QUIZ 2
Spring 2006-2007
(Wednesday May 9, 2007)
CIVE311 – STRUCTURES I
CLOSED BOOK, 1 & 1/2 HOURS

Name: [illegible] **ID#:** [illegible]

NOTES

- 1 PROBLEM – 4 QUESTIONS - 12 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: _ _ /15
QUESTION 2: _ _ /55
QUESTION 3: _ _ /10
QUESTION 4: _ _ /20
Other: _ _ _

TOTAL: /100

Problem I/I:

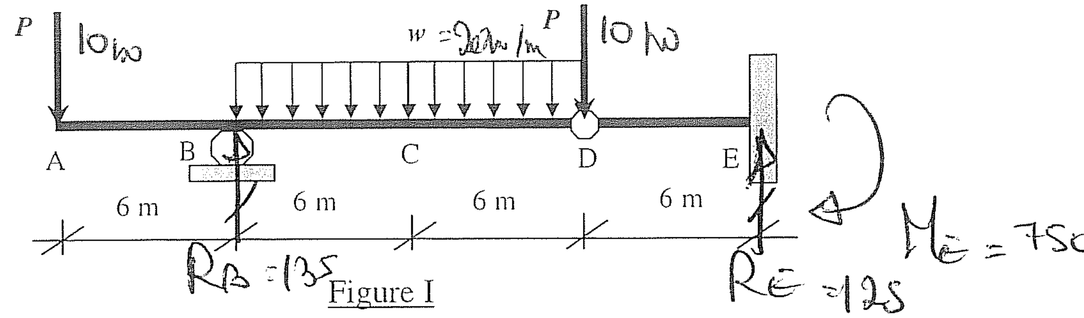
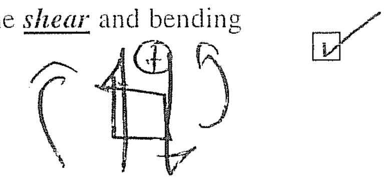
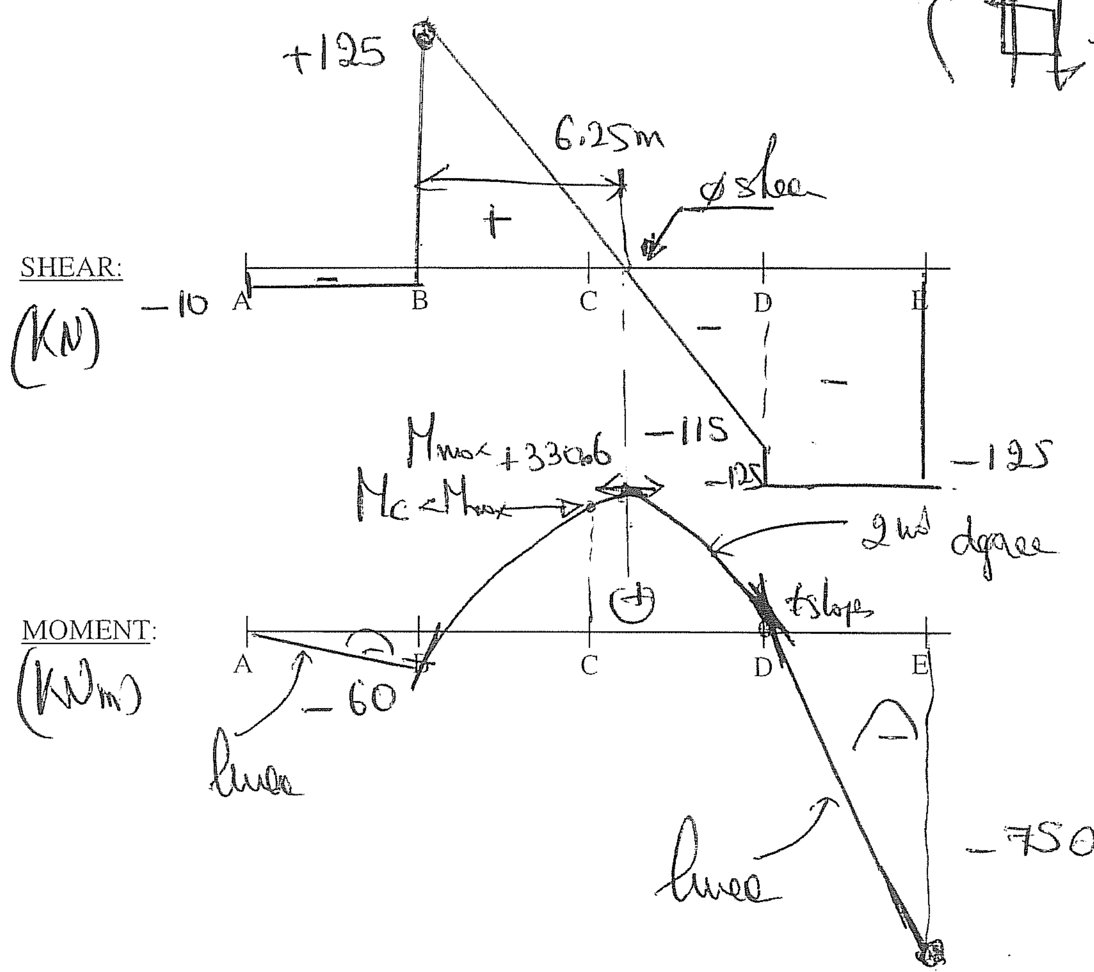


Figure I

Referring to Figure I:
EI=2,000,000 kN.m^2 throughout the beam (except in Question 4).
w=20 kN/m and P=10 kN throughout the problem (except in Question 4).
Neglect the own weight of the beam.

1. Compute the ***reactions*** (forces and moments) in the beam, and draw the ***shear*** and bending ***moment*** diagrams. *(15 points)*





Calculations and/or Diagrams:

Considering AD: $\Sigma M_D = 0$

$$\Rightarrow R_B \times 12 = 10 \times 18 + \frac{20 \times 12^2}{2}$$

$$\Rightarrow R_B = 135 \text{ kN} \uparrow$$

Considering AE $\Sigma F_y = 0$

$$\Rightarrow R_E = 10 + 10 + 20 \times 12 - 135 = 125 \text{ kN} \uparrow$$

$$\Sigma M_E = 0 \Rightarrow M_E = 10 \times 24 + 20 \times 12 \times 12 + 10 \times 6 - R_B \times 18$$

$$= 750 \text{ kN}$$

2. USING THE MOMENT-AREA METHOD

Based on the moment diagram in question 1, sketch a ***reasonable deflected shape***. (2 *points*)

In what follows, you can calculate slope and deflections in the order you find suitable.

Compute the ***slopes*** θ and vertical ***deflections*** v at all points A, B, C, D, and E. (*35 points*)

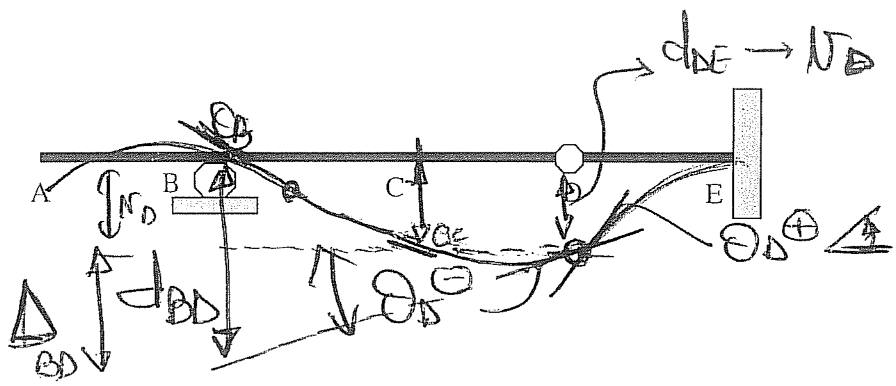
Compute the ***maximum downward deflections:***

(i) between D and E. (*5 points*)

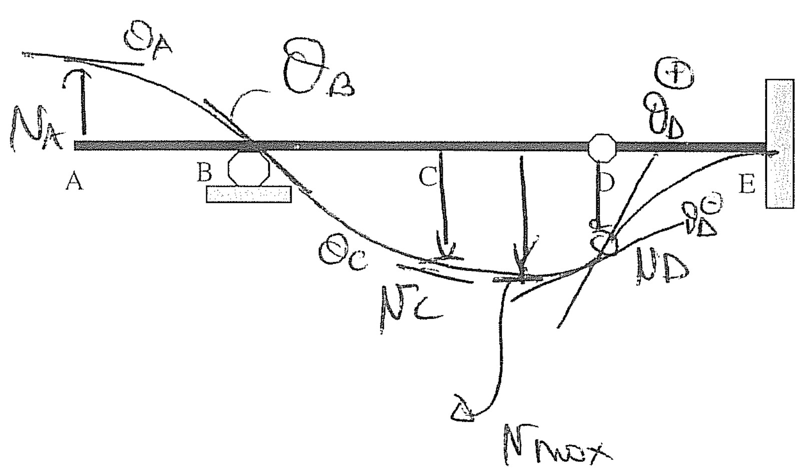
(ii) between B and D. (*10 points*) → Explain how to estimate

Based on the results obtained, neatly/clearly sketch the ***final deflected shape*** and show the results obtained. (3 *points*)

INITIAL DEFLECTION



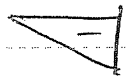
FINAL DEFLECTION



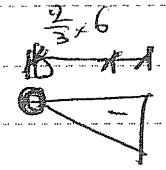
Calculations and/or Diagrams:

$\boxed{N_E + \theta_E = 0}$ (fixed end)

Considering DE

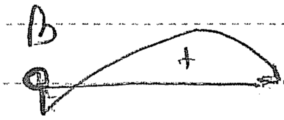
$EI(\cancel{\theta_E} - \theta_D^{+}) =$  -750 $\Rightarrow \theta_D^{+} = +\frac{1}{2}(750)(6)\times\frac{1}{EI}$

$\boxed{\theta_D^{+} = (+)0.001125 \text{ rad}}$ ↳ C.C.W

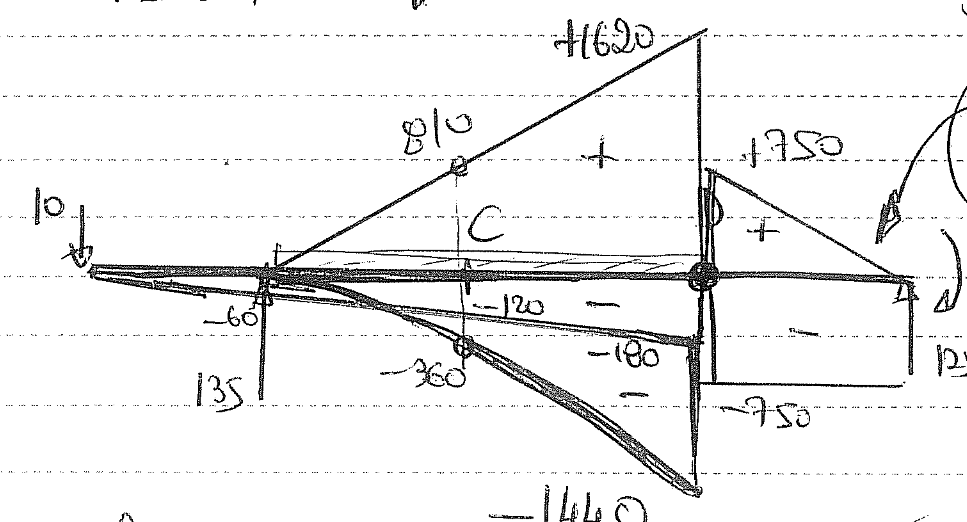
d_{DE} (point D, Li tang) $=$  $= -0.001125\times\left(\frac{2}{3}\times 6\right) = (-)0.0045$ m ↓ below tang

$\boxed{N_D = 0.0045 \text{ m} \downarrow \text{ or } (-)}$ (4.5mm)

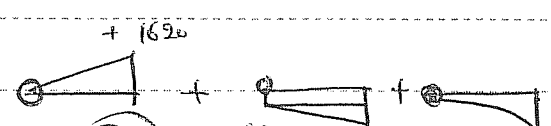
Considering AD

$d_{BD}(?) =$  $\Rightarrow$ Mom by parts

M parts / Wu



check @ D: $M^{-} - M^{+} = 0$

$EI\, d_{BD} =$ 

$= \underbrace{\frac{1}{2}(1620)\times(12)\left(\frac{2}{3}\times 12\right)}_{9720} - \underbrace{(60)(12)\times\left(\frac{1}{2}\times 12\right)}_{720} - \underbrace{\frac{1}{2}(120)(12)\left(\frac{2}{3}\times\right.}_{720}$

$- \underbrace{\frac{1}{3}(1440)(12)\left(\frac{3}{4}\times 12\right)}_{5760} \Rightarrow d_{BD}^{+} = \frac{15840}{EI} = (+)0.00792$ m (point Above)

Calculations and/or Diagrams (cont'd):

$|\Delta_{BD}| = |d_{BD}| - |N_D| = 0.00792 - 0.0045 = 0.00342$ m

$|\theta_D| = \frac{0.00342}{12} = 0.000285$ rad

$\boxed{\theta_D^{\ominus} = \ominus 0.000285 \text{ rad} \quad C.W}$

$EI(\theta_D^{\ominus} - \theta_B) = \ldots + \ldots + \ldots$

$= 2520$

$\Rightarrow EI\,\theta_B = EI\,\theta_D^{\ominus} - 2520 \Rightarrow \theta_B = \frac{570 - 2520}{EI} = \frac{-1950}{EI}$

Roller $\boxed{N_B = 0}$ $\boxed{\theta_B = \ominus 0.000975 \text{ rad}}$ (CW)

$EI(\theta_C - \theta_B) = \ldots + \ldots + \ldots$

810, 6, 6, −60, −120, 6, −360

$= \underbrace{\left(\frac{1}{2}\right)(810)(6)}_{2430} - \underbrace{\frac{1}{2}(60+120)\times(6)}_{540} - \frac{1}{3}(360)(6)$

360, 180, 720

$= 1170$

$\Rightarrow EI\,\theta_C = EI\,\theta_B + 1170 = -1950 + 1170 = -780$

$\boxed{\Rightarrow \theta_C = \ominus 0.00039 \text{ rad}}$ CW

B C

Δ_{CB} d_{CB}

$d_{CB} = \ldots - \ldots - \ldots = 2430\times(\frac{1}{3}\times6) - 180(\frac{1}{3}\times6) - 360(\frac{1}{4}\ldots$

$- 780(\frac{1}{4}6) = 2205$ Above

$= +0.00917$

$\Delta_{CB} = |\theta_B| \times 6 = 0.00585$

Curved

d Δ

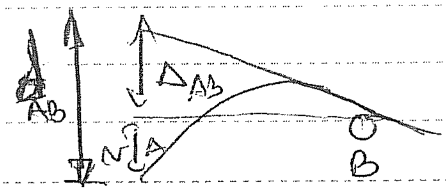
$N_c = |\Delta| - |d|$

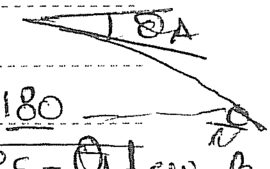
$\boxed{N_C = 0.00468 \text{ m}}$ ↓

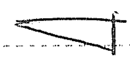
Calculations and/or Diagrams (cont'd):

v_A)

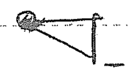
θ_A .





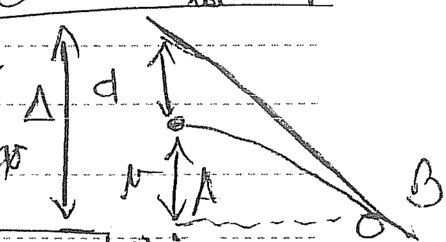
$EI(\theta_B - \theta_A) =$  $-60 = \left(\frac{1}{2}\right)(-60)(6) = -180$

$\Rightarrow \theta_A = \theta_B + \frac{180}{EI} = \frac{-1450+180}{EI} = \boxed{-0.000805 = \theta_A}$ cw rad

$EI\, d_{AB} =$  $-60 = \left(\frac{1}{2}\right)(-60)(6)\left(\frac{2}{3}\times 6\right) = -720$ below

$\Rightarrow d_{AB} = -\frac{720}{EI}$

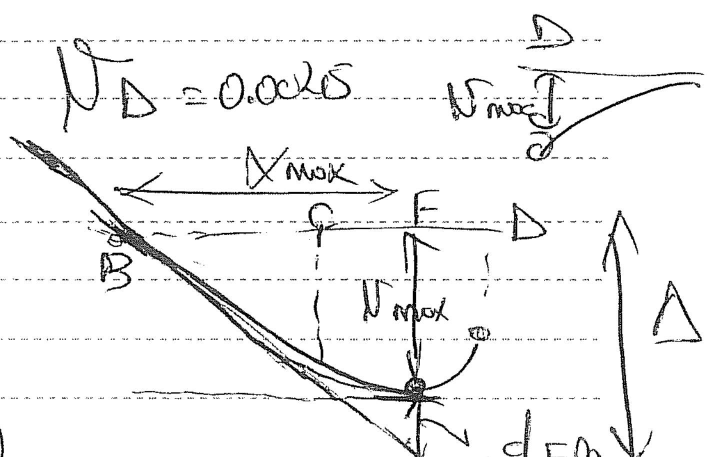
$\Delta_{AB} = |\theta_B| \times 6 = \frac{11{,}700}{EI} = \frac{10980}{EI} =$

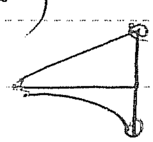
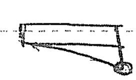


$v_A = |\Delta| - |d| = \frac{11700-720}{EI} = \boxed{0.00549\,m = v_A}$ (↑)

↓ $|v_{max}|$ D → E = $v_D = 0.0065$

↓ $|v_{max}|$ B → D



$\theta_{F_{max}}^{\,0} - \theta_B^{\,(\text{given})} =$  +  $= f(x^3)$

$X_{max} = ✓$

@ X_{max} $|v_{F\,max}| = |\Delta_{FB}| - |d_{FB}|$

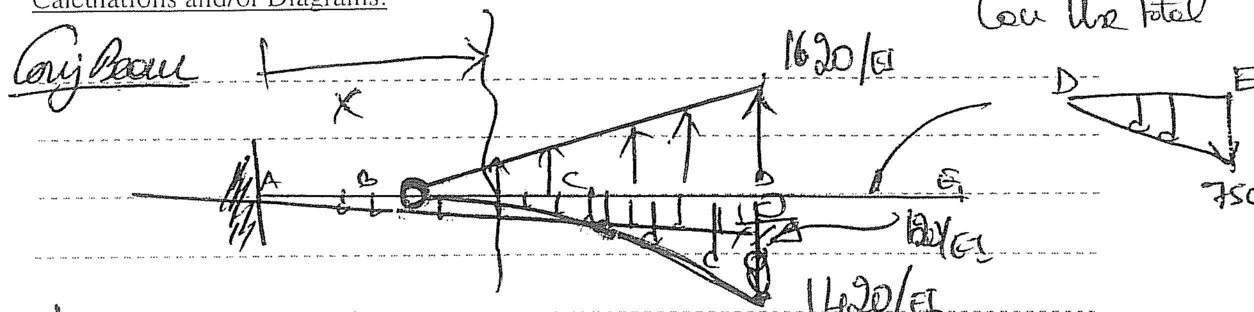
v_{max} is a bit larger than v_C & v_D

≈ -0.0048 m

3. USING THE CONJUGATE BEAM METHOD
Show the ***conjugate beam***, and explain how you would compute slopes and deflection of the beam in Figure I. *(10 points)*

Calculations and/or Diagrams:

Can Use total



- Load with $\frac{M}{EI}$ of Real Beam
- Use Mom. by Parts for calculation purposes

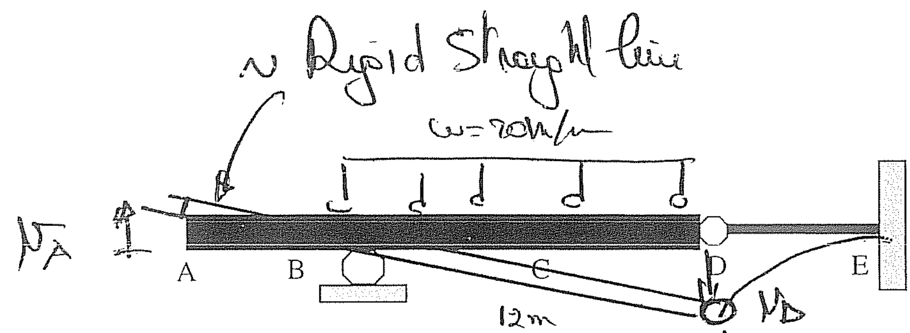
@ any point X

- $\theta_{real} = V_{conj}$
- $\Delta_{real} = M_{conj}$

4. **Let w=20 kN/m and P=0.**
For the same beam as in Figure I (with w only), and assuming member AD (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*)

Using the simplest and quickest approaches possible, calculate:
- (i) Case 1: the ***deflections v*** at points A and D. (5 points)
- (ii) Case 2: the ***deflections v*** at points A and C. (5 points)

DEFLECTION for Case 1

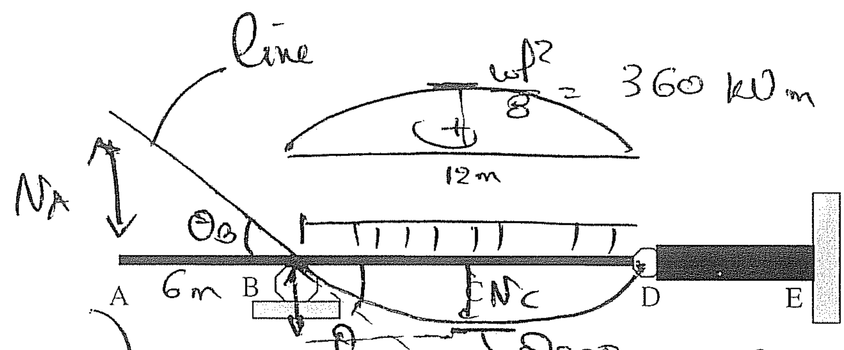


$P = \frac{20\times 12}{2}$ P 6 m

(↓) $\nu_D = \frac{P\ell^3}{3EI} = \frac{120\times 6^3}{3EI} = 0.00432$ m

(↑) $\nu_A = \frac{1}{2}\nu_D = 0.00216$ m

DEFLECTION for Case 2



($\nu_D = 0$)

~ Simple Beam between B & D

$\cancel{\theta_C} - \theta_B = \left(\frac{2}{3}\right)\times\left(\frac{360}{EI}\right)(6)$ (cw)

$\theta_B = -\frac{1440}{EI} = -0.00072$ rad

$\nu_A = |\theta_B| \times 6 = 0.00432$ m (↑)

$\nu_C = |d_{BC}|$ or $\frac{5}{384}\frac{w\ell^4}{EI} = 0.0027$ m (↓)