Lecture 14

Friday, September 29, 2017 11:21

To do ...

- Enter your student netID in Mastering Engineering **DUE Monday, Oct 2**
- **Quiz 3 – in class – Monday Oct 2**
- HW 10 PL due **Tues**
- HW 11 due **Thurs**

Calculators?

A) Yes

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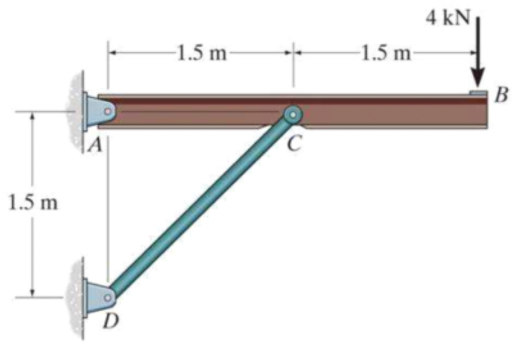
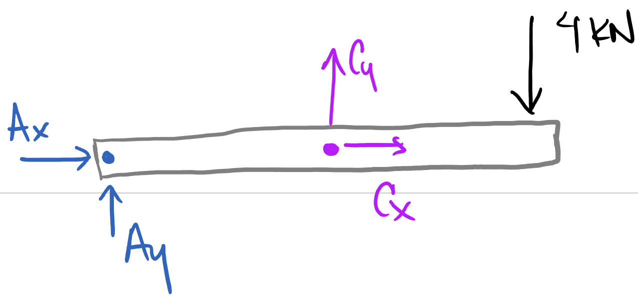


Given the 4 kN load at B of the beam is supported by pins at A and C. Find the support reactions at A and C.

- idealized model
- identify 2-force and 3-force members
- DRAW FBD
  - Determine the number of unknowns.

FBD of BEAM AB



$$\Sigma F_x: \quad A_x + C_x = 0$$

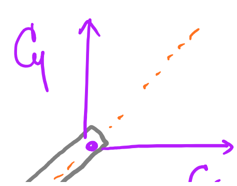
$$\Sigma F_y: \quad A_y + C_y - 4\,kN = 0$$

$$\Sigma M_A: \quad (1.5\,m)\,C_y - (3\,m)(4\,kN) = 0$$

* 4 unknowns, A_x, A_y, C_x, C_y

CAnnot solve !!

DRAW the FBD of the link DC

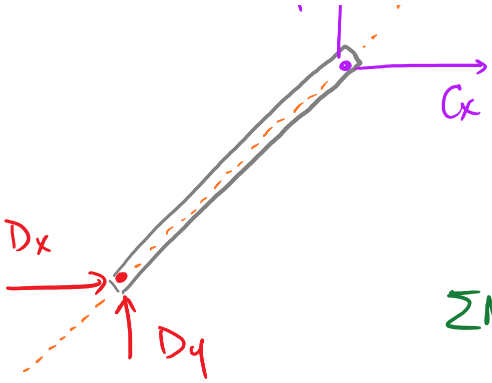


$$\Sigma F_x: \quad C_x + D_x = 0$$

$\therefore$

$C_x = -D_x$

$C_y = -D_y$



$\Sigma F_x:\ C_x + D_x = 0 \qquad C_x = -D_x$

$\Sigma F_y:\ C_y + D_y = 0 \quad \therefore \quad C_y = -D_y$

$\Sigma M_D:\ (1.5\,m)\,C_x - (1.5\,m)\,C_y = 0 \quad \therefore \quad C_x = C_y$

$\Rightarrow \quad C_x = C_y = -D_x = -D_y$

- $|\vec{C}| = |\vec{D}|$
- $\vec{C} + \vec{D} = 0$
- $\theta = \tan^{-1}\left(\frac{C_y}{C_x}\right) = \tan^{-1}\left(\frac{D_y}{D_x}\right) = \pm 45^\circ$

It is A 2-force MEMBER!!

So you know direction, not magnitude!

using ΣM_A from Above...

$\Sigma M_A:\quad (1.5\,m)\,F_c \sin(45) - 3\,(4\,kN) = 0$

$$\boxed{F_C = 11.3\ kN}$$

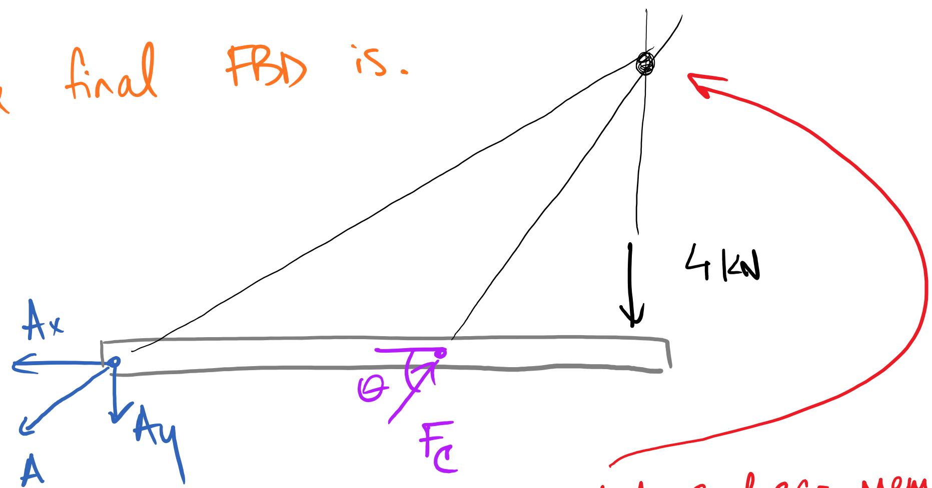
$\Sigma F_x:\qquad A_x = -F_c \cos(45) = \underline{-8.00\ kN}$

$\Sigma F_y:\qquad A_y = 4\,kN - F_c \sin(45) = \underline{-4.00\ kN}$

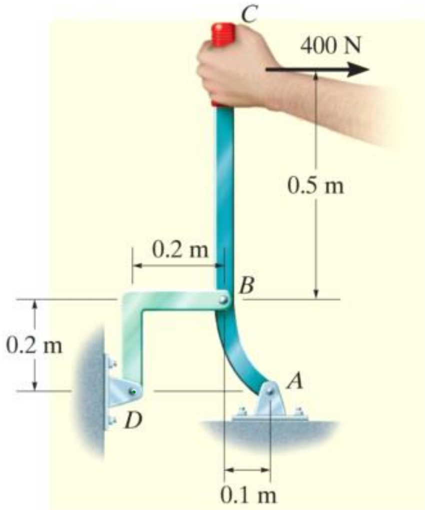
* negative sign means the sense is in

the other direction:

the final FBD is.



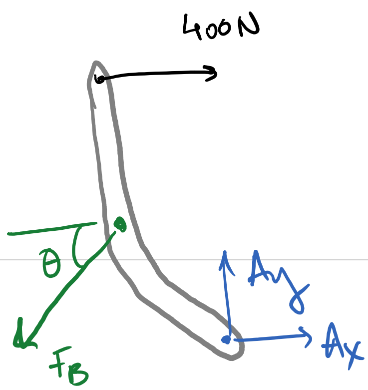
* A 3-force member in ≡M has all lines of action meet at a point!

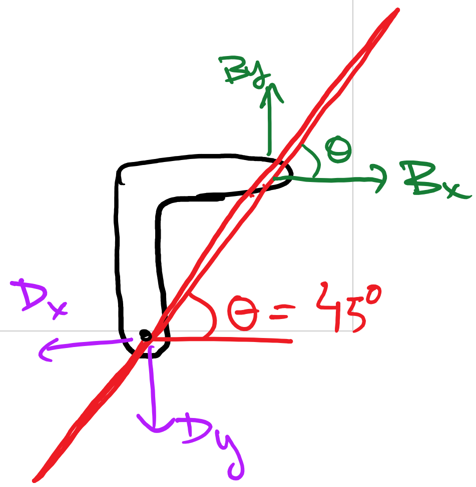


The lever *ABC* is pin supported at *A* and connected to a short link *BD*. If the weight of the members is negligible, determine the reaction forces at pins *D* and *A*.

Q: Why?

- idealized model
- note: DB is A 2 force member
  ABC is A 3 force member
- DRAW FBD.

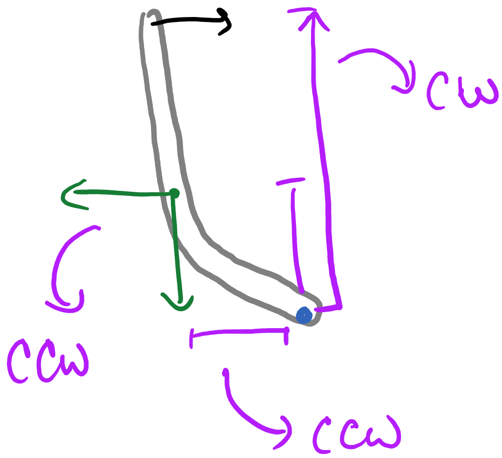




- Now, sum the forces and moments for ABC:

$$\Sigma F_x: \quad 400\,N + A_x - F_B\cos(45) = 0$$

$$\Sigma F_y: \quad A_y - F_B\sin(45) = 0$$



$$\Sigma \vec{M}_A: \quad (0.1) F_B \sin(45) + (0.2) F_B \cos(45) - (0.7) 400 = 0$$

$$F_B = \frac{(0.7)(400)}{(0.1)\sin 45 + (0.2)\cos 45} = \boxed{1.32 \text{ kN}}$$

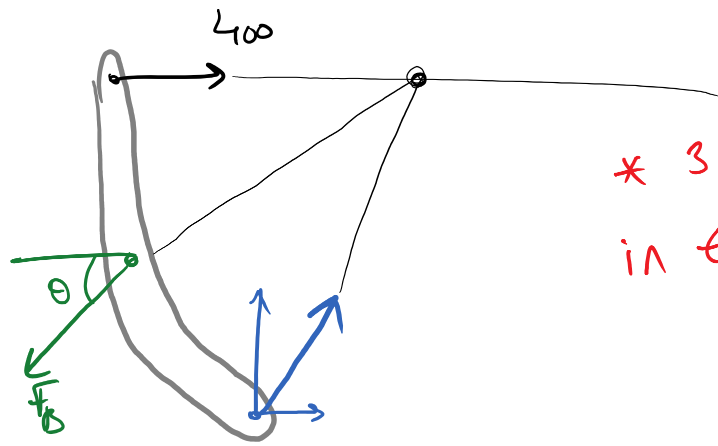
now solve for A_x & A_y:

$$\Sigma F_x: \quad A_x = F_B \cos(45) - 400 = 533 \text{ N}$$

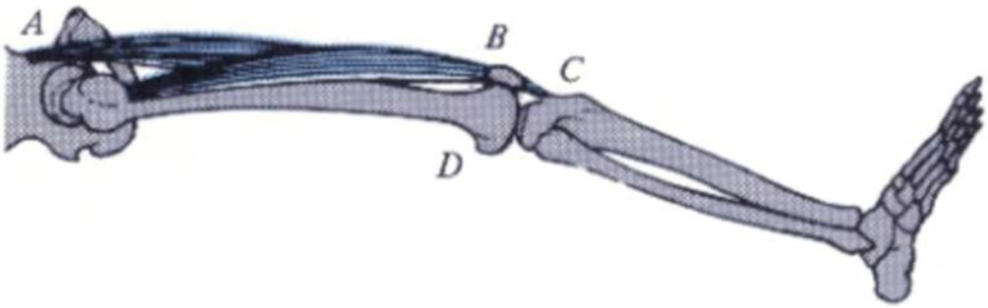
$$\Sigma F_y: \quad A_y = F_B \sin(45) = 933 \text{ N}$$

$$|\vec{A}| = \sqrt{A_x^2 + A_y^2} = \underline{1.07 \text{ kN}}$$

$$\theta_A = \tan^{-1}\left(\frac{A_y}{A_x}\right) = \underline{60.3^\circ}$$

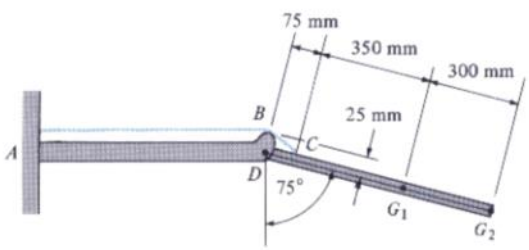


* 3-force member in equilibrium!



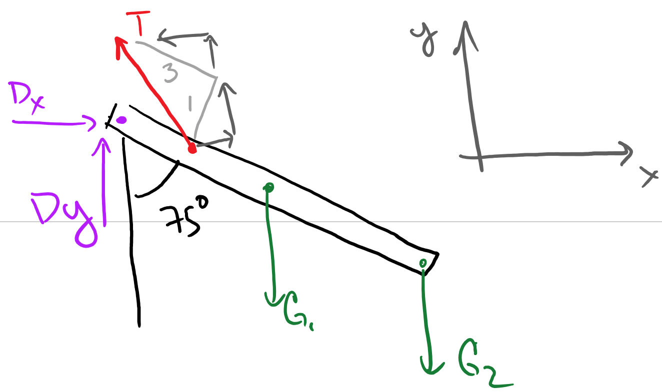
A skeletal diagram of the lower leg is shown. Model the lower leg and determine the tension T in the quadriceps and the magnitude of the resultant force at the femur (pin) at D in order to hold the lower leg in the position shown. The lower leg has a mass of 3.2 kg and the foot has a mass of 1.6 kg.

Q: What is the idealized model?



Determine the tension T in the quadriceps and the magnitude of the resultant force at the femur (pin) at D. The lower leg has a mass of 3.2 kg and the foot has a mass of 1.6 kg.

- DRAW the FBD



Sum the forces and moments:

$$\Sigma F_x: \quad D_x - \left(\frac{3}{\sqrt{10}} T\right)\cos(15) + \left(\frac{1}{\sqrt{10}} T\right)\sin(15) = 0$$

$$\Sigma F_y: \quad D_y - G_1 - G_2 + \left(\frac{1}{\sqrt{10}} T\right)\cos(15) + \left(\frac{3}{\sqrt{10}} T\right)\sin(15) = 0$$

$$\Sigma M_D: \quad \left(\frac{1}{\sqrt{10}} T\right)(.075\,m) - (31.4\,N)(0.425 \sin(75)) - (15.7\,N)(0.725\,m \sin(75)) = 0$$

Solve eqn ΣM_D for T, giving

$$\boxed{T = 1007\ N}$$

Solve eqn ΣF_x And ΣF_y for D_x ; D_y

$$D_x = \frac{T}{\sqrt{10}}\left(3\cos(15) - \sin(15)\right) = \boxed{982\ N}$$

$$D_y = G_1 + G_2 - \frac{T}{\sqrt{10}}\left(3\sin(15) + \cos(15)\right) = \boxed{508\ N}$$

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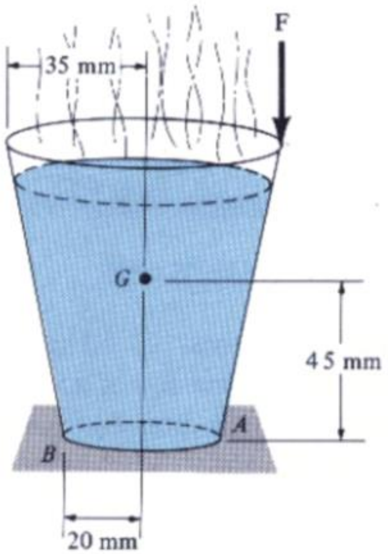
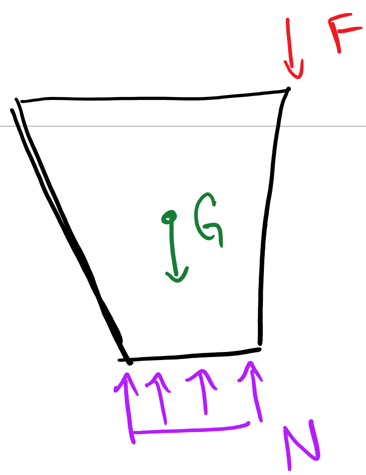


The cup is filled with 125 g of liquid. The mass center is located at G. If a vertical force F is applied to the rim of the cup, determine its magnitude so the cup is on the verge of tipping over.

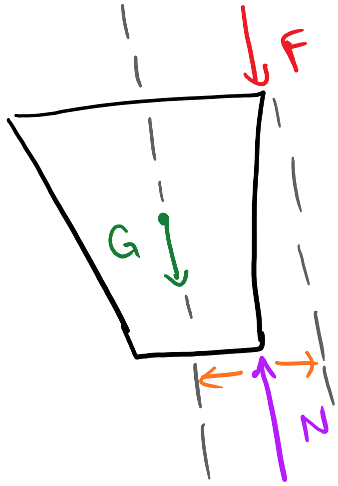
DRAW the FBD :



But this is NOT in equilibrium unless F=0! (Check it!)

Also, "on the verge of tipping" MEAS that N Acts At A specific point

MEAS



Sum forces and moments!

$$\Sigma F_x: \quad 0$$

$$\Sigma F_y: \quad N - G - F = 0$$

$$\Sigma M_A: \quad G x_1 - (x_2 - x_1) F = 0$$

$$F = \left(\frac{x_1}{x_2 - x_1}\right) G$$

$$F = \left(\frac{20\text{ mm}}{15\text{ mm}}\right)\left(.125\text{ kg} \cdot 9.81\text{ m/s}^2\right) = \boxed{1.635\text{ N}}$$

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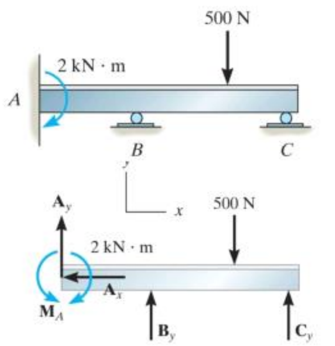
Constraints

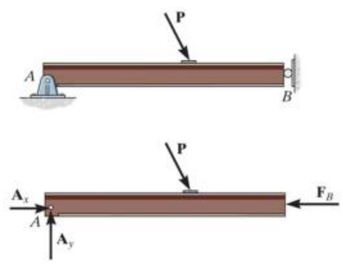
To ensure equilibrium of a rigid body, it is not only necessary to satisfy equations of equilibrium, but the body must also be properly constrained by its supports



Q: How many reaction forces?

4 forces, 1 couple moment

- **Redundant constraints**: the body has more supports than necessary to hold it in equilibrium; the problem is STATICALLY INDERTERMINATE and cannot be solved with statics alone



Q: How many reaction forces?

3 forces.

- **Improper constraints:** In some cases, there may be as many unknown reactions as there are equations of equilibrium. However, if the supports are not properly constrained, the body may become unstable for some loading cases.