FBD, 2nd Law

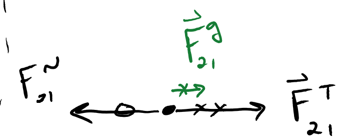
Tuesday, July 1, 2014 11:10 AM

$$\sum \vec{F}_{ext} = M \vec{a}_{com}$$

ex. outer space

<u>start w/ equilibrium</u> $\sum \vec{F} = 0 \dots \vec{a} = 0$

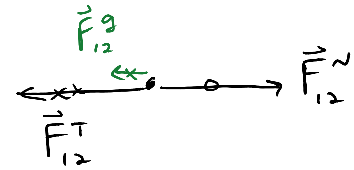
FBD (1)



$\sum \vec{F}_1 = 0$

$\vec{a}_{com_1} = 0$

FBD (2)



$\sum \vec{F}_2 = 0$

$\vec{a}_{com_2} = 0$

FBD (12)

$\sum F_{12} = 0$

$\vec{a}_{com_{12}} = 0$

Constraints

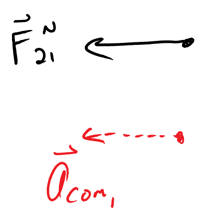
$\vec{F}^T_{21} = -\vec{F}^T_{12}$

$\vec{F}^N_{21} = -\vec{F}^N_{12}$

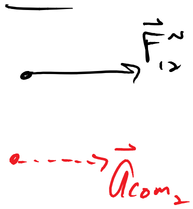
Now rope Breaks

(ignore gravity)

FBD (1)



FBD (2)



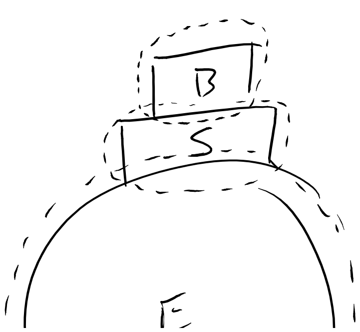
FBD (12)

$\vec{a}_{com_{12}} = 0$

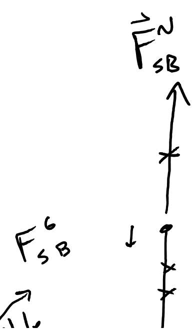
$$\sum \vec{F}_1 + \sum \vec{F}_2 = \cancel{\sum \vec{F}_{12}}^{\,0}$$

So $\sum \vec{F}_1 = -\sum \vec{F}_2$ ← 3rd Law

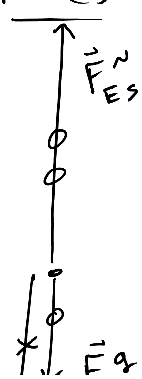
ex. equilibrium



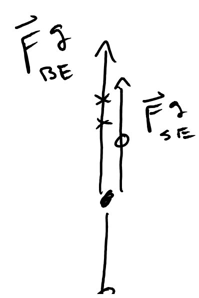
FBD (B)

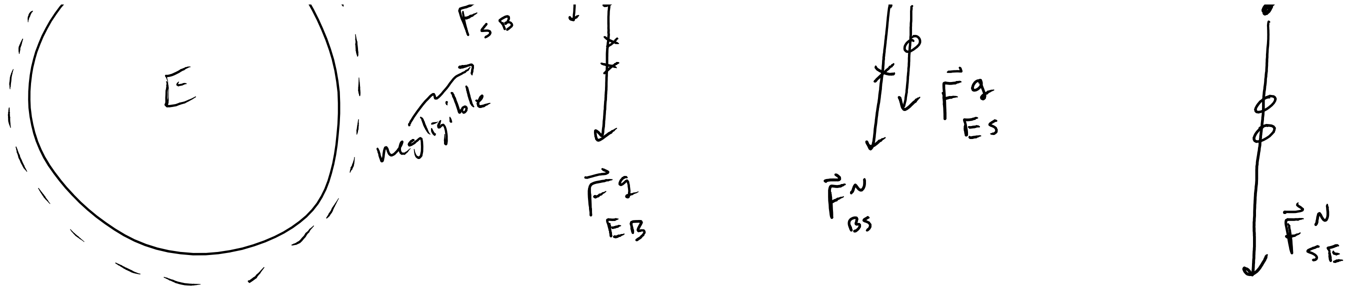


FBD (S)



FBD (E)



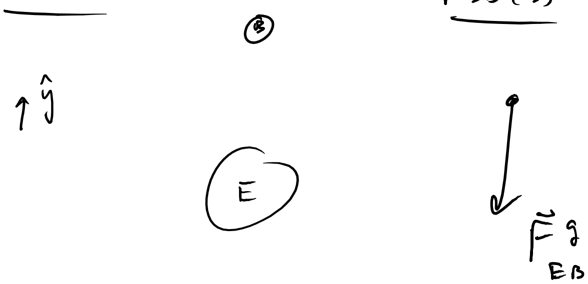


* Force (weight) of gravity near earth is eq to Mg

$g \approx 9.8\ m/s^2$

ex. Free Fall

FBD (B)



2nd Law

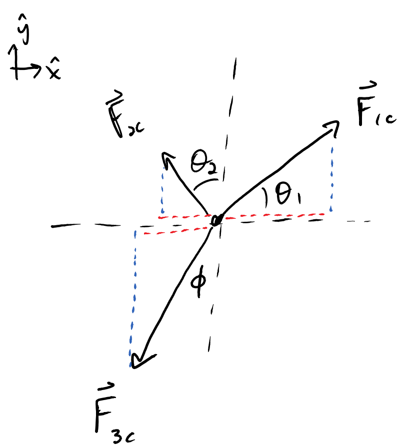
$$\sum F_y \Rightarrow \quad -|F^{g}_{EB}| = M_B a_{By}$$

$$-\cancel{M_B} g = \cancel{M_B} a_{By}$$

$$\underline{a_{By} = -g}$$

Example: Three wolves pull on a very light dead carcass. The first wolf pulls with a 10 N force in a direction 30º north of east. The second with a force of 6 N in a direction 40º west of north. What magnitude and direction must the third wolf pull if the carcass is to not accelerate? (Answer: 10.7 N, 26.6º west of south)

FBD(carcass)



2nd Law

$$\sum F_x \Rightarrow \quad \underbrace{|\vec{F}_{1c}|\cos\theta_1}_{F_{1cx}} + \left(-|\vec{F}_{2c}|\sin\theta_2\right) + \overset{?}{F_{3cx}} = M_c \cancel{a_x}^{0}$$

$$\underline{F_{3cx} = -4.8N}$$

$$\sum F_y \Rightarrow \quad \underbrace{|\vec{F}_{1c}|\sin\theta_1}_{F_{1cy}} + |\vec{F}_{2c}|\cos\theta_2 + \overset{?}{F_{3cy}} = M_c \cancel{a_y}^{0}$$

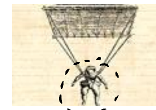
$$\underline{F_{3cy} = -9.6N}$$

$$|\vec{F}_{3c}| = \sqrt{F_{3cx}^2 + F_{3cy}^2}$$

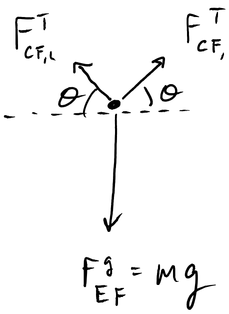
$$\tan\phi = \frac{|F_{3cx}|}{|F_{3cy}|}$$

$$\boxed{\begin{array}{l} 10.7\text{N} \\ \phi = 26.6^\circ \end{array}}$$

Felix Baumgartner recently sky dived from the stratosphere. After reaching speeds greater than the speed of sound, air resistance eventually slowed his fall and even caused a period of time where he was not accelerating. Assume he had two ropes attached to the chute, they each made an angle of 75° from the horizontal, and he is moving with a constant velocity. If the tension in each rope is 507.2 N what is the mass of Felix and his suit? Ignore the air resistance on Felix himself. (Answer = 100 kg)



FBD (Felix)



$\hat{y}$ $\hat{x}$

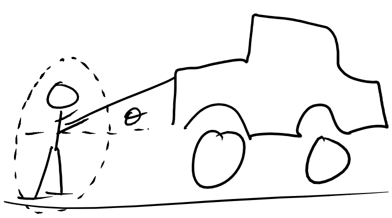
$$\Sigma F_x \Rightarrow |F^T_{CF,R}|\cos\theta - |F^T_{CF,L}|\cos\theta = m\cancel{a_x}^{0}$$

$$|\vec{F}^T_R| = |\vec{F}^T_L| \equiv F^T$$

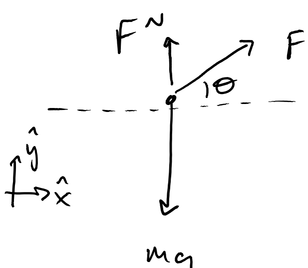
$$\Sigma F_y \Rightarrow F^T\sin\theta + F^T\sin\theta + (-mg) = m\cancel{a_y}^{0}$$

$$m = \frac{2F^T\sin\theta}{g} = \boxed{100\text{ kg}}$$

Example: A 80 kg man, wearing skis on snow (no friction), is pulled via a rope from a truck on level ground. The magnitude of the force from the truck 800 N and is directed at an angle of 30° above the horizontal.
(a) What is the man's acceleration? (Answer = <8.66, 0>m/s²)
(b) If he starts from rest, what his position and velocity as a function of time? (I'll use g = 10 m/s²)



FBD(man)



a) $$\Sigma F_x \Rightarrow \underbrace{F^T\cos\theta}_{F^T_x} = m a_x$$

$$\boxed{a_x = 8.66\text{ m/s}^2}$$

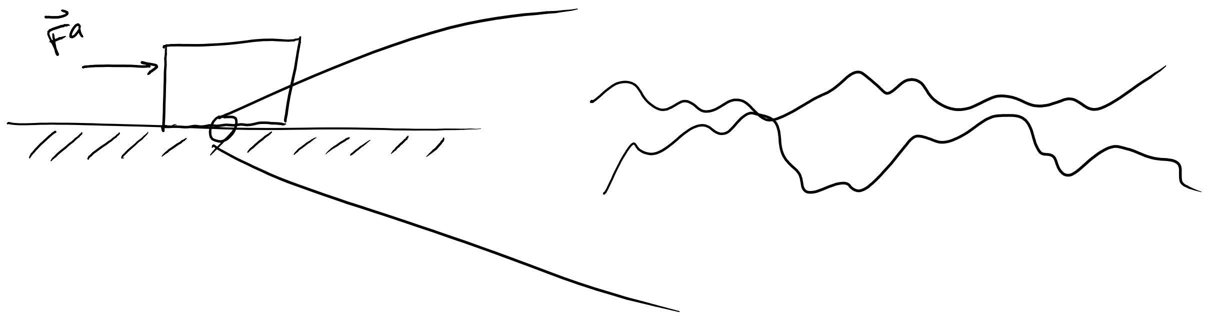
$$\Sigma F_y \Rightarrow F^N + \underbrace{F^T\sin\theta}_{400\text{N}} + \underbrace{(-mg)}_{\approx 800\text{N}} = m\cancel{a_y}^{0}$$

(b) $\vec{a}$ = const .... kin eq. for const $\vec{a}$

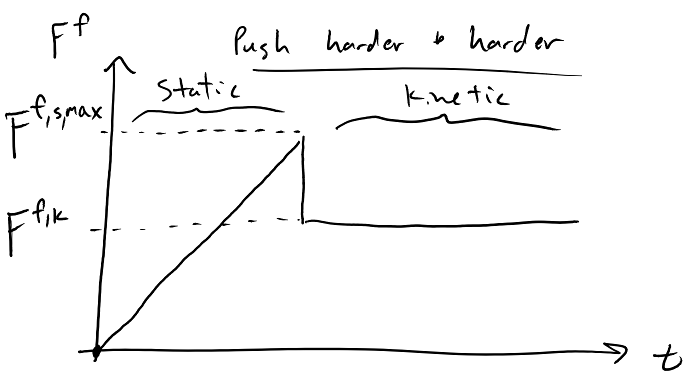
$$\Delta x(t) = \cancel{v_{ix}}^{0}\, t + \frac{1}{2} a_x t^2 \longrightarrow \underline{\Delta x(t) = 4.33\, t^2}$$

$$v_x(t) = v_{ix} + a_x t \longrightarrow \underline{v_x(t) = 8.66\, t}$$

Friction



* Hard to break free ....easier to keep moving once free



* Friction is ∥ surface
* associated w/ a normal Force
* Friction opposes the direction of relative motion
  * ask which way move if frictionless

Example: A 80 kg man, wearing skis on snow, is pulled via a rope from a truck on level ground. The magnitude of the force from the truck 800 N and is directed at an angle of 30° above the horizontal.
For part (c) and (d) consider friction present with $\mu_s = 1/3$ and $\mu_k = 1/4$ and let $g = 10\ m/s^2$.
(c) How much tension is required to get the skier to slip? (261 N)
(d) If the minimum slip tension is doubled, what will the acceleration be? (4.08 m/s^2)

Example: A force is applied to a 1-kg-block that is pressed against a vertical wall. The force is at an angle of 40° upward from the horizontal. If the coefficient of static friction between the block and the wall is 0.3, what range of forces will keep the block in equilibrium? (Answer = 11.2 – 23.7 N)

Mechanical advantage is the ratio of the force required without the use of a machine (sometimes very

simple machine) to that needed when using the machine. Compare the force to lift an object to that needed to slide the same object up a frictionless incline and show that the mechanical advantage of the inclined plane is the length of the incline divided by the height of the incline.