QUIZ 2

Spring 2002-2003

(Thursday, May 15, 2003)

CIVE 311 – STRUCTURES I

CLOSED BOOK, 1 ½ HOURS

Name: Key Key **ID#:** 0000_00000

NOTES

- 2 PROBLEM - 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.

YOUR COMMENT(S)

Complicated/heavy calculations in I.1

DO NOT WRITE IN THE SPACE BELOW

MY COMMENT(S)

I Agree - Will consider in grading

YOUR GRADE

Problem I: 75 /75
Problem II: 25 /25
Other: ___

TOTAL: 100 /100

Problem I: *(75 points)*

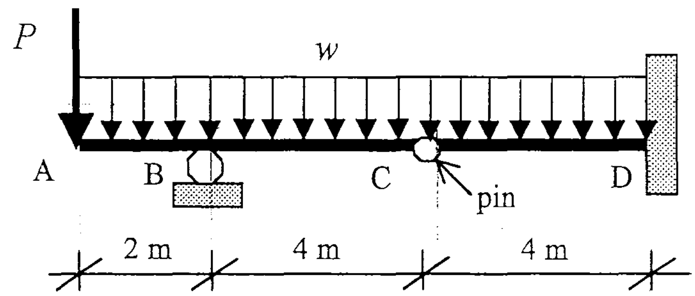
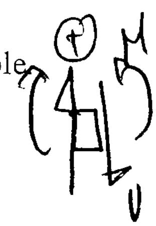


Figure I

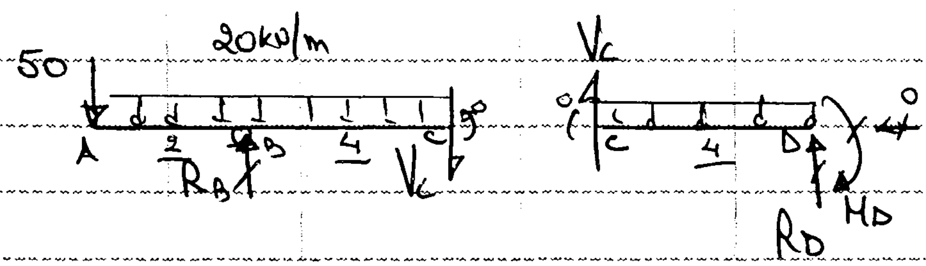
Referring to Figure I, let ***EI*=100,000 kN.m²** throughout the beam. Neglect the own weight of the beam.

USE THE MOMENT-AREA METHOD THROUGHOUT THIS PROBLEM.

1. Let **w=20 kN/m** and **P=50 kN**
   Compute the slope at C (θ_C) and the vertical deflections at A and C (v_A and v_C) (*40 points*). Indicate where the maximum downward deflection will occur between B and D and explain. (*10 points*)
   NOTE: You can calculate slopes and deflection in whichever order you find suitable.



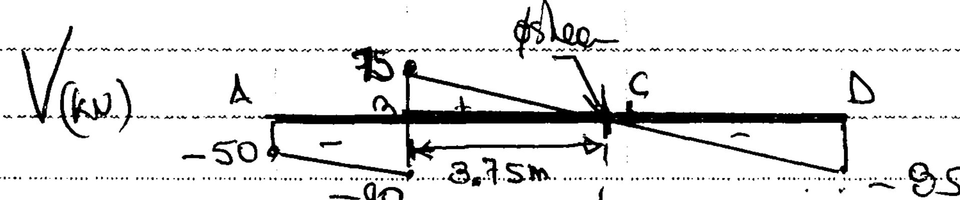
Calculations and Diagrams:

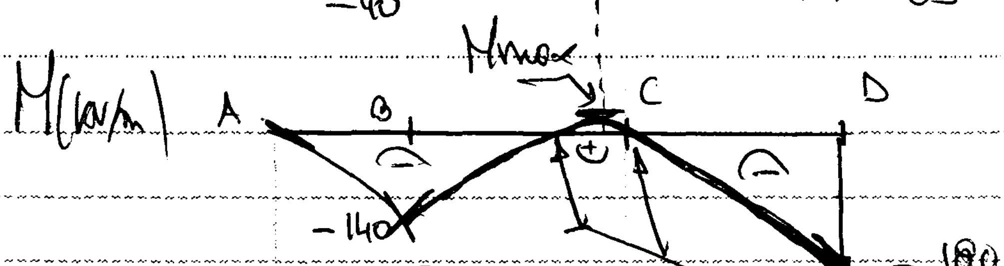


AC $\Sigma M_C = 0 \Rightarrow R_B = \ldots = 165$ kN ↑

AD $\Sigma F_y = 0 \Rightarrow R_D = \ldots = 85$ kN ↑

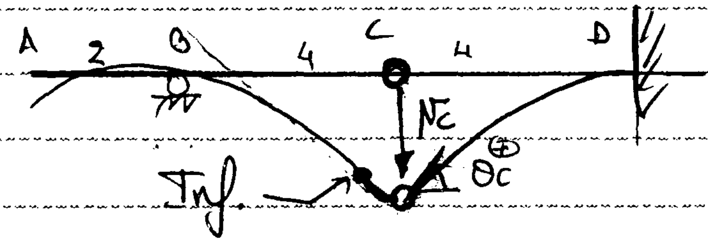
CD $\Sigma M_C = 0 \Rightarrow M_D = \ldots = 180$ kNm

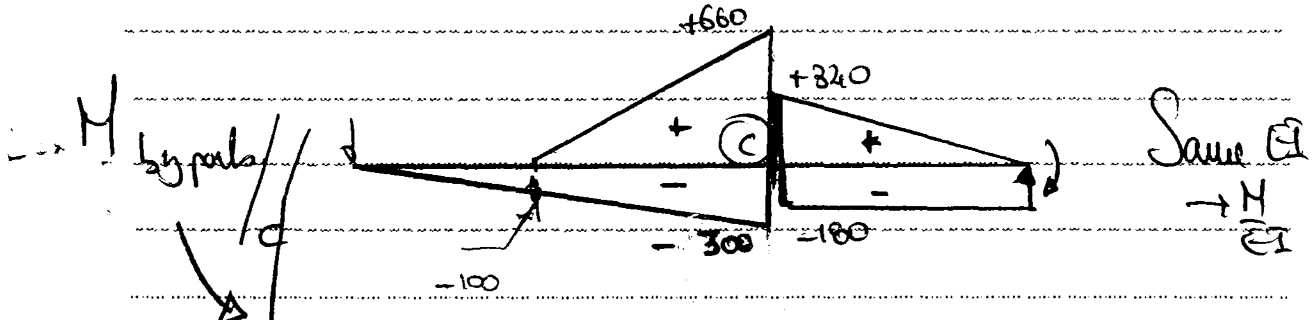


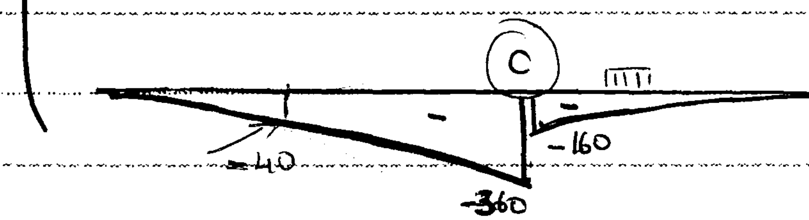


$M_{max} = -140 + \frac{1}{2} 75 \times 3.75 = 0.625$ kNm

Calculations and/or Diagrams (cont'd):







Note $\sum M_C^{left} = \sum M_C^{right} = 0$ ✓

$$\boxed{\theta_C^{\oplus} = +2.53 \times 10^{-3}\ \text{rad (CW)}}$$

CD: $EI(\theta_D^{\,0} - \theta_C^{\oplus}) = (-180)(4) + \left(\frac{1}{2}\right)(340)(4) + \left(\frac{1}{3}\right)(-160)(4)$

$\Rightarrow \theta_C^{\oplus} = +\dfrac{760}{3\,EI} = +2.53 \times 10^{-3}$ rad → C.C.W ✓

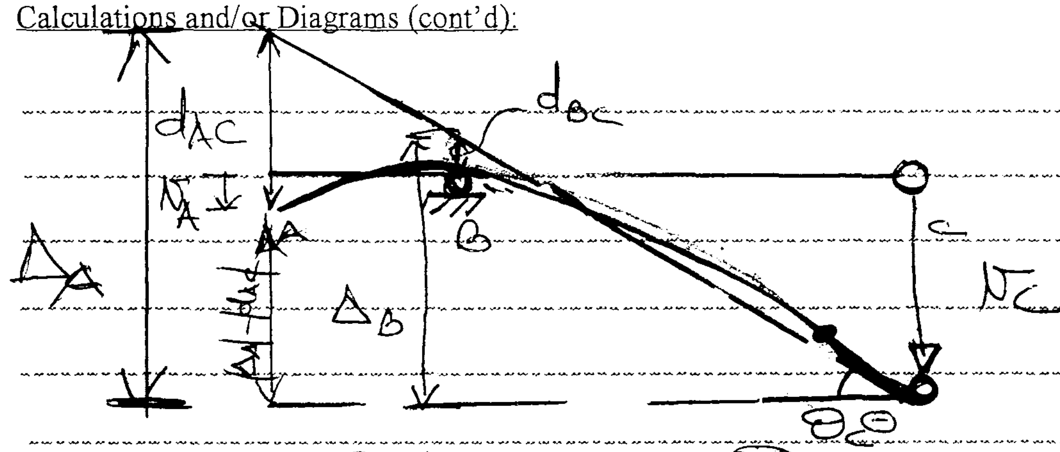
$EI\, d_{CD} = (-180)(4) \times \left(\frac{4}{2}\right) + \left(\frac{1}{2}\right)(340)(4) \times \left(\frac{1}{3} \times 4\right) + \left(\frac{1}{3}\right)(-160)(4) \times \left(\frac{1}{4} \times 4\right)$

$\Rightarrow d_{CD} = \ominus \dfrac{746.67}{EI} = -7.47 \times 10^{-3}$ m

C below tang. D ✓

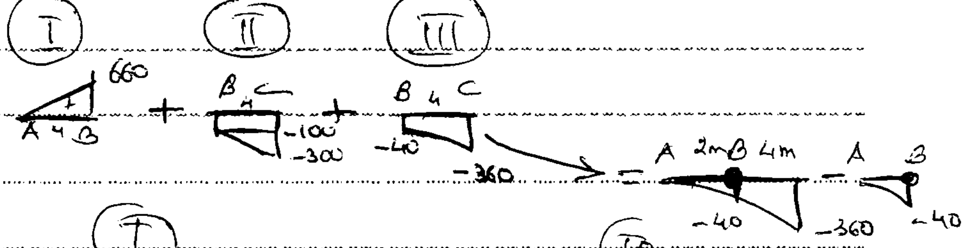
$$\Rightarrow \boxed{v_C = 7.47 \times 10^{-3}\ \text{m} \downarrow = 7.47\ \text{mm}}$$

Calculations and/or Diagrams (cont'd):



ABC

$EI\, d_{BC} =$ (point, tang)



$$= \left(\frac{1}{2}\right)(660)(4)\left(\frac{2}{3}\times 4\right) + (1)(-100)(4)\left(\frac{1}{2}\times 4\right) + \left(\frac{1}{2}\right)(-200)(4)\left(\frac{2}{3}\times 4\right)$$

$$+\left[\left(\frac{1}{3}\right)(-360)(6)\left(\frac{3}{4}\times 6-2\right) - \left(\frac{1}{3}\right)(-40)(2)\left(\frac{3}{4}\times 2-2\right)\right]$$

$$= 3520 - 800 - 1066.67 + [-1800 - 13.33] = -160$$

$[-1813.33]$

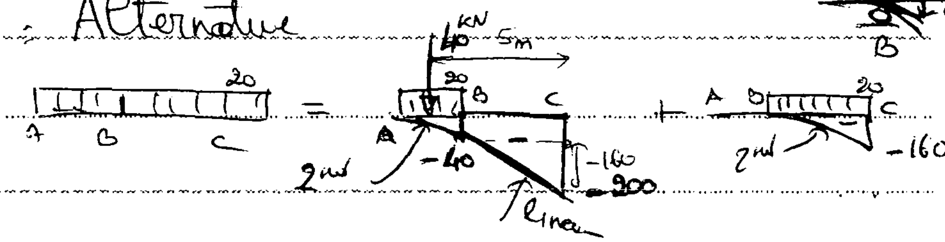
$d_{BC} = \ominus 0.00160$ m (B below ✓)

$\Delta_B = |d_{BC}| + |N_C| = 0.00907$ m $\Rightarrow |\theta_C^{\ominus}| = \left|\frac{\Delta_B}{4}\right| = 0.00227$ rad

$\theta_C = \ominus\ 0.00227$ (C.W)

(Not required) $\theta_B = (\theta_C^{\ominus} + \Delta\theta) = -0.00053$ rad, -0.00173; θ_B (C.W)

Note for III: Alternative



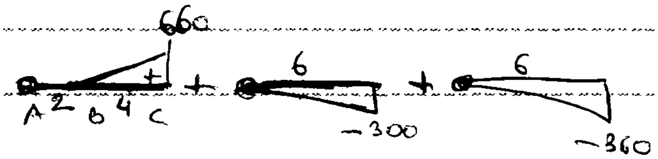
$$\text{III} = \left(\frac{1}{3}\right)(-160)(4)\left(\frac{3}{4}\times 4\right) + (1)(-40)(4)\left(\frac{1}{2}\times 4\right) + \left(\frac{1}{2}\right)(-160)(4)\left(\frac{2}{3}\times 4\right)$$

$= -1813.33$ (Same)

Calculations and/or Diagrams (cont'd):

(Figure on page 4)

$EI\, d_{AC} =$



$= \left(\frac{1}{2}\right)(660)(4)\left(2+\frac{2}{3}\times 4\right) + \left(\frac{1}{2}\right)(-300)(6)\left(\frac{2}{3}\times 6\right) + \left(\frac{1}{3}\right)(-360)(6)\left(\frac{3}{4}\times 6\right)$

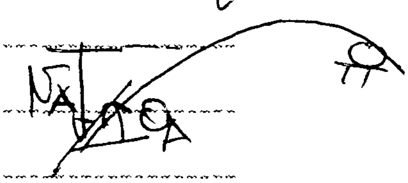
$= -680$

$d_{AC} = \ominus 0.0068$ m (A below) ✓ $|\Delta_A| = |\theta_C^{\ominus}| \times 6 = 0.01362$ m

$(|\Delta_A| - |d_{AC}|) = 0.0068$ m $(< |v_C|) \Rightarrow |v_A| = |v_C| - 0.0068$ m

$v_A = 0.00747 - 0.0068 = 0.00067$ m ↓

$|v_A = 0.00067\,\text{m} = 0.67\ \text{mm}\ \downarrow|$

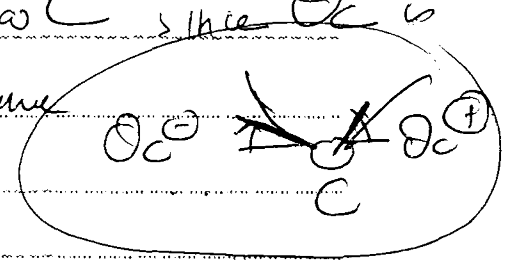


$\theta_A = \theta_C^{\ominus} - \Delta\theta$

$= +0.00073$ (CCW) − 0.003

Not required

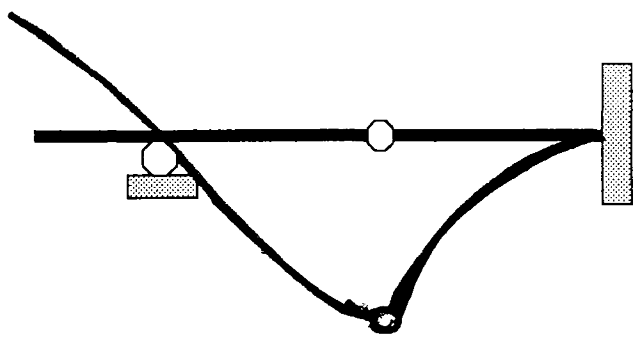
v_{max} B → D occurs @ C since $\theta_C^{\ominus}$ is clockwise & $\theta_C^{\oplus}$ is clockwise (see figure)



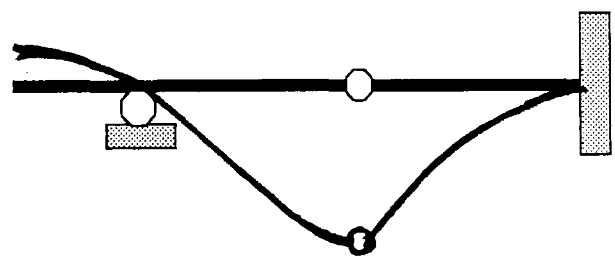
2. Let w**=20 kN/m**, and P gradually increased from 0 to 200 kN (very large value). As best as you can, sketch the expected deflected shapes of the beam for the sequence of P as shown below (NO CALCULATIONS). (*15 points*)

Deflected Shapes:

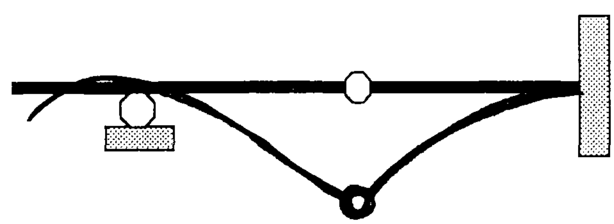
P=0 kN



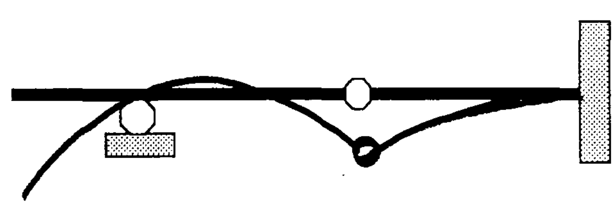
P=25 kN



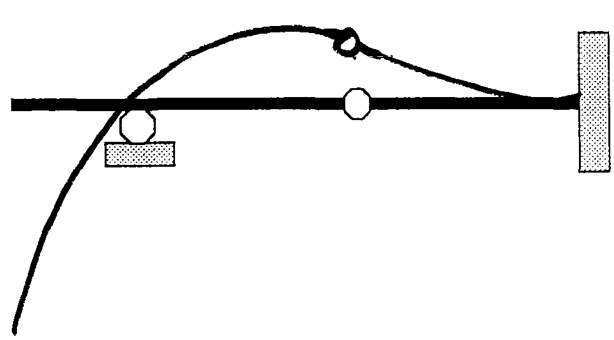
P=50 kN



P=100 kN



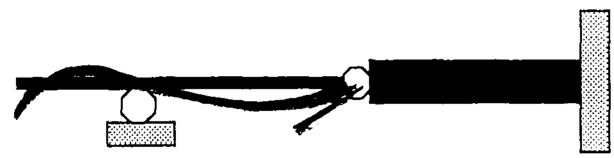
P=200 kN



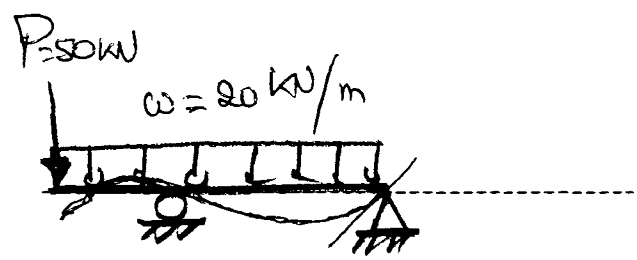
3. Let ***w*=20 kN/m** and ***P* =50 kN**
Assuming member CD to be very stiff, sketch the expected deflected shape of the beam. Can this beam analyzed using a simpler model? Show this model. (NO CALCULATIONS) (*10 points*)

Deflected Shapes:

CD very stiff



Your simplified model



Problem II: *(25 points)*

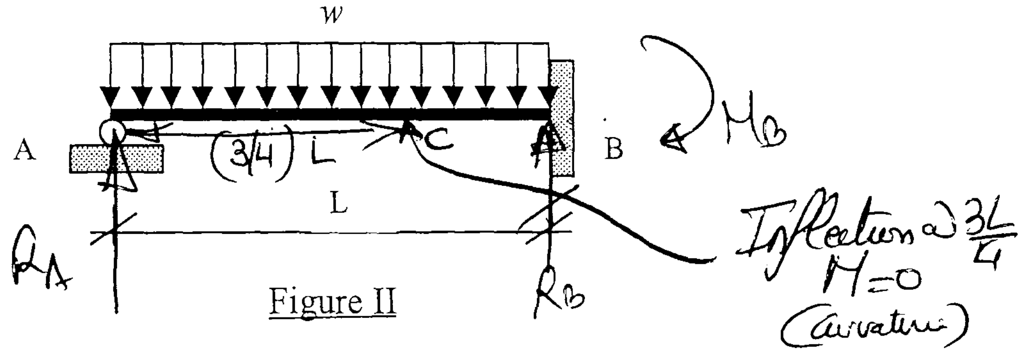
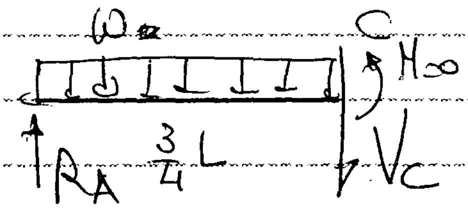


Figure II

The beam shown in Figure II is indeterminate to the first degree. Neglect the own weight. A measuring device indicated that an inflection point (zero curvature) exists at (*3L/4*) from A. Use this information to solve the problem (find reactions, draw shear and bending moments, and sketch deflected shape).

Calculations and Diagrams:



(AC) $\sum M_{C=0} \Rightarrow R_A = \left[\omega\left(\frac{3}{4}L\right)^2/2\right] / \left(\frac{3}{4}L\right) = \frac{3}{8}\omega L \uparrow$

(AB) $\sum F_y = 0 \Rightarrow R_B = \frac{5}{8}\omega L \uparrow$

$\sum M_{B=0} \Rightarrow M_B = -\frac{3}{8}\omega L \times L + \frac{\omega L^2}{2} = \frac{\omega L^2}{8}$