ME 270 –Spring 2016 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. If I detect cheating I will write a note on my exam and raise my hand as if asking a question.

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 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.

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 J Gibert 1:30-2:20PM I Bilionis 3:30-4:20PM
J Jones Distance Learning

Problem 1 __________

Problem 2 __________

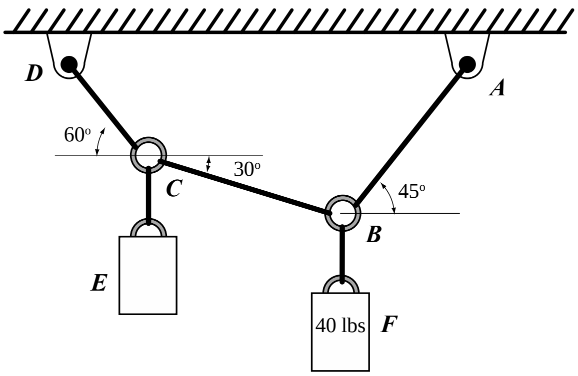
Problem 3 __________

Problem 4 __________

Problem 5 __________

Total ______________

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

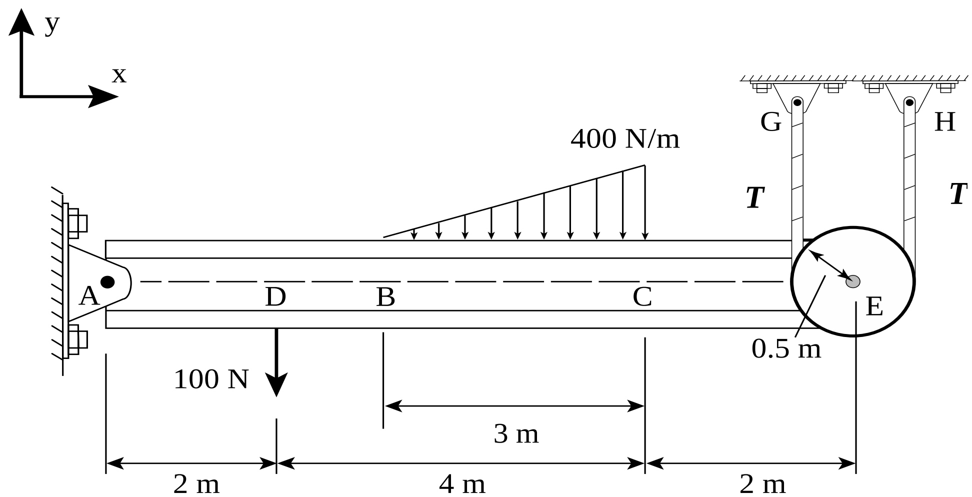


Problem 1A. (5 pts.) The cylinder F weighs 40lbs. and is supported by cables BC and BA. Cables BC and DC also support cylinder E whose weight is not known. Determine the magnitude of the tension in cables BC and BA.

T_{BC} =		lb.	**(3 pts.)**
T_{BA} =		lb.	**(2 pts.)**

ME 270 –Spring 2016 Final Exam **NAME (Last, First):** ____________________

Problem 1B. (5 pts.) The beam shown is pinned A and has a triangular distributed load with an intensity of 400 N/m at C. A chord wraps around a frictionless drum of radius 0.5 m. Determine the reaction forces at A along with the tension in the chord (T).



A =	$\bar{i}$	$\bar{j}$ N		**(2 pts.)**
T =		N		**(3 pts.)**

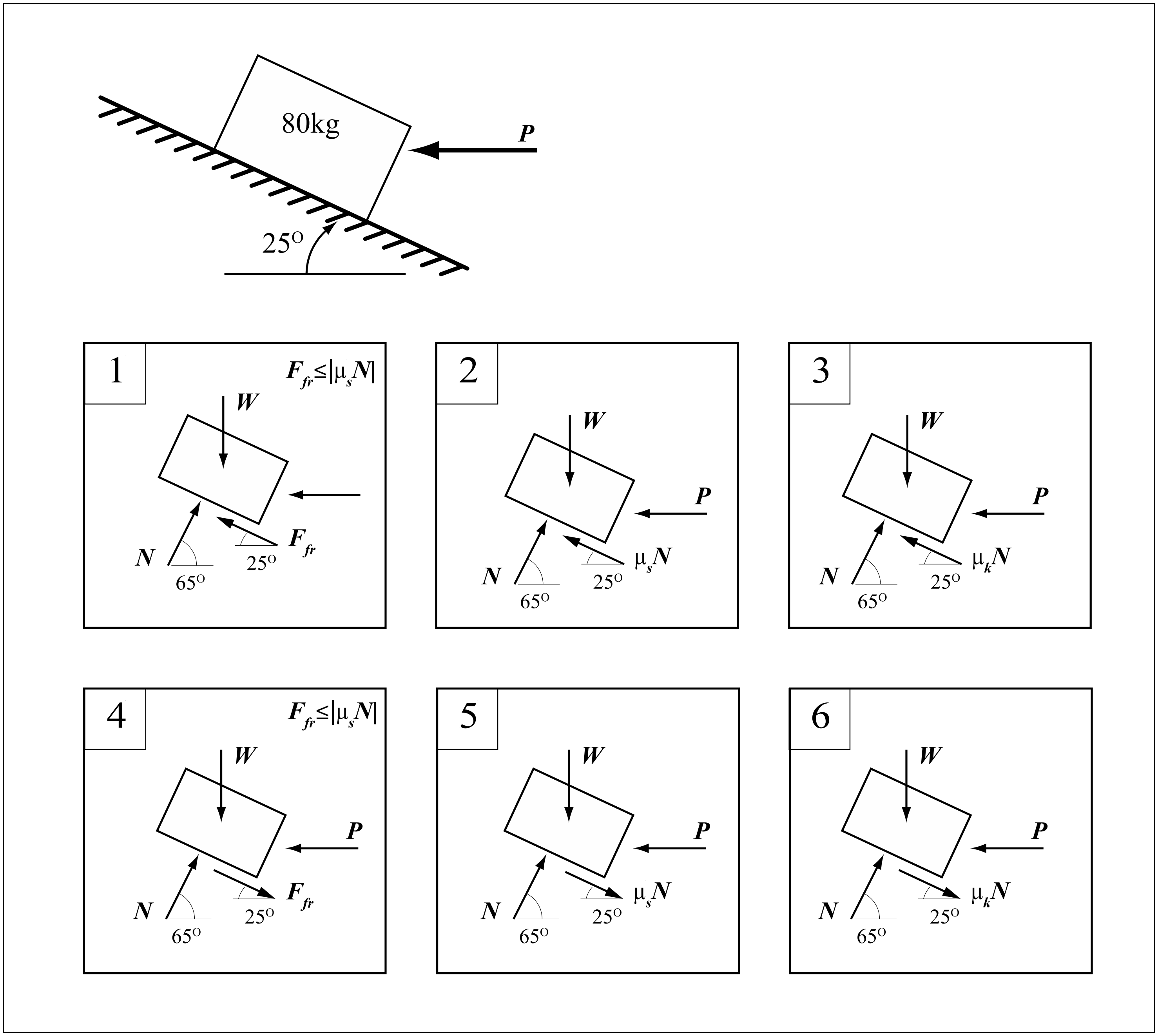
Problem 1C. The force acts P on the block. Knowing that the coefficient of friction between the block and the incline are μ_s= 0.4, and μ_k=0.25 using the six FBD that **best describes, i.e., indicates the closest description of direction and magnitude of the force** to the following situations.

a) **(2pts.)** FBD of the block right before **moving <u>up the incline</u>**, i.e., the block is <u>at impending motion</u>. ______________

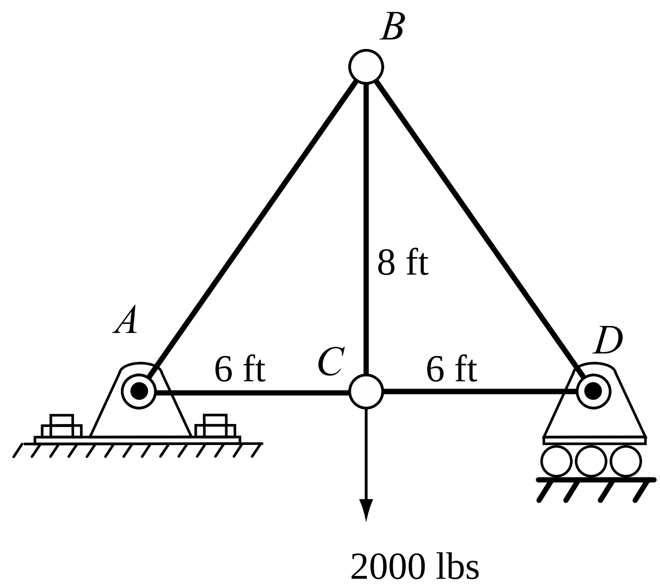
b) **(1pt.)** FBD of the block if it **moves <u>up the incline</u> with <u>constant velocity.</u>**

____

c) **(2pts.)** FBD of the block to keep it from **moving <u>down the incline</u>**, the block is <u>not at impending motion.</u> ______________



Problem 1D. Consider the truss pictured below, it is pinned at A and sits on a roller at D. A vertical force of 2000 lb. acts vertically downward on pin C. The cross sectional area of each member is 0.25 in^2.



(1 pt.) The magnitude of the force in member AC is: >, <, or = to the magnitude of the force in member CD **(circle one)**

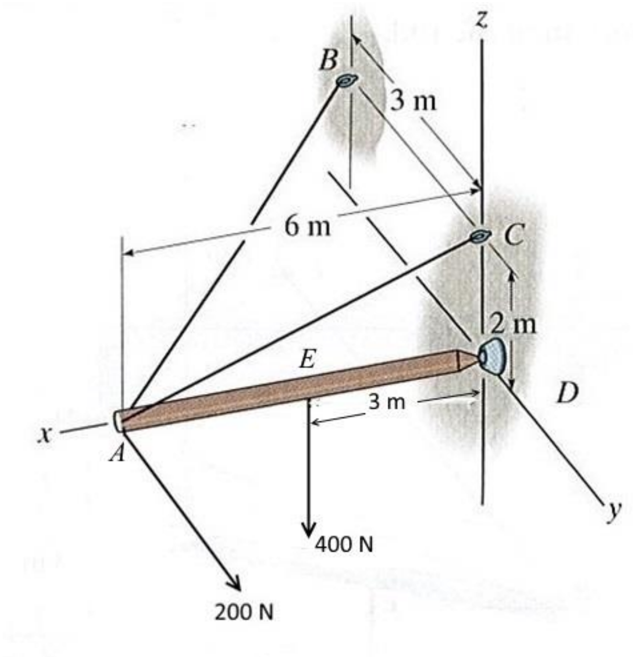
(2 pts.) The stress in rod BC is: ________________ psi and is compressive or tensile **(circle one).**

(2 pts.) The force $\mathbf{F_{AB}}$ is **(circle the correct answer)**:

a) 1250 (C), b) 1250 (T), c) 1666.67 (T), d) 1666.67 (C)

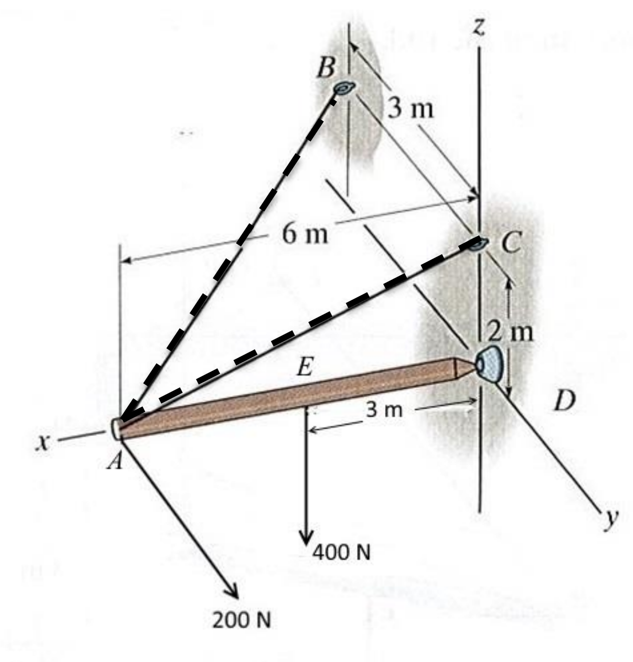
PROBLEM 2 (20 points)

Given: Boom AED is loaded with a 200N (y-direction) and a 400N (z-direction) force as shown and is held in place by a ball-and-socket support at D and cables AB and AC. Neglect the weight of the boom. (Note: Point C is on the z-axis)



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 unknown magnitudes and their known unit vectors. Write the vectors in <u>decimal form</u> (not as fractions). (4 pts)

b)

$\bar{T}_{AB} = T_{AB}$ (__________ $\bar{i}$ + __________ $\bar{j}$ + __________ $\bar{k}$) **(2 pts)**

$\bar{T}_{AC} = T_{AC}$ (__________ $\bar{i}$ + __________ $\bar{j}$ + __________ $\bar{k}$) **(2 pts)**

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

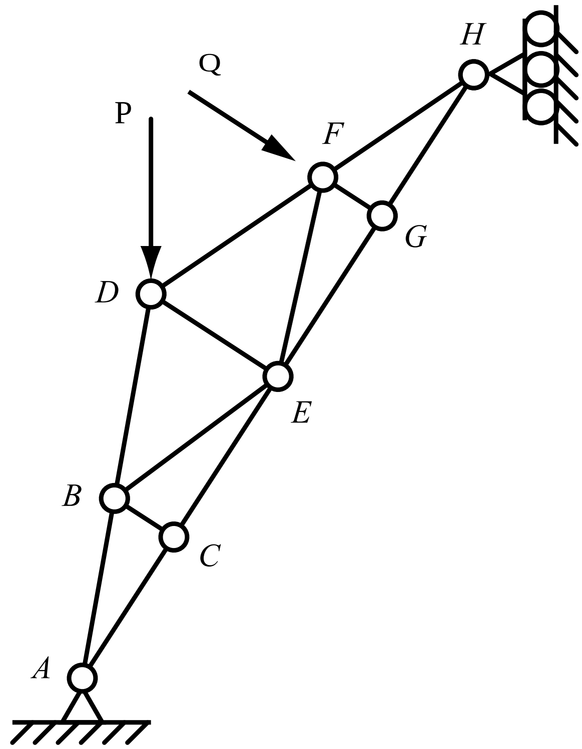
c)	$\mathbf{T_{AB}}$ =	**N**	**(3 pts)**
	$\mathbf{T_{AC}}$ =	**N**	**(3 pts)**

d) Determine the vector reaction at the ball-and-socket support at D in Newtons. Express the vector in decimal form (not as fractions). (6 pts)

d)	$\bar{\mathbf{D}} = (\_\_\_\_\_\_\_\_\_\_\ \bar{\mathbf{i}} + \_\_\_\_\_\_\_\_\_\_\ \bar{\mathbf{j}} + \_\_\_\_\_\_\_\_\_\_\ \bar{\mathbf{k}})$	**N**	**(6 pts)**

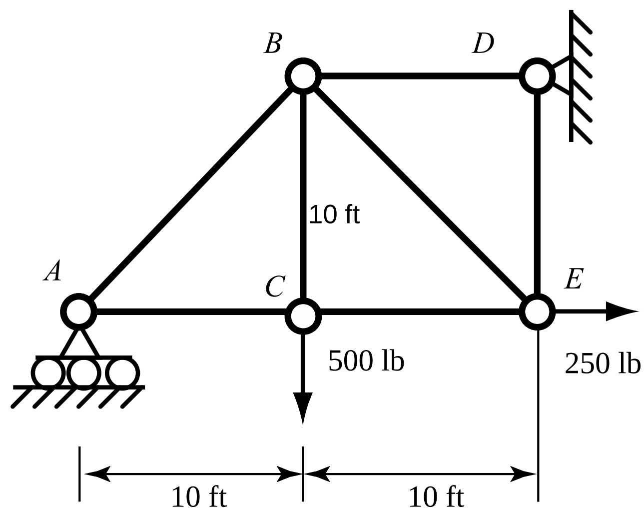
PROBLEM 3 (20 points)

Problem 3A. (3 pts.) Consider the truss below; it is pinned at A and on rollers at H. Identify the zero-force members by circling from the list at right. **There will be no partial credit on this part.**

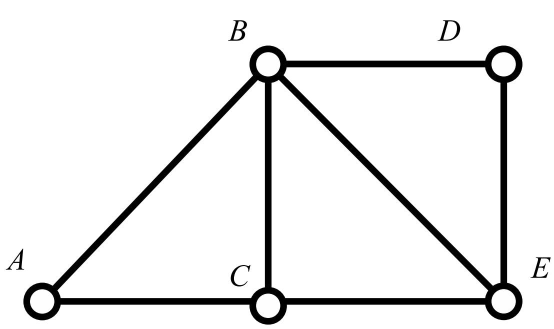


AB
AC
BC
BE
BD
CE
DE
DF
EF
EF
FG
FH
GH

Problem 3B. (13 pts.) Consider the truss below; it is on rollers at A and pinned at D. Determine the reactions at A and D and the unknown forces on pin E. Do this by answering the following questions.



i) (3pts.) Draw a FBD of the truss on the picture below. **There will be no partial credit on this part:**



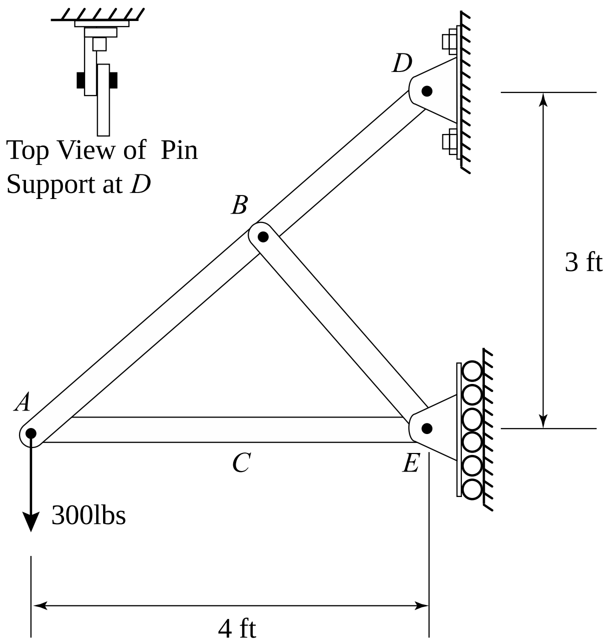
ii) Find the reaction forces in vector form

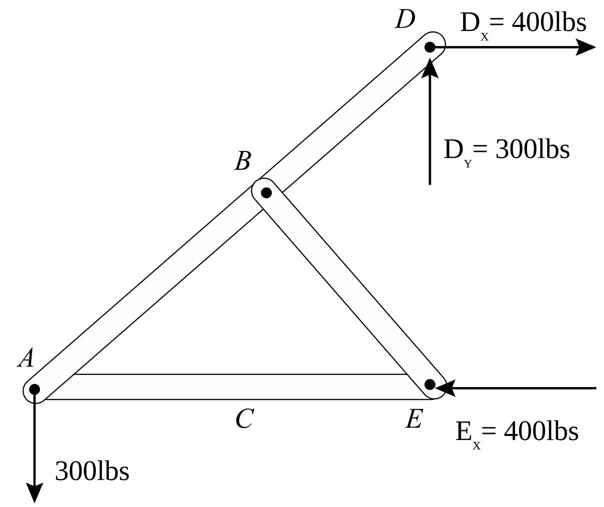
A =	**i**	**j**	lbs.	**(2 pts.)**
D =	**i**	**j**	lbs.	**(2 pts.)**

iii) Find the unknown forces acting on pin E.

F_{EB} =	**lbs. Compressive or Tensile**	**(circle one)**	**(2 pts.)**
F_{EC} =	**lbs. Compressive or Tensile**	**(circle one)**	**(2 pts.)**
F_{ED} =	**lbs. Compressive or Tensile**	**(circle one)**	**(2 pts.)**

Problem 3C. (4pts) The frame below is subjected to a 300 lb. force; it is held in equilibrium by a **single shear pin** at D and roller support at E. The modulus of elasticity (E) is 10 x 10^3 psi and the shear modulus 5 x10^3 psi. The cross section area of each member is 4 in^2 and the cross sectional area of the pin at D is 0.25 in^2.





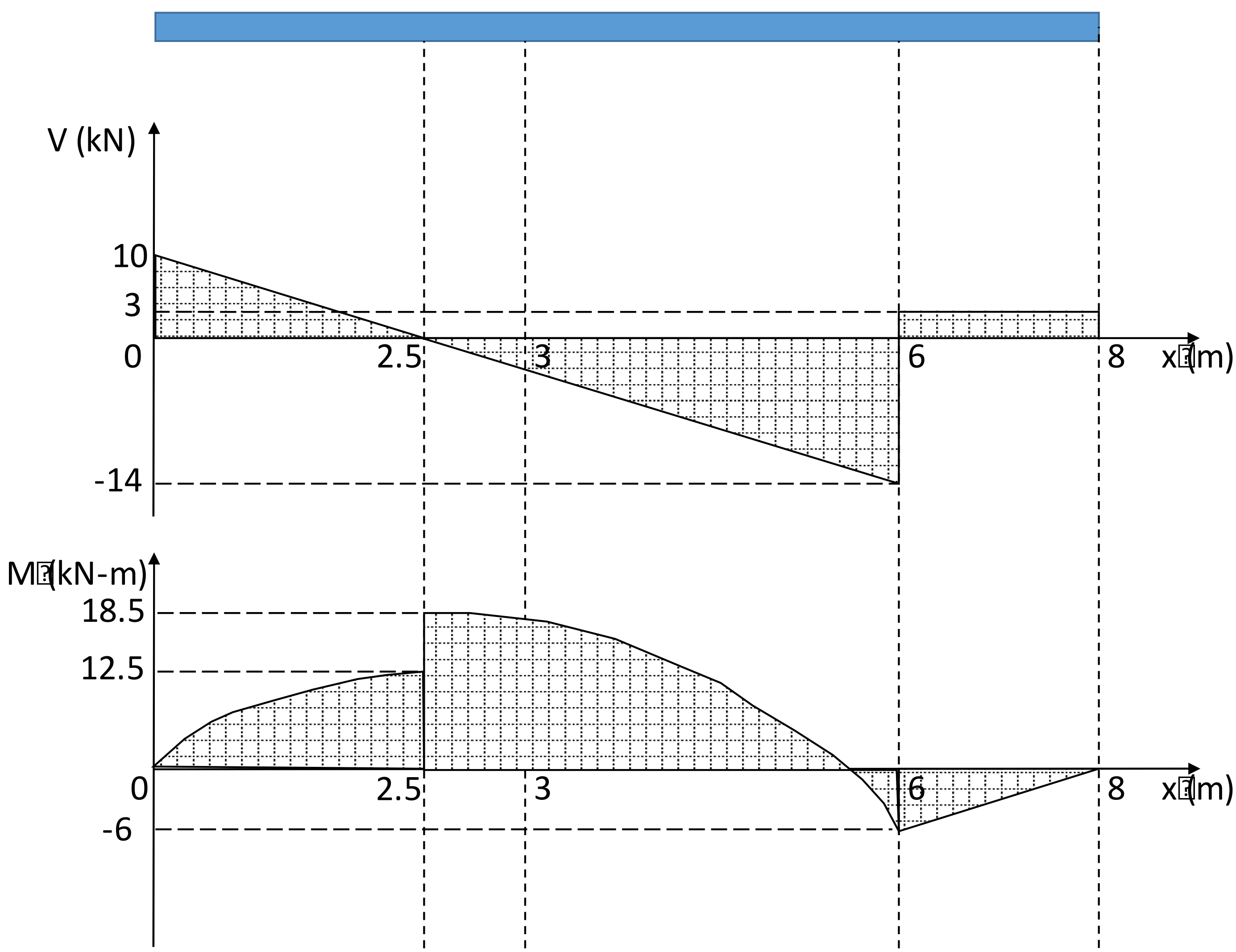
i) Determine the average shear stress and shear strain for pin D.

$(\tau)_{avg}$ =	**(2 pts.)**
$(\gamma)_{avg}$ =	**(2 pts.)**

ME 270 –Spring 2016 Final Exam **NAME (Last, First):** ___________________________________

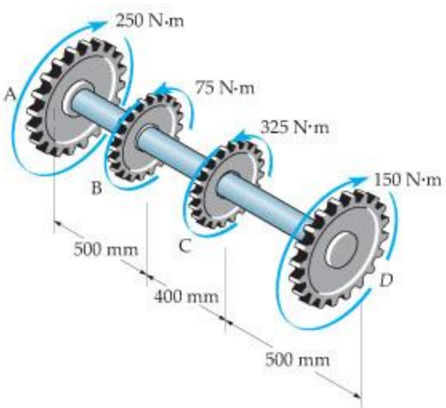
PROBLEM 4 (20 Points)
Show all work. Answers without adequate explanation will be considered wrong.

4A. (5 points)
Given the shear-force and bedning-moment diagrams provided below, sketch the equivalent loading condition on the beam provided below. Make sure you indicate both the magnitude and the direction of each load.



4B (5 Points)

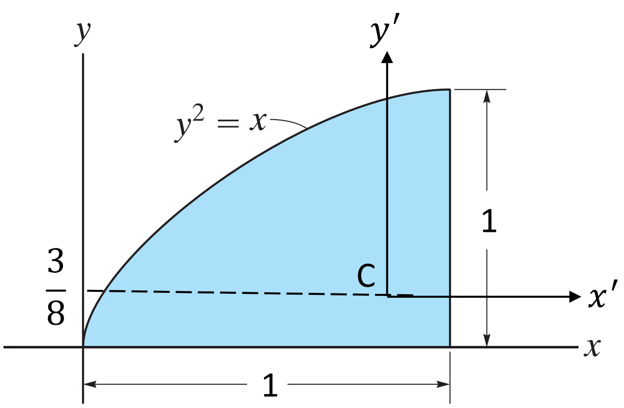
The hollow steel shaft ABCD is used to transmit the torques applied to the gears. It has outer diameter $d_o = 50$ mm and thickness $t = 5$ mm. What is the polar second area moment of the shaft? Under the loading conditions shown in the figure, what is the maximum shear stress that develops in section BC? Will the shaft break or not? The allowable shear stress $\tau_{\text{allow}} = 0.6$ GPa.



$J =$			(2 pt)
$\tau_{BC,\max} =$			(2 pt)
Is the shaft going to break? Circle the right answer	**Yes**	**No**	(1 pt)

4C (5 Points)

Compute the second area moment of the shaded shape about the x axis, I_x. Using the parallel axis theorem, find the second area moment about the x' axis. The vertical distance of the centroid from the x axis is $\frac{3}{8}$.

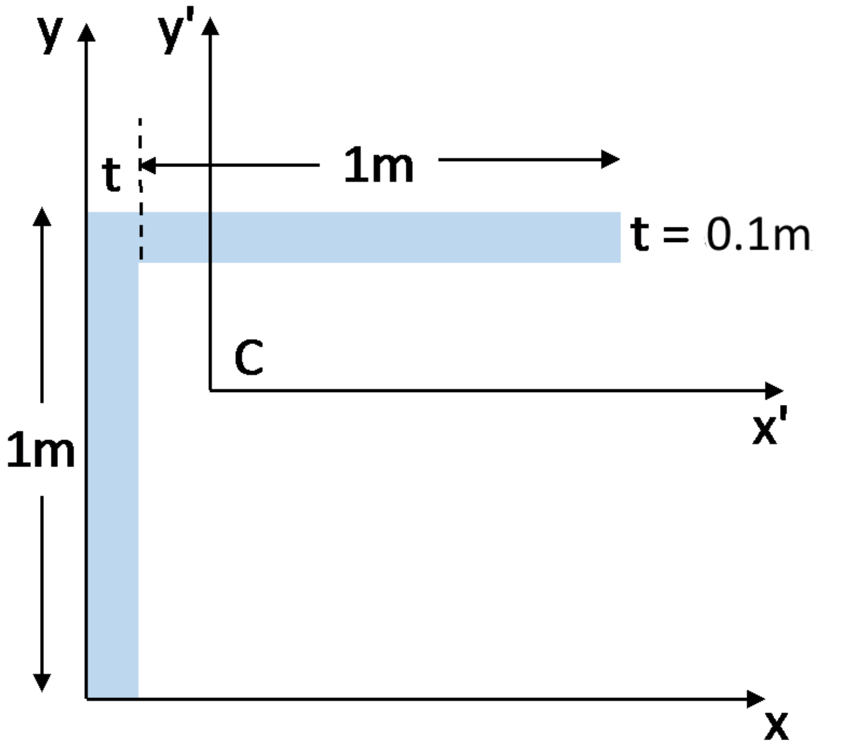


$I_x =$	(2 pt)
$I_{x'} =$	(3 pt)

ME 270 –Spring 2016 Final Exam **NAME (Last, First):** ______________________________

4D (5 Points)

Find the y coordinate of the centroid, C, of the shaded L cross section and as well as its second area moment about the x' axis. The thickness of the shape is $t = 0.1\text{m}$.



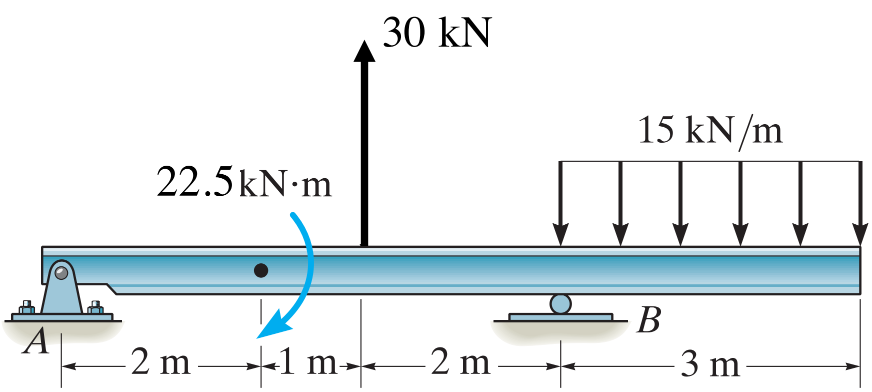
$y_c =$	(2 pt)
$I_{x'} =$	(3 pt)

PROBLEM 5 (20 points)

GIVEN: Rectangular beam AB is loaded as shown and is held in static equilibrium by a pin support at A and a roller support at B. The beam cross-section is rectangular with dimensions of 0.05m wide and 0.2m high.

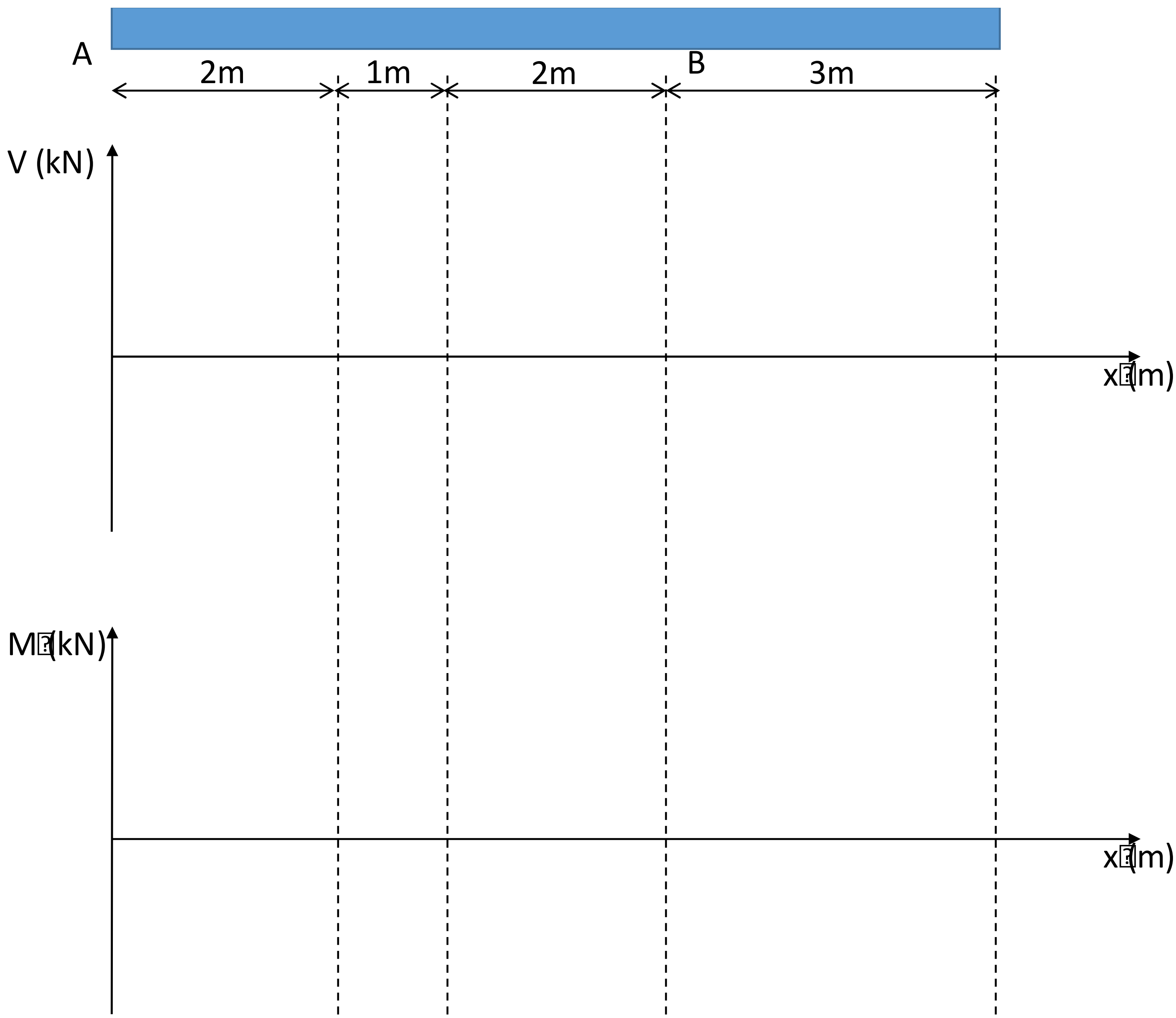
FIND:

a) Draw the free body diagram and find the support reactions at A and B. (4 pts)



Free body diagram	Sketch in white space above.	(1 pt)
$A_x =$		(1 pt)
$A_y =$		(1 pt)
$B_y =$		(1 pt)

b) Sketch the shear force and bending moment diagrams. You have to indicate the magnitudes of all quantities on graph as well as the locations where the shear the shear force (or the bending moment) is maximized or crosses zero. You may use the graphical method (11 pts).



c) Identify the section(s) of the beam where pure bending occurs and determine the maximum normal stress due to bending. (3 pts)

Pure bending section ($a \leq x \leq b$):	(1 pt)
$\sigma_{\max} =$	(2 pts)

d) Consider the bottom part of the cross section of the beam. Is it under tension or under compression? (2 pts)

The bottom part of the cross section of the beam is under (circle the right answer):	**Compression**	**Tension**	(2 pt)

ME 270 –Spring 2016 Final Exam **NAME (Last, First):** ____________________________________

Final Answers

1A) T_{BC} = 29.3 lbs.; T_{BA} = 36.0 lbs.

1B) $\bar{A} = 0\bar{\imath} + 300\bar{\jmath}\ N$; T = 200N

1C) a) 5 b) 6 c) 1

1D) a) "=" b) 8000psi (tensile) c) 1250 (C)

2a) FBD

2b) $\bar{T}_{AB} = \bar{T}_{AB}$ (-0.857$\bar{\imath}$ + -0.429$\bar{\jmath}$j + 0,286$\bar{k}$) ; $\bar{T}_{AC} = \bar{T}_{AC}$ (-0.949$\bar{\imath}$ + 0$\bar{\jmath}$ + 0.316$\bar{k}$)

2c) T_{AB} = 466 N; T_{AC} = 211 N

2d) $\bar{A} = 600\bar{\imath} + 0\bar{\jmath} + 200\bar{k}\ N$

3A) BC, BE, FG

3B) (i) FBD

(ii) $\bar{A} = 0\bar{\imath} + 375\bar{\jmath}\ lbs$;; $\bar{A} = -250\bar{\imath} + 125\bar{\jmath}\ lbs$;

(iii) F_{EB} = 177 lbs. (C); F_{EC} = 375 lbs (T); F_{ED} = 125 lbs (T);

3C) $\tau = 2000\text{psi}$; $\gamma = 0.4\text{ rad}$

4A) Loaded Beam

4B) J = 362x10^{-3} m^4; $\tau = 1.2\text{ x }10^7\ Pa$; No

4C) I_x = 0.13; $I_{x'}$ = 0.04

4D) y_c = 0.725m; $I_{x'}$ = 18.5 X 10^{-3} m^4

5A) A_x = 0kN; A_y = -30kN; B_y = 45 kN

5B) Shear-Force Bending-Moment Diagrams

5C) $(\sigma)\text{max} = 0.204\text{ GPa}$

5D) Compression

ME 270 –Spring 2016 Final Exam **NAME (Last, First): ______________________**

F

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

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

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

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

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

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

$$\bar{x} = \frac{\int x_c dA}{\int dA} \qquad \bar{y} = \frac{\int y_c dA}{\int dA}$$

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

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

Centers of Mass

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

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

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