Main Ideas

• Conservation Laws
• Forms of Energy
• Energy Transfer and Transformation
• Mass-Energy Equivalence

Conservation of Energy

Energy can be neither created nor destroyed. The total amount of energy in the universe never changes. However, energy can change from one form to another, or be transferred from one object to another.
(Note: we will have to modify this later.)

Forms of Energy

• Kinetic Energy
• Gravitational Potential Energy
• Electrical Potential Energy
• Internal Energy
  – thermal energy
  – chemical potential energy
  – elastic potential energy
  – nuclear potential energy
Kinetic Energy

- energy of motion
- kinetic energy = \( \frac{1}{2} \) (mass)(speed\(^2\))

Gravitational Potential Energy

- energy associated with the height of an object
- gravitational potential energy = (weight)(height)

Transformation of Energy

A ball tossed in the air

Gravitational Potential Energy ↔ Kinetic Energy

Total Energy
Electrical Potential Energy

- energy associated with the electrical force

Case 1

Case 2

Transformation of Energy

Electrical Potential Energy → Kinetic Energy

Two Positive charges

Kinetic Energy
Electrical Potential Energy
Total Energy

Electrical Potential Energy, cont.

- energy associated with the electrical force

Case 1

Case 2
Thermal Energy
Internal energy associated with temperature
• A warm object has more internal energy than when it is cold
• Friction causes an increase in thermal energy

Chemical Potential Energy
Electrical potential energy of molecules/atoms in a material
Examples
• burning gasoline, natural gas, or wood
• exploding firecracker
• “Instant ice”

Elastic Potential Energy
• Energy associated with the position of the atoms/molecules
• Examples:
  – Springs
  – Rubber bands
  – Compressed air
Nuclear Potential Energy

- Related to strong force and protons and neutrons in the nucleus
- \( E = mc^2 \)

Energy Transfer Processes

- Conduction: a process in which thermal energy is transferred because of a difference in temperature (electric stove, soldering iron)
- Radiation: thermal energy is transmitted by visible light, infrared radiation, ultraviolet radiation, X-rays, or radio waves (sun, space heater)
- Convection: thermal energy is transferred because matter moves from one place to another (hot air furnace, gulf stream, Santa Ana wind)
- Work: energy is transferred or transformed by forces acting on an object. (friction, muscles, electric motor)
  \[ \text{work} = \text{force} \times \text{distance parallel to force} \]

Conduction – transfers energy

Heat moves through the material but the material itself does not move or deform.
Radiation – transfers energy

The energy itself travels through space

Convection – transfers energy

Heat the material and the material moves then gives up the heat.

Work - transforming energy

- Work equals force \times \text{parallel distance}
- We do work when we go parallel to the force.
Examples

• Car stopping at a stop sign
• Pendulum with and without friction
• Bouncing a ball
• Water behind a dam

The Car

• The engine is running, doing work on the car.
• $F=ma$, but acceleration cannot increase speed past speed of light.
• Mass must increase.

$\frac{m}{\sqrt{1-\frac{v^2}{c^2}}}$

Mass-energy Equivalence

• Nothing can go faster than the speed of light.
• Mass increases with speed such that no massive object can move at the speed of light.
• Energy and mass are equivalent ($E=mc^2$).