CE 120 – Spring 2021
Instructor: M.J. DeJong

Name: Key

CE 120 – Structural Engineering

Mid-Term Examination No. 2

Instructions (as posted on bcourses prior to the exam):

Instructions:

- The exam is open book (i.e. reader) and open notes (including HW solutions). You are not permitted to use other materials.
- You may use a calculator and watch, but no other electronic devices are permitted. (Note: you may use a tablet to write your solution).
- You are not permitted to communicate with any other people during the exam.
- Do all problems. Show all relevant work.
- You may write your solutions on the exam directly, immediately following the problem statements, or you may use your own paper, but please clearly write the problem number at the top of each page, and use a new piece of paper for each problem.
- Organize and write solutions neatly. Points may be taken off for messy solutions.
- Indicate units in final solutions. Points will be taken off if units are missing or signs are unclear.

Zoom Meeting ID: 982 0166 1368 (same as lecture)

****By submitting your exam, you are agreeing to the following Honor Pledge:**

"I have neither given nor received aid during this examination. I have not concealed any violation of the Honor Code. I did not use any unapproved notes or electronic devices during the examination."

Possible Points	Score	
Problem 1	25	_____
Problem 2	25	_____
Problem 3	25	_____
Problem 4	25	_____
TOTAL	100	_____

** **Figure 1** below shows two views of a two-story steel building which is to be used for Problems 1 and 2.

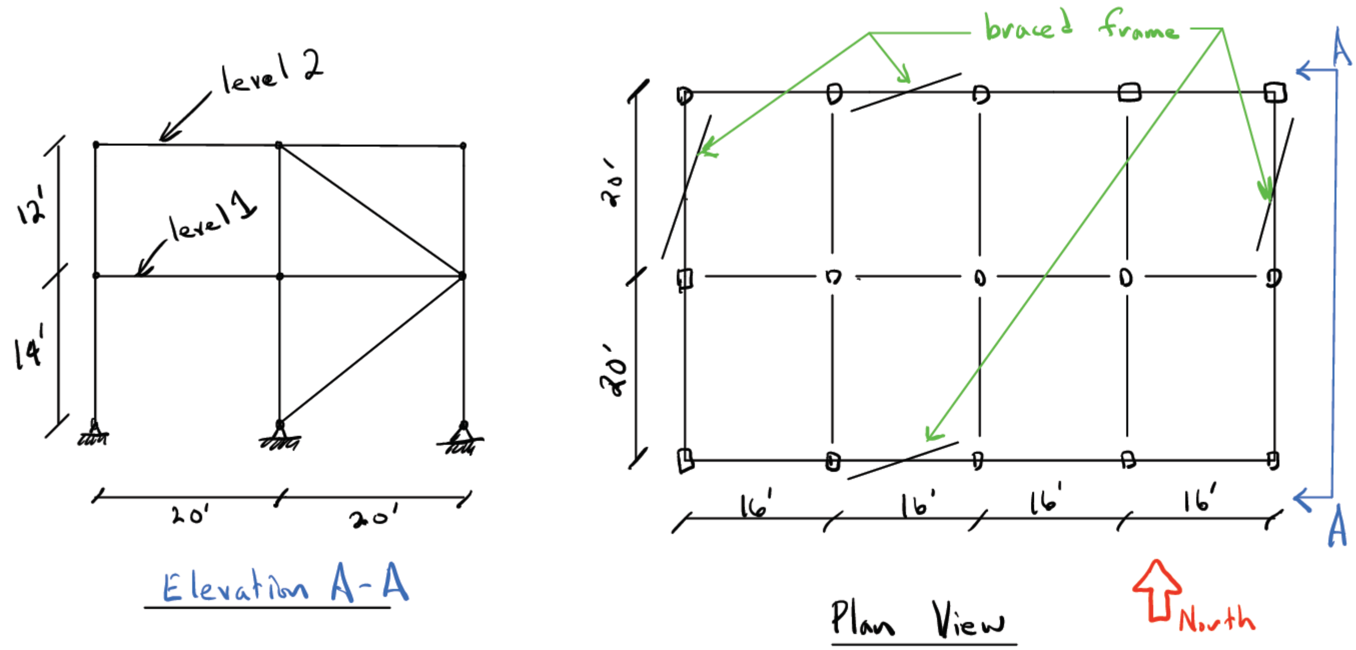

Figure 1

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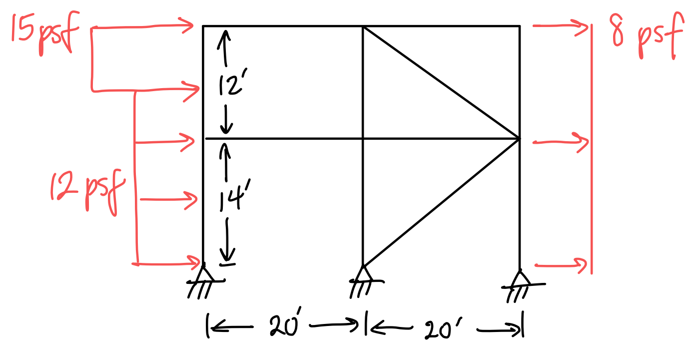
Problem 1 (25 points) – The enclosed building in Figure 1 needs to be designed for wind load. Only consider wind coming from the north. Assume that the windward pressure is 15 psf at level 2 and 12 psf at the level 1, and that the leeward pressure is 8 psf.

(a) Calculate the total base shear due to wind loading.

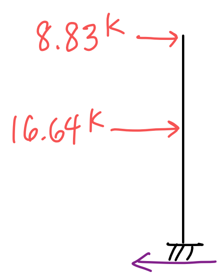
(b) Determine the minimum column dead load (at the base of the column) required to ensure that no column uplifts due to wind loading. Use only the load combination: 0.9D + 1.0W

(a) Given windward p:



Level	Δh	h_i	h_{trib}	Σp_i (psf)	f_i (plf)	F_i (k)
2	12′	26′	6′	23	138	8.83
1	14′	14′	13′	20	260	16.64

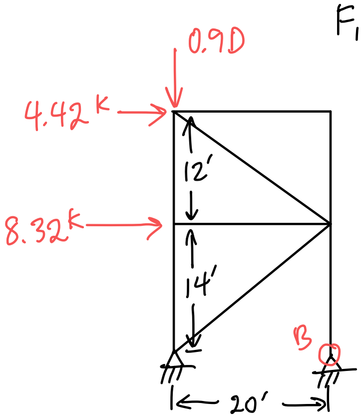
trib. width = 64′



$V_{base} = 25.5^k$

(b) Forces on 1 brace: $F_2 = 8.83/2 = 4.42^k$

$F_1 = 16.64/2 = 8.32^k$



$$\circlearrowleft + \Sigma M_B = 0 = (4.42^k)(26') + (8.32^k)(14') - 0.9D(20')$$

$D = 12.9^k$

Problem 2 (25 points) – The steel building in Figure 1 needs to be designed for seismic loads. The seismic weights of the levels have been calculated for you as:

- Level 1: W_1 = 400 kips
- Level 2: W_2 = 300 kips

(a) The following values are given for the building site: S_{DS} = 1.3g, S_{D1} = 0.65g
  - Using Table 8 of the reader (copied below), determine S_a for the building.

(b) The governing seismic response coefficient has been calculated for you as C_s = 0.22. Considering earthquake loading in the North-South direction, determine the seismic design force in one of the top-level diagonal braces.

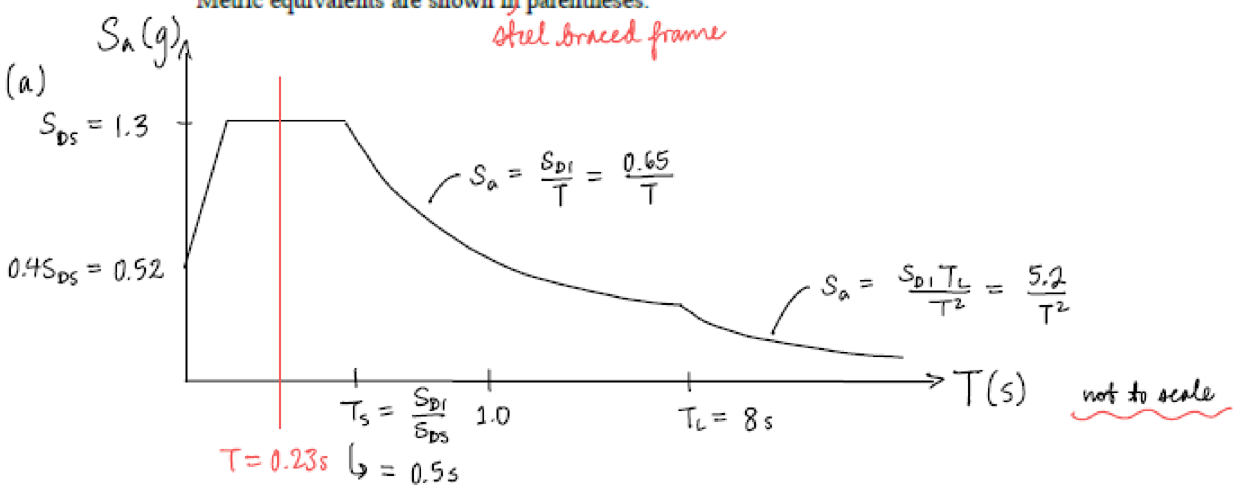
Table 11.8 Values of approximate period parameters C_t and x

Structure Type	C_t	x
Steel moment-resisting frames	0.028 (0.0724)[a]	0.8
Concrete moment-resisting frames	0.016 (0.0466)[a]	0.9
Steel eccentrically braced frames	0.03 (0.0731)[a]	0.75
Steel buckling-restrained frames	0.03 (0.0731)[a]	0.75
All other structural systems	0.02 (0.0488)[a]	0.75

[a]Metric equivalents are shown in parentheses.

steel braced frame

(a)



$T_a = C_t h_n^x = 0.02\,(26')^{0.75} = 0.23$ sec

$\rightarrow$ $S_a(T = 0.23\,s) = 1.3\,g$

(b) Given $C_s = 0.22$

$W = 400 + 300 = 700^k$

$V = C_s W = 0.22 \cdot 700 = 154^k$

Level	w_i	h_i	$w_i h_i^k$
2	300	26'	7800^k
1	400	14'	5600^k
		$\Sigma \rightarrow$	$13{,}400^k$

k = 1 for T = 0.23 sec

$F_2 = \frac{7800}{13{,}400} \cdot 154^k = 89.6^k$

$V_2 = F_2/2 = 44.8^k$ (story shear in 1 frame)

$F_{D_2} = V_2\left(\sqrt{544}'/20'\right) = 52.3^k$

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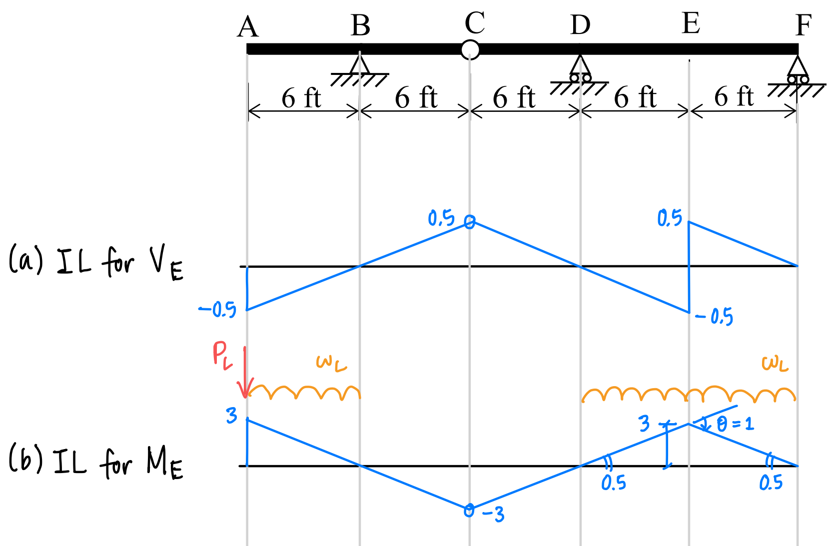
Problem 3 (25 points) –The beam shown is subjected to a single point live load of 2 kips that can be applied anywhere and a 1 klf distributed live load which can be applied to any portion of the beam. All loads only act downwards.

(a) Draw the influence line for the shear at point E.

(b) Draw the influence line for the moment at point E.

(c) Determine the maximum magnitude (either positive or negative) of the moment at point E due to the moveable live loads.



(c) $M_{max} = (1\ \text{klf})\left(\frac{1}{2}\times 6'\times 3 + \frac{1}{2}\times 12'\times 3\right) + (2^k)(3)$

$= \boxed{33\ \text{k-ft}}$

Problem 4 (25 points) – A beam supported by a cable at point C is shown in Figure 3. The axial stiffness of the cable is EA = 4000 kips. The bending stiffness of the beam is $EI = 5\text{x}10^6$ kip-in^2. Assume the beam is axially rigid, which means that the axial extension of the beam is zero.

A 10 kip point load is applied at point B resulting in a cable tension of $5\sqrt{2}$ kips, as shown.

Use the method of virtual work to determine the vertical displacement of point B due to bending of the beam and extension of the cable.

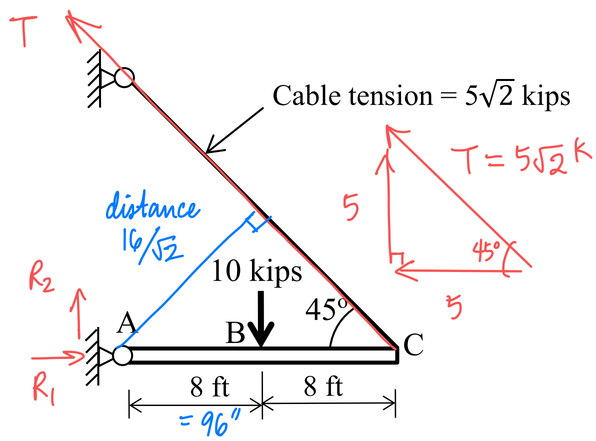
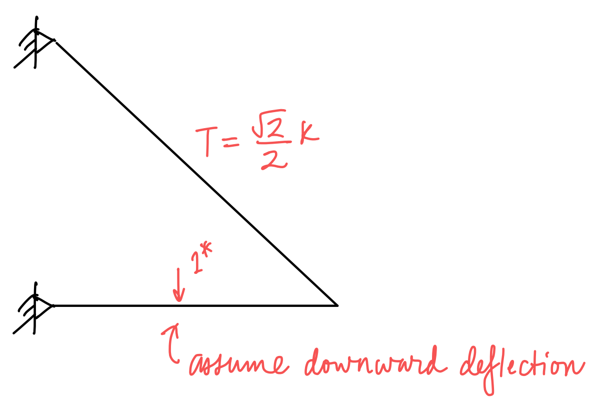


Figure 3

Virtual system:



Real system reactions:

$$\overset{+}{\rightarrow}\Sigma F_x = 0 = R_1 - 5^K$$

$$R_1 = 5^K$$

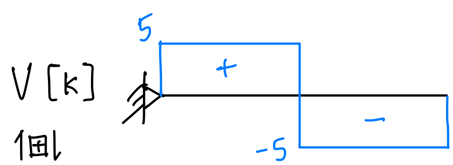
$$+\uparrow\Sigma F_y = 0 = R_2 + 5^K - 10^K$$

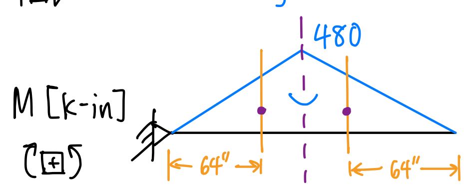
$$R_2 = 5^K$$

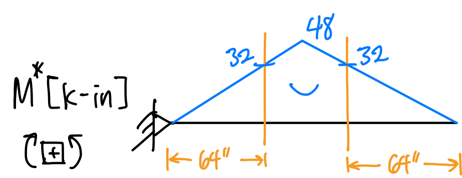
Virtual system reactions are real rxns/10

$$R_1^* = 0.5^K$$

$$R_2^* = 0.5^K$$







$$\delta W_{ext} = 1^* \times \delta_B = \delta W_{int} = p^*\left(\frac{PL}{EA}\right) + \sum_i \frac{1}{EI} A_{mi} M^*_{\bar{x}mi}$$

$$= \left(\frac{\sqrt{2}}{2}\right)\left(\frac{5\sqrt{2}\cdot 192\sqrt{2}}{4000^k}\right) + 2\left[\frac{1}{5\times10^6}\left(\frac{1}{2}\times 480 \times 96\right)(32)\right]$$

$$= 0.339 + 0.295$$

$$\boxed{\delta_B = 0.634 \text{ in.} \downarrow}$$