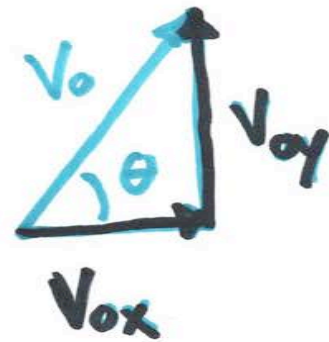
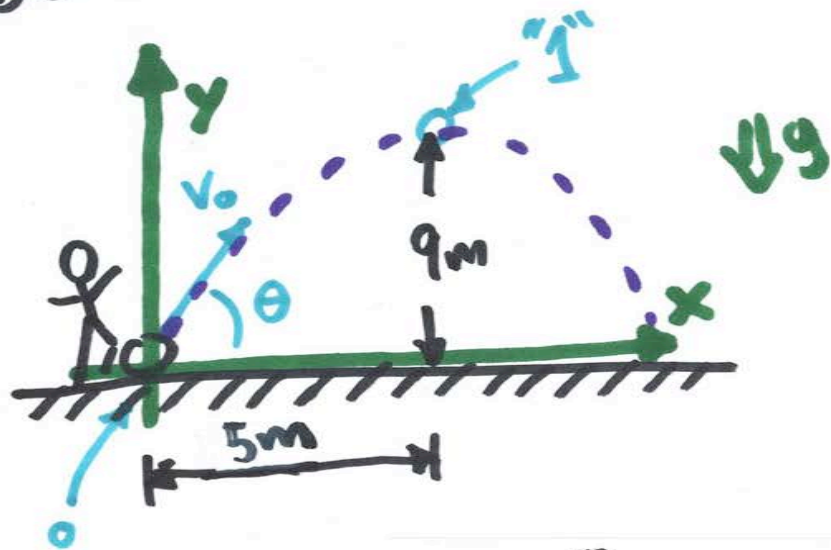


Determine initial velocity and angle of the kick?



$$v_{0x} = v_0 \cos \theta$$

$$v_{0y} = v_0 \sin \theta$$

x-dir

$$x = x_0 + v_{0x}t + \frac{1}{2}a_x t^2$$

$$\boxed{x_1 = v_0 \cos(\theta)t} \quad (1)$$

$$v_x^2 = v_{0x}^2 + 2a_x \Delta x$$

$$v_x^2 = v_{0x}^2$$

$$v_x = v_{0x} + a_x t$$

$$v_x = v_{0x} = v_0 \cos \theta$$

$$x_0 = 0 \quad y_0 = 0$$

$$x_1 = 5 \quad y_1 = 9$$

$$v_{0x} = v_0 \cos \theta \quad v_{0y} = v_0 \sin \theta$$

$$v_{1x} = v_0 \cos \theta \quad v_{1y} = 0$$

$$a_x = 0 \quad a_y = -9.81$$

$$t =$$

-y-dir

• $y = y_0 + v_{0y}t + \frac{1}{2}a_y t^2$

$$y_1 = v_0 \sin(\theta)t + \frac{1}{2}gt^2 \quad (2)$$

• $v_y^2 = v_{0y}^2 + 2a_y \Delta y$

$$0 = v_0^2 \sin^2 \theta + 2g(y_1 - 0)$$

$$0 = v_0^2 \sin^2 \theta + 2gy_1 \quad (3)$$

• $v_y = v_{0y} + a_y t$

$$0 = v_0 \sin \theta + gt \quad (4)$$

we have 4 eq's
we have 4 unknowns:

v_0, θ, t, t^2
non-linear

solve for $v_0 \sin \theta$ in (4)

$$v_0 \sin \theta = -gt$$

so $v_0^2 \sin^2 \theta = g^2 t^2 \quad (4a)$

sub (4a) into (3)

$$0 = [g^2 t^2] + 2g y_1$$

$$t = \pm \sqrt{-\frac{2y_1}{g}} = \pm \sqrt{-\frac{2(9)}{-9.81}}$$

$$t = 1.35 \text{ s}$$

solve for $v_0 \sin \theta$ in (4)

$$v_0 \sin \theta = -gt \quad (4b)$$

solve for $v_0 \cos \theta$ in (1)

$$v_0 \cos \theta = \frac{x_1}{t} \quad (1a)$$

divide (4b) by (1a)

$$\frac{v_0 \sin \theta}{v_0 \cos \theta} = \frac{-gt^2}{x_1}$$

$$\tan \theta = -\frac{gt^2}{x_1}$$

$$\theta = \tan^{-1} \left(-\frac{-9.81 \cdot t^2}{5} \right)$$

$$\theta = 74^\circ$$

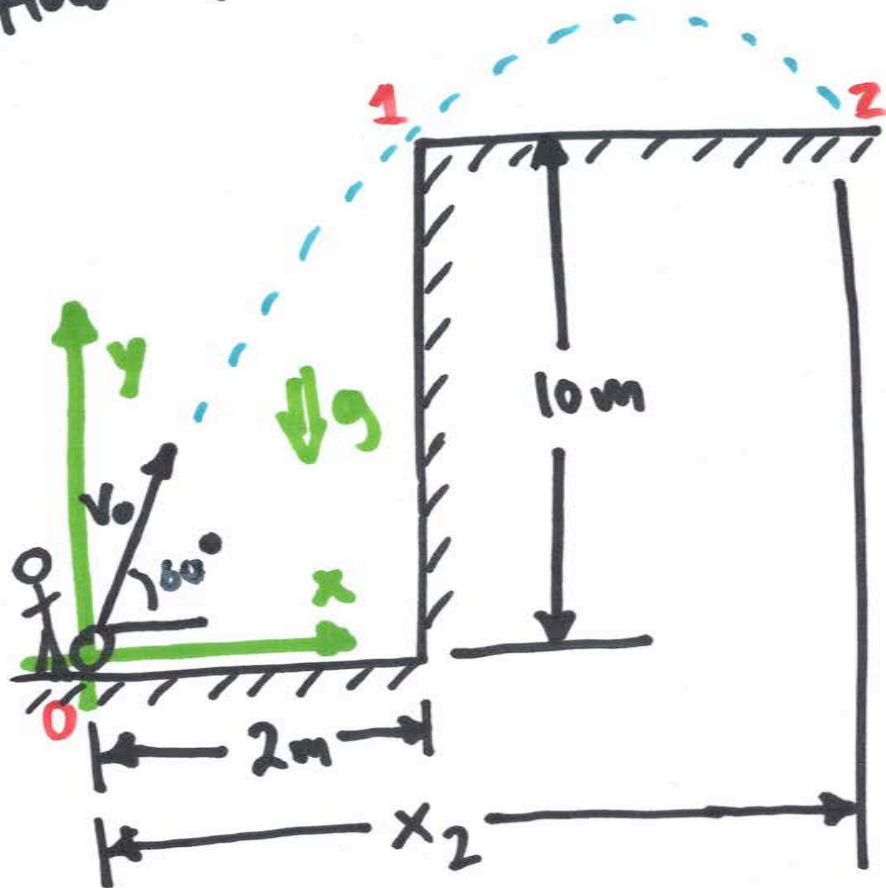
solve for V_0 in (1):

$$V_0 = \frac{x_1}{t \cos \theta}$$

$$V_0 = \frac{5}{(1.35) \cos(74)}$$

$$V_0 = 13.8 \text{ m/s}$$

How far does the ball go?



$$x_0 = 0$$

$$x_1 = 2$$

$$x_2 =$$

$$v_{0x} = v_0 \cos \theta$$

$$v_{1x} = v_0 \cos \theta$$

$$v_{2x} = v_0 \cos \theta$$

$$a_x = 0$$

$$y_0 = 0$$

$$y_1 = 10$$

$$y_2 = 10$$

$$v_{0y} = v_0 \sin \theta$$

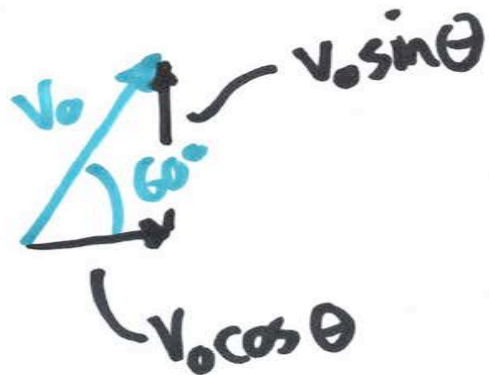
$$v_{1y} =$$

$$v_{2y} =$$

$$a_y = -9.81$$

$$t_1 =$$

$$t_2 =$$



Solve at pt 1

-y-dir

$$y_1 = y_0 + v_{0y}t_1 + \frac{1}{2}a_y t_1^2$$

$$\boxed{y_1 = \underline{v_0} \sin \theta \underline{t_1} + \frac{1}{2} a_y \underline{t_1}^2} \quad (1)$$

$$v_{1y}^2 = v_{0y}^2 + 2a_y(y_1 - y_0)$$

$$\boxed{\underline{v_{1y}}^2 = \underline{v_0}^2 \sin^2 \theta + 2a_y y_1} \quad (2)$$

$$v_{1y} = v_{0y} + a_y t_1$$

$$\boxed{\underline{v_{1y}} = \underline{v_0} \sin \theta + a_y \underline{t_1}} \quad (3)$$

unknowns:

$$\underline{v_0}, \underline{v_{1y}}, \underline{t_1}$$

solve for $v_0 \sin \theta$ in (3):

$$v_0 \sin \theta = v_{1y} - a_y t_1 \quad (3a)$$

sub (3a) into (1) & (2):

$$y_1 = [v_{1y} - a_y t_1] t_1 + \frac{1}{2} a_y t_1^2$$

$$y_1 = v_{1y} t_1 - a_y t_1^2 + \frac{1}{2} a_y t_1^2$$

$$\boxed{y_1 = \underline{v_{1y}} \underline{t_1} - \frac{1}{2} a_y \underline{t_1}^2} \quad (1a)$$

$$v_{1y}^2 = [v_{1y} - a_y t_1]^2 + 2a_y y_1$$

$$\cancel{v_{1y}^2} = \cancel{v_{1y}^2} - 2v_{1y}a_y t_1 + a_y^2 t_1^2 + 2a_y y_1$$

$$\frac{2v_{1y}a_y t_1}{2a_y} = \frac{a_y^2 t_1^2 + 2a_y y_1}{2a_y}$$

$$v_{1y} t_1 = \frac{1}{2} a_y t_1^2 + y_1$$

$$\boxed{y_1 = v_{1y} t_1 - \frac{1}{2} a_y t_1^2}$$

redundant
equation
of (1a).

back to
the
drawing
board.

x-dir

$$x_1 = \cancel{x_0} + v_{0x} t_1 + \cancel{\frac{1}{2} a_x t_1^2}$$

$$\boxed{x_1 = \underline{v_0} \cos \theta \underline{t_1}} \quad (4)$$

solve (4) for v_0 :

$$v_0 = \frac{x_1}{t_1 \cos \theta} \quad (4a)$$

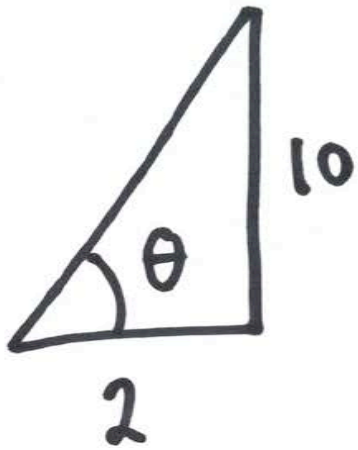
sub (4a) into (1):

$$y_1 = \left[\frac{x_1}{\cancel{t_1} \cos \theta} \right] \sin \theta \cancel{t_1} + \frac{1}{2} a_y t_1^2$$

$$y_1 = x_1 \tan \theta + \frac{1}{2} a_y t_1^2$$

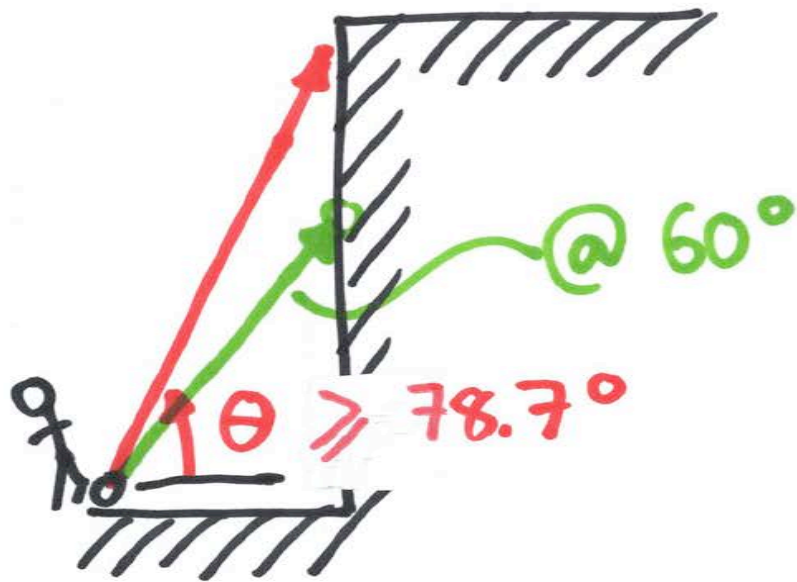
$$a_y t_1^2 = 2(y_1 - x_1 \tan \theta)$$

$$t_1 = \pm \sqrt{\frac{2(y_1 - x_1 \tan \theta)}{a_y}}$$
$$= \pm \sqrt{\frac{2(10 - 2 \tan 60)}{-9.81}}$$



$$\theta = \tan^{-1}\left(\frac{10}{2}\right)$$

$$\theta = 78.7^\circ$$



must be -ive

$$\sqrt{\frac{2(10 - 2 \tan \theta)}{-9.81}}$$

Dynamics

Branch of physics which deals with Forces.

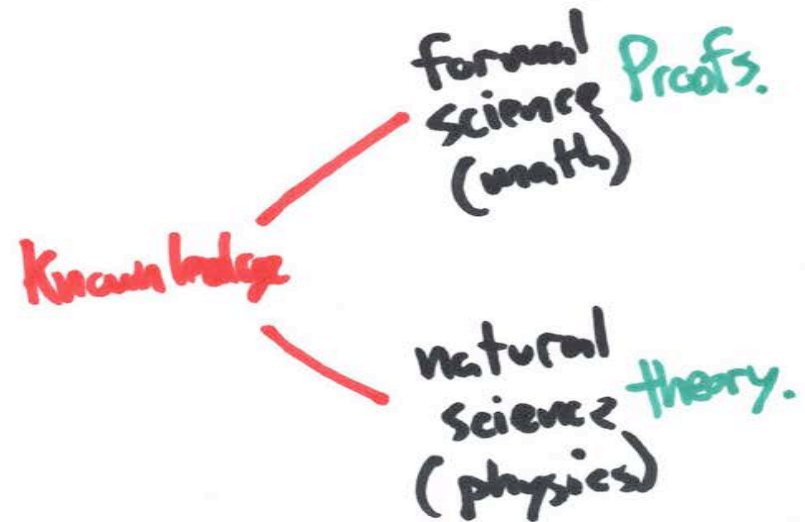
What is a force?

An interaction that when unopposed will change the motion of an object. (accelerate)

- There is no derivation of forces

- The whole branch of physics is a theory!

- Kinematics is a branch of mathematics



4 Fundamental forces:

Gravitational



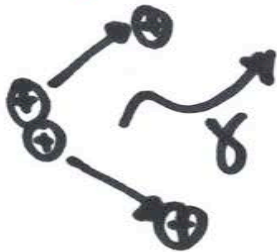
Electromagnetic



Strong nuclear



Weak nuclear



units:

$[N] = \text{Newton}$

Categories



force (energy) $[\Delta S_{\text{univ}} > 0]$

conservative
chem. bond
electromagnetic
→ normal
→ tension
gravity

non-conservative
friction
↳ air resistance

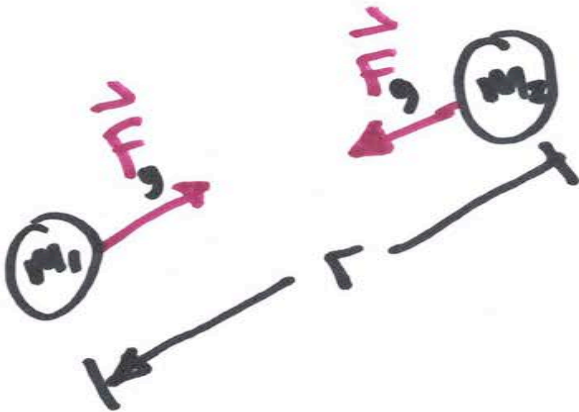
force (particle).

contact
electromagnetic
friction
air resistance

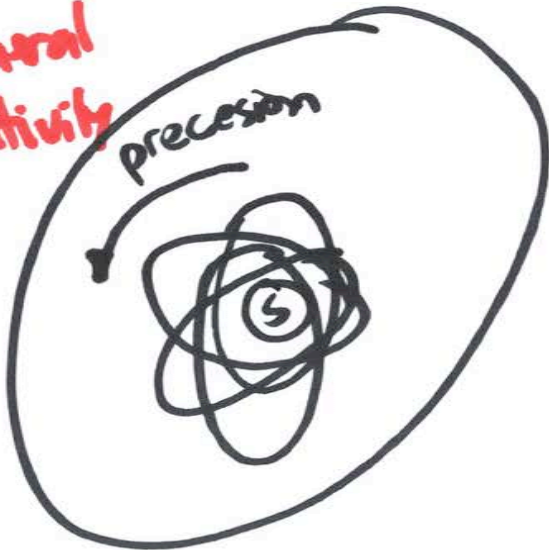
non-contact
chem. bond.
gravity

Gravitational Force

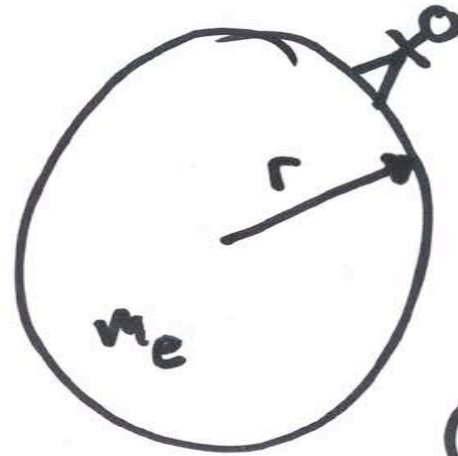
$$\vec{F}_g = G \frac{m_1 m_2}{r^2}$$



general
relativity



acceleration
on earth.



$$r = 6370 \text{ km}$$

$$m = 5.98 \times 10^{24} \text{ kg}$$

$$G = 6.67 \times 10^{-11}$$

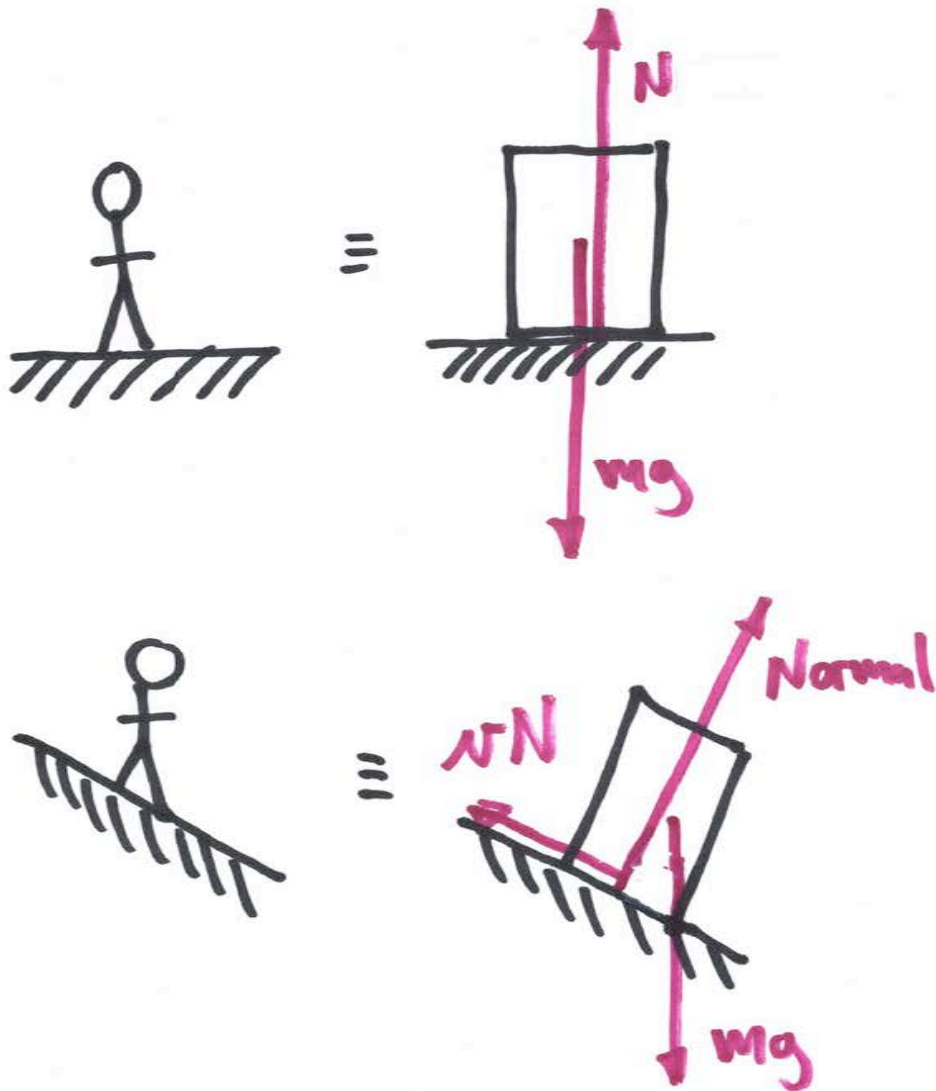
$$\vec{F}_g = \left(\frac{G m_e}{r^2} \right) m$$

$$\vec{F}_g = \left(\frac{6.67 \times 10^{-11} \cdot 5.98 \times 10^{24}}{(6370000)^2} \right) m$$

$$\vec{F}_g = (9.8) m = m g$$

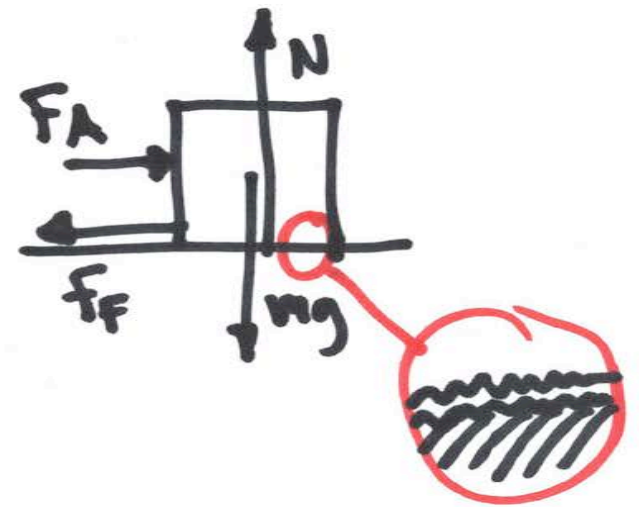
"g"

Normal Force

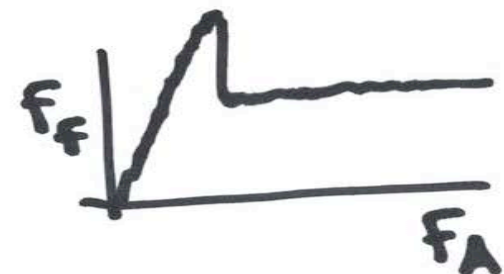


Friction Force

$$F_f = \mu N$$



Static Kinetic
 μ_s μ_k



Summary of Forces

Gravity: $\vec{F} = G \frac{m_1 m_2}{r^2}$

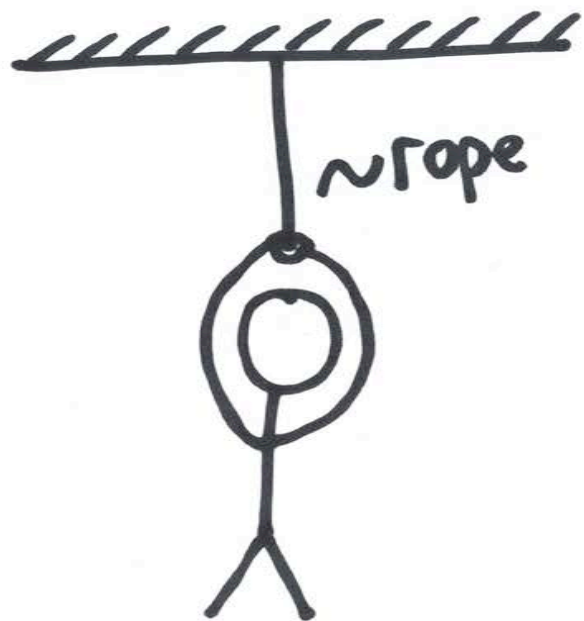
$\vec{F} = \vec{W} = m\vec{g}$ (on earth's surface)

Spring: $\vec{F} = -k \cdot \Delta\vec{x}$

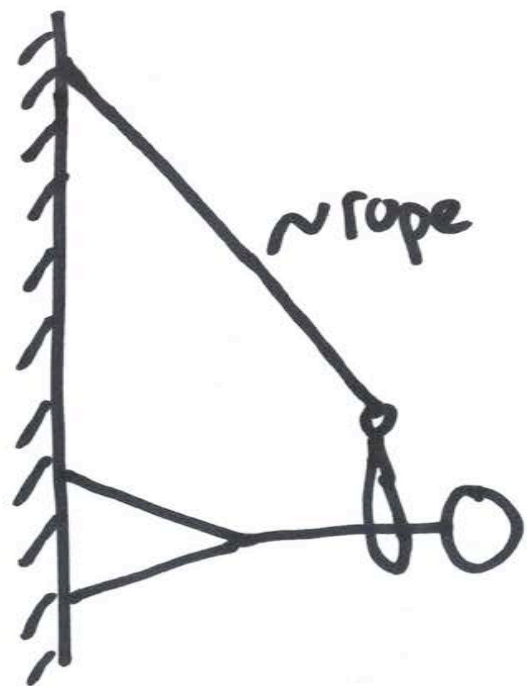
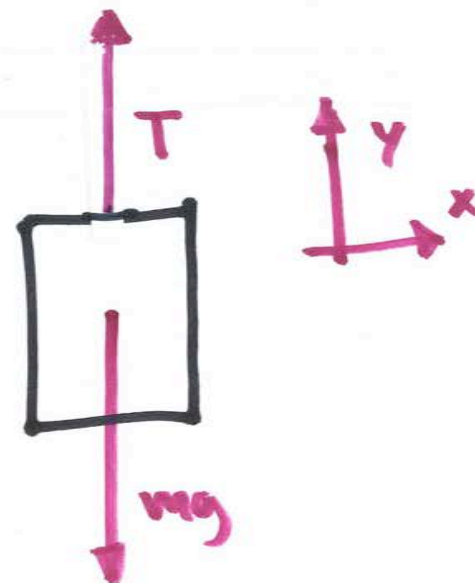
Friction: $\vec{F}_f = \mu N$ (μ_s or μ_k)

Normal: $\vec{N}$

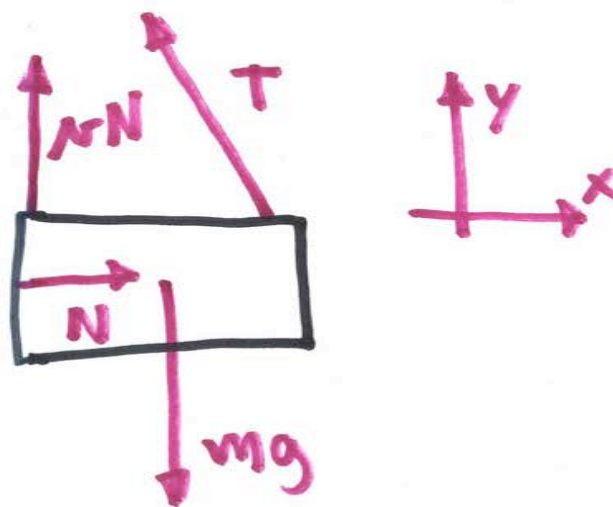
Applied: $\vec{F}_A, \vec{T}$
 / /
 pushing pulling

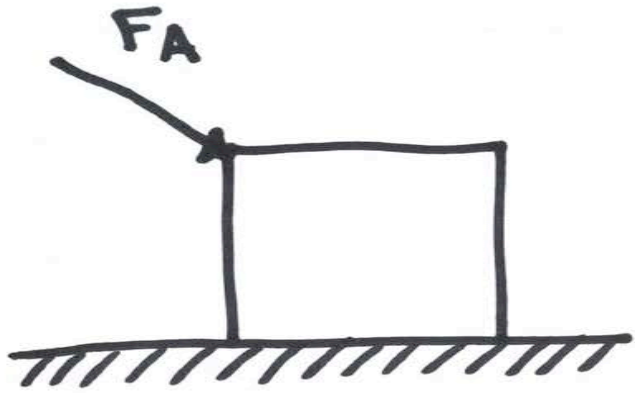


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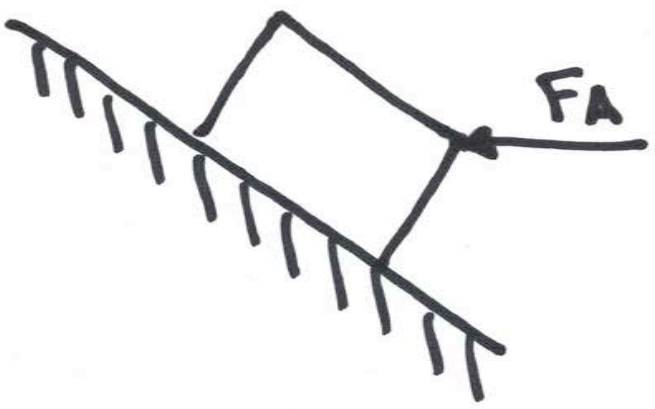
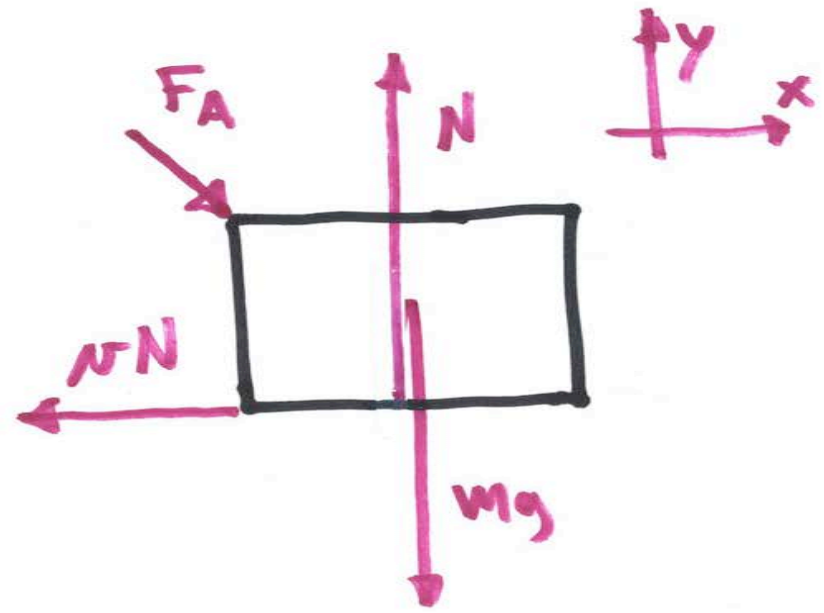


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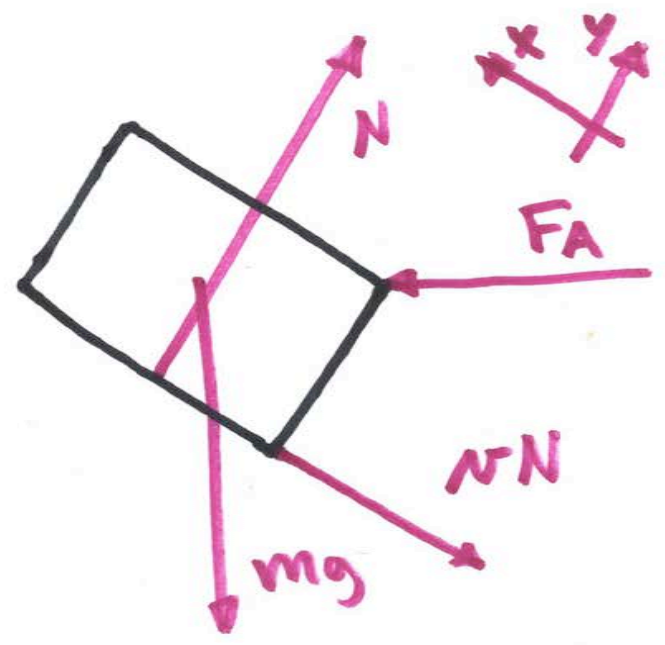


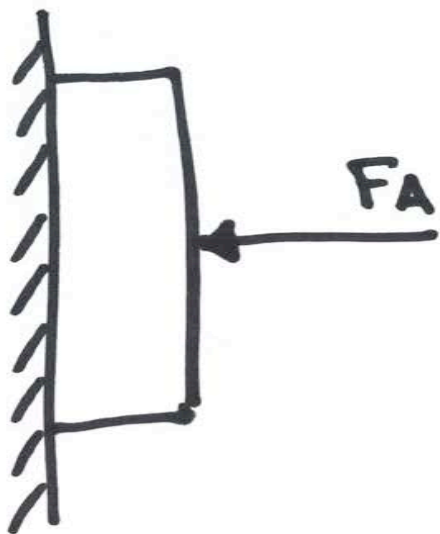


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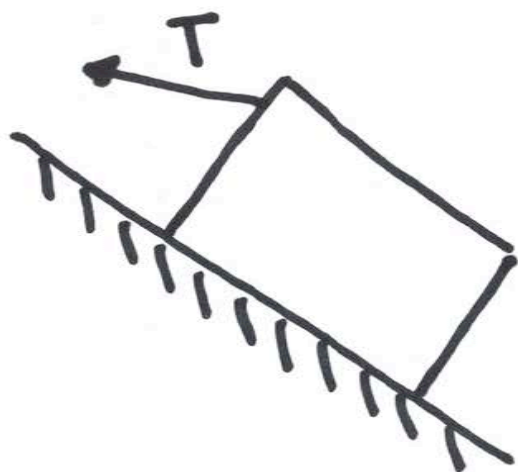
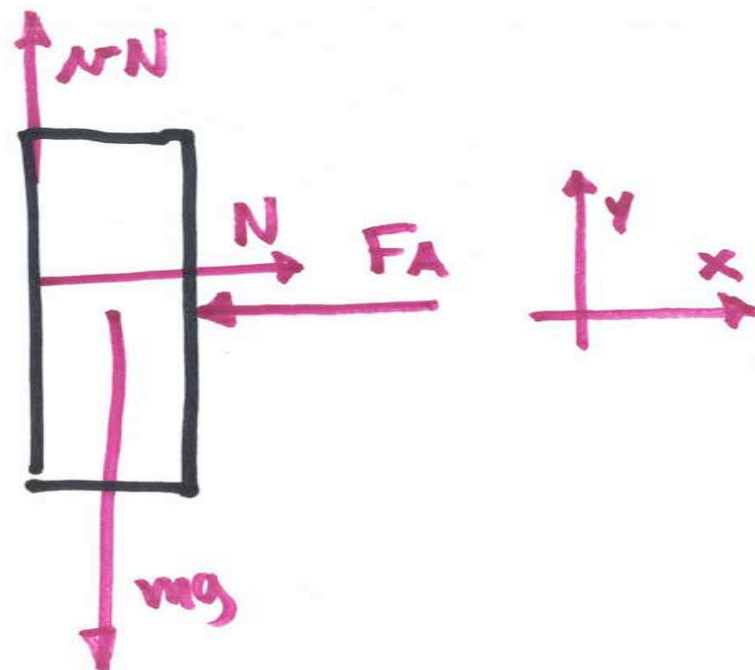


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