# QUIZ 2
## Spring 2004-2005
### (Tuesday May 12, 2005)
## CIVE311 – STRUCTURES I
## CLOSED BOOK, 1 & 1/2 HOURS

Name: *Solution*     ID#: *8878.*

## NOTES

- 1 PROBLEM – 3 QUESTIONS - 10 PAGES.
- ALL YOUR <u>ANSWERS</u> 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 <u>MUCH LESS</u> THAN THE SPACE PROVIDED.
- *DO NOT* USE THE <u>BACK</u> OF THE SHEETS FOR ANSWERS.
- <u>DRAFT</u> BOOKLET WILL BE PROVIDED; BUT DO NOT USE FOR ANSWERS.
- BOTH QUESTION SHEETS AND DRAFT BOOKLET SHOULD BE <u>RETURNED</u>.
- <u>CHECK BOXES</u> ARE TO CONFIRM THAT YOU HAVE SOLVED A QUESTION.  ☑

## YOUR COMMENT(S)

_____

_____

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## DO NOT WRITE IN THE SPACE BELOW

## MY COMMENT(S)

_____

_____

## YOUR GRADE

*QUESTION 1:* 60 /60
*QUESTION 2:* 30 /30
*QUESTION 3:* 10 /10
*Other:* ___

*TOTAL:* 100 /100

## Problem I/I:

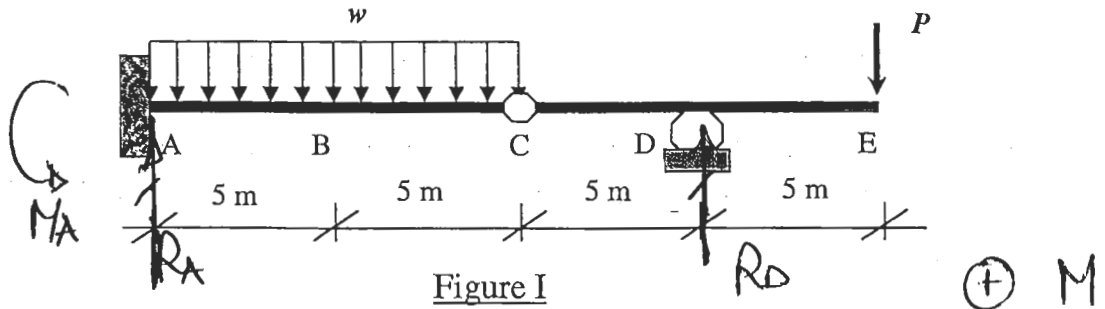

Figure I
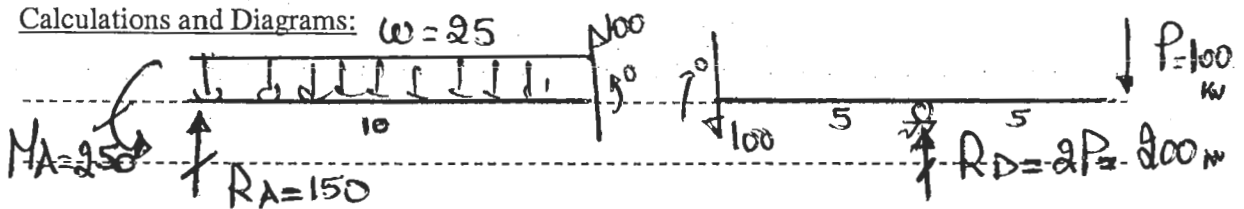
Referring to Figure I:
$EI=1,000,000$ kN.m$^2$ throughout the beam (except in Question 3).
$w=25$ kN/m and $P=100$ kN throughout the problem.
Neglect the own weight of the beam.

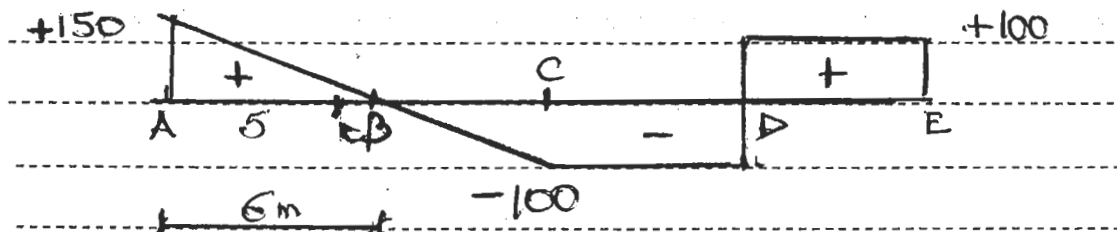1. **USING THE MOMENT-AREA METHOD**
   Compute the slopes at C and D ($\theta_C$ and $\theta_D$) and the vertical deflections at B, C and E ($v_B$, $v_C$ and $v_E$). You can calculate slopes and deflection in whichever order you find suitable. (*50 points*)
   Based on the results obtained, sketch the final deflected shape. (*10 points*)
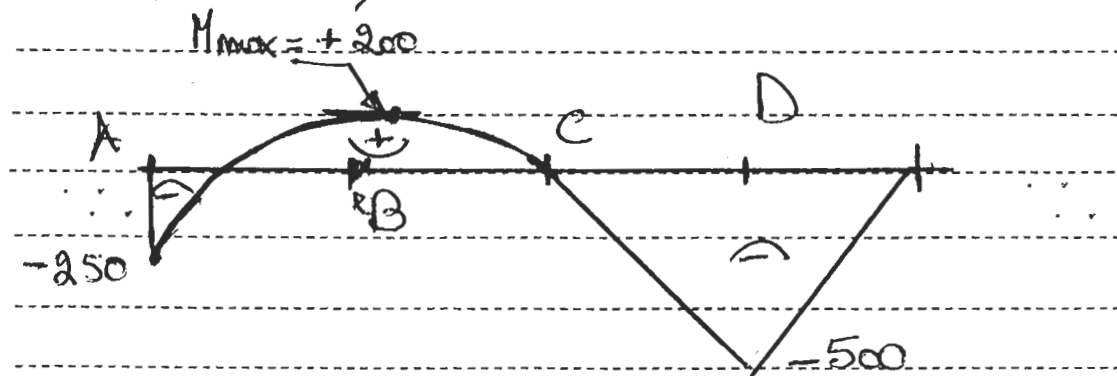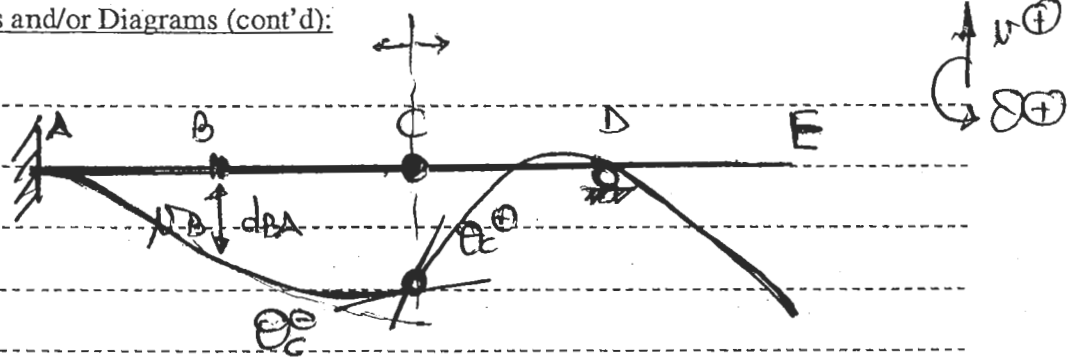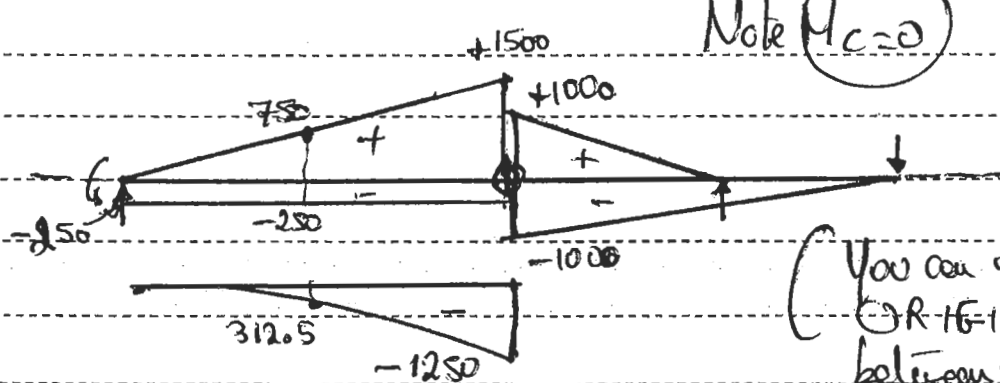
Calculations and Diagrams:

Calculations and/or Diagrams (cont'd):



Note $M_{C=0}$

$M$/parts $\left(\times \dfrac{1}{EI}\right)$ C



(You can use ORIGINAL $M_{\text{diagram}}$ between C & E

$$EI\left(\theta_C^{\ominus} - \cancel{\phi_A}^{0}\right) = \boxed{+} + \boxed{-} + \boxed{} = \left(\tfrac{1}{2}\right)(1500)(10) + (-250)(10) + \left(\tfrac{1}{3}\right)(-1250)(10)$$

$$\rightarrow \theta_C^{\ominus} = \dfrac{+833.33}{EI} = \oplus 0.833 \times 10^{-3} \text{ rad} \quad \rightarrow C.\overleftarrow{CW} \checkmark$$

$$EI\, d_{BA} = \left(\tfrac{1}{2}\right)(750)(5)\left(\tfrac{1}{3}\times 5\right) + (-250)(5)\left(\tfrac{1}{2}\times 5\right) + \left(\tfrac{1}{3}\right)(-312.5)(5)\left(\tfrac{1}{4}\times 5\right) = \ominus 651$$

points ↓ tang

$$\downarrow \mathcal{N}_B = |d_{BA}| = \dfrac{651}{EI} = 0.651 \times 10^{-3} \text{ m} = 0.651 \text{ mm} \quad \text{Point Below} \checkmark$$

$$EI\, d_{CA} = \left(\tfrac{1}{2}\right)(1500)(10)\left(\tfrac{1}{3}\times 10\right) + (250)(10)\left(\tfrac{1}{2}\times 10\right) + \left(\tfrac{1}{3}\right)(-1250)(10)\left(\tfrac{1}{4}\times 10\right) = \oplus 2083$$

$$\uparrow \mathcal{N}_C = |d_{CA}| = \dfrac{2083}{EI} = 2.083 \times 10^{-3} \text{ m} = 2.083 \text{ mm} \quad \text{POINT ABOVE}$$

See adjusted Figure ▷

3

Calculations and/or Diagrams (cont'd):
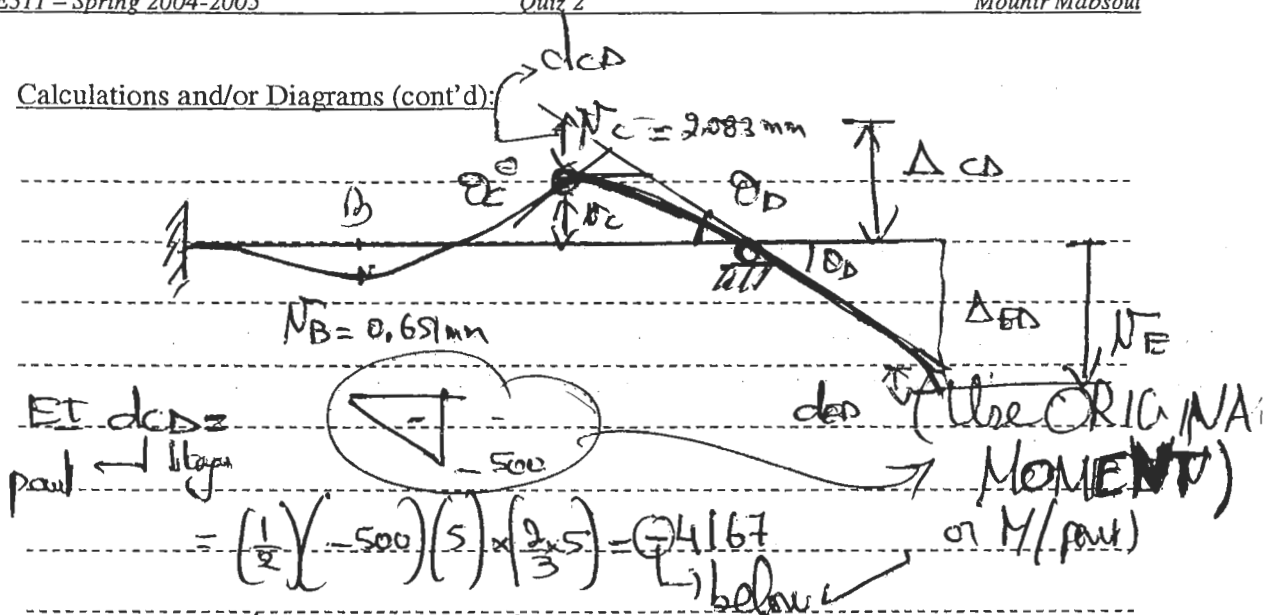


$$EI \, d_{CD} = \left(\frac{1}{2}\right)(-500)(5) \times \left(\frac{2}{3} \times 5\right) = -4167 \quad \text{(below)}$$

$$|d_{CD}| = 4.167 \times 10^{-3} \, m$$

$$|\Delta_{CD}| = |N_C| + |d_{CD}| = \frac{6250}{EI} = 6.25 \times 10^{-3} \, m$$

$$|\theta_D| = \left|\frac{\Delta_{CD}}{5}\right| = \frac{1250}{EI} = 1.25 \times 10^{-3} \, (-) \quad \text{rad}$$

$$EI(\theta_D - \theta_C^{\oplus}) = \overline{\phantom{xx}}_{-500}$$

$$\theta_C^{\oplus} = -\left(\frac{1}{2}\right)(-500)(5)\bigg/EI + \left(-\frac{1250}{EI}\right) = \phi \quad \theta_C^+$$

$$EI \, d_{ED} = \boxed{\phantom{x}}_{-500} = -4167 \quad \text{(below)} \Rightarrow d_{ED} = -4.167 \times 10^{-3} \, m$$

$$|\Delta_{ED}| = |\theta_D| \times 5 = 6.25 \times 10^{-3} \, m$$

$$N_E = |d_{ED}| + |\Delta_{ED}| = 10.417 \times 10^{-3} \, m$$
$$= 10.42 \, mm$$



$N_E = 10.42 \, mm$

## 2. USING THE CONJUGATE BEAM METHOD

Compute the maximum downward deflection between A and C. *(30 points)*

Calculations and/or Diagrams (cont'd):



$$\bar{V}_{max} (\downarrow) \quad A \rightarrow C \quad (Real)$$

$$\Rightarrow M_{max} \quad A \rightarrow C \quad \text{in Conjugate Beam} \quad ?$$

$$\Rightarrow V = 0$$

$$\Rightarrow \quad @ \quad X = ?$$

Conjugate A



$$\sum F_y = 0 \Rightarrow \left(\frac{1}{2}\right)\left(\frac{150X}{EI}\right) \times (X) = \left(\frac{250}{EI}\right)(X) + \left(\frac{1}{3}\right)\left(\frac{12.5X^2}{EI}\right)(X)$$

$$\Rightarrow X\left(\frac{12.5}{3}X^2 - 75X + 250\right) = 0 \qquad \Delta = 1458.3$$

$$X = 0 \qquad X = 4.417 \, m \checkmark \qquad (\text{to left of B})$$

$$M(X = 4.417) \quad (= \Delta_{MA})$$

$$= \left(\frac{1}{2}\right)\left(\frac{150 \times 4.417}{EI}\right)(4.417) \times \left(\frac{1}{3} \times 4.417\right)$$

$$- \left(\frac{250}{EI}\right)(4.417)(4.417/2)$$

$$- \left(\frac{1}{3}\right)\left(\frac{12.5 \times 4.417^2}{EI}\right)(4.417)\left(\frac{1}{4} \times 4.417\right) = \frac{681}{EI}$$

$$\Rightarrow \quad \bar{V}_{max} = \left(\downarrow\right) - 0.681 \times 10^{-3} \, m = 0.681 \, mm \, (\downarrow)$$

3. For the same beam and loads applied as in <u>Figure I</u>, and assuming member AC or member CE 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:

$M/EI \to 0$ (curvature $\approx 0$)

almost line (no curvature)