PowerPoint Lectures
to accompany
Physical Science, 8e

Chapter 3
Energy

New Symbols for this Chapter

W-Work
P-Power
PE-Potential Energy
KE-Kinetic Energy
E-Mechanical Energy

$$W = Fd$$

$$P = \frac{W}{t}$$

$$KE = \tfrac{1}{2}mv^2$$

$$PE = mgh$$

$$E = PE + KE$$

Core Concept

Energy is transformed through working or heating, and the total amount remains constant.

Fundamental Law: Conservation of Energy

Manifestations:

- Work, motion, position, radiation (light), heat, chemical and nuclear energy, mass itself

Sources:

- Petroleum, coal, moving water, nuclear, solar

Uses:

- Transportation, generation of electricity, heating, cooling, lighting

Work

- Work is a product of the applied force and the parallel distance through which the force acts.
- W=Fd

Work

- Units of work (and energy) = joule (J)
- Zero distance, no work
- Displacement perpendicular to applied force, no work

Units of Work

The units of work are:

$$(\text{units of force}) \times (\text{units of distance})$$

The metric unit of work is:

$$N \bullet m = kg\,\frac{m}{s^2} \bullet m = J \text{ (The Joule)}$$

Example 1 (Parallel Exercise Group B #2)

1) A force of 400.0 N is exerted on a 1,250 N car while moving it a distance of 3.0 m. How much work was done on the car?

Simple Machines

- Basic premise: work in equals work out
- Force multiplied by ratio of distances
- Examples
  - Inclined plane
  - Wedge
  - Screw
  - Lever
  - Wheel and axle
  - Pulley

$$F_{in} d_{in} = F_{out} d_{out}$$

$$F_{out} = \frac{d_{in}}{d_{out}} F_{in}$$

The Pulley

These are the different types of pulley systems:

1) Fixed A fixed or class 1 pulley has a fixed axle. That is, the axle is "fixed" or anchored in place. A fixed pulley is used to change the direction of the force on a rope.
2) Movable A movable or class 2 pulley has a free axle. That is, the axle is "free" to move in space. A movable pulley is used to multiply forces.
3) Compound -a combination of a fixed and a movable pulley system.
4) Block and tackle - A block and tackle is a type of compound pulley where several pulleys are mounted on each axle, further increasing the mechanical advantage.

Power

- The rate at which work is done or the rate at which energy is transformed.

$$P = \frac{W}{t}$$

Power

- The rate at which work is done
- Units: watts (W) or horsepower (hp)
- Example: Walking versus running upstairs
- The “power bill” - you pay for energy

Motion, Position and Energy

- Work and energy related
- Energy = ability to do work
- Work = process of changing energy level

Next:

- Relationship between work and energy associated with position
- Relationship between work and energy of motion

Potential Energy

- Energy associated with position
- Gravitational potential energy
  - Measuring h - need reference height
- Also: elastic (springs) and electric (charges) potential energy
- Work can change PE
- Kinetic energy can change into potential energy

Example 2 (Parallel Exercise Group B #10)

2) How much work is done in raising a 50.0 kg crate a distance of 1.5 m above a storeroom?

b) What is the change of potential energy as a result of this move?

c) How much kinetic energy will the crate have as it falls and hits the floor?

Kinetic Energy

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

- Energy associated with motion
- Results from work or change in potential energy
- Speed squared! (Double speed, KE increases by 4)

Energy Flow

Energy can do work as

- Work against inertia
- Work against gravity
- Work against friction
- Work against shape
- Work against combinations of above

Energy Forms

Mechanical energy

- Kinetic plus potential energy

Electrical energy

- Charges, currents, etc.

Chemical energy

- Energy involved in chemical reactions

Radiant energy

- Electromagnetic energy
- Visible light = small part of full spectrum

Nuclear energy

- Energy involving the nucleus and nuclear reactions

Energy Conversion

- Any form of energy can be converted into another form.
- Energy flows from one form to another in natural processes.
- Example - pendulum

$$E_{pendulum}\ (fixed) = KE + PE$$

Conservation of Energy

Whenever energy is transformed, it is found that no energy is gained or lost in the process.

The Law of Conservation of Energy:
The total energy is neither increased nor decreased in any process. Energy can be transformed from one form to another, or transferred from one object to another but the total amount of energy remains unchanged.

Energy Conservation

- Energy is never created or destroyed.
- Energy can be converted from one form to another, but the total energy remains constant.
- Example: free-fall
- Energy transfer mechanisms: work and/or heat

Example 3 (Parallel Exercise Group B #17)

3) A ball is dropped from 20.0 ft above the ground.

a) At what height is half of its energy kinetic and half potential?

b) Using energy considerations only, what is the velocity of the ball just as it hits the ground?

Flow of Energy

Energy is never created or destroyed. Energy can be converted from one form to another, but the total energy remains constant.

Energy Sources Today

- Primarily wood to coal to petroleum with increasing industrialization
- 89% can be traced to photosynthesis
- Uses
  - ⅓ burned for heating
  - ⅔ burned in engines and generators

Petroleum

- Oil from oil-bearing rock
- Organic sediments transformed over time by bacteria, pressure and temperature
- Natural gas formation similar, except at generally higher temperatures
- Petroleum and natural gas often found together
- Supplies are limited: 25% from offshore wells, over 50% imported

Coal

- Accumulated plant materials, processed over time by pressure and temperature
- Progression: peat to lignite to sub-bituminous to bituminous
- Impurities
  - Minerals lead to ash
  - Sulfur leads to sulfur dioxide gas (pollutant)
- Petroleum, natural gas and coal = *fossil fuels*

Moving Water

- Renewable with rainfall
- Gravitational potential energy of water converted to electrical energy
- Hydroelectric plants generate ~3% of US's total energy consumption
- Growth potential limited by decreasing availability of new sites

Nuclear

- Based on nuclear fission reactions of uranium and plutonium
- Water heated in reactor and then used to produce steam to turn generating turbines
- Safety of nuclear power generation is controversial

Energy Sources Tomorrow

Alternative source of energy: one that is different from those commonly used today

Today: fossil fuels (coal, petroleum, natural gas), nuclear and falling water

Tomorrow: solar, geothermal, hydrogen gas, fusion

Solar Technologies

- Solar cells
  - Direct conversion of light to electricity
- Power tower
  - Mirrors focus sunlight to heat water for steam generation
- Passive application
  - Designs to use solar energy flow naturally
- Active application
  - Solar collector used to heat water, air or some liquid
  - Then used for heating or electric generation

Solar Technologies, cont.

- Wind energy
  - Turbines generate electricity
  - Wind often inconsistent
- Biomass
  - Plant material formed by photosynthesis
  - Burned directly or converted to other fuels
- Agriculture and industrial heating
  - Direct use of sunlight to dry grain, cure paint, etc.
- Ocean thermal energy conversion
  - Uses temperature difference between surface and ocean depth to generate electricity

Geothermal Energy

- Hot, dry rock
  - 85% of total resource
  - Associated with volcanic activity
- Geopressurized resources
  - Underground reservoirs of hot water containing natural gas
  - 14% of available resources
- Dry steam
  - Very rare: only three sites in US
- Hot water
  - Makes up most of the *recoverable* geothermal resources
  - Can be circulated directly into homes, businesses, farms and so on

Hydrogen

- Energy storage and transport system
  - Must be generated for utilization
  - One possible source: water, H_2O
- Clean
  - Combustion produces water
- Possible problems
  - Best stored as liquid hydrogen (cold!)
  - Extremely flammable