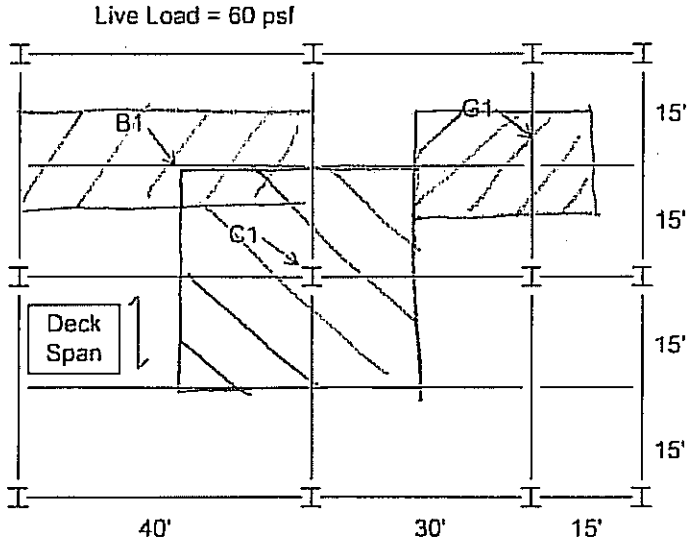
CEE2201 Spring 2010 Exam 1 **Name** SOLUTIONS

Closed Book
Closed Notes
3" x 5" Note card is allowed, Calculator is allowed.
100 points are possible

Answer all questions to the best of your ability. Attach extra sheets as necessary. **Show your work!**

Problem 1.
Find a reduced live load for the members indicated below (B1, G1, and C1). **(15 points)**



FLOOR PLAN
Figure 1. Floor plan for Problem 1

B1: $A_T = (40')(15') = 600 ft^2$

$K_{LL} = 2$

$L = L_o\left(0.25 + \frac{15}{\sqrt{K_{LL}A_T}}\right)$

$L = 60\left(0.25 + \frac{15}{\sqrt{2(600)}}\right) = 60(.683) = \boxed{41 psf}$

G1: $A_T = \left[\left(\frac{30'}{2}\right) + \left(15'/2\right)\right](15') = 337.5 ft^2$, $K_{LL} = 2 \rightarrow K_{LL}A_T > 400 ft^2$ ok

$L = 60\left(0.25 + \frac{15}{\sqrt{2(337.5)}}\right) = 60(.827) = 49.6 \rightarrow \boxed{50 psf}$

C1: $A_T = \left[\left(\frac{40'}{2}\right) + \left(\frac{30'}{2}\right)\right](30') = 1050 ft^2$

$K_{LL} = 4$

$L = (60)\left(0.25 + \frac{15}{\sqrt{4(1050)}}\right)$

$L = (60)(.481)$

Cannot be $< 0.5L_o$

$L = 0.5(60) = \boxed{30 psf}$

Problem 2.

A water tower is being designed for a location in southern Michigan. The engineer in charge of the project has asked you for some quick calculations to find the approximate lateral design load for this structure as a single force (F) applied to the tank of the structure. You want to know if wind load or seismic load will control.

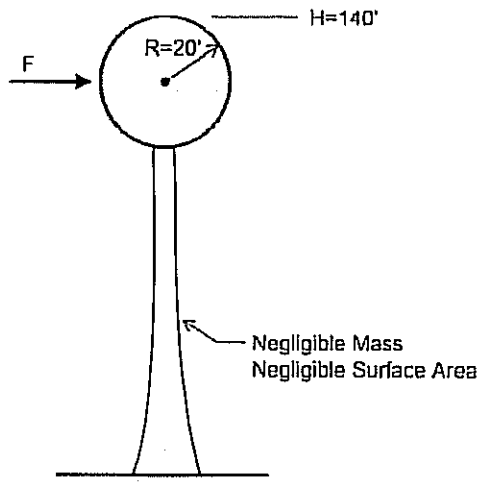


Figure 2. Water tower used in Problem 2.

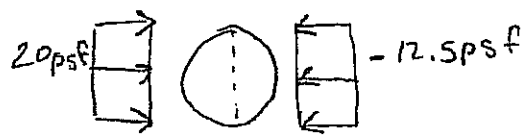
a) Find the lateral force that you would apply to the tank due to wind. You know that the bulk of the surface area of the water tower is in the tank, thus you will only consider the area of the tank as receiving wind load. You approximate $q_z = q_h = 25$ psf and GC_p on the windward side is 0.8 and GC_p on the leeward side is -0.5. **(10 points)**
(Hint: the area of a circle is πR^2.)

$P = GC_p q_z$ or $GC_p q_h$ ($q_h = q_z$)

$P_{WINDWARD} = 0.8\,(25) = 20$ psf

positive pressure is into structure.

$P_{LEEWARD} = -0.5\,(25) = -12.5$ psf



$F_w = A\,(20 - (-12.5))$

$A = \pi (20)^2 = 1257$ ft^2

$F_w = 1257\,(32.5) = 40{,}840$ lb

$F_w = 41$ kips

b) Find the equivalent lateral force due to seismic load of the empty tank. The weight of the empty tank (W) is 500 kips. Assume that the mass of the tower is negligible. You have already found the spectral response acceleration coefficients ($S_{D1} = 0.080g$, $S_{DS} = 0.128g$) and determined that the structure falls into Seismic Design Category B. The period (T) of the structure with the tank empty is 0.45 s. Use $R = 8$ and $I = 1.25$. Which controls, wind or seismic load? **(20 points)**
(Hint: the force F due to seismic load will be equal to the base shear.)

$$V = \frac{W S_{D1}}{T(R/I)} = \frac{500k\,(0.080)}{0.45\,(8/1.25)} = 13.9 \text{ kips}$$

$$V_{MAX} = \frac{S_{DS} W}{R/I} = \frac{0.128(500)}{8/1.25} = 10 \text{ kips} \leftarrow \text{less than } V_q \text{ use } V_{MAX}$$

$F_{S\,empty} = 10 \text{ kips} < F_W$
WIND CONTROLS

c) Now consider the tank with water in it. Take the seismic weight of the full tank to be 2600 kips. The period (T) of the structure is now 0.2 s. What is the seismic load based on the full tank? Does this load control over wind load? **(10 points)**

$$V = \frac{W S_{D1}}{T(R/I)} = \frac{2600\,(0.080)}{(0.20)(8/1.25)} = 162.5k$$

$$V_{MAX} = \frac{S_{DS} W}{R/I} = \frac{0.128(2600)}{8/1.25} = 52k < V_q \text{ use } V_{MAX}$$

$F_{S\,FULL} = 52^k > F_W$
Seismic Controls

Problem 3.

Find axial forces in member ***BC*** in the truss below. Indicate tension or compression. **(20 points)**
(Hint: Save time; use the correct truss solution method.)
(Hint: Save time; choose the point(s) that you sum moments around very carefully.)

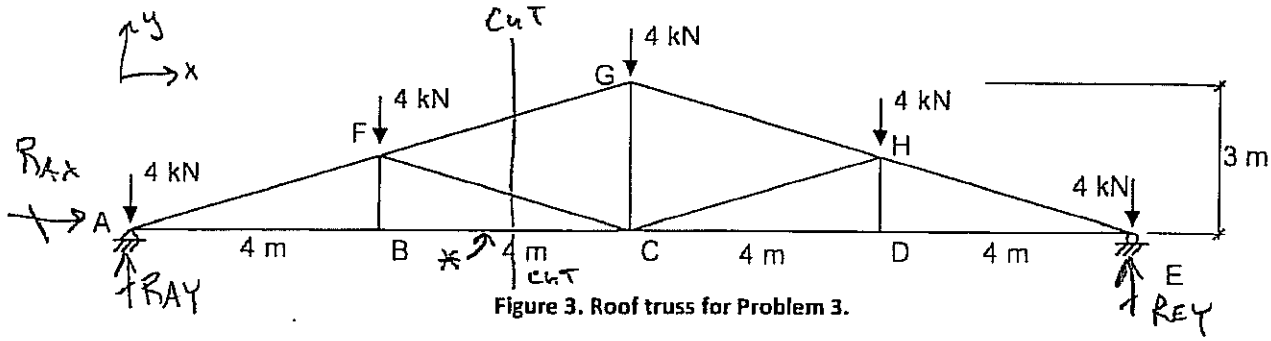
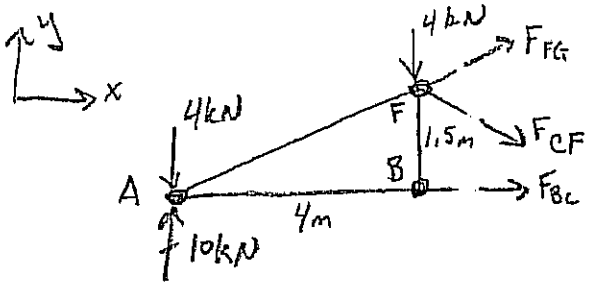


Figure 3. Roof truss for Problem 3.

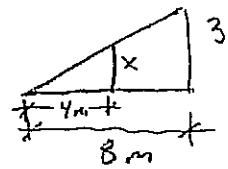
BY SYMMETRY: $R_{AY} = R_{EY} = 10\ kN$

BY INSPECTION: $R_{AX} = 0$

- use method of sections:



Length of member BF:



SIMILAR TRIANGLES:

$\frac{4}{x} = \frac{8}{3}$

$x = \frac{12}{8} = 1.5\ m$

$\circlearrowleft + \quad \Sigma M_F = 0 \quad -(10-4)(4) + 1.5\,F_{BC} = 0$

$1.5\,F_{BC} = 24$

$\boxed{F_{BC} = 16\ kN}$

Problem 4.
Find the shear and moment diagrams for this frame. Include both the horizontal beam member and the sloped member. You do not have to draw a diagram for any axial forces that may exist. **(25 points)**

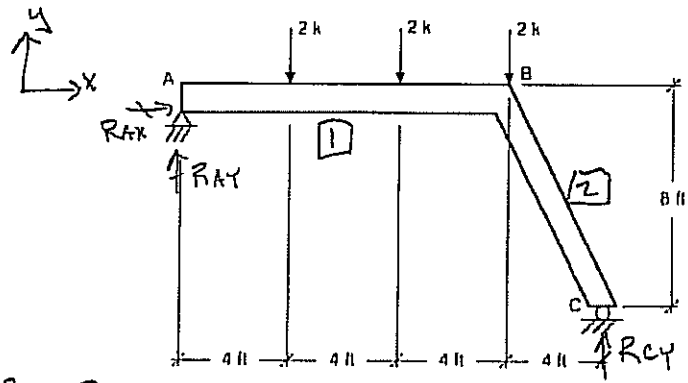


Figure 4. Frame to be analyzed in Problem 4.

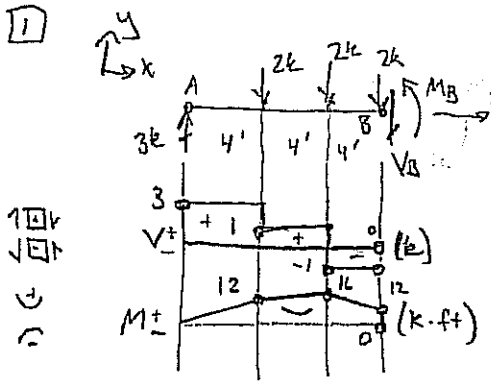
$\Sigma F_x = 0 \Rightarrow R_{AX} = 0$

$\Sigma F_y = 0 \Rightarrow R_{AY} + R_{CY} - 2 - 2 - 2 = 0$

$R_{AY} + R_{CY} = 6$

(+) $\Sigma M_A = 0 \Rightarrow -(2)4 - (2)(8) - (2)(12) + R_{CY}(16) = 0$

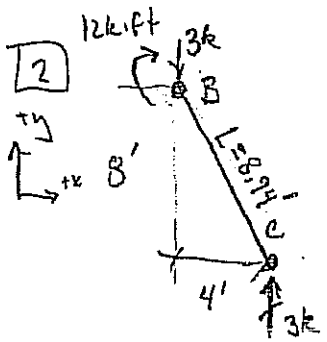
$R_{CY} = 3^k \rightarrow R_{AY} = 3^k$



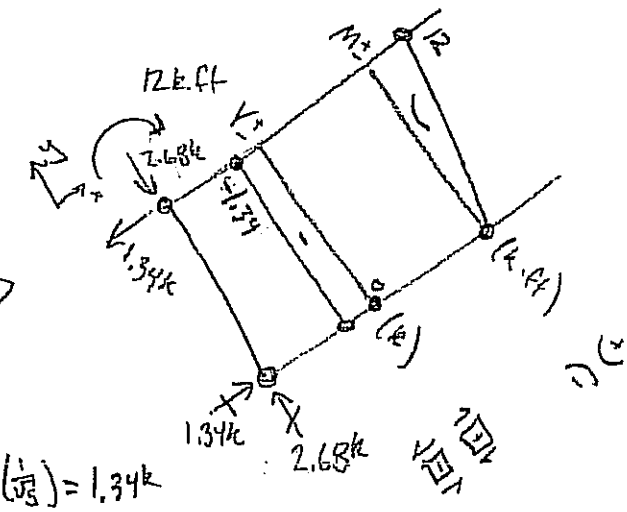
$A_B = 0$
$V_B = -3^k$ } BY INSPECTION

(+) $\Sigma M_A = 0 \Rightarrow -2(4) - 2(8) - 2(12) + 3(12) + M_B = 0$

$M_B = +12\ k \cdot ft$

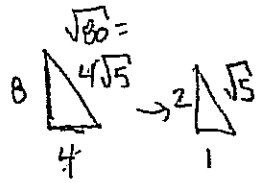


Break Forces into shear and axial forces. ⇒



$3\left(\frac{1}{\sqrt{5}}\right) = 1.34^k$

$3\left(\frac{2}{\sqrt{5}}\right) = 2.68^k$



Check: $(-1.34)(8.94) =$
$-12\ k \cdot ft$
ok