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

CE 120 – Structural Engineering

Mid-Term Examination No. 1

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	16	_____
Problem 2	30	_____
Problem 3	26	_____
Problem 4	28	_____
TOTAL	100	_____

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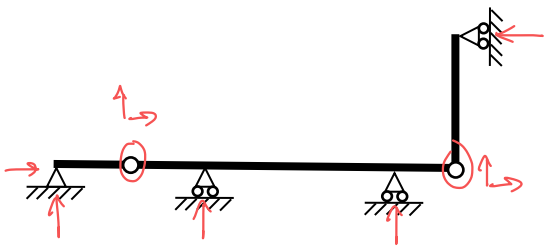
Problem 1 (16 points) – Solve the problems below:

(a) For the beam structure shown below, determine the value of n (degree of static indeterminacy), and then state whether it is statically determinate, statically indeterminate, or unstable.



$n = r - 3m$

$r = 9$

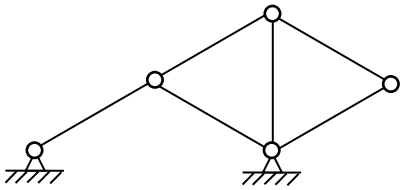
$m = 3$

$n = 9 - 3(3) = 0$

S.D., stable

(b) Determine whether each pin-jointed truss is unstable, stable and determinate, or indeterminate. They are both braced out of plane.

(i)



$n = r - 2j$

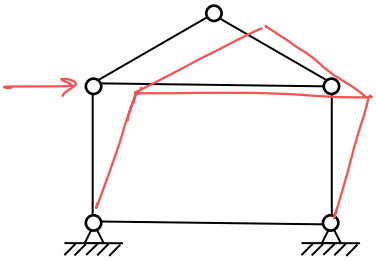
$r = b + R = 6 + 4$

$j = 5$

$n = 10 - 2(5) = 0$

S.D., stable

(ii)



$n = r - 2j$

$r = 6 + 4$

$j = 5$

$n = 10 - 2(5) = 0$

S.D. but unstable

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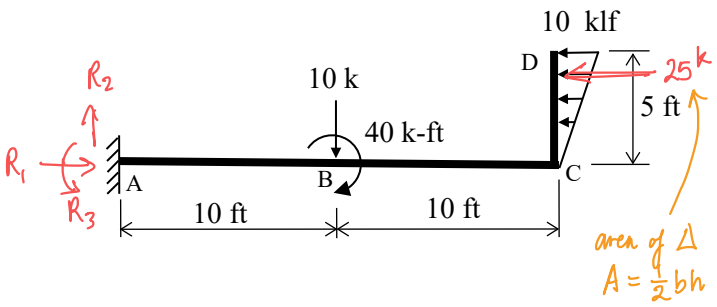
Problem 2 (30 points) – The beam shown below has a horizontal portion from A to C, and a vertical portion from C to D. The vertical portion is subjected to a linearly increasing distributed load with a maximum value of 10 klf. At point B, the beam is subjected to a point load of 10 kips and an externally applied moment of 40 kip-feet.

Draw the axial force, shear force, and bending moment diagrams. Label the peak values. Sketch the deflected shape.



area of Δ
$A = \frac{1}{2}bh$

$+\uparrow \Sigma F_y = 0 = -10 + R_2$

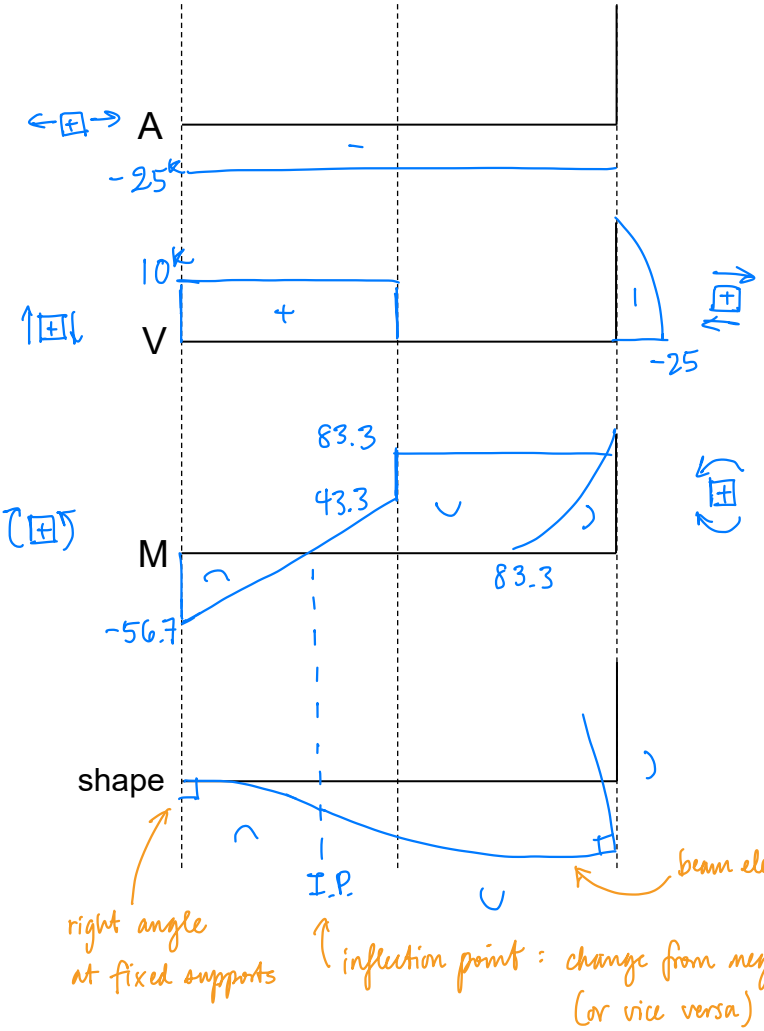
$R_2 = 10^k$

$\pm \Sigma F_x = 0 = -\frac{1}{2}(10\ klf)(5') + R_1$

$R_1 = 25^k$

$\circlearrowleft + \Sigma M_A = 0 = -R_3 + 40 + 10(10') - 25(5 \times \frac{2}{3})$

$R_3 = 140 - 83.3 = 56.7\ k\text{-}ft$



always include sign conventions
(otherwise "positive" and "negative" have no meaning)

beam elements do not experience axial shortening

right angle at fixed supports

inflection point : change from negative to positive curvature (or vice versa)

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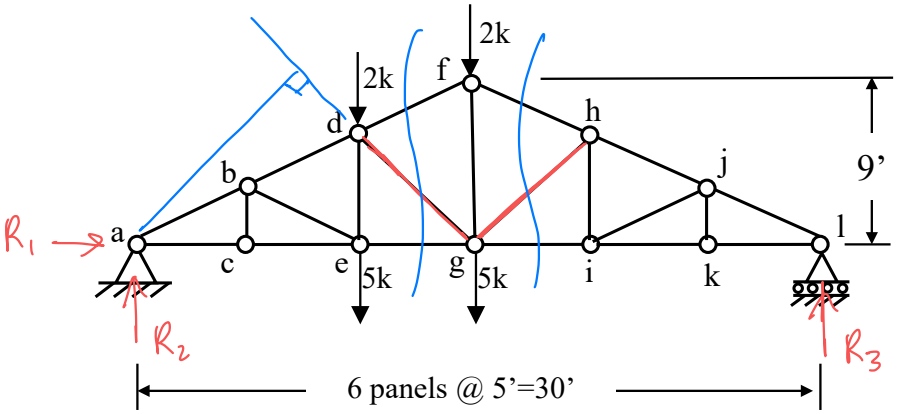
Problem 3 (26 points) – A weightless pin-jointed truss is subjected to the forces shown below. Calculate the force in members dg and gh.



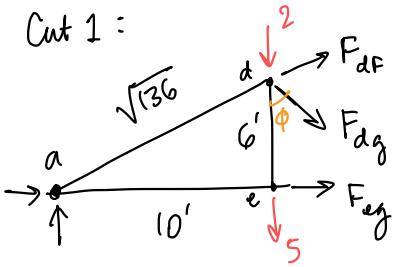
Check $n = r - 2j$

$r = 21 + 3$

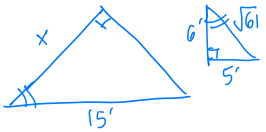
$j = 12$

$n = 24 - 2(12) = 0$ → stable, S.D.

Cut 1:



similar Δs:



$\frac{\sqrt{61}}{15} = \frac{6}{x}$

→ $x = 6(15)/\sqrt{61} = 11.52'$ (⊥ distance)

$\circlearrowleft + \Sigma M_a = 0 = (2+5)(10') + F_{dg}(11.52')$

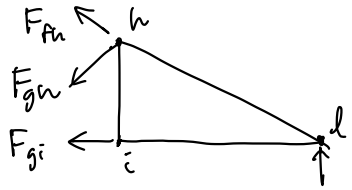
$\boxed{F_{dg} = -6.07\ k \quad \text{or} \quad 6.07\ (C)}$

OR: $\sin\phi = \frac{5}{\sqrt{61}}$, $\cos\phi = \frac{6}{\sqrt{61}}$

$\circlearrowleft + \Sigma M_a = 0 = (2+5)(10') + F_{dg}\cos\phi\,(10') + F_{dg}\sin\phi\,(6')$

$\boxed{F_{dg} = -6.07\ k\ (C)}$ same answer either way

Cut 2:



$\circlearrowleft + \Sigma M_d = 0 = F_{gh}(x_\perp)$

$\boxed{F_{gh} = 0}$

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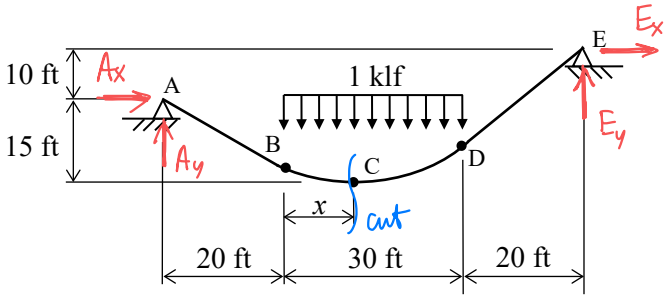
Problem 4 (28 points) – A weightless cable is subjected to a uniform load of 1 klf between points B and D. Point C represents the lowest point of the cable, which is 15 ft below point A.

Determine the horizontal position of point C, as defined by the distance labelled *x* in the diagram below.



(Note: not drawn to scale)

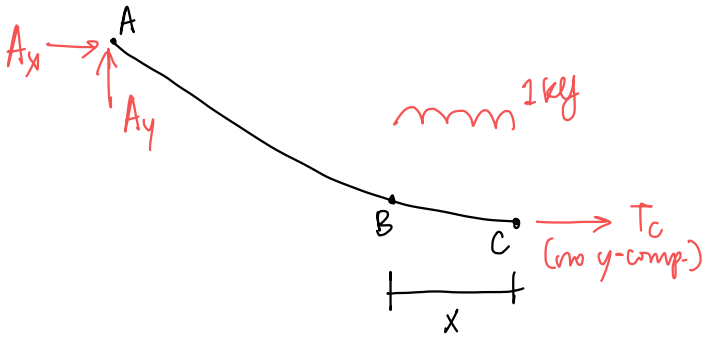
Global:

$$\circlearrowleft +\Sigma M_E = 0 = -(1\,klf)(30')(35') + A_y(70') - A_x(10')$$

$$-10A_x + 70A_y - 1050 = 0$$

$$-A_x + 7A_y - 105 = 0 \quad (1)$$

Cut at C



$$+\uparrow \Sigma F_y = 0 = A_y - 1\,klf(x) \rightarrow A_y = x$$

$$\pm \Sigma F_x = 0 = A_x + T_C \rightarrow A_x = -T_C$$

$$\circlearrowleft +\Sigma M_A = 0 = (1\,klf)(x)\left(\frac{x}{2} + 20\right) - T_C(15')$$

$$x\left(\frac{x}{2} + 20'\right) = T_C(15') \quad (2)$$

$$T_C + 7x - 105 = 0$$

$$T_C = 105 - 7x \text{ from } (1)$$

$$\frac{x^2}{2} + 20x = 15(105 - 7x)$$

$$= 1575 - 105x$$

$$\rightsquigarrow \frac{x^2}{2} + 125x - 1575 = 0$$

$$x = \frac{-125 \pm \sqrt{125^2 - 4\left(\frac{1}{2}\right)(-1575)}}{2\left(\frac{1}{2}\right)} \quad \text{(throw out negative)}$$

$$\boxed{x = 12.02'}$$