AP Physics I

Energy – NonConservative Force

Today...Wednesday

- Re-Review Work-Energy Homework
- Review Conservation of Energy Homework
- Review of Energy/Work so far
- NonConservative Forces
- Conservation of Energy

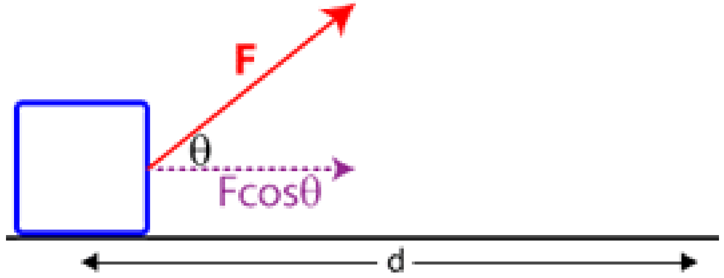
Last 6 Days

- 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

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

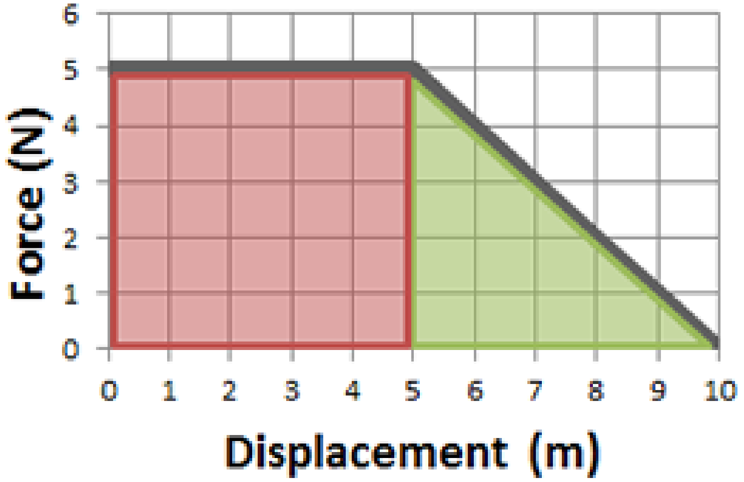
Work



Moving object by applying force – transfer of energy to the object: $W = Fd$

Only force applied in the direction of the object's displacement counts: $W = F\cos\Theta d = Fd\cos\Theta$

The area under a force vs. displacement graph is the work done by the force.



Kinetic Energy

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

Gravitational Potential Energy

$$W = Fd = mgh$$

Hooke's Law

$$|\bar{F}| = k|\bar{x}|$$

Elastic Potential Energy

$$PE = Fd = \frac{1}{2}kx^2$$

Springs & Hooke's Law

- The more you stretch a spring, the greater the force of the spring... the more you compress a spring, the greater the force.

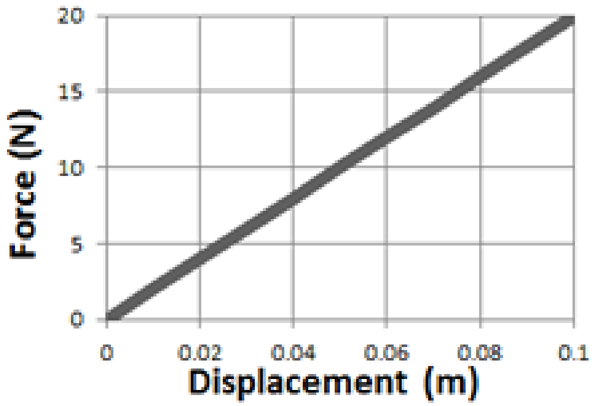
$$|\bar{F}| = k|\bar{x}|$$

- F_s is force of spring in newtons,
- x is displacement of spring from its equilibrium position
- k is spring constant how stiff or powerful a spring is, in N/m
- Larger the spring constant, k, more force the spring applies per amount of displacement.

Finding the Spring Constant

Find k by making a graph of force from a spring on the y-axis, and displacement of the spring from its equilibrium on the x-axis.

The slope of the graph will give you k.



$$k = \text{slope} = \frac{rise}{run} = \frac{\Delta F}{\Delta x} = \frac{20N - 0N}{0.1m - 0m} = 200 \text{ N/m}$$

Work must have been done to compress/stretch spring – can find that by taking the area.

Work-Energy Theorem

$$Wnet = KE_{Final} - KE_{initial}$$

$$Wnet = \frac{1}{2}mv^2 - \frac{1}{2}mv_0^2$$

Mechanical Energy

$$TME = PE + KE$$

$$ME_i = ME_f$$

$$KE_i = KE_f$$

$$E_i = E_f$$

$$KE_i + PE_i = KE_f + PE_f$$

Back to Conservative Force

- Work-energy theorem when only conservative forces are involved and that net work done by all forces acting on a system equals its change in kinetic energy.

$$Wnet = KE_{Final} - KE_{initial} = \Delta KE$$

- If only conservative forces act, then

$$W_{net} = W_c$$

- where W_c is the total work done by all conservative forces. Thus,

$$W_c = \Delta KE$$

- Now, if the conservative force, such as the gravitational force or a spring force, does work, the system loses potential energy.

$$W_c = -\Delta PE$$

- Or

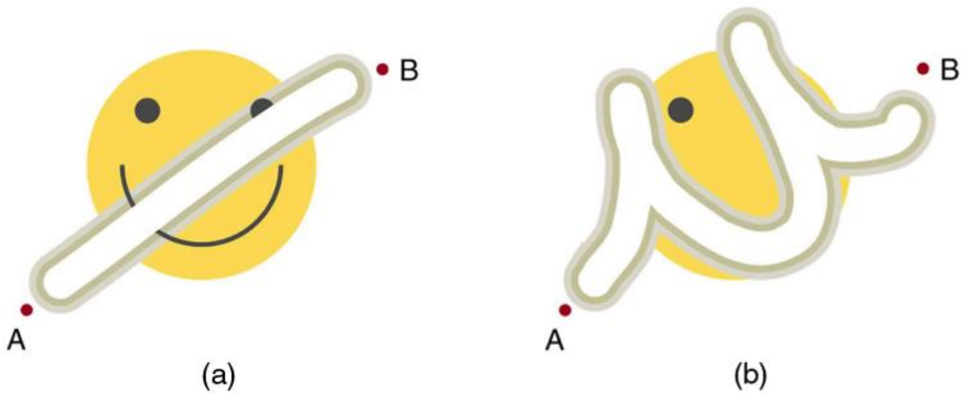
$$-\Delta PE = \Delta KE$$

Nonconservative Forces

- Work depends on the path taken.
- Because of dependence on path, there is no potential energy
- An important characteristic is that the work done by a nonconservative force *adds or removes mechanical energy from a system*.
- Furthermore, even if the thermal energy is retained or captured, it cannot be fully converted back to work, so it is lost or not recoverable in that sense as well.

Friction as a Nonconservative Force

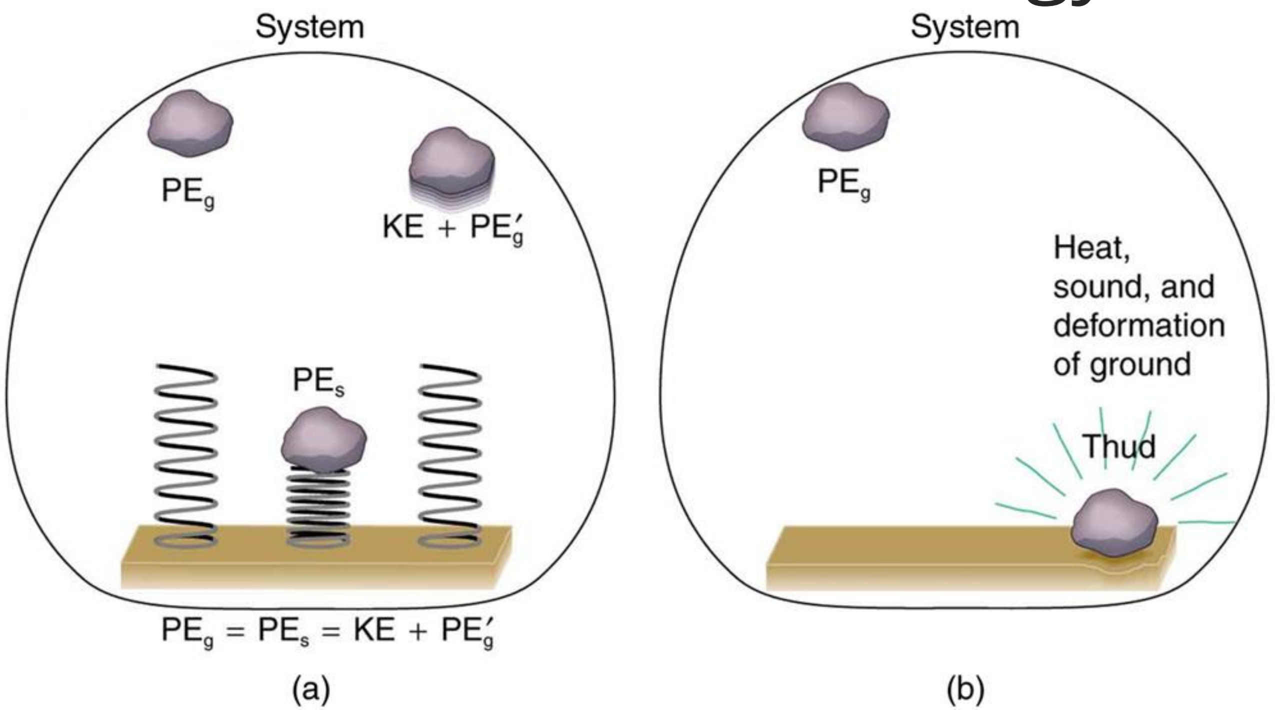
Friction is a great example.



- It is dependent on the path.
- It creates thermal energy that dissipates, removing energy from the system.

How Nonconservative Forces Affect Mechanical Energy

- Mechanical energy may not be conserved
- Example: a car is brought to a stop by friction. It loses kinetic energy which is dissipated as thermal energy which reduces its mechanical energy.



How Work-Energy Theorem Applies

- Work done by nonconservative forces equals the change in the mechanical energy of a system.
- Work-energy theorem states that the net work on a system equals the change in its kinetic energy,

$$W_{net} = \Delta KE$$

- The net work is the sum of the work by nonconservative forces plus the work by conservative forces.

$$W_{net} = W_{nc} + W_c$$

- So

$$W_{nc} + W_c = \Delta KE$$

More...

Work done by a conservative force comes from a loss of gravitational potential energy.

$$W_c = -\Delta PE$$

Substituting this equation into the previous one and solving for W_{nc} gives

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

The amount of work done by nonconservative forces adds to the mechanical energy of a system.

Affect of Nonconservative Amount of Work

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

The amount of work done by nonconservative forces adds to the mechanical energy of a system.

- If W_{nc} is positive, then ME increased .. push crate up ramp.
- If W_{nc} is negative, then ME decreased...rock hits ground.
- If W_{nc} is zero, ME is conserved.... pushing a lawn mower at constant speed over level ground. Your word done is removed by work of friction and mower has constant speed.

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

- When no change in potential energy occurs, applying the equation above amounts to the applying the work-energy theorem.
- But when seeking instead to find a change in total mechanical energy in situations that involve changes in both potential and kinetic energy,
- Can find the change in mechanical energy that would have resulted from just the conservative forces, including the potential energy changes, and add to it the work done, with the proper sign, by any nonconservative forces involved.

Class Problem

Baseball player slides to a stop on level ground. Using energy considerations, calculate the distance the 65.0-kg player slides, given that his initial speed is 6.00 m/s and the force of friction against him is a constant 450 N.

Friction stops the player by converting KE to other forms.

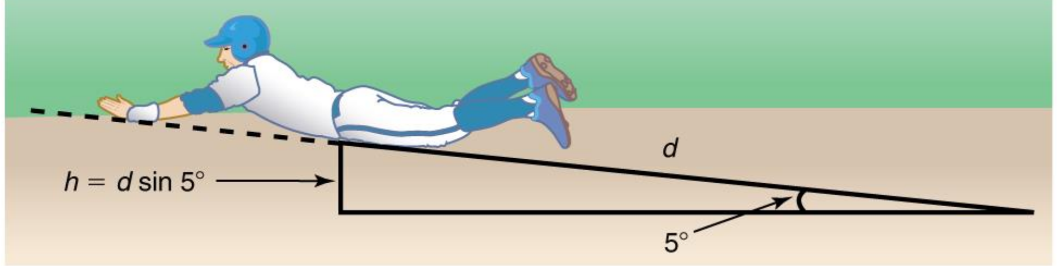
Using work-energy theorem, word done by friction which is negative is added to initial kinetic energy to reduce it to zero.

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

$$\frac{1}{2}mv_i^2 - fd = 0 \quad \Rightarrow \quad fd = \frac{1}{2}mv_i^2 \quad \Rightarrow \quad d = \frac{mv_i^2}{2f}$$

$$d = \frac{(65kg)(6.00m/s)^2}{2(450N)} = 2.60\text{m}$$

Class Problem



Now our 65.0-kg player is sliding up an incline with initial speed is 6.00 m/s and the force of friction 450 N. How far does he slide?

Friction is $W_{nc} = -fd$; $PEi = mg * 0 = 0$; $KE_i = \frac{1}{2}mv^2$

$KE_f = 0$; $PE_f = mgh = mgd\sin\theta$ for the potential energy.

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

$$\frac{1}{2}m{v_i}^2 + 0 - fd = 0 + mgd\sin\theta \Rightarrow d = \frac{1/2m{v_i}^2}{f + mg\sin\theta}$$

$$d = \frac{(.5)(65)(6.00m/s)^2}{450N + (65)(9.81)\sin(5_0)} = 2.31\text{m}$$

Homework

- Conservation of Energy Problems
- Read/watch intro to Conservation of Mechanical Energy. Possible sources:
  - Flipping Physics
  - OpenStax
  - Aplus Physics
- Write 2-4 sentences, maybe a formula. Put it in this Google Form.