ME 270 – Spring 2017 Exam 1 **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: ______________________________________

Instructor's Name and Section: (Circle Your Section)

Sections: J Jones 9:30-10:20AM A Buganza 1:30-2:20PM B Li 3:30-4:20PM
J Jones Distance Learning

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-30IIS
- The allowable exam time for Exam 1 is 70 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.

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 __________

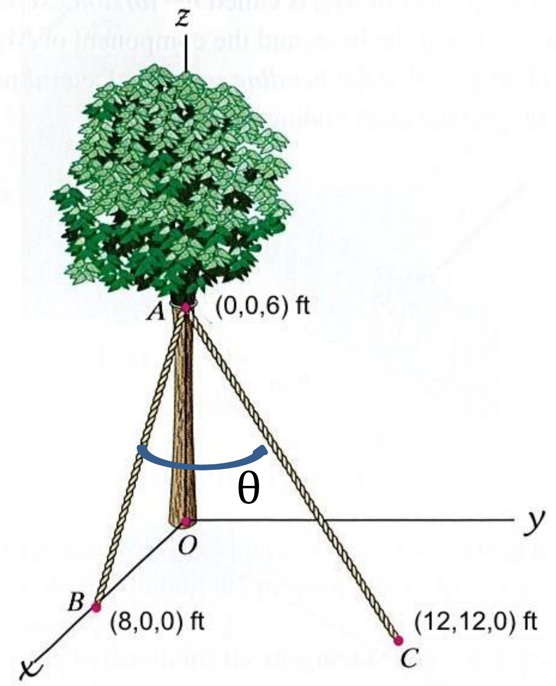
Problem 2 __________

Problem 3 __________

Total ______________

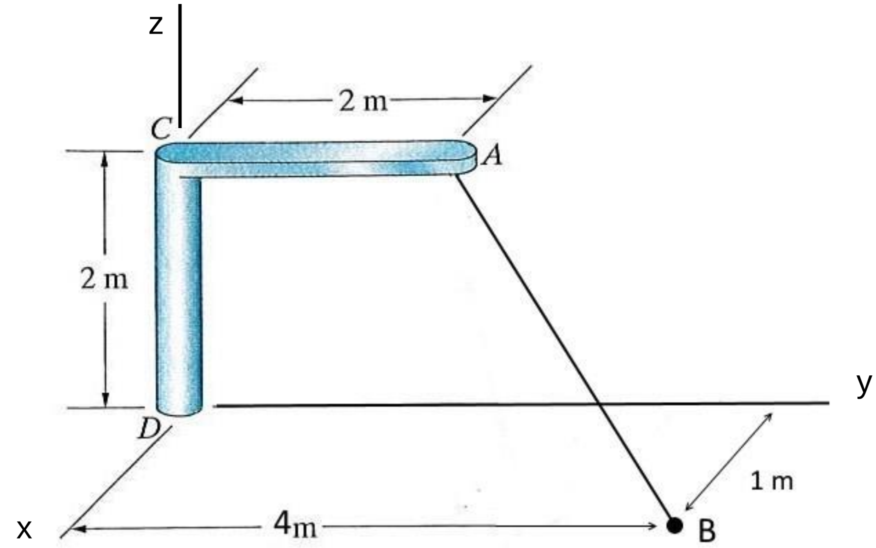
PROBLEM 1 (20 points

1A. The tension in rope AC is 100 lbs. Determine the angle (θ) between cables AB and AC and the magnitude of the projection of the tension in cable AC tension in the direction of AB.



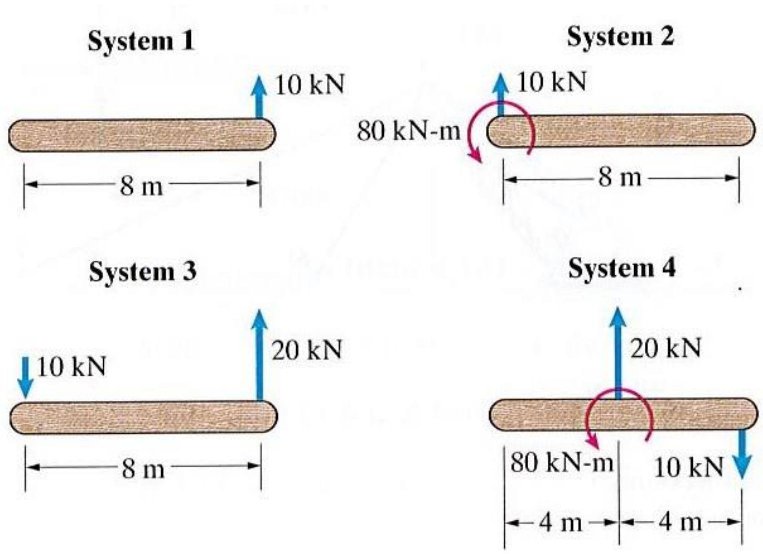
$\theta =$	(3 pts)
$\lvert \overline{Proj} \rvert =$	(2 pts)

1B. The tension in cable AB is 10kN. Determine the force vector $\bar{T}_{AB}$ and the moment vector $\bar{M}_D$ due to the cable about point D.



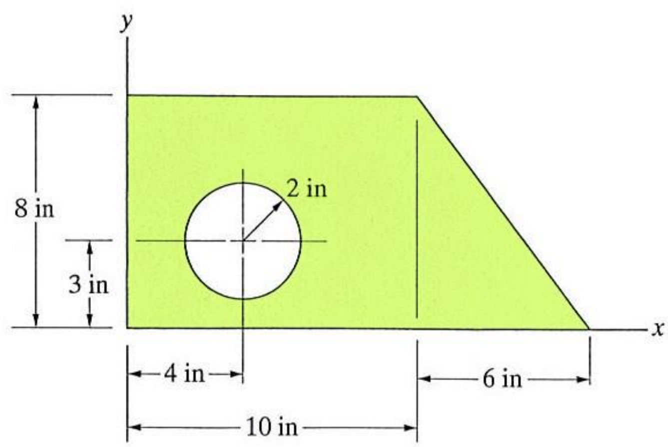
$\bar{T}_{AB}$ =	(2 pts)
$\bar{M}_D$ =	(3 pts)

1C. Three of these four systems are equivalent. Which system is not equivalent? What couple must be added to this system to make it equivalent?



System	1	2	3	4	(Circle One)	(2 pts)
$\bar{M}$ =	$\bar{k}$ kN-m					(3 pts)

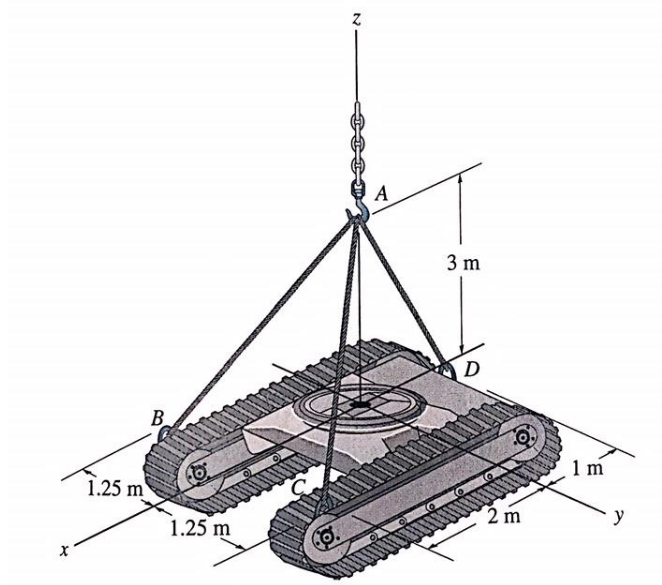
1**D.** Determine the x-centroid of the shaded area. If the 2-in radius hole was removed (i.e., the block was solid), what qualitative effect would this have on the x-centroid?



$\bar{x}$ =					(3 pts)
x-centroid would:	Increase	Remain Same	Decrease	(Circle One)	(2 pts)

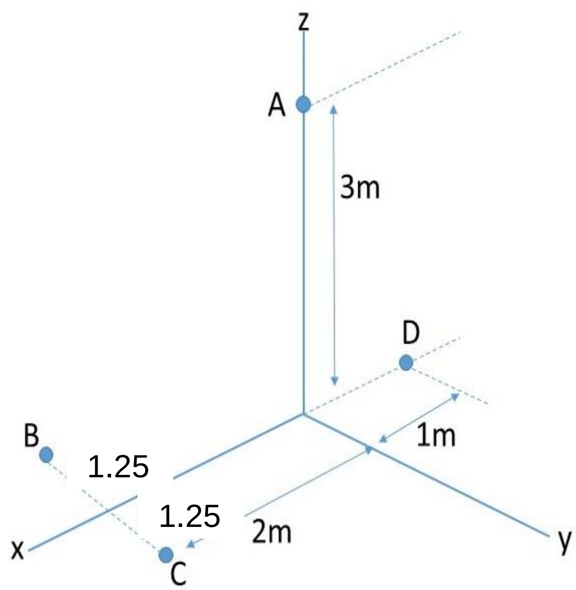
PROBLEM 2. (20 points)

GIVEN: A tractor is lifted by three independent cables as shown in the figure. Determine the tension in the cables AB, AC, and AD if the tractor's weight is 80kN.



FIND:

a) Draw the free body diagram of the system of forces acting at point A (3 pts)



b) List the cable force vectors as an unknown magnitude multiplied by a known unit vector (6 pts):

$\overline{T_{AB}} =$ ______ (________ $\bar{\imath}$ + ________ $\bar{\jmath}$ + ________ $\bar{k}$)	(2 pts)
$\overline{T_{AC}} =$ ______ (________ $\bar{\imath}$ + ________ $\bar{\jmath}$ + ________ $\bar{k}$)	(2 pts)
$\overline{T_{AD}} =$ ______ (________ $\bar{\imath}$ + ________ $\bar{\jmath}$ + ________ $\bar{k}$)	(2 pts)

c) Formulate the equations of equilibrium. (3 pts):

$\boldsymbol{\Sigma F_x = 0 =}$	(1 pt)
$\boldsymbol{\Sigma F_y = 0 =}$	(1 pt)
$\boldsymbol{\Sigma F_z = 0 =}$	(1 pt)

d) Solve the equations of static equilibrium for the magnitude of the tension in each cable. (6 pts):

$\boldsymbol{T_{AB} =}$	(2 pts)
$\boldsymbol{T_{AC} =}$	(2 pts)
$\boldsymbol{T_{AD} =}$	(2 pts)

e) What is the maximum load this cable system can hold if the largest allowable tension in any single cable is 60kN?

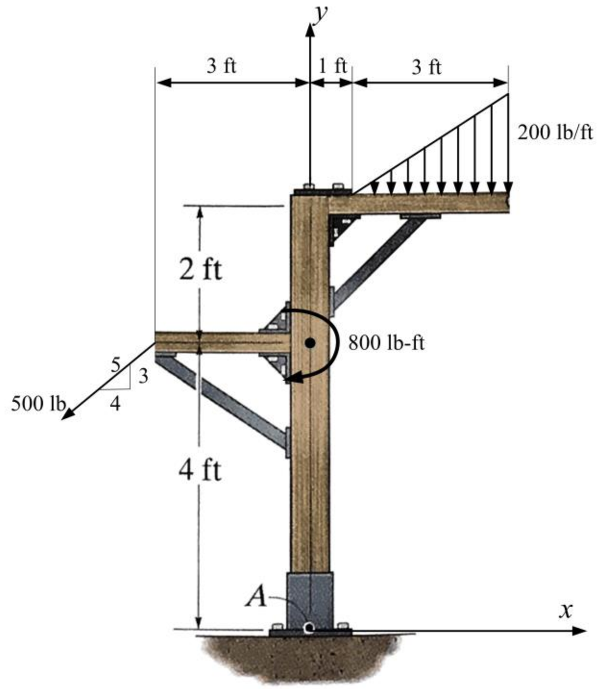
$W_{max} =$	(2 pts)

PROBLEM 3. (20 points)

GIVEN: Frame ABCD is loaded as shown and is held in static equilibrium by a fixed support at A.

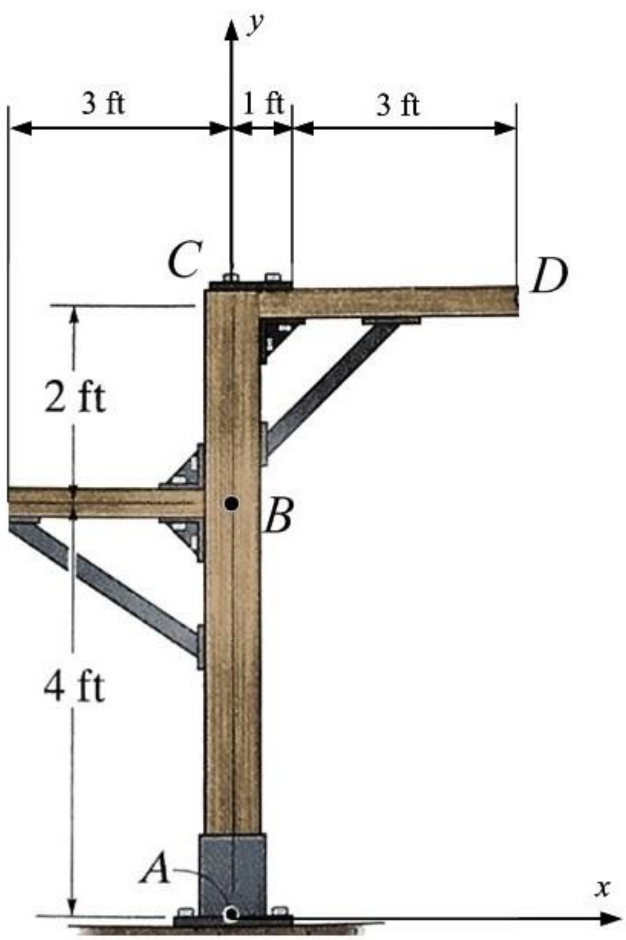
FIND:

a) For the distributed load shown, determine the magnitude of the single-force equivalent and its location measured from the y-axis.



$F_{eq} =$	(2 pts)
$x =$	(2 pts)

b) Draw the free body diagram of the system, list all applied and reaction forces and moments, replace the triangular distributed load with a single equivalent load and mark its location. (3 pts)



c) Find the reactions at point A. Express the results in vector form. (10 pts)

$\overline{\mathbf{F}}_A =$ ____________________ $\bar{\mathbf{i}} +$ ______________________ $\bar{\mathbf{j}}$	(4 pts)
$\overline{\mathbf{M}}_A =$	(6 pts)

d) Qualitatively describe the change in the magnitude of the reactions at point A if the 500 lb force is slightly <u>decreased</u> by circling the appropriate trend. (3 pts)

$(F_A)_x$	Increases	Remains Same	Decreases	(Circle One)	(1 pt)
$(F_A)_y$	Increases	Remains Same	Decreases	(Circle One)	(1 pt)
(M_A)	Increases	Remains Same	Decreases	(Circle One)	(1 pt)

SOLUTIONS

1A. $\theta = 42.8$ degrees $|\overline{Proj}| = 73.3\ lbs$

1B. $\bar{T}_{AB} = 3.33\bar{\imath} + 6.67\bar{\jmath} - 6.67\ \bar{k}\ kN$ $\bar{M}_D = -26.7\bar{\imath} + 6.67\bar{\jmath} - 6.67\ \bar{k}\ kN - m$

1C. System is 3 is not equivalent $\bar{M} = \ -80\ \bar{k}\ kN - m$

1D. $\bar{x} = 6.98\ in$ x-centroid - Decreases

2A. Free body diagram

2B. $\overline{T_{AB}} = T_{AB}\ (0.524\bar{\imath} + (-0.327)\bar{\jmath} + (-0.786)\ \bar{k})$

$\overline{T_{AC}} = T_{AC}\ \left(0.524\bar{\imath} + 0.327\bar{\jmath} + (-0.786)\ \bar{k}\right)$

$\overline{T_{AD}} = T_{AD}\ (-0.316\bar{\imath} + 0\bar{\jmath} + (-0.948)\ \bar{k})$

2C. $\sum F_x = 0 = 0.524\ T_{AB} + 0.524\ T_{AC} - 0.316\ T_{AD}$

$\sum F_y = 0 = -0.327\ T_{AB} + 0.327\ T_{AC}$

$\sum F_z = 0 = -0.786\ T_{AB} - 0.786\ T_{AC} - 0.948\ T_{AD} + 80kN$

2D. $T_{AB} = 16.94\ kN$ $T_{AC} = 16.94\ kN$ $T_{AD} = 56.29\ kN$

2E. $W_{max} = 85.2\ kN$

3A. $F_{eq} = 300\ lb$ x = 3 ft

3B. Free Body Diagram

3C. $\bar{F}_A = (\ 400\ \bar{\imath} + 600\ \bar{\jmath}\ )\ lb$ $M_A = \left(-800\bar{k}\right)lb - ft$

3D. $(F_A)x\ Decreases$ $(F_A)y\ Decreases$ $(M_A)\ Decreases$

ME 270 Exam 1 Equations

Distributed Loads

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

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

Centroids

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

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

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

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

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

Centers of Mass

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

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

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

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

Buoyancy

$$F_B = \rho g V$$

Fluid Statics

$$p = \rho g h$$

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