

CE 3202 Fall 2010 Exam 2

Name SOLUTIONS

Closed Book; Closed Notes

(2) 3"x5" Note Cards Allowed; Calculator Allowed

105 points are possible (score will be based on 100 points)

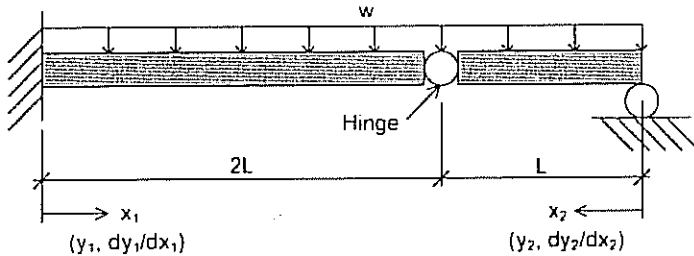
Answer all questions to the best of your ability. State any assumptions you feel are necessary. Attach extra sheets, if used. **Show your work!**

Problem 1. Double Integration Method

For each structure shown, identify the boundary conditions that you might use to solve for the constants of integration in slope and deflection equations. Do not find the slope or displacement equations!

(a) Identify (4) boundary conditions (15 points):

$$0 \leq x_1 \leq 2L, \quad 0 \leq x_2 \leq L$$



(a)

$$y_1(0) = 0$$

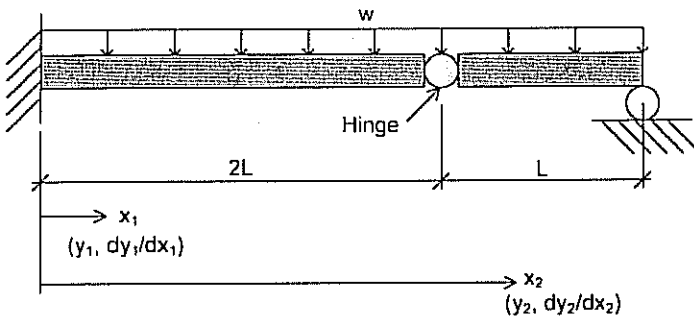
$$\left. \frac{dy_1}{dx_1} \right|_{x_1=0} = 0$$

$$y_2(0) = 0$$

$$y_1(2L) = y_2(L)$$

(b) Identify (4) boundary conditions (15 points):

$$0 \leq x_1 \leq 2L, \quad 2L \leq x_1 \leq 3L$$



(b)

$$y_1(0) = 0$$

$$\left. \frac{dy_1}{dx_1} \right|_{x_1=0} = 0$$

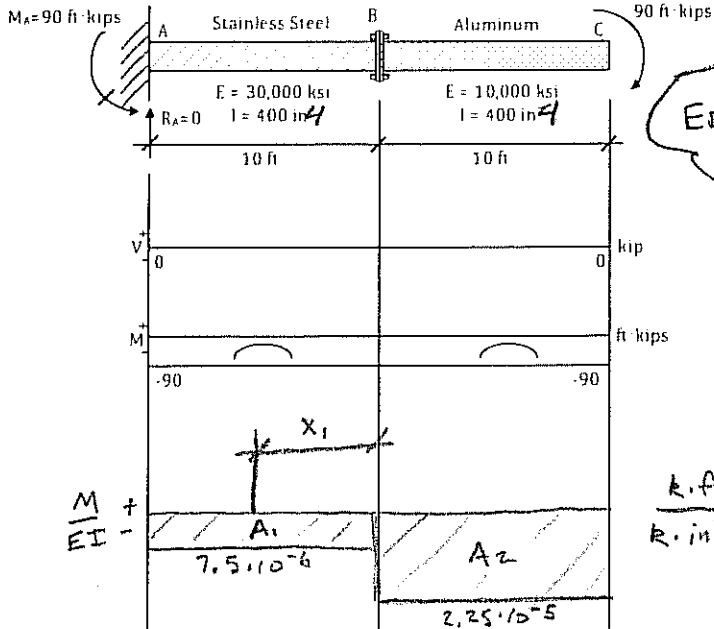
$$y_2(3L) = 0$$

$$y_1(2L) = y_2(2L)$$

NOTE THAT THESE (2) B.C.'S CHANGED!

Problem 2. Moment-Area Method

The cantilevered beam shown below is constructed from two different materials. The first segment is composed of stainless steel; the second segment is composed of aluminum. Both segments have the same cross section. The beam is loaded by a concentrated moment at the end. The reactions as well as the shear and moment diagram have been found for you.



ERROR: I is in⁴, NOT in²

(a) Using the moment-area method, find the slope at point C. Indicate direction and units for full credit (15 points).

$$\theta_C = \theta_A + \Delta \theta_{AC}$$

$$\theta_C = 0 + (A_1 + A_2)$$

$$\theta_C = (7.5 \cdot 10^{-6} \frac{k \cdot ft}{k \cdot in^2})(10 ft) (12 \frac{in}{ft})^2 + (2.25 \cdot 10^{-5})(10 ft) (12 \frac{in}{ft})^2$$

$$\theta_C = 0.0432 \text{ rad. } \downarrow$$

NOTE CURVATURE OF BEAM:

(b) Using the moment-area method, find the deflection at point B. Indicate direction and units for full credit (15 points).

$$\delta_B = t_{BA}$$

$$\delta_B = -[A_1](x_1)$$

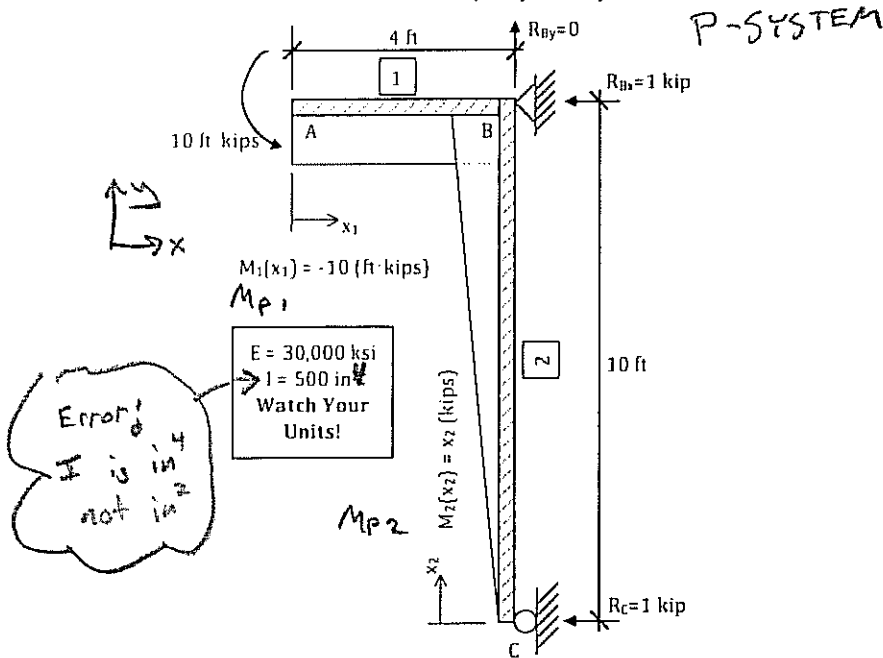
$$\delta_B = -[(7.5 \cdot 10^{-6} \frac{k \cdot ft}{k \cdot in^2})(10 ft)](5 ft) (12 \frac{in}{ft})^3$$

$$\delta_B = -0.648 \text{ in } (\downarrow)$$

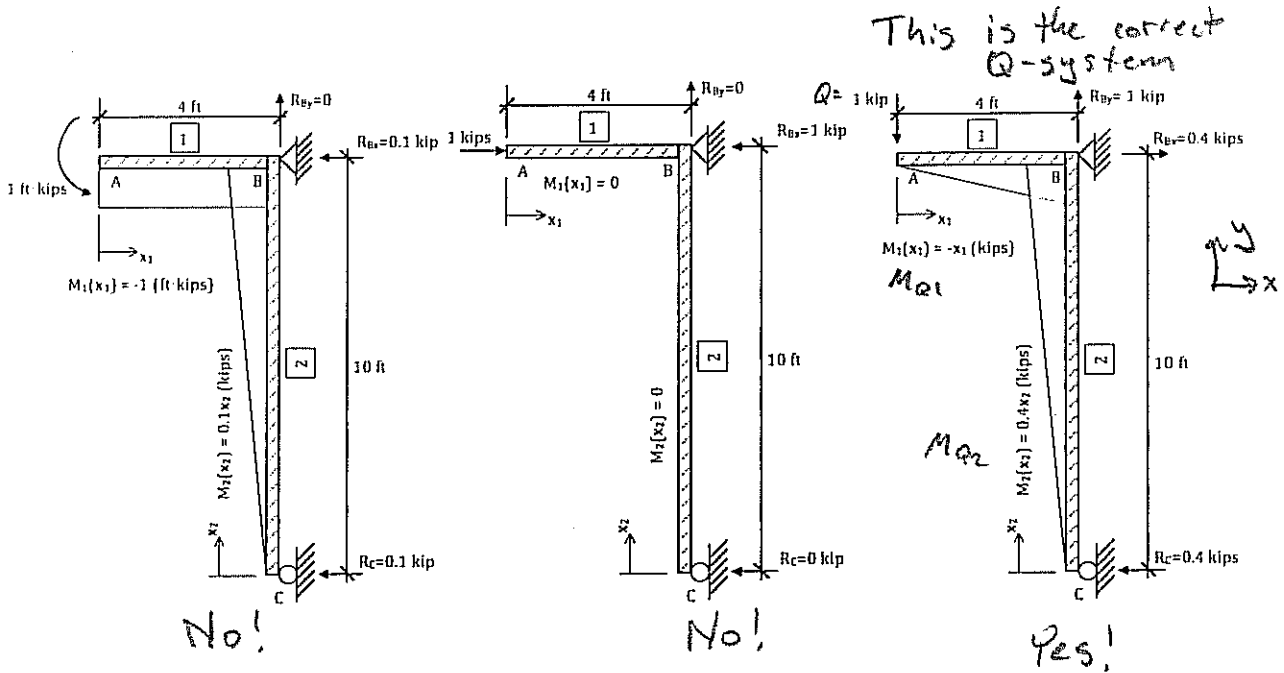
NOTE CURVATURE OF BEAM

Problem 3. Method of Virtual Work

For the structure shown find the vertical displacement at point A due to the concentrated moment at A. Moment diagrams and moment equations are given on the diagram. Indicate direction and correct units for full credit (35 points).



Some additional moment diagrams and moment equations that may be helpful to you.



Do your work for Problem 3 on the next page.

Do your work for Problem 3 on this page.

$$Q \quad \Delta A Y = \sum_{i=1}^n \int_0^{L_i} \frac{M_{P_i} M_{Q_i}}{E_i I_i} dx_i \quad (\text{Virtual work for frames})$$

$$(1k) \quad \Delta A Y = \int_0^{L_1} \frac{M_{P_1} M_{Q_1}}{E_1 I_1} dx_1 + \int_0^{L_2} \frac{M_{P_2} M_{Q_2}}{E_2 I_2} dx_2$$

$$(1k) \quad \Delta A Y = \int_0^{4\text{ft}} \frac{(-10 \text{ k}\cdot\text{ft})(-x_1 \text{ k})}{(30000 \frac{\text{k}}{\text{in}^2})(500 \text{ in}^4)} dx_1 + \int_0^{10\text{ft}} \frac{(x_2 \text{ k})(0.4 x_2 \text{ k})}{(30000 \frac{\text{k}}{\text{in}^2})(500 \text{ in}^4)} dx_2$$

$$(1k) \quad \Delta A Y = \frac{1}{1.5 \cdot 10^7 \text{ k}\cdot\text{in}^2} \left[\int_0^{4\text{ft}} 10 x_1 (\text{k}^2 \cdot \text{ft}) dx_1 + \int_0^{10\text{ft}} 0.4 x_2^2 (\text{k}^2) dx_2 \right]$$

$$(1k) \quad \Delta A Y = \frac{1}{1.5 \cdot 10^7 \text{ k}\cdot\text{in}} \left[5 x_1^2 \Big|_0^{4\text{ft}} (\text{k}^2 \cdot \text{ft}) + \frac{0.4}{3} x_2^3 \Big|_0^{10\text{ft}} (\text{k}^2) \right]$$

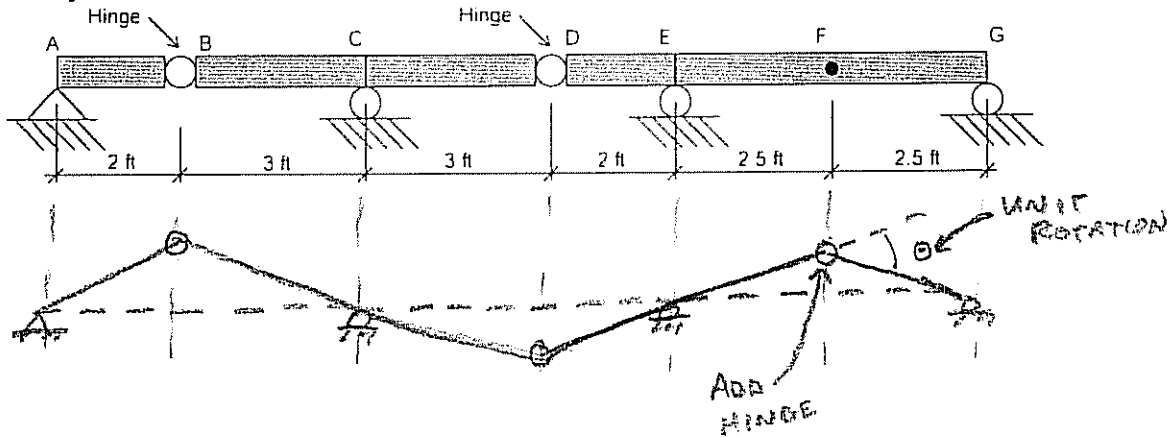
$$(1k) \quad \Delta A Y = \frac{(12 \text{ in}/\text{ft})^3}{1.5 \cdot 10^7 \text{ k}\cdot\text{in}} \left[80 \text{ k}^2 \cdot \text{ft}^3 + 133.3 \text{ k}^2 \cdot \text{ft}^3 \right]$$

$$\Delta A Y = 0.0246 \text{ in } (\downarrow)$$

NOTE: Since Q was assumed in downward direction, positive result tells us deflection due to real loads is downward (same direction as Q).

Problem 4. Influence Line Diagrams

(a) Sketch the influence line diagram for the moment at Point F for the structure shown below. Be sure to draw your assumed moment direction (5 points).



(b) **Bonus Problem (do this problem last)! Sketch** the influence line diagram for the moment at Point B for the structure shown below. Be sure to draw your assumed moment direction (5 bonus points).

