ME 270 Exam 2 - Summer 2024

NAME (Last, First): SOLUTION

(Please PRINT) PUID#

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 Distance Section (Section Y01)

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, please request additional paper from your instructor.

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. Also, please make note of the following instructions.

- The allowable exam time for Exam 2 is 90 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 or dark lead pencil** for the exam.
- Do not write on the back side of your exam paper.

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

When submitting your exam on Gradescope, 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. Also, be sure to identify the page numbers for each problem before final submission on Gradescope. Do not include the cover page or the equation sheet with any of the problems.

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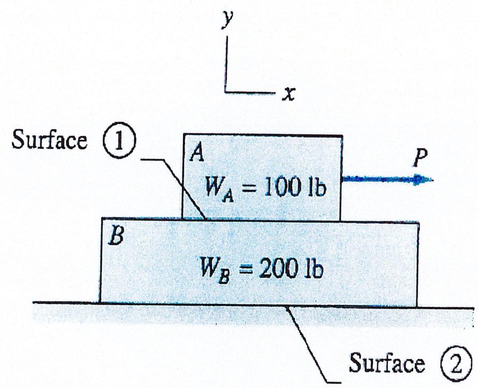
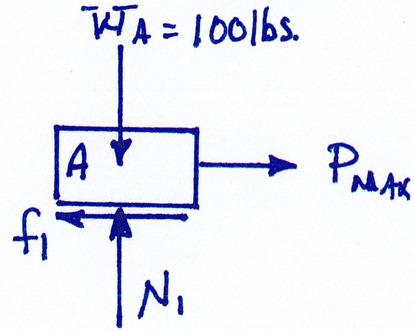
Problem 1 (20 points)

1A) Determine the maximum force (P_{max}) that can be applied to block A without either block moving. Assume μ_s for Surface 1 is $\mu_{s1} = 0.35$ and μ_s for surface 2 is $\mu_{s2} = 0.1$. What is the nature of the impending motion? Be sure to include your free body diagrams and equilibrium equations. **(5 Pts)**



Assume Impending Motion at ① $(f_1 = \mu_{s_1} N_1)$

$\Sigma F_y = 0 = N_1 - W_A \Rightarrow N_1 = W_A = 100$ lbs.

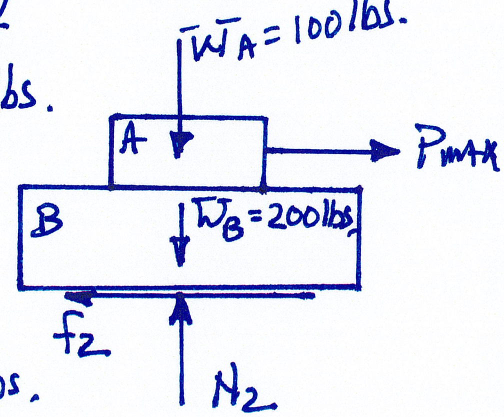


$\Sigma F_x = 0 = P_{MAX} - f_1 \Rightarrow P_{MAX} = f_1$

$P_{MAX} = \mu_{s_1} N_1 = 0.35(100) = 35$ lbs.

Assume Impending Motion at ② $(f_2 = \mu_{s_2} N_2)$

$\Sigma F_y = 0 = N_2 - W_A - W_B \Rightarrow N_2 = W_A + W_B = 300$ lbs.



$\Sigma F_x = 0 = P_{MAX} - f_2 \Rightarrow P_{MAX} = f_2$

$P_{MAX} = \mu_{s_2} N_2 = 0.1(300) = 30$ lbs.

Since $P_{MAX_2} < P_{MAX_1} \Rightarrow P_{MAX} = 30$ lbs.

P_{max} = 30 lbs (3 pts)

Impending Motion = Block A Slides Block B Slides Both Blocks A and B slide (Circle One) (2 pts)

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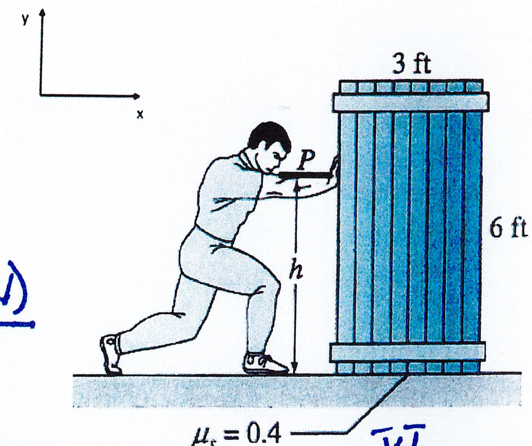
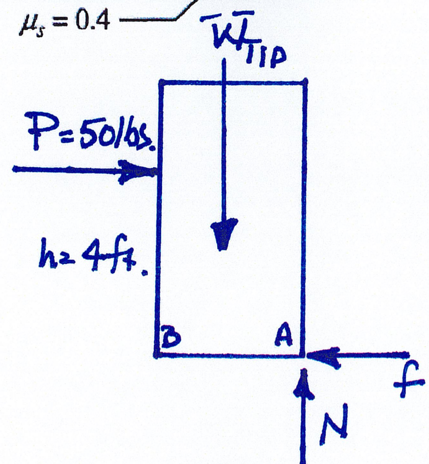
1B) A man pushes a crate of weight W with a force of P = 50 lbs at a height of h = 4 ft. What is the lightest weight crate the man can push without the crate tipping (W_T)? What is the lightest weight crate the man can push without the crate slipping (W_s)? What is the minimum weight of the crate for which no motion occurs and circle the impending motion. Be sue to include your free body diagrams and equilibrium equations. **(5 Pts)**



Assume Impending Tipping ($f \leq \mu_s N$)

$\Sigma M_A = 0 = W_{Tip}(1.5) - P(4)$

$$\boxed{\therefore W_{Tip} = (50)(4)/1.5 = 133 \text{ lbs.}}$$



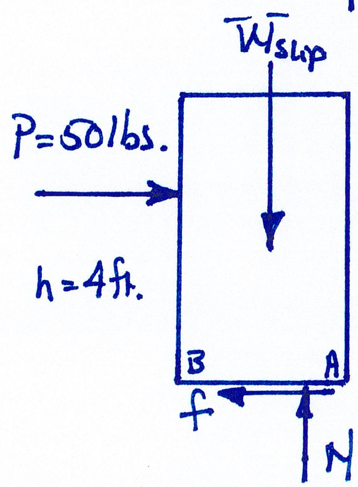
Assume Impending Slipping ($f = \mu_s N$)

$\Sigma F_y = 0 = N - W_{slip} \Rightarrow N = W_{slip}$

$\Sigma F_x = 0 = P - f = P - \mu_s N$

$\therefore P = \mu_s N \Rightarrow 50 = 0.4(W_{slip})$

$$\boxed{\therefore W_{slip} = 125 \text{ lbs.}}$$



W_{Tip} = 133 **lbs (2 pts) W_{Slip} =** 125 **lbs (2 pts)**

W_{min} = 133 **lbs** **Impending Motion = Tip Slip Neither (1 pt)**

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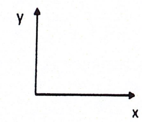
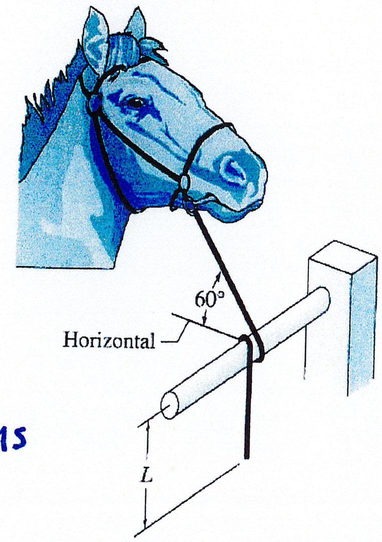
1C) A leather lead rope used to fasten a horse to a hitching rail weighs 0.25 lbs/ft of length. The lead rope is wrapped as shown. What is the angle of wrap (β) of the lead rope? If a 40-lb force acting on the horse is sufficient to restrain the horse, determine the shortest length (L) of the lead rope that needs to hang over the hitching post to safely restrain the horse? **(5 pts)** Assume $\mu_s = 0.7$





$$\boxed{\beta = 360^\circ + 30^\circ = 390^\circ}$$

$$= 2\pi + \frac{\pi}{6} = \frac{13\pi}{6} = 6.81 \text{ radians}$$

$$\frac{T_L}{T_S} = e^{\mu_s \beta} \qquad \frac{40}{T_s} = e^{(0.7)(6.81)}$$

$$\therefore T_s = 0.340 \text{ lbs.} = \left(0.25 \frac{\text{lbs}}{\text{ft}}\right)(L)$$

$$\boxed{\therefore L = \frac{0.340}{0.25} = 1.36 \text{ ft}}$$

β= 390° degrees **(3 pts)** L = 1.36 ft **(2pts)**

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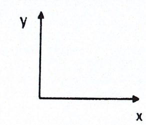
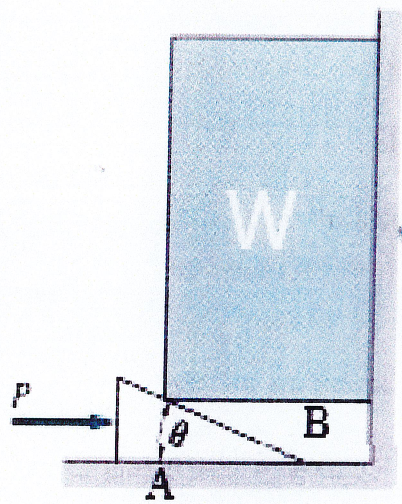
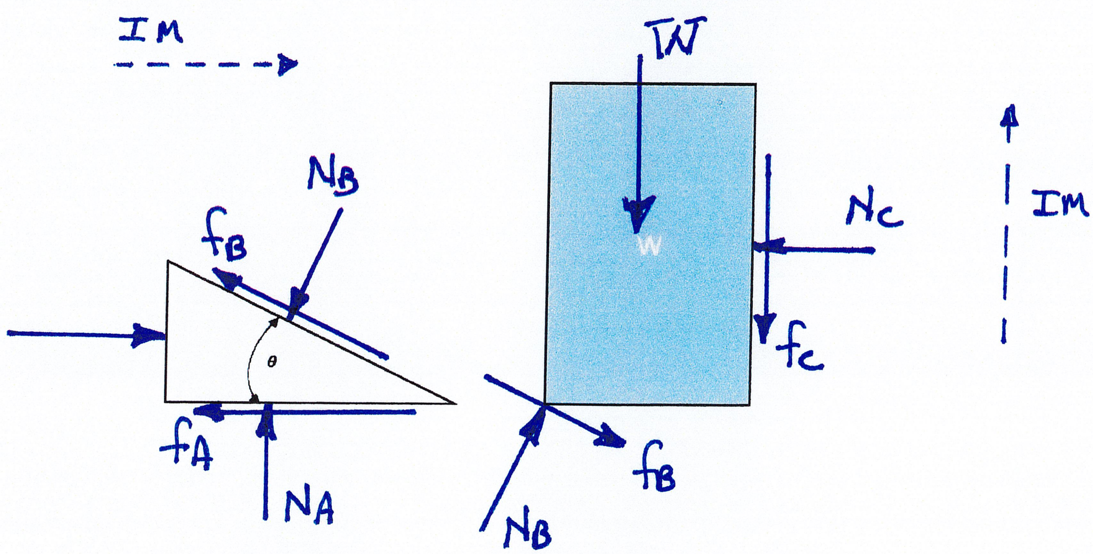
1D) A massless wedge of angle θ is used to lift a box of weight W. On the artwork provided below, complete the free body diagrams of the wedge and box. If the minimum force P to raise the weight was 25 lbs, would the wedge be self-locking, not self-locking or cannot tell from the information provided? No Justification needs to be provided. Friction exists at all three surfaces (A, B, and C). **(5 pts)**







(2 pts) **(2 pts)**

Wedge =	**Self-Locking**	**Not Self-Locking**	**Can't Tell**	**(Circle One)**	**(1 pt)**

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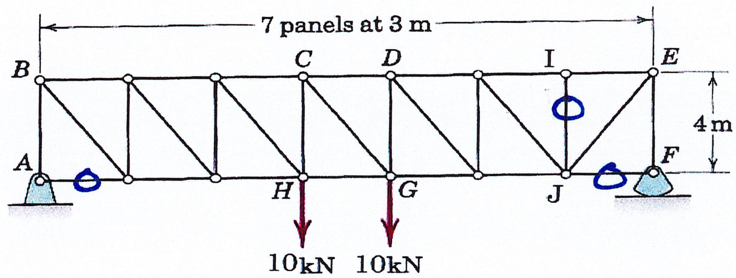
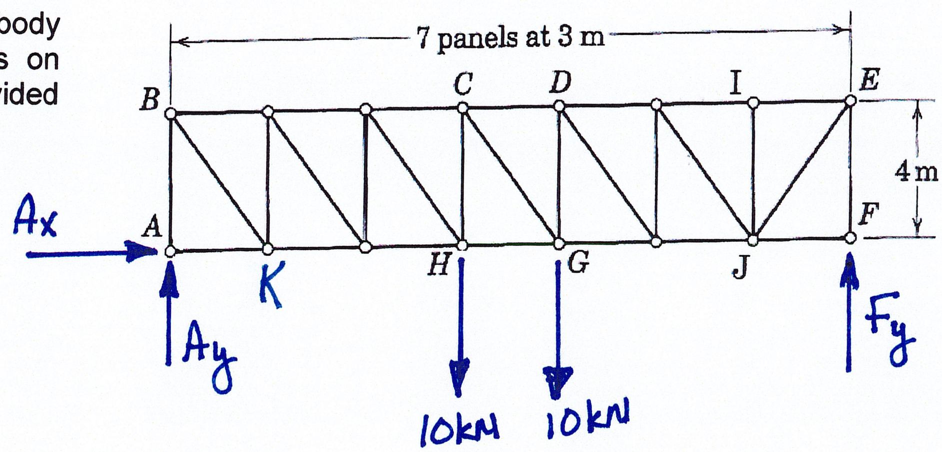
Problem 2 (20 points)

GIVEN: The truss shown is loaded with two 10kN loads at joints G and H and is held in static equilibrium by a pin support at joint A and a rocker support at joint F.



FIND:

a) Complete the free body diagram of the truss on the artwork provided below. **(1 pt)**



b) Calculate the reaction forces at supports A and F ($\vec{F}_A$ and $\vec{F}_F$) in vector form. **(7 pts)**

$$\underline{\Sigma M_A = 0} = -10(9) - 10(12) + F_y(21) \Rightarrow \boxed{F_y = 10\text{kN}}$$

$$\underline{\Sigma F_x = 0} = A_x \Rightarrow \boxed{A_x = 0\text{kN}}$$

$$\underline{\Sigma F_y = 0} = A_y - 10 - 10 + 10 \Rightarrow \boxed{A_y = 10\text{kN}}$$

$\bar{F}_A$ = (0)$\bar{\imath}$ + (+10 $\bar{\jmath}$) kN **(4pts)** $\bar{F}_F$ = (+10 $\bar{\jmath}$) kN **(3pts)**

c) Place a zero on all zero-force members in the truss above (No work needs to be shown). **(3 pts)**

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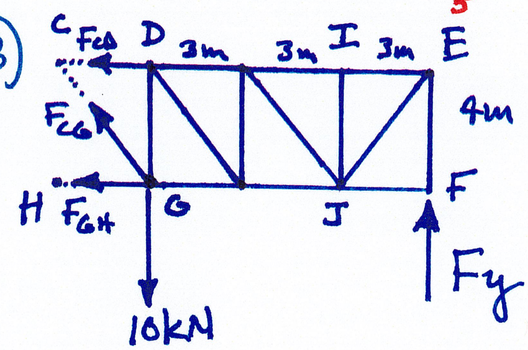
d) Using the method of sections, determine the magnitude of the load in the members GH and CG. Indicate whether the load is T, 0 or C. Include a free-body diagram and equilibrium equations. **(~~6~~ 5 pts)**

$$\Sigma M_C = 0 = \overset{(10kN)}{F_y}(12) - F_{GH}(4) - 10(3)$$

$$\boxed{\therefore F_{GH} = +22.5\text{ kN} = 22.5\text{ kN (T)}}$$



$$\Sigma F_y = 0 = \overset{(10kN)}{F_y} - 10 + \left(\tfrac{4}{5}\right) F_{CG}$$

$$\boxed{\therefore F_{CG} = 0\text{ kN (Zero Force Member)}}$$

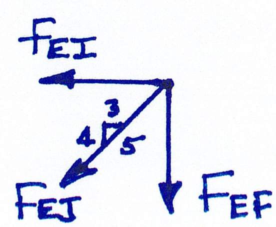
F_{GH} = ___22.5___ kN Tension Zero Compression (circle one) **(3 pts)**

F_{CG} = ___0___ kN Tension Zero Compression (circle one) **(~~3~~ 2 pts)**

e) Knowing the load in member EF from the support reaction at F, use the method of joints to determine the magnitude of the force in the members EI and EJ. Indicate whether each member is T, 0 or C. Include a free-body diagram and equilibrium equations. **(~~3~~ 4 pts)**

$$\Sigma F_y = 0 = -\overset{(-10kN)}{F_{EF}} - \left(\tfrac{4}{5}\right) F_{EJ}$$

$$\therefore F_{EJ} = +12.5\text{ kN} = 12.5\text{ kN (T)}$$



$$\Sigma F_x = 0 = -F_{EI} - \left(\tfrac{3}{5}\right) \overset{(12.5kN)}{F_{EJ}}$$

$$\therefore F_{EI} = -7.5\text{ kN} = 7.5\text{ kN (C)}$$

F_{EI} = ___7.5___ kN Tension Zero Compression (circle one) **(~~3~~ 2 pts)**

F_{EJ} = ___12.5___ kN Tension Zero Compression (circle one) **(~~3~~ 2 pts)**

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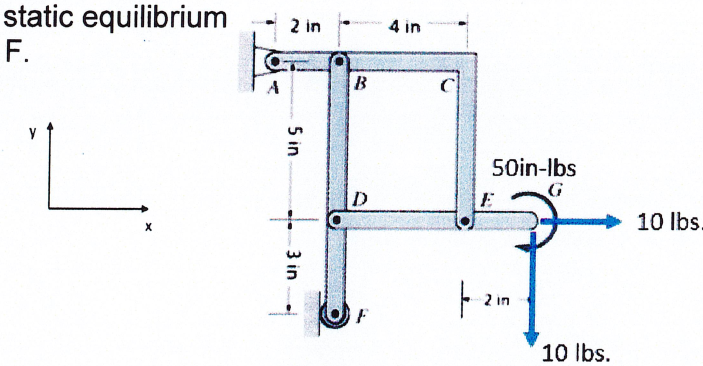
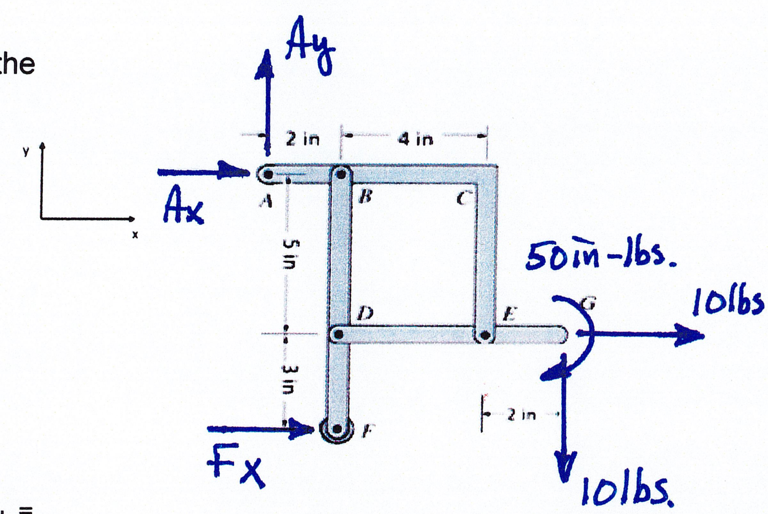
Problem 3 (20 points)

<u>GIVEN</u>: Frame A-G is loaded with two 10-lb forces and one 50 in-lb couple as shown and is held in static equilibrium by a pin support at A and a roller support at F.



<u>FIND</u>:

a) Complete the overall free-body diagram on the artwork provided. **(2 pts)**



b) Determine the reactions at supports $\bar{F}_A$ and $\bar{F}_F$.
<u>Express these reactions in vector form.</u> **(5 pts)**

$\Sigma M_A = 0 = -50 + 10(5) - 10(8) + F_x(8) \Rightarrow \boxed{F_x = 10\,lbs}$

(10lbs)

$\Sigma F_x = 0 = A_x + F_x + 10 \Rightarrow \boxed{A_x = -20\,lbs}$

$\Sigma F_y = 0 = A_y - 10 \Rightarrow \boxed{A_y = +10\,lbs}$

$\bar{F}_A$ = -20 $\bar{\imath}$ + +10 $\bar{\jmath}$	lbs	**(3 pts)**
$\bar{F}_F$ = (+10) i	lbs	**(2 pts)**

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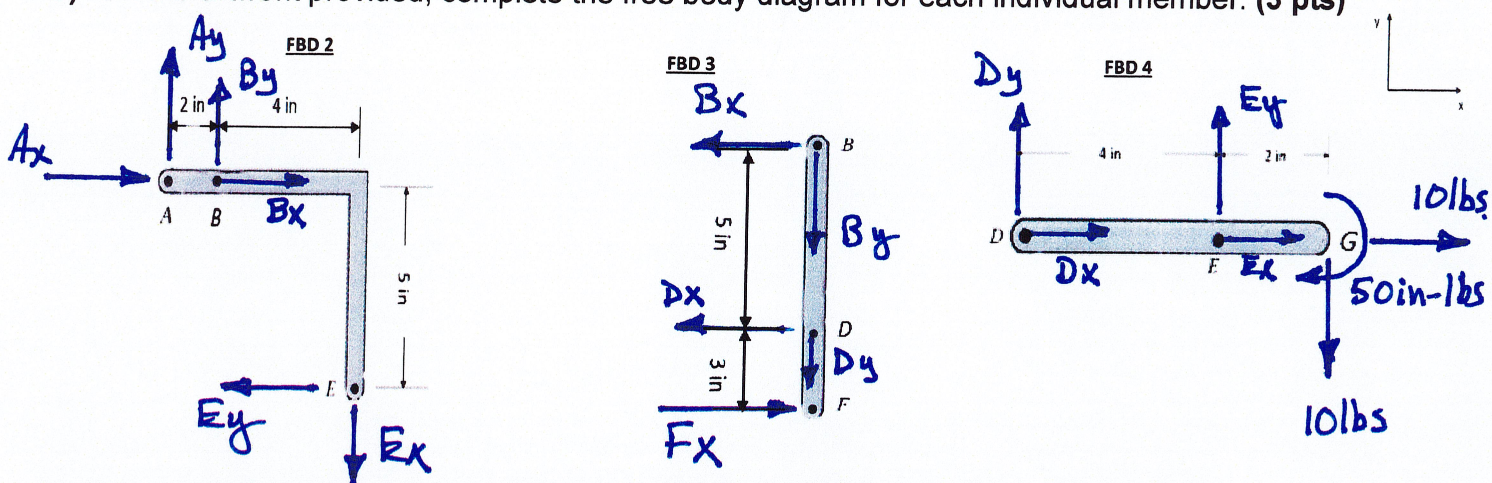
c) On the artwork provided, complete the free body diagram for each individual member. **(3 pts)**



d) Determine the forces on member DEG at joints D and E. <u>Express these forces in vector form.</u> Remember to reference the free-body diagrams used in your calculations. **(8 pts)**

FBD3: $\sum M_B = 0 = -D_x(5) + \overset{(10\,lbs)}{F_x}(8) \Rightarrow D_x = +16\,lbs.$

FBD4: $\sum F_x = 0 = \overset{(16\,lbs)}{D_x} + E_x + 10 \Rightarrow E_x = -26\,lbs.$

$\sum M_D = 0 = E_y(4) - 50 - 10(6) \Rightarrow E_y = +27.5\,lbs.$

$\sum F_y = 0 = D_y + \overset{(27.5\,lbs)}{E_y} - 10 \Rightarrow D_y = -17.5\,lbs.$

$(\bar{F}_D)$ on DEG=	+16 $\bar{\imath}$ +	−17.5 $\bar{\jmath}$ lbs		(4 pts)
$(\bar{F}_E)$ on DEG =	−26 $\bar{\imath}$ +	+27.5 $\bar{\jmath}$ lbs		(4 pts)

e) How does the force at joint D on member BDF compare to the force at joint D on member DEG?

$(\bar{F}_D)$ on BDF = Same Magn.,Same Direction   Sam Magn.,Opposite Direction   Can't Tell   **(2 pts)**