ME 270 – Fall 2026 Exam 2 (B) **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, Section 002, MWF 8:30AM-9:20AM
J. Jones, Section 003, MWF 9:30AM-10:20AM
A. McDonald, Section 001, MWF 10:30AM-11:20AM
J. Jones, Section 005, MWF 11:30AM-12:20PM
F. Semperlotti, Section 008, MWF 12:30PM-1:20PM
J. Choi, Section 009, MWF 1:30PM-2:20PM
F. Semperlotti, Section 010, MWF 2:30PM-3:20PM
A. McDonald, Section 032, MWF 3:30PM-4:20PM
T. Ballance, Section 033, MWF 4:30PM-5:20PM
M. Murphy, Section 034, TuTh 9:00AM-10:15AM
J. Jones, Section Y01, Distance Learning
Indianapolis Campus (PIN)
E. Goff, Section 031, MWF 9:30AM-10:20AM
F. Bipasha, Section 029, MWF 1:30PM-2:20PM
N. Saqib, Section 030, TuTh 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 work from 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 the cover page.

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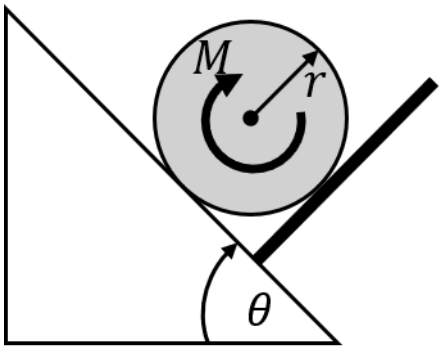
PROBLEM 1 (20 pts)

1A. A cylinder of weight **W = 150 N** and radius **r = 0.25 m** is held in static equilibrium by an applied couple **M** and a smooth wall on an inclined plane with angle $\boldsymbol{\theta = 45°}$**.** The coefficient of friction between the incline and the cylinder is $\boldsymbol{\mu_s = 0.50}$. Consider the case where the cylinder is on the verge of slipping on the incline. Assume the smooth wall is perpendicular to the inclined plane.

i. Annotate the FBD for the case where the cylinder is on the verge of slipping on the incline. (**2 pts**)

ii. Find the value of the couple moment **M** needed to initiate slipping between the cylinder and the incline (**2 pts**)

iii. What is the magnitude of force $\boldsymbol{N_B}$ that the cylinder imparts on the smooth wall? (**1 pt**)



Slip condition: $f_A = u_s N_A$

$$\sum F_y = 0 = N_A - W\cos 45°$$

$$N_A = W\cos 45° = 106.1\ N$$

$$f_A = u_s N_A = 53.03\ N$$

$$\sum M_o = 0 = f_A r - M$$

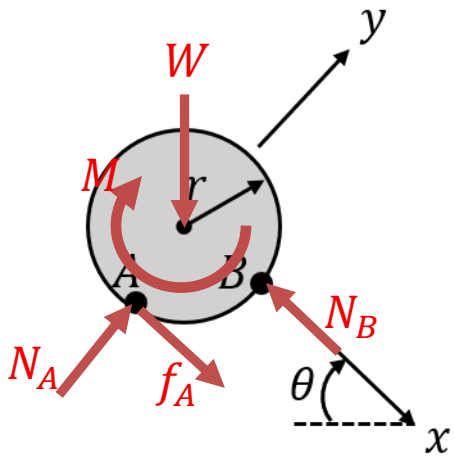
$$M = f_A r = 32.26\ N-m$$

$$\sum F_x = 0 = f_A + W\sin 45° - N_B$$

$$N_B = f_A + W\sin 45°$$

$$N_B = 159.1\ N$$

FBD



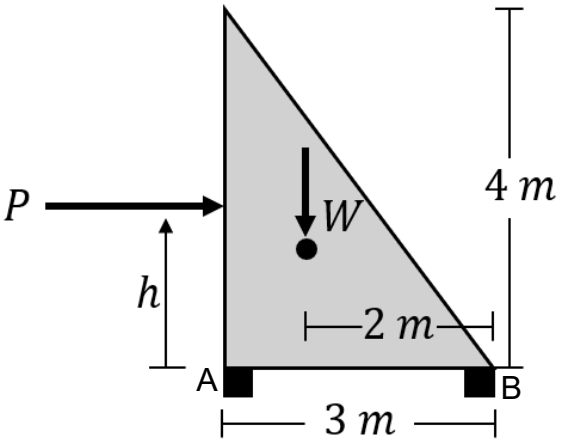
M = _____**32.26**_____ **N·m (2 pts)**

N_B = _____**159.1**_____ **N (1 pt)**

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1B. The triangular block of weight **W = 100 N** has two legs of negligible mass that rest on a rough surface with coefficient of friction $\mu_s = 0.8$. A force of **P** is applied at some height **h** on the left side of the block.

i. On the FBD annotate the friction and normal forces for tipping about point B. (**1 pt**)
ii. Find the force, **P,** for which both slipping and tipping occur simultaneously. (**2 pts**)
iii. Find the height, **h**, for which both slipping and tipping occur simultaneously. (**2 pts**)



Slipping condition: $f_A = u_s N_B$

$$\sum F_y = 0 = N_B - W$$

$$N_B = W = 100\ N$$

$$f_B = u_s N_B = 80\ N$$

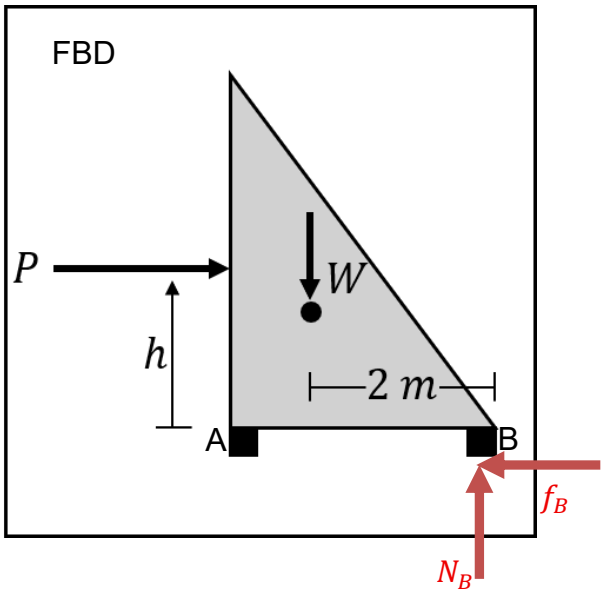
$$\sum F_x = 0 = f_B - P$$

$$P = f_B = 80\ N$$

$$\sum M_B = 0 = W(2m) - Ph$$

$$h = \frac{W(2m)}{P}$$

$$h_{\min} = 2.5\ m$$

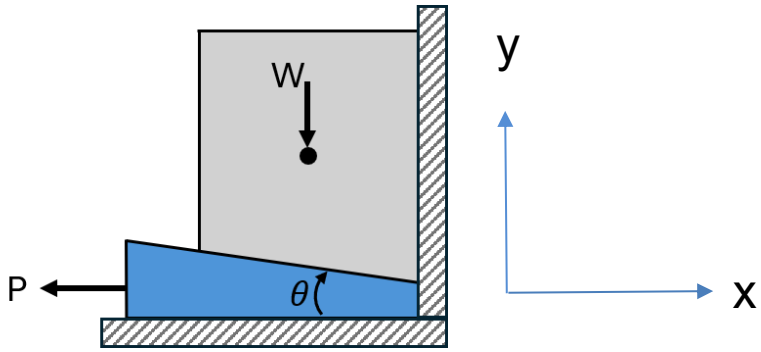


P = _____80_____ **N (2 pts)**

h = _____2.5_____ **m (2 pts)**

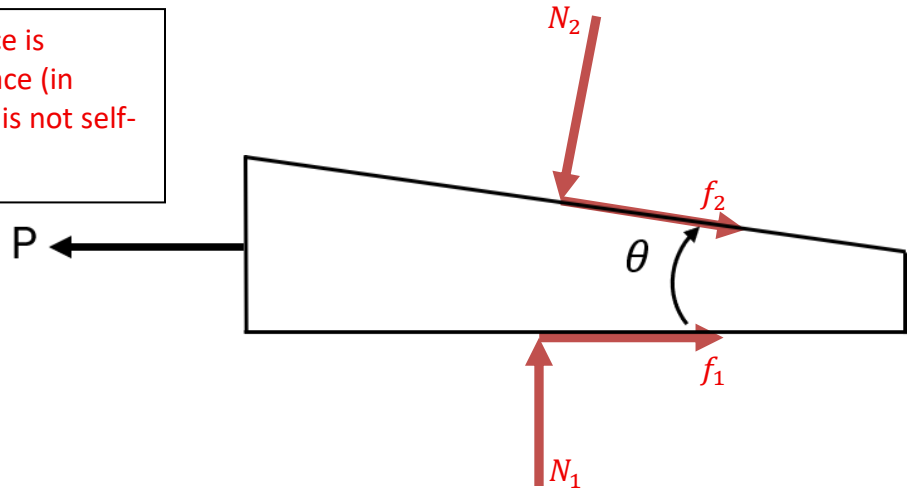
1C. A block is in the condition of impending motion down and is supported by a massless wedge.

i. On the FBD of the wedge annotate the friction and normal forces for impending motion of the wedge to the left. **(1 pt)**
ii. Write the static equilibrium equation in the x-direction for the wedge. **(2 pts)**
iii. If you solved this wedge problem and found $\boldsymbol{P < 0}$ for impending motion of the wedge to the left, circle the statement below that is true about the wedge. **(2 pts)**



$$\sum F_x = 0 = f_1 + f_2 cos\theta - N_2 \sin\theta - P$$

$P < 0$ means that a pushing force is needed to keep the wedge in place (in static equilibrium) so the wedge is not self-locking



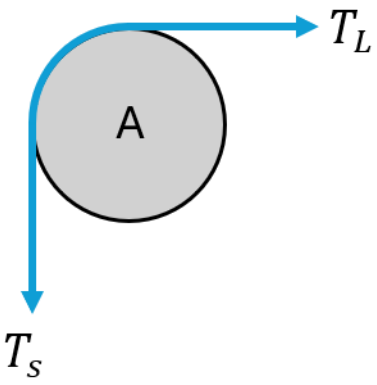
$\sum \boldsymbol{F_x} = \mathbf{0} =$ $f_1 + f_2 cos\theta - N_2 \sin\theta - P$ **(2 pts)**

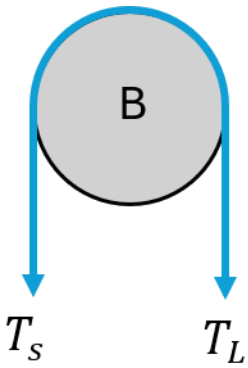
Circle one (2 pts):

a) The wedge is self-locking
b) The wedge is not self-locking
c) It cannot be determined from this information

1D. Consider two cases of a stationary, rough-surfaced pulley that is fixed against rotation. The belt in both Case A and Case B is on the verge of slipping around the stationary pulley toward the free end labeled "T_L" (Clockwise). For both cases the smaller tension is $T_s = 150\ lb$. The coefficient of friction for each case is initially $\mu_s = 0.5$.

i. For Case A what is the value of T_L needed to have impending motion clockwise? (**1.5 pts**)
ii. For Case B what is the value of T_L needed to have impending motion clockwise? (**1.5 pts**)
iii. What value of β would case B need to have to produce the same value of T_L computed in Case A if the coefficient of friction in Case B was reduced to $\mu_s = 0.3$? (**2 pts**) (continue to use $\mu_s = 0.5$ for pulley A)





For Case A

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

$$T_L = 150e^{0.5*\frac{\pi}{2}}$$

$$T_L = 329\ lbs$$

For Case B

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

$$T_L = 150e^{0.5*\pi}$$

$$T_L = 722\ lbs$$

From

$$ln\frac{T_L}{T_s} = \mu_s \beta$$

$$\beta = \ln\left(\frac{T_L}{T_s}\right)\frac{1}{\mu_s}$$

$$\beta = \ln\left(\frac{329}{150}\right)\frac{1}{0.3}$$

$$\beta = 2.62\ rads$$

Case A: T_L= 329 **lb (1.5 pts)**

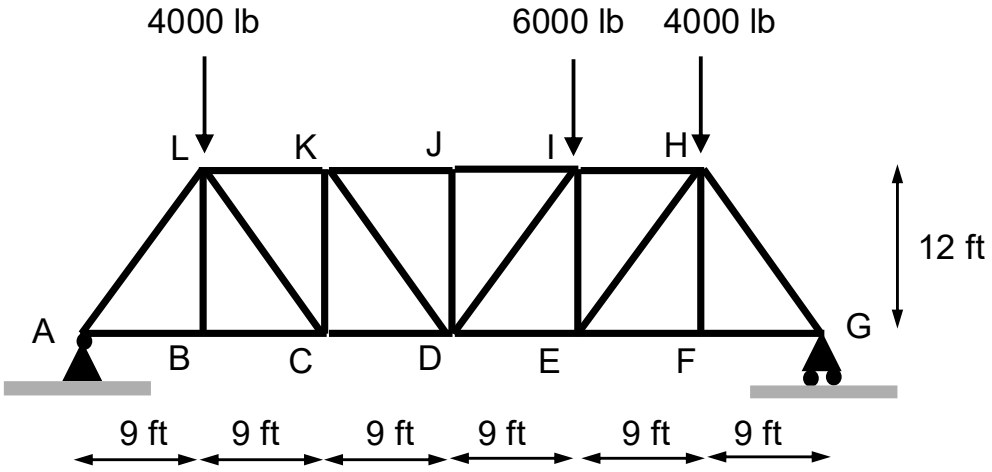
Case B: T_L= 722 **lb (1.5 pts)**

$(\beta)_B$= 2.62 **rad (2 pts)**

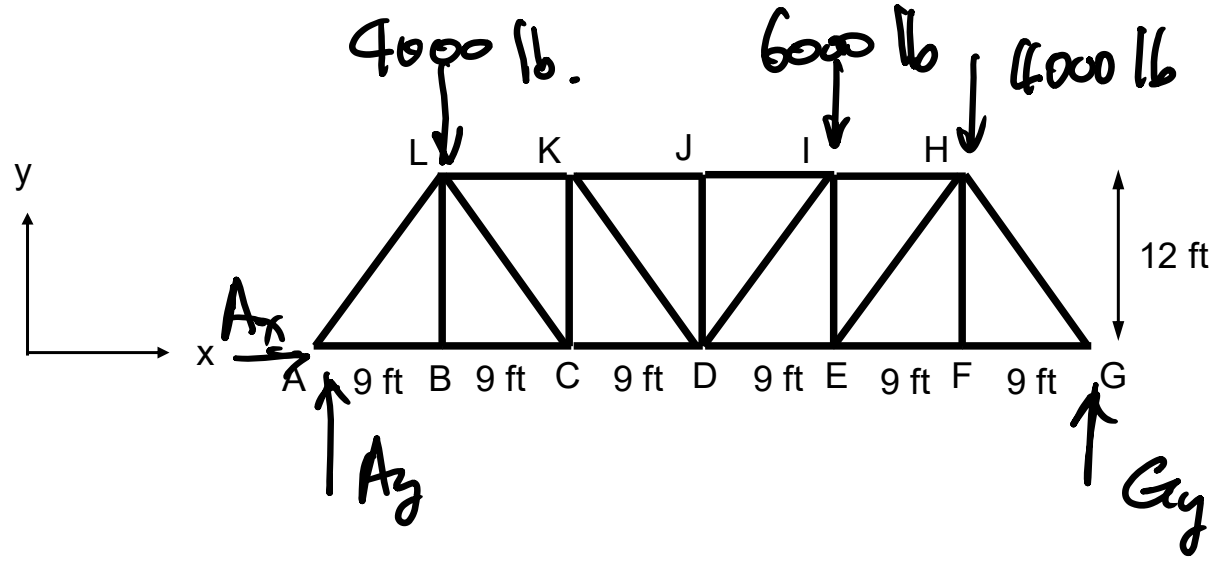
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PROBLEM 2. (20 pts)

A truss A-L has the dimensions shown in the figure. The truss is held in static equilibrium by a pin-joint support at A and a roller support at G and is loaded with three applied loads at H, I, and L.



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



(b) Identify all zero-force members in the truss. No work needs to be shown. **(3 pts)**

Zero-Force Members = DJ, BC, FH **(3 pts)**

(c) Calculate the reaction forces at supports A and G ($\vec{A}$ *and* $\vec{G}$). Write your answers in vector form. **(6 pts)**

$$\Sigma M_A = 0 = G_y(54) - 4000(9) - 6000(36) - 4000(45)$$

$$G_y = \frac{1}{54}(36000 + 216000 + 180600)$$

$$= 8000 \text{ lb.}$$

$$\Sigma F_x = 0 = A_x$$

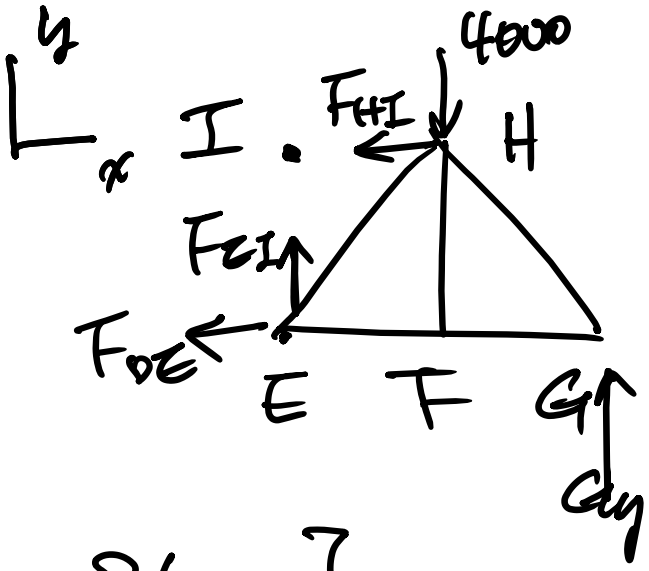
$$\Sigma F_y = 0 = A_y + G_y - 4000 - 6000 - 4000$$

$$A_y = -G_y + 14000 = 6000 \text{ lb.}$$

$\vec{A}$ = (0 $\hat{\imath}$ + 6000 $\hat{\jmath}$) lb. **(3 pts)**

$\vec{G}$ = (8000 $\hat{\jmath}$) lb. **(3 pts)**

(d) Using the method of sections, determine the magnitude of the forces in members DE, EI, and HI. Indicate whether each force is in tension, zero or compression. Include a free-body diagram used for the analysis and specify the units. **(9 pts)**



$\Sigma M_E = 0$

$= G_y(18) + F_{HI}(12) - 4000(9)$

$F_{HI} = \frac{1}{12}[-G_y(18) + 36000]$

$= -9000$ lb. or 9000 lb (C)

$\Sigma M_I = 0 = G_y(18) - F_{DE}(12) - 4000(9)$

$F_{DE} = 9000$ lb. or 9000 lb (T)

$\Sigma F_y = 0 = F_{EI} + G_y - 4000$

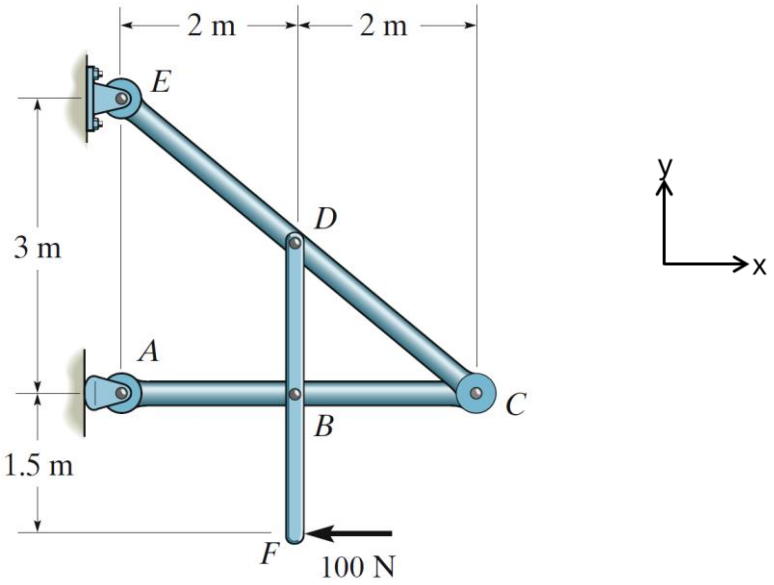
$F_{EI} = -4000$ lb or 4000 lb (C)

F_{DE}= 9000 lb	Tension	Zero	Compression	(circle one)	**(3 pts)**
F_{EI}= 4000 lb	Tension	Zero	Compression	(circle one)	**(3 pts)**
F_{HI}= 9000 lb	Tension	Zero	Compression	(circle one)	**(3 pts)**

Extra Page (if needed)

PROBLEM 3. (20 pts)

GIVEN: Frame A-F is loaded with a 100 N force applied at F, as shown below. The frame is held in static equilibrium by a pin support at E and a frictionless roller support against the vertical wall at A. 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 A and E and express the results in vector form. **(6 pts)**

- $\sum M_E = 0$

$\Rightarrow 3m \times A_x - 4.5m \times 100N = 0$

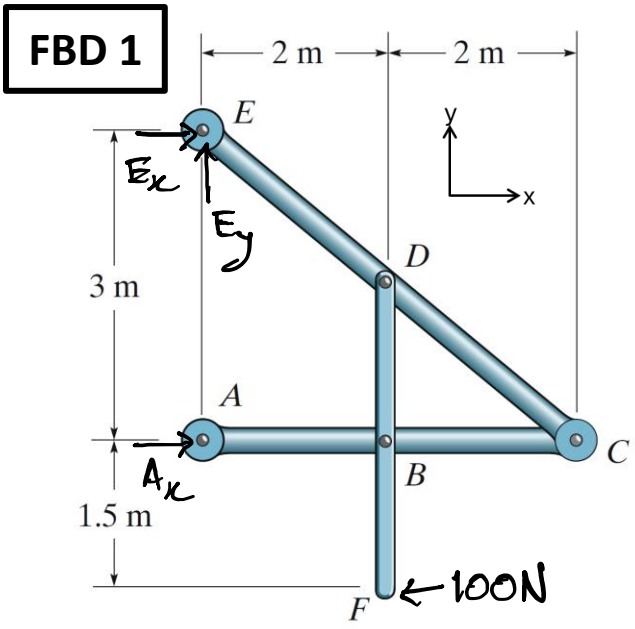
$\Rightarrow A_x = 150N$

- $\sum F_y = 0 \Rightarrow E_y = 0$

- $\sum F_x = 0 \Rightarrow A_x + E_x - 100N = 0$

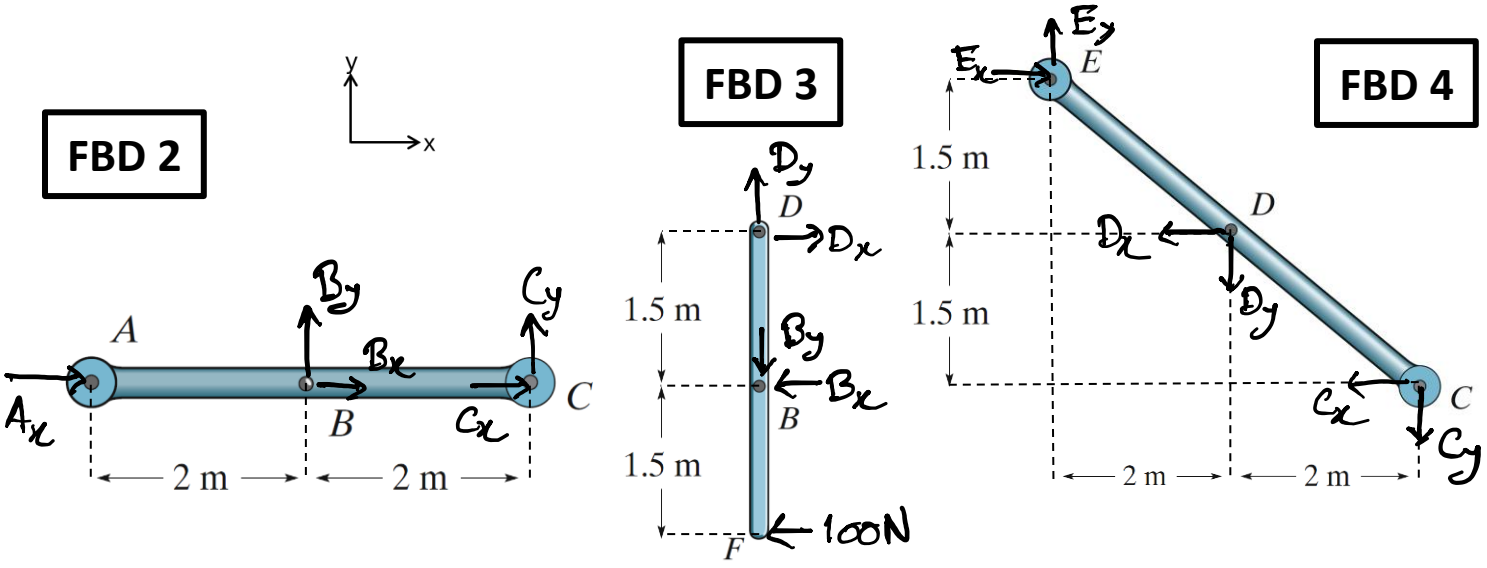
$\Rightarrow E_x = -50N$

FBD 1



$\vec{A} =$ 150 $\hat{\imath}$ N	**(3 pts)**
$\vec{E} =$ (−50 $\hat{\imath}$ + 0 $\hat{\jmath}$) N	**(3 pts)**

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



d) Determine the forces exerted on member CDE at joints C and D. Express each force in vector form. **(8 pts)**

FBD 3

- $\Sigma M_B = 0 \Rightarrow -1.5m \times 100N - D_x \times 1.5m = 0 \Rightarrow D_x = -100N$

FBD 4

- $\Sigma M_C = 0 \Rightarrow 1.5m \times D_x + 2m \times D_y - 3m \times E_x - 4m \times E_y = 0$

$\Rightarrow D_y = 0$

- $\Sigma F_y = 0 \Rightarrow E_y - D_y - C_y = 0 \Rightarrow C_y = 0$

- $\Sigma F_x = 0 \Rightarrow E_x - D_x - C_x = 0 \Rightarrow C_x = 50N$

$\overrightarrow{(C)}_{\text{on CDE}}$ = (−50 $\hat{\imath}$ + 0 $\hat{\jmath}$) N	**(4 pts)**
$\overrightarrow{(D)}_{\text{on CDE}}$ = (100 $\hat{\imath}$ + 0 $\hat{\jmath}$) N	**(4 pts)**

Extra Page (if needed)

ME 270 Exam 2 Equations

Belt Friction

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

where β is the belt contact angle in radians.