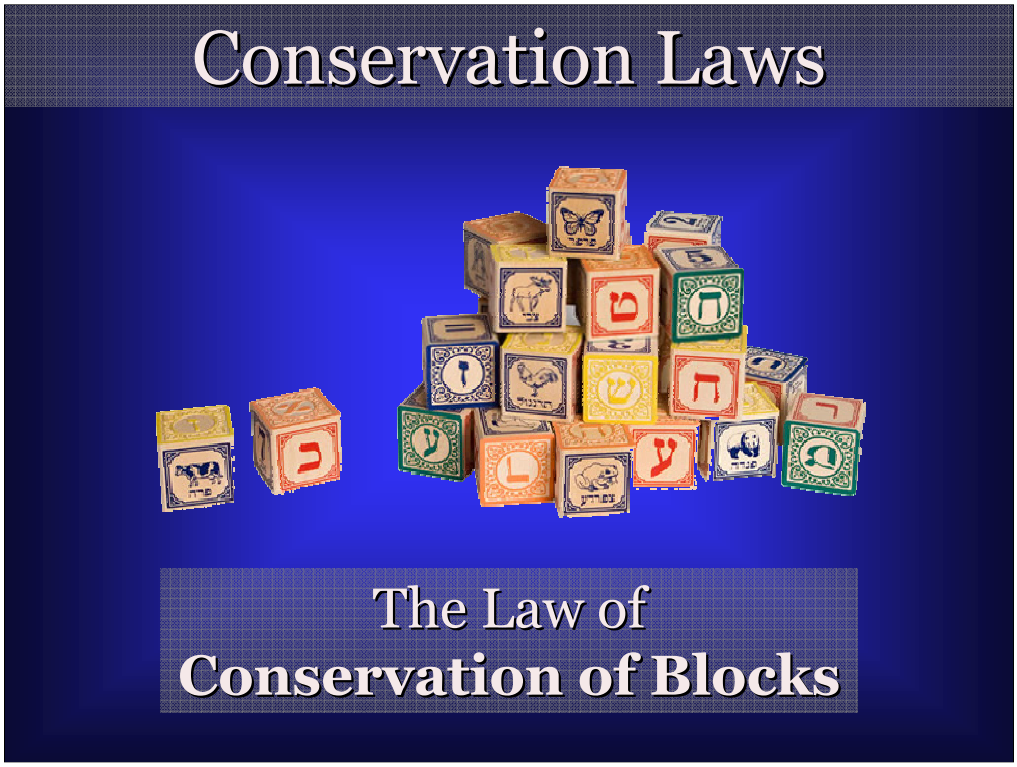
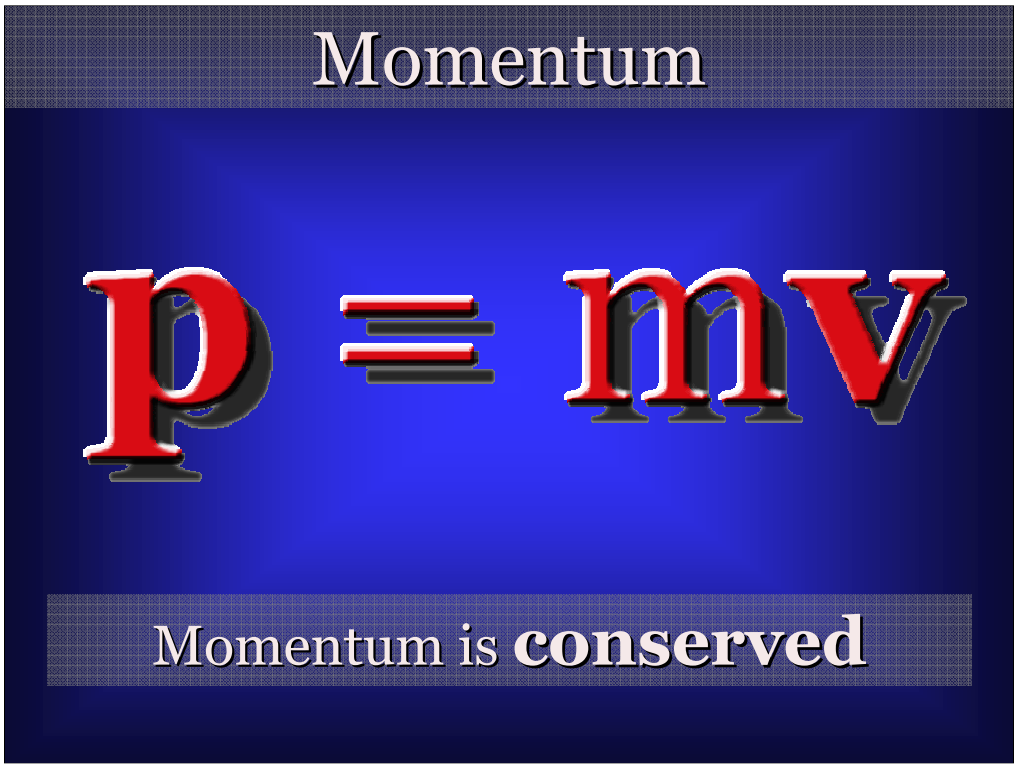


We buy it in the form of electricity and gas

We gather it when we eat food and expend it when we do things.



Our first conservation law.

In a closed system MOMENTUM IS ALWAYS CONSERVED.
This includes situations where the gravitational force is involved.
It also includes situations where energy is transferred such as:

Friction robs kinetic energy
and explosion occurs (potential energy transfers into kinetic energy)

Rockets Conserve Momentum

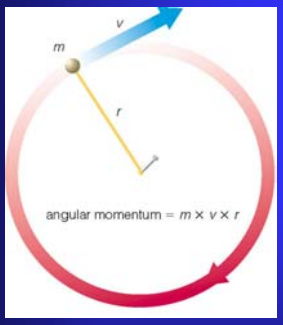
In the rocket, an EXPLOSION occurs that propels exhaust out the back of the rocket and propels the rocket forward.

The system conserves momentum.

If the rocket fuel system has zero momentum initially, the momentum of the rocket plus the momentum of the exhaust will be zero afterward.

Angular Momentum

$$l = mvr$$



Also conserved...

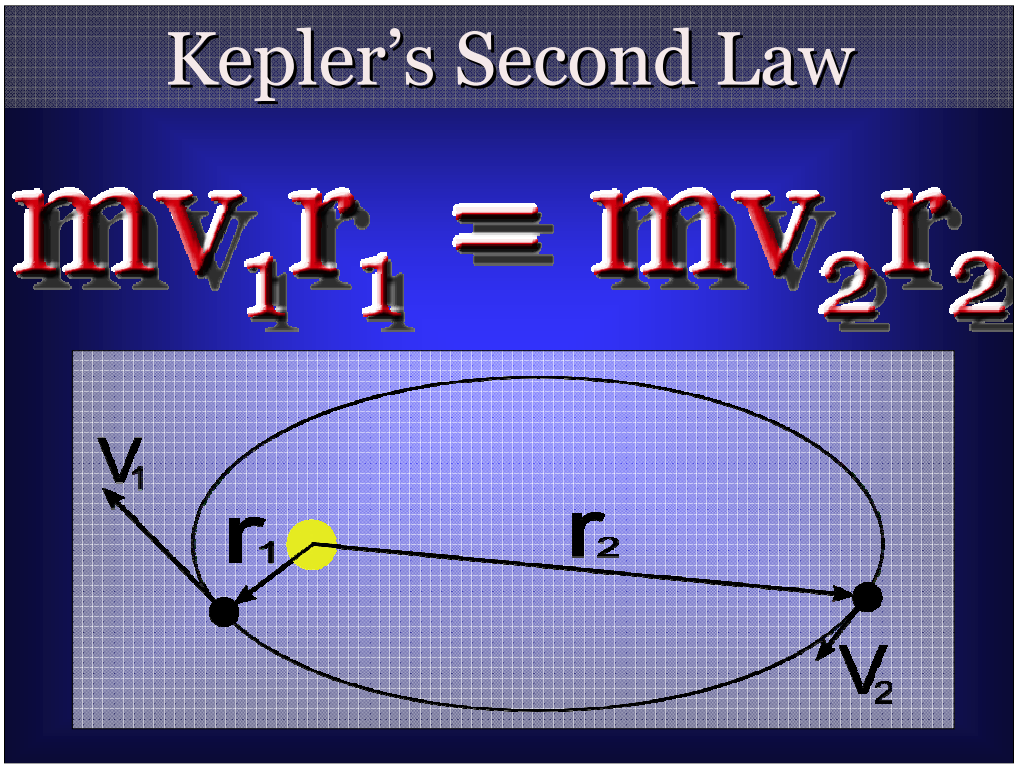
Closed systems also conserve ANGULAR momentum.

Angular momentum takes into account the distance of the massive object from a pivot point.

The skater spins faster when her arms are tucked in.

Initially, r is large (her arms are far from her body) and v is small.

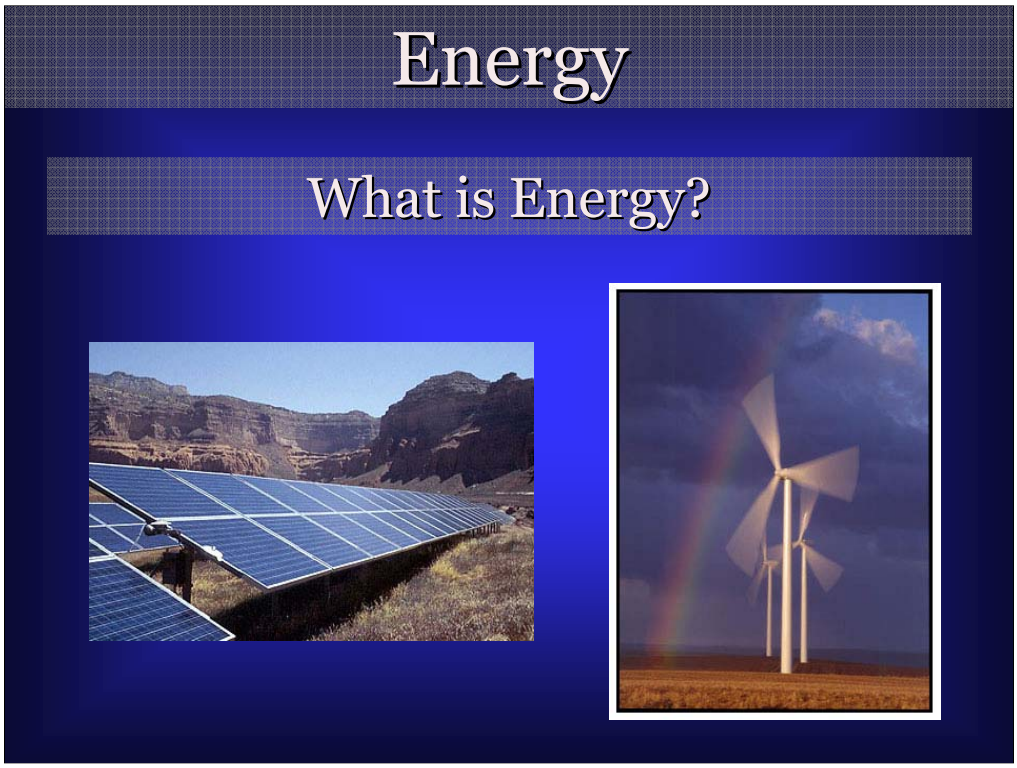
Later, r is small (her arms are close to her body) and v is big.



Kepler's second law is a restatement of the conservation of angular momentum.

At perihelion, r is small and v is large.
At aphelion, r is large and v is small.

r times v NEVER changes for planets in orbit.



We buy it in the form of electricity and gas

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Types of Energy

Kinetic
- Motion
- Heat

Potential
- Gravitational
- Chemical
- Springs/Rubber Bands

Radiative
- Light

All of the energy forms that you can think of fit into one of these three types.

Kinetic Energy

$$K = \frac{1}{2} mv^2$$

Kinetic energy depends on

mass

A truck moving at 10 miles an hour has more energy than a bb at moving at 10 miles per hour

And the SQUARE of the velocity.

You can see this empirically (as we do in the Impact lab), or through the definition of energy (work).

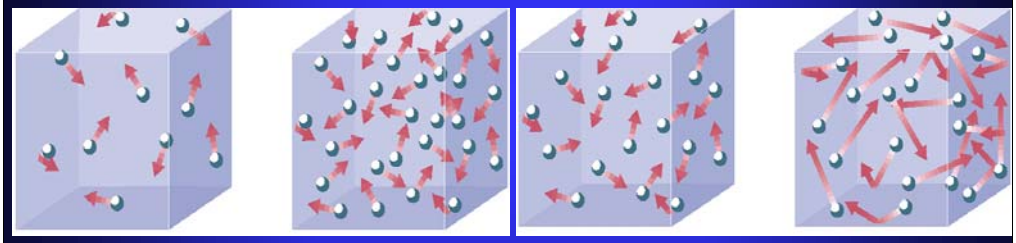
So… 2 times the velocity is 4 times the energy

4 times the velocity is 16 times the energy

Fast moving asteroids carry ENORMOUS kinetic energy.

Thermal Energy

Heat: The **total** kinetic energy of a collection of particles



Temperature:

The **average** kinetic energy of a collection of particles

Potential (stored) Energy

ABCD

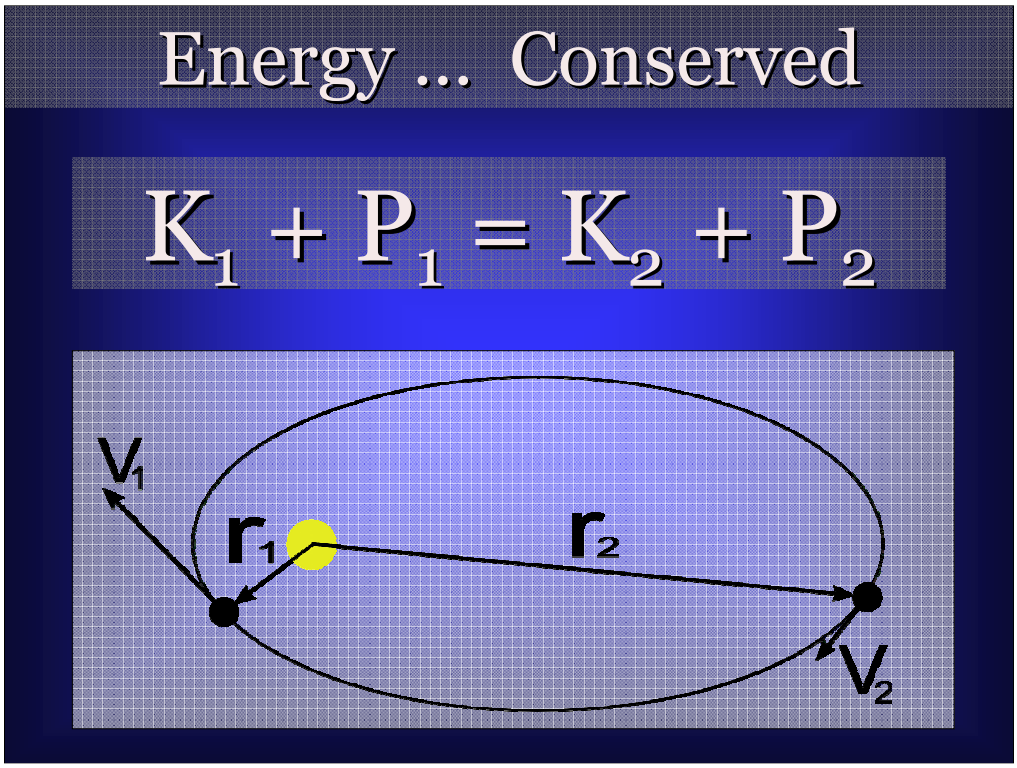
A pot of water is heated for a long time in an oven. Why will you burn your hand by sticking it into the water but not when you stick it into the oven?

A. The water has a higher temperature than the oven.

B. The molecules in the oven are moving slower than those in the water.

C. The water has more heat than the oven.

D. The oven has a higher temperature than the water.



ANOTHER way to understand Kepler's 2nd law.

Energy is exchanged between potential and kinetic in the orbit.

at perihelion, BIG kinetic and small potential.

at aphelion, BIG potential and small kinetic.

ABCD

A rock held above your head has potential energy. When it is released, the potential energy converts to kinetic energy. Where does the energy go when it hits the ground?

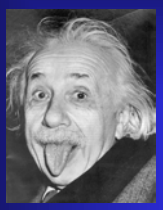
A. It slightly changes the Earth's orbit around the Sun

B. The rock stores it for later use.

C. The rock and the ground are heated slightly

D. It is transformed into gravitational potential energy.

Mass Energy



$$E = mc^2$$

Principle behind
- Nuclear Fission (Nuclear reactors)
- Nuclear Fusion (The Sun)

It is another form of potential energy

Einstein says, Mass is another form of energy.

And… there's a LOT of energy locked up in massive objects.

Newton was wrong!

Any new scientific theory MUST explain why the old theory appeared to work