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Announcements

- Quiz 1 Next Week!!! (How's your MATLAB skills?)
  - Practice quiz available on PL

Upcoming deadlines:

- Friday (9/8 – TODAY!)
  - Quiz 1 Sign-up
- Tuesday (9/12)
  - PL HW4
- Thursday (9/14)
  - ME HW5

Anteater

1 L5 - Force along a line Cross product

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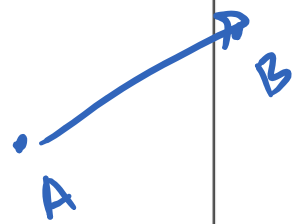
Recap

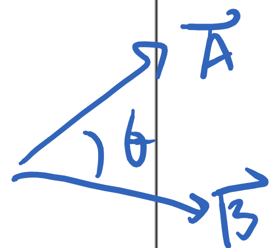
- Position vectors

$$\vec{r}_{AB} = \vec{r}_B - \vec{r}_A$$



- Dot (scalar) product

$$\vec{A} \cdot \vec{B} = C = |A||B| \cos\theta = \sum_{i=x,y,z} A_i B_i$$



- Cross (vector) product

$$\vec{A} \times \vec{B} = \vec{C}$$

3 L5 - Force along a line Cross product

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Chapter 3: Equilibrium of a particle

Goals and Objectives

- Practice following general procedure for analysis.
- Introduce the concept of a free-body diagram for an object modeled as a particle.
- Solve particle equilibrium problems using the equations of equilibrium.

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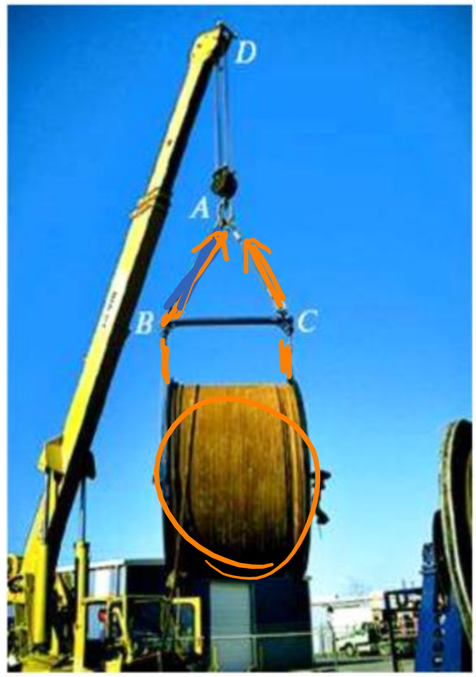
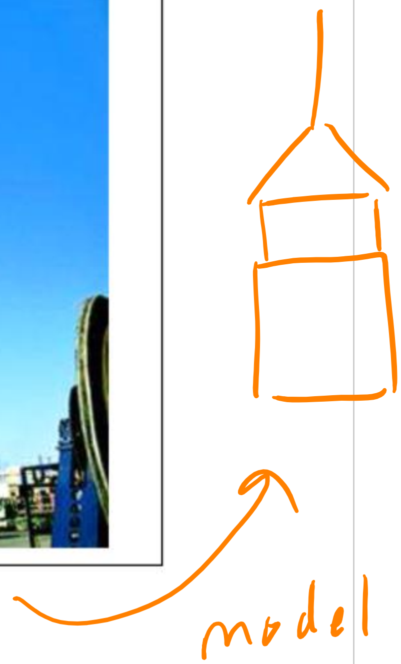
Applications

For a spool of given weight, how would you find the forces in cables AB and AC?

If designing a spreader bar (BC) like this one, you need to know the forces to make sure the rigging (A) doesn't fail.



6 L5 - Force along a line Cross product



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General procedure for analysis

1. Read the problem carefully; write it down carefully.

2. MODEL THE PROBLEM: Draw given diagrams neatly and construct additional figures as necessary.

3. Apply principles needed.

4. Solve problem symbolically. Make sure equations are dimensionally homogeneous

5. Substitute numbers. Provide proper units *throughout*. Check significant figures. Box the final answer(s).

6. See if answer is reasonable.

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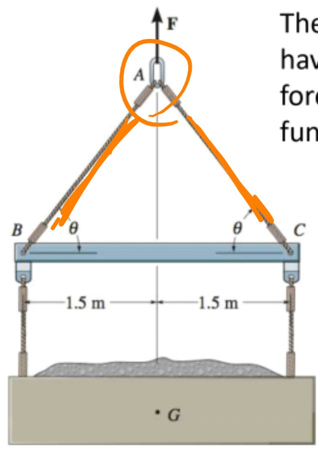
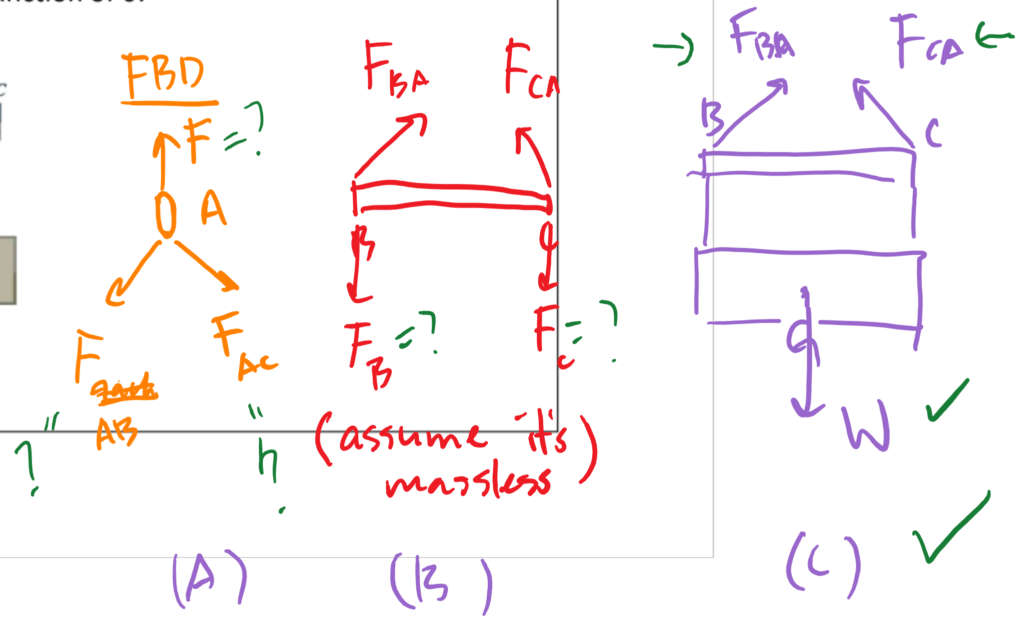
Free body diagram



The lift sling is used to hoist a container having a mass of 500 kg. Determine the force in each of the cables *AB* and *AC* as a function of θ.

Given: $m \Rightarrow W = mg$

Find: F_{AB}, F_{AC}



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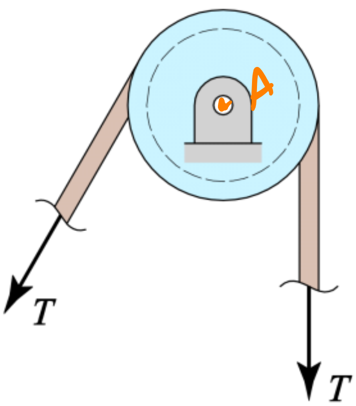
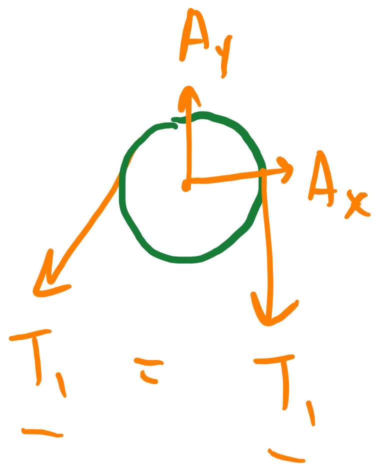
Idealizations

– massless

Pulleys are (usually) regarded as frictionless; then the tension in a rope or cord around the pulley is the same on either side.



Frictionless pulley



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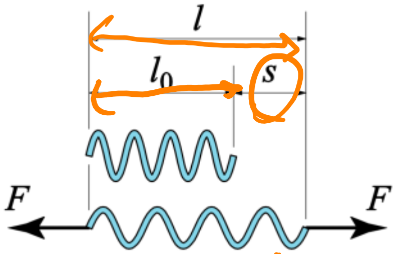
Idealizations

Springs are (usually) regarded as linearly elastic; then the tension is proportional to the *change* in length *s*.

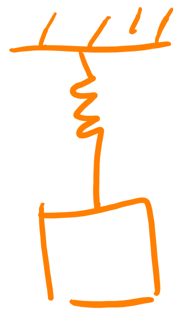


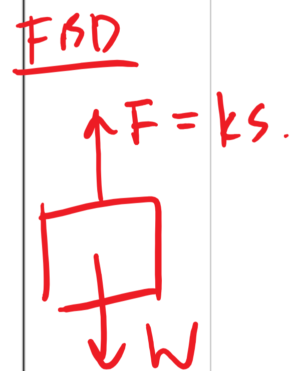
$$F = ks = k(l - l_0)$$

spring constant, or $\left[\frac{N}{m}\right]$ $\left[\frac{lb}{ft}\right]$

$[N] = [?][m]$

Linearly elastic spring





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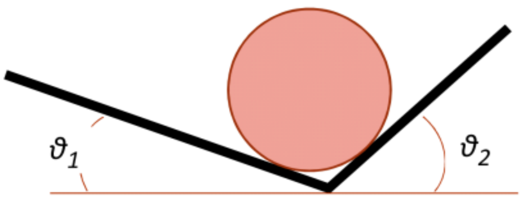
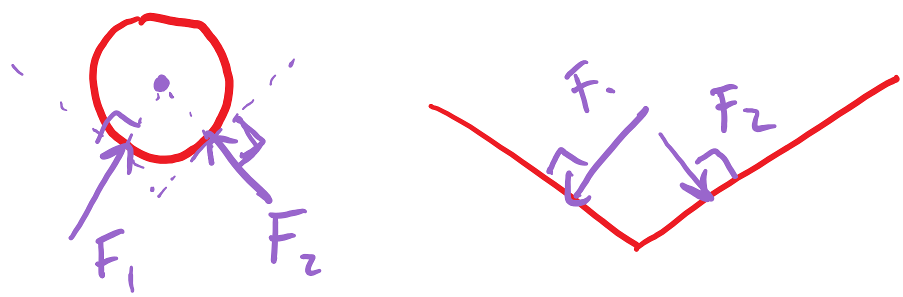
Idealizations



Contact force in smooth surface:

(no friction)



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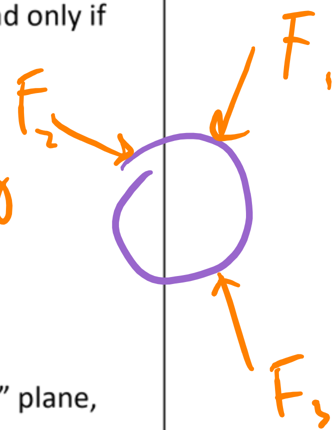
Equilibrium of a particle

According to Newton's first law of motion , a particle will be in **equilibrium** (that is, it will remain at rest or continue to move with constant velocity) if and only if

$$m\vec{a} = \sum \vec{F} = 0 = \vec{F}_1 + \vec{F}_2 + \vec{F}_3 + \dots + \vec{F}_n = 0$$



In three dimensions, equilibrium requires:

$$\sum F_x = 0 \qquad \sum F_y = 0 \qquad \sum F_z = 0 .$$

Coplanar forces: if all forces are acting in a single plane, such as the "xy" plane, then the equilibrium condition becomes

$$\sum F_x = 0 \qquad \sum F_y = 0$$

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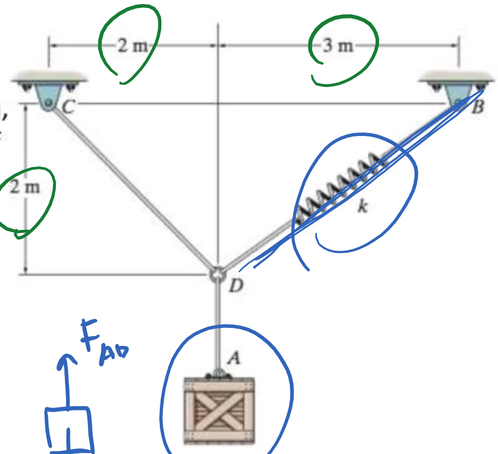
Example

If the spring *DB* has an unstretched length of 2 m, determine the stiffness of the spring to hold the 40-kg crate in the position shown.



15 L5 - Force along a line Cross product

Given: $l_0, m, \hat{u}_{DC}, \hat{u}_{DB}$

Find: k

FBD

F_{DB}, F_{DC}, D, $F_{DA} = W$

F_{AD}, W

$$\Sigma F_y = 0 = F_{AD} - W = 0$$

$$F_{AD} = W$$

EoE

$$\Sigma F_y = 0 = F_{DBy} + F_{DCy} - W$$

$$= F_{DB}\left(\frac{2}{\sqrt{3^2+2^2}}\right) + F_{DC}\left(\frac{2}{\sqrt{2^2+2^2}}\right) - W$$

$$= ks\left(\frac{2}{\sqrt{13}}\right) + F_{DC}\left(\frac{2}{2\sqrt{2}}\right) - W$$

$$\Sigma F_x = 0 = F_{DBx} + F_{DCx}$$

$$= F_{DB}\left(\frac{3}{\sqrt{3^2+2^2}}\right) - F_{DC}\left(\frac{2}{\sqrt{2^2+2^2}}\right)$$

$$0 = ks\left(\frac{3}{\sqrt{3^2+2^2}}\right) - F_{DC}\left(\frac{2}{\sqrt{2^2+2^2}}\right)$$

$$\Rightarrow F_{DC} = \frac{ks\left(\frac{3}{\sqrt{3^2+2^2}}\right)}{\left(\frac{2}{2\sqrt{2}}\right)}$$

$$0 = ks\left(\frac{2+3}{\sqrt{13}}\right) - W$$

$$k = \frac{W}{s\left(\frac{5}{\sqrt{13}}\right)}$$

$$W = mg = (40\ kg)\left(9.81\ \frac{m}{s^2}\right)$$

$$s = \sqrt{13}\ m - 2m$$

$$s = (l - l_0)$$