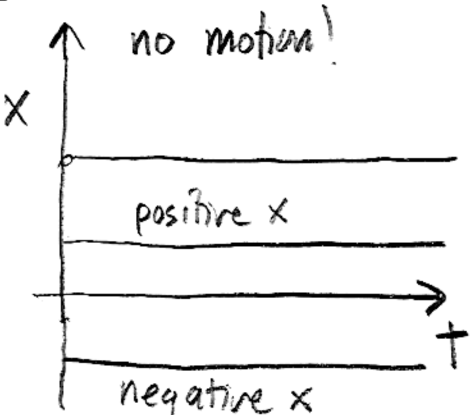
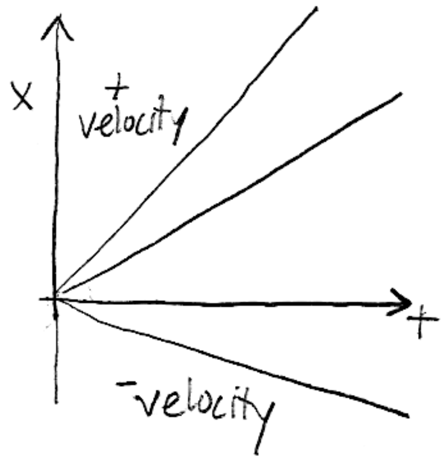
$\vec{r}, \vec{v}, \vec{a}$

in one dimension, $\vec{r} \longrightarrow x$
(technically, always displacement from an initial position).

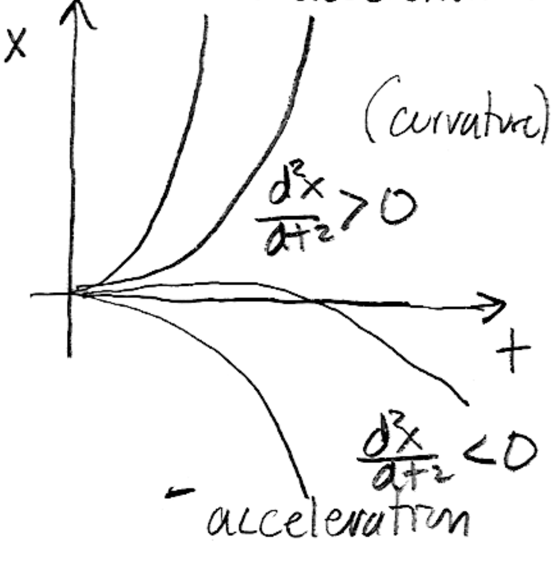
some $x(t)$:



constant speed



$\frac{dx}{dt}$ = constant (different values)



$$v_x = \frac{dx}{dt} \qquad a_x = \frac{d^2x}{dt^2}$$

Lookout: value of x not same as $\frac{dx}{dt}$

could be (+, 0, −) — (+, 0, −) all combo's possible

<u>Speed</u>: magnitude of velocity.

<u>2-d, 3-d</u>: $\vec{r} = (x(t), y(t), z(t))$

$$= x(t)\hat{\imath} + y(t)\hat{\jmath} + z(t)\hat{k}$$

$$\vec{v} = \frac{dr}{dt} = \left(\frac{dx}{dt}, \frac{dy}{dt}, \frac{dz}{dt}\right)$$

$$= \frac{dx}{dt}\hat{\imath} + \frac{dy}{dt}\hat{\jmath} + \frac{dz}{dt}\hat{k}$$

$$|\vec{v}| = \sqrt{\left(\frac{dx}{dt}\right)^2 + \left(\frac{dy}{dt}\right)^2 + \left(\frac{dz}{dt}\right)^2}$$

$$\vec{a} = \frac{d\vec{v}}{dt} = \left(\frac{d^2x}{dt^2}, \frac{d^2y}{dt^2}, \frac{d^2z}{dt^2}\right)$$

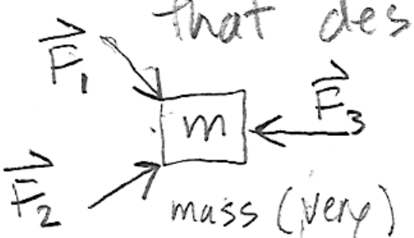
$$|\vec{a}| = \sqrt{\left(\frac{d^2x}{dt^2}\right)^2 + \left(\frac{d^2y}{dt^2}\right)^2 + \left(\frac{d^2z}{dt^2}\right)^2}$$

we'll re-visit

<u>Newton's Laws</u> (like Chap. 5 of H+R)

① "Every body persists in its state of rest or of constant velocity unless the body is compelled to change that state."

② There is a new vector called force that describes a "push" on something



$$\sum \vec{F}_i = m\vec{a} = m\frac{d^2\vec{x}}{dt^2}$$

(3) "To every action there is always opposed an equal reaction; or, the mutual actions of two bodies upon each other are always equal, and directed to contrary parts."

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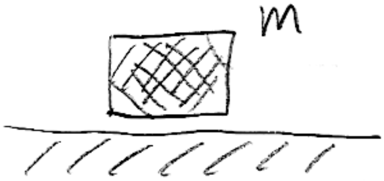
start applying....



block at rest.....

(N1) stays there unless gets hit by a force

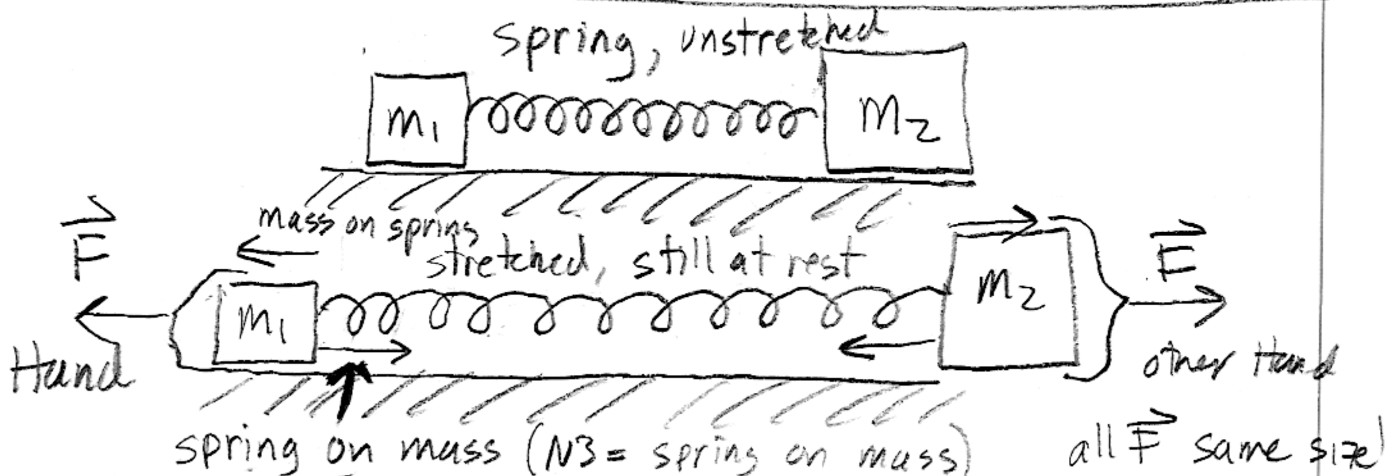
(N2) when forces do hit it, acceleration related to

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

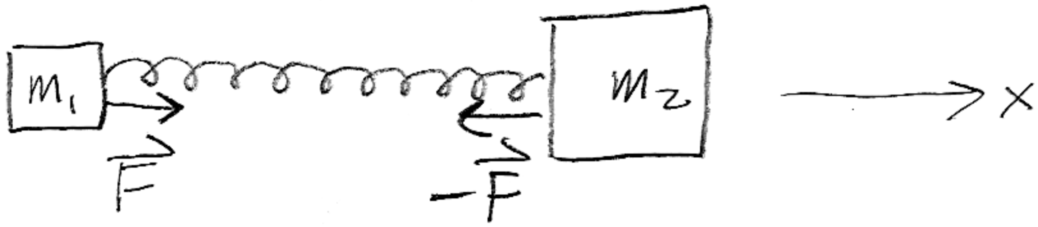
dimensions: m → kilograms; $\vec{a}$ → $\frac{d^2\vec{x}}{dt^2}$ ← $\frac{\text{meters}}{s^2}$

dimension of $|\vec{F}|$ ⇒ $\frac{kg \cdot m}{s^2}$ ≡ "Newton"

(N3) If you push, you will a push back on you



Now release! look at forces on masses



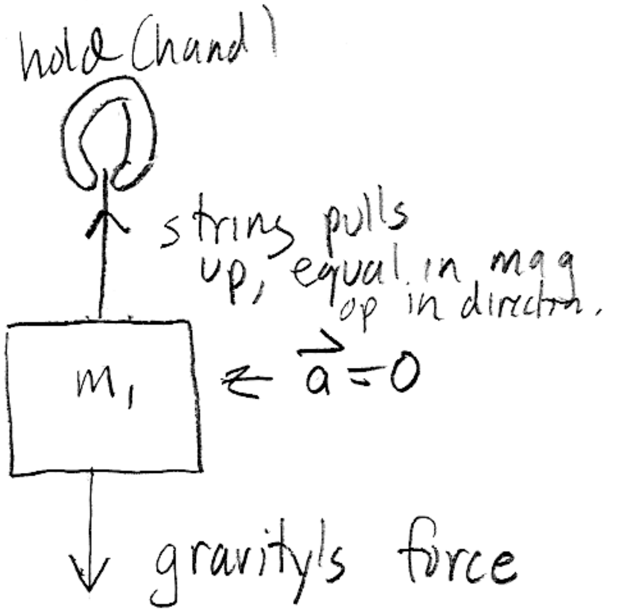
x-direction

$$m_1 a_1 = F \qquad\qquad m_2 a_2 = -F$$

$$a_1 = \frac{F}{m_1} \qquad\qquad a_2 = -\frac{F}{m_2}$$

so $$\left|\frac{a_2}{a_1}\right| = \frac{|-F/m_2|}{|-F/m_1|} = \frac{m_1}{m_2}$$

Spring Scales + Weight

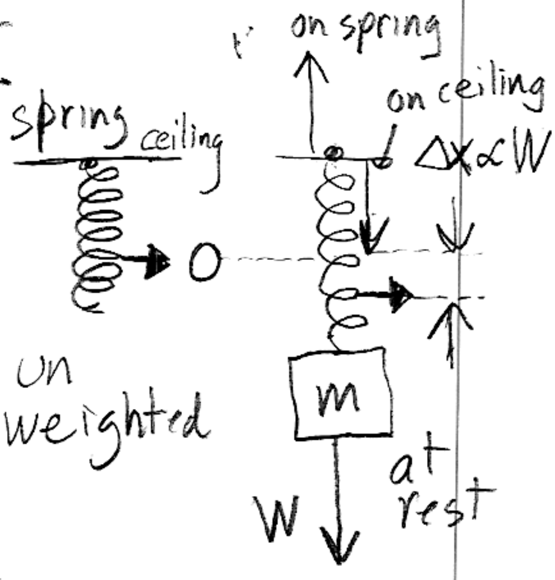


gravity's force

$W \propto m_1$

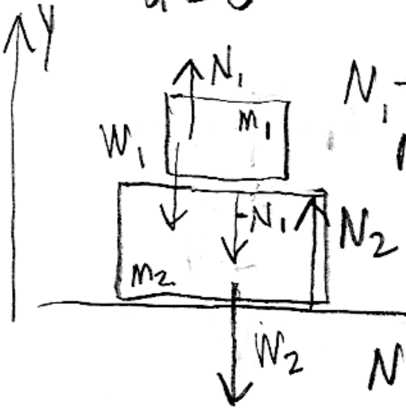
$|W| = m_1 \cdot g$

↑ same for all



origin of force on far end of spring is irrelevant.

$\vec{a} = 0$



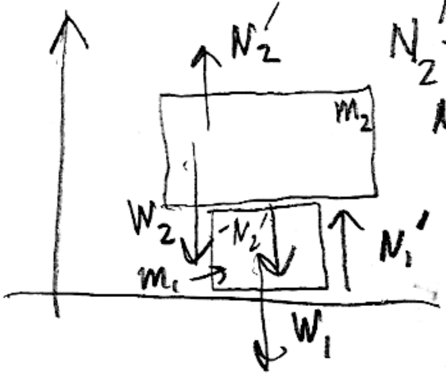
$N_1 - W_1 = 0$

$N_1 = W_1$

$N_2 - N_1 - W_2 = 0$

$N_2 = N_1 + W_2$

$N_2 = W_1 + W_2$



$N_2' - W_2 = 0$

$N_2' = W_2$

but

$N_1' = W_1 + W_2$