CV2011 Structural Analysis 1

Wednesday, 31 May 2023 11:41 AM

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PYP 2021 - 2022 SEM 2

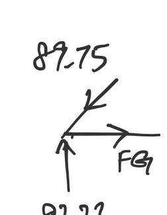
1. (a)
$m = 11$
$r = 3$
$j = 7$
$m + r = 14$
$2j = 14$
$m + r = 2j$ Statically determinate

(b)
$\Sigma M_G = 0$
$-F_y(9) + 50(10) + 50(5) = 0$
$F_y = 83.33$

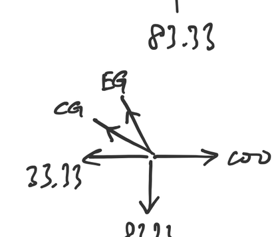
$\Sigma F_y = 0$
$83.33 + G_y = 0$
$G_y = -83.33$

$\Sigma F_x = 0$
$G_x + 50 + 50 = 0$
$G_x = -100$

(c)

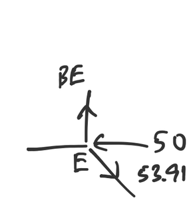


$\Sigma F_x = 0$
$89.75 \cos 68.2 = FG$
$FG = 33.33$

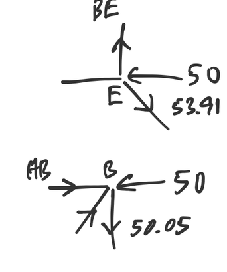


$\Sigma F_y = 0$
$EG \sin 68.2 + CG \sin 35.5 = 83.33$
$EG = \dfrac{83.33 - CG \sin 35.5}{\sin 68.2}$
$= 53.91$

$\Sigma F_x = 0$
$EG \cos 68.2 + CG \cos 35.5 + 33.33 = 100$
$\dfrac{83.33 \cos 68.2 - CG \sin 35.5 \cos 68.2}{\sin 68.2} + CG \cos 35.5 = 66.67$
$-CG \sin 35.5 \cos 68.2 + CG \cos 35.5 \sin 68.2 = 30.96$
$CG(-\sin 35.5 \cos 68.2 + \cos 35.5 \sin 68.2) = 30.96$
$CG = 57.31$

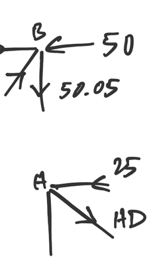


$\Sigma F_y = 0$
$BE = 53.91 \sin 68.2 = 50.05$



$\Sigma F_y = 0$
$BD \cos 26.57 = 50.05$
$BD = 55.96$

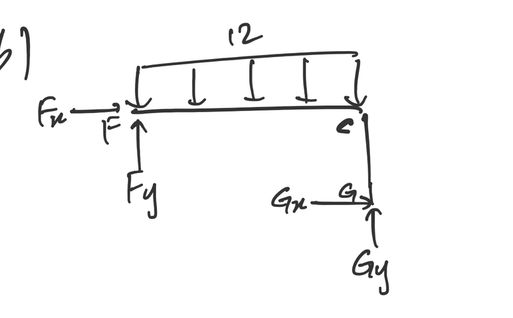
$\Sigma F_x = 0$
$AB + 55.96 \sin 26.57 = 50$
$AB = 25$



$\Sigma F_x = 0$
$AD \sin 26.57 = 25$
$AD = 55.9$

2. (a)
$r = 12$
$n = 4$
$r = 3n$ (statically determinate)

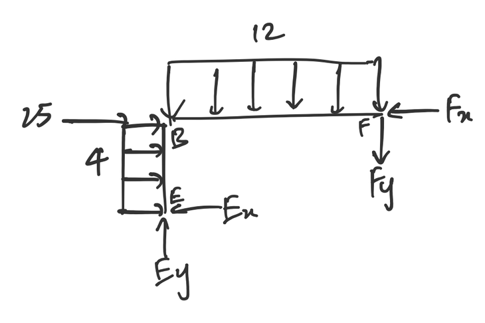
(b)



$\Sigma M_G = 0$
$12(5)(2.5) - F_y(5) - F_x(3) = 0$
$5F_y = 150 - 3F_x$
$F_y = 30 - \frac{3}{5}F_x$
$= 30 - \frac{3}{5}(71.6)$
$= -12.96$

$\Sigma F_y = 0$
$F_y + G_y - (12)(5) = 0$
$-12.96 + G_y - 60 = 0$
$G_y = 72.96$

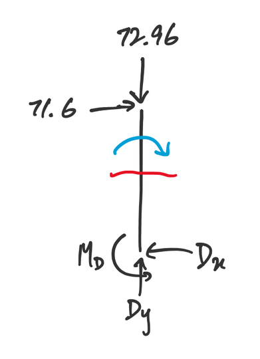
$\Sigma F_x = 0$
$F_x + G_x = 0$
$G_x = -F_x$
$= -71.6$



$\Sigma M_E = 0$
$-F_y(5) + F_x(2) - 12(5)(2.5) - 25(2) - 4(2)(1) = 0$
$-5F_y = 208 - 2F_x$
$-5(30 - \frac{3}{5}F_x) = 208 - 2F_x$
$-150 + 3F_x = 208 - 2F_x$
$5F_x = 358$
$F_x = 71.6$

$\Sigma F_y = 0$
$E_y - 12(5) - F_y = 0$
$E_y - 60 - (-12.96) = 0$
$E_y = 47.04$

$\Sigma F_x = 0$
$25 + 4(2) - F_x - E_x = 0$
$25 + 8 - 71.6 - E_x = 0$
$E_x = -38.6$

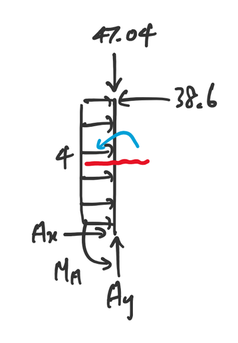


$\Sigma M_D = 0$
$M_D - 71.6(3) = 0$
$M_D = 214.8$

$\Sigma F_y = 0$
$D_y = 72.96$

$\Sigma F_x = 0$
$D_x = 71.6$

$\Sigma M = 0$
$M + 71.6(6 - x) - 214.8 = 0$
$M + 429.6 - 71.6x - 214.8 = 0$
$M = 71.6x - 214.8$



$\Sigma M_A = 0$
$M_A + 38.6(2) - 4(2)(1) = 0$
$M_A = -69.2$

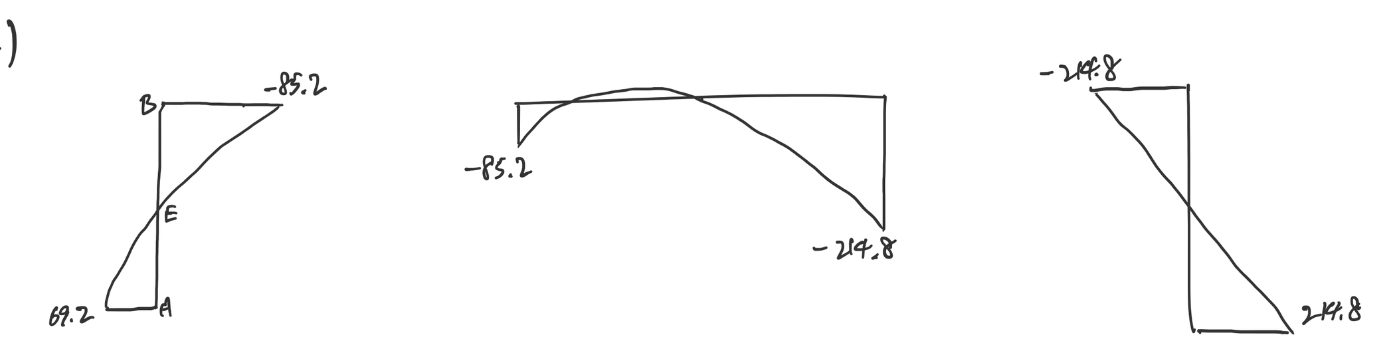
$\Sigma F_y = 0$
$A_y = 47.04$

$\Sigma F_x = 0$
$A_x + 4(2) - 38.6 = 0$
$A_x = 30.6$

$\Sigma M = 0$
$M + M_A + 4x(\frac{x}{2}) + 30.6x = 0$
$M - 69.2 + 2x^2 + 30.6x = 0$
$M = -2x^2 - 30.6x + 69.2$
When $x = 2$, $M = 0$
$x = 4$, $M = -85.2$

$M + 12(x)(\frac{x}{2}) - 47.04x + 85.2 = 0$
$M = -6x^2 + 47.04x - 85.2$

(c)



3. (a)
$\Sigma M_A = 0$
$C_y(L) + \frac{3PL}{2} - P(\frac{L}{2}) = 0$
$C_y(L) = \frac{1}{2}PL - \frac{3}{2}PL$
$C_y = -\frac{PL}{L} = -P$

$\Sigma F_y = 0$
$A_y + C_y = P$
$A_y = P - (-P)$
$= 2P$

$\Sigma M = 0$
$M - 2P(x_1) = 0$
$M = 2Px_1$
$EIv'' = 2Px_1$
$EIv' = \frac{2Px_1^2}{2} + C_1$
$EIv = \frac{2Px_1^3}{6} + C_1x_1 + C_2$

$\Sigma M = 0$
$M - Px_2 = 0$
$M = Px_2$
$EIv'' = Px_2$
$EIv' = \frac{Px_2^2}{2} + C_3$
$EIv = \frac{Px_2^3}{6} + C_3x_2 + C_4$

$v(0) = 0$
$C_2 = 0$

$v(0) = 0$
$C_4 = 0$

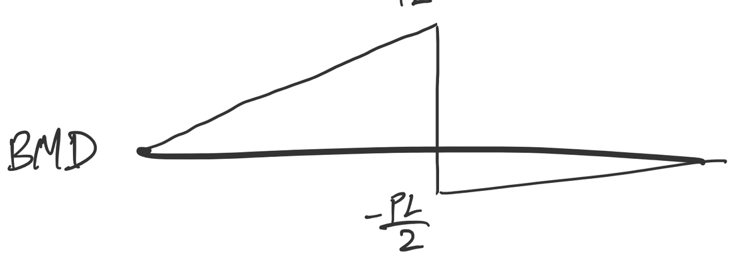
CC: $\theta_1 = \theta_2$
$P(\frac{L}{2})^2 + C_1 = \frac{P(\frac{L}{2})^2}{2} + C_3$
$P(\frac{L^2}{4}) + C_1 = P(\frac{L^2}{8}) + C_3$
$C_1 = C_3 + \frac{PL^2}{8} - \frac{PL^2}{4}$
$= C_3 - \frac{PL^2}{8}$
$= -\frac{PL^2}{8}$

$v_1 = -v_2$
$\frac{P(\frac{L}{2})^3}{3} + C_1(\frac{L}{2}) = \frac{P(\frac{-L}{2})^3}{6} + C_3(\frac{-L}{2})$
$P(\frac{L^3}{24}) + (C_3 - \frac{PL^2}{8})(\frac{L}{2}) = P(\frac{-L^3}{48}) + C_3(\frac{-L}{2})$
$P(\frac{L^3}{24}) + C_3(\frac{L}{2}) - \frac{PL^3}{16} = P(\frac{-L^3}{48}) - C_3(\frac{L}{2})$
$2C_3(\frac{L}{2}) = -\frac{PL^3}{48} + \frac{PL^3}{16} - \frac{PL^3}{24}$
$C_3 = 0$

$EIv = \frac{Px_1^3}{3} - \frac{PL^2x_1}{8}$
$\theta_A = \frac{P(0)^2}{EI} - \frac{PL^2}{8EI}$
$= -\frac{PL^2}{8EI}$
$= \frac{PL^2}{8EI}$ ↻

$EIv = \frac{Px_2^3}{6}$
$\theta_C = \frac{P(0)^2}{2} = 0$

(b)



$A_1 = \frac{1}{2}(\frac{L}{2})(PL) = \frac{PL^2}{4}$
$A_2 = \frac{1}{2}(-\frac{PL}{2})(\frac{L}{2}) = -\frac{PL^2}{8}$

x_{c1} (from A) $= \frac{2}{3}(\frac{L}{2}) = \frac{L}{3}$
x_{c2} (from A) $= \frac{L}{2} + \frac{1}{3}(\frac{L}{2}) = \frac{2L}{3}$

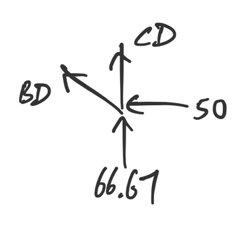
$t_{B/A} = (v_B - v_A) - (x_B - x_A)\theta_A = \Sigma \bar{x} \cdot A_i$
$v_B - (\frac{L}{2})(-\frac{PL^2}{8EI}) = \frac{L}{6}(\frac{PL^2}{4EI})$
$v_B = \frac{PL^3}{24EI} - \frac{PL^3}{16EI} = -\frac{PL^3}{48EI} = \frac{PL^3}{48EI}$ ↓

4. (a)
$\Sigma M_A = 0$
$D_y(0.9) - 50(1.2) = 0$
$D_y = 66.67$

$\Sigma F_y = 0$
$A_y + 66.67 - 20 = 0$
$A_y = -46.67$

$\Sigma F_x = 0$
$D_x + 50 = 0$
$D_x = -50$

Real



$\Sigma F_x = 0$
$BD \sin 36.87 + 50 = 0$
$BD = -83.33$

$\Sigma F_y = 0$
$66.67 + (-83.33 \cos 36.87) + CD = 0$
$CD = 0$

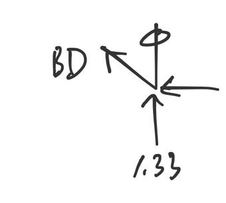
	n(N)	N(kN)	L(m)	nNL
AB	1.33	46.67	1.2	74.485
BC	1	50	0.9	45
BD	-1.67	-83.33	1.5	208.742
			Σ	328.227

Virtual

$\Sigma M_A = 0$
$D_y(0.9) - 1(1.2) = 0$
$D_y = 1.33$

$\Sigma F_y = 0$
$A_y + 1.33 = 0$
$A_y = -1.33$

$\Sigma F_x = 0$
$D_x + 1 = 0$
$D_x = -1$



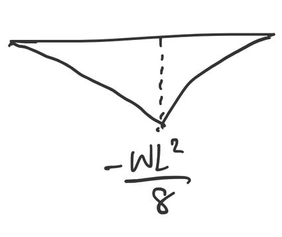
$\Sigma F_x = 0$
$BD \sin 36.87 + 1 = 0$
$BD = -1.67$

$1 \Delta_{CH} = \dfrac{253.742 \times 10^3}{(200 \times 10^9) \times (600 \times 10^{-6})} + \dfrac{74.485 \times 10^3}{(200 \times 10^9) \times (1200 \times 10^{-6})}$
$= 0.00211 \text{ m} + 0.00031$
$= 2.11 + 0.31$
$= 2.42 \text{ mm}$ ⟶

(b)
$\Sigma M_A = 0$
$B_y(L) - w(\frac{L}{2})(\frac{5L}{4}) = 0$
$LB_y = \frac{5wL^2}{8}$
$B_y = \frac{5wL}{8}$

$\Sigma F_y = 0$
$A_y + B_y - w(\frac{L}{2}) = 0$
$A_y = \frac{wL}{2} - \frac{5wL}{8}$
$= -\frac{wL}{8}$

(M)



AB
$\Sigma M = 0$
$M + \frac{wL}{8}x_1 = 0$
$M = -\frac{wLx_1}{8}$

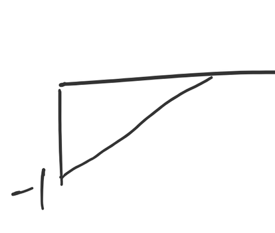
BC
$\Sigma M = 0$
$M - wx_2(\frac{x_2}{2}) = 0$
$M = \frac{wx_2^2}{2}$

$1 \cdot \theta_A = \Sigma \int \frac{mM}{EI} dx$
$= \frac{1}{EI}[\frac{1}{6}(-\frac{wL^2}{8})(-1)(L)]$
$= \frac{wL^3}{48EI}$ ↺

$\Sigma M_A = 0$
$1 + B_y(L) = 0$
$B_y = -\frac{1}{L}$

$\Sigma F_y = 0$
$A_y + B_y = 0$
$A_y = \frac{1}{L}$

(m)



AB
$\Sigma M = 0$
$M + 1 - \frac{1}{L}x_1 = 0$
$M = \frac{x_1}{L} - 1$

BC
$\Sigma M = 0$
$M = 0$