CE 120 – Spring 2020
Instructor: M.J. DeJong Name:_____

CE 120 – Structural Engineering

Mid-Term Examination No. 1

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, and a calculator. Phones and other electronic devices are not permitted.
- Do 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 may 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.

Please sign the following Honor Pledge before starting the exam:

"I have neither given nor received aid during this examination. I have not concealed any violation of the Honor Code. I did not use lecture or study notes, the Internet, or any software/program during the examination."

Signature: _____

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	18	_____
	Problem 2	26	_____
	Problem 3	26	_____
	Problem 4	30	_____
	TOTAL	100	_____

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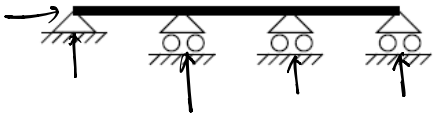
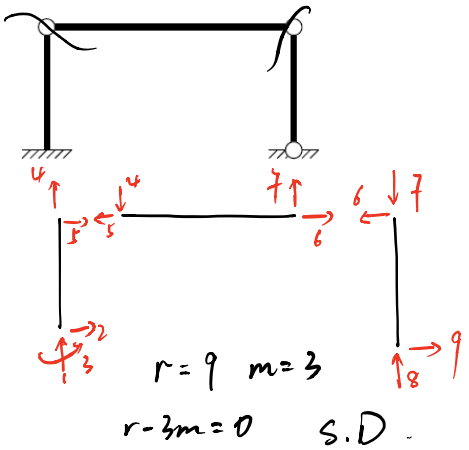
Problem 1 (18 points)

(a) For each of the two structures below, determine the value of n (degree of static indeterminacy), and then state whether it is statically determinate, statically indeterminate, or unstable. Write your answer below the structure.



$r = 5 \quad m = 1$

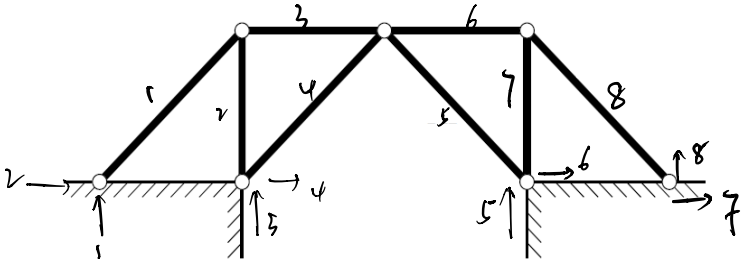
$r - 3m = 5 - 3 \times 1 = 2 > 0$. S.I .



$r = 9 \quad m = 3$

$r - 3m = 0$ S.D .

(b) The structure below is a pin-jointed truss and is to be loaded only at the joints. Determine whether the structure is unstable, stable and determinate, or indeterminate. It is braced out of plane.



$N = r - 2j$

$= (b + R) - 2j$

$= (8 + 8) - 2 \times 7$

$= 2 > 0$

check .

S.I

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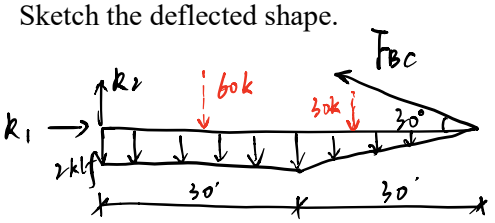
Problem 2 (26 points) – The beam shown in Figure 2 is supported by a pin at point A and a weightless cable that is attached at point B and point C. Assume the beam is weightless.

Draw axial, shear and bending moment diagrams, and label the maximum and minimum values.
Sketch the deflected shape.



$\curvearrowleft +\Sigma M_A = 60k(15') + 30k(40') - F_{BC}(\sin 30°)60' = 0$

$\rightarrow F_{BC} = 70k$

$\Sigma F_x = k_1 - F_{BC}\cos 30° = 0$

$\rightarrow k_1 = 60.62k$

$\Sigma F_y = k_2 - 60 - 30 + F_{BC}\cdot\sin 30° = 0$

$\rightarrow k_2 = 55k$

Find M_{max}.

assume M_{max} @ x ft from A

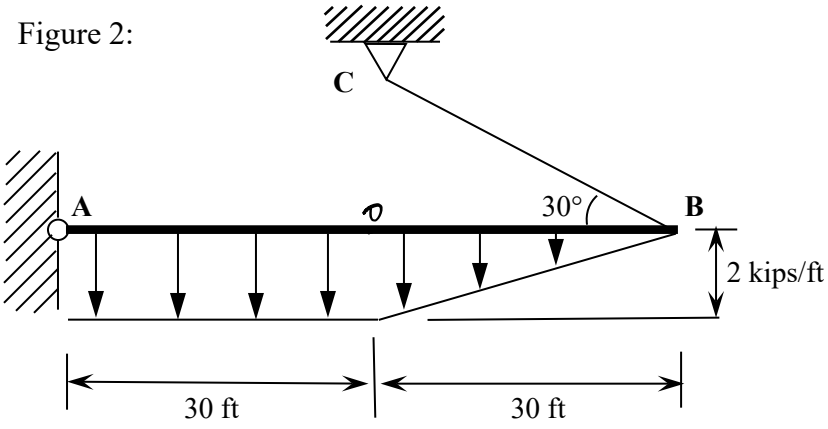
$\frac{x}{55} = \frac{30}{55-(-5)}$

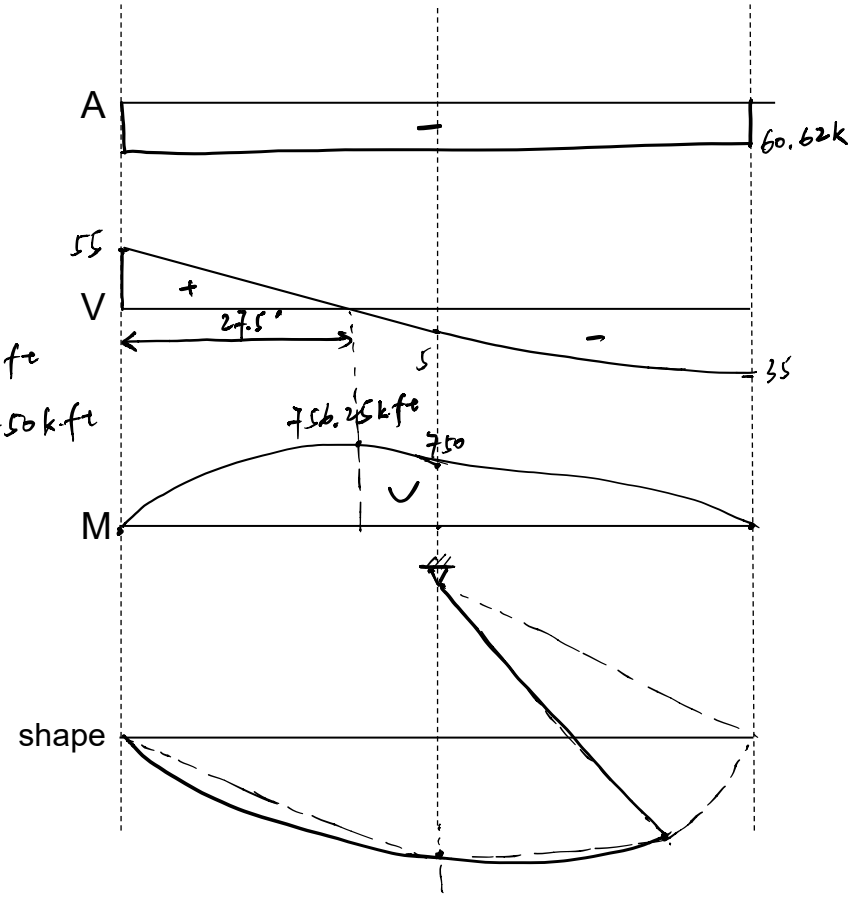
$\rightarrow x = 27.5'$

$M_{max} = 55 \times 27.5 \times \frac{1}{2} = 756.25$ k-ft

$M_0 = M_{max} - \frac{1}{2} \times 5 \times (30 - 27.5) = 750$ k-ft

Figure 2:





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Problem 3 (26 points) – Figure 3 shows a pin-jointed truss with a point load 1 kip applied at joint D.

Find the force in members AD and BD.

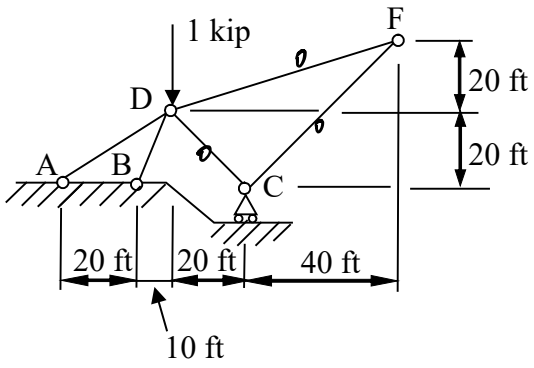
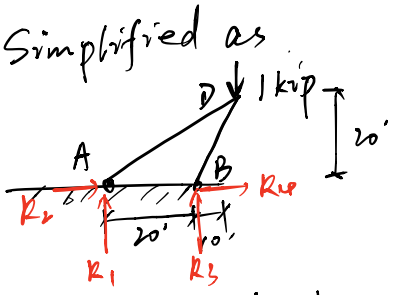


Figure 3

Simplified as



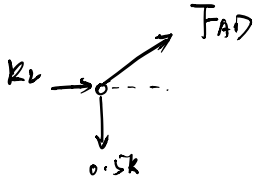
$\curvearrowleft +\Sigma M_A = 1k(30') - R_3(20') = 0$

$\rightarrow R_3 = 1.5k$

$\Sigma F_y = R_1 + R_3 - 1 = 0$

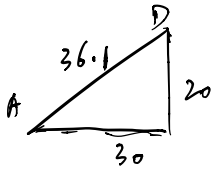
$\rightarrow R_1 = 1 - R_3 = -0.5k$

at joint A

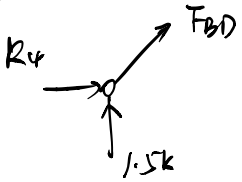


$\Sigma F_y = F_{AD} \cdot \frac{20}{36.1} - 0.5 = 0$

$\rightarrow \boxed{F_{AD} = 0.903\ k}$

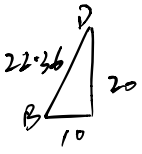


at joint B



$\Sigma F_y = F_{BD} \cdot \frac{20}{22.36} + 1.5 = 0$

$\rightarrow \boxed{F_{BD} = -1.677\ k}$



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Problem 4 (30 points) – Figure 4 shows a flexible cable attached at point O and point A. The cable is loaded vertically by a distributed load which varies linearly in intensity from *w* to 3*w* across the horizontal span *L*. Assume the cable is weightless. Point A is at height *h* above point O. The tangent of the cable is horizontal at point O.

(a) Find the tension in the cable at point O. Note that point O is at the origin of the x-y coordinate system.

(b) Derive an equation for the shape of the cable using the x-y coordinate system.

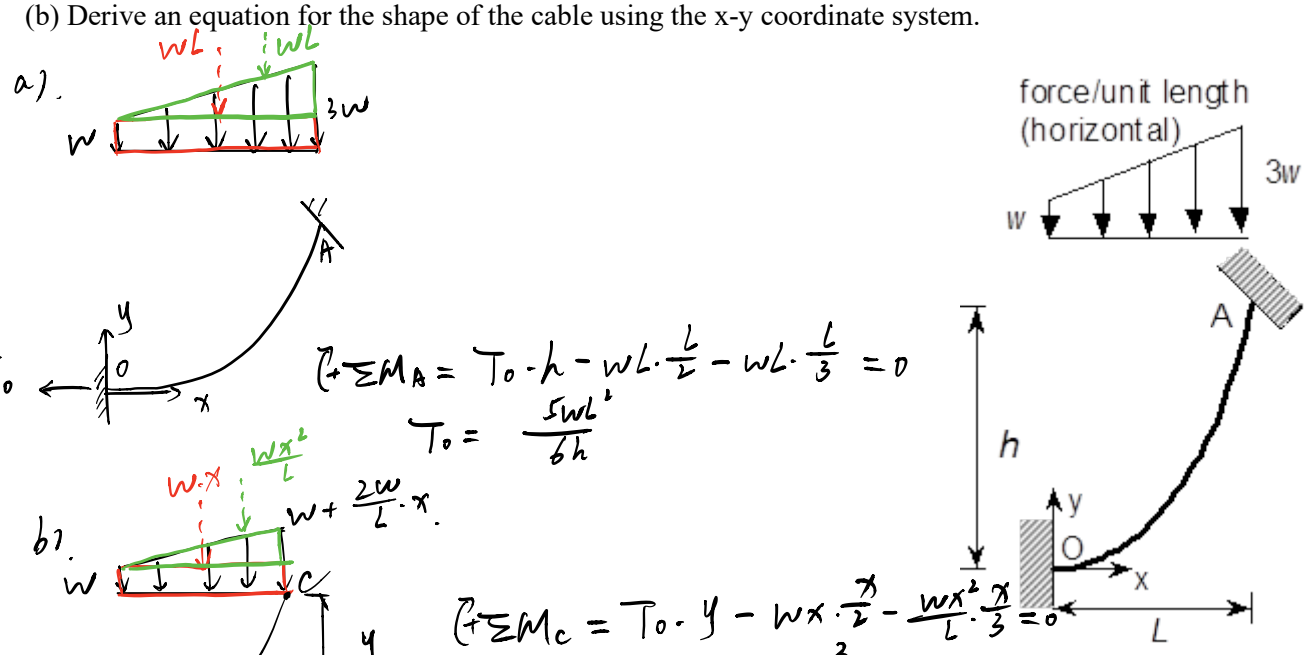

Figure 4

a)

$$\circlearrowleft \Sigma M_A = T_0 \cdot h - wL \cdot \frac{L}{2} - wL \cdot \frac{L}{3} = 0$$

$$T_0 = \frac{5wL^2}{6h}$$

b)

$$\circlearrowleft \Sigma M_C = T_0 \cdot y - wx \cdot \frac{x}{2} - \frac{wx^2}{L} \cdot \frac{x}{3} = 0$$

$$T_0 \cdot y = \frac{1}{2} wx^2 + \frac{wx^3}{3L}$$

$$y = \left(\frac{wx^2}{2} + \frac{wx^3}{3L} \right) \frac{6h}{5wL^2}$$

$$= \boxed{\frac{3h}{5L^2} \cdot x^2 + \frac{2h}{5L^3} \cdot x^3}$$