 NAME (Last, First): SOLUTION
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	MWF 9:50AM-10:50AM (Section 001)
	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 1 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. After uploading the exam, be sure to assign each exam page to the appropriate problem in Gradescope before submitting the exam. Do not assign the cover page, any unused blank pages, or the equation sheet to any problems.

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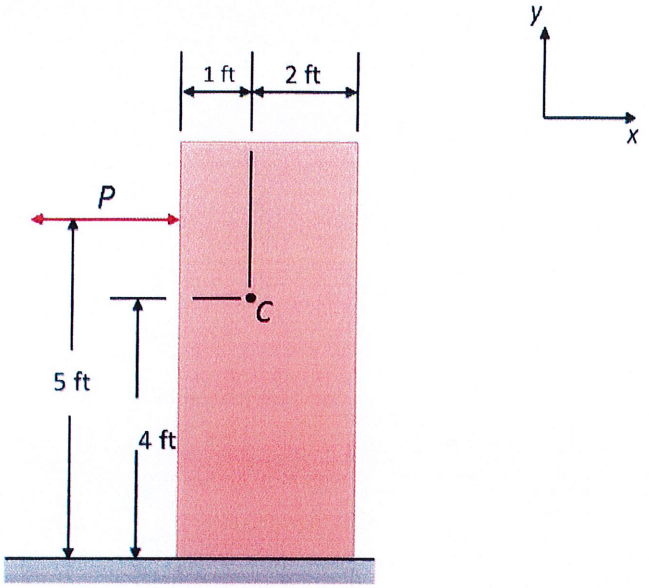
PROBLEM 1. (20 points)

1A. Given: A 200-lb cabinet is 7.5 ft tall. Its gravitational center is shown at point C. The coefficient of friction between the cabinet and the floor is 0.25. (5 points)

Find: Without disturbing equilibrium, how large a force can be applied:

a) To the right?

b) To the left?



Right

Tip $\Sigma M_O = 0 = -P_T(5) + \bar{W}(2)$

$\therefore P_T = \frac{200(2)}{5} = \boxed{80 \text{ lbs.}}$

Slip $\Sigma F_y = 0 = N - W \Rightarrow N = \bar{W}$

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

$\therefore P_s = \mu_s \bar{W} = (0.25)(200) = \boxed{50 \text{ lbs}}$

Left

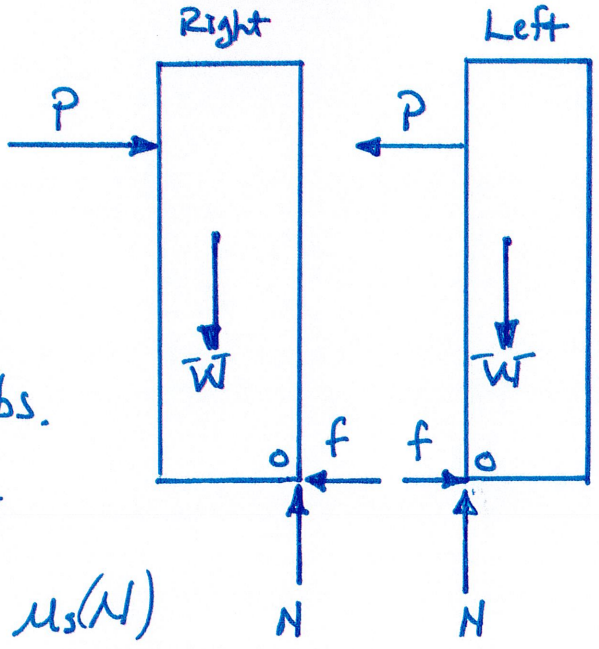
Tip $\Sigma M_O = 0 = P_T(5) - \bar{W}(1)$

$\therefore P_T = \frac{200(1)}{5} = 40 \text{ lbs.}$

Slip $\Sigma F_y = 0 = N - \bar{W} \Rightarrow N = \bar{W}$

$\Sigma F_x = 0 = -P_s + f = -P_s + \mu_s(N)$

$\therefore P_s = \mu_s N = (0.25)(200) = \boxed{50 \text{ lbs.}}$

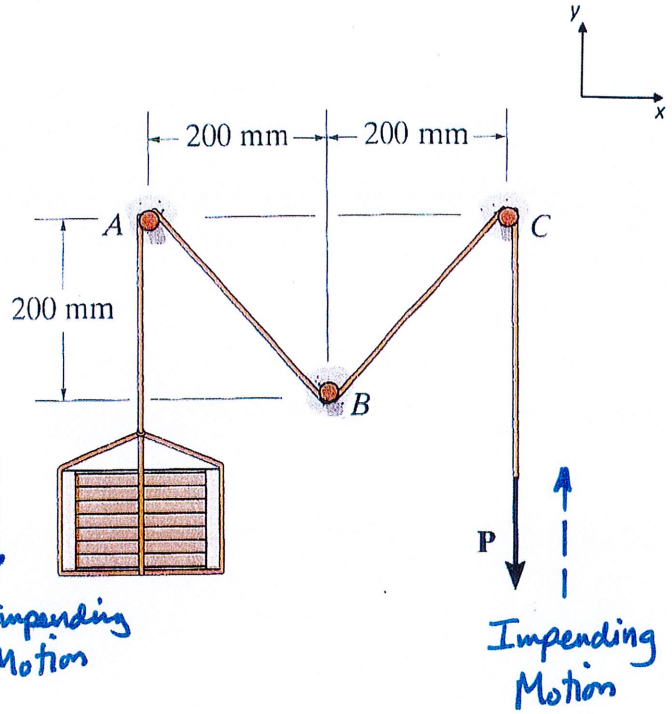


$(P_{Max})_{Right}$ = 50 lbs (2.5 pts) $(P_{Max})_{Left}$ = 40 lbs (2.5 pts)

1B. Given: A crate weighing 200 N is held in place by a rope passing through three pegs with an applied force P. Assume the coefficient of static friction is $\mu_s = 0.2$. (5 points)

Find: Determine the total combined angle of wrap of pegs A, B, and C ($\beta_A + \beta_B + \beta_C$). (2 pts)

Determine the smallest force (P) for which the system will remain in static equilibrium. (3 pts)



$\beta_A + \beta_B + \beta_C = 135° + 90° + 135°$

$= 360°$

$= 2\pi$ radians

$= 6.28$ radians

$\frac{T_L}{T_S} = e^{\mu_s(\beta_A + \beta_B + \beta_C)}$

$T_L = W_C = 200$ lbs.

$\frac{200}{T_S} = e^{(0.2)(6.28)}$

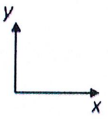
$T_S = \frac{200}{3.511} = \boxed{57.0\ N}$

$(\beta_A + \beta_B + \beta_C) =$ 6.28 radians (2 pts) P = 57.0 N (3 pts)

1C. Given: A angled gate ABCD is supported by a pin support at A and a roller support at D. The gate contains fresh water ($\rho g = 62.5\ lbs/ft^3$) and has a width of 2 ft (into the page). The total weight of the gate is 2400 lbs with each panel (AB, BC and CD) weighing 800 lbs, uniformly distributed. (5 pts.)

Find: If the water depth is known to be d = 6 ft, determine

- The magnitude of the equivalent force F_{eq} produced by the water on gate ABCD.
- The magnitude of the reaction force at D.

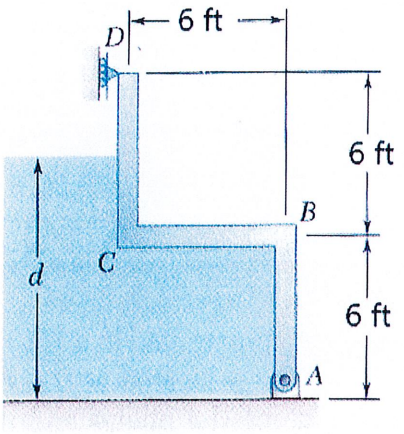


$P_A = \rho g(h_N) = \rho g(d) = \left(62.5 \frac{lbs}{ft^3}\right)(6\,ft)$

$= 375 \frac{lbs}{ft^2}$

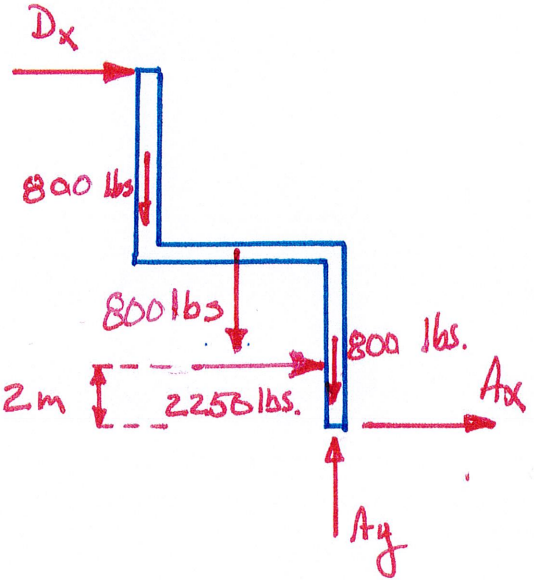
$F_{eq} = \frac{1}{2}(6\,ft)\left(375 \frac{lbs}{ft^2}\right)(2\,ft)$

$\boxed{F_{eq} = 2250\ lbs.}$



$\Sigma M_A = 0 = 800\,(3ft) + 800\,(6ft) - D_x(12\,ft) - 2250(2)$

$\boxed{\therefore D_x = 225\ lbs.}$

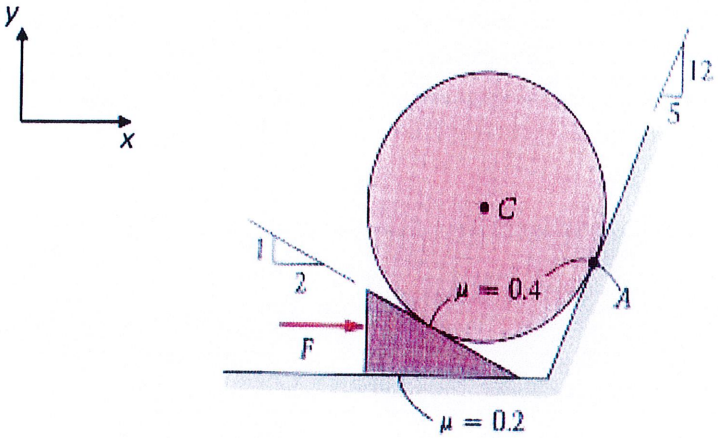


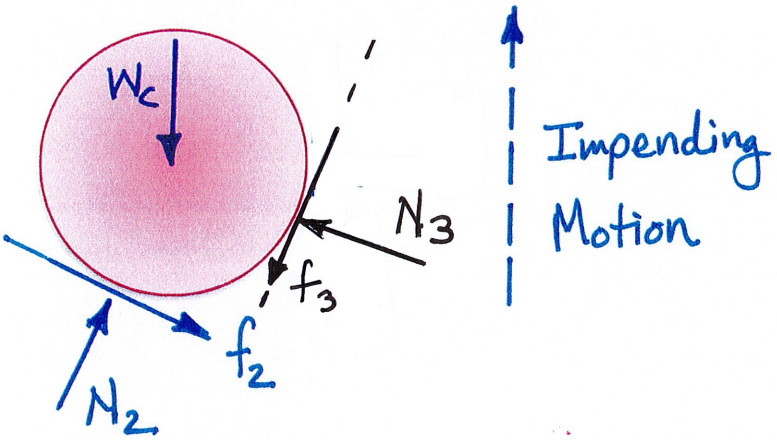
F_{eq} = 2250 lbs (2 pts)	D_x = 225 lbs (3 pts)

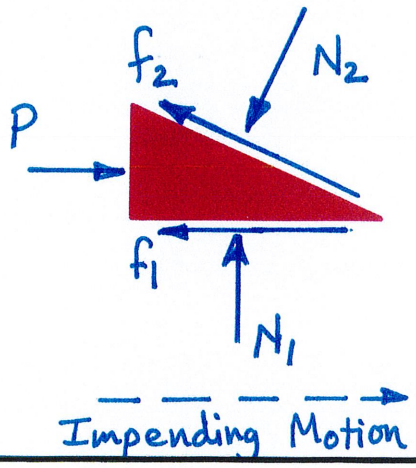
1D. **Given:** A wedge is used to move a cylinder of weight W_C up an inclined plane. Friction exists on all contact surfaces as shown. Neglect the weight of the wedge. A force F is applied that the wedge is about to start moving forward. (5 pts.)

Find:

- On the wedge and cylinder artwork provided, complete the free body diagrams (FBDs) of both the wedge and the cylinder (4 pts).
- If the force F required to lift the cylinder was F = 100N, what would this imply regarding whether the wedge was self-locking? (1 pt)



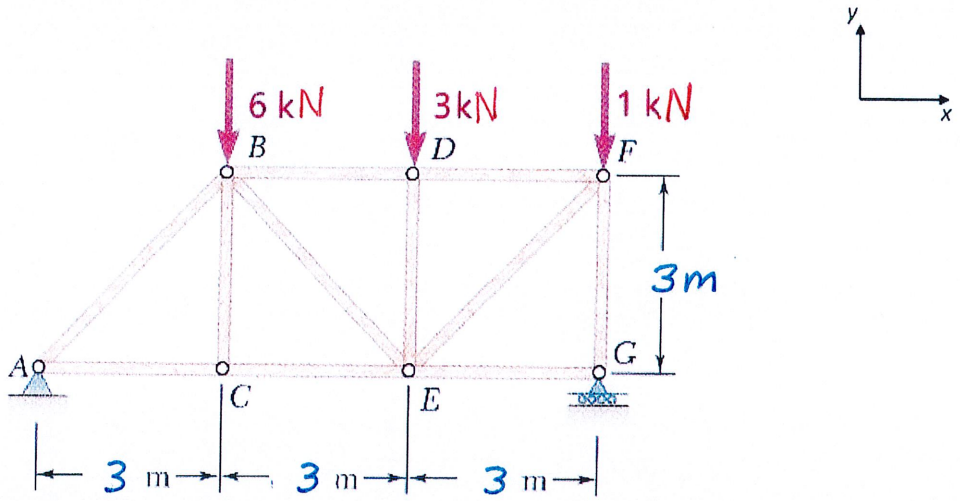




Wedge =	Self-Locking	Not Self-Locking	Cannot Determine (Circle One)	(1 pts)

Problem 2 (20 points)

GIVEN: The truss A-G is loaded with a force 6 kN at joint B, a force 3 kN at joint D, and a force 1 kN at joint F, as shown. The truss is held in static equilibrium by a pin support at A and a roller support at G.

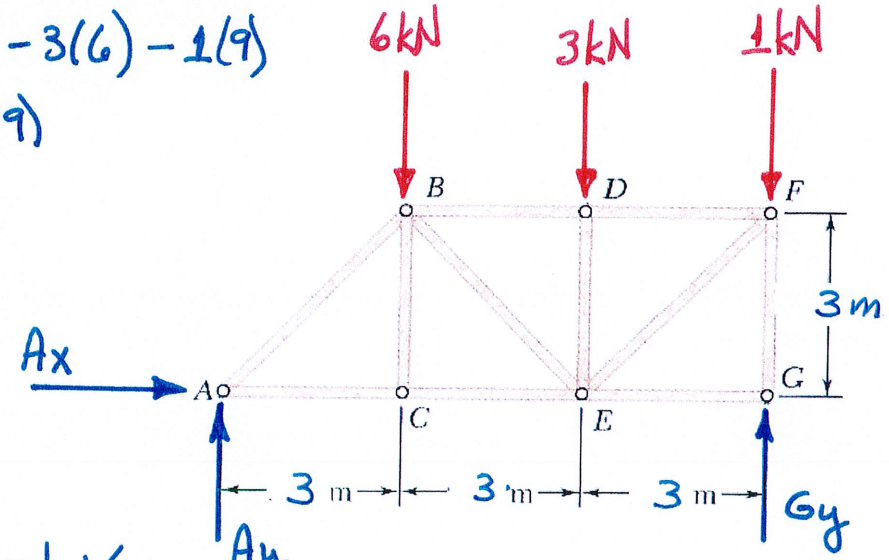


FIND:

a) Draw the free body diagram of the truss (2 pts). Determine the reactions at A and G. Express the reaction forces in vector form. (3 pts)

$\Sigma M_A = 0 = -6(3) - 3(6) - 1(9) + G_y(9)$

$G_y = 5\ kN$



$\Sigma F_x = 0 = A_x$

$A_x = 0\ kN$

$\Sigma F_y = 0 = -6 - 3 - 1 + G_y + A_y$

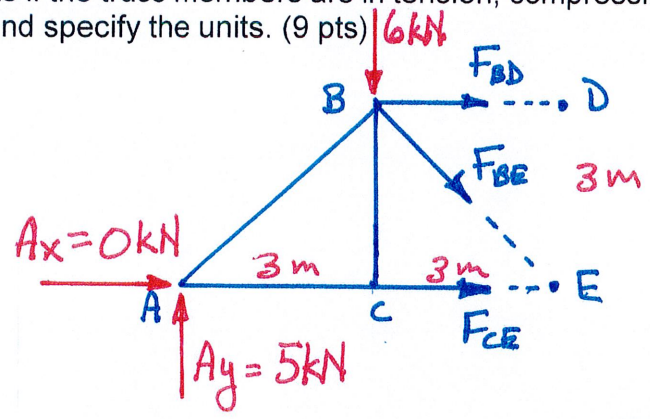
$A_y = 5\ kN$

$\bar{F}_A$ = (0) $\hat{\imath}$ + (5) $\hat{\jmath}$ kN	(2 pts)
$\bar{F}_G$ = (5) $\hat{\jmath}$ kN	(1 pts)

b) List the zero-force members below. No work needs to be shown.

Zero-Force Members = BC, EG	(2 pts)

c) Use the **method of sections** to find the magnitude of the loads in the members BD, BE, and CE. Clearly state if the truss members are in tension, compression, or zero force. Include a free-body diagram and specify the units. (9 pts)



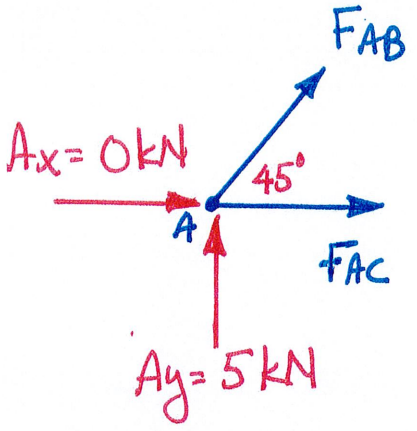
$\Sigma M_B = 0 = -5(3) + F_{CE}\left(\frac{3}{4}\right) \Rightarrow \boxed{F_{CE} = 5\ kN}$

$\Sigma M_E = 0 = 6(3) - 5(6) - F_{BD}(3) \Rightarrow \boxed{F_{BD} = -4kN}$

$\Sigma F_y = 0 = 5 - 6 - F_{BE}\cos 45° \Rightarrow \boxed{F_{BE} = -1.414\ kN}$

F_{BD}= 4 kN	Tension	(Compression)	Zero	(circle one)	(3 pts)
F_{BE}= 1.414 kN	Tension	(Compression)	Zero	(circle one)	(3 pts)
F_{CE}= 5 kN	(Tension)	Compression	Zero	(circle one)	(3 pts)

d) Use the **method of joints** to find the magnitude of the loads in the members AB and AC. Clearly state if the truss members are in tension, compression, or zero force. Include a free-body diagram and specify the units. (4 pts)



$$\Sigma F_y = 0 = 5 + F_{AB} \sin 45°$$

$$\therefore F_{AB} = -7.07\ kN$$

-7.07

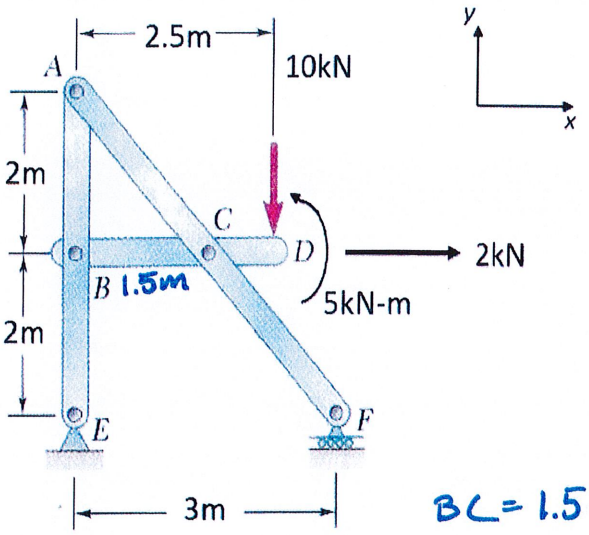
$$\Sigma F_x = 0 = F_{AC} + F_{AB} \cos 45°$$

$$\therefore F_{AC} = 5\ kN$$

F_{AB} = 7.07	Tension	(Compression)	Zero (circle one)	(2 pts)
F_{AC} = 5 kN	(Tension)	Compression	Zero (circle one)	(2 pts)

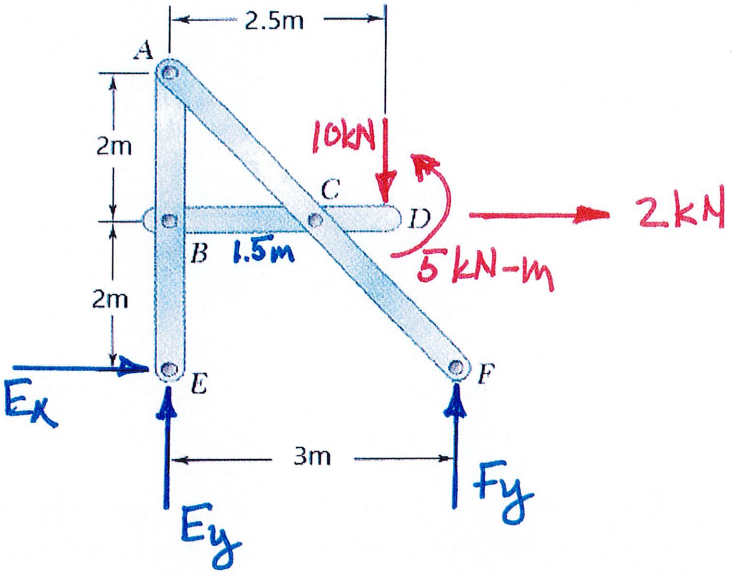
PROBLEM 3. (20 points)

Given: Frame A-F is loaded with two applied forces and a couple at *D* as shown below. The frame is supported by a pin at E and a roller support at F.



Find:

a) On the art work shown below, complete the overall free body diagram. (3 pts)



b) Solve for the reactions at E and F and express the results in vector form.

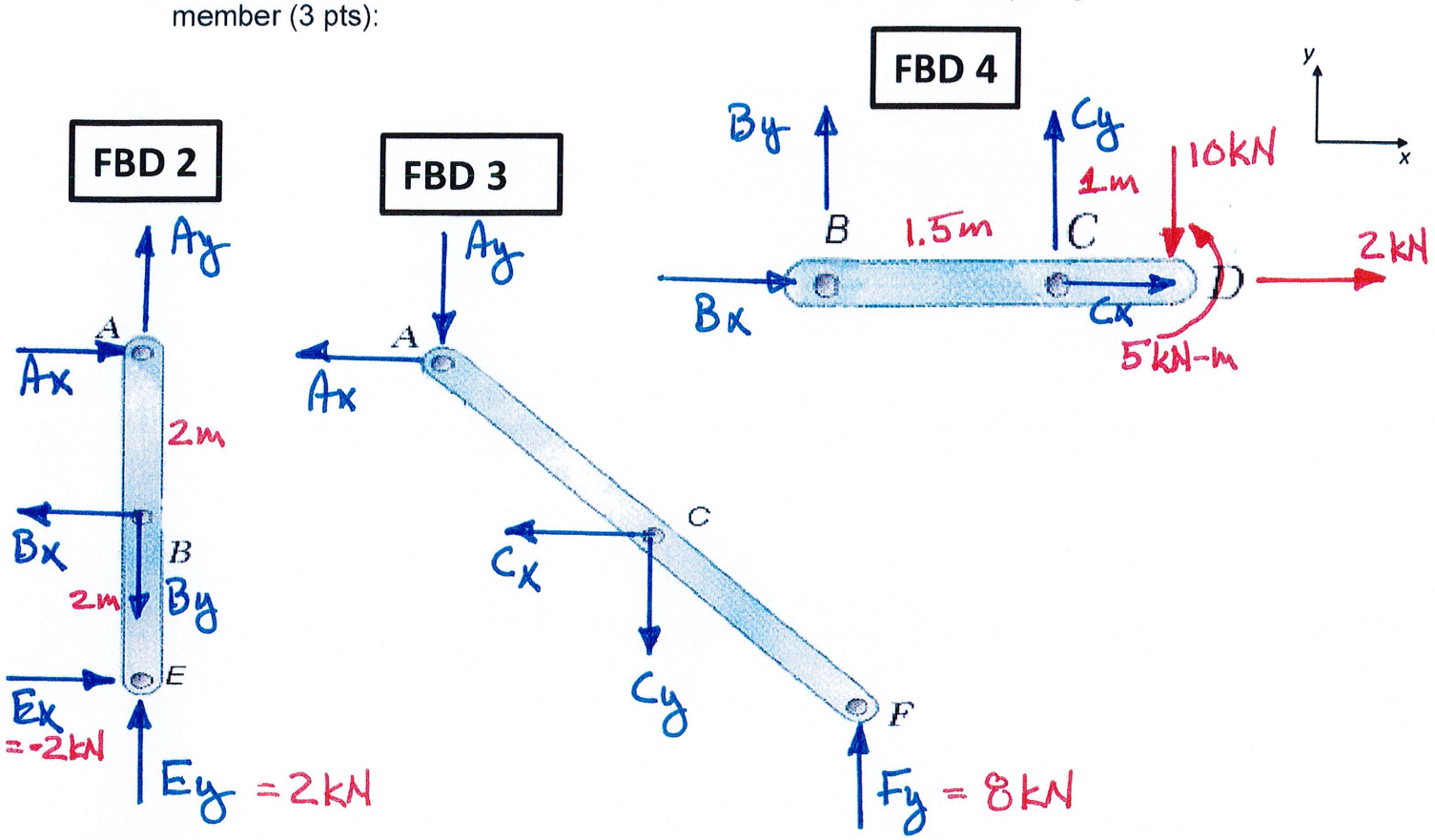
$\Sigma M_E = 0 = -(10)(2.5) - 2(2) + 5 + F_y(3) \Rightarrow \boxed{F_y = 8\,kN}$

$\Sigma F_x = 0 = E_x + 2 \Rightarrow \boxed{E_x = -2\,kN}$

$\Sigma F_y = 0 = E_y + F_y - 10 \Rightarrow \boxed{E_y = 2\,kN}$ (8 kN)

$\vec{E} = (\,-2\,)\hat{i} + (\,2\,)\hat{j}$ kN (3 pts) $\quad \vec{F} = (\,8\,)\hat{j}$ kN (3 pts)

c) On the art work provided below, complete the individual free body diagrams for each individual member (3 pts):



d) Solve for the internal forces at pins B and C on member BCD. Express the resultant forces in vector form.

FBD 2

$\Sigma M_A = 0 = -B_x(2) + E_x(4)$ ($E_x = -2$ kN) $\Rightarrow$ **$B_x = -4$ kN**

FBD 4

$\Sigma M_C = 0 = -B_y(1.5) - 10(1) + 5$ **$B_y = -3.33$ kN**

$\Sigma F_x = 0 = B_x + C_x + 2$ ($B_x = -4$ kN) **$C_x = +2$ kN**

$\Sigma F_y = 0 = B_y + C_y - 10$ ($B_y = -3.33$ kN) **$C_y = 13.33$ kN**

$(\vec{B})_{\text{on BCD}} = (\underline{-4})\hat{i} + (\underline{-3.33})\hat{j}$ kN (4pts) $(\vec{C})_{\text{on BCD}} = (\underline{2})\hat{i} + (\underline{13.33})\hat{j}$ kN (4pts)

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Exam 2 – Equation Sheet

Buoyancy

$$F_B = \rho g V$$

Fluid Statics

$$p = \rho g h$$

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

Belt Friction

$$\frac{T_L}{T_s} = e^{\mu\beta}$$