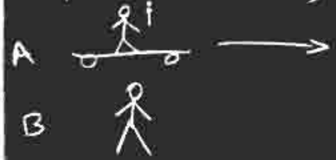
· Relative velocity



if A is moving at velocity $\vec{v}_0$ with respect to B

(relative velocity)

if object has velocity $\vec{v}_A$ in frame A

has velocity $\vec{v}_A + \vec{v}_0$ in frame B

still

← 2 mi/hr

→ 2 mi/hr

1 mi

Still water:

2 mi

1st 1/2 hr

2nd 1/2 hr

1 hr ⇒ 2 mi/hr

current

← 2+1 = 3 mi/hr — 1/3 hr

→ 1 mi/hr — 2-1 = 1 mi/hr — 1 hour

$\frac{4}{3}$ hour

$$\frac{2 \text{ mi}}{\frac{4}{3} \text{ hour}} = \frac{3}{2} \frac{\text{mi}}{\text{hr}}$$

ch5 Newton's laws of motion

1) if an object has no forces acting on it, its velocity is constant.

Force: that which causes an object to accelerate.

Force is a vector

Units of force: Newtons.

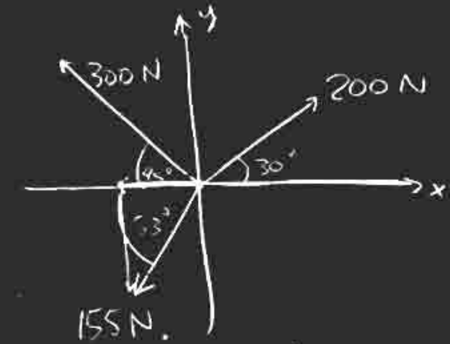
for instance,
Can measure force by using a deformation of a spring

Force is a vector

$\vec{F}_1 \downarrow + \vec{F}_2 \rightarrow \quad \searrow \vec{F}_1 + \vec{F}_2$

$\vec{F}_1 \uparrow + \vec{F}_2 \downarrow = 0$

Add forces



Signs!

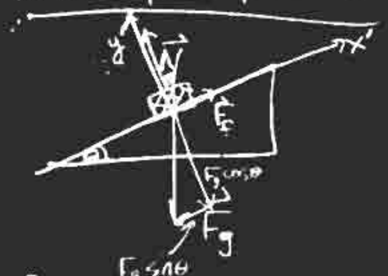
$\lvert F \rvert$	F_x	F_y
200 N	$(200\,N)\cos 30° = 173\,N$	$(200\,N)\sin 30° = 100\,N$
300 N	$-(300\,N)\cos 45° = -212\,N$	$(300\,N)\sin 45° = 212\,N$
155 N	$-(155\,N)\cos 53° = -93\,N$	$-(155\,N)\sin 53° = -124\,N$
X	$F_x = -132\,N$	$F_y = 188\,N$

magnitude of sum

$$= \sqrt{F_x^2 + F_y^2} = \sqrt{(-132)^2 + (188)^2} = 230\,N$$

$$\text{angle} = \tan^{-1}\left(\frac{-188}{132}\right) = -35°$$

inclined plane problems



often useful to choose axes ∥ and ⊥ to inclined plane

$$\vec{F}_g = -F_g\hat{j} = -F_g\cos\theta\,\hat{j}' - F_g\sin\theta\,\hat{i}'$$

$$\vec{N} = N\hat{j}'$$

$$\vec{F}_f = \vec{F}_f\,\hat{i}'$$

total force

$$\vec{F} = (-F_g\sin\theta + F_f)\,\hat{i}' + (-F_g\cos\theta + N)\,\hat{j}'$$

if object is not accelerating $\Rightarrow \vec{F} = 0$

$$F_g\sin\theta = F_f \qquad F_g\cos\theta = N$$

Inertial reference frame:
a frame in which Newton's first law applies

Newton's Third Law

Force exerted by object 1 on object 2, $\vec{F}_{12}$, is equal in magnitude and opposite in direction to the force exerted by 2 on 1, F_{21} $\vec{F}_{12} = -\vec{F}_{21}$

Newton's 2nd law

$$\sum \vec{F} = m\vec{a}$$

acceleration of body is proportional to NET force acting on it

proportionality const : mass

mass: scalar

units are kg

$\sum \vec{F} = m\vec{a}$ is really saying

$F_x = m a_x$

$F_y = m a_y$

$F_z = m a_z$

---

m has units kg

a has units m/s^2

Force has units $(kg \cdot m)/s^2$

$1N \equiv 1 kg \cdot m/s^2$

Mass measures inertia

$[\vec{F} = m\vec{a}]$

weight   Force due to gravity $= -mg\hat{j}$