READ THE FOLLOWING GENERAL EXAMINATION RULES:

1) Do not put your completed work anywhere that it can be seen. If any part of your work can be seen by others it will be confiscated and you will not be permitted to rework those problems. Place any pages of your work face down on your desk under your existing work, not on the floor next to you where it is visible.
2) Please remove your hat. If it is part of your head, turn it around backwards.
3) If your work is not legible, or if I cannot follow your logic at a glance, it will receive no credit. This paper must be written to acceptable engineering standards for credit. Please take this seriously as it will affect your grade.
4) You may work on the front or back of this paper. Just note if any work is on the back.
5) You can use your own paper or paper supplied at the front of the room.
6) You MUST specify what you are doing every step of the way. If you mentally check something but don’t write down why you have decided it is OK, I must assume that no check was performed. If I can follow where you got your numbers from, you will likely receive partial credit should you go off track.
7) Write big and use lots of paper, leaving me room to grade your paper. If there is no room to tell you why points were deducted, I will only show you the point deduction and let you try and figure out why.
8) You must present your work in a linear fashion, i.e. state what you are doing and then write down all necessary calculations you used in determining that value. Be sure to box your final answers.

I have read and understand all of the above instructions: ______________ (Initials)

Ethical Standards:

Upon accepting admission to Texas A&M University, a student immediately assumes a commitment to uphold the Honor Code, to accept responsibility for learning, and to follow the philosophy and rules of the Honor System. Students will be required to state their commitment on examinations, research papers, and other academic work. Ignorance of the rules does not exclude any member of the TAMU community from the requirements or the processes of the Honor System.

"On my honor, as an Aggie, I have neither given nor received unauthorized aid on this exam."

______________________________
Signature of student

Please do not open this exam until you are told to do so.
### VOLUME INTEGRALS

<table>
<thead>
<tr>
<th>Shape</th>
<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>$Lac/2$</td>
</tr>
<tr>
<td>b</td>
<td>$Lac/6$</td>
</tr>
<tr>
<td>c</td>
<td>$Lc(a+b)/6$</td>
</tr>
<tr>
<td>d</td>
<td>$(L+L_2)ac/6$</td>
</tr>
<tr>
<td>e</td>
<td>$Lc(a+2b)/6$</td>
</tr>
<tr>
<td>f</td>
<td>$L(c+d)/2$</td>
</tr>
<tr>
<td>g</td>
<td>$L(2c+d)/6$</td>
</tr>
<tr>
<td>h</td>
<td>$L(2d+c)/6$</td>
</tr>
<tr>
<td>i</td>
<td>$Lc(2c+d)+Lb(c+2d)/6$</td>
</tr>
<tr>
<td>j</td>
<td>$ac(L+L_2)+ad(L+L_1)/6$</td>
</tr>
</tbody>
</table>

For $L_3 \leq L_1$ ONLY:

<table>
<thead>
<tr>
<th>Shape</th>
<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>k</td>
<td>$(L+L_4)ac/6$</td>
</tr>
<tr>
<td>l</td>
<td>$(L+L_3)ac/6$</td>
</tr>
<tr>
<td>m</td>
<td>$ac(L+L_4)+bc(L+L_3)/6$</td>
</tr>
<tr>
<td>n</td>
<td>$acl(2-(L_1-L_3)^2/L_1/L_4)/6$</td>
</tr>
<tr>
<td>o</td>
<td>$Lac/3$</td>
</tr>
<tr>
<td>p</td>
<td>$Lc/12$</td>
</tr>
<tr>
<td>q</td>
<td>$Lc(a+3b)/12$</td>
</tr>
<tr>
<td>r</td>
<td>$2lad/3$</td>
</tr>
<tr>
<td>s</td>
<td>$lad/3$</td>
</tr>
<tr>
<td>t</td>
<td>$lad/3$</td>
</tr>
<tr>
<td>u</td>
<td>$lad(a+b)/3$</td>
</tr>
<tr>
<td>v</td>
<td>$ad(L+(L_1L_2)/L)/3$</td>
</tr>
</tbody>
</table>

$L$ is the total length of the member.

$d$ is the central ordinate of the parabola.

The parabola values $c$, $d$, $e$, can be positive or negative.

The trapezoid $a/c$ value can be greater or smaller than its $b/d$ value.
Problem 1) (20 points) For the frame supported as shown, draw three valid primary structures which could be used to solve for the redundants, and show those redundants on the primary structure:
Problem 2) (40 points) Solve for the terms listed below, necessary to determine the redundants for the frame loaded as shown. Use the reactions at the pin as the redundants: $R_{Ax} = R_1$ and $R_{Ay} = R_2$. For use in the equation below, solve for $\Delta_{10}$, $\delta_{11}$, and $\delta_{12}$. Use $w = 2k/ft$, $L_1 = 20$ feet, $L_2 = 10$ feet, $L_3 = 25$ feet. All members have $E = 30,000$ ksi and $I = 4000$ in$^4$.

$$\Delta_1 = \Delta_{10} + \delta_{11} R_1 + \delta_{12} R_2$$
$$\Delta_2 = \Delta_{20} + \delta_{21} R_1 + \delta_{22} R_2$$

Blank sheets follow to work the problem on.

For moment diagrams. Indicate what each is used for:
For moment diagrams. Indicate what each is used for:

\[ E = 30,000 \text{ psi} \]
\[ I = 4000 \text{ in}^4 \]
Quiz 1 Prob 2

\[ \Delta_{10} = \sum \frac{m \cdot M_{\text{e}}}{EI} = \frac{400(12)}{(20)(12)} + \frac{300(12)}{25} \]

\[ = \frac{L \cdot a}{2EI} \]

\[ = -\frac{(25 \text{ ft})(12 \text{ in./ft})(300 \text{kft})(12 \text{ in./ft})(25 \text{ ft})(12 \text{ in./ft})}{2(EI)} \]

\[ = \frac{18,000 \text{ kft}^2 \cdot 12 \text{ in./ft} \cdot 12 \text{ in./ft} \cdot 25 \text{ ft} \cdot 12 \text{ in./ft}}{21,600 \text{ in.}^4} = \frac{\text{KIN}^3}{\text{KIN}^2} = 1 \text{ in.} \]

\[ = -\frac{1}{6} \cdot 2 \times 10^7 \text{ in.} \]

\[ = \frac{1}{(30,000)(4000)} = -1.35 \text{ in.} \]

\[ S_{11} = \sum \frac{m \cdot m_{\text{dy}}}{EI} = \frac{25 \text{ ft}}{25 \text{ ft}} = \frac{L \cdot a}{3EI} \]

\[ = \frac{(25 \text{ ft})(12 \text{ in./ft})(25 \text{ ft})(12 \text{ in./ft})(25 \text{ ft})(12 \text{ in./ft})}{3(30,000 \text{ KIN}^2)(4000 \text{ in.}^4)} \]

\[ = \frac{1 \text{ IN}^3}{\text{KIN}^2} = \frac{1 \text{ IN}}{\text{ K}} = \text{deflection per K of reaction} \]

\[ = +0.075 \text{ in./kip} \]
\[ \sigma_{12} = \frac{\int m_1 m_2 \text{d}x}{E I} = \frac{25 \text{ft}}{20 \text{ft}} = \frac{\text{Lac}}{2E I} \]

\[ = \frac{(25 \text{ft})(12''/\text{ft})(25 \text{ft})(12''/\text{ft})(20 \text{ft})(12''/\text{ft})}{2 (30,000 \text{ kips}/\text{in}^2)(4,000 \text{ in}^4)} \]

\[ = +0.09''/\text{k} \]
Problem 3) (40 points) Using Virtual Work, solve for the horizontal deflection of joint c for the truss shown.
Use $P = 26k$, $n = 5$, $m = 12$, $X = 16$ ft, $Y = 12$ ft.
Properties for member ac are Area $= 1$ in$^2$, $E = 10,000$ ksi, $I = 400$ in$^4$. For member bc, Area $= 2$ in$^2$, $E = 30,000$ ksi, $I = 600$ in$^4$. Blank pages follow.
\[ F_y = \frac{12}{13} (26) = 24^k \]
\[ P_x = \frac{5}{13} (26) = 10^k \]
\[ \sum F_y = 0 = + \frac{12}{26.83} F_{ac} - 24^k \Rightarrow F_{ac} = \frac{53.67^k}{12/26.83} \]
\[ \sum F_H = 0 = -F_{bc} - F_{ac} \left( \frac{24}{26.83} \right) - 10 \]
So \[ F_{bc} = -58^k \]

Unit Horizontal Load: \[ \frac{K \text{ in.} \text{in}^2}{\text{in.}^2 \text{K}} = \text{in.} \]
\[ f_{bc} = \frac{12}{26.83} \]
\[ \sum F_y = 0 = f_{bc} \left( \frac{12}{26.83} \right) \Rightarrow f_{bc} = 0 \]
\[ \sum F_H = 0 = -f_{bc} + 1 \Rightarrow f_{bc} = 1 \]

Deflection Chart:

<table>
<thead>
<tr>
<th>Member</th>
<th>L (in)</th>
<th>Fij</th>
<th>fij</th>
<th>( E )</th>
<th>( A )</th>
<th>( FF/LAE )</th>
</tr>
</thead>
<tbody>
<tr>
<td>ac</td>
<td>322in</td>
<td>53.67^k</td>
<td>0</td>
<td>10,000^k/in^2</td>
<td>1/in^2</td>
<td>0</td>
</tr>
<tr>
<td>bc</td>
<td>192in</td>
<td>-58^k</td>
<td>1</td>
<td>30,000^k/in^2</td>
<td>2/in^2</td>
<td>-0.18561in</td>
</tr>
</tbody>
</table>

\[ \delta_c = -0.18561 \text{ in.} \text{ (i.e. to the left)} \]
\[
\Delta_{10} = \sum_{E \in \overline{E}} \int_{0}^{L} \frac{M_w M_z}{E I} \, dx \Rightarrow h \left( \Delta_{10} \right) = \frac{1}{E I} \left[ \int_{0}^{10} (x-25)(300 \, 1dx) \right]
\]

\[
h \left( \Delta_{10} \right) = \frac{1}{E I} \left[ \int_{0}^{10} (700x - 7500) \, dx \right] \Rightarrow h \left( \Delta_{10} \right) = \frac{1}{E I} \left[ \frac{(150x^2 - 7500x)}{2} \right]
\]

\[
h \left( \Delta_{10} \right) = \frac{1}{E I} \left[ \int_{0}^{10} (50z^2 - 7500z) \, dx \right] \Rightarrow h \left( \Delta_{10} \right) = \frac{1}{E I} \left[ \frac{93750 - 187500}{2} \right]
\]

\[
h \left( \Delta_{10} \right) = \frac{93750 \, h^2 \cdot h^3}{(30000 \, h^3) \cdot (4000 \, h^3)} \left( \frac{1728 \, h^3}{1 \, h^3} \right) \Rightarrow \Delta_{10} = -1.35 \, \text{in}
\]

\[
\Delta_{20} = \sum_{E \in \overline{E}} \int_{0}^{L} \frac{M_w M_z}{E I} \, dx = \frac{1}{E I} \left[ \int_{0}^{25} (300)(x-25) \, dx + \int_{0}^{10} (20x-100-x^2) \, dx \right]
\]

\[
h \left( \Delta_{20} \right) = \frac{1}{E I} \left[ \int_{0}^{25} x^2 \, dx - 600x + \int_{0}^{10} (20x^2 - 100x) \, dx \right] \Rightarrow h \left( \Delta_{20} \right) = \frac{1}{E I} \left[ \frac{1}{2} x^3 + \frac{2000}{3} \right]
\]

\[
h \left( \Delta_{20} \right) = \frac{1}{E I} \left[ \int_{0}^{25} x^2 \, dx - 600x + \int_{0}^{10} (20x^2 - 100x) \, dx \right] \Rightarrow h \left( \Delta_{20} \right) = \frac{1}{E I} \left[ \frac{1}{2} x^3 + \frac{2000}{3} \right]
\]

\[
h \left( \Delta_{20} \right) = \frac{1}{E I} \left[ \int_{0}^{10} (x-25)(50x+25) \, dx \right] \Rightarrow h \left( \Delta_{20} \right) = \frac{1}{E I} \left[ \frac{1}{2} x^3 - 25(x^2) + 625 \right]
\]

\[
h \left( \Delta_{20} \right) = \frac{1}{E I} \left[ \int_{0}^{25} (x^2 - 50x + 25) \, dx \right] \Rightarrow h \left( \Delta_{20} \right) = \frac{1}{E I} \left[ \frac{520 \, 33 \, h^2 \cdot h^3}{(30000 \, h^3) \cdot (4000 \, h^3)} \right]
\]

\[
\delta_{11} = \sum_{E \in \overline{E}} \int_{0}^{L} M_w M_z \, dx \Rightarrow h \left( \delta_{11} \right) = \frac{1}{E I} \left[ \int_{0}^{25} (x-25)(x-25) \, dx \right] \Rightarrow h \left( \delta_{11} \right) = \frac{1}{E I} \left[ \int_{0}^{25} x^2 - 50x + 25 \, dx \right]
\]

\[
h \left( \delta_{11} \right) = \frac{1}{E I} \left[ \int_{0}^{25} x^2 - 50x + 25 \, dx \right] \Rightarrow h \left( \delta_{11} \right) = \frac{1}{E I} \left[ \frac{1}{2} x^3 - 25(x^2) + 625 \right]
\]

\[
h \left( \delta_{11} \right) = \frac{1}{E I} \left[ \int_{0}^{25} (x^2 - 50x + 25) \, dx \right] \Rightarrow h \left( \delta_{11} \right) = \frac{1}{E I} \left[ \frac{520 \, 33 \, h^2 \cdot h^3}{(30000 \, h^3) \cdot (4000 \, h^3)} \right]
\]

\[
\delta_{12} = \sum_{E \in \overline{E}} \int_{0}^{L} M_w M_z \, dx \Rightarrow h \left( \delta_{12} \right) = \frac{1}{E I} \left[ \int_{0}^{25} (x-25)(x-25) \, dx \right] \Rightarrow h \left( \delta_{12} \right) = \frac{1}{E I} \left[ \int_{0}^{25} x^2 - 50x + 25 \, dx \right]
\]

\[
\delta_{12} = \frac{1}{E I} \left[ \int_{0}^{25} x^2 - 50x + 25 \, dx \right] \Rightarrow h \left( \delta_{12} \right) = \frac{1}{E I} \left[ \frac{1}{2} x^3 - 25(x^2) + 625 \right]
\]

\[
h \left( \delta_{12} \right) = \frac{1}{E I} \left[ \int_{0}^{25} (x^2 - 50x + 25) \, dx \right] \Rightarrow h \left( \delta_{12} \right) = \frac{1}{E I} \left[ \frac{1}{2} x^3 - 25(x^2) + 625 \right]
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\]
\[ \Delta_1 = \Delta_{10} + E_1 h_1 + k_{12} R_2 = 0 \]
\[ \Delta_1 = -1.35 + 0.075 n_1 + 0.04 R_2 \]

\[
\begin{align*}
-1.35 + 0.075 n_1 + 0.09 (9.4) &= 0 \\
-1.35 + 0.075 n_1 + 0.044 &= 0 \\
-0.504 + 0.075 n_1 &= 0 \\
R_1 &= 6.72 h
\end{align*}
\]

\[ \Delta_2 = \Delta_{20} + E_2 h_1 + k_{22} R_2 = 0 \]
\[ \Delta_2 = -2.364 + 0.09 n_1 + 0.1872 n_2 = 0 \]

\[
\begin{align*}
0.1215 - 0.00675 n_1 - 0.0081 h_2 &= 0 \\
-0.1773 - 0.00675 n_1 + 0.01404 n_2 &= 0 \\
-0.0558 + 0.00594 R_2 &= 0 \\
R_2 &= 9.4 h
\end{align*}
\]

FB

- \[ \Sigma M_0 E84 = 0 \]
\[ R_5 + (60)(5) - (9.4)(20) - (6.72)(25) = 0 \]
\[ h_5 + 300 - 188 - 168 = 0 \]
\[ R_5 = 56 h \]

- \[ + \Sigma F_y E84 = 0 \]
\[ R_3 - 60 + 9.4 = 0 \]
\[ R_3 = 50.6 h \]

- \[ - \Sigma F_x E84 = 0 \]
\[ 6.72 - R_4 = 0 \]
\[ R_4 = 6.72 h \]