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: (Y) / N

3. (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.)

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

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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.

Change the supports of the column to either \( \text{fix-fx} \) or \( \text{fix-fx} \). It will decrease the effective length of the column, raising the load needed to make the column collapse without changing the smallest \( \text{fix-fx} \) or \( \text{cross-section dimension} \).

(Problem 4 got deleted... )

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

The distribution factor is the percent of the fixed-end moment that gets transferred through a member to the joint on the opposite end. \( \times \)
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.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>D.F.</td>
<td>0.449</td>
<td>0.558</td>
<td>0.556</td>
<td>0.444</td>
<td>0.558</td>
<td>0.556</td>
<td>0.444</td>
</tr>
<tr>
<td>F.E.M.</td>
<td>78.1</td>
<td>-78.1</td>
<td>50</td>
<td>-50</td>
<td>78.1</td>
<td>-78.1</td>
<td></td>
</tr>
<tr>
<td>Balance Jts.</td>
<td>16.2</td>
<td>24</td>
<td>4.54</td>
<td>6.19</td>
<td>24</td>
<td>16.2</td>
<td></td>
</tr>
<tr>
<td>Carriage</td>
<td>1.74</td>
<td>2.17</td>
<td>2.17</td>
<td>1.74</td>
<td>2.17</td>
<td>1.74</td>
<td></td>
</tr>
<tr>
<td>Balance Jts.</td>
<td>0.14</td>
<td>0.14</td>
<td>0.14</td>
<td>0.14</td>
<td>0.14</td>
<td>0.14</td>
<td></td>
</tr>
<tr>
<td>Carriage</td>
<td>0.08</td>
<td>0.09</td>
<td>0.09</td>
<td>0.08</td>
<td>0.09</td>
<td>0.08</td>
<td></td>
</tr>
</tbody>
</table>

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. $E I = \text{constant}$

Assume $L_1$ is to increase and write the equation in terms of $L_1$.

$$M_{ne} = \frac{2EI}{L} \left[ 2\theta_n + \theta_c - \gamma \right] + F.E.M_{ne}$$

$$\theta_n = 0 + \frac{\gamma}{L}$$

$$F.E.M_{ne} = 78.1$$

$$M_{AB} = 816.70 = \frac{2EI}{L} \left[ 2\delta_n + \delta_c - \gamma \right] + 78.1$$

$$M_{AB} = 816.70 = \frac{2EI}{L} \left[ \frac{15}{L} - \gamma \right] + 78.1$$
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.

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**E = Constant**

**Use slope-deflection method**

1st Freedom: $\theta_0$

(Other joints' constants aren't used as unknowns in Eqs.)

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**Fixed-end Moments**

$FEM_{CD} = \frac{WL^2}{12} = \frac{2(20)^2}{12} = 100$ in·lb

$FEM_{BE} = (-1)100^{\circ}$ (correct)

$FEM_{BE} = \frac{WL^2}{12} = \frac{3(20)^2}{12} = 50$ in·lb

$FEM_{EC} = \frac{15(b)(10)^2}{10^2} = 150$ in·lb

$FEM_{CA} = \frac{PaL}{L^2} = \frac{16(10)(20)^2}{10^2} = 3200$ in·lb

$FEM_{EB} = -150^{\circ}$

$FEM_{BC} = 150^{\circ}$

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**Member-end Moments**

$M_{BE} = 0$

$M_{DE} = \frac{3E(2I)}{2b} \left( \theta_0 - \theta_1 \right) + \frac{1b(20)^2}{2} (\frac{1}{b})$

$M_{AD} = 0.3EI \theta_0 - 100$

$M_{CE} = \frac{3E(2I)}{2b} \left( \theta_0 - \theta_1 \right) + \frac{1b(20)^2}{2} (\frac{1}{b})$

$M_{AB} = 0.2EI \theta_0 + 25$

$K_{st} = 2$
Equilibrium Equation for J + D

\[
\sum M_b = (0.3EIb - 150) + (0.2EIb + 2E) + (1.2EIb + 9.375) = 0
\]

\[
1.7EIb - 15.015 = 0
\]

\[
1.7EIb = 15.015
\]

\[
\theta_b = \frac{68.915}{EI} \times
\]

Compute member-end moments using \( \theta_b \)

\[
M_{bd} = 0
\]

\[
M_{bd} = 0.3EI \left( \frac{68.915}{EI} \right) - 150 = -129.15
\]

\[
M_{db} = 1.2EI \left( \frac{68.915}{EI} \right) + 9.375 = 90.943
\]

\[
M_{da} = 0
\]

\[
M_{da} = 0.3EI \left( \frac{68.915}{EI} \right) + 125 = 38.803
\]

\[
M_{db} = 0
\]

Shear Moment Diagram for Member AD

CE 461—Final Exam
CRB
9. (25 pts.) Solve for the deflection at point C in the following beam. You may choose from one of the methods listed below.

**a. Conjugate Beam Method**

**b. Castigliano's Second Theorem (Method of Least Work)**

\[ E = \text{constant} \]
\[ I = 500 \times 10^4 \text{ mm}^4 \]

**Solve for reactions:**

\[ \delta S_{F_1} = A_y - 100 \text{ kN} = 0 \]
\[ A_y = 100 \text{ kN} \]

\[ (2M_0 - M_0 - 300) = 0 \]
\[ M_0 = 300 \text{ kN mm} \]

\[ E = (70 \text{ GPa}) (500 \times 10^4 \text{ mm}^4) \left( \frac{10^6 \text{ kN}}{1 \text{ GPa}} \right) \left( \frac{1 \text{ mm}}{1000 \text{ mm}} \right)^4 = 3.5 \times 10^9 \text{ kN m}^2 \]
Conjugate Beam Loaded w/ \( \frac{M}{EI} \) from real beam

\[
\begin{align*}
\text{Equate for reactions} \quad & \quad \sum F_y = \frac{150 \text{ kN}}{E I} (a) + \frac{1}{2} (\frac{300 \text{ kN}}{E I}) (b) + \frac{150 \text{ kN}}{E I} (3) - (y^*) = 0 \\
& \quad y^* = \frac{2700 \text{ kN m}}{E I} \\
\sqrt{2} M_e = M_e^* & = \left( \frac{150 \text{ kN}}{E I} \right) (a) (4.5) - \left( \frac{1}{2} \right) \left( \frac{300 \text{ kN}}{E I} \right) (b) (5+4) - \left( \frac{150 \text{ kN}}{E I} \right) (3) (1.5) = 0 \\
& \quad M_e^* = \frac{3000 \text{ kN m}}{E I} = y_e
\end{align*}
\]

\[ y_e = \frac{13.060}{E I} \]

\[ y_e = 3.731 \text{ kN m} \]

\( \text{RBD? should be matches...} \)
10. (20 pts.) Draw the influence line for the force in member CE for the following determinate truss.

Unit Load at A:

\[ A_y = 1 \text{k} \]
\[ E_y = 0 \]

Make a cut through FC - solve for \( F_C \) in terms of \( A_y \):

Unit load to the right of C:

\[ F_{EC} = A_y \left( \frac{1}{3} \right) - \left( \frac{1}{3} \right) F_{FA} \left( \frac{1}{3} \right) F_{ER} = 0 \]

\[ 82A_y + 184.32 E_y = 0 \]

\[ F_{FA} = -1.332 A_y \]

\[ F_{EC} = 0 \]

\[ F_{ER} = 0 \]

\[ (\text{cancel}) \]
Unit Load to the Left of F

- Solve for \( F_{cr} \) in terms of \( E_y \)

\[
\sum M_c = E_y (\overline{BC}) + \left( \frac{2}{13} \right) F_{cr} (\overline{BC}) + \frac{6}{13} F_{cr} y - 0
\]

\[
32E_y = 18.475F_{cr} \quad \Rightarrow \quad F_{cr} = -1.73E_y
\]

\[
4 \times E_y = E_y \left( \frac{1}{13} \right) F_{cr} - \left( \frac{6}{13} \right) (-1.73E_y) = 0
\]

\[
F_{cr} = 0
\]

\[
\boxed{F_{cr} = 0} \quad \text{always \ X}
\]

IL for \( F_{cr} \):

\[
\begin{array}{cccccc}
A & B & C & D & E \\
\end{array}
\]

Steps
1. Make a cut through the member CF \( \checkmark \)
2. Solve for \( F_{cr} \) in terms of \( A_y \) & \( E_y \) \( \checkmark \)
3. Solve for \( A_y \) & \( E_y \) when a unit load is moving across truss \( \checkmark \)
4. Compute \( F_{cr} \) for each point. Connect with straight lines
Extra Credit No. 1 (3 pts.)
Describe the role of the following fictional figure with regard to the slope-deflection method.

The Green Giant hold the ends of each member to create fixed-end-moments even if the ends aren't really fixed. FEMs are used for calculations in the slope-deflection method.

Extra Credit No. 2 (2 pts.)
What's the magic number? 😊