Note on Posted Slides

- These are the slides that I intended to show in class on Wed. Jan. 23, 2013.
- They contain important ideas and questions from your reading.
- Due to time constraints, I was probably not able to show all the slides during class.
- They are all posted here for completeness.

PHY205H1S
Physics of Everyday Life
Class 6: **Energy**

- Energy
- Power
- Potential and Kinetic
- Conservation of Energy
- Efficiency
- Recycled Energy
- Energy for Life
- Sources of Energy

[image from http://www.nytimes.com/imagepages/2006/11/28/business/28plug.ready.html]

Ch. 6 Review Question on Conservation of Momentum

- An object is flying through the air with nothing touching it.
- Neglect air resistance.
- Is momentum of the object conserved?

A. Yes
B. No

Chapter 7. Pre-Class Reading Question

- When the useful energy output of a machine is 100 J, and total energy input is 200 J, what is the efficiency?

A. 25%
B. 50%
C. 75%
D. 100%
E. 200%

Chapter 7. Pre-Class Reading Question

- Chapter 7 opens with a story about the physicist who first advocated the correct equation for kinetic energy. Who was this physicist?

A. Du Châtelet
B. Einstein
C. GaliJustin
D. Leibniz
E. Newton

Work

- involves force and distance.
- is force × distance.
- in equation form: $W = Fd$.

Two things occur whenever work is done:

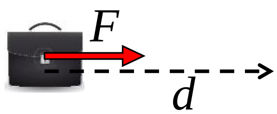
- application of force
- movement of something by that force

Unit of work:

newton-meter (N·m) or joule (J)

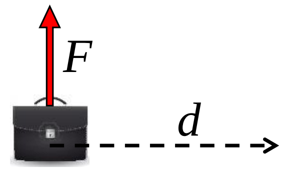
Work can be positive, zero or negative

- When the force and the distance are in the *same* direction, you are *helping* the motion with the force, so the work done on the object is **positive**.
- The force is *adding energy* to the object + environment.
- Maybe this force is speeding the object up.



Work can be positive, zero or negative

- When the force and the distance are *at right angles*, you are *not* helping the motion with the force, so the work is **zero**.
- This force is *not changing* the energy of the object.
- This force won't speed the object up or slow it down.



Work can be positive, zero or negative

- When the force and distance are in *opposite* directions, you are *hindering* the motion with the force, so the work done on the object is **negative**.
- This force is *reducing* the energy of the object.
- Maybe this force is slowing the object down.

Discussion Question

- Justin is doing a bench press, and he slowly pushes the bar up a distance of 0.30 m while pushing upwards on the bar with a force of 200 N. The bar moves with a constant velocity during this time.
- During the upward push, how much **work** does Justin do on the bar?

A. 60 J
B. 120 J
C. 0 J
D. -60 J
E. -120 J

Discussion Question

- Justin is doing a bench press, and he slowly lowers the bar down a distance of 0.30 m while pushing upwards on the bar with a force of 200 N. The bar moves with a constant velocity during this time.
- During the downward lowering, how much **work** does Justin do on the bar?

A. 60 J
B. 120 J
C. 0 J
D. -60 J
E. -120 J

Discussion Question

- Justin is doing a bench press, and he slowly lowers the bar down a distance of 0.30 m while pushing upwards on the bar with a force of 200 N. He then pushes it up slowly the same distance of 0.30 m back to its starting position, also pushing upwards on the bar with a force of 200 N.
- During the complete downward and upward motion, how much total **work** does Justin do on the bar?

A. 60 J
B. 120 J
C. 0 J
D. -60 J
E. -120 J

Power

- Measure of how fast work is done
- In equation form:

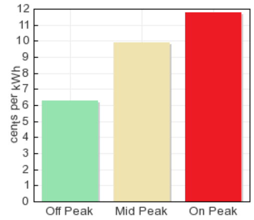
$$Power = \frac{work\ done}{time\ interval}$$

Unit of power

- joule per second, called the watt after James Watt, developer of the steam engine
  - 1 joule/second = 1 watt
  - 1 kilowatt = 1000 watts

Power

- The unit of power is the watt, which is defined as 1 watt = 1 W = 1 J/s
- Energy is measured by Ontario Hydro in kWh "kiloWatt hours".



- 1 kWh is the amount of energy used by a power of 1kW over 1 hour
- 1 kWh = 1000 J/s * 60 min/hour * 60 s/min
- 1 kWh = 3.6 million Joules

[Chart downloaded Jan.23 2013 from http://www.ontario-hydro.com/index.php?page=current_rates]

Example

- Your clothes dryer uses 5000 Watts and you need to run it for 1 hour to dry your clothes.
- If you run it during "on peak" time, such as between 7 and 11am on a weekday, the cost is 12 cents/kWh.
- If you run it during "off peak" on the weekend the price for Ontario Hydro electricity is 6 cents/kWh.
- How much money do you save per load by doing your laundry on the weekend?

[image downloaded Jan.23 2013 from http://www.sierraclubgreenhome.com/go-green/appliances/washers-and-dryers/]

Elastic Potential Energy

Stored energy held in readiness with a potential for doing work

Examples:

- A stretched bow has stored energy that can do work on an arrow.
- A stretched rubber band of a slingshot has stored energy and is capable of doing work.
- Demonstration: A mousetrap that is "set" has elastic potential energy that is capable of killing the mouse!

Gravitational Potential Energy

Potential energy due to elevated position

Example:

- coffee mug on the top shelf

- In equation form:

Potential energy

= mass × acceleration due to gravity × height

$$U_g = mgh$$

Gravitational Potential Energy

Demonstration

A rectangular solid such as a domino has more gravitational potential energy when it is tipped up on its edge, because its centre of mass is higher

The energy is added to the domino by the work you do in tipping it up on its edge.

$$U_g = mgh$$

[image retrieved Jan.23 2013 from http://www.decodedscience.com/a-quick-explanation-of-mathematical-induction/1420]

Kinetic Energy

- Energy of motion
- Depends on the mass of the object and square of its speed:

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

If object speed is doubled ⇒ kinetic energy is quadrupled.

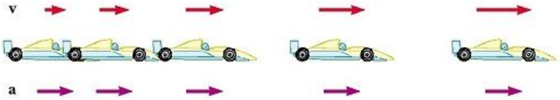
What is "energy"?

- Energy is a property of an object, like age or height or mass.
- Every object that is moving has some Kinetic Energy.
- Objects in a gravitational or electric field may also have Potential Energy.
- Energy has units, and can be measured.
- Energy is relative; kinetic energy of car is different for an observer in the car than it is for an observer standing on the side of the road.

Work and Kinetic Energy

- If an object starts from rest and there is a net force doing work on it, the work done will be equal to the final kinetic energy of the object.
- In equation form:

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



Work-Energy Theorem

Work-energy theorem

- Gain or reduction of energy is the result of work.
- In equation form: work = change in kinetic energy ($W = \Delta K$).
- Doubling speed of an object requires 4 times the work.

Work-Energy Theorem

- Applies to decreasing speed:
  - reducing the speed of an object or bringing it to a halt

Example: Applying the brakes to slow a moving car, work is done on it (the friction force supplied by the brakes × distance).

Work-Energy Theorem
CHECK YOUR NEIGHBOR

The work done in bringing a moving car to a stop is the force of tire friction × stopping distance. If the initial speed of the car is doubled, the stopping distance is

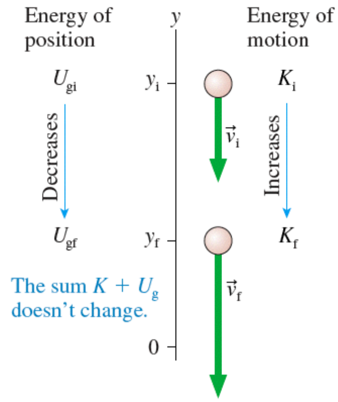
A. actually less.
B. about the same.
C. twice.
D. None of the above.

Chapter 7 big idea: "Conservation of Energy"

- A system of particles has a total energy, E.
- If the system is isolated, meaning that there is no work or heat being added or removed from the system, then:

$$E_f = E_i$$

- This means the energy is "conserved"; it doesn't change over time.
- This is also the first law of thermodynamics; "You can't get something for nothing."



EXAMPLE 1: The speed of a sled

- Claire runs forward with her sled at 2 m/s.
- She hops at the top of a very slippery slope.
- The slope is 7° below the horizontal, and extends down a total vertical distance of 5 m.
- What is her speed at the bottom? [neglect friction]

EXAMPLE 2: The speed of a sled

- Claire runs forward with her sled at 2 m/s.
- She hops at the top of a very slippery valley.
- The valley goes down to 5 m below her starting position, then back up to the same initial height.
- What is her speed when she reaches the other side of the valley? [neglect friction]

Discussion Question on Conservation of Energy

- An object is flying through the air with nothing touching it.
- Neglect air resistance.
- Is energy of the object conserved?

A. Yes

B. No

Discussion Question

- A 1 kg object is dropped from rest a height of 3 m above the ground.
- Just before it hits the ground, what is its kinetic energy? [Neglect air resistance.]

A. 3 J

B. 15 J

C. 30 J

D. 90 J

E. 150 J

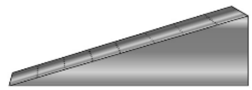
A situation to ponder…
CHECK YOUR NEIGHBOR

Suppose the potential energy of a drawn bow is 50 joules and the kinetic energy of the shot arrow is 40 joules. Then

A. energy is not conserved.
B. 10 joules go to warming the bow.
C. 10 joules go to warming the target.
D. 10 joules are mysteriously missing.

Machines

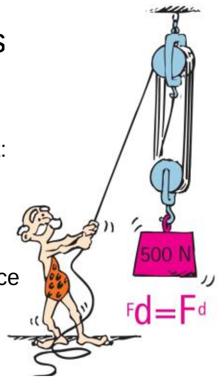
- Devices for multiplying forces or changing the direction of forces
- Cannot create energy but can transform energy from one form to another, or transfer energy from one location to another
- Cannot multiply work or energy



Machines

Principles of a machine:

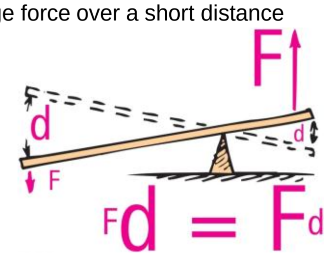
- Conservation of energy concept:
  Work input = work output
- Input force × input distance =
  Output force × output distance



- (Force × distance)$_{input}$ = (force × distance)$_{output}$

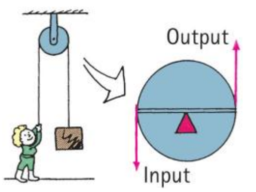
Simplest machine:

- Lever
  - rotates on a point of support called the fulcrum
  - allows small force over a large distance and large force over a short distance

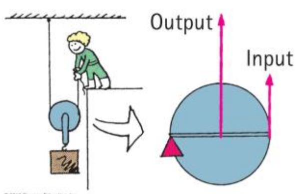


Pulleys

This arrangement operates like a lever with equal arms— changes the direction of the input force:



This arrangement can allow a load to be lifted with half the input force:



Efficiency

- Percentage of work put into a machine that is converted into useful work output
- In equation form:

$$Efficiency = \frac{useful\ energy\ output}{total\ energy\ input}$$

Recycled Energy

- Re-employment of energy that otherwise would be wasted.
- Edison used heat from his power plant in New York City to heat buildings.

- Typical power plants waste about 30% of their energy to heat because they are built away from buildings and other places that use heat.

Sources of Energy

Sun

Examples:

- Sunlight evaporates water; water falls as rain; rain flows into rivers and into generator turbines; then back to the sea to repeat the cycle.
- Wind power turns generator turbines.

Sources of Energy

Example:

- Photovoltaic cells on rooftops catch the solar energy and convert it to electricity.

More energy from the Sun hits Earth in 1 hour than all of the energy consumed by humans in an entire year!

Sources of Energy

Concentrated energy

- Nuclear power
  - stored in uranium and plutonium
  - doesn't pollute our atmosphere
  - creates radioactive waste which, if stored near humans, can be toxic.

Before Class 7 on Monday

- Please read Chapter 8, or at least watch the 10-minute pre-class video for class 7
- Keep in mind:
  - **Test** in 1 week: Wednesday during class time in EX100, which is 255 McCaul St.
  - Test will begin promptly at 10 minutes past the hour and will be 50 minutes long – if you can be there a bit early that would be great.
  - Please bring a calculator, and, if you wish, a 3x5 notecard upon which you may write anything you wish on both sides
  - Test will cover Hewitt chapters 2-8, and will include some multiple choice and some short-answer