ME 270 – Fall 2017 Final – Exam **NAME (Last, First):** ________________________________

Please indicate your group number ____________ **(If applicable)**

Circle Your Instructor's Name and Section:

MWF 8:30-9:20 AM	Prof. Kai Ming Li	MWF 2:30-3:20 PM	Prof. Fabio Semperlotti
MWF 9:30-10:20 AM	Prof. Jim Jones	MWF 4:30-5:30 PM	Prof. Vahid Zeinoddini Meimand
MWF 11:30-12:20 PM	Prof. Daniel Hoyniak	TTH 9:00-10:15 AM	Prof. Morgan Murphy
MWF 12:30-1:20 PM	Prof. Adrian Buganza Tepole	Distance Learning	Prof. Jim Jones

Please review and sign the following statement:

Purdue Honor Pledge – "As a Boilermaker pursuing academic excellence, I pledge to be honest and true in all that I do. Accountable together – We are Purdue."

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.,

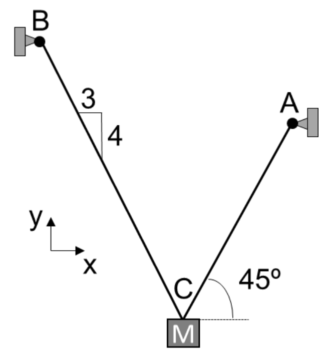
- The only authorized exam calculator is the TI-30XIIS or the TI-30Xa.
- The allowable exam time for the Final Exam is 120 minutes.
- The coordinate system must be clearly identified.
- Where appropriate, free body diagrams must be drawn. These should be drawn separately from the given figures.
- Units must be clearly stated as part of the answer.
- You must carefully delineate vector and scalar quantities.
- Please use a **black pen** for the exam.

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.

PROBLEM 1 (20 points)

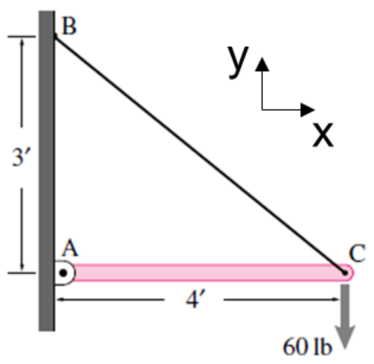
1A. A mass M producing a force of 100 N is suspended using two inextensible cables. **Find** the forces in the cables CA and CB and express them in vector form.



$\vec{F}_{CB} = (\qquad\qquad)\hat{\imath} + (\qquad\qquad)\hat{\jmath}$	(2 pts)
$\vec{F}_{CA} = (\qquad\qquad)\hat{\imath} + (\qquad\qquad)\hat{\jmath}$	(2 pts)

1B. The bar AC is pinned at point A and connected to an inextensible wire at C. A load of 60lb is applied at point C.

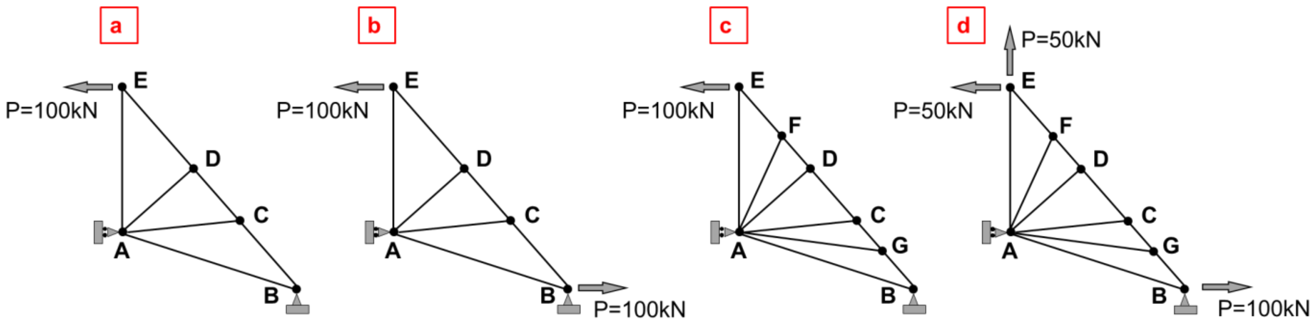
- Sketch the free body diagram.
- Find the force F in the cable. Express the results in vector form.
- Find the reaction forces at A. Express the results in vector form.



FBD (2 pts)

$\vec{F}_{CB} = (\qquad\qquad)\hat{\imath} + (\qquad\qquad)\hat{\jmath}$	(2 pts)
$\vec{A} = (\qquad\qquad)\hat{\imath} + (\qquad\qquad)\hat{\jmath}$	(2 pts)

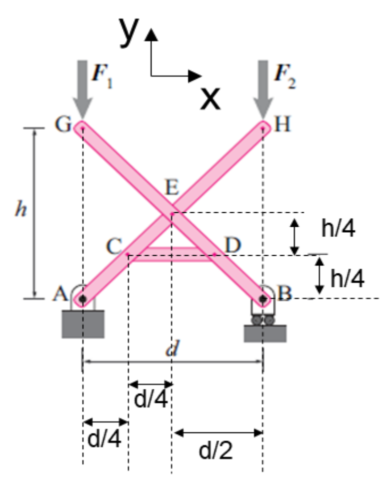
1C. Consider the truss structure in figure where B is a pinned joint and A is a roller. Which one of the situations depicted results in the members AD and AC being simultaneously zero-force members?



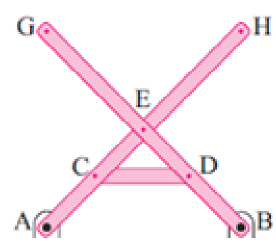
Circle one						
(a)	**(b)**	**(c)**	**(d)**	**none of the above**	**all of the above**	(4 pts)

1D. The braced X-frame in figure is under the effect of two external loads F_1=2kN and F_2=3kN. Assume d = h = 2m. Find:

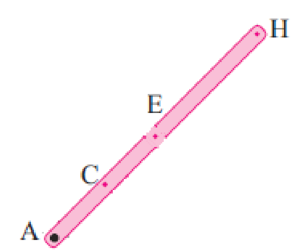
- Skecth the free body diagram of the whole frame on the schematic provided below.
- Skecth the free body diagram of the bar AH on the schematic provided below.
- Find the force in the member CD and specify if the member is in tension or compression.



FBD #1 (pts #1)



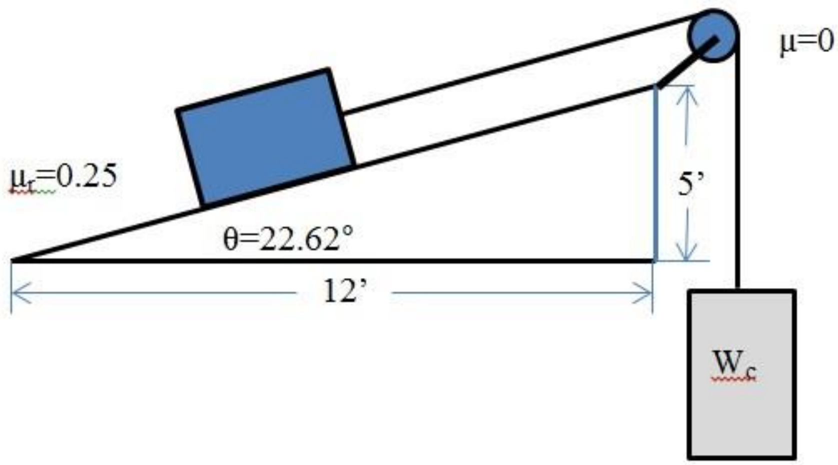
FBD #2 (pts #2)



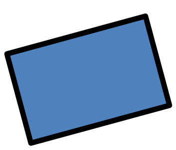
$CD =$	Tension	Compression	Zero	(circle one)	(3 pts)

PROBLEM 2 (20 points)

2a. 104-lb box is held in place by a counter weight, W_c. The friction between the block and the ramp, $\mu_r = 0.25$. The angle of the ramp is 22.62°. Use the figures provided for your free-body diagrams and show your axes. (12 points)



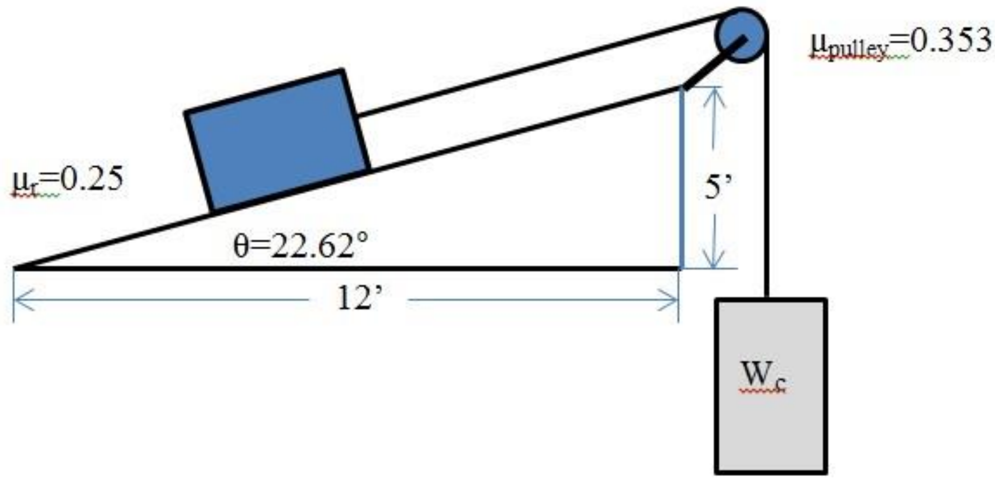
If there is NO friction at the pulley, draw a free-body diagram (show your coordinate axes) and determine the maximum weight, W_c, that can be applied without causing the 104-lb box to **slide up** the ramp.



W_c

Maximum W_c to prevent the 104-lb box from sliding **UP** the ramp________lb.

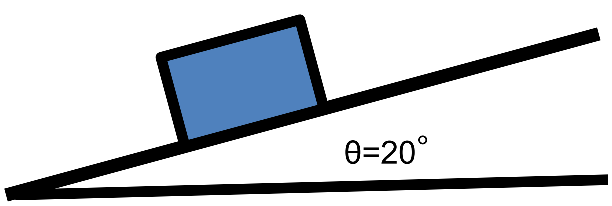
2b. Now assume the pulley friction applied and μ_{pulley}=0.353.



If the friction is applied at the pulley, what will be the maximum weight, W_c, before the 104-lb box will begin sliding **up** the ramp (4 points)

When friction is applied to pulley, the maximum weight, W_c, before the 104-lb box will begin sliding **up** the ramp is____________lb.

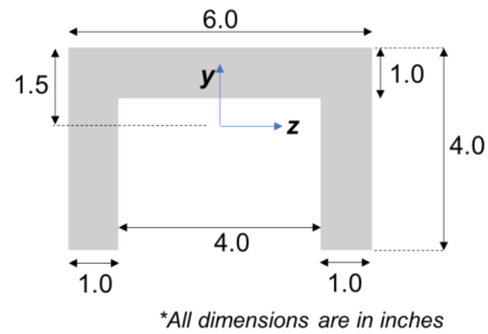
2c. A 10-lb box is placed on a ramp and is at the point of pending sliding down the ramp when θ=20°. Please determine the coefficient of friction, μ, between the block and the ramp. Please place your answer on the line provided (4 points).



μ = ____________________

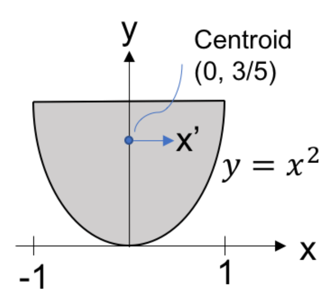
PROBLEM 3 (20 points)

3A Determine the second moment of area I_z of the following shape with respect to the coordinate system at the centroid (shown in the figure). Use the method of composite parts (**3 pts**). Without doing any calculations, do you expect that the second moment of area with respect to the y axis, I_y, to be greater than, equal, or less than I_z (**2 pts**)?

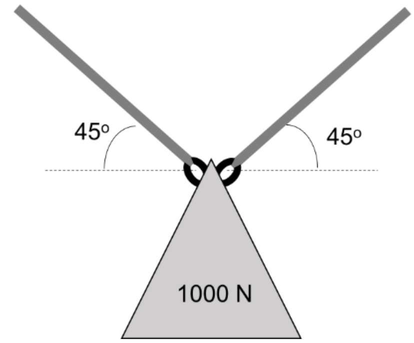


I_z =	**(3 pts)**
Circle the correct option: $I_y > I_z$ $I_y < I_z$ $I_y = I_z$	**(2pts)**

3B Using the method of integration, determine the second moment of area of the following shape with respect to the axis *x* (**3 pts**). The coordinates of the centroid of the shape are also shown in the figure. Using I_x and the parallel axis theorem, determine the second moment of area with respect to the centroid axis *x'* (**2 pts**). All dimensions are in inches.



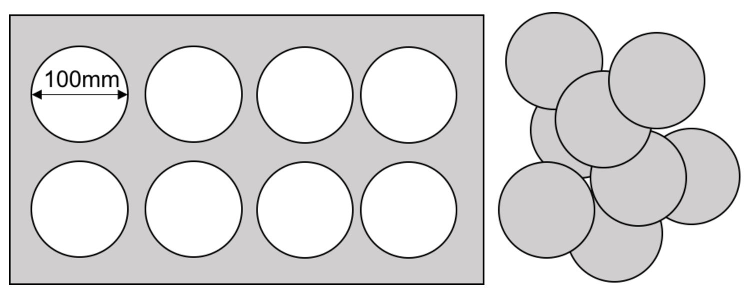
I_x =	**(3 pts)**
$I_{x'}$ =	**(2 pts)**



3C A weight of 1000 N hangs from two steel cables as shown in the figure. The yield stress for steel is 250MPa. Using a factor of safety FS=2, determine the minimum diameter of the steel cables (**3 pts**). Considering that the Young's modulus of steel is E=200 GPa, determine the axial strain of the cables (**2 pts**). (Mega = 10^6, Giga = 10^9)

d_{min} =	**(3 pts)**
ϵ_{axial} =	**(2 pts)**

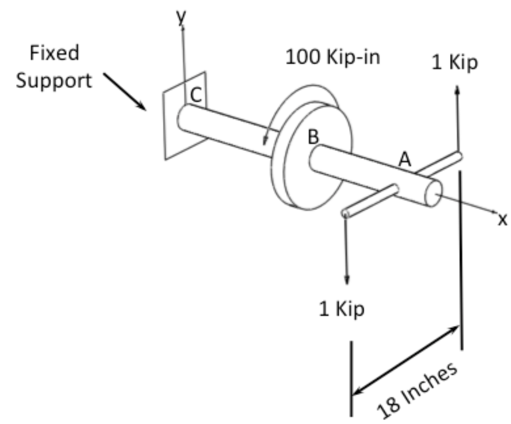
3D A punch press is used to create 8 circular holes at a time out of an aluminum plate of 10mm thickness as shown in the figure. If the shear strength of aluminum is 200MPa, what is the minimum force necessary to punch the holes? (**3 pts**) With that force, what is the maximum diameter we can cut if we want to make 16 holes at the same time? (**2 pts**)



F =	**(3 pts)**
$d_{16holes}$ =	**(2 pts)**

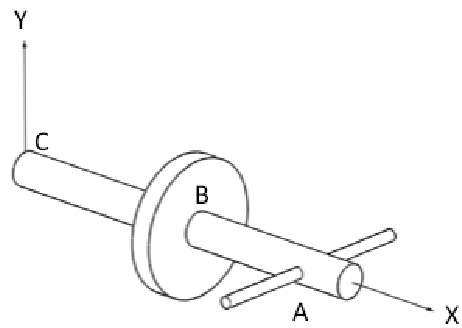
PROBLEM 4 (20 points)

GIVEN: The bar shown below is to be designed to transmit the specified forces and moments. You may assume the shaft is fixed to a wall as shown.



FIND:

a) On the figure below complete the Free Body Diagram of the shaft. (**4 pts**)



b) Determine the magnitude of the torque in sections AB and BC of the bar. (**6 pts**)

$T_{AB} =$	**(3 pts)**
$T_{BC} =$	**(3 pts)**

c) If the bar is to be designed as a hollow circular shaft with an outer radius of 2 inches and an inside radius of 1.871 inches, calculate the polar moment of inertia and determine the maximum shear stress in the shaft. (**5 pts**)

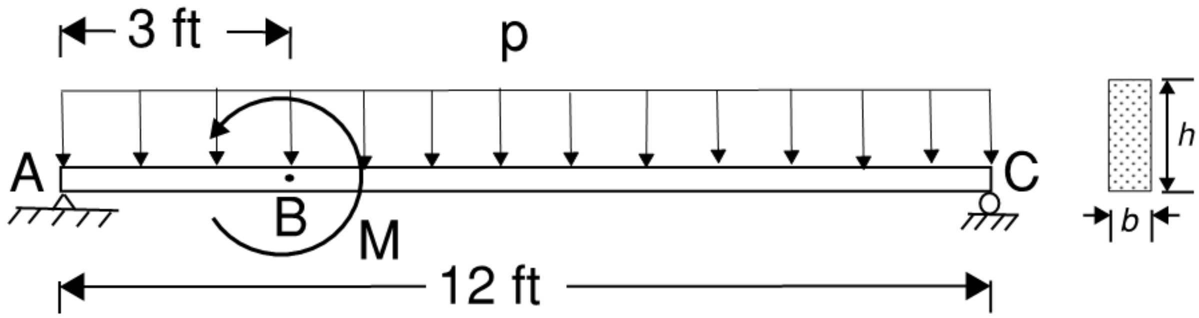
$J =$	**(2 pts)**
$\tau_{max} =$	**(3 pts)**

d) The hollow shaft is to be replaced by solid circular shaft made of a material with an ultimate shear stress of 60000psi. If this design requires a factor of safety of 1.5, determine the allowable shear stress and the diameter of the solid shaft. (**5 pts**)

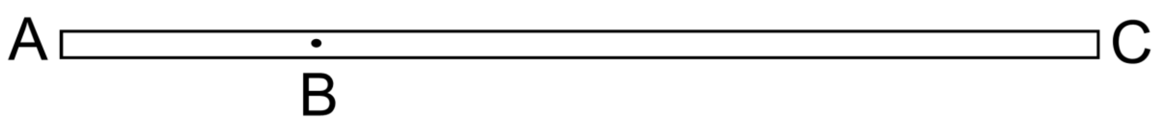
$\tau_{allow} =$	**(2 pts)**
$d =$	**(3 pts)**

PROBLEM 5 (20 points)

A wooden beam AC is loaded with a uniform distributed load p = 2 kip/ft and a moment of M = 48 ft-kip applied at point B, see the following diagram. The beam, which has a width of b and depth of h, is held in static equilibrium.



(a) Draw the free body diagram of the beam AC and calculate their support forces, R_A and R_C, at point A and C. Express the reactions in vector form.
(6 points)

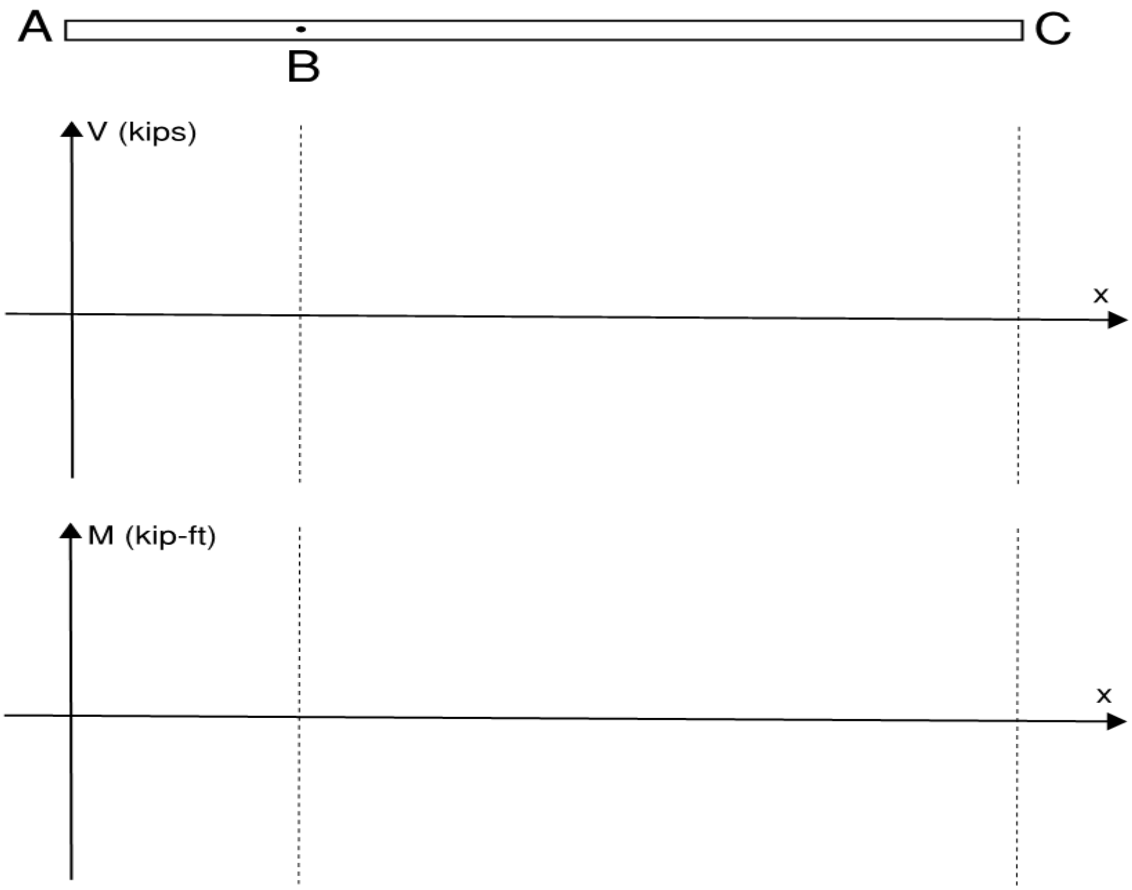


(2 points for FBD)

$\bar{R}_A =$ (2 pts)

$\bar{R}_C =$ (2 pts)

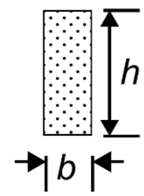
(b) Sketch the shear force and bending moment diagrams. Indicate in the diagrams the shear forces and bending moments at points A, B and C.
(6 points)



(c) Identify point(s) where the beam is subjected to pure bending moment by giving its/their distance(s) *d* from point A. What is/are the moment(s) M_0 at this/these point(s)?
(3 points)

$d =$ (1 pts)

$M_0 =$ (2 pts)



(d) Recall that the cross section of the beam is shown in the diagram with b = 1 inch and h = 3 inches. Calculate the 2[nd] moment of area of the section, *I, about the neutral axis.* **(1 point)**

(e) Determine the bending stress, σ_x, at the upper surface of the beam at the point(s) of pure bending. State whether it is tensile or compressive stress. **(4 points)**

$I =$					(1 pts)
$\sigma_x =$	Tension	Compression	Zero	(circle one)	(4 pts)

Final Answers

1A. $\vec{F}_{BC} = (-42.857)\hat{\imath} + (57.162)\hat{\jmath}$
$\vec{F}_{AC} = (42.857)\hat{\imath} + (42.857)\hat{\jmath}$

1B. $\vec{F}_{CB} = (-80)\hat{\imath} + (60)\hat{\jmath}$ **lb**
$\vec{A} = (80)\hat{\imath} + (0)\hat{\jmath}$ **lb**

1C. **Circle: all of the above**

1D. **Free Body Diagrams** $CD = 10\ kN$ **Tension**

2A. **Free Body Diagram** $(W_c)_{Max}$ **= 64 lb.**

2B. $(W_c)_{Max}$ **= 128 lbs.**

2C. $\mu = 0.364$

3A. $I_z = 17 in^4$ **Correct Option:** $I_y > I_z$

3B. $I_x = 0.571\ in^4$ $I_{x^1} = 0.091\ in^4$

3C. $d_{min} = 2.68\ mm$ $\epsilon_{axial} = 6.25x10^{-4}$

3D. $F = 5.03x10^6\ N$ $d_{16holes} = 50\ mm$

4A. **Free Body Diagram**

4B. $T_{AB} = 18\ kip - in$ $T_{BC} = 118\ kip - in$

4C. $J = 5.883\ in^4$ $\tau_{max} = 40116\ lb/in^2$

4D. $\tau_{allow} = 40000\ psi$ $d = 2.47\ in$

5A. **Free Body Diagram** $\bar{R}_A = 0\vec{\imath} + 16\bar{\jmath}\ kip$ $\bar{R}_C = 0\vec{\imath} + 8\bar{\jmath}\ kip$

5B. **Sketch**

5C. $d = 8\ ft.$ $M_0 = 16\ ft - kip$

5D. $I = 2.25\ in^4$ $\sigma_x = -128\ ksi$ **Compression**