Energy, Work, and Power

Conservation Laws – an Alternative to Newton's Laws

Energy, Work, and Power

I. Energy
  - kinetic and potential
  - conservation

II. Work
  - dot product
  - work-energy relations

III. Springs

IV. Power
  - machines and efficiency

	The student will be able to:	HW:
1	Define and apply the concepts of kinetic and potential energy and use the conservation of energy to explain physical phenomena.	1 – 5
2	Calculate mechanical kinetic energy and gravitational potential energy (in Joules) and use conservation of energy to solve related problems.	6 – 16
3	Define and calculate work and solve related problems.	17 – 23
4	Relate and equate work and energy and solve related problems.	24 – 30
5	Solve problems involving work and energy for a mass attached to a spring.	31 – 33
6	Define and calculate power (in Watts or horsepower) and solve related problems.	34 – 41
7	Solve problems involving machines and efficiency.	42 – 45

Do you have any energy today?

What is energy?

Energy is the ability to do work.

But, what is *work*?

Work involves a *force* that acts over a certain *distance*.

(Caution: this is <u>not</u> the strict definition of work.)

The JOULE

The **joule** is the SI unit for measuring energy or work. It is the amount of energy needed to do the work of exerting one newton of force over a distance of one meter.

$$1 \text{ joule} = 1 \text{ newton} \times 1 \text{ meter}$$

$$J = Nm$$

$$J = kg\ m^2/s^2$$

What are some other units for measuring energy?

1 calorie ≈ 4.19 J

1 Calorie ≈ 4190 J

1 BTU ≈ 1060 J

Two *Types* of Energy

Kinetic Energy

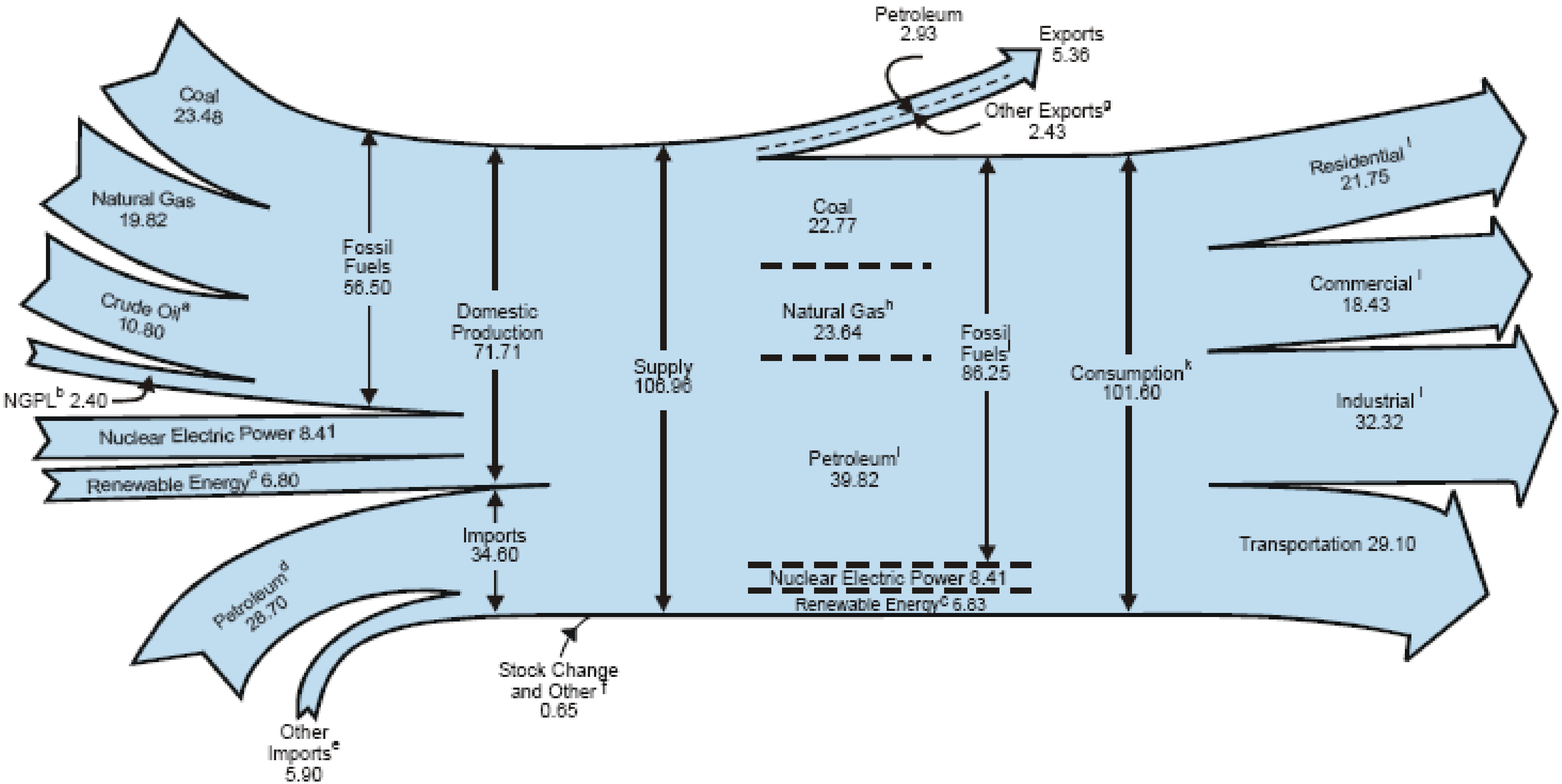
Potential Energy

Two *Types* of Energy

Kinetic Energy is energy due to motion.

Potential Energy is energy due to position or arrangement (and associated with a particular force).

US Energy Flow 2007 (quadrillion BTU)



Name or Type of Energy	*Example*	*Kinetic or Potential*	*Energy is due to…*	*Means by which work can be done*
Mechanical Kinetic Energy	Wind Farm	Kinetic		
Gravitational Potential Energy	Hydroelectric Dam	Potential		
Chemical Energy	Fossil Fuels (Coal, gas, oil, etc…)			

Name or Type of Energy	***Example***	***Kinetic or Potential***	***Energy is due to…***	***Means by which work can be done***
Mechanical Kinetic Energy	Wind Farm	Kinetic	**Motion** of air molecules	air exerts force on turbine causing motion
Gravitational Potential Energy	Hydroelectric Dam	Potential	Elevated **position** of water	Water exerts force on turbine causing motion
Chemical Energy	Fossil Fuels (Coal, gas, oil, etc…)	Potential	Arrangement and **positions** of atoms in molecules (bonds)	Chemical reaction releases heat. This can cause expansion and move objects

Name or Type of Energy	***Example***	***Kinetic or Potential***	***Energy is due to…***	***Means by which work can be done***
Nuclear Energy	Uranium		**Position** and arrangement	Nuclei undergo fission, releasing heat, which can
Thermal Energy	Geothermal power plant		Random **motion** of	Heat of Earth is used to generate steam and turn turbines
	Clock Spring			

Name or Type of Energy	***Example***	***Kinetic or Potential***	***Energy is due to…***	***Means by which work can be done***
Nuclear Energy	Uranium	Potential	**Position** and arrangement of protons and neutrons in the nucleus	Nuclei undergo fission, releasing heat, which can cause expansion and move objects
Thermal Energy	Geothermal power plant	Kinetic	Random **motion** of molecules	Heat of Earth is used to generate steam and turn turbines
Elastic Potential Energy	Clock Spring	Potential	Stressed **position** of wound up spring	Spring exerts force that turns the clock's moving parts

	The student will be able to:	HW:
1	Define and apply the concepts of kinetic and potential energy and use the conservation of energy to explain physical phenomena.	1 – 5
2	Calculate mechanical kinetic energy and gravitational potential energy (in Joules) and use conservation of energy to solve related problems.	6 – 16
3	Define and calculate work and solve related problems.	17 – 23
4	Relate and equate work and energy and solve related problems.	24 – 31
5	Solve problems involving work and energy for a mass attached to a spring.	32 – 33
6	Define and calculate power (in Watts or horsepower) and solve related problems.	34 – 41
7	Solve problems involving machines and efficiency.	42 – 45

Mechanical Kinetic Energy

The kinetic energy that an object possesses due to its translational motion is given by:

$$KE = \frac{1}{2} m v^2$$

where: m = mass of the object
v = speed of the object

Gravitational Potential Energy

The gravitational potential energy of an object near earth's surface is given by:

$$GPE = mgh$$

where: m = mass of the object
g = acceleration due to gravity
h = height above a reference

Notes on $PE = mgh$

- The value of h is arbitrary! There is no "absolute" or "correct" value for h; it depends upon the chosen reference.
- Therefore the amount of potential energy is *relative* to a position at which h is zero.
- The values of m and g are always positive; however the value of h can be negative if the object is *below* the chosen reference level.

Conservation Laws

Conservation laws state that certain aspects of the universe are *conserved*.

Which is to say…

Certain things can neither be created nor destroyed.

The total amount of such things must therefore remain constant through time.

Conservation Laws

Some aspects of the universe that are conserved:

matter, mass, energy, charge,
spin, momentum…

Conservation of Energy

There are only two things that can happen to an energy form:

It can be **transferred** from one object or set of objects to another.

It can be **transformed** from one type of energy into another.

Special exception: Mass can be transformed into energy and vice versa. ($E = mc^2$) This occurs to a significant extent only in nuclear reactions.

Most any action or occurrence can be understood as a transfer and/or transformation of energy…

1. A cat jumps up onto a table.
2. A car accelerates from a stoplight.
3. An archer shoots an arrow into a bale of hay.
4. A cue ball is used to “break” the 15 colored balls on a billiard table.
5. A light is turned on.

Using Conservation to Solve Problems

Because energy is conserved, the total amount of it should remain constant:

$$\underbrace{KE_1 + PE_1}_{\text{total energy at one point in time}} = \underbrace{KE_2 + PE_2}_{\text{total energy at a different point}}$$

Using Conservation to Solve Problems

Because energy is conserved, the total amount of it should remain constant:

$$KE_1 + PE_1 = KE_2 + PE_2$$

Note: it is sometimes difficult to account for *all* of the energy forms that are present before and after a particular event.