Announcements

1. More tutorial sessions – (feedback welcome)

   schedule

2. Physics seminar today – 4 PM – research presentations by 5 newest members of Physics Department.

3. Some comments about Tuesday's lecture and HW 4

4. Today's topic –

Causes of motion

Newton's "laws" of motion

Isaac Newton 1642-1727

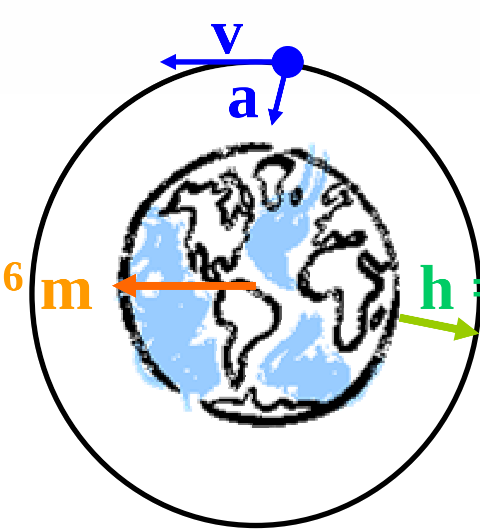
5. HRW6 4.P.043. [52978] An Earth satellite moves in a circular orbit 630 km above the Earth's surface. The period of the motion is 97.1 min.

(a) What is the speed of the satellite?

[0.0740741] ______ m/s

(b) What is the magnitude of the centripetal acceleration of the satellite?

[0.0740741] ______ m/s^2



$$v = \frac{\Delta R}{\Delta t}$$

$$\mathbf{a} = -\frac{v^2}{R_{total}} \hat{\mathbf{R}}_{total}$$

The basic laws of motion

Sir Isaac Newton (1642-1727)

mass

$$\mathbf{F} = m\,\mathbf{a}$$

acceleration

net “force”

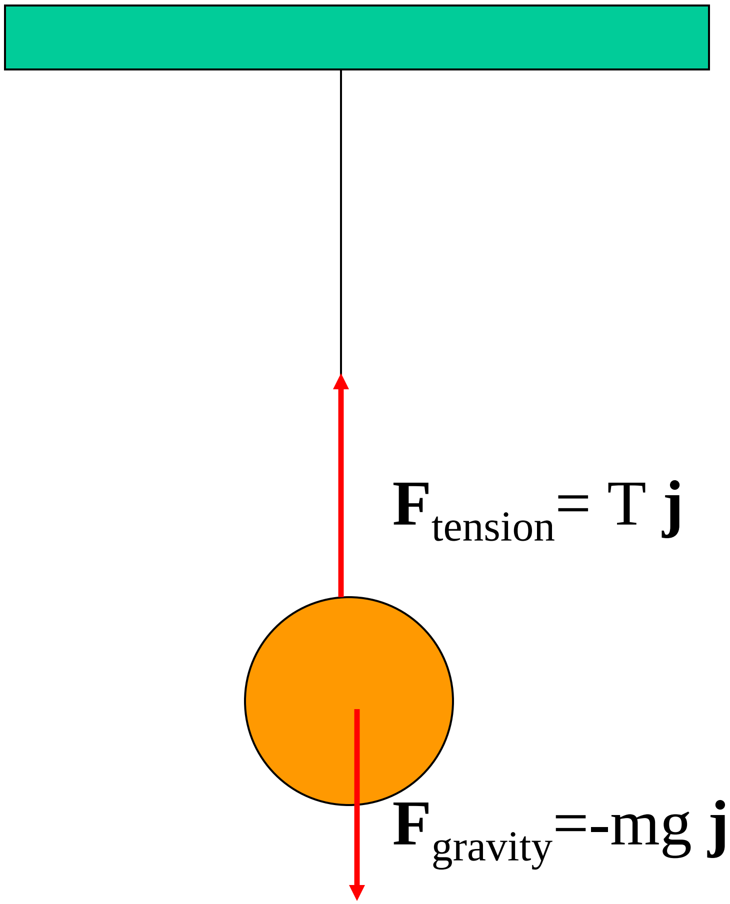
1. In absence of a net force, an object remains at constant velocity or at rest.
2. In the presents of a net force, the motion of an object of mass m is described by $\mathbf{F} = m\,\mathbf{a}$.

3. $\mathbf{F}_{12} = -\mathbf{F}_{21}$

Units of force: 1 N = 1kg m/s^2 = 0.2248 lb

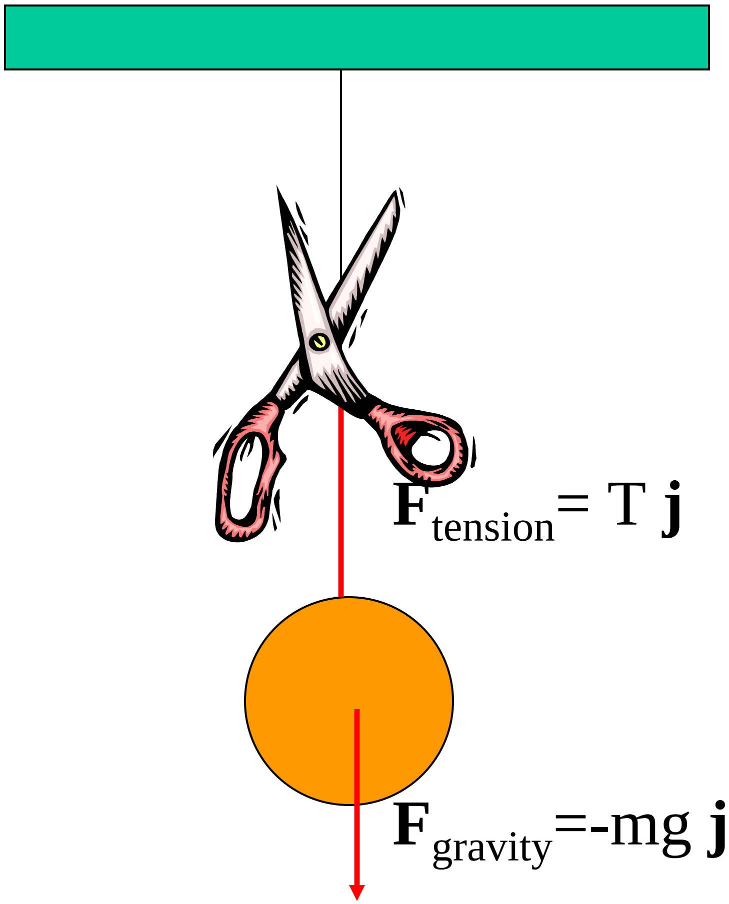
(quarter pound hamburger ~ 1 Newton burger)

Examples



$$\mathbf{F} = \mathbf{F}_{net} = \mathbf{F}_{tension} + \mathbf{F}_{gravity} = (T - mg)\ \mathbf{j} = \mathbf{0}$$

Examples



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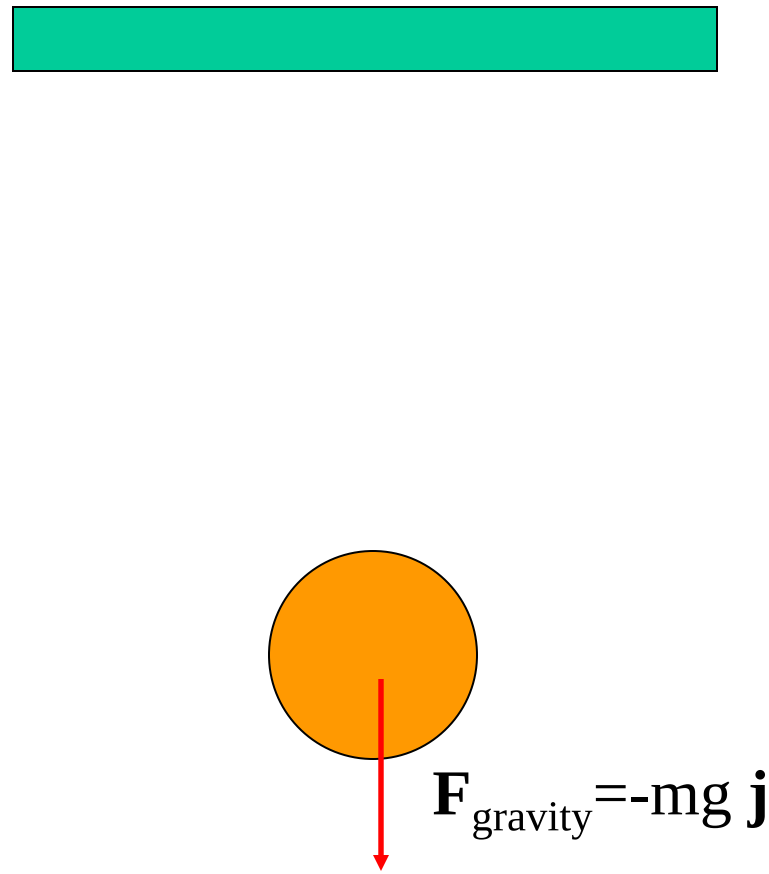


$$\mathbf{F} = \mathbf{F}_{net} = \mathbf{F}_{gravity} = (-mg)\,\mathbf{j} = m\mathbf{a}$$

$\Rightarrow$ $\mathbf{a} = -g\mathbf{j}$

On line quiz

An object having a mass of 2 kg is moving at constant velocity of 3 m/s in the upward direction near the surface of the Earth. What is the net force acting on the object?

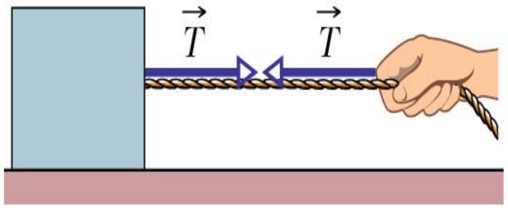
a. 0 N.

b. 6 N in the upward direction.

c. 25.6 N in the upward direction.

d. 19.6 N in the downward direction.

Example: (assume surface is frictionless)



Suppose **T** measured

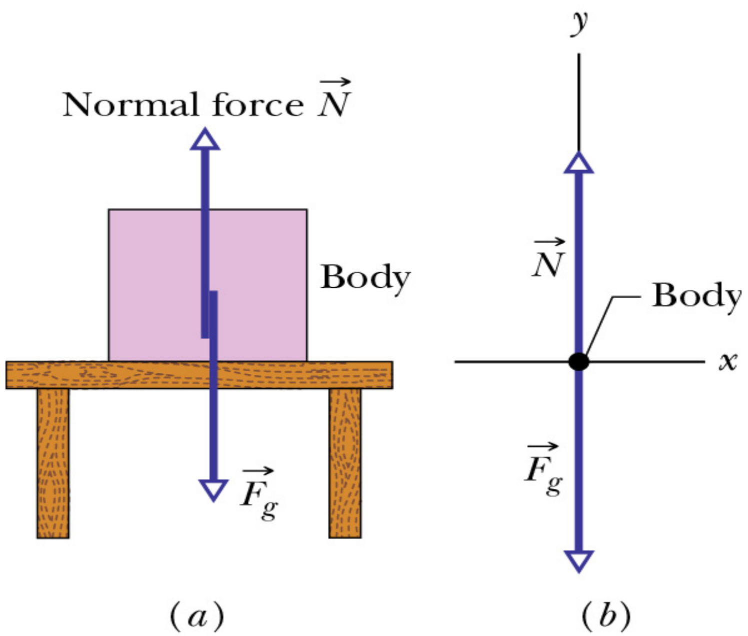
a observed & measured

T = m **a**

$$T = 5\text{N};\ \ a = 0.1\,\text{m/s}^2$$

$$m = \frac{T}{a} = \frac{5\text{N}}{0.1\text{m/s}^2} = 50\text{kg}$$

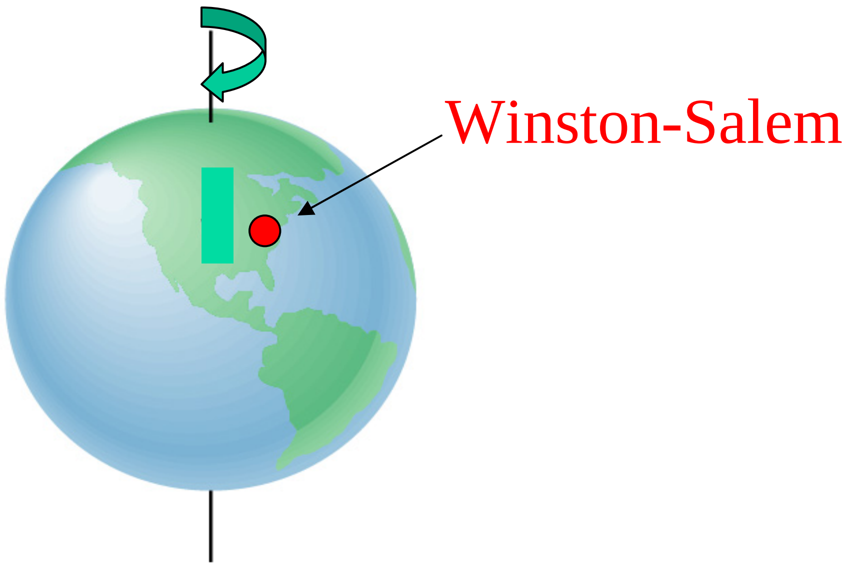
Example – support forces



$$\mathbf{F}_g = -mg\hat{\mathbf{y}}$$

$$\mathbf{F}_{\text{support}} = -\mathbf{F}_{\text{applied}}$$ ➔acts in direction ⊥ to surface

(in direction of surface "normal")


Winston-Salem

Peer instruction question

Realizing that the Earth rotates about its axis once every 24 hrs. and that in Winston-Salem, this means that you are moving in a circular at a speed of v~400 m/s at a radius of r~5000 km from the axis of rotation. What can you say about your centripetal acceleration?

(a) It is too small to measure.

(b) Is is measureable.

(c) There is no effect, since you are moving together with everything else.

Newton's second law

$$\mathbf{F} = m\,\mathbf{a}$$

Types of forces:

Fundamental	Approximate	Empirical
Gravitational	$F = -mg\,\mathbf{j}$	Friction
Electrical		Support
Magnetic		Elastic
Elementary particles		

$$\mathbf{F} = m\mathbf{a} = m\frac{d\mathbf{v}}{dt} = m\frac{d^2\mathbf{r}}{dt^2}$$

Examples (one dimension):

$F = F_0$ (constant) => $x(t) = x_0 + v_0 t + \frac{1}{2}\frac{F_0}{m}t^2$

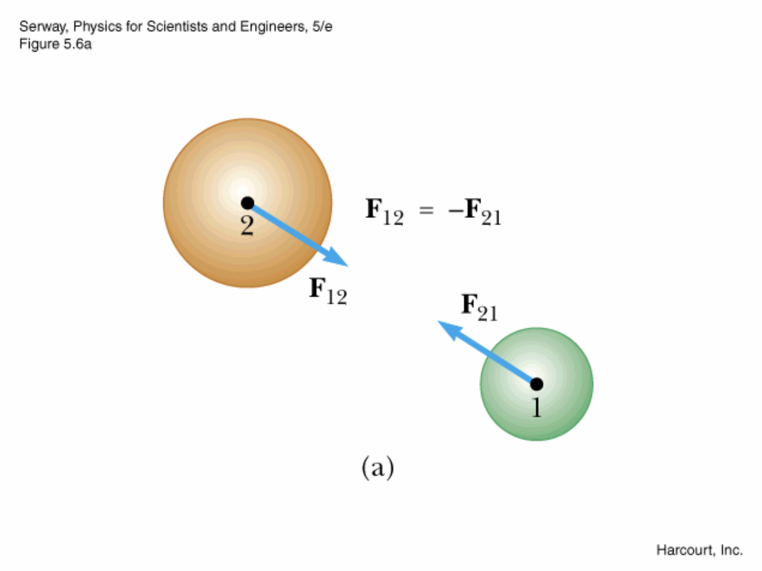
$F = F_0 \sin \omega t$ => $x(t) = x_0 + v_0 t - \frac{F_0}{m\omega^2}\sin \omega t$

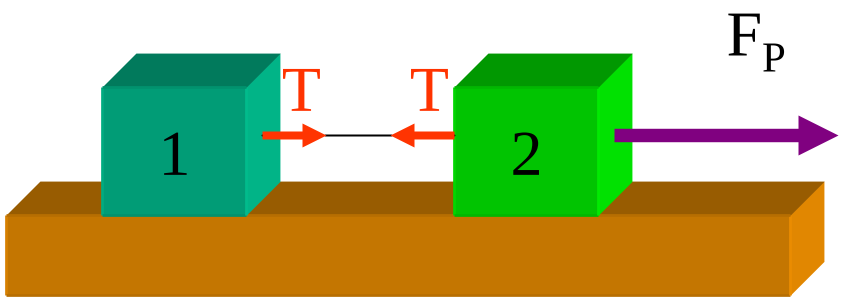
$F = -kx$ => $x(t) = x_0 \cos\sqrt{\frac{k}{m}}t$

$F = F_0 - mbv$ => $v(t) = -\frac{g}{b} + \frac{g}{b}e^{-bt}$

Newton's third law

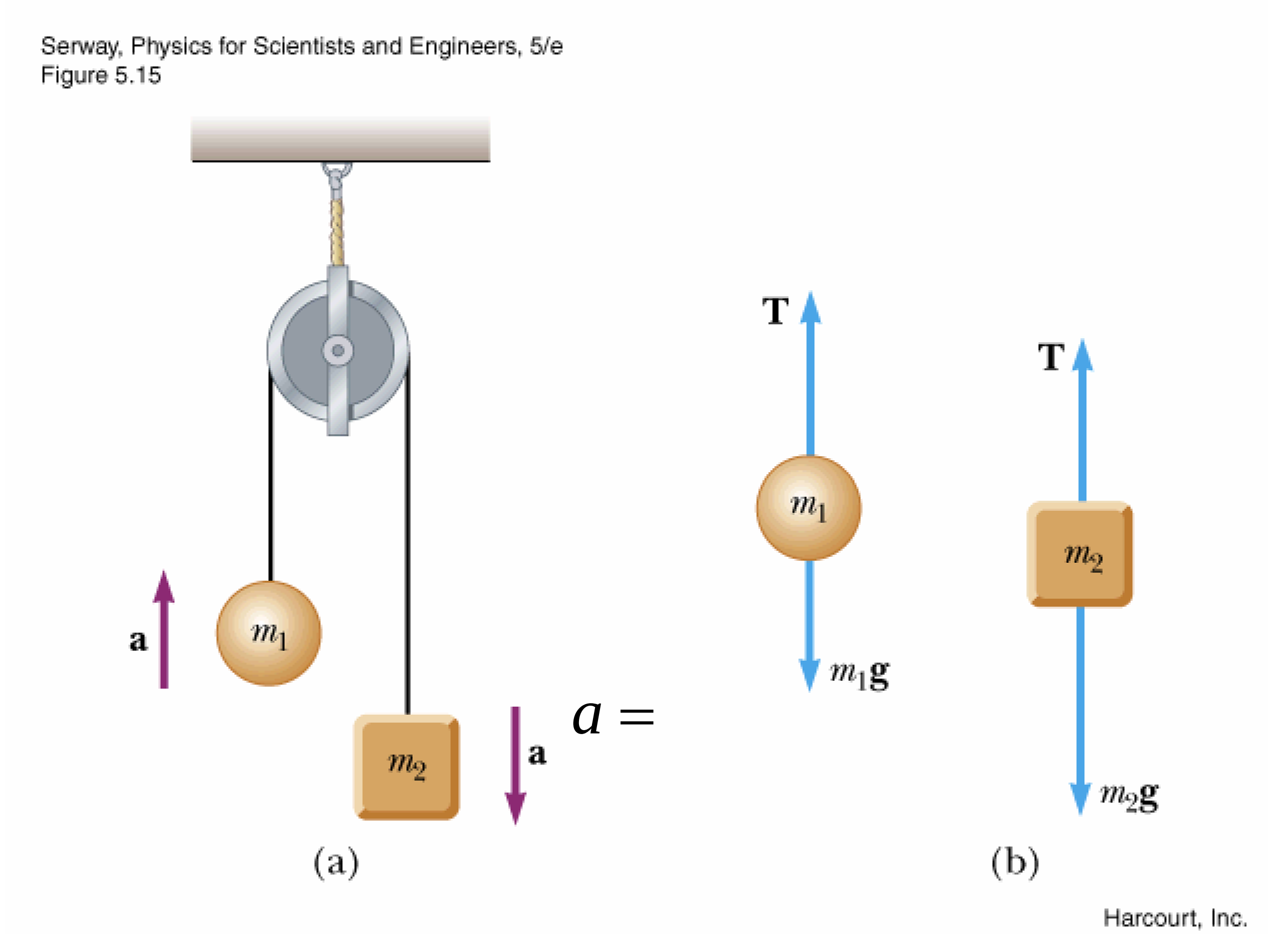
$$\mathbf{F}_{12} = - \mathbf{F}_{21}$$





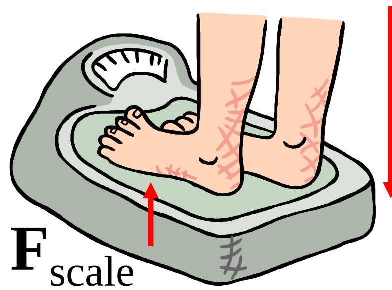
$T=m_1a$ $\qquad$ $a=F_P/(m_1+m_2)$

$F_P-T=m_2a$ $\qquad$ $T=F_P\,(m_1/(m_1+m_2))$



$T - m_1 g = m_1 a$ $\quad$ $T - m_2 g = -m_2 a$ $\quad$ => after some algebra:

$$a = \frac{m_2 - m_1}{m_2 + m_1} g \qquad T = \frac{2 m_1 m_2}{m_2 + m_1} g$$



$\mathbf{F}_{gravity} = -mg\ \mathbf{j}$

$\mathbf{F}_{scale}$

$$\mathbf{F}_{scale} + \mathbf{F}_{gravity} = \mathbf{0};\ F_{scale} = mg$$

Question: What if you step on the scale in the elevator?

$$\mathbf{F}_{scale} + \mathbf{F}_{gravity} = m\ \mathbf{a}; \quad F_{scale} = mg + m\ a$$

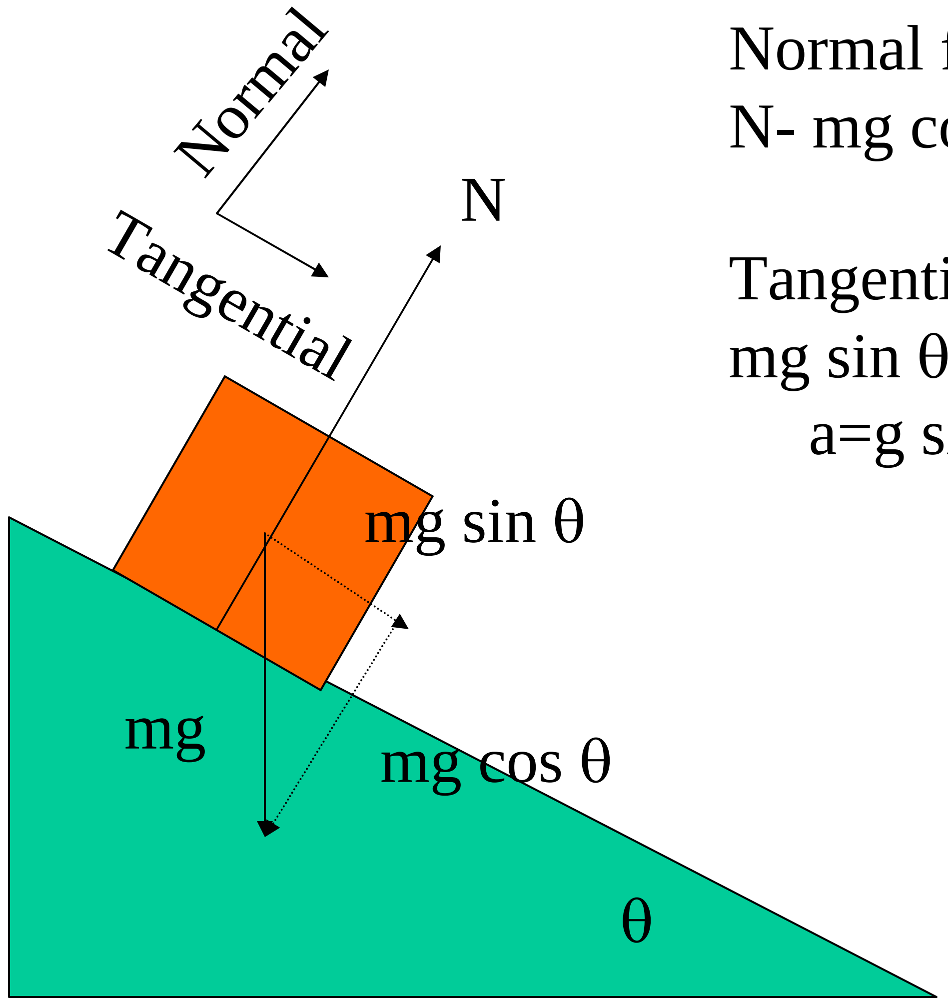
Exercise

For this exercise, you should ride the elevator from the first floor of Olin Physical Laboratory up to the second or third floor. While in the elevator, stand on the scale and record the scale readings to answer the following questions.

1. What is the scale reading when the elevator is stationary? x

2. What is the scale reading when the elevator just starts moving upward? >x

3. What is the scale reading when the elevator is coming to a stop just before your destination floor? <x



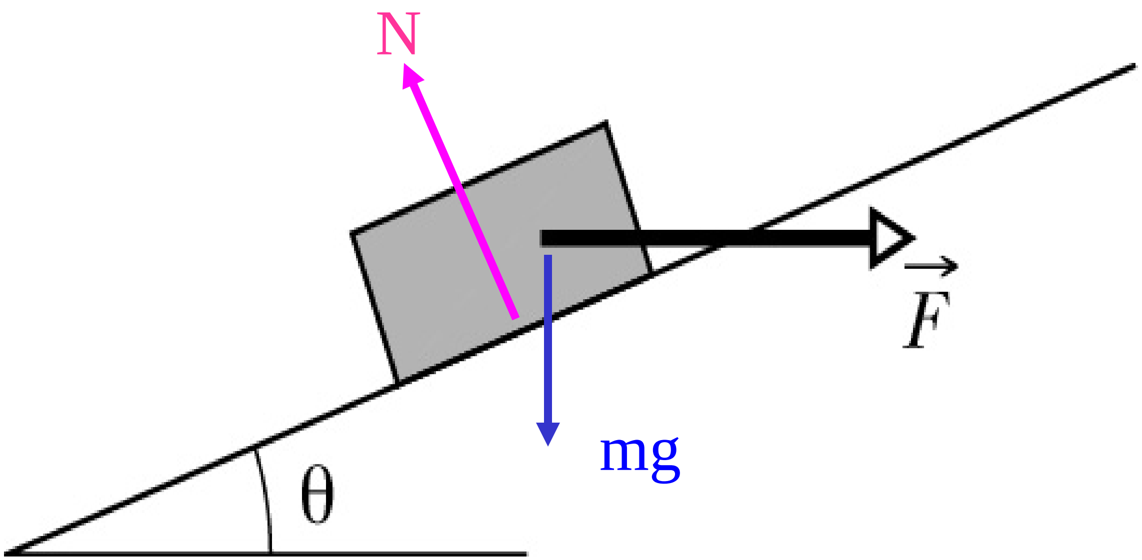
Normal forces:

$N - mg\cos\theta = 0$

Tangential forces:

$mg\sin\theta = ma$

$a = g\sin\theta$


N
$\vec{F}$
mg
θ