CE 120 – Spring 2018
Instructor: Abe Lynn

Name: SOLUTION

CE 120 – Structural Engineering

Mid-Term Examination No. 1

Instructions:

- Read these instructions. Do not open the exam until instructed to do so.
- This exam is closed notes and closed book. You are permitted to use writing and drawing instruments, a calculator, and a watch or other timepiece. Phones and other electronic devices are not permitted.
- Work all problems. Pace yourself so that you have time to work on each problem. Show all relevant work.
- Start solutions alongside or immediately following problem statements. If additional space is required, insert additional sheets. Do not show the work for more than one problem on any given sheet of paper.
- Organize and write solutions neatly. Points will be taken off for messy solutions.
- Indicate units and sign conventions in final solutions. Points will be taken off if units are missing or signs are unclear.
- If you have any questions, or need any paper or other materials, walk to the front of the classroom and ask the instructor. Do not raise your hand to get the instructor's attention, and do not call out questions from your seat.

Some potentially useful equations:

$\Sigma F_x = 0;\ \Sigma F_y = 0;\ \Sigma M = 0$

$n = r - 3m; \quad n = r - 2j$

	Possible Points	Score
Problem 1	20	_____
Problem 2	30	_____
Problem 3	25	_____
Problem 4	25	_____
TOTAL	100	_____

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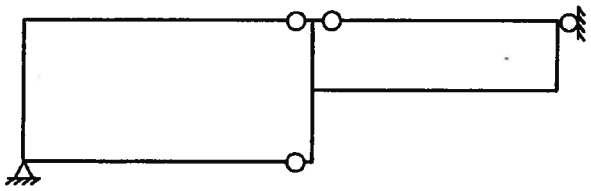
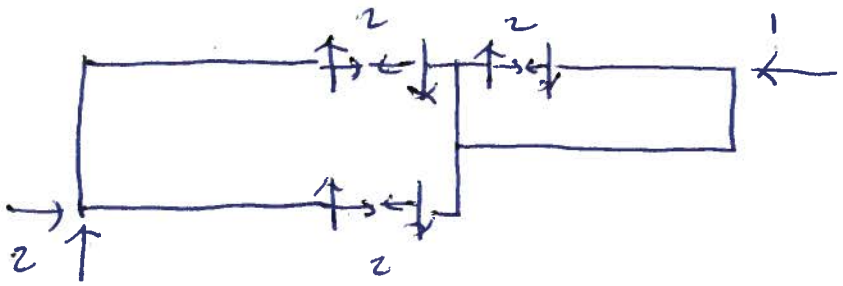
Problem 1 (20 points) – Solve the two problems below:

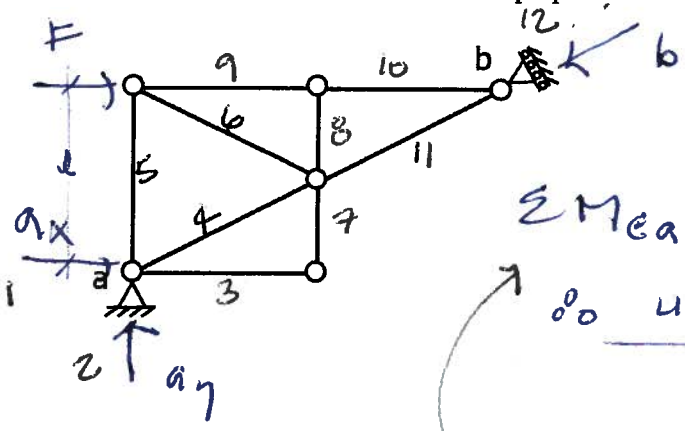
(a) Determine whether the structure is unstable, stable and determinate, or indeterminate (the circles within the structure are internal pins).



$r = 9$ UNKNOWNS
$m = 2$ RIGID BODIES
$n = r - 3m$
$= 9 - 3(2)$
$= 3°$ INDET.



(b) Determine whether the structure is unstable, stable and determinate, or indeterminate. It is braced out of plane and the surface that roller **b** sits on is perpendicular to the line formed by **ab**.



$\Sigma M_{@a} = F \cdot l \neq 0$

∴ UNSTABLE

$r = 12$
$j = 6$
$n = r - 2j$
$= 12 - 2(6)$
$= 0$ ∴ STATICALLY DETERMINATE

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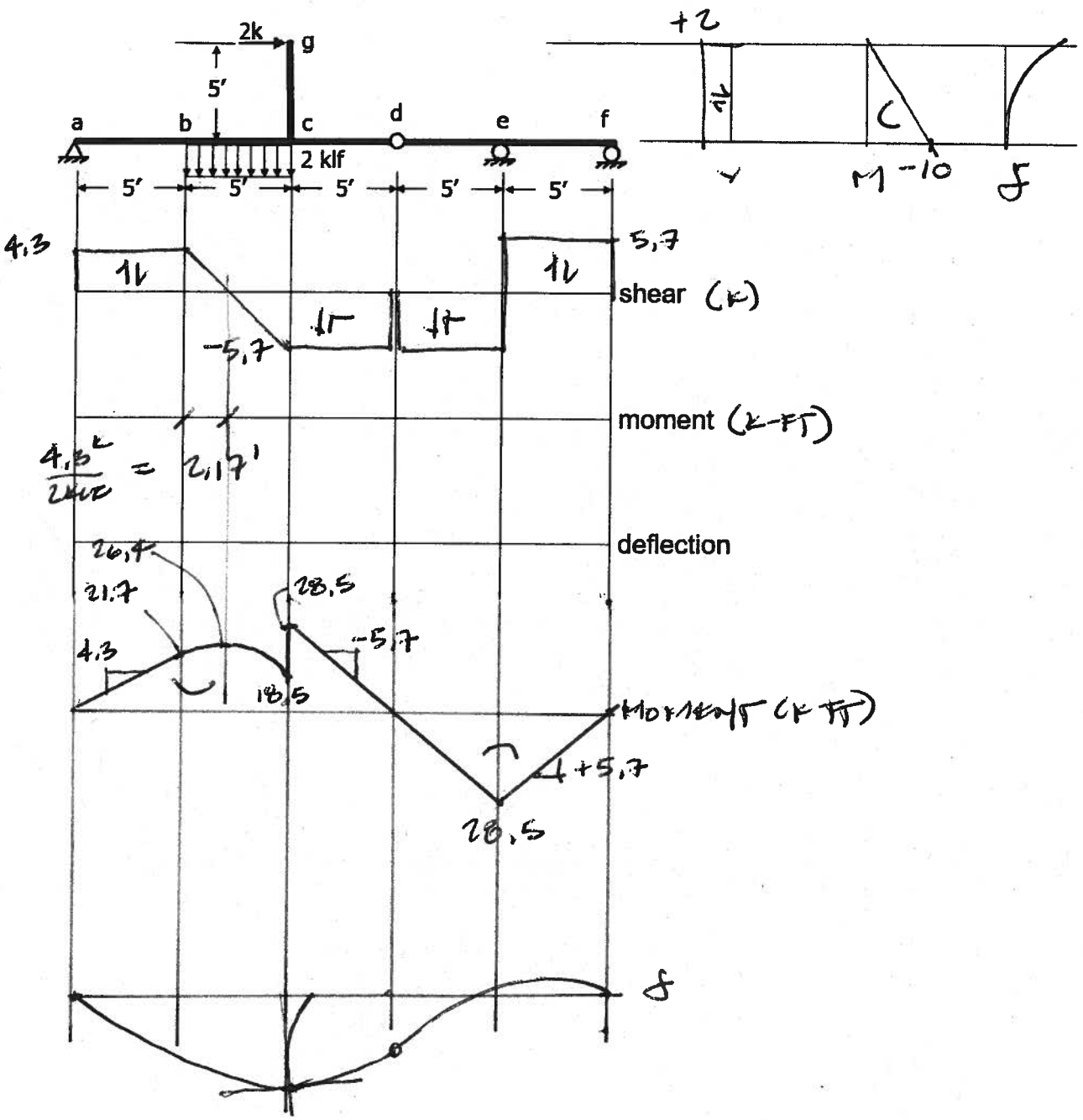
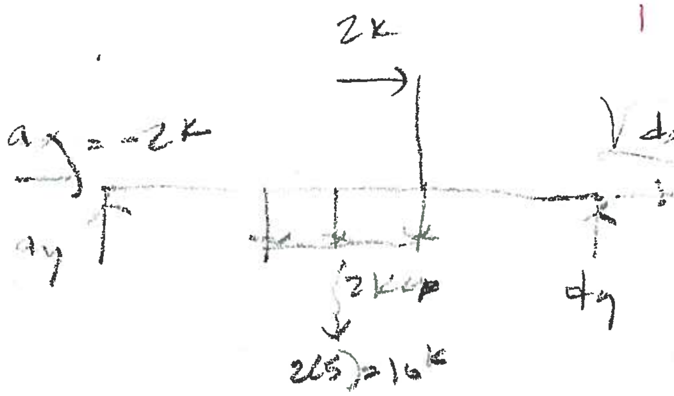
Problem 2 (30 points) – A beam supports uniformly distributed load and a point load. Draw shear and moment diagrams, labeling all local maxima, and sketch the displaced shape.



FBD ag:



$\Sigma F_x = 0 = a_x + 2K$

so $a_x = -2K$

$d_x = 0$

$\Sigma M_a = 0$

$= -2K(5') + d_y(15') - 10K(7.5')$

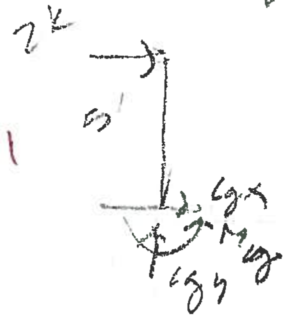
so $d_y = 5.7K$

$\Sigma F_y = 0 = -10K + 5.7K + a_y$

so $a_y = 4.3K$

4

FBD cg:



$\Sigma F_y = 0 = cg_y =$

$\Sigma F_x = 0 = cg_x + 2K$

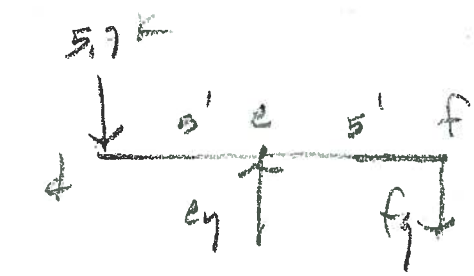
so $cg_x = -2K$

$\Sigma M_{cg} = 0 = M_{cg} - 2(5')$

$M_{cg} = 10K\text{ft}$

3

FBD def:



$\Sigma M_e = 0 = 5.7K(5') - f_y(5')$

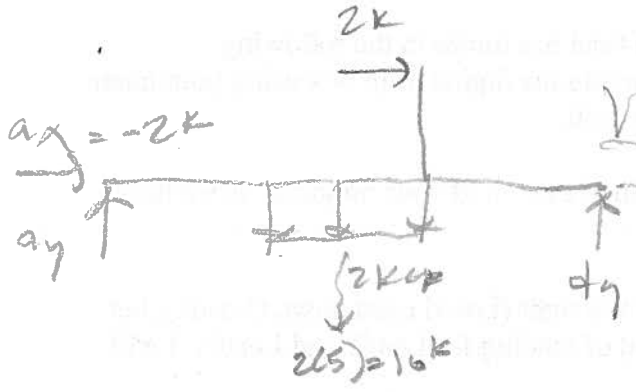
so $f_y = 5.7K$

$\Sigma F_y = 0 = -5.7 - 5.7K + e_y$

so $e_y = 11.3K$

3

FBD ag"



$\Sigma F_x = 0 = d_x + 2k$

$\therefore a_x = -2k$

$d_x = 0$

$\Sigma M_{eg} = 0$

$= -2^k(5') + d_y(15') - 10^k(7.5')$

$\therefore d_y = 5.7^k$

$\Sigma F_y = 0 = -10^k + 5.7^k + a_y$

$\therefore a_y = 4.3^k$

FBD cg"

$\Sigma F_y = 0 = c_{gy}$

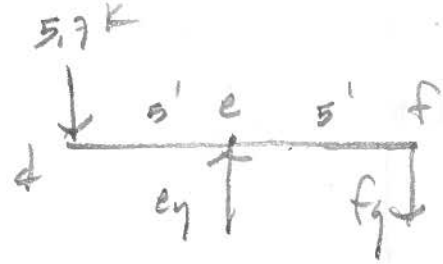
$\Sigma F_x = 0 = c_{gx} + 2k$

$\therefore c_{gx} = -2k$

$\Sigma M_{cg} = 0 = M_{cg} - 2^k(5')$

$\therefore M_{cg} = 10^{k\text{-}ft}$

FBD def"



$\Sigma M_{eg} = 0 = 5.7^k(5') - f_y(5')$

$\therefore f_y = 5.7^k$

$\Sigma F_y = 0 = 5.7^k - 5.7^k + e_y$

$\therefore e_y = 11.3^k$

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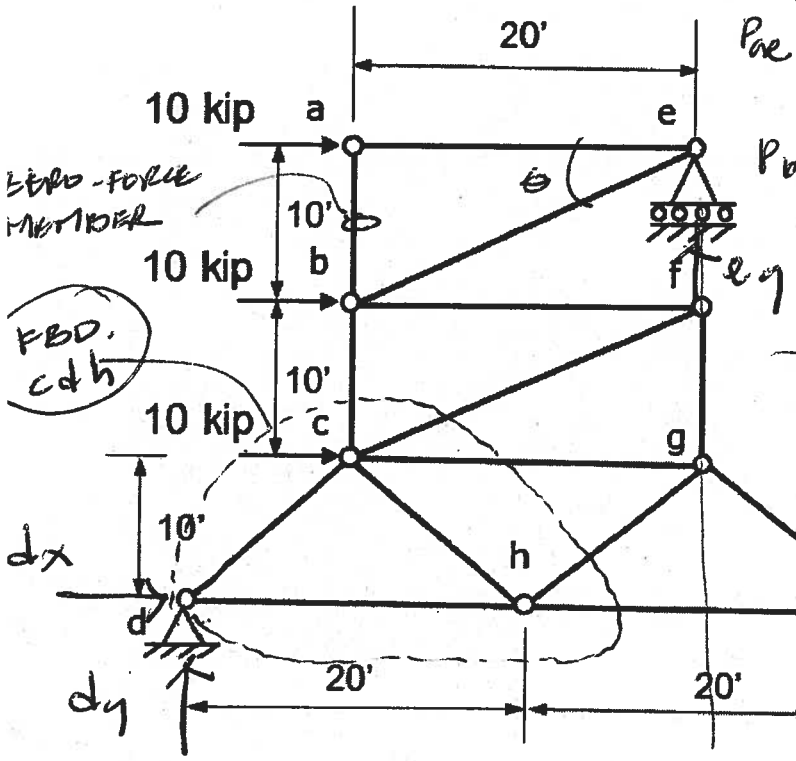
Problem 3 (25 points) – A weightless braced frame acts as a truss to resist 10-kip lateral forces at each level. Using clearly and correctly sketched free-body diagrams (the triangles at the base are equilateral):

(a) Calculate the force in member cf.

(b) Calculate the force in member cg.

$\theta = \tan^{-1}\left(\frac{10}{20}\right) = 26.56°$



OVERALL F.B.D.:

$\Sigma F_x = 0 = d_x + 10^k(3)$

$d_x = -30^k = 30^k \leftarrow$

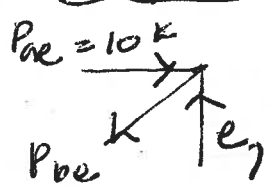
$\Sigma M_{ei} = 0 = -d_y(40') - 10^k(10') - 10^k(20') - 10^k(30') - 5^k(10')$

$d_y = -16.25^k = 16.25^k \downarrow$

$\Sigma F_y = 0 = -16.25^k + i_y$

$i_y = 11.25^k \uparrow$

JOINT e:



$\Sigma F_x = 0$

$= 10^k - P_{be}\cos\theta$

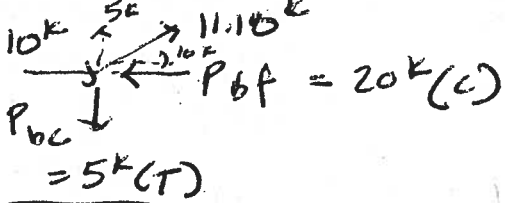
$P_{be} = 11.18^k$ (T)

$\Sigma F_y = 0$

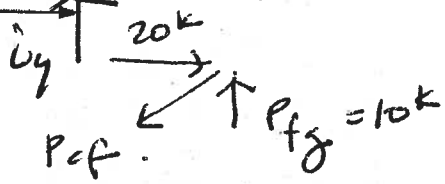
$e_y = P_{be}\sin\theta$

$e_y = 5^k \uparrow$

JOINT b:



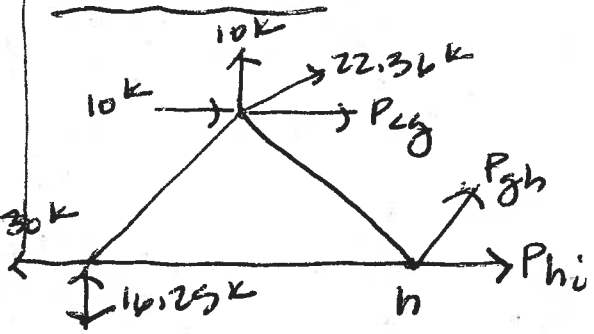
JOINT f:



$= 2(11.18^k)$

$= \boxed{22.36^k\ (T) = P_{cf}}$

FBD. cdh:



$\Sigma M_{ch} = 0 = -P_{cg}(10') - 20(10) - 10(10) - 10(10) + 16.25^k(20')$

$\therefore \boxed{P_{cg} = -32.5^k = 32.5^k\ (C)}$

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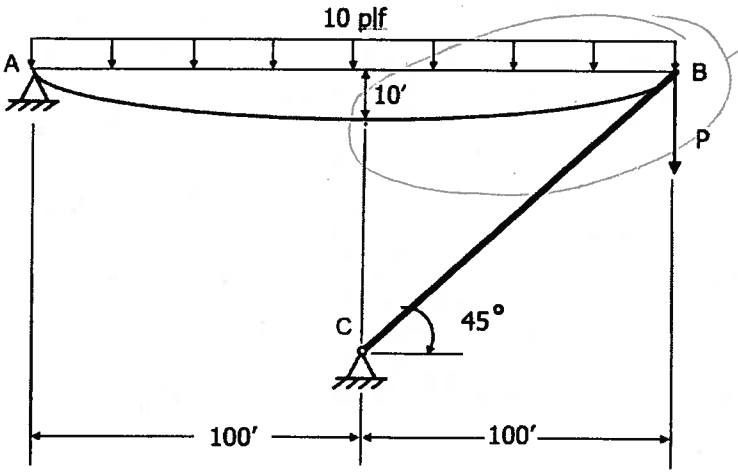
Problem 4 (25 points) A uniformly loaded cable is supported by a rigid mast, BC and the load balanced by a block of weight P. The mast is weighs 10 lb per horizontal foot of length.

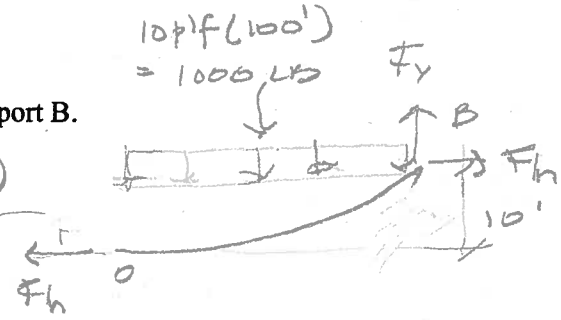
8 (a) Calculate the horizontal cable force acting on the support at A.

8 (b) Calculate the vertical cable force acting on the support at A.

9 (c) Using the given geometry, calculate the required weight P at support B.



a)



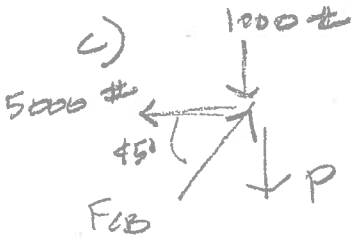
$\Sigma M_B = 0 = 1000 \text{ LBS}(50') - F_h(10')$

$\boxed{F_h = 5000 \text{ LBS} = F_{Ax}}$

b) $\Sigma M_{C_0} = 0 = F_v(100') - 1000 \text{ LBS}(50') - (5000 \text{ LBS})(10')$

$\therefore \boxed{F_v = 1000 \text{ LBS} = F_{Ay}}$

c)



$\Sigma F_x = 0 = -5000 \text{ LB} + \frac{F_{CB}}{\sqrt{2}}$

$\therefore F_{CB} = 7070 \text{ LB}$ (C)

$\Sigma F_y = 0 = -P - 1000 \text{ LB} + 5000 \text{ LBS}$

$\therefore \boxed{P = 4000 \text{ LB}}$