truss system ***BCDE*** through a pin connection at ***B***. The axial rigidity is ***AE*** for the truss members (i.e., ***BC***, ***BD***, ***CD***, ***CE***, ***DE***).

Problem 4

Find the **<u>horizontal displacement of point *G*</u>** for the frame shown in ***Fig. 4***. Take flexural rigidity as ***EI*** and **<u>neglect axial and shear deformations</u>**.

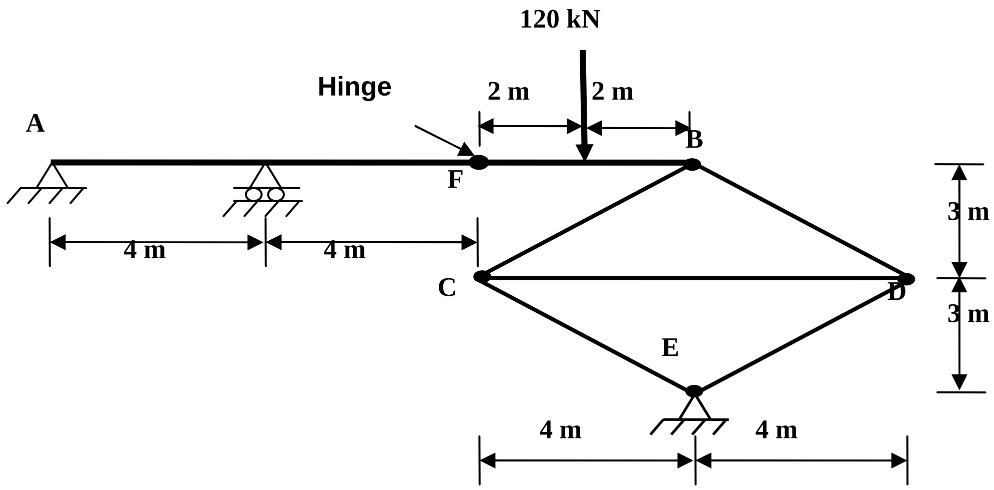

Fig. 3

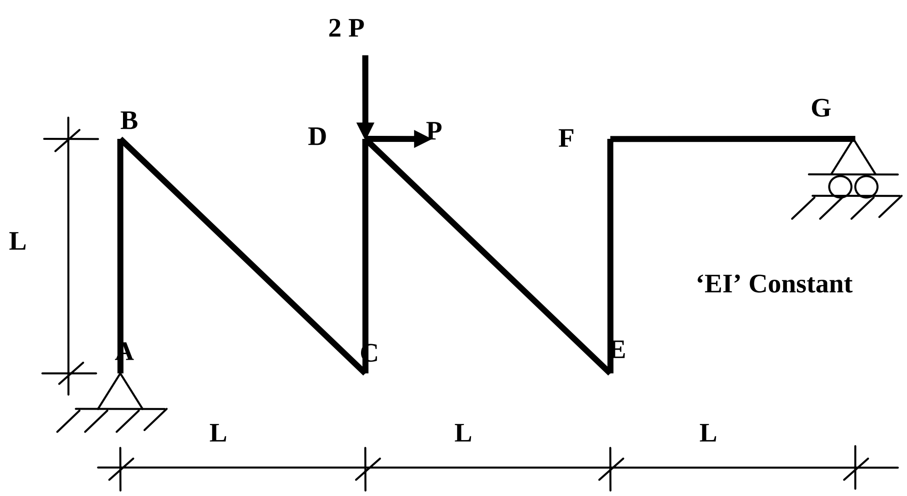

Fig. 4

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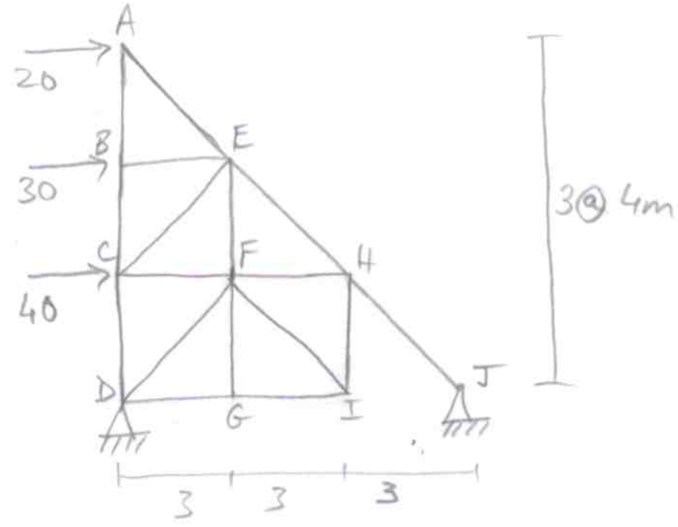
3)



Due to real load.

$$(20)(12)+(30)(8)+(40)(4)+HJ\left(\tfrac{4}{5}\right)(6)+HJ\left(\tfrac{3}{5}\right)(4)=0$$

$$HJ=-\frac{800}{9}$$

Due to unit vertical load, (↓),

$$AB=-1,\quad AE=HJ=0$$

Due to unit horizontal load, (→),

$$AE=-\left(\tfrac{5}{3}\right),\quad AB=\left(\tfrac{5}{3}\right)\left(\tfrac{4}{5}\right)=\left(\tfrac{4}{3}\right)$$

$$HJ=-\frac{(1)(12)}{\left(\frac{4}{5}\right)(6)+\left(\frac{3}{5}\right)(4)}=-\frac{5}{3}$$

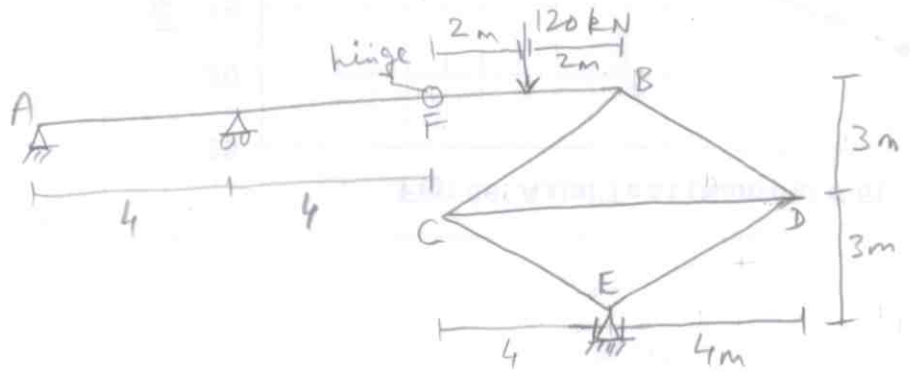
change displ.

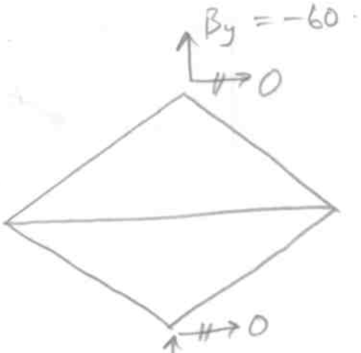
$$\Delta(\Delta_{AH})=-\left\{\left(-\tfrac{5}{3}\right)(-20)+\left(\tfrac{4}{3}\right)(200)(10^{-6})(4*10^3)\right\}+\left(-\tfrac{5}{3}\right)\left(-\tfrac{800}{9}\times10^3\right)(5000)\left(\frac{1}{400*200E3}-\frac{1}{200*200E3}\right)$$

$$=-43.659\text{ mm.}$$

$$\Delta(\Delta_{AV})=-\left\{(-1)(200)(10^{-6})(4*10^3)\right\}=0.8\text{ mm.}$$

2)





$$\Sigma M_F=0\Rightarrow E_y=\frac{120*2}{4}=60$$

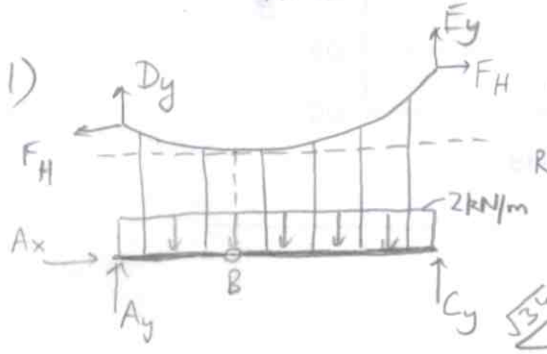
Real loads: $CE=DE=-\left(\frac{60}{2}\right)\left(\frac{5}{3}\right)=-50=CB=DB.$

$$CD=(2)(50)\left(\tfrac{4}{5}\right)=80$$

Unit vertical load: $E_y=1,\quad CE=DE=CB=DB=-\frac{5}{6},\quad CD=\frac{4}{3}$

$$\Delta_v=\frac{1}{AE}\left(4*(-50)\left(-\tfrac{5}{6}\right)(5)+(80)\left(\tfrac{4}{3}\right)(8)\right)=\frac{5060}{3AE}=\frac{1686.7}{AE}$$

1)



$$\underset{\text{whole}}{\Sigma M_A=0}\Rightarrow 40(C_y+E_y)-8F_H-\tfrac{2}{2}(40)^2=0$$

$$\underset{\text{RHFBD}}{\Sigma M_B=0}\Rightarrow 30(C_y+E_y)-9F_H-\tfrac{2}{2}(30)^2=0.$$

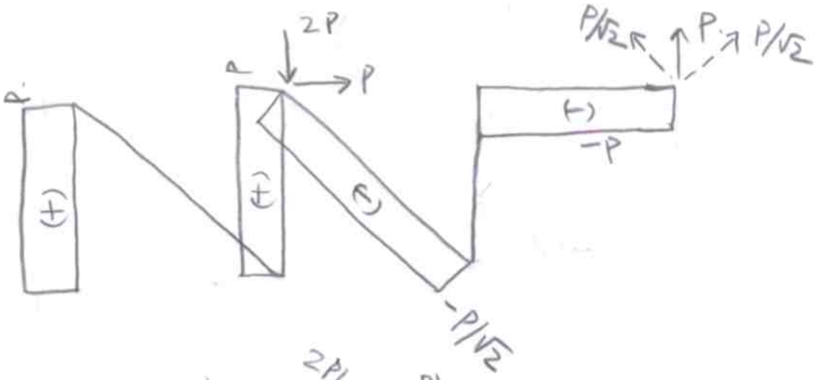
$$\Rightarrow 24F_H+4800-36F_H-3600=0\Rightarrow F_H=100$$

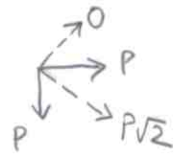
$$T_{max}=\frac{100}{\cos\theta_{max}},\quad y=\frac{x^2}{100},\ y'=\frac{x}{50},\ \tan\theta_{max}=\frac{30}{50}$$

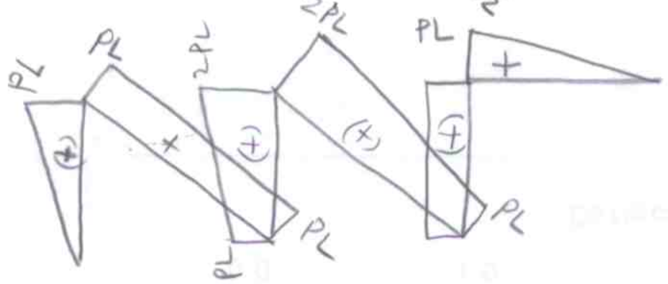
$$\Rightarrow T_{max}=100/(5/\sqrt{34})=116.6\text{ kN.}$$

4) Real Load

$$G_y = \frac{2PL + PL}{3L} = P$$

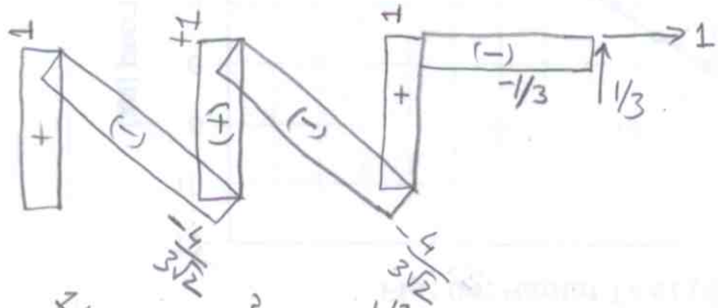


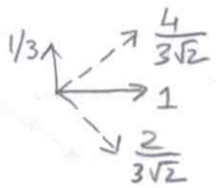


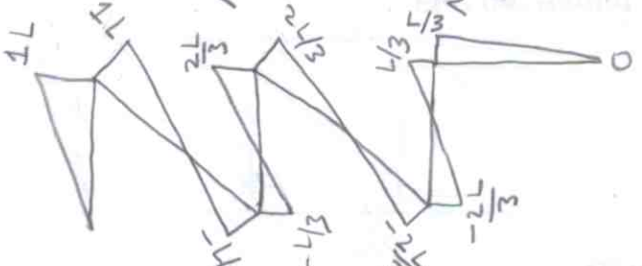


Unit horizontal load at G

$$G_y = \frac{(1)(L)}{3L} = \frac{1}{3}$$







$$\Delta_{Gh} = \frac{1}{EI}\Big\{\left(\tfrac{1}{3}\right)(1)(1)(1) + \left(\tfrac{1}{2}\right)(1)(1)\left(\tfrac{3\sqrt{2}}{4}\right) + \left(\tfrac{1}{2}\right)\left(-\tfrac{1}{3}\right)(1)\left(\tfrac{\sqrt{2}}{4}\right) + \left(\tfrac{1}{6}\right)\left(-\tfrac{1}{3}\right)\left(2*1 + \tfrac{4}{3}\right)\left(\tfrac{1}{3}\right)$$
$$+ \left(\tfrac{1}{6}\right)\left(\tfrac{2}{3}\right)\left(\tfrac{4}{3} + 2*2\right)\left(\tfrac{2}{3}\right) + \left(\tfrac{1}{6}\right)\left(\tfrac{2}{3}\right)\left(2*2 - 2*1\right)\left(\tfrac{1}{2}\cdot\sqrt{2}\right) + \left(\tfrac{1}{2}\right)\left(-\tfrac{2}{3}\right)(1)\left(\tfrac{2}{3}\right)$$
$$+ \tfrac{1}{2}\left(\tfrac{1}{3}\right)(1)\left(\tfrac{1}{3}\right) + \left(\tfrac{1}{3}\right)\left(\tfrac{1}{3}\right)(1)(1)\Big\} PL^3 = 1.2397\,\frac{PL^3}{EI}.$$