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100

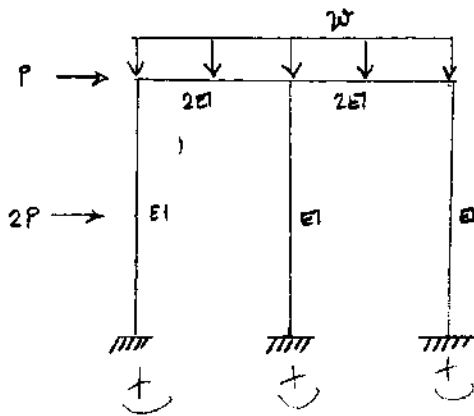
CE 461 – Structural Analysis
Final Exam

Name: _____

Thanks for all your hard work this semester, and best of luck in your future studies and professional endeavors. It has been a pleasure having each of you in this course. If you would like your final exam grade and your final course grade emailed to you, please indicate so here:

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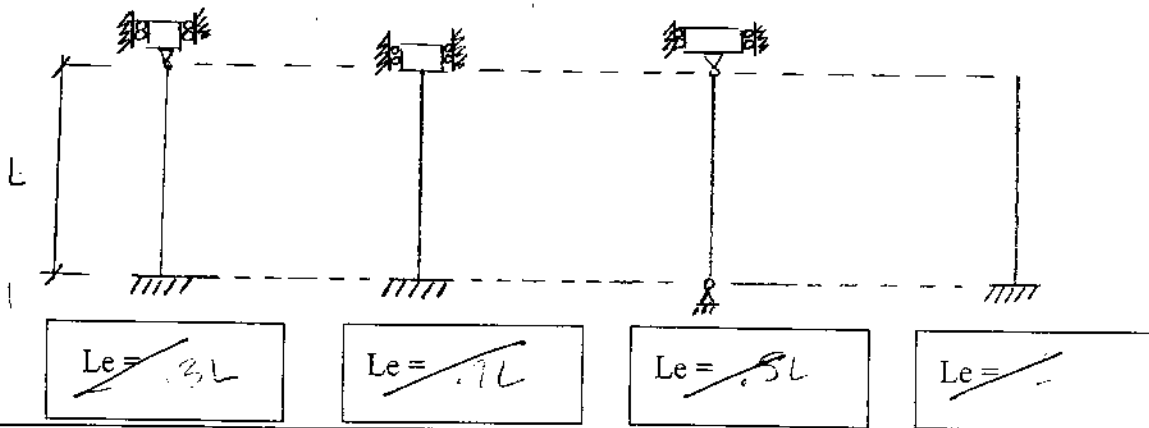
- 3 1. (3 pts.) Which method of indeterminate analysis that we covered in class would probably be the most *efficient* choice (least computationally intensive) to determine support reactions for the following frame? You only have a pencil, calculator, and paper as tools with which to solve the problem. Your choices are: (1) **Force Method**, (2) **Stiffness Method – Slope Deflection**, and (3) **Stiffness Method – Moment Distribution**. Support your answer. (You will not receive any credit without sufficient reasoning.)



6° indet.

moment distribution
slope deflection
best
Force Method
Stiffness Method
Through Moment Distribution
works better
it is more computationally intensive
EI method is iterative

- 0 2. (4 pts.) Please supply the effective lengths for each of the following columns.



2 3. (3 pts.) You have been asked by your boss to design a column of prescribed length L . The material and cross-section dimensions have been chosen for you by the architect. Your preliminary design shows that a pin-pin column of that length, material, and cross-section will buckle under the given loads. What can you do as the engineer-of-record to increase the capacity of the column without changing the overall length, material, or cross-section dimensions? Please be specific.

you could add more rebar to make it stronger.
column make it fixed-fixed adds redundancy to each end

Does not make it any more stable,
just increases buckling capacity

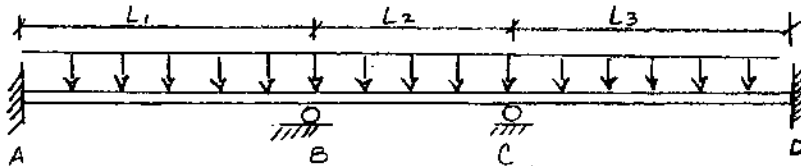
(Problem 4 got deleted...)

3 5. (3 pts.) What does a distribution factor in the moment distribution procedure physically describe?

describes the fraction of the amount of moment it takes to rotate the ~~rod~~ end of beam, rod.

$$\underline{\text{sum @ ea } j = 1. \checkmark}$$

6. (8 pts.) Fill in the following moment distribution table given the following beam, distribution factors, and fixed end moments. Carry out your precision to 0.10 ft-kip. You may not need to use all the rows in the table to successfully complete this problem.



D.F.s	0	0.444	0.556	0.556	0.444	0
FEMs	+78.1	-78.1	50	-50	78.1	-78.1
Balance		12.148	15.67	-15.67	-12.148	
Carry over	6.074		-7.81	7.81		-6.074
B		18.47	11.34	-11.34	-18.47	
C	9.235		-5.67	5.67		-9.235
B		14.63	1.21	-1.21	-14.63	
C	4.82		-0.61	0.61		-4.82
B		10.28	1.34	-1.34	-10.28	
C	1.34		-0.17	0.17		-1.34
B		8.75	0.95	-0.95	-8.75	
C						

← iterated til within 1/10 accuracy

FINAL MEMBER END MOMENTS: 86.7 ✓ ✓ -60.88 ✓ 60.85 ✓ -60.85 ✓ 60.85 ✓ -86.7 ✓

7. (4 pts.) For the beam in Problem 6, write the complete, numerical slope-deflection equation for M_{AB} if the support at B is subjected to a 4" upheaval due to soil swell. $EI = \text{CONSTANT}$. Assume L_1 is in inches, & write the equation in terms of L_1 .

$$M_{AB} = \frac{2EI}{L_1} (2\theta_B + \theta_C - 3\psi) + FEM_{AB}$$

$$M_{AB} = \frac{2EI}{L_1} (2\theta_B + \theta_C - 3(\frac{4''}{L_1})) + FEM_{AB}$$

(use the distributed load case value of ψ derived)

$$\psi = \frac{wL_1^2}{12}$$

complete equation:

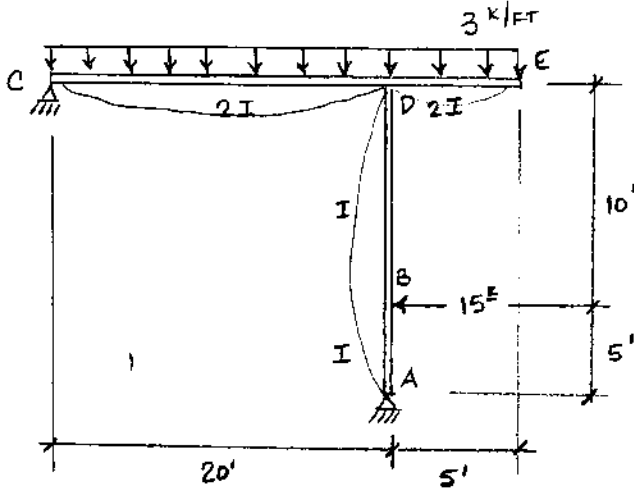
$$M_{AB} = \frac{2EI}{L_1} (\theta_B - 3(\frac{4''}{L_1})) + \left(\frac{wL_1^2}{12}\right)^2$$

30 GREAT JOB !!

8. Given the following indeterminate frame,

(a) (22 pts.) Solve for the member end moments using either the **slope-deflection method** or **moment distribution method**. Please begin the problem by stating which approach you have chosen.

(b) (8 pts.) Draw the shear and moment diagrams for member AD. Be sure to draw moment positive on the compression-side of the member.

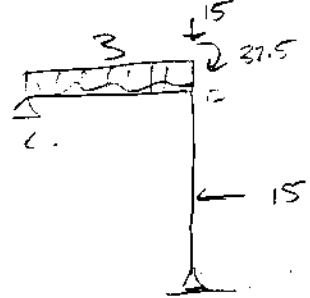


E = CONSTANT

Slope-Deflection Method

Degrees of freedom = θ_D

Simplified structure:



$$M_{AD} = 0$$

$$M_{DA} = \frac{3EI}{15} (\theta_D - \frac{1}{2}) + \left[FEM_{DA} - \frac{FEM_{AD}}{2} \right]$$

$$FEM_{CD} = \frac{wL^2}{12} = \frac{3(20)^2}{12} = 100$$

$$FEM_{DC} = -100$$

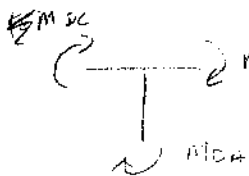
$$M_{CD} = 0$$

$$M_{DC} = \left(\frac{3EI}{20} \right) (\theta_D - \frac{1}{2}) - \left[FEM_{DC} - \frac{FEM_{CD}}{2} \right]$$

$$FEM_{DA} = \frac{Pab^2}{L^2} = 16.667$$

$$FEM_{AD} = \frac{Pa^2b}{L^2} = -33.33$$

apply equilibrium to D.

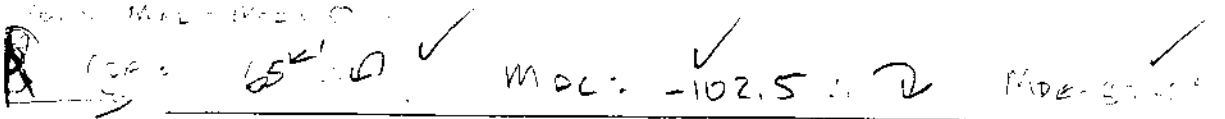


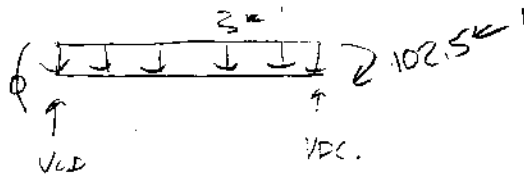
$$\frac{EI\theta_D}{5} + 33.33 + \left(\frac{3EI}{20} EI\theta_D - 150 \right) + 37.5 = 0$$

$$.5EI\theta_D = +79.17$$

plug into member end moments:

$$EI\theta_D = +158.34 \text{ rad}$$

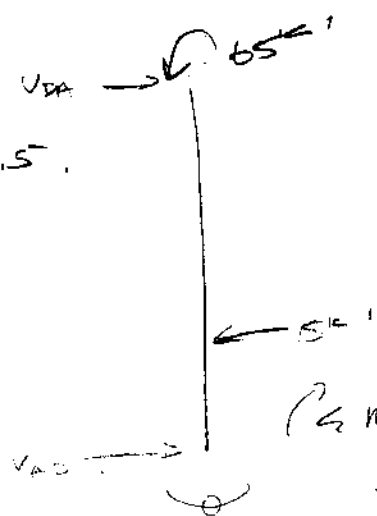
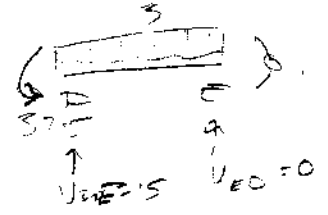




$$\sum M_C = 0 = -3(20)(10) + V_{DC}(20) - 102.5$$

$$\therefore V_{DC} = 35.13 \text{ k}$$

$$\therefore V_{CD} = 24.88 \text{ k}$$



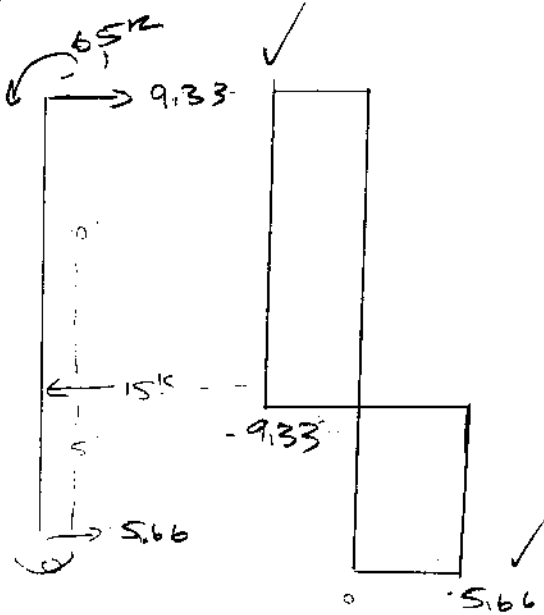
$$\sum M_A = 0 = 15(15) - V_{DA}(15) + 65$$

$$\therefore V_{DA} = 9.33 \text{ k}$$

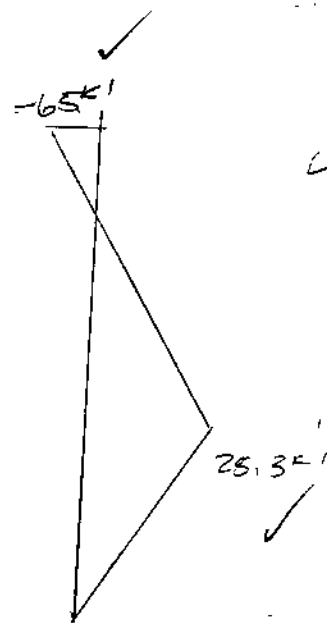
$$\therefore V_{AD} = 5.66 \text{ k}$$

(B)

member AD.



$V(x)$

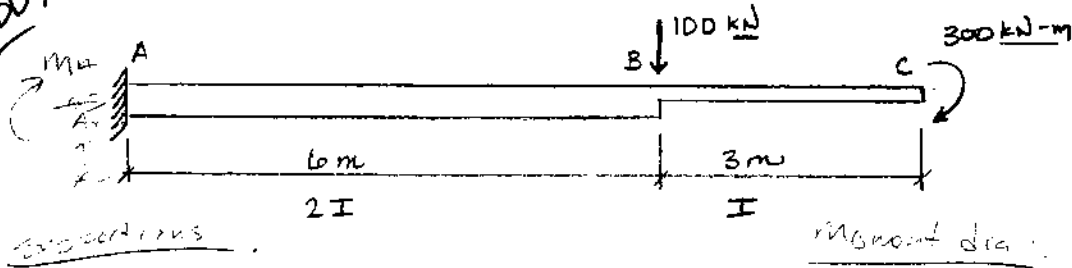


(+) compression side

9. (25 pts.) Solve for the deflection at point C in the following beam. You may choose from one of the methods listed below.

25
GOOD!

- a. Conjugate Beam Method
 b. Castigliano's Second Theorem (Method of Least Work)



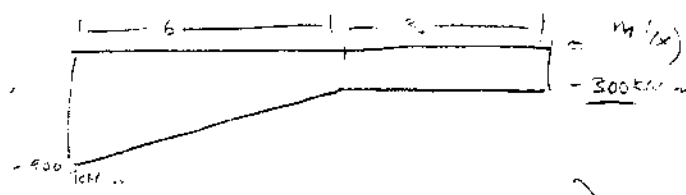
$E = \text{Constant} = 70 \text{ GPa}$
 $I = 500(10^6) \text{ mm}^4$

continuous

Moment dia.

$\sum M_A = M_A + 100(6) + 300 = 0$
 $M_A = -900 \text{ kN}\cdot\text{m}$

$\sum F_y = A_y - 100 = 0 \Rightarrow A_y = 100$

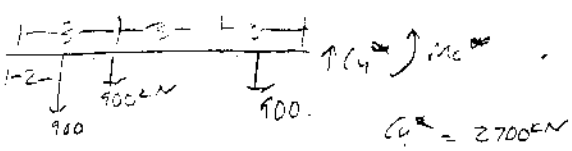
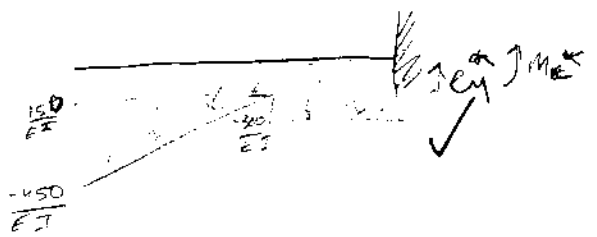
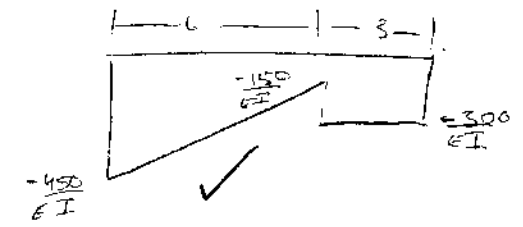


Conj. beam

Curvature dia. (\propto proportional to $1/I$)

load of curvature dia.

$\Delta_C = \frac{M_C^*}{EI}$



$M_C^* = -900(6) - 900(6) - 900(7) = -13050$

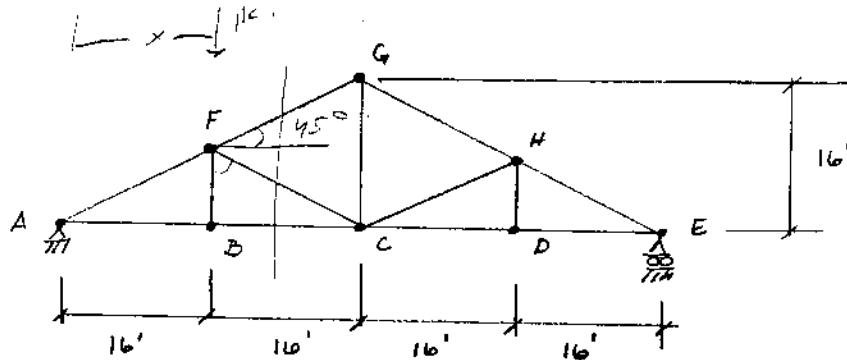
$= -13050 \text{ kN}\cdot\text{m}^2$

$\frac{-13050 \text{ kN}\cdot\text{m}^2}{70 \times 10^6 \frac{\text{kN}}{\text{m}} \cdot 500(10^6) \text{ mm}^4 \left(\frac{1 \text{ m}}{10^3 \text{ mm}}\right)^4} = \frac{-13050 \text{ kN}\cdot\text{m}^3}{70 \times 10^6 \frac{\text{kN}}{\text{m}} \cdot (500 \times 10^{-6}) \text{ m}^4} =$

$\Delta_C = 0.3729 \text{ m}$

10. (20 pts.) Draw the influence line for the force in member CF for the following determinate truss.

10



any.

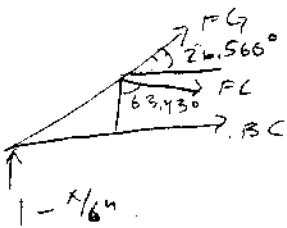
SUPPLEMENTARY

$$\sum M_A = -1x + E_y(64)$$

$$E_y = x/64 \quad \checkmark$$

$$\sum F_y = A_y + E_y - 1$$

$$A_y = \cancel{1 - x/64} - x/64 \quad \checkmark$$



$$\sum F_y = (1 - x/64) + FG \sin 26.566 - FC (\cos 63.433) = 0$$

$$2 - x/32$$

$$\sum F_x = BC + FG \cos 26.566 + FC (\sin 63.433) = 0$$

$$\sum M_F = BC(8) - (1 - x/64)(16) \quad \times$$

$$\therefore BC = \cancel{2} - x/32$$

Solve simultaneously.

$$2 \left(-1 + x/64 = FG(1.4472) - FC(1.4473) \right)$$

$$-2 + x/32 = FG(1.8944) + FC(1.8944)$$

$$-4 + x/16 = FG(1.789) \quad \text{S}$$

$$FG = -2.24 + 1.035x$$

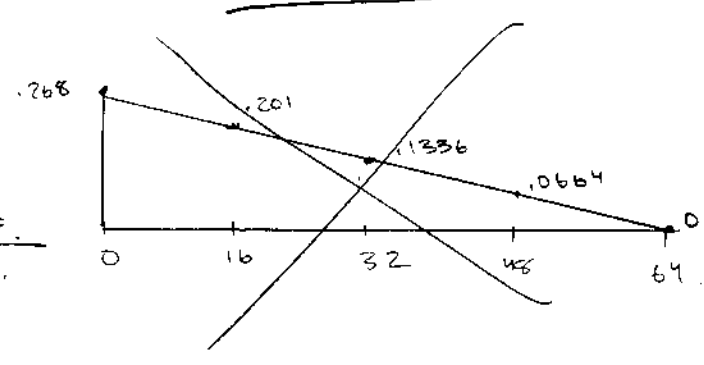
$$\frac{-2 + 2.24 - x/32 - 1.035x}{1.8944} = FC = .268 - .0042x$$

(eqn for IL)

u(x)

$$CF_x = .268 - .0042x$$

1.L for CF.



@x=0 $CF_L = .268$

@x=16' $CF_L = .201$

@x=32' $CF_L = .1336$

@x=48' $CF_L = .0664$

@x=64' $CF_L = -.0000$

3

Extra Credit No. 1 (3 pts.)

Describe the role of the following fictional figure with regard to the slope-deflection method.



(Green Giant)

he ~~locks~~ the joints
he locks the joints w/ his hands to
make them fixed-fixed members.

2

Extra Credit No. 2 (2 pts.)

What's the magic number? ☺

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