Part I

1. The bonding agent placed between individual masonry units is called **mortar**.

2. **Grout** is poured into masonry unit cells to bond the reinforcement with the masonry unit.

3. What is the purpose of a control joint in a masonry wall? **allow relative movement**

4. Draw a graph on the axes below that shows the moment vs. curvature relationship for a reinforced masonry wall. Indicate the location of the cracking moment, the working stress design range, the point where the steel yields, and the ultimate strength of the wall.

5. Assume the curve you drew for Question 4 was for a wall with one #4 bar every 48 inches. Draw another curve on the figure above for an identical wall but with one #6 bar every 48 inches.

6. Set up the derivation for (but do not derive) the equation used to calculate the location of the neutral axis in a reinforced masonry section with flexure only.

<table>
<thead>
<tr>
<th>Name/Description of Basic Principle</th>
<th>Equation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Σ Normal Forces = 0</td>
<td>C - T = 0</td>
</tr>
<tr>
<td>Strain varies linearly</td>
<td>( \varepsilon = \varepsilon_c + \varepsilon_s )</td>
</tr>
<tr>
<td>Constitutive relations</td>
<td>( \sigma = E \varepsilon )</td>
</tr>
</tbody>
</table>
7. Write the equation used to calculate the location of the neutral axis (x) in a reinforced masonry section with flexure only. Refer to the figure below for the appropriate symbols.

\[ \frac{V}{b} \times x = n A_s \left( d - x \right) \]

8. Describe in a sentence one interpretation of the equation above.
The 1st area moment of the concrete in compression equals the 1st area moment of the steel about the NA.

9. Write the principles and equations from Question 6 for a reinforced masonry section with flexure and axial compression.

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<tr>
<td>( \varepsilon = \text{Normal Forces} = \mathbf{P} )</td>
<td>( C - T = P )</td>
</tr>
<tr>
<td>( \text{same} )</td>
<td>( \text{same} )</td>
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10. Bonus question for Part I (work only after completing Parts I and II). Can the equations in Question 9 be used to calculate the location of the neutral axis? If not, which additional equation(s) is(are) needed?

In deriving eqn. to find x shown for question 9, we used \( \varepsilon - T = 0 \) to get \( \frac{1}{2} \varepsilon_c \varepsilon_c x b - A_s \varepsilon_c \frac{d - x}{x} \varepsilon_s = 0 \) and solved for x because \( \varepsilon_c \) canceled out.

Part II
(Work these problems on engineering paper)

11. An 8” CMU masonry wall with Fm’=1500 psi and Em = 1350 ksi is reinforced at 24” o.c. with #4 Grade 40 rebar, 2500 psi grout. Mortar is type M with Portland cement and hydrated lime, face shell mortar only. Using working stress design, determine the point (M, P) on the interaction diagram assuming x = 7”.

12. During construction the wall in Question 11 is built to a height of 15 feet before the cells with reinforcement are grouted. Assuming that the wall is free standing and not braced for lateral loads at this time during construction, what is the maximum uniformly distributed lateral load that can be applied to the wall? Give your answer in psf.

Now we have \( \varepsilon - T - P = 0 \) and get \( \frac{1}{2} \varepsilon_c \varepsilon_c x b - A_s \varepsilon_c \frac{d - x}{x} \varepsilon_s - P = 0 \) and \( \varepsilon_c \) does not cancel.
10. Cont'd
We have 2 unknowns, X & Ee, in this eqn. Therefore we need another equation.
Use \( \Sigma M_{int} = M_{service} \).

**Solve Procedure**

Using spreadsheet to solve by trial & error:

1. Assume a \( Ee \) and \( X \)
2. Case: \( P_e, P_S \)
3. Case: \( C, T \)

Check if \( C - T + P = 0 \)
\[ C \times \text{arm} - T \times \text{arm} - M = 0 \]

If not, choose new values of \( Ee \) & \( X \)

Spreadsheet can be programmed to find \( Ee \) & \( X \) "automatically".