EXAM 2

CIEG 301: STRUCTURAL ANALYSIS
FALL 2006

NAME	SECTION
Solution	

	POINTS EARNED
PROBLEM 1	
PROBLEM 2	
PROBLEM 3	
PROBLEM 4	
TOTAL	

Instructions:

1. NO talking.
2. Turn off cell phones.
3. Show **ALL** work. **NO** credit will be given for **problems** containing unsubstantiated calculations!

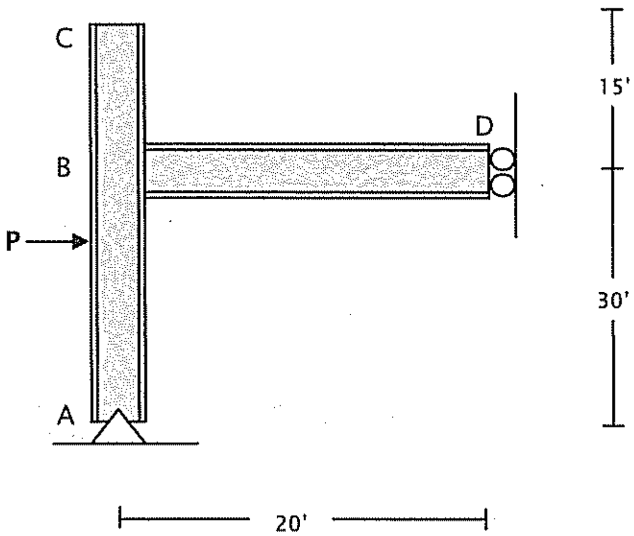
PROBLEM 1 [15 points]

The horizontal load P can act at any location along the length of member AC. Joint A is pinned; there is a moment connection at joint B; joint C is free and a roller exists at joint D.

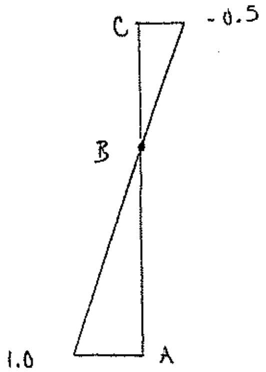
(a) **Draw quantitative influence lines** for the horizontal reactions at A and D.

(b) **Indicate the location where a uniformly distributed load should be placed** to maximize (absolute value) both of these reactions.

(c) **Indicate the direction** these reactions (i.e., left or right) when they are maximized.



I. L. for A_x ($\leftarrow = +$)



$\sum M_D = (1)(30 - x) - A_x(30) = 0$ for $x \leq 30$

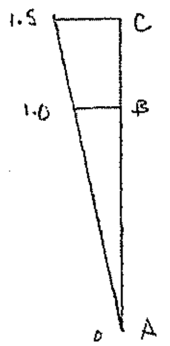
$A_x = 1 - x/30$

$\sum M_D = -(1)(x - 30) + A_x(30) = 0$ for $x \geq 30$

$A_x = 1 - x/30$

∴ UDL should be placed between A and B for A_x-max. This results in A_x acting to the left.

I. L. for D_x ($\leftarrow = +$)



$\sum F_x = 1 - A_x - D_x = 0$

$D_x = 1 - A_x$

$D_x = 1 - (1 - x/30)$

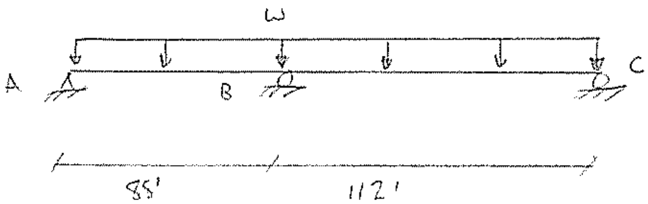
$D_x = x/30$

∴ UDL should be placed between A and C for D_x-max. D_x always acts to the left.

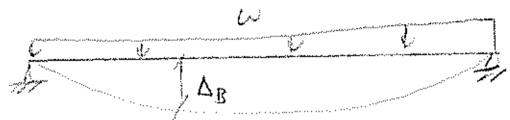
PROBLEM 3 [30 points]

A new two-span bridge is being built across the Delaware River. Span One has a length of 88′ and Span Two has a length of 112′, resulting in the total length of the beams being 200′. However, the maximum length beam that can be shipped to the site is 140′. Thus, the girders must be fabricated in the field by splicing together two parts.

Determine where the splice should be located addressing the above practical limitations AND such that the moment at the splice due to a uniformly distributed load is minimized. Assume steel beams with constant cross-section.



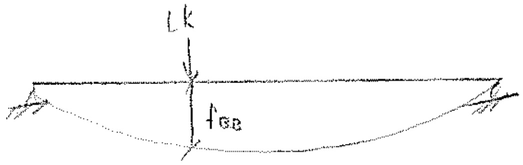
Primary Structure:



$\Delta_B = \frac{w(88)}{24EI}\left(88^3 - 2(200)(88)^2 + 200^3\right)$

$\Delta_B = \frac{20.47(10^6)\,w}{EI}\ ft^4$

w/ B_y as Redundant:



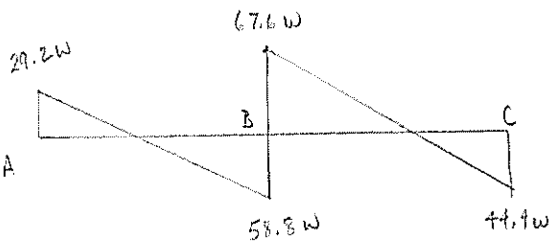
$f_{BB} = \frac{(112)(88)}{6(200)EI}\left(200^2 - 112^2 - 88^2\right)$

$f_{BB} = \frac{0.1619(10^6)}{EI}\ ft^3$

$B_y = -\Delta_B / f_{BB}$

$B_y = 126.4w\ (ft)\ \uparrow$

V Diagram

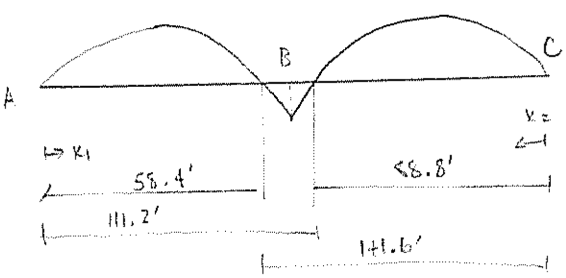


$\Sigma M_A = w(200)(100) - (126.4w)(88) - C_y(200) = 0$

$C_y = 44.37w\ (ft)$

$\Sigma F_y \Rightarrow A_y = 200w - 126.4w - 44.4w = 29.2w$

M Diagram



V: Span 1: $(29.2 - x_1)\,w$

M: Span 1: $\left(29.2x_1 - \frac{x_1^2}{2} + C_1^{\,0}\right)w$

$M(\text{Span 1}) = \frac{-x_1^2}{2} + 29.2x_1$

V span 2: $(-44.4w + x_2 w)$

M span 2: $\left(\frac{x_2^2}{2} - 44.4x + C_2^{\,0}\right)w$

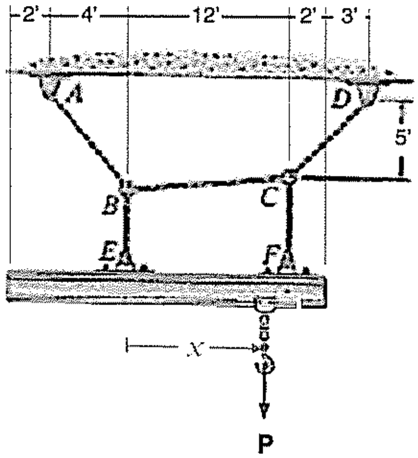
Roots: $x_2 = 88.8, 0$

Roots: $x_1 = 0, 58.4$

∴ The splice should be located 88.8′ to the left of C. Here the moment is zero and two shipping pieces of 88.8 and 111.2′ can be used, satisfying all requirements

PROBLEM 3 [40 points]

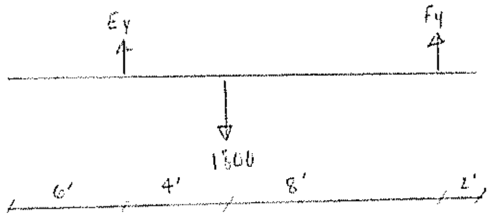
Cable ABCD supports a crane rail with a self weight of 1800 lb. The maximum sag is 6.5 ft. Ignore load factors.



(a) **What is the maximum tension** in the cable considering dead load only? (20 points)

(b) The maximum capacity of the crane is 10 kip. **What is the maximum tension** in the cable due to live load? Note that the crane travels between E and F such that $0 \le x \le 12$. (20 points)

(a)

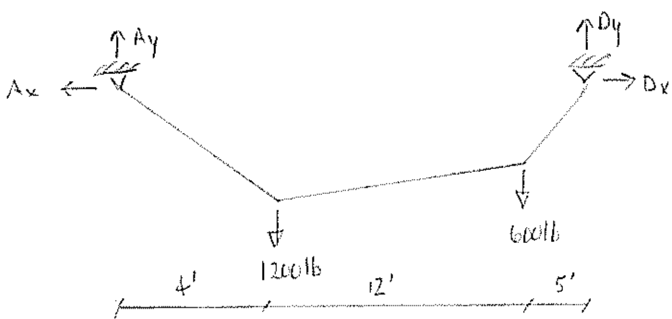


$\sum M_E = 1800(4) - F_y(12) = 0$

$F_y = 600$ lb

$\sum F_y = 0 = E_y + 600 - 1800 = 0$

$E_y = 1200$ lb



$\tan\theta_{AB} = \frac{6.5}{4}$

$\tan\theta_{BC} = \frac{1.5}{12}$

$\tan\theta_{CD} = \frac{5}{5}$

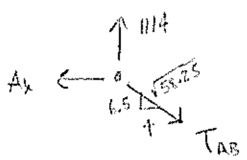
$\therefore$ by inspection $\theta_{MAX} = \theta_{AB}$

$\therefore T_{MAX} = T_{AB}$

$\sum M_D = 600(5) + 1200(17) - A_y(21) = 0$

$A_y = 1114$ lb $\uparrow$

FBD of Joint A:

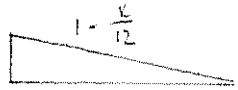


$\sum F_y = 1114 - \left(\frac{6.5}{\sqrt{58.25}}\right) T_{AB} = 0$

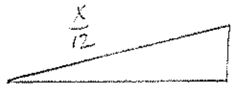
$T_{AB} = T_{MAX} = 1308$ lb

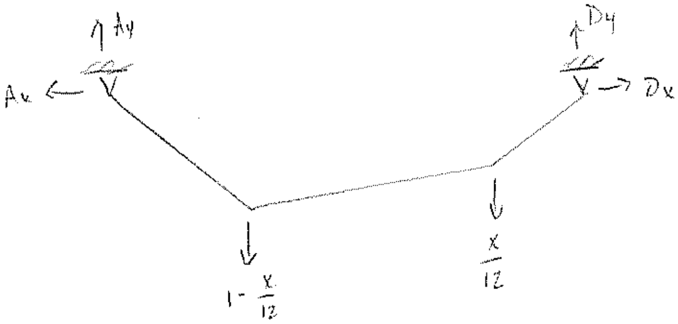
One potential approach:

(b) I.L. E_y



I.L. F_y





$$\sum M_D = \left(\frac{x}{12}\right)(5) + \left(1-\frac{x}{12}\right)(17) - A_y(21) = 0$$

$$\text{I.L. } A_y = \left(\frac{5}{12}x + 17 - \frac{17}{12}x\right)/21$$

$$\text{I.L. } A_y = \frac{17-x}{21}$$

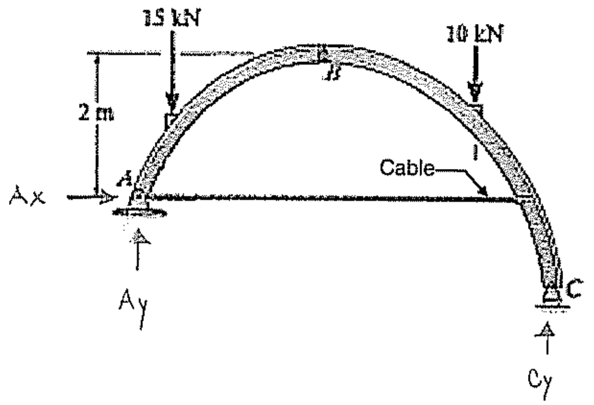
$$T_{MAX} = T_{AB} = A_y\left(\frac{\sqrt{58.25}}{6.5}\right)$$

$$A_{y\text{-}max} = \left(\frac{17-0}{21}\right)10 = 8.095 \text{ k}$$

$$T_{MAX} = 8.095\left(\frac{\sqrt{58.25}}{6.5}\right) = \boxed{9.5 \text{ k}}$$

PROBLEM 1 [15 points]

Use the arch shown below to complete parts (a), (b), and (c). In the schematic, A is a pinned support, B is a hinge, and C is a roller support.



(a) **Indicate the direction** (e.g., left, right, up, down) of all external reaction forces. (5 points)

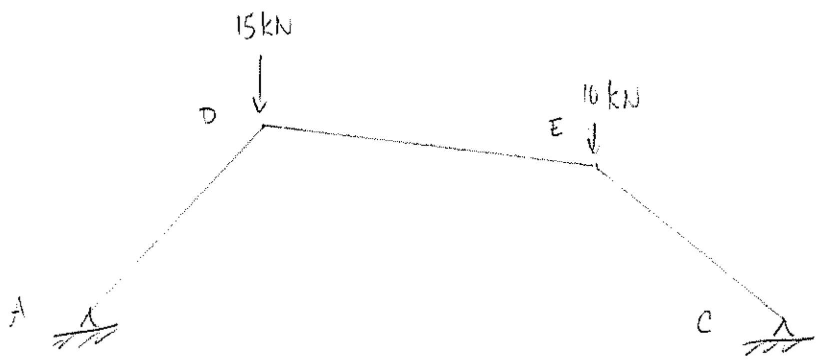
See schematic above.

or, Ax and Ay can be resolved into a single reaction (R_A) acting parallel to the tangent of the arch @ A.

(b) **What would be the consequence** of removing the cable from this structure? (5 points)

the structure would be unstable and would collapse

(c) The arch shown is not a funicular arch. **Qualitatively sketch** the shape that would result in a funicular arch for the loading shown. (5 points)



EXTRA CREDIT [10 points]

1. In the method of consistent deformations, **explain** how the compatibility equations are modified to account for support displacements.

The compatibility eqns are set equal to the support displacement instead of zero.

2. **List** the primary disadvantage and two advantages of statically indeterminant structures.

Primary disadvantage: more sensitive to support settlements, temp. changes, and fabrication errors.

Advantages:
- Capacity for redistribution
- Less deflection
- Lower member stresses
- More aesthetically pleasing