ME 270 – Spring 2015 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: ______________________________________

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.

Instructor's Name and Section:

Sections: J Jones 9:30-10:20AM I Bilionis 1:30-2:20PM J Ackerman 3:30-4:20PM
J Jones Distance Learning

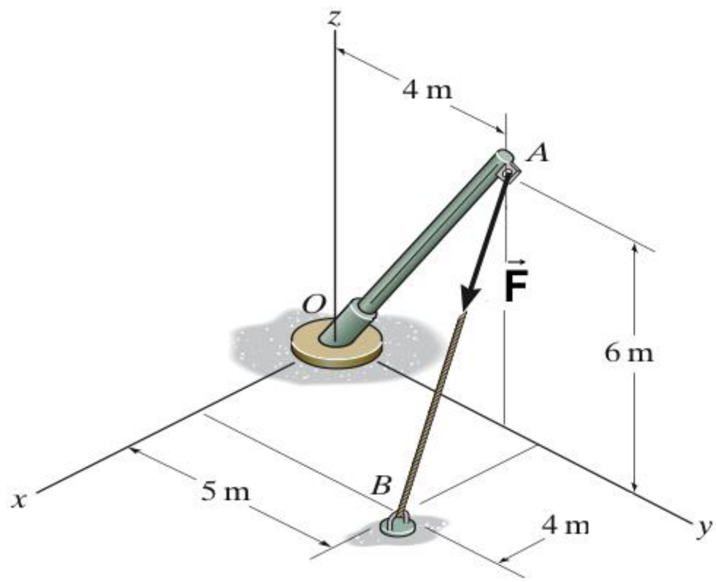
Problem 1 __________

Problem 2 __________

Problem 3 __________

Total ______________

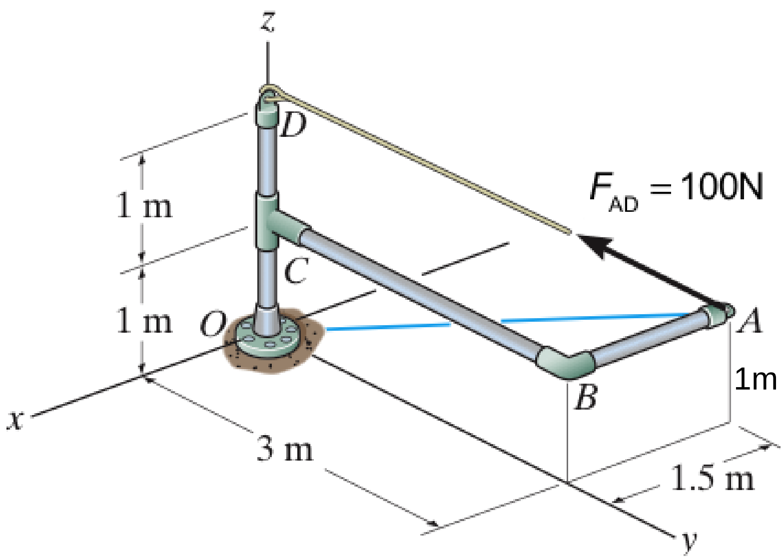
PROBLEM 1 (20 points) – Prob. 1 questions are all or nothing.



1A. Determine the unit vector $\hat{\mathbf{u}}_{AO}$ that characterizes the direction of the pipe AO. Then, compute the <u>magnitude</u> of the projection of the force $\vec{\mathbf{F}} = 4\hat{\mathbf{i}} + \hat{\mathbf{j}} - 6\hat{\mathbf{k}}$ N along the pipe AO.

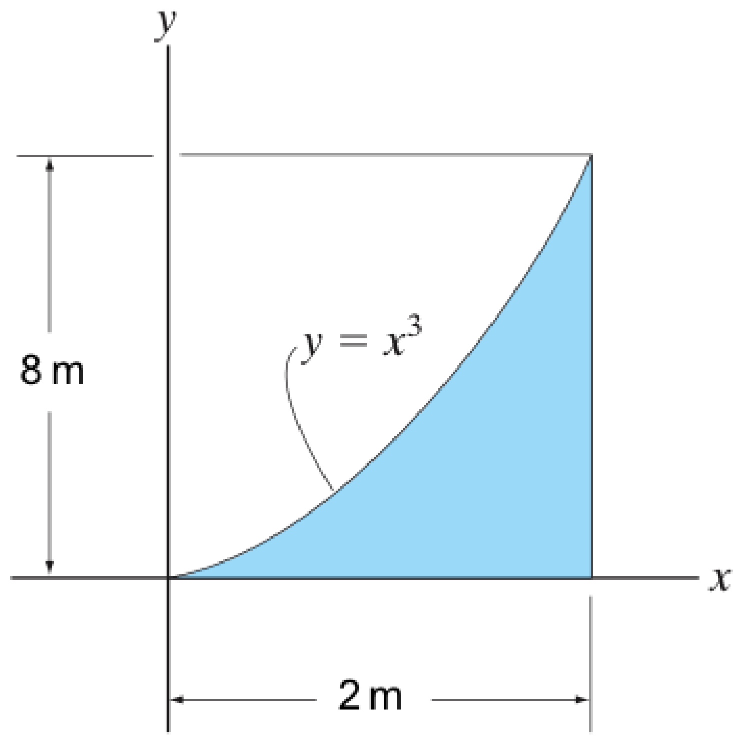
$\hat{\mathbf{u}}_{AO}$ =	(2 pts)
$\lvert$Projection$\rvert$ =	(3 pts)

1B. The tension in the cable AD (see Figure on the right) is $F_{AD} = 100\text{N}$. Express this force (F_{AD}) in vector form ($\vec{\mathbf{F}}_{AD}$). Then, calculate the vector form of the moment ($\vec{\mathbf{M}}_O$) about O caused by the force $\vec{\mathbf{F}}_{AD}$.



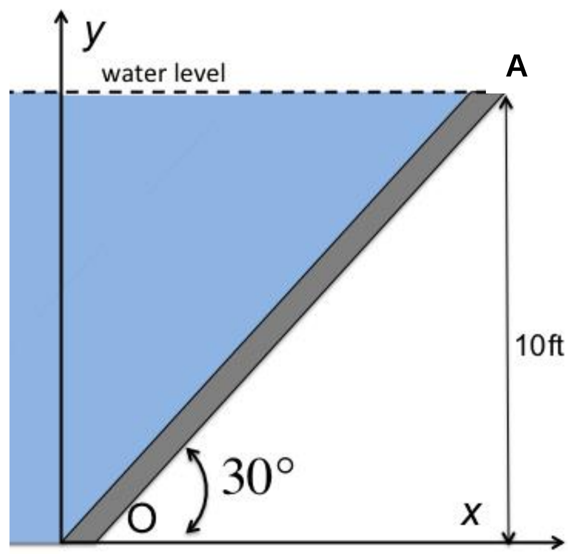
$\vec{\mathbf{F}}_{AD} =$	(2 pts)
$\vec{\mathbf{M}}_O =$	(3 pts)

1C. Compute <u>by integration</u> the area (A) and the x-coordinate of the centroid ($\bar{X}$) for the shaded shape shown in the figure.

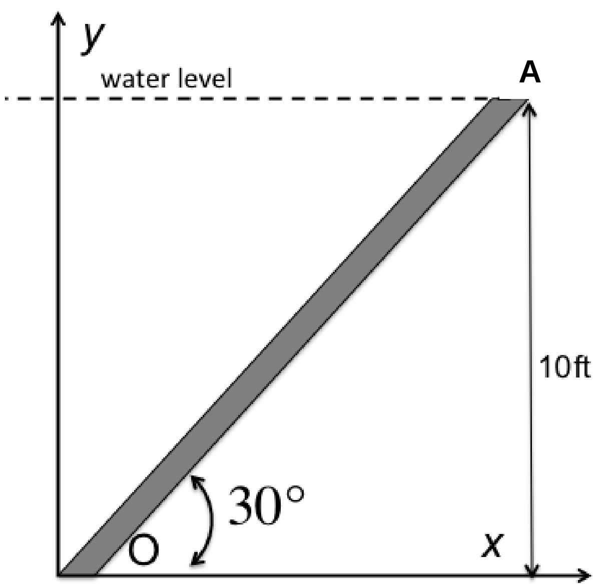


A = (2 pts)

$\bar{x}$ = (3 pts)



1**D.** On the figure provided below, draw the hydrostatic force per unit length that acts the wall. Make sure that the numerical values of this *distributed load* are clearly shown on the diagram. Then, compute the equivalent force (F_{equiv}) as well as the distance of its point of application (d_{equiv}, measured from the origin O of the coordinate system attached to the figure, along the gate OA). The specific weight of water is $\gamma = \rho g = 62.4\,\text{lb/ft}^3$ and the width of the wall (that is how deep into the page it goes) is 2 ft.



$F_{equiv} =$	(3 pts)
$d_{equiv} =$	(2 pts)

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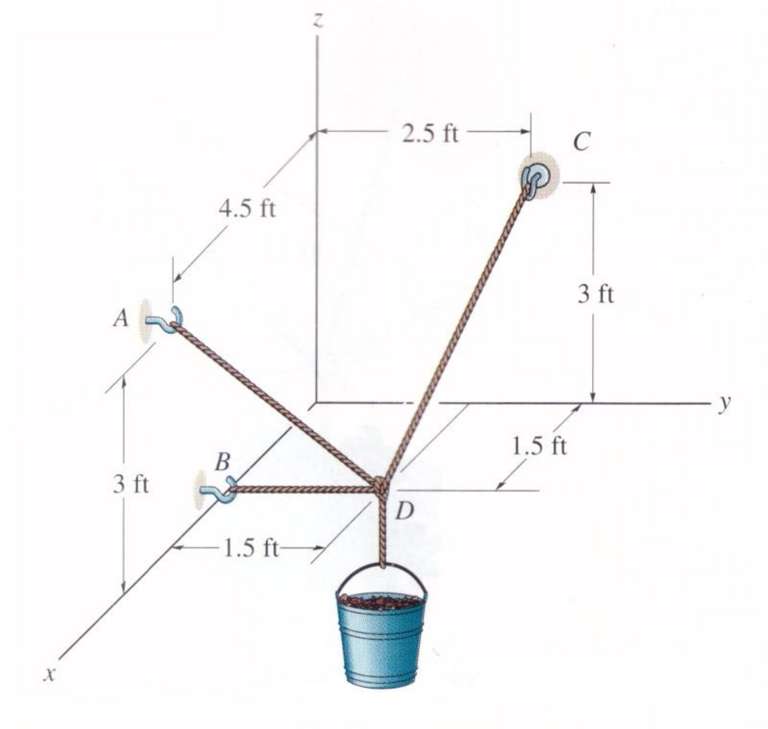
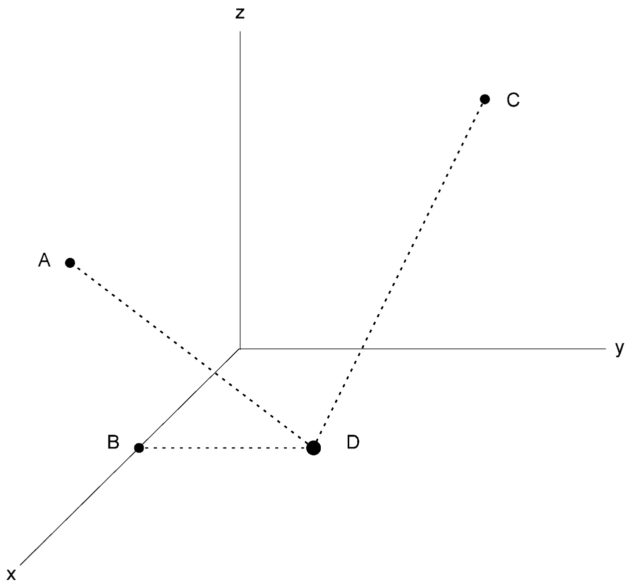
PROBLEM 2. (20 points)

GIVEN: A heavy bucket is suspended from three ropes in a construction site. The bucket weighs 50 lb by itself.



FIND: a) On the diagram below, show a complete free-body diagram for point D (4 pts):



b) Write the tension in cables DA, DB, and DC in vector form (an <u>unknown</u> magnitude multiplied by a <u>known</u> unit vector) (6 pts):

$\overline{T_{DA}} =$	(2 pts)
$\overline{T_{DB}} =$	(2 pts)
$\overline{T_{DC}} =$	(2 pts)
Example format: $\overline{T_{DA}} = T_{DA}(u_x\bar{\imath} + u_y\bar{\jmath} + u_z\bar{k})$	

c) Determine the magnitude of the tension in each cable (7 pts):

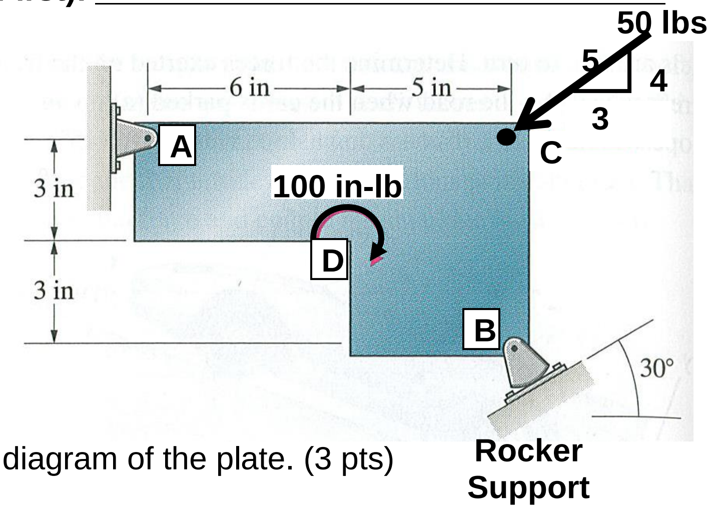
$\boldsymbol{T_{DA}} =$	(2 pts)
$\boldsymbol{T_{DB}} =$	(3 pts)
$\boldsymbol{T_{DC}} =$	(2 pts)

d) Determine the maximum weight that can be stored in the bucket without the cable system (T_{DA}, T_{DB}, T_{DC}) failing given that each rope has a maximum tensile strength of 1000 lb (3 pts):

$\boldsymbol{W_{max}} =$	(3 pts)

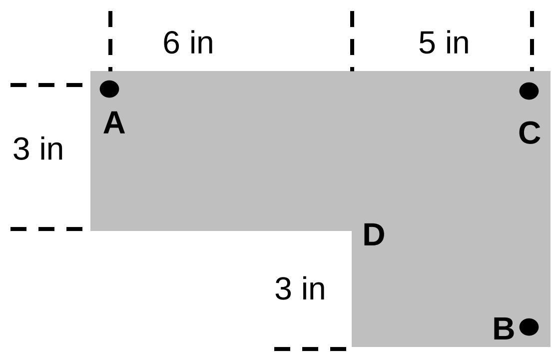
PROBLEM 3. (20 points)

GIVEN: Plate ABCD is loaded with a 50-lb force at C and a 100 in-lb couple at D. The plate is held in static equilibrium by a pin support at A and a rocker support at B. You can assume that point C is aligned with points A (horizontally) and B (vertically).



FIND:

a) On the sketch provided, show a complete free-body diagram of the plate. (3 pts)



b) Determine the magnitudes of the reactions at supports A and B. (11 pts)

N_B =	(5 pts)
A_x =	(3 pts)
A_y =	(3 pts)

c) If the 100 in-lb couple at D was moved to point C, qualitatively what impact would this have on the magnitudes of the reactions? <u>No calculations are required</u>. (3 pts)

N_B = (	increase,	decrease,	remain the same)	(Circle One)
A_x = (	increase,	decrease,	remain the same)	(Circle One)
A_y = (	increase,	decrease,	remain the same)	(Circle One)

d) If the magnitude 100 in-lb couple is increased, qualitatively what impact would this have on the magnitudes of the reactions? <u>No calculations are required</u>.(3 pts)

N_B = (	increase,	decrease,	remain the same)	(Circle One)
A_x = (	increase,	decrease,	remain the same)	(Circle One)
A_y = (	increase,	decrease,	remain the same)	(Circle One)

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

$$p = \rho g h$$

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

ME 270 Exam 1 Solutions – Spring 2015

1a. $\hat{u}_{AO} = -0.55\vec{j} - 0.83\vec{k}$ $\quad$ $|\text{Projection}| = 4.43$ N

1b. $\vec{F}_{AD} = 42.9\vec{i} - 85.7\vec{j} + 28.6\vec{k}$ N $\quad$ $\vec{M}_O = 171.4\vec{i} + 85.8\vec{j}$ N-m

1c. $A = 4m^2$ $\quad$ $\bar{x} = 1.6m$

1d. FBD $\quad$ $F_{equiv} = 12{,}480$ lbs $\quad$ $d_{equiv} = 6.67$ ft

2a. FBD

2b. $\bar{T}_{DA} = T_{DA}\left[0.667\bar{i} - 0.333\bar{j} + 0.667\bar{k}\right]$ $\quad$ $\bar{T}_{DB} = T_{DB}\left[-1\bar{j}\right]$

$\bar{T}_{DC} = T_{DC}\left[-0.429\bar{i} + 0.286\bar{j} + 0.857\bar{k}\right]$

2c. $T_{DA} = 25$ lb $\quad$ $T_{DB} = 2.77$ lb $\quad$ $T_{DC} = 38.8$ lb

2d. $W_{max} = 1{,}290$ lb

3a. FBD

3b. $N_B = 82.7$ lbs $\quad$ $A_x = 71.4$ lbs $\quad$ $A_y = -31.7$ lbs

3c. N_B = remain the same $\quad$ A_x = remain the same $\quad$ A_y = remain the same

3d. N_B = increase $\quad$ A_x = increase $\quad$ A_y = increase