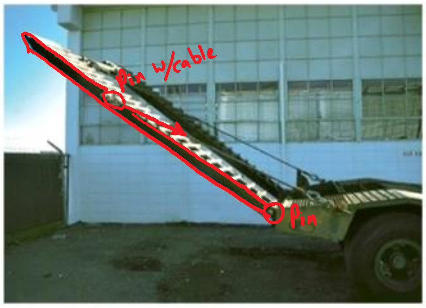
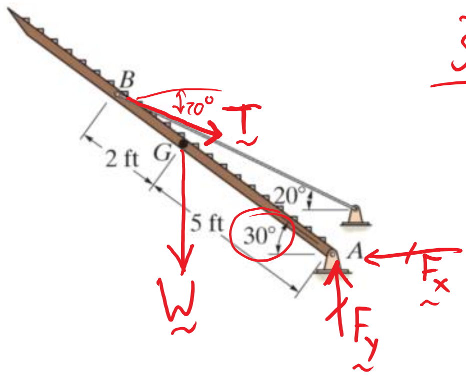
The uniform truck ramp has weight 400 lb and is pinned to the body of the truck at each side and held in the position shown by the two side cables. Determine the reaction forces at the pins and the tension in the cables.





3 unknowns

T, F_x, F_y

One other force

W (weight of ramp)

Sum forces:

In x-direction

$$\Sigma F_x = 0 \Rightarrow T\cdot\cos(20^\circ) - F_x = 0$$
$$\Rightarrow F_x = T\cdot\cos(20^\circ)$$

In y-direction

$$\Sigma F_y = -W - T\cdot\sin(20^\circ) + F_y = 0$$

Sum moments about A: $\Sigma M_A = 0$

Zero moment created by F_x and F_y

$$W\cdot(5')\cdot\cos(30^\circ) + (T\cdot\sin(20^\circ))(7'\cdot\cos 30^\circ) - (T\cdot\cos(20^\circ))(7'\cdot\sin(30^\circ)) = 0$$

1 eqn.
1 unknown

algebra

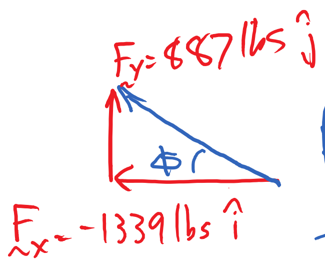
$$T = \frac{W\cdot 5\cdot\cos 30^\circ}{\quad}$$

$$T = \frac{W \cdot 5 \cdot \cos 30^\circ}{7 \cdot (\cos 20^\circ \cdot \sin 30^\circ - \sin 20^\circ \cdot \cos 30^\circ)}$$

$$\boxed{T = 1425 \text{ lbs}}$$

Solve $\boxed{F_x = T \cdot \cos(20^\circ) = 1339 \text{ lbs}}$

$\boxed{F_y = W + T \cdot \sin 20^\circ = 887 \text{ lbs}}$



Resultant force is

$$\underset{\sim}{F} = (-1339\hat{i} + 887\hat{j}) \text{ lb}$$

Find ϕ: $\phi = \tan^{-1}\left(\frac{887}{1339}\right) = 33.5^\circ$!

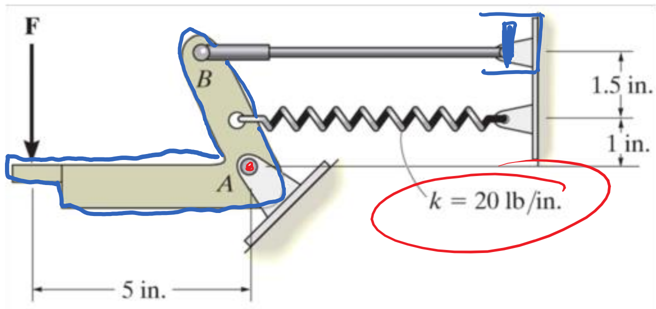
<u>NOT</u> 30°!

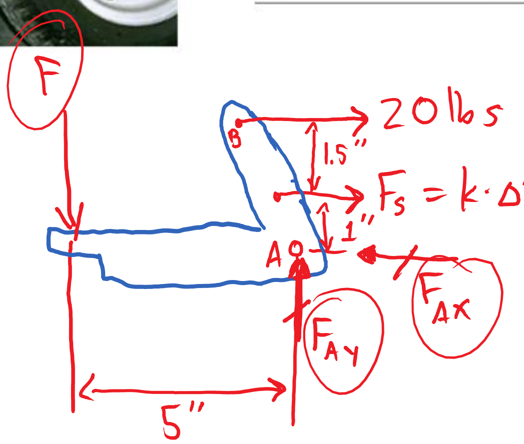
Page 12

Monday, February 13, 2017 12:55 AM

The operator applies a vertical force to the pedal so that the spring is stretched 1.5 in. and the force in the short link at B is 20 lb. Determine the vertical force applied to the pedal.

Δx





$F_s = k \cdot \Delta x = \left(20 \frac{lb}{in}\right)(1.5") = 30 \text{ lbs}$

Unknowns

F, F_{Ax}, F_{Ay}

$$\Sigma F_x = -F_{Ax} + (20 \text{ lbs}) + (30 \text{ lbs}) = 0$$

$$\Rightarrow F_{Ax} = 50 \text{ lbs}$$

$$\Sigma F_y = -F + F_{Ay} = 0 \Rightarrow F_{Ay} = F$$

$$\Sigma M_A = (5") \cdot F - (1")(30 \text{ lbs}) - (2.5")(20 \text{ lbs}) = 0$$

$$5 \cdot F = 30 \text{ lbs} + 50 \text{ lbs} = 80 \text{ lbs}$$

$$\Rightarrow \boxed{F = \frac{80}{5} \text{ lbs} = 16 \text{ lbs}}$$

Note: ΣF_x & ΣF_y was not necessary to arrive at the solution.

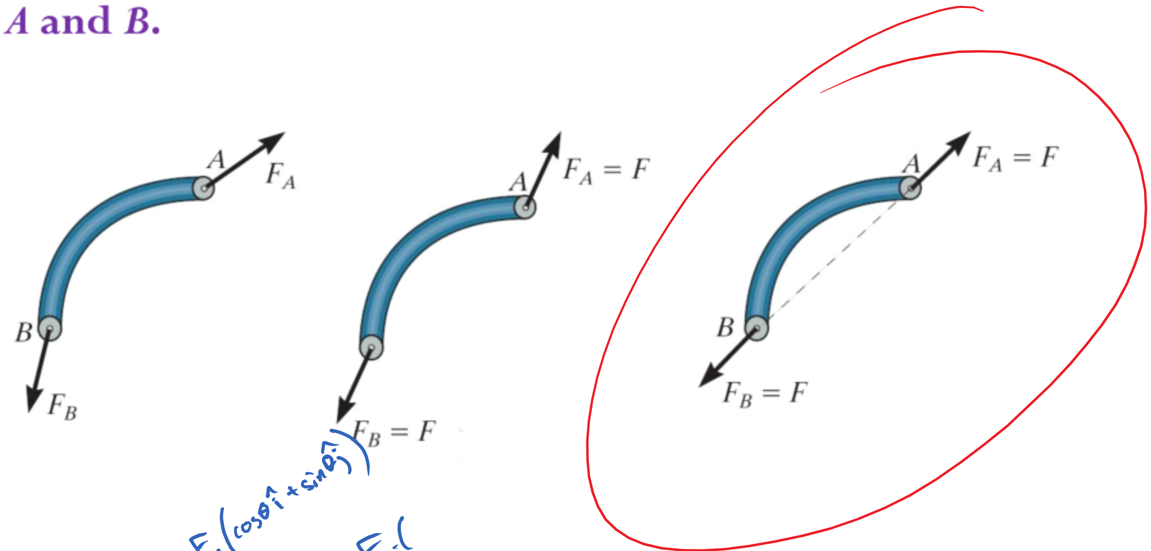
Page 13

Monday, February 13, 2017 12:55 AM

Two-force members

As the name implies, two-force members have forces applied at only two points.

If we apply the equations of equilibrium to such members, we can quickly determine that **the resultant forces at *A* and *B* must be equal in magnitude and act in the opposite directions along the line joining points *A* and *B*.**



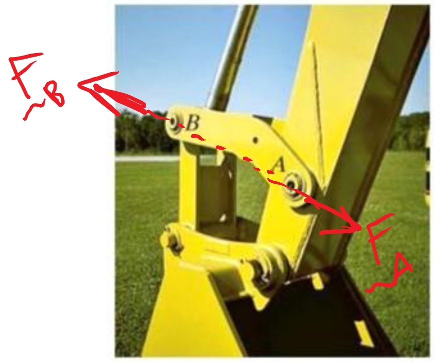
$$\sum \underset{\sim}{F} = \underbrace{\underset{\sim}{F}_A}_{= F_A(\cos\theta\,\hat{i} + \sin\theta\,\hat{j})} + \underbrace{\underset{\sim}{F}_B}_{= F_B\cdot(} = 0$$

$$\Rightarrow \underset{\sim}{F}_A = -\underset{\sim}{F}_B$$

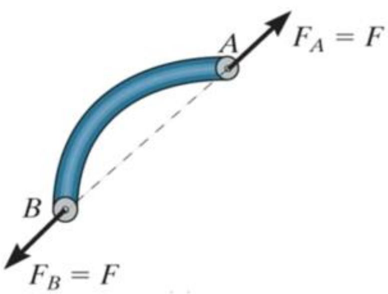
this expression tells us that $\underset{\sim}{F}_A$ & $\underset{\sim}{F}_B$ are:

1. collinear
2. equal in magnitude
3. opposite in direction
4. create no moment

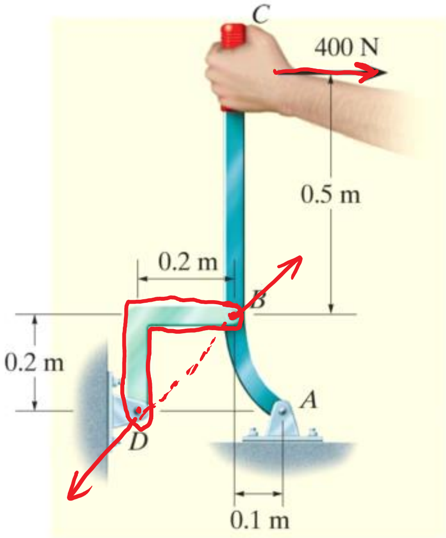
Examples of two-force members



In the cases above, members *AB* can be considered as two-force members, provided that their weight is neglected.



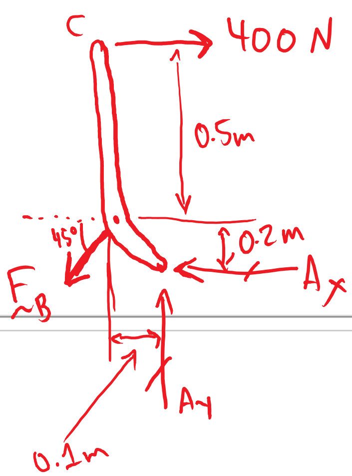
This fact **simplifies** the equilibrium analysis of some rigid bodies since the directions of the resultant forces at *A* and *B* are thus known (along the line joining points *A* and *B*).

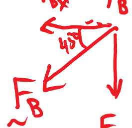


The lever *ABC* is pin supported at *A* and connected to a short link *BD*. If the weight of the members is negligible, determine the reaction forces at pins *D* and *A*.

1. Is the lever ABC a 2-force member?
   A) Yes
   B) No
2. Is the link BD a 2-force member?
   A) Yes
   B) No

FBD of ABC





$F_{Bx} = F_B \cdot \frac{\sqrt{2}}{2}$

$F_{By} = F_B \cdot \frac{\sqrt{2}}{2}$

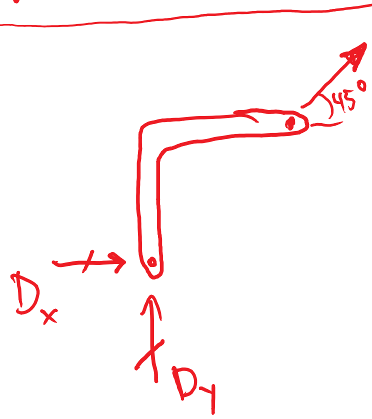
$$\Sigma M_A = \underbrace{-(0.7m)(400N)}_{-280N} + \overbrace{(0.2m)\left(F_B \tfrac{\sqrt{2}}{2}\right)}^{\text{moment caused by horiz. component of } F_B} + \overbrace{(0.1m)\left(F_B \cdot \tfrac{\sqrt{2}}{2}\right)}^{\text{moment caused by vertical component of } F_B} = 0$$

$$-280\,N + F_B \cdot \frac{\sqrt{2}}{2}(0.2m + 0.1m) = 0$$

$$\therefore \boxed{F_B = 1320\,N}$$

Reaction at D

$$\underset{\sim}{F_B} = (1320N)\left(\frac{\sqrt{2}}{2}\hat{i} + \frac{\sqrt{2}}{2}\hat{j}\right) = 933(\hat{i} + \hat{j})\,N$$



$$\Sigma F_x = \underbrace{(\underset{\sim}{F_B} \cdot \hat{i})}_{F_{Bx}} + D_x = 0$$

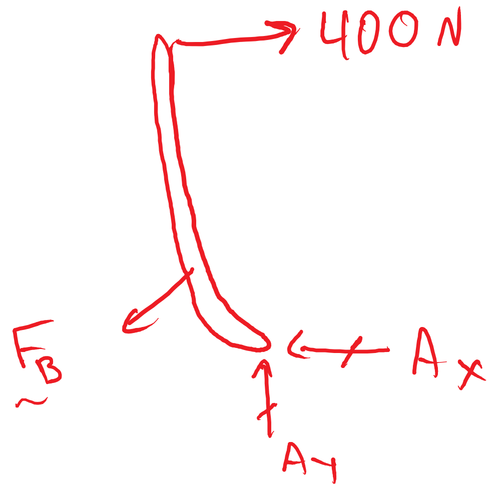
$$\Rightarrow \boxed{\underset{\sim}{D_x} = -\left(1320\tfrac{\sqrt{2}}{2}\right)N\hat{i} = -933\,N\,\hat{i}}$$

$$\sum F_y = (\underset{\sim}{F_B}\cdot\hat{j}) + D_y = 0$$

$$\Rightarrow \boxed{\underset{\sim}{D_y} = -933N\ \hat{j}}$$

So the reaction force is $\underset{\sim}{D} = -933(\hat{i}+\hat{j})N$, which equals $-\underset{\sim}{F_B}$, as expected, because the short link $\overline{BD}$ is a two-force member.

Reaction at A



$$\sum F_x = 400N - A_x - 1320\tfrac{\sqrt{2}}{2}N = 0$$

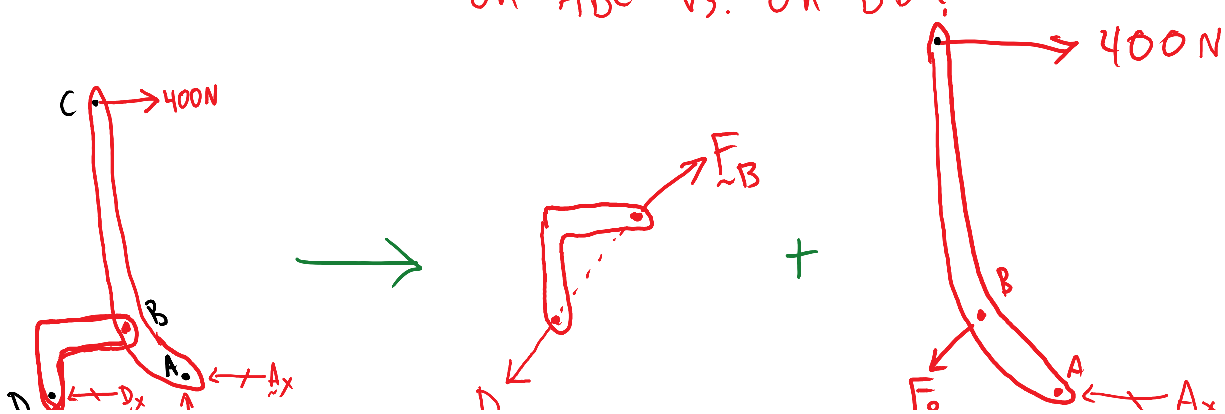
$$\Rightarrow A_x = 933N - 400N$$

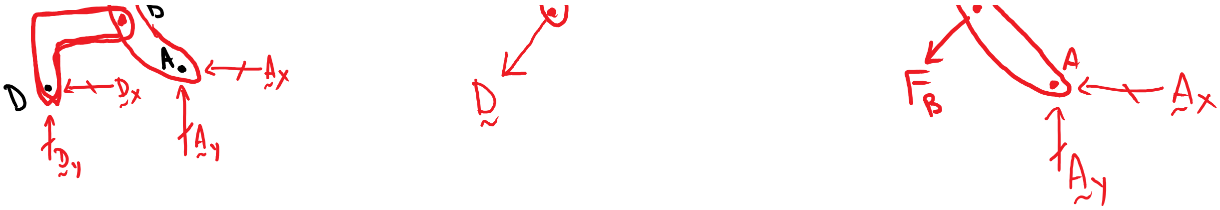
$A_x = 533N$ to the left

$$\sum F_y = A_y - \left(1320\tfrac{\sqrt{2}}{2}\right)N = 0$$

$$\boxed{A_y = 933N \text{ acting upward}}$$

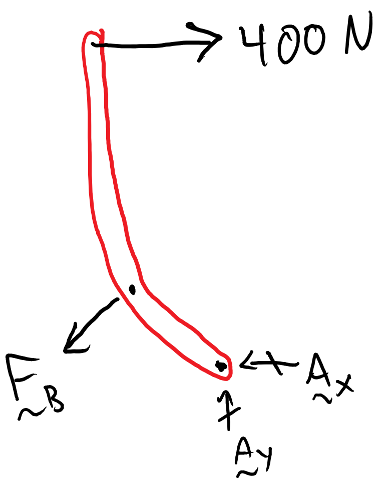
Student Question: Why do we write $\underset{\sim}{F_B}$ in opposite directions acting on $\overline{ABC}$ vs. on $\overline{BD}$?



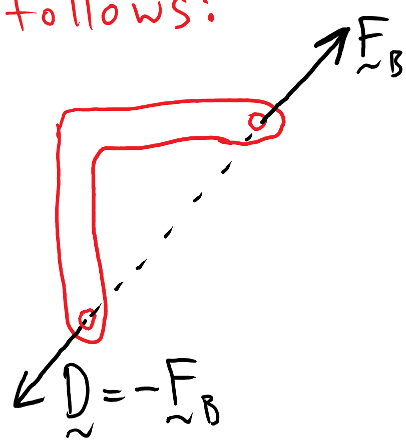


<u>Answer 1</u>: Newton's 3rd Law:
For every action (force), there is always an equal and opposite reaction (force).

<u>Answer 2</u>: Consider firstly how the link acts against the lever. As the operator pulls, the link at B resists the motion. So the force $\tilde{F}_B$ acts in a sense that counteracts the 400 N pulling force.

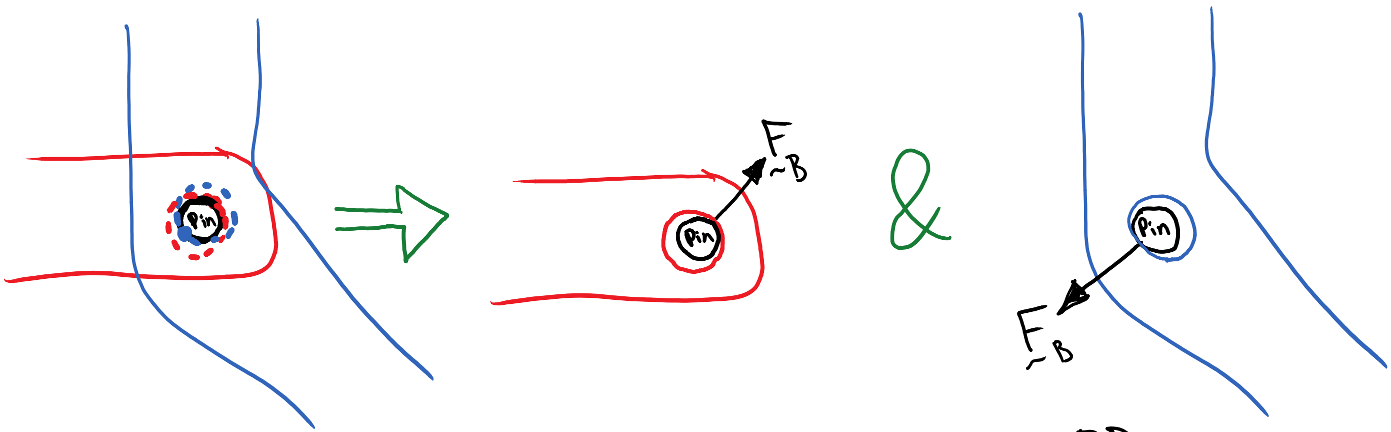


Next, consider what the short link $\overline{BD}$ "feels". It is "stretched", so it must carry a tension force. Its free-body diagram must be as follows:

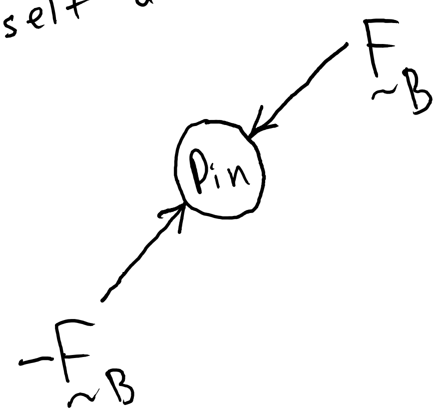


<u>Answer 3</u>: Consider the pin itself. Each of the members $\overline{ABC}$ and $\overline{BD}$ have holes through which the pin

$\overline{ABC}$ and $\overline{BD}$ have holes through which the pin is inserted. In order to fit and allow frictionless rotation, the pin diameter must be less than the hole diameter.



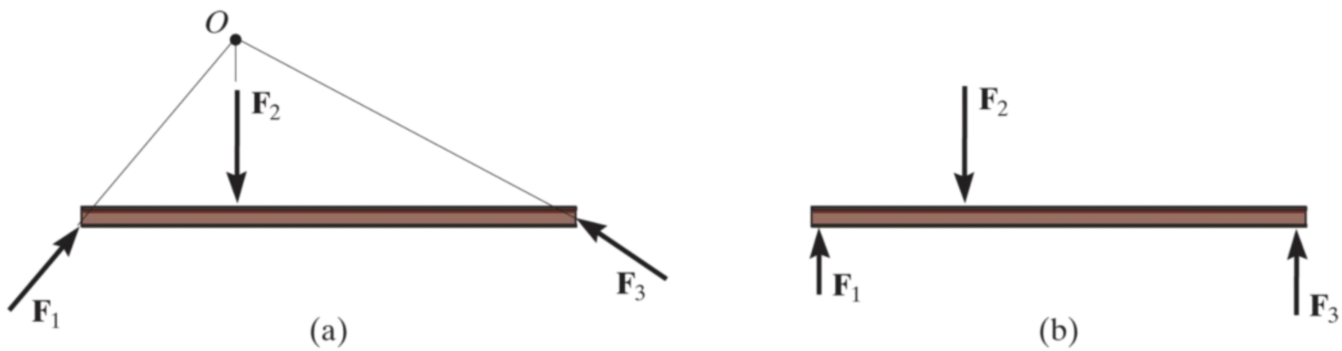
The pin carries the force from ABC to link BD.
The pin is itself a two-force member.



Three-force members

As the name implies, three-force members have forces applied at only three points.

Moment equilibrium can be satisfied only if the three forces are concurrent or parallel force system



Three-force member