7th Grade
Forces and Energy

Chapter 4: Energy

Lesson 1 (What is Energy?)

Work – force exerted on an object that causes it to move in the same direction of the applied force

- If the object does not move, no work is done, no matter how much force is applied.
- For work to be done, the object must move in the same direction as the force.
- The amount of work done depends on the amount of force you exert and the distance the object moves.

work = force x distance

Example: If you lift a 5-newton trumpet up 0.5 meters, you do ___2.5*J*___ of work.

w = f x d = 5*N* x 0.5*m* = 2.5*N•m* (or 2.5 joules, or 2.5*J*)

Joule – unit of work

- the amount of work you do when you exert a force of 1 newton to move an object a distance of 1 meter

Power – the rate at which work is done

- the amount of work done on something in a certain amount of time
- An object that has more power than other objects does more work in the same amount of time, or does the same amount of work in less time.

$$power = \frac{work\ (joules)}{time\ (seconds)} \quad \textbf{OR} \quad power = \frac{force\ x\ distance}{time}$$

Watt (*W*) – a unit of power equal to 1 joule of work done in 1 second

1 J/s = 1W

Kilowatt(*kW*) – 1,000 watts

1 kW = 1,000W

Horsepower(*HP*) – 746 watts

1 HP = 746W

Example: How much power does a truck provide if it pulls a 200 newton wagon a distance of 50 meters in 5 seconds?

$$power = \frac{force\ x\ distance\ (work)}{time} = \frac{200N\ x\ 50m}{5s} = \frac{10{,}000\ J}{5s} = \textbf{2,000W}$$

Energy – the ability to do work or cause change

- When you do work on an object, some of your energy is transferred to that object.
- You can think of work as "the transfer of energy".
- Both work and energy are measured in ***joules***.

Kinetic energy – energy that an object has due to its motion

- depends on the object's speed and mass
- The faster an object moves, the more kinetic energy it has.
- Kinetic energy also increases as mass increases.

Kinetic Energy = ½ x Mass x Speed²

Example: A boy is pulling a 12*kg* wagon at a speed of 1.5*m/s*. What is the kinetic energy of the wagon?

KE = ½ x 12 kg x (1.5 m/s)² = 13.5 kg•m²/s² = 13.5 joules

Potential energy – energy that results from the position or shape of an object

- also is the internal stored energy of an object, such as energy stored in chemical bonds
- This stored energy is held in readiness and has the potential to do work.

Gravitational potential energy

- energy that depends on the height of an object
- is equal to the work done to lift the object to that height
- The force you use to lift an object is equal to its weight.

gravitational potential energy = work done

AND

work = force x distance

SO

gravitational potential energy = force x distance

AND

force = weight

AND

distance = height

SO

gravitational potential energy = weight x height

***Example*:** If a book that has a weight of 13*N* is lifted 2.6 meters off the ground, how much potential energy does it have?

gravitational potential energy = 13N x 2.6m = ***33.8 joules***

How much work was done on the book?

work = force x distance = 13N x 2.6m = ***33.8 joules***

elastic potential energy – the energy of stretched or compressed objects

Lesson 2 (Forms of Energy)

mechanical energy – the form of energy associated with the motion, position, or shape of an object

- is a combination of its potential and kinetic energy

mechanical energy = potential energy + kinetic energy

***Example*:** A 5*N* ball is flying through the air at 20*m/s* at a height of 8 meters off the ground. What is the ball's mechanical energy?

potential energy = weight x height = 5N x 8m = 40 joules
kinetic energy = ½ x mass x speed ^{2} = ½ x 5N x (20m/s)^2 = 1,000 joules

Mechanical energy = PE + KE = ***1,040 joules***

Types of Energy Associated With the Particles of Objects:

1. **Nuclear Energy** – the potential energy stored in the nucleus of an atom
   - This energy is released during a nuclear reaction.

   nuclear fission – a nuclear reaction in which the nucleus of an atom splits
   - Nuclear power plants use fission reactions to produce electricity.

   nuclear fusion – a nuclear reaction in which the nuclei of atoms join together
   - This occurs in the sun, releasing huge amounts of energy in form of heat and light.

2. **Thermal Energy** – the total kinetic and potential energy of all the particles of an object
   - Adding heat causes particles to move faster (more kinetic energy), so the higher its temperature, the more thermal energy an object has.

3. **Electrical Energy** – the energy of charged particles in an object
   - **can be kinetic energy** if the particles are moving through a conductor (current electricity) or **can be potential energy** if they are not flowing, but could move at any time (static electricity)

4. **Electromagnetic Energy**
   - the energy of light and other forms of radiation, which travels through space as waves
   - caused by vibrating electric charges
   - This energy does not require a **medium** (something to carry it), so it can travel through empty space.

   ***Examples*:** visible light, microwaves, x-rays, ultraviolet (UV) rays, infrared (heat) waves, radio waves

5. **Chemical Energy**
   - potential energy stored in bonds between atoms and molecules
   - When chemical bonds are broken during chemical reactions, the stored (potential) energy is often released and can be used to do work.

   ***Examples*:** energy in batteries, foods, matches, fuels, and energy in your cells

Lesson 3 (Energy Transformations and Conservation)

All forms of energy can be transformed (changed) into other forms of energy.

Energy transformation:

- a change from one form of energy to another
- Sometimes one form of energy needs to be changed into another form to get work done.
- Some energy changes involve single transformations, while others involve many transformations.

Law of Conservation of Energy:

- Energy cannot be created or destroyed, only changed to other forms.
- When one form of energy is transformed to another, no energy is lost in the process.
- The total amount of energy is the same before and after any transformation.