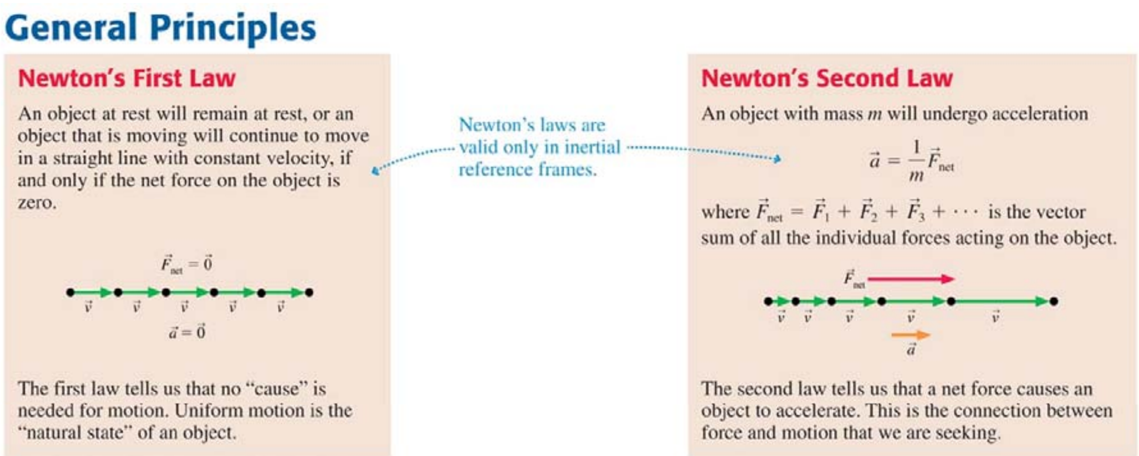
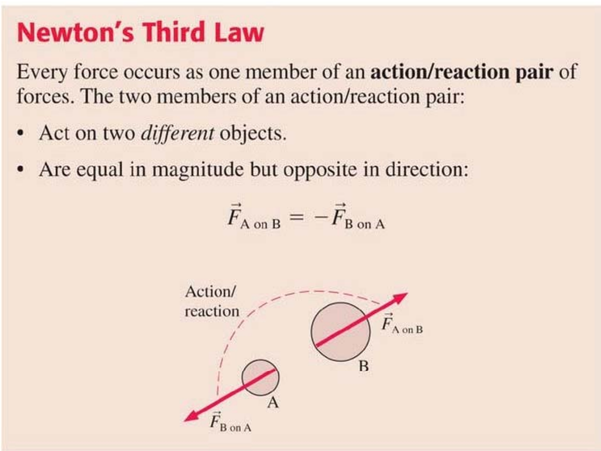
P2211K

9 / 21 / 2010

These lead us to the discussion of interactions that “cause” acceleration, or ***Forces.***

- For our working purposes, we need to know that
  - o ***Force*** “causes” an object to accelerate;
  - o The amount of acceleration is inversely proportional to the object’s mass;
  - o Mass is proportional to weight, but is not the same thing as weight;
  - o Forces are vectors;
  - o The object’s acceleration is the ***vector*** result of ***ALL*** forces acting it.
- Also, from the nature of ***Forces,*** we can conclude that
  - o If an object accelerates, the ***net force*** on it is non-zero;
  - o If the ***net force*** on an object is non-zero, it will accelerate.
- Newton’s 1st and 2nd laws describe the quantitative nature of ***Forces***:





Focus on Newton's 2nd Law: ***(Chapter 6)***

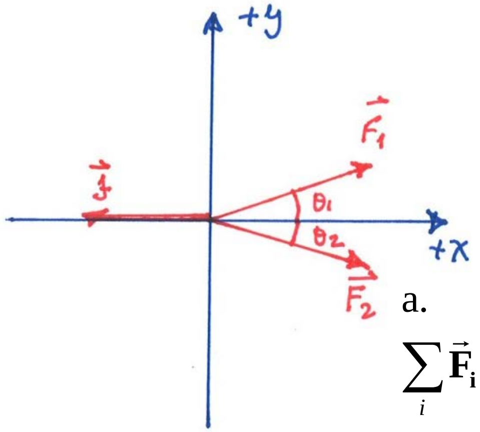
- Equilibrium—a special case when $\vec{\mathbf{F}}_{\mathbf{net}} = 0$:
- Action by constant forces leading to constant accelerations: $\vec{\mathbf{F}}_{\mathbf{net}} = \mathrm{m}\vec{\mathbf{a}} \neq 0$
- Another special case: weight & elevators
- Models, approximations, & variable forces
  - Gravity: $F_g = G\dfrac{m_1 m_2}{r^2} = m\left(G\dfrac{m_E}{R_E^2}\right) = mg$
  - Friction: $\left\{\begin{array}{l}\Im_s < \mu_s N, \text{static friction} \\ \Im_k = \mu_k N, \text{kinetic friction}\end{array}\right\}$, opposite to $\vec{v}$
  - Air resistance---"drag": $\left\{\begin{array}{l}D_A = kv^2, \text{ Air resistance; opposite to } \vec{v} \\ D_W = kv, \text{ Water resistance; opposite to } \vec{v}\end{array}\right.$

Focus on Newton's 2nd Law: ***(Chapter 6)***

$$\vec{\mathbf{F}}_{\mathbf{net}} = 0$$

Problem 6.4: A football coach (125 kg) sits on a sled (50 kg) while two of his players build their strength by dragging the sled across the field with ropes. The friction force on the sled is 1000 N and the angle between the two ropes is 20°.

a. How hard must each player pull to drag the coach at a steady 2.50 m/s?



a.

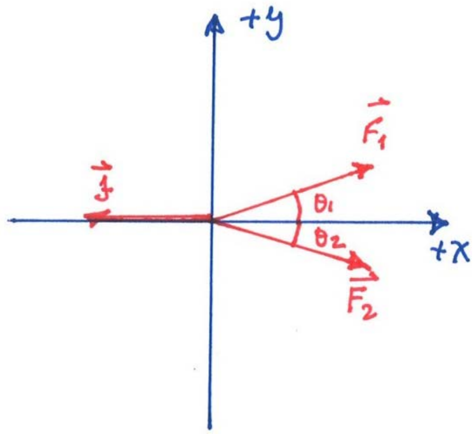
$$\sum_i \vec{\mathbf{F}}_{\mathbf{i}} = 0 \quad \text{(constant velocity} \Rightarrow \vec{\mathbf{a}} = 0)$$

Assume each player pulls equally and set the coordinate system as shown with $\theta_1 = \theta_2$.

$$\sum_i \mathrm{F_{xi}} = 0 = \mathrm{F_1}\cos\theta_1 + \mathrm{F_2}\cos\theta_2 - \Im = 2\mathrm{F}\cos 10° - 1000\mathrm{N}$$

$$\therefore\ \mathrm{F} = \frac{1000\mathrm{N}}{2\cos 10°} = 507.7\ \mathrm{N}$$

$$\left\{ \text{Note that } \sum_i \mathrm{F_{yi}} = 0 = \mathrm{F_1}\sin\theta_1 - \mathrm{F_2}\sin\theta_2 = \mathrm{F}\sin\theta - \mathrm{F}\sin\theta \right\}$$



b. How hard must they pull to accelerate the coach from rest to 2.50 m/s over the distance 5.0 m?

b. ***Like a. except that there's non - zero acceleration and a non - zero net force***

$$\sum_i \vec{\mathbf{F}}_\mathbf{i} = \vec{\mathbf{F}}_{\text{net}} = m\vec{\mathbf{a}}$$

Get a from v_0, v_f, and d: $a = \dfrac{\left(v_f^2 - v_0^2\right)}{2d} = 0.625\,\text{m/s}^2$

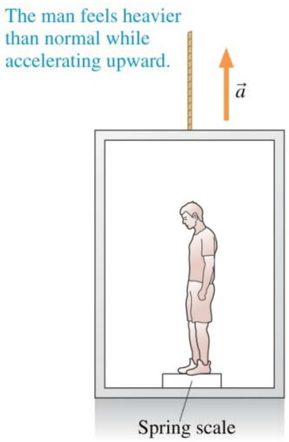
Assume each player pulls equally and set the coordinate system as shown with $\theta_1 = \theta_2$.

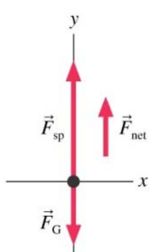
$$\sum_i F_{xi} = ma_x = F_1\cos\theta_1 + F_2\cos\theta_2 - \Im = 2F\cos 10° - 1000\text{N} = \left(m_{\text{coach}} + m_{\text{sled}}\right)\, 0.625\text{ m/s}^2 = 109.375\text{N}$$

$$\therefore\ F = \frac{1109.375\text{N}}{2\cos 10°} = 563.2\text{ N}$$

$$\left\{\text{Note that } \sum_i F_{yi} = 0 = F_1\sin\theta_1 - F_2\sin\theta_2 = F\sin\theta - F\sin\theta\right\}$$

Weight & elevators:





- The “heavier” or “lighter” effect in elevators and “free-fall” is a result of the way scales measure weight. They measure the force of contact and indicate that as weight.
- For the case indicated on the side,

$$\vec{F}_{net} = m\vec{a} = \vec{F}_{sp} + \vec{F}_g$$

- If $a = 0$, then $F_{sp} = F_g$ and F_g is W. However, if $a \neq 0$, then

$$\vec{F}_{sp} = m\vec{a} - \vec{F}_g = m\vec{a} - m\vec{g} = m(\vec{a} - \vec{g})$$

Since $\vec{g}$ is down, when component values are entered this becomes:

$$F_{sp} = m(a+g) = m(1+\frac{a}{g})$$

Example: a 75 kg person (about 150 lb.) is in an elevator accelerating upwards at 2.0 m/s^2. (Use g = 10 m/s^2)

a. What is their apparent weight? (900 N)

b. What is it if the acceleration is downwards at the same rate? (600 N)

Assignment: Read and work on Chapter 6