Did you read chapter 9 before coming to class?

A. Yes
B. No
Reminder

- Vocabulary available this afternoon. *(Go to blackboard, click on vocabulary quiz.)* Score is out of 4 points.

- Test will be available by Thursday
Newton’s Cradle

- There are five balls, each with mass $m$.
- Write down an expression for the momentum of 1, 2, 3, or 4 balls if they are all traveling with velocity $v$.
- Can conservation of momentum explain this behavior alone?
Sometimes it is hard to describe all of the motion in a system, and we want something simpler.
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- A more complicated example: Power plant
Energy

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Energy

- Energy is
  - the capacity “to do something”
  - Ability to exert a force on an object while moving it through a distance

- Energy can either be associated with an object's position (potential) or its motion (kinetic)

- Total energy is conserved: 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.
Kinetic Energy

- Kinetic energy is the energy of motion.
- Kinetic Energy = \( \frac{1}{2} \, mv^2 \)

What about a ball rolling up a hill?
Gravitational Potential Energy

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

**Examples**
- Balls rolling on tracks (energy transfers from potential to kinetic)
- Pendulum
- Ski Jump
- Bouncing ball
In physics, the word “work” has precise meaning that is somewhat different than you may be used to.

\[ \text{Work} = (\text{force}) \times (\text{distance parallel to force}) \]

- For work to be done in the physics sense, a force must be applied and the object must have some motion parallel to the force.
- Work is a method of \textit{transferring} energy, it is not a form of energy itself.
Internal Energy

- Internal energy is energy “hidden” inside materials. It is associated with the temperature of the materials (thermal energy) and the chemical potential energy of materials.

Examples
- Mass on a spring
- Garage Door
Electrical Potential Energy (energy associated with position)

- Energy associated with the electrical force
- Unlike charges attract and behave like gravitational potential (farther apart = more potential)
- Like charges repel and have more potential when close together
- Gives rise to chemical potential energy
Thermal Energy

Internal energy associated with kinetic energy of individual particles.

- Related to temperature (average KE of atoms and molecules)
- A warm object has more internal energy than when it is cold
- Two objects at the same temperature may have different amounts of thermal energy
  - water 1 cal/g°C
  - gold 0.03 cal/g°C
Chemical Potential Energy

Internal electrical potential energy of atoms in a material

Examples

- change of state (rearrangement of atoms)
- chemical bonds
  - burning gasoline, natural gas, or wood
  - exploding firecracker
Elastic Potential Energy

- Energy stored in a material by deforming it in such a way that its molecules are displaced from their equilibrium positions.
- A form of internal electrical potential energy
- Examples:
  - deformation (springs, balls)
  - Rubber band
  - Trampoline
Radiant Energy
Summary: Forms of energy

- Kinetic Energy
- Gravitational Potential Energy
- Electrical Potential Energy
- Internal Energy
  - Thermal (internal kinetic)
  - Elastic potential (internal electrical)
  - Chemical Potential (internal electrical)
- Radiant Energy
Energy Transfer and Transformation

- **Radiation**: energy is transmitted by visible light, infrared radiation, ultraviolet radiation, X-rays, or radio waves. (sun, space heater)
- **Conduction (Heat Flow)**: a process in which internal energy is transferred because of a difference in temperature. (electric stove, soldering iron)
- **Convection**: internal energy is transferred because matter moves from one place to another. (hot air furnace)
- **Work**: energy is transferred or transformed by forces acting on an object. (friction, muscles, electric motor)
- **Combustion**: chemical potential energy is transformed into another form (gasoline engine, dynamite, light stick)
The Mechanical Universe...and Beyond

ENERGY TRANSFER IN A POLE VAULT

Playing Time: 1:23
The gulf stream carries warm water into the north Atlantic making Europe somewhat warmer than it otherwise would be.

- This is an example of
  A. Convection
  B. Conduction
  C. Radiation
  D. Combustion
The method of heat transfer used to cook microwave popcorn is

a) radiation
b) conduction
c) convection
Three methods for popping popcorn

- Microwave -- Radiation
- Hot air -- Convection
- Stove top -- Conduction

Identify the method of heat transfer for each.
Kinetic energy at very high speeds

- The engine is running, doing work on the car.
- Energy is going in, but speed can’t increase past the speed of light.
- Energy depends on Mass and Speed -- Mass must increase.
Conservation of Mass-Energy

- $E=mc^2$
- Mass and energy are two manifestations of the same quantity
- The total amount of mass-energy in an isolated system is constant
- Mass and energy can be converted from one form to the other
Nuclear Potential Energy

- By studying the masses of nuclear decay products, we find that the products are significantly less-massive than the original nucleus.