SOLUTION

Write your full name, ID number, and circle the section that you are registered in.

Name: M. TABBARA ID: ______ Section: **10 AM** **11 AM** **1 PM**

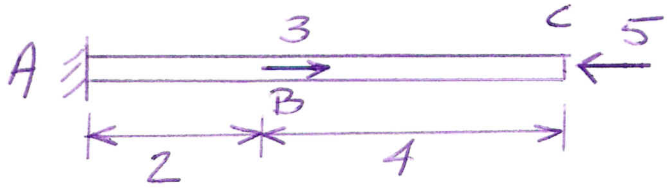
Problem 1	Problem 2	Problem 3	Problem 4	Score
/ 25 Points	/ 25 Points	/ 25 Points	/ 25 Points	/ 100

Make sure that you are aware of all the following

- Show all your calculations, points will be deducted for answers that are not supported by proper calculations.
- Use the Virtual Work Method to determine all displacement; using any other method will not count.
- Use the specified Virtual structure; using any other virtual structure will not count.
- If the Virtual structure is not specified, choose your own Virtual structure.
- Ignore shear deformations unless stated otherwise.
- All members have the same E , G, I, J and A, unless otherwise stated in the problem.
- Use the specified redundant; using any other redundant will not count.
- Use matrix inversion to solve simultaneous equations. Any other method will not count.
- If a redundant is not specified, choose your own redundant.

<u>Problem 1 (25 points)</u>

The bar shown below is fixed at A and free at C. Determine the reaction at A and the deflection at C. Use EA = 1.



Use only the Stiffness Method, DO NOT use statics to solve this problem. Any other method will not count. The structural model is as follows:

Joints:	Joint 1 is A	Joint 2 is B	Joint 3 is C
Elements:	Element 1 is AB	Element 2 is BC	

Stiffness of a bar element is $k = \frac{EA}{L}\begin{bmatrix} 1 & -1 \\ -1 & 1 \end{bmatrix}$

Inverse of a 2x2 matrix is $\begin{bmatrix} a & b \\ c & d \end{bmatrix}^{-1} = \frac{1}{ad-bc}\begin{bmatrix} d & -b \\ -c & a \end{bmatrix}$

$$\begin{bmatrix} 0.5 & -0.5 & \\ -0.5 & 0.75 & -0.25 \\ & -0.25 & 0.25 \end{bmatrix}\begin{bmatrix} d_1 \\ d_2 \\ d_3 \end{bmatrix} = \begin{bmatrix} R_1 \\ 3 \\ -5 \end{bmatrix}$$

$$\begin{bmatrix} 0.75 & -0.25 \\ -0.25 & 0.25 \end{bmatrix}\begin{bmatrix} d_2 \\ d_3 \end{bmatrix} = \begin{bmatrix} 3 \\ -5 \end{bmatrix}$$

$$\begin{bmatrix} d_2 \\ d_3 \end{bmatrix} = \frac{1}{0.125}\begin{bmatrix} 0.25 & 0.25 \\ 0.25 & 0.75 \end{bmatrix}\begin{bmatrix} 3 \\ -5 \end{bmatrix} = \begin{bmatrix} -4 \\ -24 \end{bmatrix}$$

Δ_c

$\Delta_c = 24 \leftarrow$

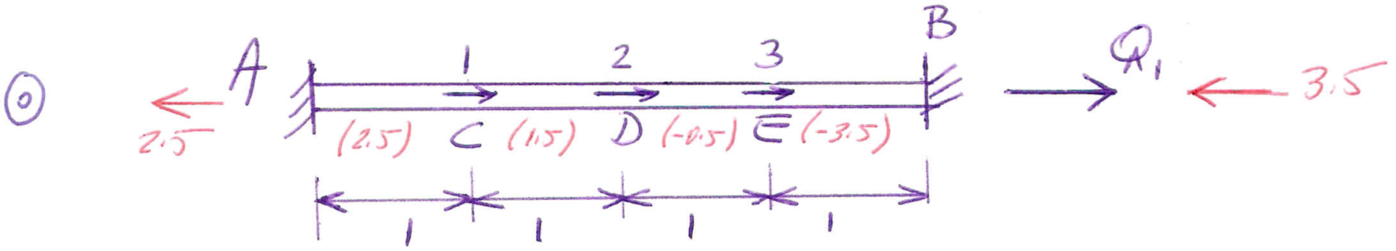
-4

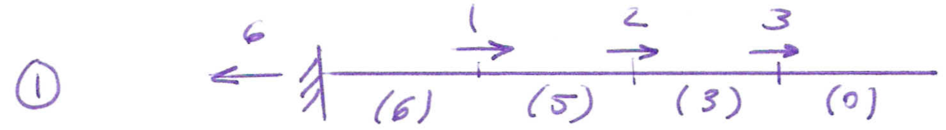
(1) $R_1 = -0.5 d_2 = 2$ $\qquad A = 2 \rightarrow$

A

Problem 2 (25 points)

For the fixed-fixed bar shown below, determine the horizontal deflection at D. Use the flexibility method (with Q_1 as shown below), Virtual Work, and Statics. Any other method will not count. Use EA = 1.



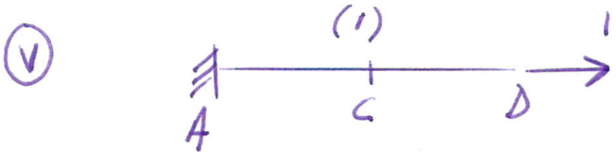


$$D_{QL1} = 14$$

$$\frac{(1)(6)}{1}(1) + \frac{(1)(5)}{1}(1) + \frac{(1)(3)}{1}(1)$$

$$F_{11} = \frac{(1)(1)}{1}(4) = 4$$

$$0 = 14 + 4Q_1 \;, \; Q_1 = -3.5$$



EXT. VW = INT VW

$$+\vec{(1)}\,\vec{\Delta}_D = \frac{(1)(2.5)}{1}(1) + \frac{(1)(1.5)}{1}(1) \;, \; \Delta_D = 4 \rightarrow$$

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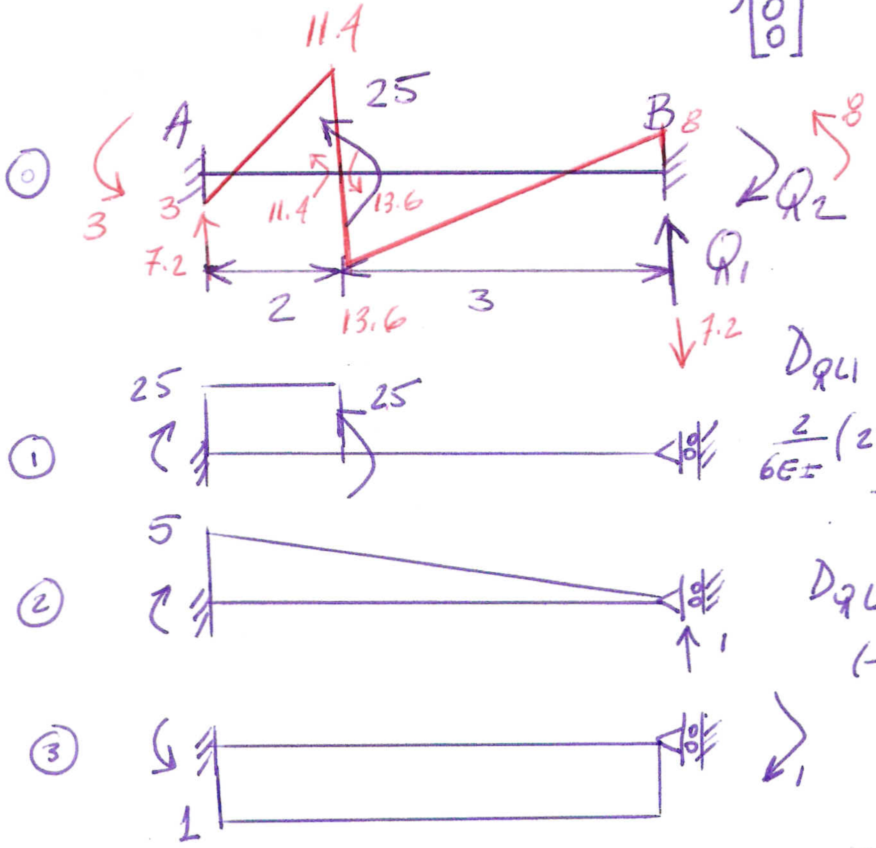
Problem 3 (25 points)

For the fixed-fixed beam shown below draw the moment diagram on the compression side. Use the flexibility method with Q_1 and Q_2 as shown below.

Given the inverse of the **F** matrix: $F^{-1} = \frac{2EI}{L^3}\begin{bmatrix} 6 & 3L \\ 3L & 2L^2 \end{bmatrix}$

$\underset{\sim}{D_Q} = \underset{\sim}{D_{QL}} + \underset{\sim}{F}\underset{\sim}{Q}$

$\underset{\sim}{D_Q} = \begin{bmatrix} 0 \\ 0 \end{bmatrix}$



$D_{QL1} = \frac{200}{EI}$

$\frac{2}{6EI}(2\times5\times25 + 2\times3\times25 + 5\times25 + 3\times25)$

$D_{QL2} = \frac{-50}{EI}$

$\frac{(-1)(25)(2)}{EI}$

$\underset{\sim}{Q} = -\underset{\sim}{F}^{-1}\underset{\sim}{D_{QL}} = -\frac{2EI}{5^3}\begin{bmatrix} 6 & 15 \\ 15 & 50 \end{bmatrix}\frac{1}{EI}\begin{bmatrix} 200 \\ -50 \end{bmatrix}$

$\underset{\sim}{Q} = \begin{bmatrix} -7.2 \\ -8 \end{bmatrix}$

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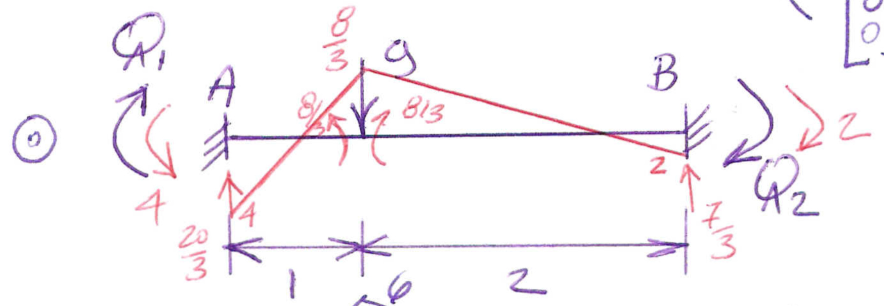
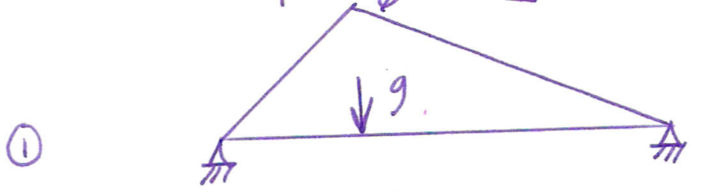
Problem 4 (25 points)
For the fixed-fixed beam shown below draw the moment diagram on the compression side. Use the flexibility method with Q_1 and Q_2 as shown below.

Given the inverse of the **F** matrix: $F^{-1} = \frac{2EI}{L}\begin{bmatrix} 2 & 1 \\ 1 & 2 \end{bmatrix}$

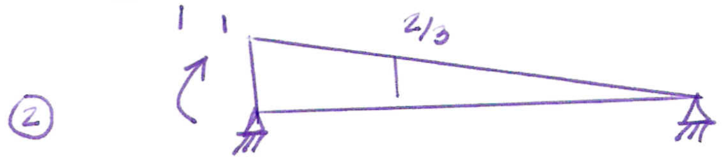
$$\underset{\sim}{D_Q} = \underset{\sim}{D_{QL}} + \underset{\sim}{F}\,\underset{\sim}{Q} \qquad \underset{\sim}{D_Q} = \begin{bmatrix} 0 \\ 0 \end{bmatrix}$$





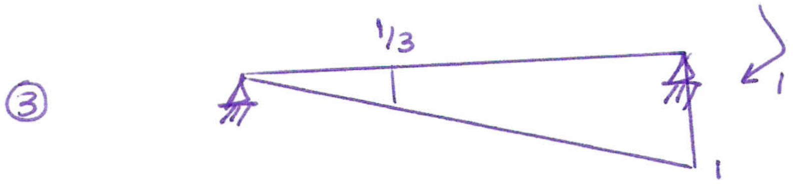
$$D_{QL1} = \frac{5}{EI}$$

$$\frac{1}{6EI}\left(2\times\frac{2}{3}\times 6 + 1\times 6\right) + \frac{2}{6EI}\left(2\times\frac{2}{3}\times 6\right)$$



$$D_{QL2} = -\frac{4}{EI}$$

$$\frac{1}{6EI}\left(-2\times\frac{1}{3}\times 6\right) + \frac{2}{6EI}\left(-2\times\frac{1}{3}\times 6 - 1\times 6\right)$$



$$\underset{\sim}{Q} = -\underset{\sim}{F}^{-1}\underset{\sim}{D_{QL}} = -\frac{2EI}{3}\begin{bmatrix} 2 & 1 \\ 1 & 2 \end{bmatrix}\frac{1}{EI}\begin{bmatrix} 5 \\ -4 \end{bmatrix}$$

$$\underset{\sim}{Q} = \begin{bmatrix} -4 \\ 2 \end{bmatrix}$$