ME 270 –Spring 2014 Final Exam **NAME (Last, First): ________________________________**

Please review the following statement:

I certify that I have not given unauthorized aid nor have I received aid in the completion of this exam.

Signature: ______________________________________

INSTRUCTIONS

Begin each problem in the space provided on the examination sheets. If additional space is required, use the white lined paper provided to you.

Work on one side of each sheet only, with only one problem on a sheet.

Each problem is worth 20 points.

Please remember that for you to obtain maximum credit for a problem, it must be clearly presented, i.e.

- The coordinate system must be clearly identified.
- Where appropriate, free body diagrams must be drawn. These should be drawn separately from the given figures.
- Units must be clearly stated as part of the answer.
- You must carefully delineate vector and scalar quantities.

If the solution does not follow a logical thought process, it will be assumed in error.

When handing in the test, please make sure that all sheets are in the correct sequential order and make sure that your name is at the top of every page that you wish to have graded.

Instructor's Name and Section:

Sections: J Jones 9:30-10:20AM P Sojka 1:30-2:20PM J Silvers 3:30-4:20PM
J Jones Distance Learning

Problem 1 __________

Problem 2 __________

Problem 3 __________

Problem 4 __________

Problem 5 __________

Total ______________

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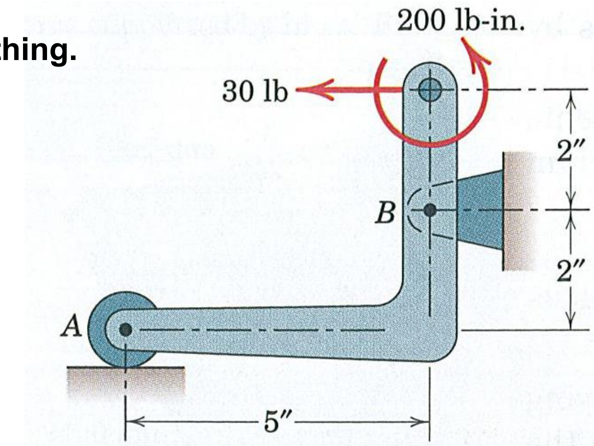
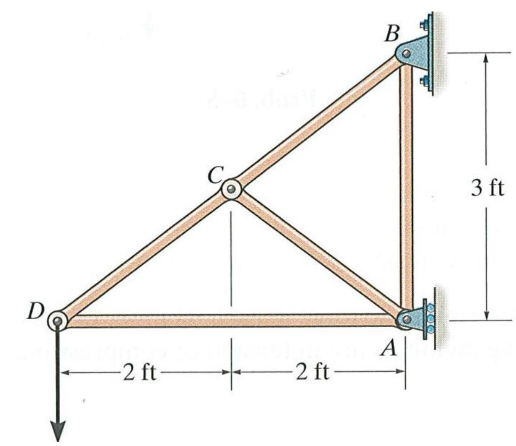
PROBLEM 1 (20 points) – Prob. 1 questions are all or nothing.

1(a) Determine the reaction forces acting on bar AB with the loading shown. Express the forces in vector form.



$\bar{A}$ =	(2 pts)
$\bar{B}$ =	(3 pts)

1(b) Determine the magnitude of the load in member CD and whether it is in tension or compression. Also list all zero-force members.



F_{CD} =	T	or	C	(3pts)
Zero-Force Members =				

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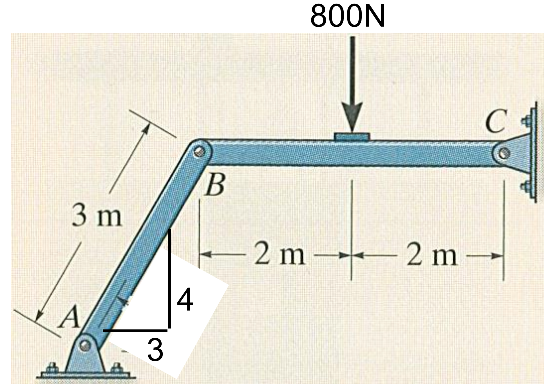
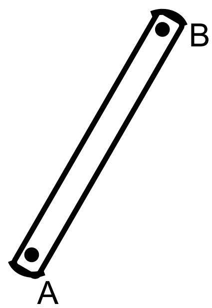
1(c) One the members provided, sketch the free body diagram of the two member frame. Determine the force F_{AB} acting on member BC in vector form.



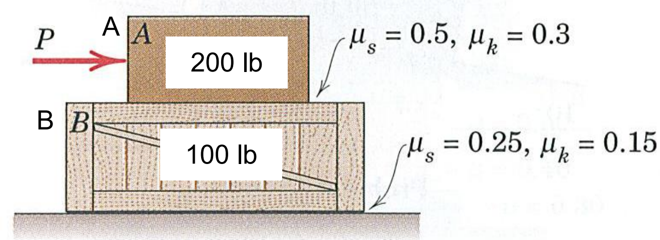
FBD (2 pts)



$\bar{F}_{AB_{\text{on BC}}} =$	(3 pts)

1(d) The force P is applied to a 200 lb block A which rests atop the 100-lb crate. The system is at rest when P is first applied. There are four possible motions.

a) Neither A nor B move
b) A moves, B doesn't
c) A and B both move as a unit
d) A and B both move, but separately



For P = 60 lbs, circle the resulting motions	a	b	c	d	(2 pts)
For P = 80 lbs, circle the resulting motions	a	b	c	d	(3 pts)

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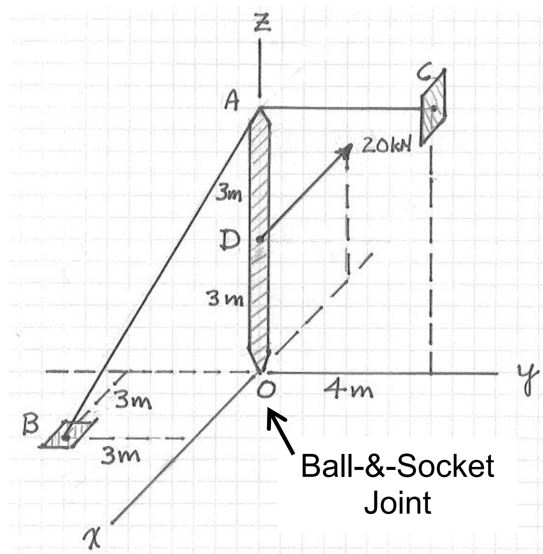
PROBLEM 2 (20 points)

Given: A small tower has a 20 kN load as shown and is held in static equilibrium by a ball-and-socket support at O and cables AB and AC. Neglect the weight of the tower.



Find:

a) Complete the free-body diagram of the boom on the sketch provided below. (4 pts)

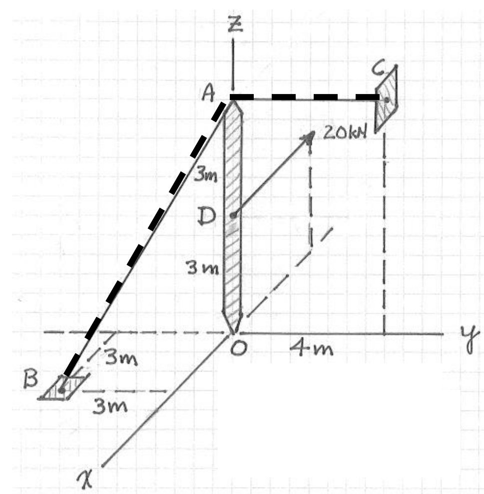
b) Express the tension in cables $\bar{T}_{AB}$ and $\bar{T}_{AC}$ in terms of their known unit vectors and their unknown magnitudes. (4 pts)

c) Determine the magnitudes of the tensions in cables T_{AB} and T_{AC}. (6 pts)

d) Determine the vector reaction at the ball-and-socket support at O. (6 pts)

a)

a) Free-body diagram (4 pts)



b)

b) $\bar{T}_{AB}$ = (2 pts)

$\bar{T}_{AC}$ = (2 pts)

c)

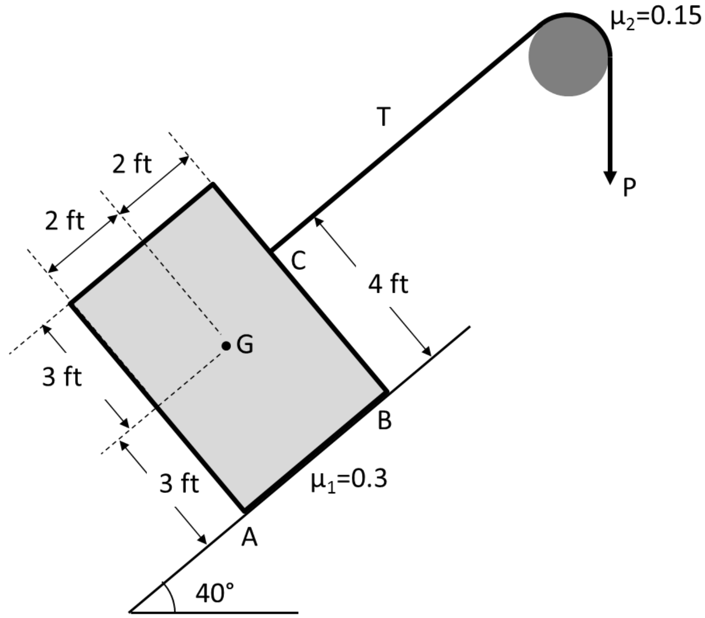
c)	T_{AB} =	(3 pts)
	T_{AC} =	(3 pts)

d)

d)	$\bar{O}$ =	(6 pts)

PROBLEM 3 (20 points)

The 60 lb block shown is held up by a cable, which wraps around a fixed drum, and has an applied force, P. Between point C and the drum, the cable has a tension, T.



First, consider just the block:

a) Determine the minimum tension, T_{tip}, needed to prevent the block from tipping. Your solution must include a free body diagram. (7 pts)

b) Determine the minimum tension, T_{slip}, required to prevent the block from slipping. Your solution must include a free body diagram. (7 pts)

c) In order to prevent motion, what is the minimum tension in the cable? Is the block on the verge of tip or slip? (2 pts)

Now, consider the cable wrapping around the drum.

d) What force, P, must be applied to the cable in order to prevent motion of the block? (4 pts)

a) FBD for Tipping case
T_{tip} =

b) FBD for Slipping case

T_{slip} =

c) T =

Tip or Slip (circle one)

d) P =

PROBLEM 4 (20 points) Prob. 4 questions are all or nothing

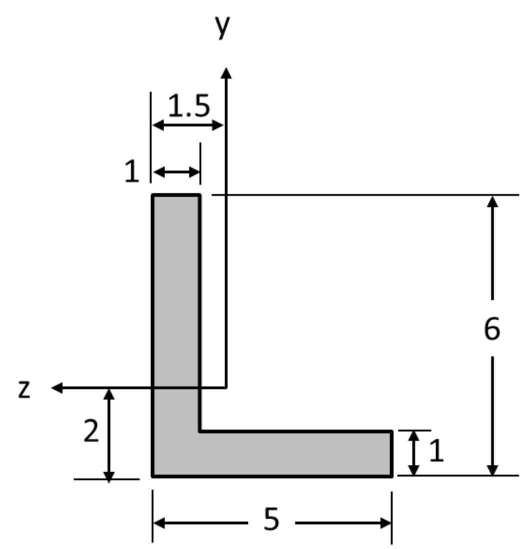
4A. In your own words, state each of Newton's three laws of motion. Be sure to write legibly. Unreadable definitions will be marked wrong. (6 pts)

1st Law =

2nd Law =

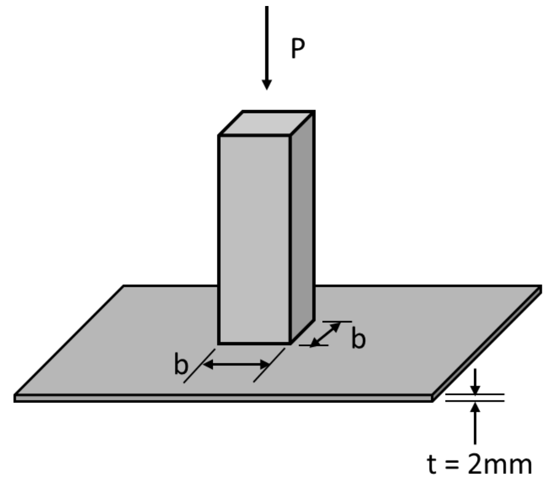
3rd Law =

4B. Determine the second area moment, I_Z, of the L-beam shown as it rotates about the z-axis. Dimensions are given in inches.



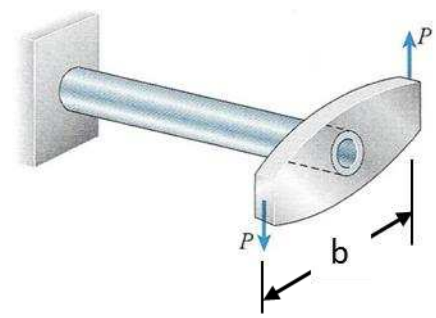
$I_Z =$ (4 pts)

4C. Square holes, where each side has a length b = 10 cm, are being punched out of a 2 mm thick metal plate. The punching shear resistance of the plate is 250 MPa. Determine the force, P, necessary to punch out the square.



P =	(4 pts)

4D. A circular tube of inner radius 39 mm and outer radius 44 mm is subjected to a torque produced by the pair of forces P = 420N. The forces are separated by a distance b = 300 mm. Determine the shear stress at the outer and inner walls of the tube; give the answer in Pa. Determine the shear strain at the outer wall of the tube. E = 52 GPa, ν = 0.30, G = 20 GPa.



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$\tau_{\text{outer}} =$	Pa	(2 pts)
$\tau_{\text{inner}} =$	Pa	(2 pts)
$\gamma_{\text{outer}} =$		(2 pts)

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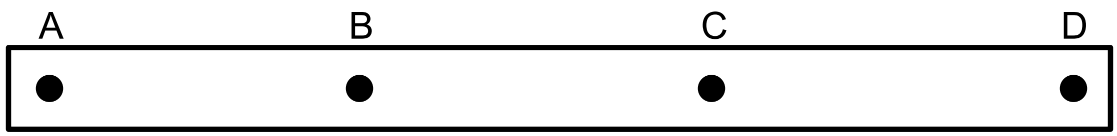
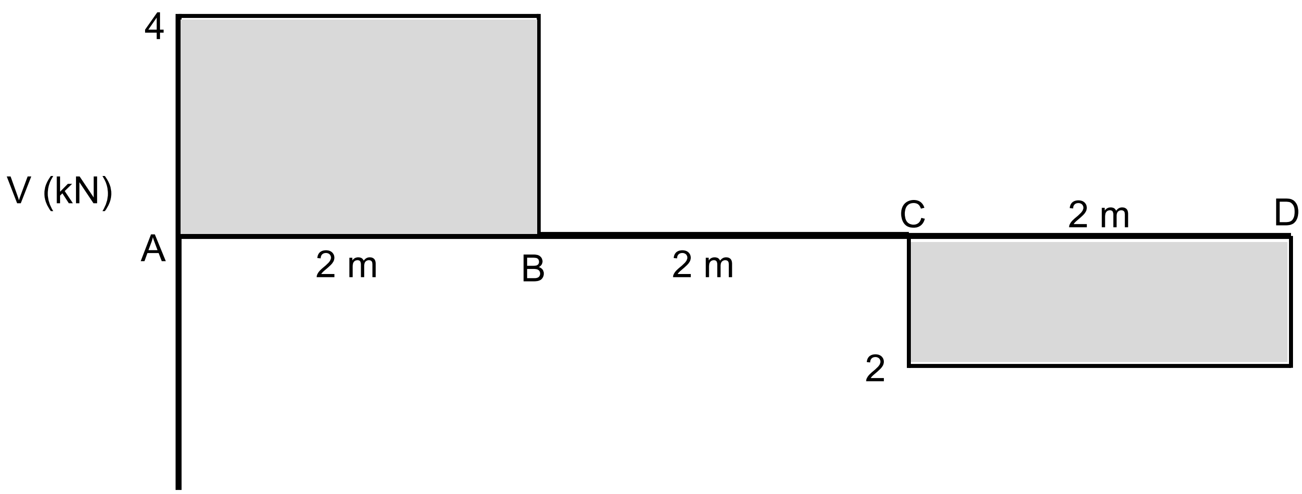
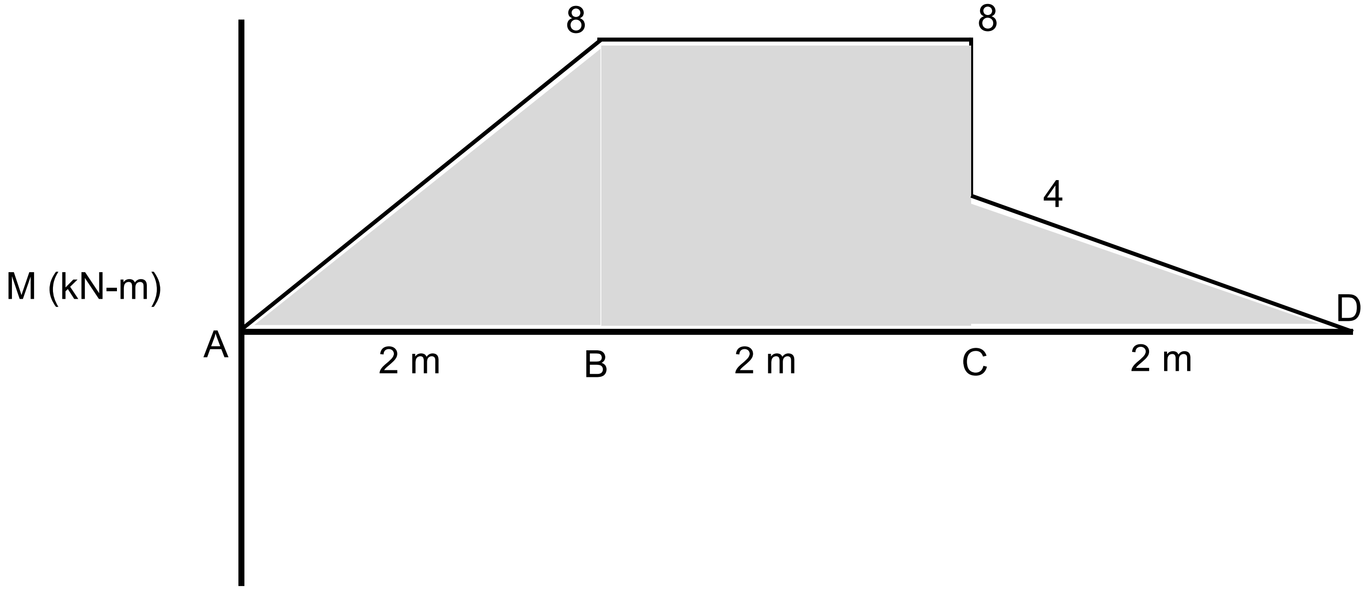
Problem 5. (20 pts)

Given: Beam ABCD is held in static equilibrium by a pin joint at A and a roller support at D. The loading on the beam is such that it results the given shear-force and bending-moment diagrams provided below. Assume there is no loading in the x-direction.

Find: See the following page.





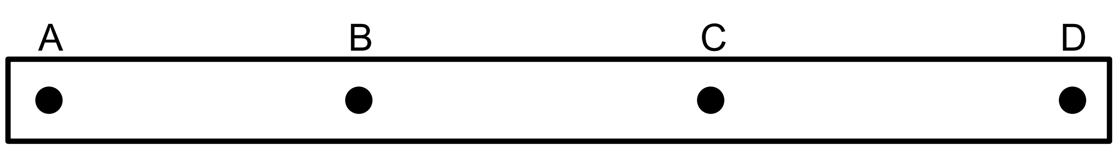


Prob 5 Cont.

5a. Assuming no external loads exist at supports A and D, determine the magnitudes of the reactions at these supports based on the diagrams provided. Express the results in vector form. Explain briefly how you arrived at these values based on the shear-force and bending moment diagrams provided.

a)	$\bar{A} =$	(2 pts)
	$\bar{D} =$	(2 pts)

5b. Given the shear-force and bending-moment diagrams provided, sketch a valid loading condition that would be consistent with these diagrams. On the beam provided, show the magnitude direction, and location of all loads needed to create the shear-force and bending-moment diagrams provided. Explain briefly how you arrived at these values based on the diagrams provided. (9 pts)



Prob 5 Cont.

5c. If the beam has a tubular cross-section with an outer diameter of 10 cm and an inner diameter of 8 cm, determine the second moment of area for bending about the centroid of the tube (**Hint** – this is bending, not torsion).

c)	I_z =	(3 pts)

5d. In the segment of the beam that exhibits pure bending, determine the maximum tensile stress. Circle the location of the maximum tensile stress.

d)	σ_{Max} =					(3 pts)
	Max Tension	(Circle One)	Top	Bottom	Middle	(1 pts)

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Normal Stress and Strain

$$\sigma_x = \frac{F_n}{A}$$

$$\sigma_x(y) = \frac{-My}{I}$$

$$\varepsilon_x = \frac{\sigma_x}{E} = \frac{\Delta L}{L}$$

$$\varepsilon_y = \varepsilon_z = -\vartheta\varepsilon_x$$

$$\varepsilon_x(y) = \frac{-y}{\rho}$$

$$FS = \frac{\sigma_{fail}}{\sigma_{allow}}$$

Shear Stress and Strain

$$\tau = \frac{V}{A}$$

$$\tau(\rho) = \frac{T\rho}{J}$$

$$\tau = G\gamma$$

$$G = \frac{E}{2(1+\vartheta)}$$

$$\gamma = \frac{\delta_s}{L_s} = \frac{\pi}{2} - \theta$$

Second Area Moment

$$I = \int_A y^2 dA$$

$$I = \frac{1}{12}bh^3 \quad \text{Rectangle}$$

$$I = \frac{\pi}{4}r^4 \quad \text{Circle}$$

$$I_B = I_O + Ad_{OB}{}^2$$

Polar Area Moment

$$J = \frac{\pi}{2}(r_o^4 - r_i^4) \quad \text{Tube}$$

Shear Force and Bending Moment

$$V(x) = V(0) + \int_0^x p(\epsilon)d\epsilon$$

$$M(x) = M(0) + \int_0^x V(\epsilon)d\epsilon$$

Buoyancy

$$F_B = \rho g V$$

Fluid Statics

$$p = \rho g h$$

$$F_{eq} = p_{avg}(Lw)$$

Belt Friction

$$\frac{T_L}{T_S} = e^{\mu\beta}$$

Distributed Loads

$$F_{eq} = \int_0^L w(x)dx$$

$$\bar{x}F_{eq} = \int_0^L x\, w(x)dx$$

Centroids

$$\bar{x} = \frac{\int x_c dA}{\int dA}$$

$$\bar{y} = \frac{\int y_c dA}{\int dA}$$

$$\bar{x} = \frac{\sum_i x_{ci}A_i}{\sum_i A_i} \qquad \bar{y} = \frac{\sum_i y_{ci}A_i}{\sum_i A_i}$$

In 3D, $\bar{x} = \dfrac{\sum_i x_{ci}V_i}{\sum_i V_i}$

Centers of Mass

$$\tilde{x} = \frac{\int x_{cm}\rho dA}{\int \rho dA} \qquad \tilde{y} = \frac{\int y_{cm}\rho dA}{\int \rho dA}$$

$$\tilde{x} = \frac{\sum_i x_{cmi}\rho_i A_i}{\sum_i \rho_i A_i}$$

$$\tilde{y} = \frac{\sum_i y_{cmi}\rho_i A_i}{\sum_i \rho_i A_i}$$

Spring 2014 Final Exam Solutions

1A. $\bar{A} = 52\bar{j}$ lbs $\bar{B} = 30\bar{i} - 52\bar{j}$ lbs

1B. $F_{CD} = 1000$ lbs Tension Zero-Force Members = AC, AB

1C. $\bar{F}_{AB_{onBC}} = 300\bar{i} + 400\bar{j}$ N

1D. a c

2A. Free-body diagram

2B. $\bar{T}_{AB} = T_{AB}(0.408\bar{i} - 0.408\bar{j} - 0.816\bar{k})$ $\bar{T}_{AC} = T_{AC}\,\bar{j}$

2C. $T_{AB} = 24.5$ kN $T_{AC} = 10.0$ kN

2D. $\bar{O} = 10\bar{i} + 20\bar{k}$ kN

3A. Free-body diagram $T_{tip} = 5.94$ lb

3B. Free-body diagram $T_{slip} = 24.78$ lb

3C. $T = 24.78$ Slip

3D. P = 17.63 lb

4A. Newton's Three Laws of Motion

4B. $I_z = 33.33$ in^4

4C. P = 200 kN or 200,000 N

4D. $\tau_{outer} = 2{,}464{,}000$ Pa $\tau_{inner} = 2{,}184{,}000$ Pa $\gamma_{outer} = 1.232 \times 10^{-4}$ $({}^{m}/_{m})$

5A. $\bar{A} = 4\bar{j}$ kN $\bar{D} = 2\bar{j}$ kN

5B. Sketch of valid loading condition and explanations for values based on the diagram

5C. $I_z = 290$ cm^4 $= 2.90 \times 10^{-6}$ m^4

5D. $\sigma_{Max} = 138$ M Pa Max Tension = bottom