ME 270 – Fall 2025 Exam 2 **NAME (Last, First):** SOLUTION **(Please Print)**

PUID #: ____________________ **(Please Print)**

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: **West Lafayette Campus (PWL)**

J. Osorio Pinzon, Section 033, MWF 7:30AM-8:20AM
J. Jones, Section 005, MWF 9:30AM-10:20AM
S. C. Boregowda, Section 008, MWF 10:30AM-11:20AM
J. Jones, Section 003, MWF 11:30AM-12:20PM
L. Krest, Section 009, MWF 12:30PM-1:20PM
F. Semperlotti, Section 001, MWF 1:30PM-2:20PM
A. Ramkumar, Section 010, MWF 2:30PM-3:20PM
T. Ballance, Section 032, MWF 4:30PM-5:20PM
M. Murphy, Section 007, TR 9:00AM-10:15AM
M. Murphy, Section 002, TR 10:30AM-11:45AM
J. Jones, Section Y01, Distance Learning

Indianapolis Campus (PIN)

N. Saqib, Section 031, MWF 9:30AM-10:20AM
A. McDonald, Section 029, MWF 1:30PM-2:20PM
D. Wagner, Section 030, TTh 12:00PM-1:15PM

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.

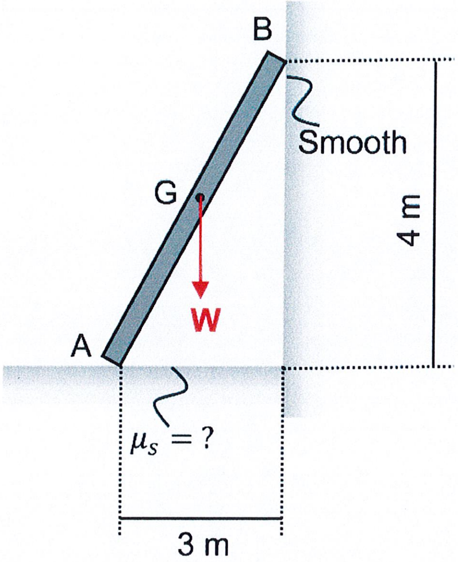
If the solution does not follow a logical thought process, it will be assumed in error.

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 the cover page. 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.

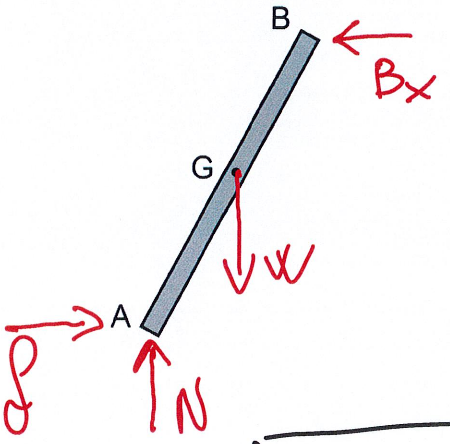
PROBLEM 1 (20 points)

1A. The uniform bar in figure is resting against the wall. The wall is smooth while the floor has an unknown coefficient of static friction μ_s. Knowing that the bar has a weight W applied at the center of gravity G (at the geometric center of the bar) **(5 pts)**:

a) Sketch the free body diagram using the diagram provided below.
b) Determine the **minimum** value of the coefficient of static friction μ_s for the bar to remain in equilibrium.



FBDs: (2 pt each)



$\Sigma F_x = 0$ $f - B_x = 0$

$f = \mu_s N$ $\boxed{\mu_s N - B_x = 0}$

$\Sigma F_y = 0$ $N - W = 0$ $\boxed{N = W}$

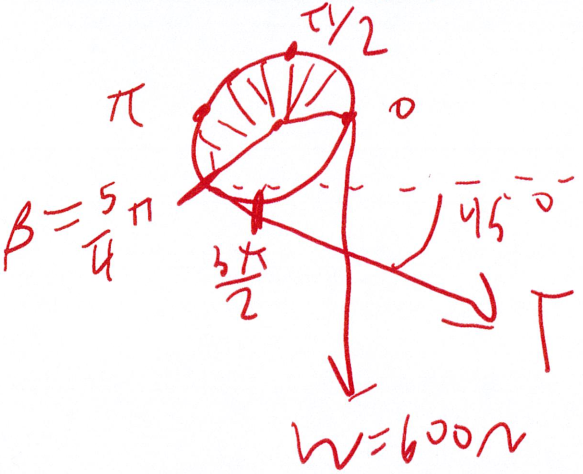
$\Sigma M_A = 0$ $B_x \cdot (4) - W(1.5) = 0$

$\boxed{B_x = \frac{3}{8} W = 0.375\, W}$

$\boxed{\mu_s = \frac{B_x}{N} = 0.375}$

$(\mu_s)_{\min}$ = 0.375 **(3 pt)**

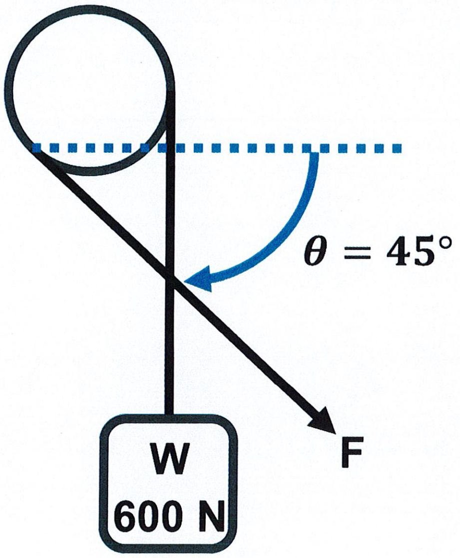
1B. A storage container with a weight of **W=600N** is suspended from a rope that passes over a tree branch as shown. The coefficient of friction between the branch and the rope is $\mu = 0.4$. Determine the total angle of wrap about the tree branch. Determine the force, (**F**), needed to hold the storage container in static equilibrium for the case of **impending motion of the storage container downward**. For **impending motion of the storage container upward,** is the force needed to maintain static equilibrium larger, smaller or equal to the force needed for static equilibrium in the case of impending downward motion? **(5 pts)**



$\mu = 0.4$

$\beta = \frac{5}{4}\pi$

$\beta = 3.93$ rad



$$\frac{T_1}{T_2} = e^{\mu\beta} = e^{0.4(3.93)} = 4.82$$

downward: $T_1 = W$ $\quad F = T_2 = T_1/4.81 = \frac{600}{4.82} = 124.481$

upward: $T_2 = W$ $\quad F = T_1 = T_2 \cdot 4.81 = 600 \cdot 4.82$

$= 2,892$ N

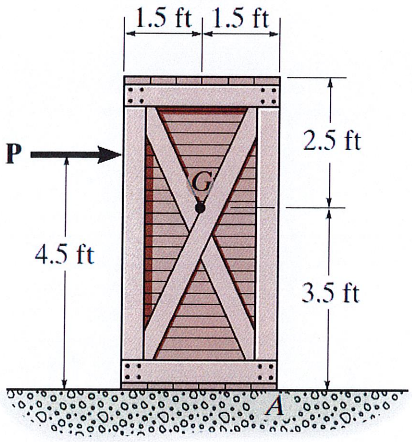
2890 N > 124 N

β = 3.93 rad **(1 pt)**

F = 124 N **(3 pt)**

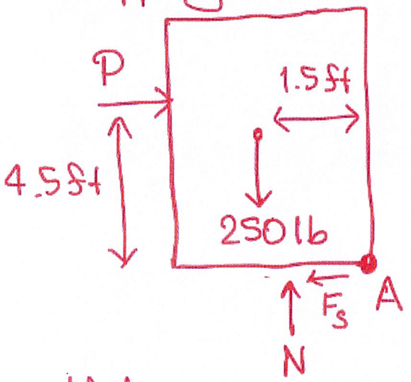
P = [✓ **Larger**] **Smaller** **Remain the Same** **(Circle One)** **(1 pt)**

1C. Determine the maximum force P that can be applied without causing **a) slipping** and **b) tipping** of the 250-lb crate that has a center of gravity at G. The coefficient of static friction at the floor is $\mu_s = 0.4$. Will the crate slip or tip first? **(5 pts)**



FBDs (1pts)

slipping



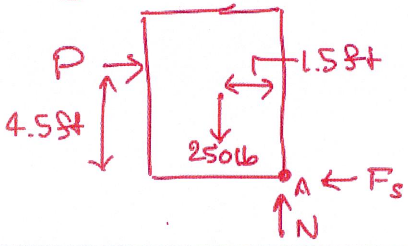
If slipping occurs:

$\Sigma F_y = 0 \Rightarrow N = 250\,lb$

$\Sigma F_x = 0 \Rightarrow P - F_s = P - \mu_s N = 0$

$\Rightarrow P = 0.4 \times 250lb = 100\,lb$

tipping



If tipping occurs:

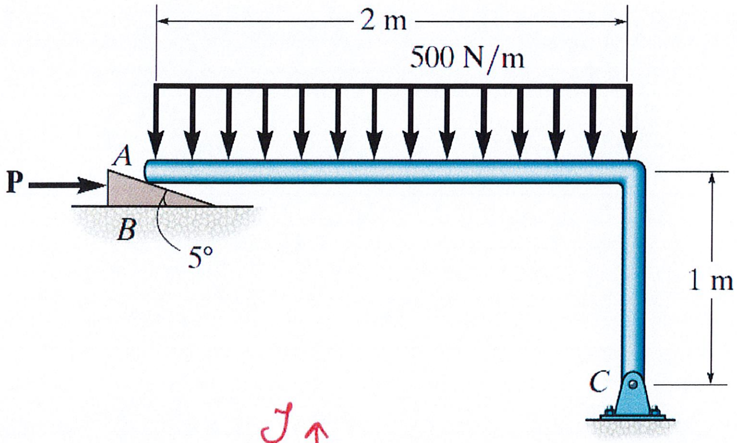
$\Sigma M_A = 0 \Rightarrow 250lb \times 1.5ft - P \times 4.5ft = 0$

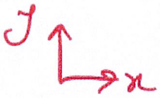
$\Rightarrow P = 83.3\,lb$

$P_{slipping}$ = 100 lb **(2 pts)**

$P_{tipping}$ = 83.3 lb **(2 pts)**

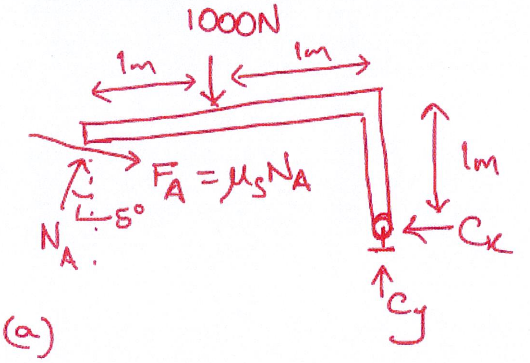
1D. The wedge is used to level the member shown below. Determine the horizontal force **P** that must be applied to begin to push the wedge **forward**. The coefficient of static friction between the wedge and the two surfaces of contact is μs = 0.2. Neglect the weight of the wedge. **(5 pts)**



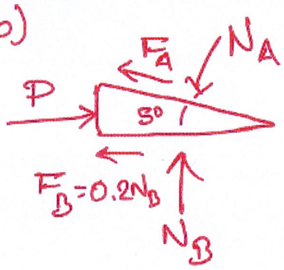


FBDs (2pts)

(a)



(b)



FBD (a)

$$\Sigma M_C = 0 \Rightarrow 1000N \times 1m - N_A \cos5^\circ \times 2m - N_A \sin5^\circ \times 1m$$
$$-0.2N_A \cos5^\circ \times 1m + 0.2N_A \sin5^\circ \times 1m = 0$$

$$\Rightarrow N_A = 445.65N$$

FBD (b)

$$\Sigma F_y = 0 \Rightarrow N_B - N_A \cos5^\circ + 0.2N_A \sin5^\circ = 0 \Rightarrow N_B = 436.18N$$

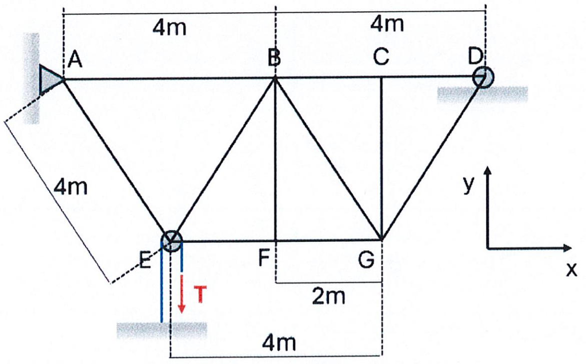
$$\Sigma F_x = 0 \Rightarrow P - 0.2N_A \cos5^\circ - N_A \sin5^\circ - 0.2N_B = 0 \Rightarrow P = 215N$$

P = 215 N **(3 pts)**

PROBLEM 2. (20 points)

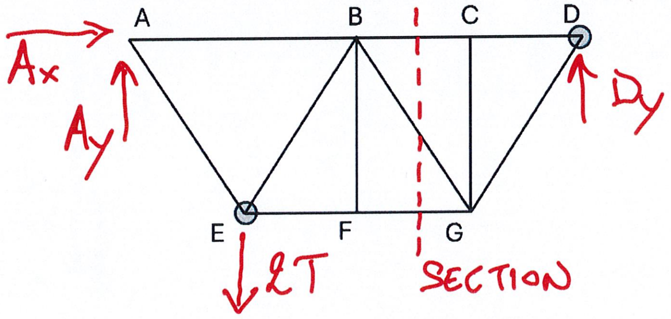
Problem 2 (20 points)

Given: A truss has the dimensions shown in the figure. It has a pin-joint support at A, a roller support at D, a smooth pulley at E with an applied load T = 1000 N. The truss is in static equilibrium.



Find:

a) Complete the free body diagram of the truss on the artwork provided below. **(2 pts)**



b) Calculate the reaction forces at supports A and D ($\vec{F}_A$, and $\vec{F}_D$). Write your answers in vector form. **(4 pts)**

$\Sigma F_x = 0$ $A_x = 0$

$\Sigma F_y = 0$ $A_y - 2T + D_y = 0$

$\Sigma M_A = 0$ $-2T \cdot (2) + D_y \cdot (8) = 0$

$\boxed{A_y = +\frac{3}{2}T = 1.5\,T}$

$\boxed{D_y = \frac{T}{2}}$

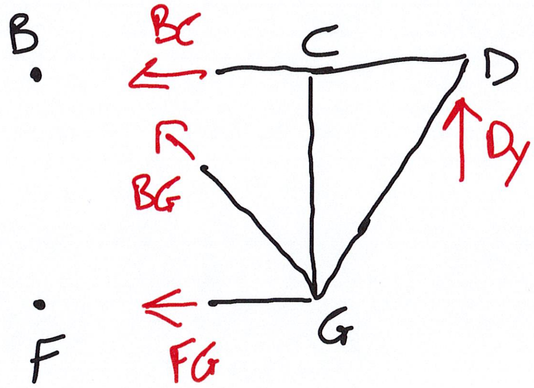
$\vec{F}_A$ = 0 $\hat{\imath}$ + 1.5 T $\hat{\jmath}$ N **(2 pts)**

$\vec{F}_D$ = 0 $\hat{\imath}$ + $T/2$ $\hat{\jmath}$ **(2 pts)**

c) Identify all zero-force members in the truss. No work needs to be shown. **No partial credit**. **(4 points)**

Zero-Force Members = AB BC CD [✓ CG] DG [✓ BF] BG (Circle your choice(s)) **(4 pts)**

d) Use the **method of sections** to determine the magnitude of the load in the member FG. Indicate whether the load is in tension, zero or compression. Include a free-body diagram used for the analysis and specify the units. No credit will be awarded if the requested methodology is not used. **(4 points)**

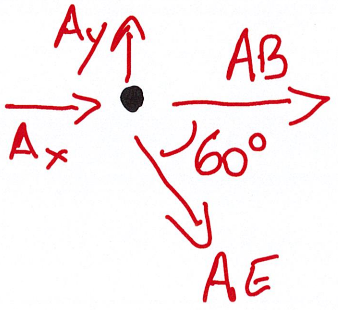


$\Sigma M_B = 0 \qquad -FG \cdot (3.46) + D_y(6) = 0$

$$\boxed{FG = 1.15\, D_y = 0.57\, T}$$

F_{FG}= 0.57 T N [✓ Tension] Zero Compression (circle one) **(4 pts)**

e) Use the **method of joints** to determine the magnitude of the loads in the members AB and AE. Indicate whether the load is in tension, zero or compression. Include a free-body diagram used for the analysis and specify the units. No credit will be awarded if the requested methodology is not used. **(6 points)**



$$\Sigma F_y = 0 \qquad A_y - AE \sin(60^\circ) = 0 \qquad \boxed{AE = \frac{2}{\sqrt{3}} A_y = 1.73 T}$$

$$\Sigma F_x = 0 \qquad A_x + AB + AE \cos(60^\circ) = 0$$

$$\boxed{AB = -AE \cos(60^\circ) = -0.866\ T}$$

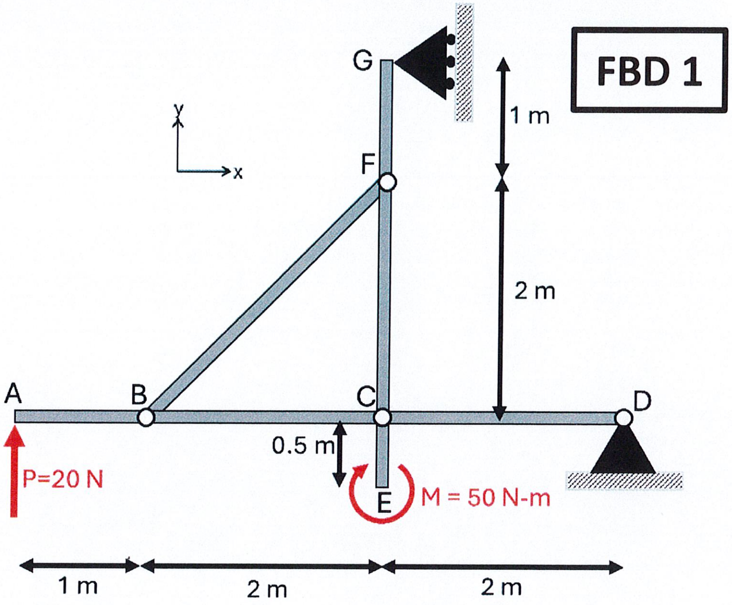
F_{AB} = -0.866 T N Tension Zero [✓ Compression] (circle one) **(3 pts)**

F_{AE} = 1.73 T N [✓ Tension] Zero Compression (circle one) **(3 pts)**

PROBLEM 3. (20 points)

GIVEN:

Frame A-G is loaded with an applied force (P = 20 N) at A and a moment (M = 50 N-m) at E as shown below. The frame is held in static equilibrium by a roller support at G and a pin support at D. Neglect the weight of the frame members.



Find:

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

b) Solve for the reactions at D and G and express the results in vector form. **(6 pts)**

$$\Sigma M_D = 0 = G_x(3) - 20(5) - 50$$

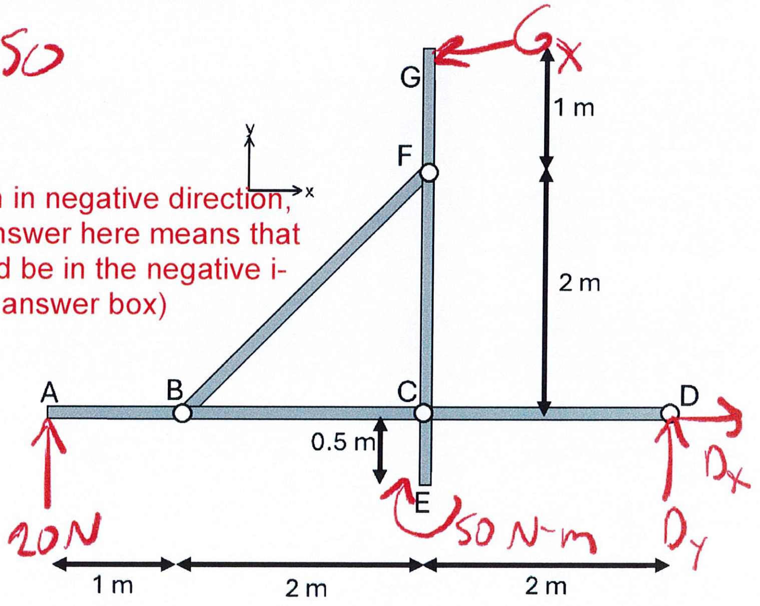
$$\Rightarrow G_x = 50$$

(arrow is drawn in negative direction, so a positive answer here means that the force should be in the negative i-direction in the answer box)

$$\Sigma F_x = D_x - G_x$$

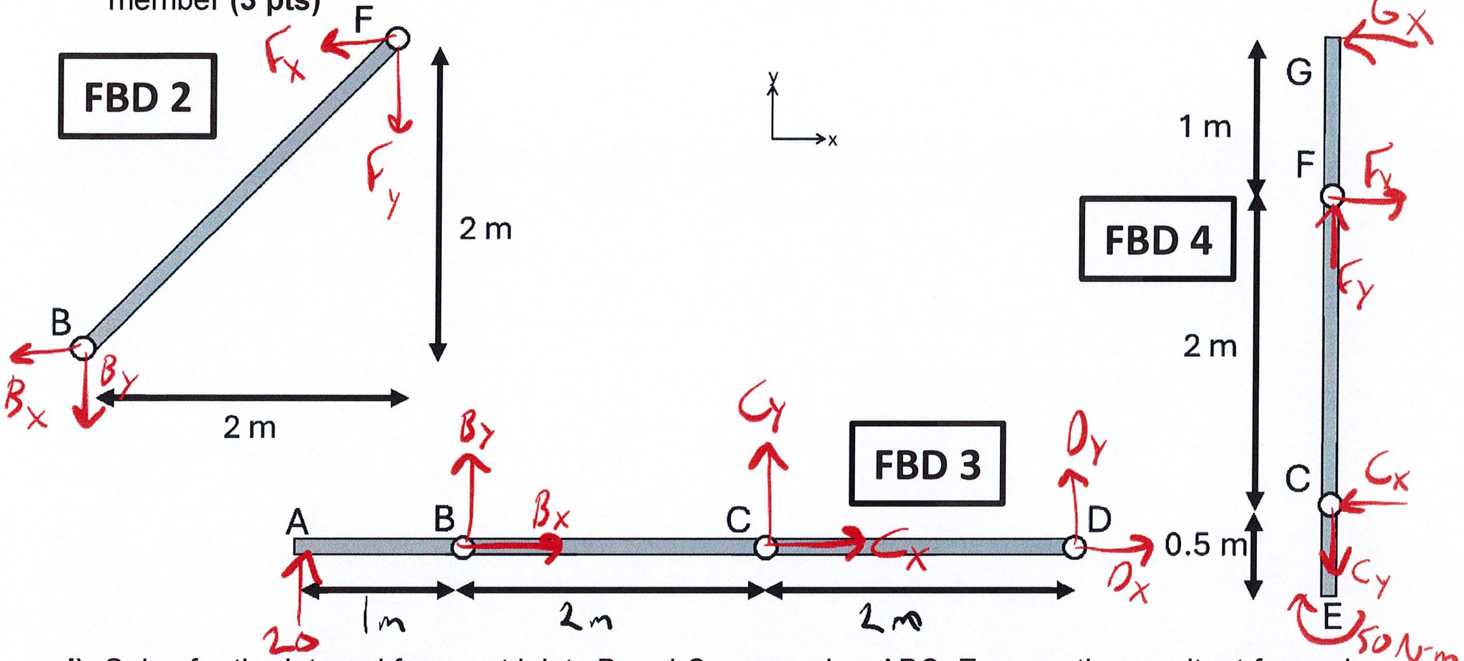
$$\Rightarrow D_x = 50$$

$$\Sigma F_y = 20 + D_y \Rightarrow D_y = -20$$



$\vec{G}$ = -50 $\hat{\imath}$ N (one point for negative sign, two for magnitude)	**(3 pts)**
$\vec{D}$ = 50 $\hat{\imath}$ + -20 $\hat{\jmath}$ N	**(3 pts)**

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



d) Solve for the internal forces at joints B and C on member ABC. Express the resultant forces in vector form. **(8 pts)**

FBD 3: $\Sigma M_C = 0 = D_y(2) - B_y(2) - 20(3) \Rightarrow B_y = -50$

$\Sigma F_y = 0 = 20 + B_y + C_y + D_y \Rightarrow \underline{C_y = 50}$

FBD 4: $\Sigma M_F = -C_x(2) + G_x(1) - 50 = 0 \Rightarrow \underline{C_x = 0}$

FBD 2: $\Sigma M_F = B_y(2) - B_x(2) = 0$

$\Rightarrow B_x = B_y = -50$

$(\overrightarrow{\mathbf{B}})_{\text{on ABC}}$ = -50 $\hat{\imath}$ + -50 $\hat{\jmath}$ N	**(4 pts)**
$(\overrightarrow{\boldsymbol{C}})_{\text{on ABC}}$ = 0 $\hat{\imath}$ + 50 $\hat{\jmath}$ N	**(4 pts)**