General examination rules:

1) Do not put your completed work on your desk or on the floor or on the desk next to you or anywhere it can be seen by others. 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 it face down on your desk under your existing work.

2) Please remove your hat. If it is part of your head, turn it around backwards.

3) If your work not legible, or if I cannot follow your logic at a glance, or if you use a #9 nail for a pencil with 2 point font, it will receive no credit. Such work will be marked UES (Unacceptable by Engineering Standards) with appropriate deductions. This paper must be written to acceptable engineering standards for full credit.

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8) **READ!** If unstated: material is A36 steel, if applicable the design is to be based on ultimate stress, and factors of safety should be 1.6.

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

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"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.
### Singularity functions, Stress equations

<table>
<thead>
<tr>
<th>Diagram</th>
<th>Equation for $w(x)$</th>
<th>Equation for $V(x)$</th>
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</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Diagram 1" /></td>
<td>$w(x) = M_0 (x - a)^{-2}$</td>
<td>$V(x) = M_0 (x - a)^{-1}$</td>
<td>$M(x) = M_0 (x - a)^0$</td>
</tr>
<tr>
<td><img src="image2.png" alt="Diagram 2" /></td>
<td>$w(x) = P_0 (x - a)^{-1}$</td>
<td>$V(x) = P_0 (x - a)^0$</td>
<td>$M(x) = P_0 (x - a)^1$</td>
</tr>
<tr>
<td><img src="image3.png" alt="Diagram 3" /></td>
<td>$w(x) = w_0 (x - a)^0$</td>
<td>$V(x) = w_0 (x - a)^1$</td>
<td>$M(x) = \frac{w_0}{2} (x - a)^2$</td>
</tr>
<tr>
<td><img src="image4.png" alt="Diagram 4" /></td>
<td>$w(x) = \frac{w_0}{b} (x - a)^1$</td>
<td>$V(x) = \frac{w_0}{2b} (x - a)^2$</td>
<td>$M(x) = \frac{w_0}{6b} (x - a)^3$</td>
</tr>
</tbody>
</table>

\[
\sigma_{x1} = \sigma_x \cos^2 \theta + \sigma_y \sin^2 \theta + 2\tau_{xy} \sin \theta \cos \theta
\]

\[
\tau_{xy1} = - (\sigma_x - \sigma_y) \sin \theta \cos \theta + \tau_{xy} (\cos^2 \theta - \sin^2 \theta)
\]
Problem 1) Use singularity functions to set up the equations necessary to solve for the reactions on the structure shown. You must state and plug any applicable boundary conditions into your equations, but you do not have to solve for the final answers. You must also completely state all equations that are needed in the solution. You can assume that I will then take them, put them into Matlab, and solve for the final answers. Use $P = 200 \text{ kN}$, $w = 10 \text{ kN/m}$, and $L = 8 \text{ m}$. A blank sheet is given at the end of the quiz.
\[ M_x = -200x + R_B \langle x-4 \rangle + R_c \langle x-8 \rangle \]

\[ -10 \frac{\langle x-8 \rangle^2}{2} - \frac{20}{8} \frac{\langle x-8 \rangle^3}{2.3} \]

\[ EI \frac{dy}{dx} = -200x^2 \frac{\langle x \rangle^2}{2} + R_B \frac{\langle x-4 \rangle^2}{2} + R_c \langle x-8 \rangle^2 \]

\[ -10 \frac{\langle x-8 \rangle^3}{2.3} - \frac{20}{8} \frac{\langle x-8 \rangle^4}{2.3.4} + C_1 \]

\[ EI y = -200x^3 \frac{\langle x \rangle^3}{2.3} + R_B \frac{\langle x-4 \rangle^3}{2.3} + R_c \langle x-8 \rangle^3 \]

\[ -10 \frac{\langle x-8 \rangle^4}{2.3.4} - \frac{20}{8} \frac{\langle x-8 \rangle^5}{2.3.4.5} + C_1 x + C_2 \]

\[ @ x = 4, y = 0 \text{ so plug this into } y: \]

\[ C = -200(4) \frac{\langle 4 \rangle^2}{2.3} + R_B \cdot 0 + \text{not there} \]

\[ - \text{not there} - \text{not there} + C_1(4) + C_2 \]

\[ C = -200(4)^3 \frac{\langle 4 \rangle^3}{2.3} + 4 C_1 + C_2 \]
\( \omega = 8, y = 0 \approx 0 \)

\[
0 = -\frac{200(8)^3}{2.3} + \frac{R_B(8-4)^3}{2.3} + \frac{R_c(0)}{2.3}
- 10(0) - \frac{20(0)}{8} + 8C_1 + C_2
\]

\[
0 = -\frac{200(8)^3}{2.3} + \frac{R_B(4)^3}{2.3} + 8C_1 + C_2
\]

\( \omega = 16, y = 0 \approx 0 \approx 0 \)

\[
0 = -\frac{200(16)^3}{2.3} + \frac{R_B(16-4)^3}{2.3} + \frac{R_c(16-8)}{2.3}
\]

\[
-10(16-8)\frac{4}{2.3, 4} - \frac{20(16-8)^5}{8} \frac{5}{2.3, 4, 5} + C_1(16) + C_2
\]

\[
0 = -\frac{200(16)^3}{2.3} + \frac{R_B(12)^3}{2.3} + \frac{R_c(8)}{2.3}
\]

\[
-10(8)^4\frac{4}{2.3, 4} - \frac{20(8)^5}{8} \frac{5}{2.3, 4, 5} + 16C_1 + C_2
\]
Equations of statics: (Amy OK)

\[ \sum M_b = 0 = +200(4) - (10)(8)(8) - (20)(8)(4 + \frac{3}{8}) + 4R_c + 12R_D \]

\[ \sum F_H = 0 \]
\[ \sum F_V = 0 = -200 + R_B + R_C + R_D - 10(8) - 20(8)(\frac{1}{2}) \]
Problem 2) Design the lightest W shape for member "de" in the truss shown. Use X = 30 feet, Y = 40 feet, P1 = 100 kip. If you are unable to solve for the force in the member you can assume that it is 28k compression, but that will cost you.
Prob 2a  \( P_1 = 100^k \)  

Member is in compression, hence a column.

Reactions: \( R_a = 75^k \), \( R_i = 25^k \)

\[ \sum M_m = 0 = F_{de} (40') - 25^k (4.30') \]

\[ F_{de} = 75^k \]

\[ FOS = 75^k (1.6) = 120^k \] required capacity

\[ = P_{cn} \]

\[ P_{cn} = \frac{\pi^2 EI}{(KL)^2} \quad \text{so} \quad I = \frac{(KL)^2 P_{cn}}{\pi^2 E} \]

\[ I_{min} = (1.0) (30\text{ft} \times 12\text{in/ft})^2 \cdot (120^k) \]

\[ \frac{\pi^2 (29,000 \text{kip/in}^2)}{29,000 \text{kip/in}^2} \]

\[ = 54,341 \text{in}^4 \]

Try W10\times4.9

Check Tull = \( \frac{P_{ult}}{FOS} = \frac{58 \text{ksi}}{1.6} = 36.25 \text{ksi} \)

\[ \sigma = \frac{P}{A} = \frac{120^k}{14.4 \text{in}^2} = 8.33 \text{ksi} < 36.25 \text{ksi} \]

OK

Use W10\times4.9
If used $P_{de} = 28\, k$

$$P_{cr} = (1.16)(28) = 44.8\, k$$

$$F = \frac{44.8\, k(1.30.12)^2}{\pi^2(29,000)} = 20.28\, \text{in}^4$$

Try W16 x 36

Check $T_{all} = \frac{P_{ult}}{FOS} = 36.25\, \text{kpsi}$

$$T = \frac{44.8\, k}{10.6\, \text{in}^2} = 4.23\, \text{kpsi} < 36.25\, \text{kpsi}$$

OK

Use W16 x 36
Problem 3) Design the lightest W shape for member “nm” in the truss shown. Use \( X = 30 \) feet, \( Y = 40 \) feet, \( P_1 = 500 \) kip. If you are unable to solve for the force in the member you can assume that it is 550k tension, but that will cost you.
Prob 3a \quad P_1 = 500k \quad \text{Member is in tension.}

\quad R_A = 375k \quad R_B = 125k

\quad \Sigma M_d = 0 = (125k)(5\times30') - F_{mm}(40')

\quad F_{mm} = 468.8k \quad \text{Tension}

\quad \sigma = \frac{F_{ult}}{F_{os}} = \frac{58ksi}{1.6} = 36.25 ksi

\quad \sigma = \frac{P}{A} \quad A = \frac{P}{\sigma} = \frac{468.8k}{36.25 ksi/\text{in}^2}

\quad = 12.93 \text{ in}^2

\quad \text{Use W21\times44}
Prob 3c

If used wrong $F = 550^k$

$T = P/A$ so $A_{\text{min}} = P/T_{\text{all}}$

$T_{\text{all}} = \frac{T_{\text{ult}}}{F_{OS}} = \frac{58 \text{kpsi}}{1.6} = 36.25 \text{kips/in}^2$

$A_{\text{min}} = \frac{550^k}{36.25 \text{kips/in}^2} = 15.17 \text{in}^2$

Use W14 × 53
Problem 4) A Kevlar reinforced plastic liner is used to protect the interior of a steel pressure vessel from corrosion. The forces applied to a typical patch of the liner are as shown. The dimensions of the patch are 1" wide, 2" tall, and 0.25" thick. A heat-welded seam runs through the liner at an angle of beta = 32 degrees as shown. Determine the allowed force P permitted to prevent overstressing the liner in tension along the seam. You can use Mohr's Circle or the equations on page 3.
Problem 4a: \( \theta = +122^\circ = 90^\circ + 32^\circ \)

\[
\tau_x = \frac{P_x}{A_x} = \frac{P}{A} = \frac{P}{(2" \times 0.25")} = 2P \text{ compression} = -2P
\]

\[
\tau_y = \frac{P_y}{A_y} = \frac{3P}{A_y} = \frac{3P}{(1" \times 0.25")} = 12P \text{ tension} = +12P
\]

\[
\tau_{xy} = -\frac{4P}{(2" \times 0.25")} = -8P
\]

\[
\text{Total} = \tau_x \cos^2 \theta + \tau_y \sin^2 \theta + 2\tau_{xy} \sin \theta \cos \theta
\]

\[
= (-2P) \cos^2 (122^\circ) + 12P \sin^2 (122^\circ) + 2(-8P)(\sin 122^\circ \cos 122^\circ)
\]

\[
= -0.5616P + 8.630P + 7.190P = 15.258P
\]

\[
\tau_m = 15.258P (\text{Tension})
\]

\[
\tau_{all} = 104 \text{ ksi} / 1.6 = 65 \text{ ksi tension}
\]

So \( 15.258P = 65 \)

\[
P = 4.26 \text{ ksi}
\]
"Shear stress down on left face is positive"
"Principals stresses and stresses on any angle theta"

\[ Sx_{any} = \frac{(Sx+S_y)}{2} + \frac{(Sx-S_y)\cos(2\theta)}{2} + T_{xy}\sin(2\theta) \]
\[ T_{xy_{any}} = -\frac{(Sx-S_y)\sin(2\theta)}{2} + T_{xy}\cos(2\theta) \]
\[ Sy_{any} = \frac{(Sx+S_y)}{2} - \frac{(Sx-S_y)\cos(2\theta)}{2} - T_{xy}\sin(2\theta) \]

\[ Sx_{max} = \frac{(Sx+S_y)}{2} + \sqrt{\left(\frac{(Sx-S_y)}{2}\right)^2 + T_{xy}^2} \]
\[ Sx_{min} = \frac{(Sx+S_y)}{2} - \sqrt{\left(\frac{(Sx-S_y)}{2}\right)^2 + T_{xy}^2} \]
\[ T_{xy_{max}} = \sqrt{\left(\frac{(Sx-S_y)}{2}\right)^2 + T_{xy}^2} \]
\[ \tan(2\theta_{\text{thetap}}) = \frac{2T_{xy}}{(Sx-Sy)} \]

\[ Sx = -2 \]
\[ Sy = 12 \]
\[ T_{xy} = -8 \]
\[ \theta = 122 \text{ "enter theta in DEGREES!"} \]

"Proof" \[ \sin(\theta_{\text{squad}}) = \sin(\theta); \quad \cos(\theta) = \cos(\theta) \]

\[ 65 = (SxP)(\cos(\theta))^2 + SyP(\sin(\theta))^2 + 2T_{xyP}\sin(\theta)\cos(\theta) \]

**SOLUTION**

**Unit Settings:** SI C kPa kJ mass deg

\[ \cos(\theta) = -0.5299 \quad P = 4.26 \quad \text{sin(}\theta_{\text{squad}}) = 0.848 \]
\[ Sx = -2 \quad \text{Sx}_{any} = 15.26 \quad \text{Sx}_{max} = 15.63 \]
\[ Sx_{min} = -5.63 \quad \text{Sy} = 12 \quad \text{Sy}_{any} = -5.259 \]
\[ \theta = 122 \quad \text{Thetap} = 24.41 \quad \text{T}_{xy} = -8 \]
\[ T_{xy_{any}} = -2.785 \quad \text{T}_{xy_{max}} = 10.63 \]

7 potential unit problems were detected.
Problem 5) Determine the state of stress at the top of the tank directly above the right support, if loaded as shown. Properties of the tank are: Douter = 48", Dinner = 47", L1 = 10 feet, L2 = 4 feet. Loads are internal pressure = 200 psi, F = 1,000 k, P = 500 k, T = 800 k ft,
Problem 5) Determine the state of stress at the top of the tank directly above the right support, if loaded as shown. Properties of the tank are: Douter = 48", Dinner = 47", L1 = 10 feet, L2 = 4 feet. Loads are internal pressure = 200 psi, F = 1,000 k, P = 500 k, T = 800 k ft.

Pressure vessels:
\[ \sigma_z = \frac{P}{t} = \frac{200 \times (23.5)}{2} = 9400 \text{ psi} \]
\[ \sigma_y = \frac{P}{2t} = \frac{200 \times (23.5)}{2} = 4700 \text{ psi} \]

\[ \sigma_{xy} = \frac{P}{A} = \frac{1000}{24.413} = 12403 \text{ ksi} \]

Bending:
\[ \sigma_{bend} = -\frac{M y}{I} = -\frac{24000 \times 24}{21045} = 27.36 \text{ ksi} \]

Shear:
\[ \tau = \frac{T c}{J} = \frac{9600 \times 24}{42090.9} = 5.474 \text{ ksi} \]

\[ F = 980 \text{ k ft} \times \frac{12}{12} = 980 \]

\[ \sigma_{ave} = -13.752 \text{ ksi} \]
\[ \sigma_{max} = 10.372 \text{ ksi} \]
"Properties of pipes"

\[
\begin{align*}
\text{OD} &= 48 \quad \text{"inches"} \\
\text{ID} &= 47 \quad \text{"inches"} \\
\text{c} &= \text{OD}/2 \\
\text{Paxial} &= 1000 \quad \text{"kips"} \\
\text{Mom} &= 500*4*12 \quad \text{"k in"} \\
\text{Torq} &= 800*12 \quad \text{"k in"} \\
\text{pres} &= 0.2 \quad \text{"ksi"}
\end{align*}
\]

\[
\begin{align*}
t &= (\text{OD} - \text{ID})/2 \quad \text{"in"} \\
A &= \pi*(\text{OD}^2 - \text{ID}^2)/4 \quad \text{"in}^2\text{"} \\
I &= \pi*(\text{OD}^4 - \text{ID}^4)/64 \quad \text{"in}^4\text{"} \\
J &= I/2 \quad \text{"in}^4\text{"}
\end{align*}
\]

\[
\begin{align*}
\text{SigAxial} &= \text{Torq}*c/J \\
\text{SigAxial} &= \text{Paxial}/A \\
\text{SigBend} &= \text{Mom}*c/l \\
\text{SigHoopPress} &= \text{pres}*c/t \\
\text{SigLongPress} &= \text{pres}*c/(2*t)
\end{align*}
\]

\[\text{SOLUTION}\]

\[\text{Unit Settings: SI C kPa kJ mass deg}\]

\[
\begin{align*}
A &= 74.61 \\
\text{ID} &= 47 \\
\text{OD} &= 48 \\
\text{SigAxial} &= 13.4 \\
\text{SigLongPress} &= 4.8 \\
\text{Torq} &= 9600 \\
\text{c} &= 24 \\
J &= 42091 \\
\text{Paxial} &= 1000 \\
\text{SigBend} &= 27.37 \\
\text{SigTau} &= 5.474 \\
l &= 21045 \\
\text{Mom} &= 24000 \\
\text{pres} &= 0.2 \\
\text{SigHoopPress} &= 9.6 \\
t &= 0.5
\end{align*}
\]

No unit problems were detected.
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"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.
Problem 1) For member "nm" in the truss shown, design the lightest W shape. Use X = 30 feet, Y = 40 feet, P = 600 kip. If you cannot solve for the force you can assume that it is 550k tension, but that will cost you.
Member is in tension.

Problem \[ P_i = 600 \text{ k} \]

\[ RA = 150 \text{ k} \quad R_i = 450 \text{ k} \]

\[ \Sigma M_e = 0 = -150 \text{ k}(4 \times 30') + F_{mm}(40') \]

\[ F_{mm} = 450 \text{ k} \]

\[ S_{all} = \frac{S_{ult}}{1.6} = \frac{58 \text{ ksi}}{1.6} = 36.25 \text{ ksi} \]

\[ T = \frac{P}{A} \text{ so } A_{min} = \frac{P}{T} = \frac{450 \text{ k}}{36.25 \text{ ksi}} = 12.41 \text{ in}^2 \]

Use W 21\times 44
Problem

If used wrong \( F = 550 \text{ k} \)

\( C = P/A \) so \( A_{\text{min}} = P/C \) all

\[ C = \frac{Fult}{FOS} = \frac{58 \text{ ksi}}{1.6} = 36.25 \frac{\text{k}}{\text{in}^2} \]

\[ A_{\text{min}} = \frac{550 \text{ k}}{36.25 \frac{\text{k}}{\text{in}^2}} = 15.17 \text{ in}^2 \]

Use W14 x 53
Problem 2) A Kevlar reinforced plastic liner is used to protect the interior of a steel pressure vessel from corrosion. The forces applied to a typical patch of the liner are as shown. The dimensions of the patch are 2" wide, 4" tall, and 0.50" thick. A heat-welded seam runs through the liner at an angle of $\beta = 23$ degrees as shown. Determine the allowed force $P$ permitted to prevent overstressing the liner in tension along the seam. You can use Mohr's Circle or the equations on page 3.
Prob 2 \[ \theta = 90 - 23^\circ = 67^\circ \]

\[ T_x = \frac{P_x}{A_x} = \frac{2P}{(4'' \times 0.5'')} = P \text{Tension} = +P \]

\[ T_y = \frac{P_y}{A_y} = \frac{P}{(2'' \times 0.5'')} = P \text{compression} = -P \]

\[ T_{xy} = \frac{-6P}{(4'' \times 0.5'')} = -3P \text{ (negative shear stress)} \]

Solve as before

\[ T_{normal} = -2.853P \text{ (Compressive)} \]

\[ \sigma_{all} = 70 \text{ ksi Compl}/1.6 = 43.75 \text{ ksi} \text{ Compression} \]

Set \[ 2.853P = 43.75 \text{ ksi} \]

\[ P = 15.33 \text{ kips} \]
"Shear stress down on left face is positive"  
"Principal stress are on any angle theta"

\[ Sx = \frac{(Sx+Sy)}{2} + \frac{(Sx-Sy)\times\cos(2\theta)}{2} + Txy\times\sin(2\theta) \]

\[ Txy = \frac{-((Sx-Sy)\times\sin(2\theta))}{2} + \frac{Txy\times\cos(2\theta)}{2} \]

\[ Sy = \frac{(Sx+Sy)}{2} - \frac{(Sx-Sy)\times\cos(2\theta)}{2} - Txy\times\sin(2\theta) \]

\[ Sx_{max} = \frac{(Sx+Sy)}{2} + \sqrt{\left(\frac{(Sx-Sy)}{2}\right)^2 + \frac{Txy^2}{2}} \]

\[ Sx_{min} = \frac{(Sx+Sy)}{2} - \sqrt{\left(\frac{(Sx-Sy)}{2}\right)^2 + \frac{Txy^2}{2}} \]

\[ Txy_{max} = \sqrt{\left(\frac{(Sx-Sy)}{2}\right)^2 + \frac{(Txy^2}{2}} \]

\[ \tan(2\theta) = \frac{(2\times Txy)}{(Sx-Sy)} \]

\[ Sx = 1 \]

\[ Sy = -1 \]

\[ Txy = -3 \]

\[ \theta = 67 \text{  "enter theta in DEGREES!"} \]

"Proof"  \[ \sin(\theta) = \sin(\theta); \quad \cos(\theta) = \cos(\theta) \]

\[ 43.75 = (Sx^2)\times\cos(\theta)^2 + Sy^2\times\sin(\theta)^2 + 2\times(Txy^2)\times\sin(\theta)\times\cos(\theta) \]

**SOLUTION**

Unit Settings: SI C kPa kJ mass deg

\[ \cos(\theta) = 0.3907 \]

\[ Sx = 1 \]

\[ Sx_{min} = -3.162 \]

\[ \theta = 67 \]

\[ Txy = 1.365 \]

\[ P = -15.34 \]

\[ Sx_{any} = -2.853 \]

\[ Sy = -1 \]

\[ Sx_{max} = 3.162 \]

\[ Sy_{any} = 2.853 \]

\[ Thetap = -35.78 \]

\[ Txy_{max} = 3.162 \]

7 potential unit problems were detected.
Problem 3) For the tank loaded as shown, determine the state of stress at the top of the tank directly above the right support.
Properties of the tank are: $L_1 = 12$ feet, $L_2 = 5$ feet, $D_{outer} = 42''$, $D_{inner} = 40''$. Loads are $F = 1200$ k, $P = 600$ k, $T = 500$ k ft, internal pressure = 100 psi.
"Properties of pipes"

OD = 42
ID = 40
C = OD/2
Paxial = 1200
Mom = 600*5*12
Torq = 500*12
Pres = 0.1

\[ t = \frac{(OD - ID)}{2} \]
\[ A = \pi \left( OD^2 - ID^2 \right)/4 \]
\[ l = \pi \left( OD^4 - ID^4 \right)/64 \]
\[ J = l^2 \]

SigTau = Torq\*c/J
SigAxial = Paxial/A
SigBend = Mom\*c/l
SigHoopPress = pres\*c/t
SigLongPress = pres\*c/(2*t)

\[ \text{SOLUTION} \]
\[ \text{Unit Settings: SI C kPa kJ mass deg} \]

A = 128.8
ID = 40
OD = 42
SigAxial = 9.316
SigLongPress = 1.05
Torq = 6000

\[ c = 21 \]
\[ J = 54163 \]
\[ Paxial = 1200 \]
\[ SigBend = 27.92 \]
\[ SigTau = 2.326 \]

\[ l = 27081 \]
\[ Mom = 36000 \]
\[ pres = 0.1 \]
\[ SigHoopPress = 2.1 \]
\[ t = 1 \]

No unit problems were detected.
Problem 4) Given the structure shown, use singularity functions to set up the equations necessary to solve for the reactions. You must state and plug any applicable boundary conditions into your equations, but you do not have to solve for the final answers. You must also completely state all equations that are needed in the solution.

Use $P = 2500$ kN, $w = 20$ kN/m, and $L = 10$ m. You can assume that I will then take your equations and put them into EES and solve for the final answers. A blank sheet is available at the end of the quiz.

Boundary conditions:

$x = 10$, $y = 0$

$x = 20$, $y = 0$

$x = 40$, $y = 0$

$\phi = \frac{-1250}{3}x^3 + C_1y + C_2 \rightarrow C_2 = 416666.6 - 10C_1$

$\theta = \frac{-1250}{3}x^3 - \frac{5}{6}y^4 - \frac{10y^5}{60} + \frac{5}{6}x^2 + C_1y + 416666.6 - 10C_1$

$x1 = 292666.6 - \frac{500}{3}b + 10C_1 \rightarrow C_1 = 292666.6 - \frac{500}{3} b$

$\phi = \frac{-1250}{3}x^3 - \frac{5}{6}y^4 - \frac{10y^5}{60} + \frac{5}{6}x^2 + C_1y + 416666.6 - 10C_1$

$x2 = 2500(10) - (15)(30)(20) - \frac{60}{2}(30)(\frac{3}{2}15) + C(20) + d(30)$

$-4000 = 20c + 30d$

$z = 0 \Rightarrow -2500 + b + c + d - (20)(30) - \frac{60}{2}$

$4000 = b + c + d$
Problem 4) Given the structure shown, use singularity functions to set up the equations necessary to solve for the reactions. You must state and plug any applicable boundary conditions into your equations, but you do not have to solve for the final answers. You must also completely state all equations that are needed in the solution.

Use \( P = 2500 \text{ kN} \), \( w = 20 \text{ kN/m} \), and \( L = 10 \text{ m} \). You can assume that I will then take your equations and put them into EES and solve for the final answers. A blank sheet is available at the end of the quiz.

\[
\begin{align*}
W &= P \langle x - 0 \rangle^2 + 20 \langle x - 10 \rangle^2 \\
&\quad + 80 \langle x - 10 \rangle^3 + \frac{80}{30} \langle x - 10 \rangle^3 + By \langle x - 10 \rangle^3 + C_y \langle x - 20 \rangle^3 + Dy \langle x - 40 \rangle^3 \\
\frac{dv}{dx} &= +P \langle x - 0 \rangle^2 - 20 \langle x - 10 \rangle^2 - \frac{80}{30} \langle x - 10 \rangle^3 - By \langle x - 10 \rangle^3 - C_y \langle x - 20 \rangle^3 - Dy \langle x - 40 \rangle^3 \\
V &= P \langle x - 0 \rangle^3 - 20 \langle x - 10 \rangle^3 - \frac{90}{2} \langle x - 10 \rangle^3 - By \langle x - 10 \rangle^3 - C_y \langle x - 20 \rangle^3 - Dy \langle x - 40 \rangle^3 \\
M &= Px - 20 \langle x - 10 \rangle^2 - \frac{80}{2} \langle x - 10 \rangle^3 + By \langle x - 10 \rangle^3 - C_y \langle x - 20 \rangle^3 - Dy \langle x - 40 \rangle^3 \\
E_{\text{dy}} &= \frac{dx}{dy} = \frac{P \langle x - 10 \rangle^3 - 10 \langle x - 10 \rangle^3 - \frac{80}{2} \langle x - 10 \rangle^3 - By \langle x - 10 \rangle^3 - C_y \langle x - 20 \rangle^3 - Dy \langle x - 40 \rangle^3}{3} \\
E_{\text{gy}} &= \frac{dx}{dy} = \frac{P \langle x - 10 \rangle^4 - 2 \langle x - 10 \rangle^5 - By \langle x - 10 \rangle^2 - C_y \langle x - 20 \rangle^2 - Dy \langle x - 40 \rangle^2}{6}
\end{align*}
\]

Boundary conditions:

\begin{align*}
\text{at } x = 10, y = 0: \\
0 &= (2500)(10)^3 - 0 - 0 - 0 - 0 - 0 + 10C_1 + C_2 \\
10C_1 + C_2 &= -410500 \Rightarrow -410500 \Rightarrow \text{(continued on last page!)}
\end{align*}
\[ \sum \vec{E}_D = 0 \]

\[ 900(10) - C_y(20) - B_y(30) + 2500(40) = 0 \]

\[ 20C_y + 30B_y = 109000 \]

\[ \sum \vec{E}_C = 0 \]

\[ B_y(20) - 900(10) - B_y(10) + 2500(20) = 0 \]

\[ 20D_y - 10B_y = -41000 \]

\[ \sum \vec{E}_B = 0 \]

\[ 2500(10) + C_y(10) - 900(20) + D_y(30) = 0 \]

\[ 10C_y + 30D_y = -7000 \]

More boundary conditions...

\[ x = 40, \ y = 0 \]:

\[ 0 = \frac{2500(40)^3}{6} - \frac{10(30)^4}{12} - \frac{2(30)^5}{90} - \frac{B_y(30)^3}{6} - \frac{C_y(20)^3}{6} - D_y \]

\[ 40C_1 + C_2 - 1333.33C_y - 4500B_y + 25451666.67 + C_1(40) + C_2 \]
Problem 5) For member "de" in the truss shown, design the lightest W shape. Use $X = 30$ feet, $Y = 40$ feet, $P = 200$ kip. If you cannot solve for the force you can assume that it is $28k$ compression, but that will cost you.
Member is in compression, hence a column.

Prob. 5 \[ P_1 = 200^k \]

Reactions \( R_A = 50^k \), \( R_i = 150^k \)

\[ \Sigma M_n = 0 = F_{de}(40') - 50^k(3 \times 30') \]

\[ F_{de} = 112.5^k \]

\[ P_n = 1.6(F_{de}) = 180^k \]

\[ P_n = \frac{\pi^2 EI}{(KL)^2} \Rightarrow I = \frac{P_n(KL)^2}{\pi^2 E} \]

\[ = 180^k(1.0 \times 30' \times 12^\text{in}/\text{ft})^2 \]

\[ \frac{\pi^2 (29,000 \text{ ksi})}{11.6} = 81.5 \text{ ksi}^4 \]

Try \( W_{12 \times 53} \)

Check \( f_{all} = \frac{P_{ult}}{1.6} = \frac{58 \text{ ksi}}{1.6} = 36.25 \text{ ksi} \)

\[ \gamma = \frac{P}{A} = \frac{180^k}{15.6 \text{ in}^2} = 11.54 \text{ ksi} < 36.25 \text{ ksi} \]

\[ \text{OK} \]

Use \( W_{12 \times 53} \)
If used $P_{de} = 28 \ k$.

$$P_{cr} = (1.6)(28) = 44.8 \ k.$$  

$$I = \frac{44.8 \ k \ (1.30.12)^2}{\pi^2 \ (29,000)} = 20.28 \ \text{in}^4$$

Try. W16 x 36

Check Tack = $\frac{P_{ult}}{FOS} = 36.25 \ \text{ksi}$

$$I = \frac{44.8 \ k}{10.6 \ \text{in}^2} = 4.23 \ \text{ksi} < 36.25 \ \text{ksi}$$

OK

Use W16 x 36