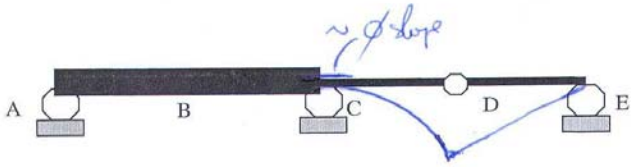
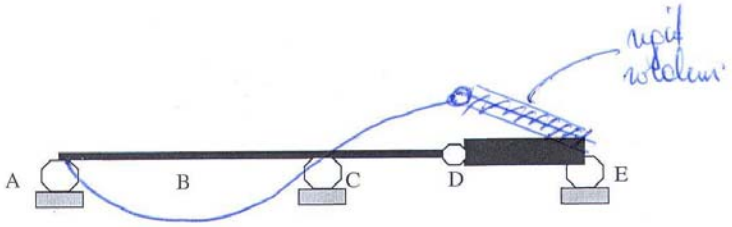
3. For the same beam and loads applied as in Figure I, and assuming member AC (Case 1) or member DE (Case 2) to be very stiff, sketch the expected deflected shape of the beam for each of the cases as shown below. (NO CALCULATIONS) (*10 points*)

Deflected Shapes:

Case 1:



Case 2:



In this Case 2, explain how the deflection and slope results will change from Questions 1 and 2 (ONE LINE ONLY) and comment (ONE LINE ONLY). If your write more than TWO LINES, you will not be credited. (*5 points*)

- Same def. + slope since DE is not subject to curvature & regardless of its stiffness EI ($\frac{M}{EI}=0$ in DE).

QUIZ 2
Spring 2005-2006
(Wednesday May 3, 2006)
CIVE311 – STRUCTURES I
CLOSED BOOK, 1 & 1/2 HOURS

Name: Solutions **ID#:** 0000000

NOTES

- 1 PROBLEM – 3 QUESTIONS - 10 PAGES.
- ALL YOUR ANSWERS SHOULD BE PROVIDED ON THE QUESTION SHEETS.
- ONE EXTRA SHEET IS PROVIDED AT THE END.
- ASK FOR ADDITIONAL SHEETS IF YOU NEED MORE SPACE.
- SOME ANSWERS MAY REQUIRE MUCH LESS THAN THE SPACE PROVIDED.
- *DO NOT* USE THE BACK OF THE SHEETS FOR ANSWERS.
- DRAFT BOOKLET WILL BE PROVIDED; BUT DO NOT USE FOR ANSWERS.
- BOTH QUESTION SHEETS AND DRAFT BOOKLET SHOULD BE RETURNED.
- CHECK BOXES ARE TO CONFIRM THAT YOU HAVE SOLVED A QUESTION. ☑

YOUR COMMENT(S)

DO NOT WRITE IN THE SPACE BELOW

MY COMMENT(S)

YOUR GRADE

QUESTION 1: 55 /55
QUESTION 2: 30 /30
QUESTION 3: 15 /15
Other: ---

TOTAL: 100 /100

Problem I/I:

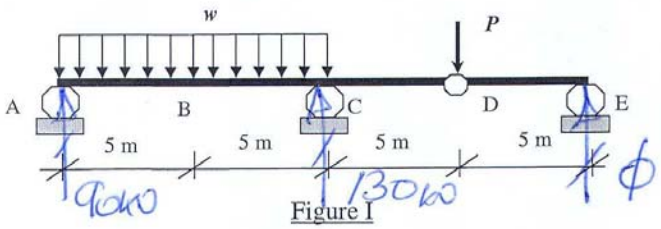


Figure I

Referring to Figure I:
EI=**1,000,000 kN.m^2** throughout the beam (except in Question 3).
w=**20 kN/m** and P=**20 kN** throughout the problem.
Neglect the own weight of the beam.

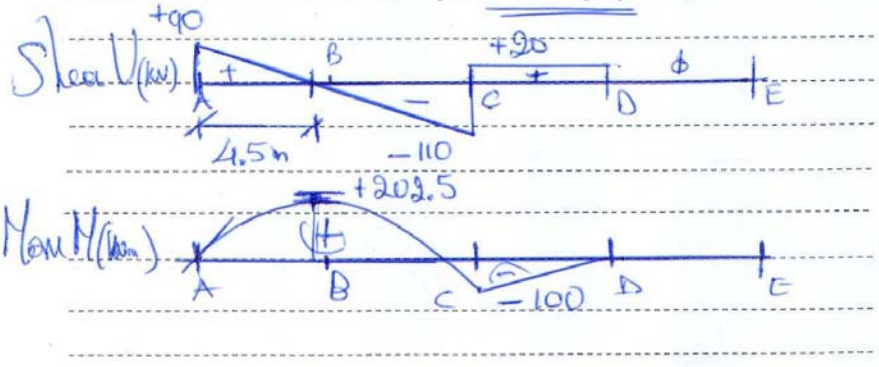
1. USING THE MOMENT-AREA METHOD

Compute the slope at C (θ_C), the vertical deflections at B and D (v_B and v_D), and the maximum downward deflection between A and C. You can calculate slope and deflections in whichever order you find suitable. (*45 points*)

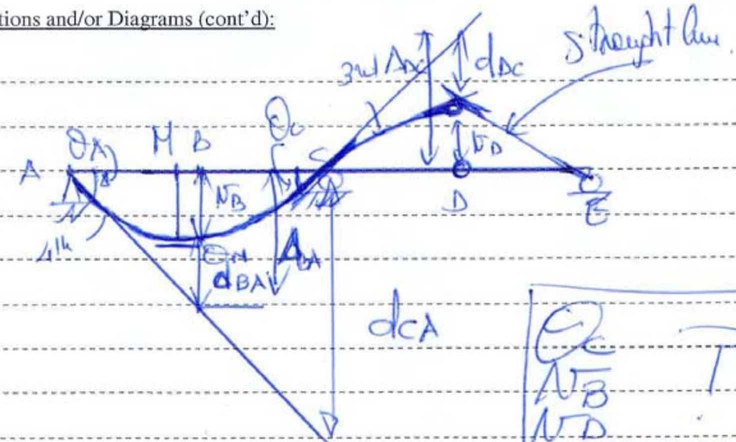
Based on the results obtained, neatly/clearly sketch the final deflected shape and show the results obtained. (*10 points*)

Calculations and Diagrams:

- DE: $\Sigma M_D = 0 \Rightarrow R_E = 0$
- AE: $\Sigma M_A = 0 \Rightarrow R_C \times 10 = P \times 15 + 60 \times \frac{10}{2}$
  $\Rightarrow R_C = 130\,kN \uparrow$
  $\Sigma F_y = 0 \Rightarrow R_A = 60 \times 10 + P - R_C$
  $\Rightarrow R_A = 90\,kN \uparrow$

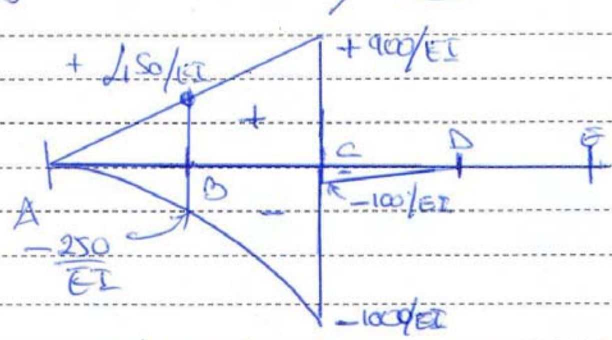


Calculations and/or Diagrams (cont'd):



θ_C
v_B
v_D
$v_{max} - v_M (A \to C)$

Mom by Parts: M/EI (C)



$d_{CA} = \left(\frac{1}{2}\right)\left(\frac{900}{EI}\right)(10)\left(\frac{1}{3}\times 10\right) + \left(\frac{1}{3}\right)\left(\frac{-1000}{EI}\right)\left(\frac{1}{4}\times 10\right)$

Point C below tang.

$= (-) 6.67 \times 10^{-3}$ m

Point below tangent

$|\theta_A| = \frac{|d_{CA}|}{10} = 0.667 \times 10^{-3}$ rad C.W

$\Rightarrow \theta_A = (-) 0.667 \times 10^{-3}$ rad

$\theta_C - \theta_A = \text{Area} = \left(\frac{1}{2}\right)\left(\frac{900}{EI}\right)(10) + \left(\frac{1}{3}\right)\left(\frac{-1000}{EI}\right)(10)$

$\hookrightarrow = -0.667 \times 10^{-3}$

$\Rightarrow \theta_C = (+) 0.5 \times 10^{-4}$ C.CW

Calculations and/or Diagrams (cont'd):

- $|\Delta_{BA}| = |\theta_A| \times 5 = 3.33 \times 10^{-3}$ m

$d_{BA} = \left(\frac{1}{2}\right)\left(\frac{450}{EI}\right)(5)\left(\frac{1}{3}\times 5\right) + \left(\frac{1}{3}\right)\left(-\frac{250}{EI}\right)(5)\left(\frac{1}{4}\times 5\right)$

$= (+) 1.354 \times 10^{-3}$

↳ Point Above tangA ✓

$|v_B| = |\Delta_{BA}| - |d_{BA}| = 1.976 \times 10^{-3}$ m ↓ down ⊖

$v_B = -1.976 \times 10^{-3}$ m (↓)

- $|\Delta_{DC}| = |\theta_C| \times 5 = 2.5 \times 10^{-3}$ m

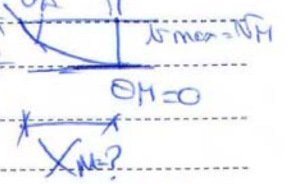
$d_{DC} = \left(\frac{1}{2}\right)\left(-\frac{100}{EI}\right)(5)\left(\frac{2}{3}\times 5\right) = (-) 0.33 \times 10^{-4}$

↳ Point Below ✓

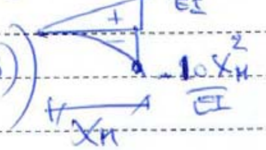
$|v_D| = |\Delta_{DC}| - |d_{DC}| = 1.67 \times 10^{-3}$ m ↑ ⊕

$v_D = +1.67 \times 10^{-3}$ m ↑

- $\theta_H - \theta_A = \left(\frac{1}{2}\right)\left(\frac{90 X_H}{EI}\right)(X_H) + \left(\frac{1}{3}\right)\left(-\frac{10 X_H^2}{EI}\right)(X_H)$ ($\theta_H = 0$, $\theta_A = -0.667\times10^{-3}$)



$\Rightarrow +\frac{0.667 \times 10^{3}}{EI} - \frac{45 X_H^2}{EI} + \frac{3.33 X_H^3}{EI} = 0$



$X_H = 4.79$ m $(< 5$ m (before B))

Trial (Start with $X_H = 5$)

Calculations and/or Diagrams (cont'd):

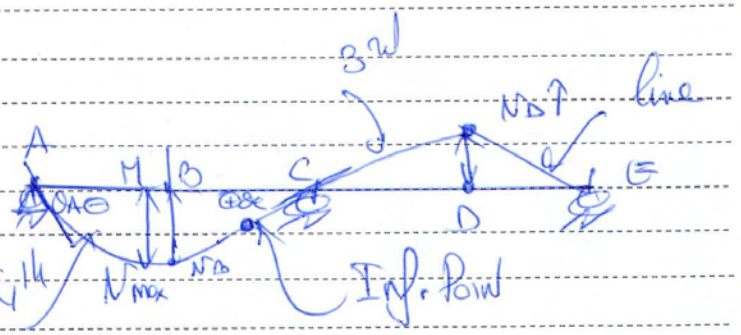
$$\Delta_{A/M} = \left(\frac{1}{2}\right)\left(\frac{90\times 4.79}{EI}\right)(4.79)\left(\frac{2}{3}(4.79)\right) + \left(\frac{1}{3}\right)\left(-\frac{10\times 4.79^2}{EI}\right)(4.79)\left(\frac{3}{4}\times 4.79\right)$$

$$\Delta_{A/M} = \pm 1.981\times 10^{-3}\ m$$

(Above)

$$\Delta_M = \Delta_{max} = 1.981\times 10^{-3}\ m\ (\downarrow)$$

Check: $\Delta_B = 1.976\times 10^{-3}\ m\ (\downarrow)$

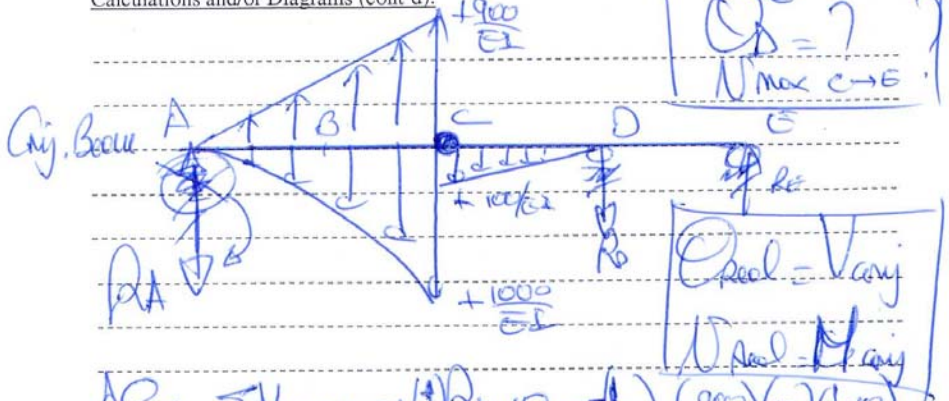


2. USING THE CONJUGATE BEAM METHOD

Compute the slope at D and the maximum downward deflection between C and E. *(25 points)*

Deduce (with a brief comment) the slope at E. *(5 points)*

Calculations and/or Diagrams (cont'd):



Calculations and/or Diagrams (cont'd):

$\Sigma F_y = 0 \Rightarrow V_D^{\ominus} = V_D^{\oplus} + R_D$

$\Rightarrow V_D^{\ominus} = -0.333\times10^{-3} + 0.583\times10^{-3}$

$= +0.25\times10^{-3}$ rad

$V_D^{\oplus} = -0.333\times10^{-3}$

$R_D = 0.583\times10^{-3}$

$\theta_D^{\ominus} = +0.25\times10^{-3}$ rad CCW

Since $\theta_D^{\ominus} > 0$, $\theta_D^{\oplus} < 0$ $\Rightarrow N_{Max}$ c → E

$= N_D$

$N_{Max} = N_D$ (question 1) $= +1.67\times10^{-3}$ m ↑

$\theta_E = \theta_D = -0.333\times10^{-3}$ rad