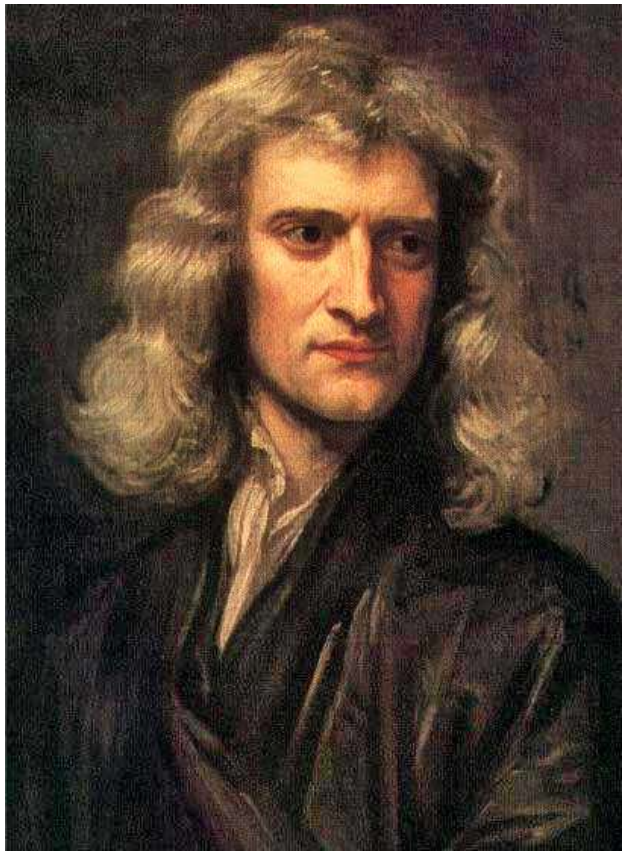
FORCES

Newton's Three Laws of Motion

1. An object at rest tends to stay at rest and an object in motion tends to stay in motion unless acted on by an outside force. This is due to an object's *inertia*.

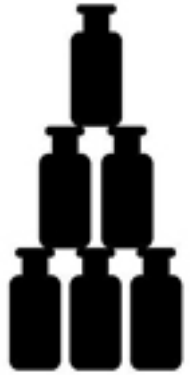
2. The relationship between an object's mass *m*, its acceleration *a*, and the forces *F* acting on it is $\Sigma F=ma$, where F is measured in a unit called "Newtons."
   - Σ: ??

3. For every action there is an equal and opposite reaction.



Newton's Three Laws of Motion Demos

For each demonstration, determine which of Newton's Three Laws can be used to describe the phenomenon.



Newton’s Three Incorrect Laws of Motion

https://www.youtube.com/watch?v=Yf0BN0kq7OU

Explain each phenomena using one or more of Newton's Three Laws:

1. When a convertible gets in an accident with an 18 wheeler, why does the convertible get so much more damaged?

2. Why don't school buses have seat belts?

3. The inner parts of your ear are filled with fluids that are essential to developing a sense of balance. The fluids, when moved, push tiny hairs in your ear that signal to the brain that the body is in motion. After spinning around a lot and stopping, why do you still feel like you are spinning?

Contact vs. Non-Contact Forces

Contact forces have to be in contact with an object to cause an acceleration.

Non-contact forces create a “field” and can cause acceleration even when not in contact.

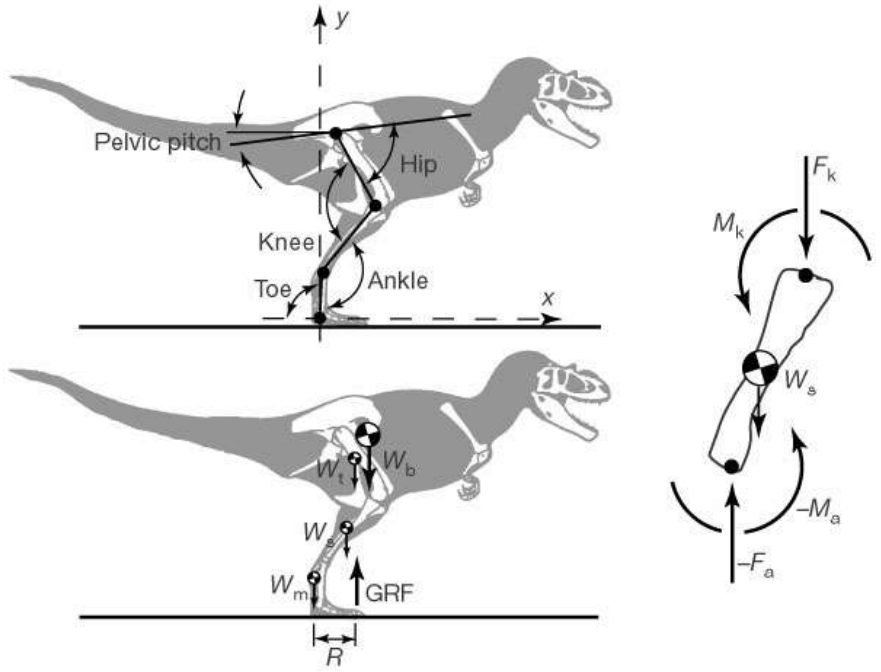
Contact Forces	Non-contact forces
Applied force Friction force Normal force Tension Spring force Centripetal force	Gravitational force (weight) Electrostatic force

Freebody Diagram

A force is a vector, so it has magnitude and direction.

A freebody diagram is a diagram of force vectors acting on an object. NOTHING ELSE.

Ask yourself: What is touching the object? Is there a gravitational field or an electrostatic field?

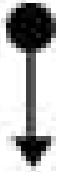


An egg is free-falling from a nest in a tree. Neglect air resistance.

A softball is tossed upwards into the air. Neglect air resistance. The ball has already left the hand

A

B



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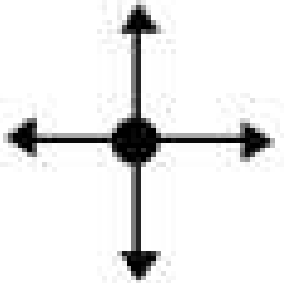
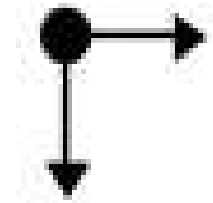


A softball is tossed from the pitcher's mound to home plate. Neglect air resistance. The ball has already left the hand.

A



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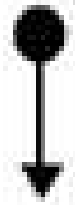

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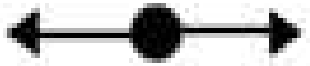

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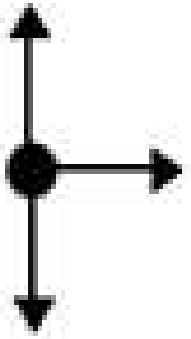


Newton's Second Law: Equilibrium vs. Not in Equilibrium

Not in equilibrium: $\Sigma F = ma$

An object is not in equilibrium when the net forces on the object create an acceleration. The forces are not balanced.

Equilibrium: $\Sigma F = 0$

An object is in equilibrium when there are no net forces acting on the object. The object is not accelerating (a=0)

Does this necessarily mean there are no forces acting on it?

Does this necessarily mean that it is not moving?

Steps to take to solve a problem dealing with forces:

1. Draw a freebody diagram (FBD).
   - Ask yourself: What is touching the object? Is there a gravitational field or an electrostatic field?

2. Write your net force equation ($\Sigma F = ma$) in the x- and in the y-directions.

3. Determine if your object is in equilibrium or not. Adjust your net force equation accordingly.

4. Solve!

Scenario #1: An apple falling from a tree

Gravitational force (F_g): when a massive object is attracted to another massive object. Also known as weight.

- Equation: $F_g = mg$, where $g = 9.8\ m/s^2$
- Why is g not negative?
- What is the force of the apple pulling on the earth?
- Net force equation:

Scenario #2: An apple sitting on a desk

Normal force, (F_N): When an object is resting on a surface, the surface pushes back up. It is like a supporting force.

- An effect of Newton's 3rd law

- Net force equation:

Scenario #3: An apple hanging on a rope

Tension (F_T): when a push or pull is transmitted through a rope. A rope can only have the same tension throughout the entire rope.

Net force equation:

Scenario #4: I push an apple resting on a table

Applied force (F_a): a direct push or pull from an outside source.

Net force equationSSS:

Scenario #5: I push an apple at an angle of 45°

Net force equations:

Problem

Two forces act on a 55 kg block. The magnitudes are F1=79 N and F2= -41 N. What is the horizontal acceleration of the block?

Problem

In a grocery store, you push a 14.5-kg cart with a force of 12.0 N. If the cart starts at rest, how far does it move in 3.00 seconds?

Friction

WE'RE TURNING THE FRICTION SWITCH ON!

Friction Lab

What do you think affects friction? How can we increase friction?

Friction Post-Lab

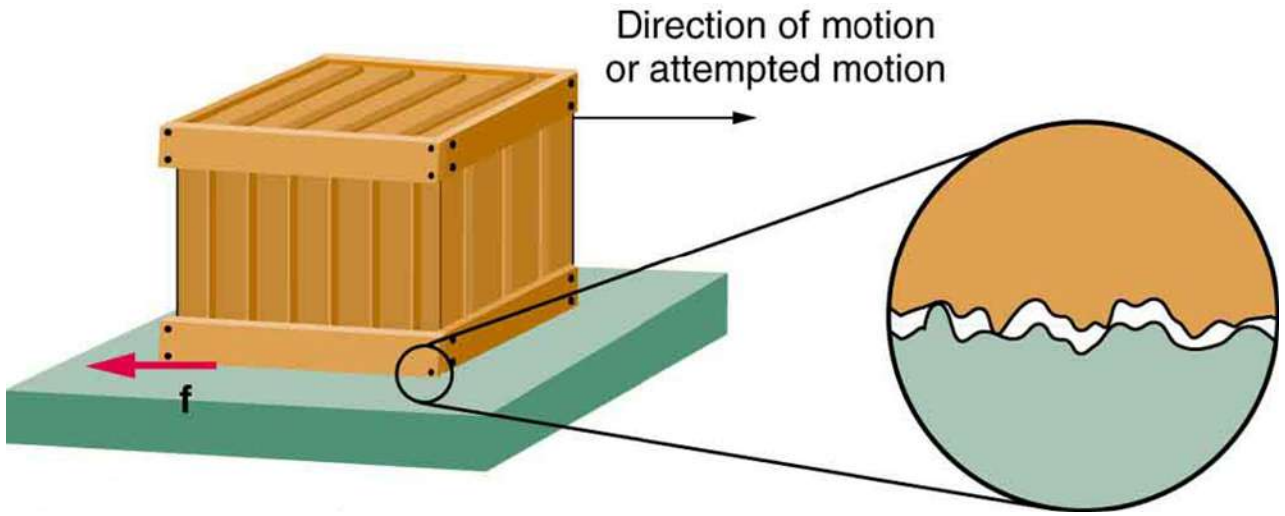
What were the things that affected friction?

Friction: What causes it?

Friction: A force present whenever an object moves or attempts to move that opposes motion.

- Affected by:
  - Material of surfaces
  - Normal Force

Recent debates and developments on friction: Is it caused by rough surfaces or electromagnetic bonding?



Two Types of Friction

1. Static Friction: Static friction is present when the object is not moving. This is the minimum force needed to overcome a threshold to begin motion.
2. Kinetic Friction: Kinetic friction occurs when objects are in motion. It is always less than static friction.

What examples of static and kinetic friction did we see in the lab?

Formulas

STATIC FRICTION

$$F_s = \mu_s F_N$$

F_s = static friction

μ_s = coefficient of static friction

F_N = normal force

KINETIC FRICTION

$$F_k = \mu_k F_N$$

F_k = kinetic friction

μ_k = coefficient of kinetic friction

F_N = normal force

Problem

Kendall Cunnings is pushing a refrigerator box that has a mass of 135 kg. If the coefficient of static friction is 0.47, what minimum force does he need to move the box?

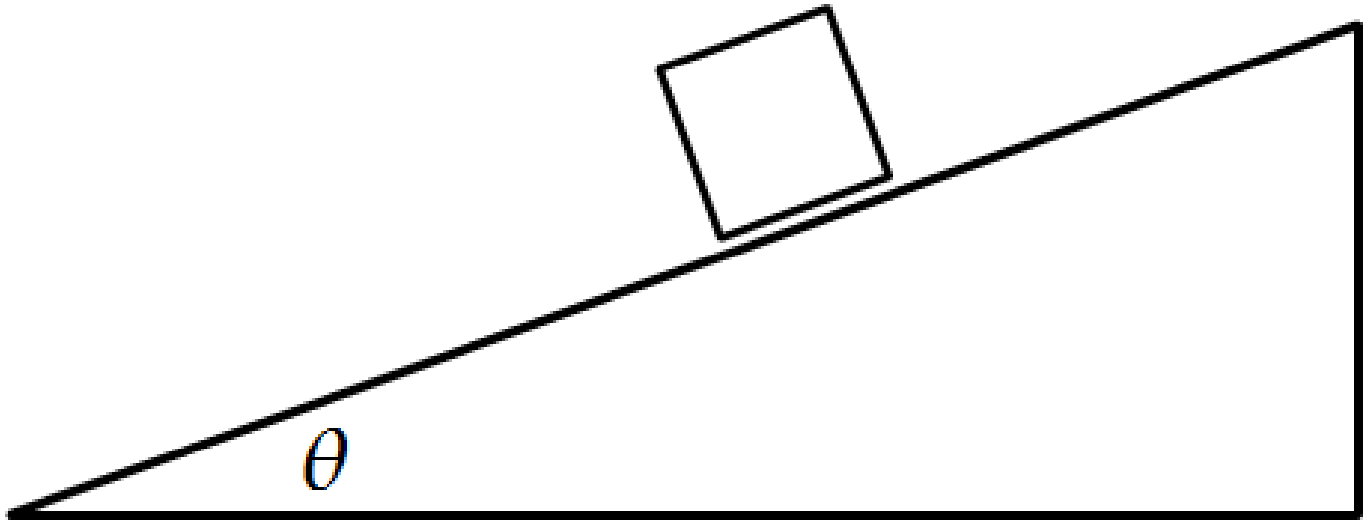
Problem, Part II

If the coefficient of kinetic friction is 0.35 N and Kendall continues the same force from before, what is the acceleration of the box?

Inclined Planes

Discussion: Why do ramps make our lives easier? Why is it easier to roll something up a ramp than it is to lift it directly upwards? Chris larson

Inclined Planes: The FBD



Which component of gravity goes along the plane?

Which component of gravity goes into the plane?

Which component of gravity causes us to go down the ramp?

Big Bang Theory Clip (Thank you, Riya!)

https://www.youtube.com/watch?v=9HsuKvNhGcc

Problem

Chance Chatman slides down a frictionless slide. The slide is inclined at 25 degrees and Chance has a mass of 60 kg. What is Chance's acceleration down the slide?

How fast is Chance going at the bottom of the slide if it's 10 meters long?

Problem for Chris

Chris Larson is pushing a boulder up a hill. If the hill is inclined at 14 degrees and the boulder has a mass of 100 kg, how much force does Chris need to exert on the boulder so that it doesn't roll down the hill?