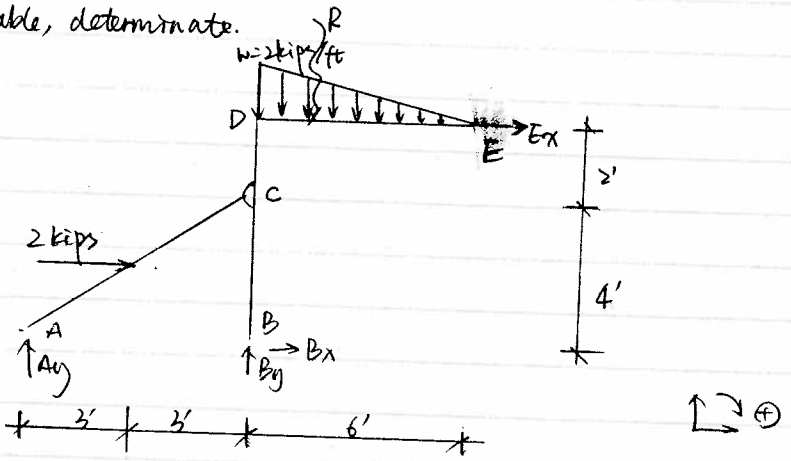
Introduction to structural Engineering Exam1 SOLUTION

(50) Total points

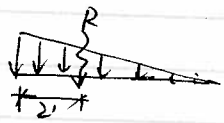
Q1. a) It is stable, determinate.
(2.5)



$R-(3+C)=4-(3+1)=0$

R~ external reactions ; C~ inner hinge — conditional eqn.

(b) Write 3 equilibrium equations:



$R=\frac{2\times6}{2}=6$ kips ↓

(10)

$\Sigma F(x)=0$ $B_x+E_x=0$ $\underline{x_B=1.33^k\rightarrow}$

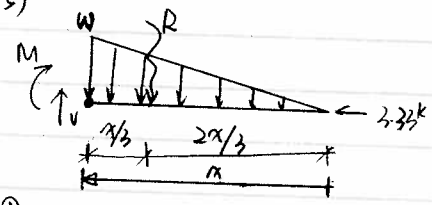
$\Sigma F(y)=0$ $A_y+B_y-\frac{2\times6}{2}=0$ $\Rightarrow \underline{y_B=5.33\text{ kips}\uparrow}$ Ans.

$\Sigma M_B=0$ $y_A\times6+2\times2+6\times2+x_E\times6=0$ $\underline{x_E=-1.33\text{ kips}\leftarrow}$ Ans.

Write 1 conditional equation:

$M_C^{AC}=y_A\times6-2\times2=0$ $\Rightarrow \underline{y_A=2/3=0.67\text{ kips}\uparrow}$ Ans.

(c) Write the eqns for shear & Moment for DE with a local coordinate origin at E.
(5)



$\frac{2\text{kips/ft}}{6\text{ft}}=\frac{w}{x}\Rightarrow w=x/3$

$R=\frac{x}{3}\times x/2=\frac{1}{6}x^2$

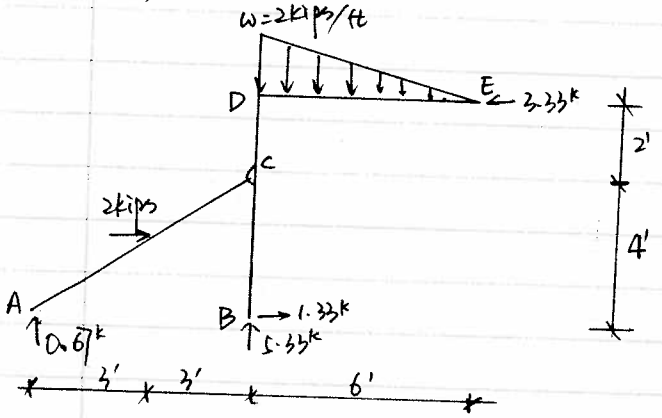
⊕↑ $\Sigma F_y=0$ $V-\frac{1}{6}x^2=0$ $\underline{V=\frac{1}{6}x^2}$ $(0\le x\le6)$

↻ ⊕ $\Sigma M(-x)=0$ $M+R\cdot x/3=M+\frac{1}{6}x^2\cdot x/3=0$ $\underline{M=-\frac{1}{18}x^3}$ $(0\le x\le6)$

(d) The Maximum moment occurs at the end of the beam where $x=6'$
(2.5)

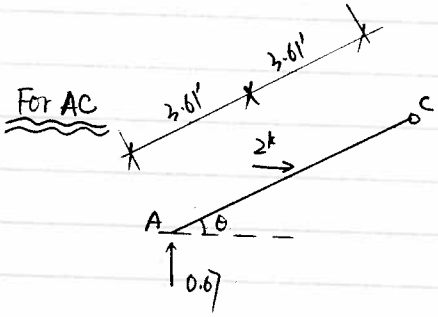
$M(x=6)=-\frac{1}{18}\times6^3=\underline{-12\text{kips}\cdot\text{ft}}$ Ans.

(e) Draw the FBD of the entire structure.
(25)

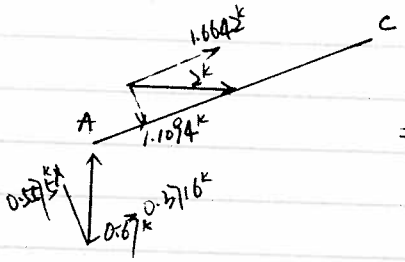


$\cos\theta = 0.832$, $\sin\theta = 0.554$

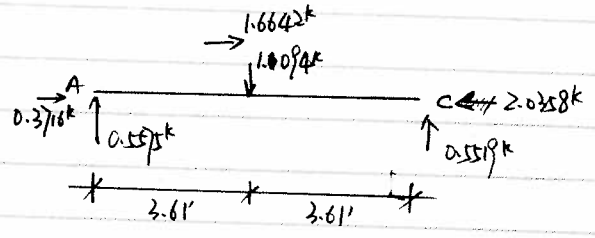
For AC



we decompose these 2 forces →2kips & ↑0.6 kips into 2 forces respectively.
1 along the beam, which contribute to axial force.
1 90° degrees to the beams - - - - to shear force.

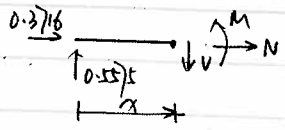


⇒



Origin at A

$0 \le x \le 3.61'$

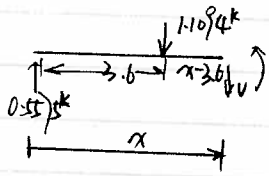


$\Sigma F_y = 0 \quad 0.555 - V = 0 \quad V = 0.555\ k$

$\Sigma M_x = 0 \quad 0.555x - M = 0 \quad M = 0.555x$

$M(3.61) = 0.555 \times 3.61 = 2.01\ k\cdot ft$

$3.61' \le x \le 3.61 + 2'$

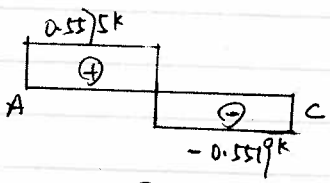


$\uparrow \Sigma F(y) = 0 \quad 0.555 - 1.104 - V = 0 \quad V = -0.5514\ k$

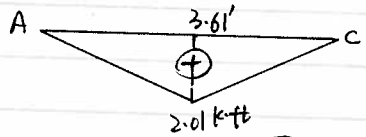
$\curvearrowright \Sigma M(x) = 0 \quad 0.555x - 1.104(x - 3.61) - M = 0$

$M(7.22) = 0$ (because of hinge at C)

So:

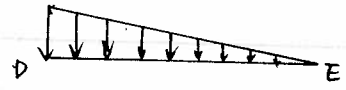


(V)



(M)

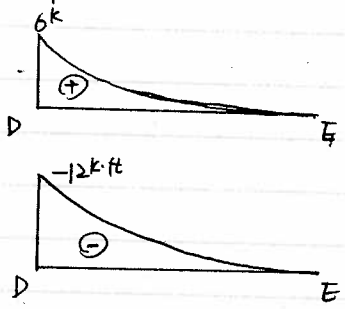
For DE



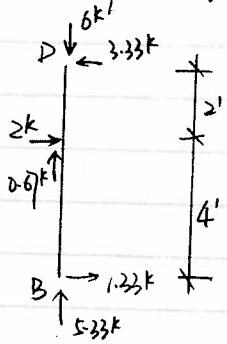
we already have shear and Moment equations:

$V = \frac{1}{8}x^2 \ (0 \le x \le 6)$, $M = -\frac{1}{18}x^3 \ (0 \le x \le 6)$

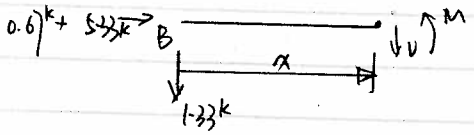
Observing that V should be function of x^2, M is function of x^3, they're both curves.



For DB (with origin at B)



$0 \le x \le 4'$

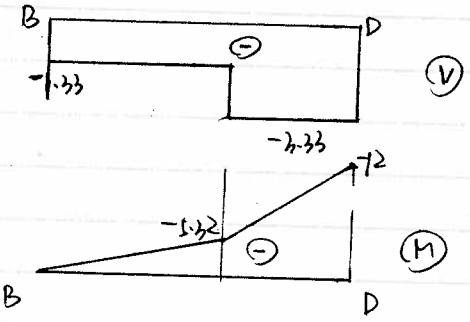


$\Sigma F_y = 0 \quad -1.33^k - V = 0 \quad V = -1.33^k \ (0 \le x \le 4)$

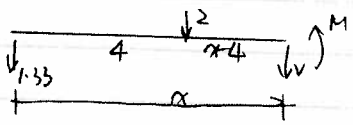
$\Sigma M(x) = 0 \quad -1.33x - M = 0 \quad M = -1.33x \ (0 \le x \le 4)$

$M(4) = -1.33 \times 4 = -5.32 \text{ k·ft}$

So, we get:



$4' \le x \le 6'$



$\Sigma F_y = 0 \quad -1.33 - 2 - V = 0 \quad V = -3.33^k$

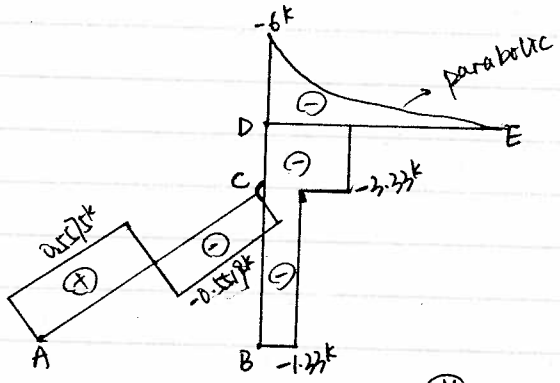
$\Sigma M(x) = 0$

$-1.33x - 2(x-4) - M = 0$

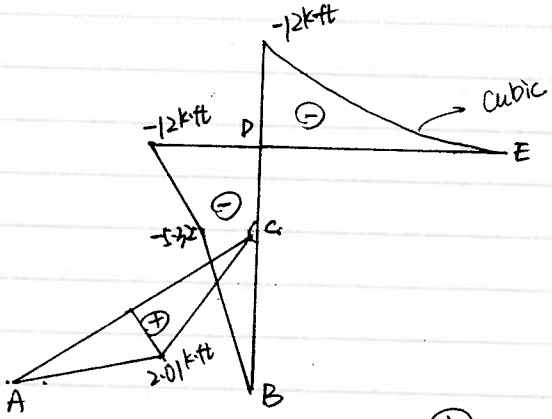
$M = -3.33x + 8$

$(M(6) = -3.33 \times 6 + 8 = -12 \text{ k·ft}$

Then we can draw ~~FBD of~~ Shear & Moment Diagrams for the entire structure.



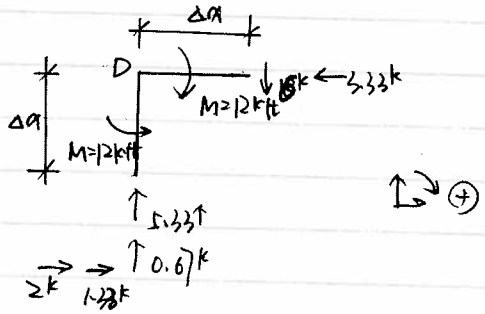
(V)



(M)

(f) Draw FBD of joint D. Show equilibrium status.

(5)



Considering infinitesimal cut off points

$\Delta\alpha \to 0$

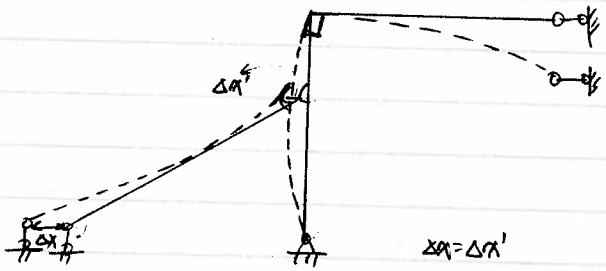
$\Sigma F(x)=0 \quad 2^k+1.33^k-3.33^k=0$

$\Sigma F(y)=0 \quad 5.33+0.67-6=0$

$\Sigma M(D)=0 \quad 12-12=0$

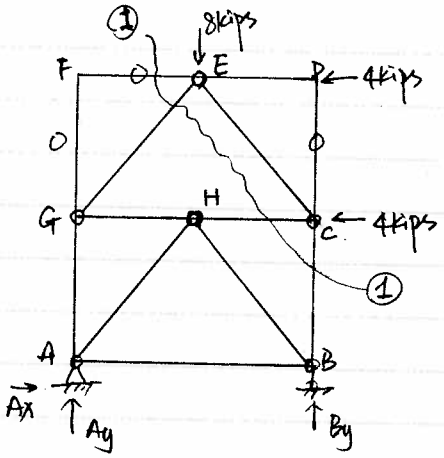
So in equilibrium status

(g) (Optional) Deflected shape.
(+5)



(30 total points)

Q2.



(a) Identify zero bars

(5) FG, FE, CD

↕ ↘ ⊕

(b) Compute external reactions:

(10)

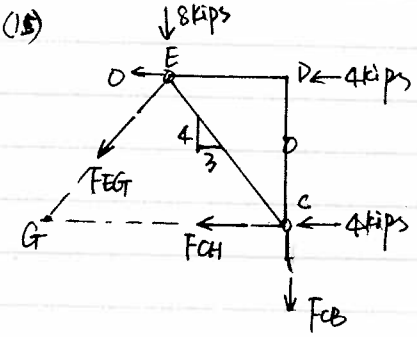
$\Sigma F(x)=0 \quad A_x - 4 - 4 = 0 \quad A_x = 8\text{kips} \rightarrow$

$\Sigma M(A)=0 \quad 8\times 3 - 4\times 8 - 4\times 4 - y_B \times 6 = 0 \quad y_B = -4\text{kips} \downarrow$

$\Sigma F_y=0 \quad y_A + y_B - 8 = 0 \quad y_A = 12\text{kips} \uparrow$

(c) Choose section ①-①, use Method of Sections.

(15)



Take Moment about G

$\Sigma M_G = F_{CB}\times 6 + 8\times 3 - 4\times 4 = 0$

$F_{CB} = -1.33\text{kips (C)}$ Ans.

$\Sigma F_y=0 \quad -F_{EG}\times 0.8 - 8 - F_{CB} = 0$

$F_{EG} = -8.3\text{kips (C)}$ Ans.

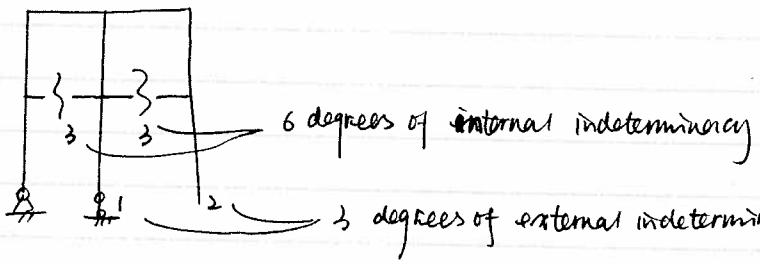
$\Sigma F(x)=0 \quad -F_{CH} - F_{EG}\times 0.6 - 8 = 0$

$F_{CH} = -3.02\text{kips} \approx -3\text{kips (C)}$ Ans.

20 total points

Q3. (a)

(7分)



$3+6=9^\circ$

(b) No. 6 unknows > 3 equilibrium equations (7分)

(c) 2.092" → (5)