

AP Physics I

Energy – Conservation of Energy

Today...Thursday

- Review Nonconservative Forces Homework
- Is PE Negative?
- Review Conservation of Energy
- Other Forms of Energy
- Power!!!!

Last 5 Days

- **Thursday:** Power & Efficiency
- **Friday:** Wrap Up – Big packet of review problems for weekend
- **Monday:** Review of packet
- **Tuesday:** Unit Test
- **Wednesday:** Final Wrap

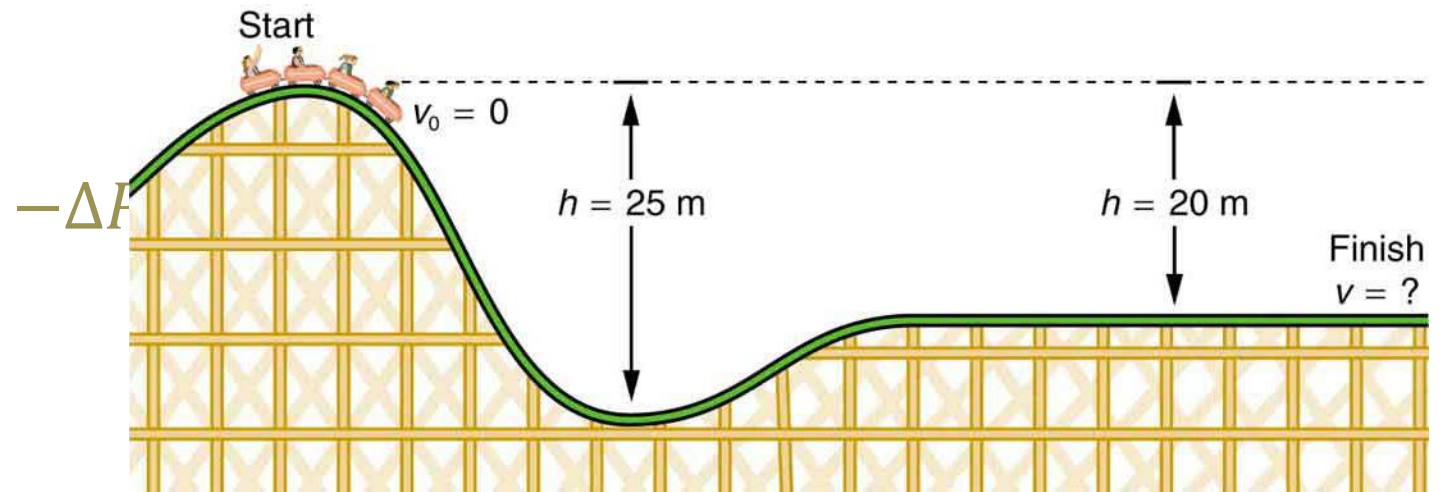
Come Get Help

- Thursday (Today!): Lunch
- Monday: After School
- Tuesday: Unit Test – can finish at lunch or after school

Is PE Negative?

What is final speed of roller coaster if it starts from rest at the top of the **20.0 m** hill and work done by frictional forces is negligible?

- The roller coaster loses potential energy as it goes downhill.
- The net work on the roller coaster is then done by gravity alone.
- The loss of PE_g from moving downward through a distance h equals the gain in KE .
- This can be written in equation form as
- Using equations for KE and PE_g , can solve for the v



Is PE Negative?

- KE_i is zero, so that $KE = \frac{1}{2}mv^2$
- The equation for change in potential energy states that

$$\Delta PE_g = mg\Delta h$$

- Since h is negative in this case, we will rewrite this as below to show the minus sign clearly.

$$\Delta PE_g = -mg\Delta h$$

- Thus, $-\Delta PE = \Delta KE$
- becomes

$$mg|h| = \frac{1}{2}mv^2$$

Review Conservation of Energy

- Work done by nonconservative forces equals the change in the mechanical energy of a system.

$$KE_i + PE_i + W_{nc} = KE_f + PE_f$$

Other Forms of Energy

- Lump all other forms of energy together in other energy.

$$KE_i + PE_i + W_{nc} + OE_i = KE_f + PE_f + OE_f$$

- All types of energy and work can be included in this very general statement of conservation of energy.
- Kinetic energy is KE , work done by a conservative force is PE , work done by nonconservative forces is W_{nc} , and all other energies are included as OE .

What is OE?

- When you eat – food is oxidized with the release of carbon dioxide, water and energy.
- Some of this chemical energy is converted to *KE* when the person moves, to *PE* chemical if they change altitude and to thermal energy (another form of *OE*)
- Other forms?
 - Electrical energy
 - Chemical energy
 - Radiant energy – EM radiation – light and other waves
 - Nuclear
 - Thermal

Problem Solving Strategies for Energy

1. Determine system of interest. Id knowns and what you are finding. Sketch!
2. Examine forces & determine PE from the work done.
3. If know PE for the forces and all are conservative – can apply conservation of mechanical energy simply.

$$KE_i + PE_i = KE_f + PE_f$$

4. If know PE for only some – use most general form.

$$KE_i + PE_i + W_{nc} + OE_i = KE_f + PE_f + OE_i$$

5. Eliminate terms wherever possible.
6. Plug in formulas & numbers.

Efficiency

Even though energy is conserved in an energy conversion process, the output of useful energy or work will be less than the energy input.

The efficiency **Eff** of an energy conversion process is defined as

$$\text{Efficiency}(Eff) = \frac{\text{useful energy or work output}}{\text{total energy input}} = \frac{W_{out}}{E_{in}}$$

Power

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

- The rate at which work is done
- Because work is energy transfer, power is also the rate at which energy is expended.
- A 60-W light bulb, for example, expends 60 J of energy per second.
- Great power means a large amount of work or energy developed in a short time.
- For example, when a powerful car accelerates rapidly, it does a large amount of work and consumes a large amount of fuel in a short time.

Class Problem

- What is the **power output** for a **60.0-kg** woman who runs up a **3.00 m** high flight of stairs in **3.50 s**, starting from **rest** but having a final speed of **2.00 m/s**?
- Work going into mechanical energy is $W = PE_g + KE$
- At the bottom of the stairs, both **KE** and PE_g initially 0

$$W = PE_g + KE = mgh + \frac{1}{2}mv^2$$

- where **h** is the vertical height of the stairs.
- Because all terms are given, we can calculate W and then divide it by time to get power.
$$P = \frac{W}{t} = \frac{\frac{1}{2}mv^2 + mgh}{t}$$

Finishing Solving Class Problem

- What is the power output for a 60.0-kg woman who runs up a 3.00 m high flight of stairs in 3.50 s, starting from rest but having a final speed of 2.00 m/s?

$$P = \frac{W}{t} = \frac{\frac{1}{2}mv^2 + mgh}{t}$$

$$P = \frac{.5(60.0)(2.00)^2 + (60\text{kg})(9.81\text{m/s})^2(3.00\text{m})}{3.5\text{s}}$$
$$= \frac{120\text{J} + 1764\text{J}}{3.5\text{s}} = 538\text{W}$$

More to Power

- Since power is defined as work over time and work is equal to force multiplied by displacement.

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

- Since displacement divided by time is average velocity:

$$P = \frac{W}{t} = \frac{Fdcos\Theta}{t} = F\bar{v}$$

Power & Energy Consumption

- Have to pay for energy we use.
- Energy consumed over time is:

$$E = Pt$$

- Electricity bills state energy used in kilowatt-hours(kWh) which is just power (kilowatts) times time (hours)

Class Problem

- What is the cost of running a 0.200 kW computer 6 hours per day for 30 day if the cost of electricity is \$0.12 per kW-h?
- Cost is based on energy consumed so find **E**

$$E = Pt$$

$$= (0.200\text{kW})(6.00\text{h/d})(30.0\text{d})$$

$$= 36.0 \text{ kW-h}$$

- Cost is simply given by

$$\text{cost} = (36\text{kW} - \text{h})(\$0.12 \text{ per kW} - \text{hr}) = \$4.32 \text{ month}$$

Work-Energy Theorem or Conservation of Energy

- We can either use the work-energy principle on a given object and include work done by resistance to compression and gravity in the net work, and say all of that work contributes to changing kinetic energy,
- or instead use the Law of Conservation of Energy and instead say that work done by elastic forces and gravity contributes to elastic potential energy and gravitational energy instead of kinetic energy.
- Either way is equivalent, as we have just seen.
- <https://openoregon.pressbooks.pub/bodyphysics/chapter/comparing-work-energy-and-energy-conservation/>