Energy and the Environment

HNRS 228
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Good to Know
- Units of length, mass and time
- Metric Prefixes
- Relationship of Mass, Volume and Density
- The Scientific Method
- Speed, velocity, acceleration
- Force
- Falling objects
- Newton’s Laws of Motion
- Newton’s Law of Universal Gravity

Main Concepts For Understanding Energy
- Work
- Potential Energy
- Kinetic Energy
- Conservation of Energy
- Types/Sources of Energy

Question
- What is acceleration?
  A The change in distance per change in time.
  B The change in position per unit of time.
  C The ratio of the change in velocity per change in time.
  D The change of time per unit of length.

Question
- Neglecting air resistance, what are the forces acting on a bullet after it has left the barrel of a rifle?
  A The force of air acting up and gravity acting down.
  B Only the force of gravity acting straight down.
  C There are no forces acting at this point.
  D All of the above are true.

Question
- How does the force of gravity on a ball change as a ball is thrown straight up in the air?
  A The force of gravity increases.
  B The force of gravity decreases.
  C The force of gravity remains the same.
  D The force of gravity increases then decreases.
  E The force of gravity decreases then increases.
**Work = Force times distance**

- **Definition of work**
  - "work is equal to the force that is exerted times the distance over which it is exerted"
  - \[ W = f \times d \]

**Question for Thought**

A spring clamp exerts a force on a stack of papers it is holding together. Is the spring clamp doing work on the papers?

- A: Yes
- B: No

If the spring clamp does not cause the paper to move, it is not acting through a distance and no work is done.

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**Power - Work per unit time**

- **Power defined**
  - "power is the amount of work done divided by the time it takes to do that work"
  - \[ P = \frac{W}{t} \]

**Question for Thought**

A lamp bulb is rated 100 Watts. Is there a time factor included in the rating?

- A: Yes
- B: No

Because a time factor is in the rating. A watt is a unit of power, and power is work per unit time. A 100 W light bulb uses energy at a rate of 100 J per s.

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**Kinetic Energy**

**Definition**

- "Kinetic energy equals the mass of the moving object times the square of that object’s speed, times the constant \(\frac{1}{2}\)."
- \[ K.E. = 0.5 \times m \times v^2 \]

**Question for Thought**

A kWhr is

- A: a unit of work
- B: a unit of energy
- C: a unit of power
- D: More than one of the above is true.

A kWhr is a unit of work, and since energy is the ability to do work, it is also a unit of energy. In terms of units, a watt is a joule per second, and an hour, as a second, is a unit of time. The time units cancel, leaving a unit of a joule, which can be used to measure either work or energy.
Question for Thought

Is work related to energy?
- A Yes
- B No

Energy is the ability to do work, and doing work on something gives it energy.

Question for Thought

Does a person standing motionless in the aisle of a moving bus have kinetic energy?
- A Yes
- B No

Relative to the bus, the person has no kinetic energy because the person is at rest relative to the bus. Relative to the ground, however, the person does have kinetic energy because the person is moving with the same speed as the bus.

Question for Thought

A joule of work and a joule of energy are fundamentally the same?
- A Yes
- B No

A joule is one newton-meter. A joule of work is from a force acting through a distance while a joule of energy is the ability to perform one joule of work. The use of the same unit means that work and energy are fundamentally the same thing.

Potential Energy

Definition
- "gravitational potential energy of any object equals its weight times its height above the ground"
- gravitational potential energy in Joules = mass in kilograms * acceleration due to gravity * height in meters
- \( P.E. = m \times g \times h \)

Question for Thought

What is the relationship between the work done while moving a book to a higher bookshelf and the potential energy that the book has on the higher shelf?

The work done is equal to the increase in gravitational potential energy.

Question for Thought

Compare the energy needed to raise a mass 10 meters on Earth to the energy needed to raise the same mass 10 meters on the Moon. Explain the difference, if any.

The energy required is less on the moon because the weight of the object (the downward force due to gravity) depends upon the force of gravity, which is less on the moon than on the earth. Less energy is needed to do the work of raising the mass on the moon, and the elevated object on the moon has less potential energy as a consequence of the work done.
**Question for Thought**

What happens to the kinetic energy of a falling book when the book hits the floor?
- A The kinetic energy is destroyed.
- B The kinetic energy is converted to heat only.
- C The kinetic energy is converted to heat and sound.

**Mass as Energy**

**Definition**
- "every object at rest contains potential energy equivalent to the product of its mass times the speed of light squared"
- Energy in joules = mass in kilograms * speed of light in meters per second * speed of light in meters per second
- \( E = m \cdot c^2 \)

**Energy Interchangeability**

**Potential Energy**
- gravitational
- chemical
- elastic
- electromagnetic

**Kinetic Energy**
- moving objects
- heat
- sound and other waves

Energy is Conserved

**Energy is eventually converted into unrecoverable radiant energy, so new sources of convertible energy must be found in order to continue performing useful work.**

**Question for Thought**

If energy cannot be destroyed, why do some people worry about the energy supplies?

**Question for Thought**

Why are petroleum, natural gas, and coal called fossil fuels?

Fossil fuels contain energy from plants or animals that lived millions of years ago. These plants and animals are known from the fossils they left behind, and the energy in the fuels represents energy stored from these ancient organisms.

**Question for Thought**

From time to time people claim to have invented a machine that will run forever without energy input and develops more energy than it uses (perpetual motion). Why would you have reason to question such a machine?

The machine would not be in accord with the principle of conservation of energy.
In the diagram above, a box is on a frictionless horizontal surface with forces $F_1$ and $F_2$ acting as shown. If the magnitude of $F_2$ is greater than the magnitude of $F_1$, then the box is

- A. moving at constant speed in the direction of $F_1$
- B. moving at constant speed in the direction of $F_2$
- C. accelerating in the direction of $F_1$
- D. accelerating in the direction of $F_2$
- E. not moving at all.

The metric unit of a Joule (J) is a unit of

- A. potential energy.
- B. work.
- C. kinetic energy.
- D. All of the above (A, B, and C) are measured in Joules.
- E. None of the above (A, B, and C) are measured in Joules.

Which statement is true about the concept of power?

- A. Power is the distance over which work is done.
- B. Power is the time at which energy is expended.
- C. Power is the work done per unit time.
- D. All of the above (A, B, and C) can be said about power.
- E. None of the above (A, B, and C) is true about power.

The kilowatt-hour is a unit of

- A. power.
- B. work.
- C. time.
- D. area.
- E. volume.

Which of the following best describes the law of conservation of energy?

- A. Energy must not be used up faster than it is created or the supply will run out.
- B. Energy can be neither created nor destroyed.
- C. Energy is conserved because it is easily destroyed.
- D. Conservation is a law describing how to destroy matter.
- E. Energy conservation is a law recently passed by Congress.

Physics Education Research Findings

- Students have an incoherent view of energy.
  - Potential energy is often ignored.
  - “Just a number”
  - An invented quantity
  - Potential energy is not actual energy.
  - It often is thought to have nowhere to exist, so it cannot really exist.
Students have an incoherent view of energy.
- Energy can be “produced.”
- Energy conservation only weakly constrains student thinking. It does not force inferences.
- Energy is not useful to students in describing and explaining natural phenomena.
  - They often have to be prompted even to invoke it!

Textbooks present a fragmented and sometimes misleading view of energy.
- Energy is said to be “invented,” and “abstract.”
- Energy can be “converted” to different “forms.”

“National science standards present a problematic view of energy.”

From the opening sentence of the energy section in the AAAS/Project 2061 Standards:

“Energy is a mysterious concept....”

“Students do not find energy to be very useful, even for prototypical school science phenomena.”