# Everyday Forces

has direction

The gravitational force ($F_g$) exerted on the ball by Earth is a vector directed toward the center of the earth.

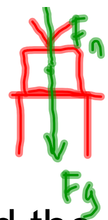
The magnitude of this force is a scalar quantity called **weight**.

no direction

On Earth's surface (sea level), acceleration due to gravity ($a_g$) = g and the force due to gravity ($F_g$) = mg

Objects at higher altitudes weigh less than objects at sea level because the value of g decreases as distance from Earth's surface increases

Weight - a measure of the gravitational force exerted on an object



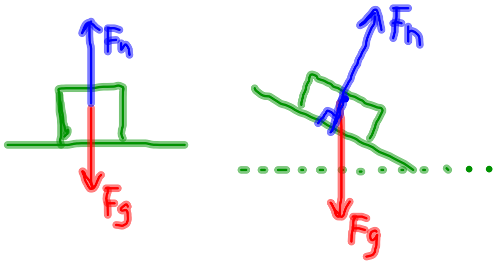

# Normal Force

How come objects at rest do not continue to fall toward the center of the Earth?

We know that $F_g$ is acting downward, however the forces acting on the object must be at equilibrium. Therefore, there must be another force equal in magnitude to force $F_g$ but in the opposite direction.

This is the force exerted on the object by the ground/table and is called **normal force**, $F_n$.

Normal Force: a force that acts on a surface in a direction perpendicular to the surface




$F_n$, will always be perpendicular to the surface, but is not always opposite in direction to the force due to gravity

ie: object on flat table vs. object on slanted table

# Force of Friction

Static friction: the force that resists the initiation of sliding motion between two surfaces that are in contact and at rest

Abbreviated, $F_s$

As long as an object does not move, the force of static friction is always equal to and opposite in direction to the component of the applied force that is parallel to the surface

$$F_s = -F_{applied}$$

As applied forces increase, the force of static friction also increases, and vice versa.

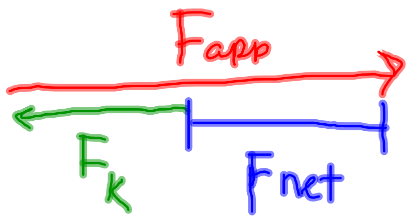
When applied force is as great as it can be without causing the object to move, the force of static friction reaches its maximum value, $F_{s,max}$.

Kinetic friction: the force that opposes the movement of two surfaces that are in contact and are sliding over each other

When applied force exceeds frictional force, the object accelerates. Frictional force is still acting on the object but is less than $F_{s,max}$. The frictional force of an object in motion is called **kinetic friction**.

The magnitude of the net force acting on the object is equal to the difference between applied force and the force of kinetic friction.

$$F_{net} = F_{applied} - F_k$$



## Coefficient of Friction

The ratio of the magnitude of the force of friction between two objects in contact to the magnitude of the normal force with the objects press against each other.

Ratio of the force of friction to the normal force between 2 surfaces.

$$\mu_k = \frac{F_k}{F_n}$$ Coefficient of KINETIC friction

$$\mu_s = \frac{F_{s,max}}{F_n}$$ Coefficient of STATIC friction

$$F_f = \mu F_n$$ Calculating the magnitude of the force of friction

$$\rightarrow F_k = \mu_k F_N$$

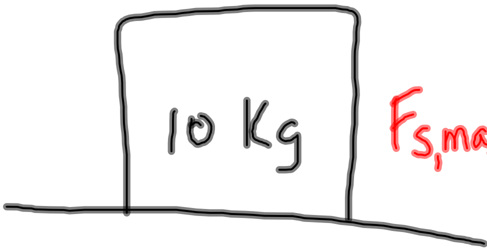
$$\rightarrow F_{s,max} = \mu_s F_N$$

The coefficient of friction (static or kinetic) is **a measure of how difficult it is to slide a material of one kind over another**; the coefficient of friction applies to a pair of materials, and not simply to one object by itself.

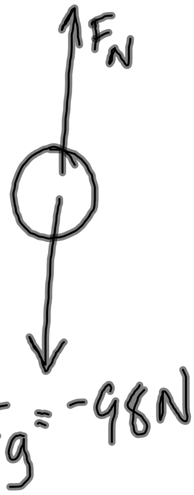
An object with a coefficient of friction of zero would essentially have no friction at all. Therefore, the closer a coefficient is to 1, the more friction there is between the 2 surfaces.

Ex:

Find $F_{s,max}$:




$F_{s,max} = \mu_s F_N$




$\mu_s = 0.6$

$\mu_k = 0.5$

$F_N = +98N$

$F_{s,max} = (0.6)(98)$

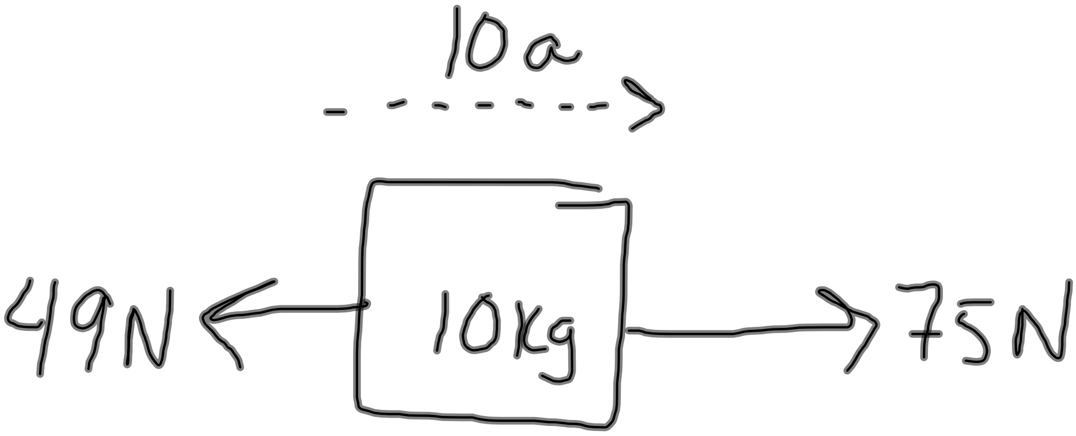
$F_{s,max} = 58.8N$

b) Find $F_k$:

$F_k = \mu_k F_N$

$= (.5)(98) = 49N = F_k$

c) If 75 N right are applied, what is the accel?




$$10a = 75 - 49$$

$$10a = 26$$

$$a = 2.6\ m/s^2$$

$F_{s,max} = 75 N$

$F_{applied} = 75 N$

$m = 24 kg$

$\mu_s = ?$

$$\mu_s = \frac{F_{s,max}}{F_n}$$

# Overcoming Friction

A student attaches a rope to a 20.0 kg box of books. He pulls with a force of 90.0 N at an angle of 30 degrees to the horizontal. The coefficient of kinetic friction between the box and the sidewalk is 0.5. Find the acceleration of the box.

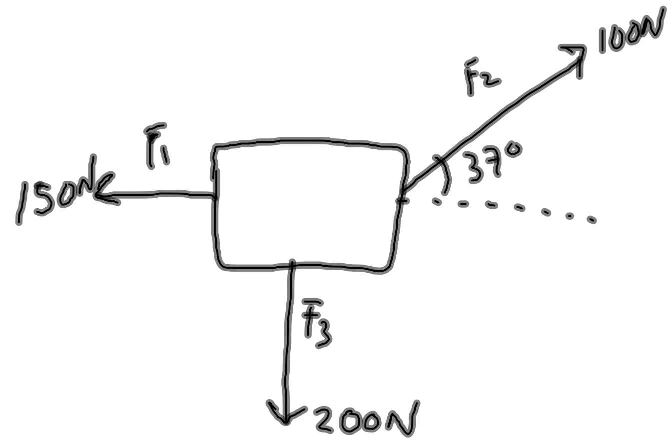
1) Select BEST x and y axis

2) Resolve all forces into x and y components

3) Solve for $F_n$ (assume that $F_{y,total} = 0$)

4) Use $F_n$ to solve for $F_k$

5) Use F=ma to find accel.




a) Determine components for each force

$F_1 = (-150N, 0)$ $F_3 = (0, -200)$

$F_2 = (79.9N, 60.2N)$

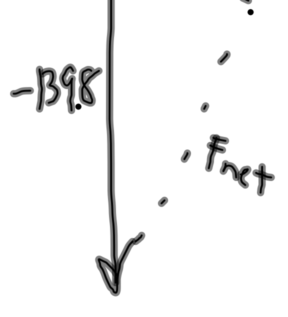
b) $F_{x\,total} = -150N + 79.9N + 0$

$= -70.1N$

$F_{y\,total} = 0 + 60.2N + -200N$

$= -139.8N$

c)



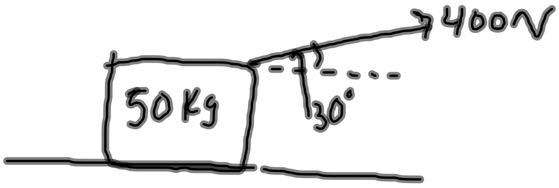

$F_{net} = \sqrt{(-70.1)^2 + (-139.8)^2}$

$= 327.4N$

$\theta = \tan^{-1}\left(\frac{139.8}{70.1}\right) = 63.4°$ SW

Ex. 2:

A 50 kg block on a horizontal surface is pulled with a force of magnitude 400 N at an angle of 30°. The coefficient of kinetic friction between the block and the surface is $\mu_k = 0.3$




a) Draw a free body diagram representing all forces acting on the block

b) Determine the contact force between the block and the surface

$F_N = 290.5 N$

c) Determine the force of friction between the block and the surface

$F_K = 87.15 N$

d) Determine the acceleration of the block.

$a = 5.2 m/s^2$

Ex. 3:

A student moves a box of puppies up a ramp inclined at $12^o$ with the horizontal. If the box weighs 35 kg, starts from rest at the bottom of the ramp, and is pulled at an angle of $25^o$ with respect to the incline and with a force of 185 N, what is the acceleration up the ramp? Assume that $\mu_k = 0.27$


1) Resolve $F_g$
2) Resolve $F_{app}$
3) Find $F_{net}$
4) Find $F_k$
5) Find $a$