ENCE353: Introduction to Structural Analysis
Instructor: Noah C. Blum
Midterm #2

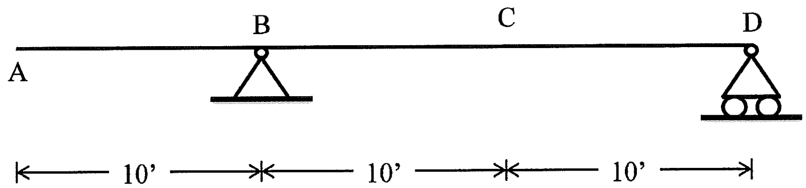
Name: Solution

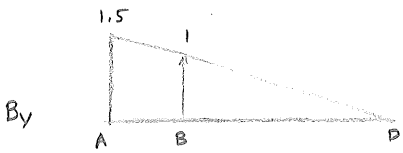
CSI 2117: 9:00-9:50AM, November 12, 2012
Closed book, closed notes, one sheet of notes and integration tables allowed
Show all work

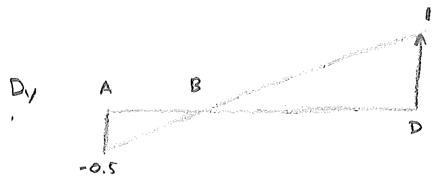
Problem	Points	Score
1	10	10
2	10	10
3	10	10
4	10	10
Total	40	40

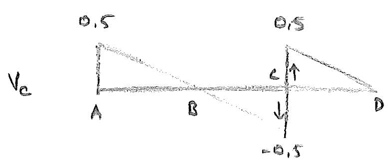
Problem 1 (10 Points)

Draw the influence lines for $\mathbf{B_y}$, $\mathbf{D_y}$, $\mathbf{V_c}$, $\mathbf{M_c}$
Hint: Use the Müller-Breslau principle to save time



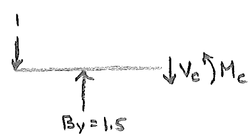


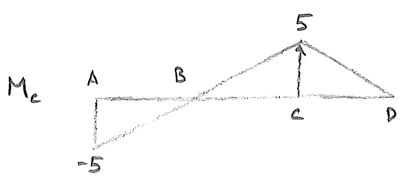




V_c due to load at A $+\uparrow \Sigma F_y = 0: \ -1 + 1.5 - V_c = 0$

$\Rightarrow V_c = 0.5$





M_c due to load at A

$\circlearrowleft \Sigma M_o = 0: \ 1(20) - 1.5(10) + M_c = 0$

$\Rightarrow M_c = -5$

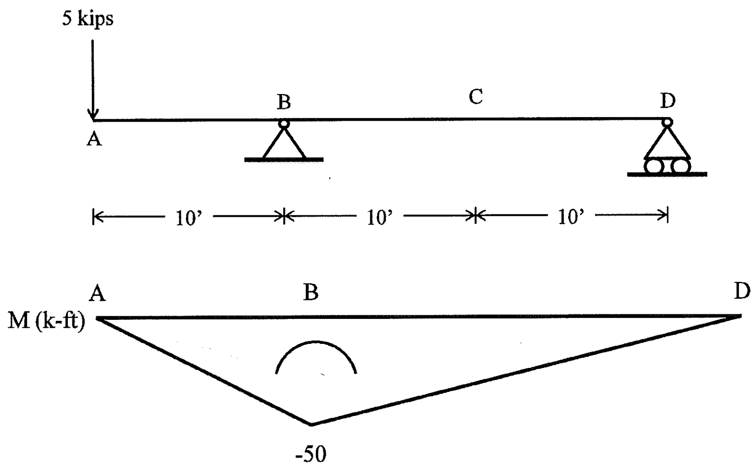
Problem 2 (10 Points)

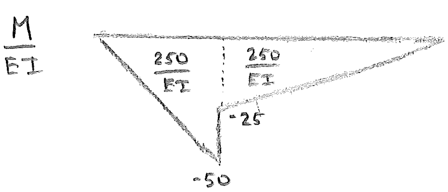
Use the **moment-area** method to determine θ_D & y_A

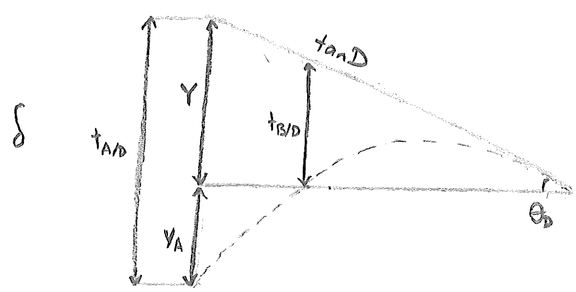
$2\,(EI)_{AB} = (EI)_{BD}$

For AB: **E = 29,000 ksi, I = 100 in.^{4}**

Provide solutions in radians and inches







$$\theta_D = \frac{t_{B/D}}{20} = \frac{1}{20}\left[\frac{250}{EI}\left(\frac{20}{3}\right)\right] = \frac{250}{3EI} = \frac{250(12^2)}{3(29000)(100)} = 0.004138 \text{ rad} \quad \Rightarrow \boxed{\theta_D = 0.004138 \text{ rad} \circlearrowleft}$$

$$Y = \frac{30}{20} t_{B/D} \text{ or } 30\,\theta_D = \frac{2500}{EI}$$

$$t_{A/D} = \frac{250}{EI}\left(\frac{2}{3}\cdot 10\right) + \frac{250}{EI}\left(10 + \frac{1}{3}20\right) = \frac{17500}{3EI}$$

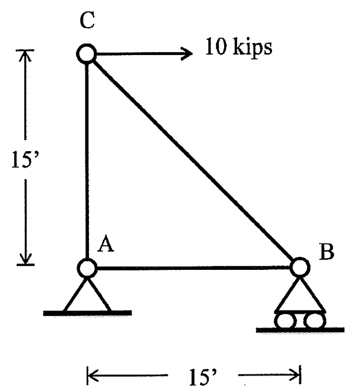
$$y_A = t_{A/D} - Y = \frac{17500}{3EI} - \frac{2500}{EI} = \frac{10000}{3EI} = \frac{10000(12^3)}{3(29000)(100)} = 1.99 \text{ in.} \quad \Rightarrow \boxed{y_A = 1.99 \text{ in.} \downarrow}$$

Problem 3 (10 Points)

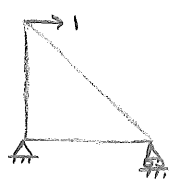
Use **virtual work** to determine the **displacement** at **C** in the **horizontal direction**
$E = 29{,}000\ ksi$ for all members
Area of members: $A_{AB} = A_{AC} = 2\ in.^2$ $\qquad A_{BC} = 3\ in.^2$
Hint: For the given 10 kip load, the axial forces are

$$F_{AB} = F_{AC} = 10\ k\ (\text{T}) \qquad F_{BC} = 10\sqrt{2}\ k\ (\text{C})$$

Provide solution in inches



Virtual load



Same position and
direction as real load
⇒ virtual axial = $\frac{1}{10}$ real

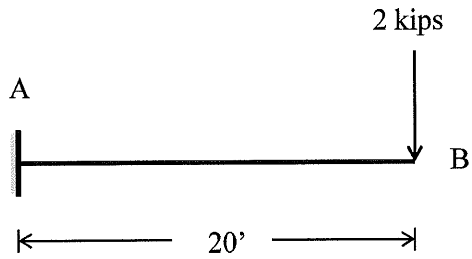
(1) $\Delta_{cx} = \sum \frac{nNL}{EA}$

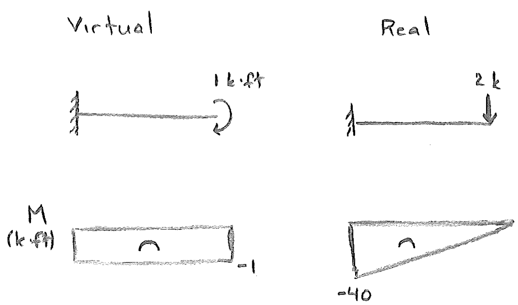
	(k) n	(k) N	(ft) L	(ksi) E	(in.²) A	(in.) $\frac{nNL}{EA} \times 12$
AB	1	10	15	29000	2	0.031
AC	1	10	15	29000	2	0.031
BC	$-\sqrt{2}$	$-10\sqrt{2}$	$15\sqrt{2}$	29000	3	0.059
						$\Sigma = 0.121$

⇒ $\boxed{\Delta_{cx} = 0.121\ in.}$

Problem 4 (10 Points)

Use **virtual work** to determine the **rotation** at **B**
E = 29,000 ksi, I = 100 in.^{4}
Provide final solution in radians





$$(1)\theta_B = \Sigma \int \frac{mM}{EI}\,dx$$

$$\theta_B = \frac{1}{EI}\int_0^{20} (-1)(-40+2x)\,dx = \frac{400}{EI}$$

or

$$\theta_B = \frac{1}{EI}\int_0^{20} [\text{-1}][\text{-40}]\,dx = \frac{1}{EI}\,\frac{1}{2}(-1)(-40)(20) = \frac{400}{EI}$$

$$\theta_B = \frac{400 \times 12^2}{(29000)(100)} = 0.0199 \text{ rad}$$

$$\Rightarrow \boxed{\theta_B = 0.0199 \text{ rad}}$$