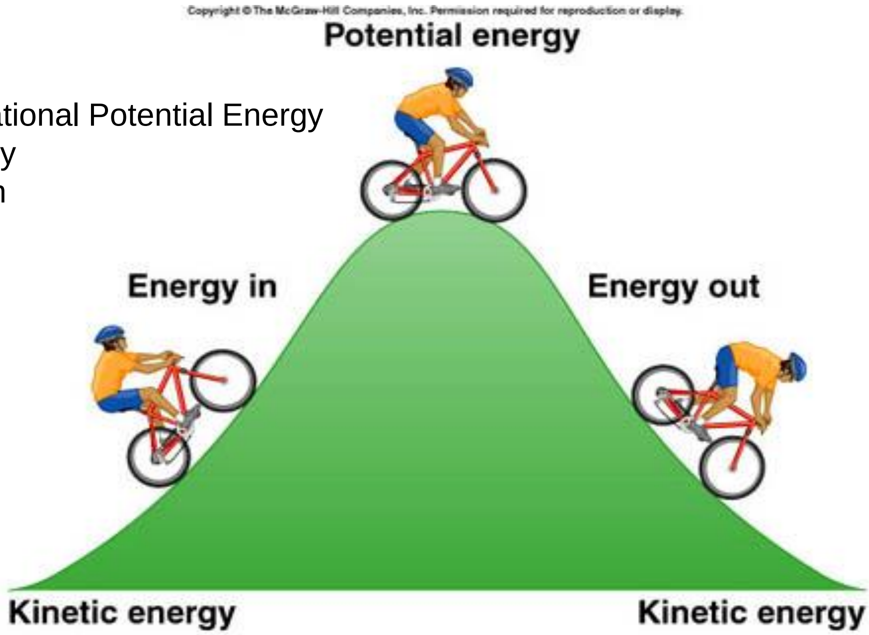
PHY131H1F - Hour 20

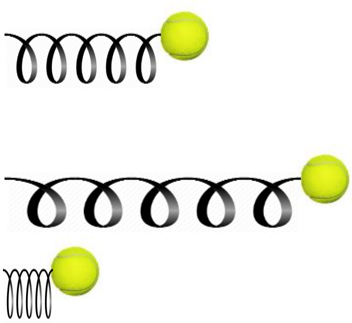
Today:

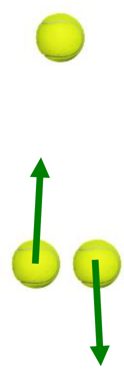
7.3 Kinetic Energy, Gravitational Potential Energy
7.4 Elastic Potential Energy
7.5 Work of Sliding Friction



Conservative Forces

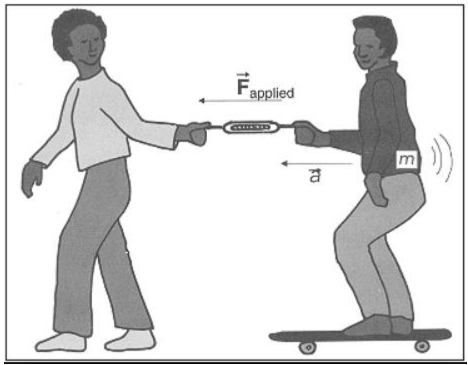
- A **conservative force** stores any work done against it, and can "give back" the stored work as kinetic energy.
- For a conservative force, the work done in moving between two points is independent of the path.
- Two examples: Gravity and Spring Force
- Also in PHY132 you will learn about the Electric Force, which is conservative.



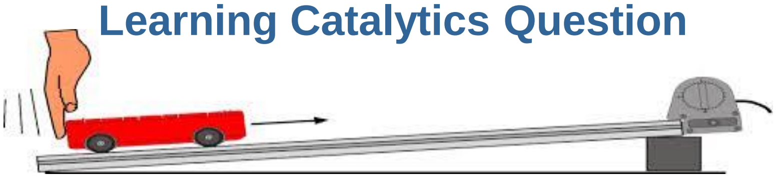


Nonconservative Forces

- A **nonconservative force** does not store work done against it, the work done may depend on path, and the work done going around a closed path need not be zero.
- Nonconservative forces include:
  - Sliding Friction
  - Pushing force of a human or animal
  - Automobile engine



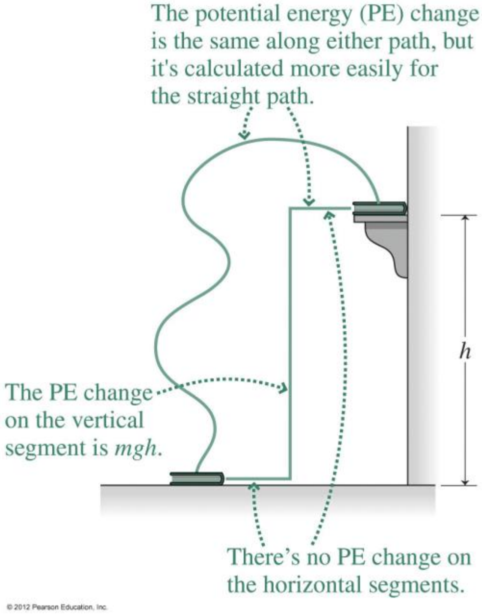
Learning Catalytics Question



A cart rolls up a frictionless incline. It starts with speed v_i, but stops near the top ($v_f = 0$). As it rolls up the ramp, its kinetic energy is transformed to

A. stopping energy.
B. gravitational potential energy.
C. energy of motion.
D. internal thermal energy.
E. energy of rest.

Gravitational Potential Energy



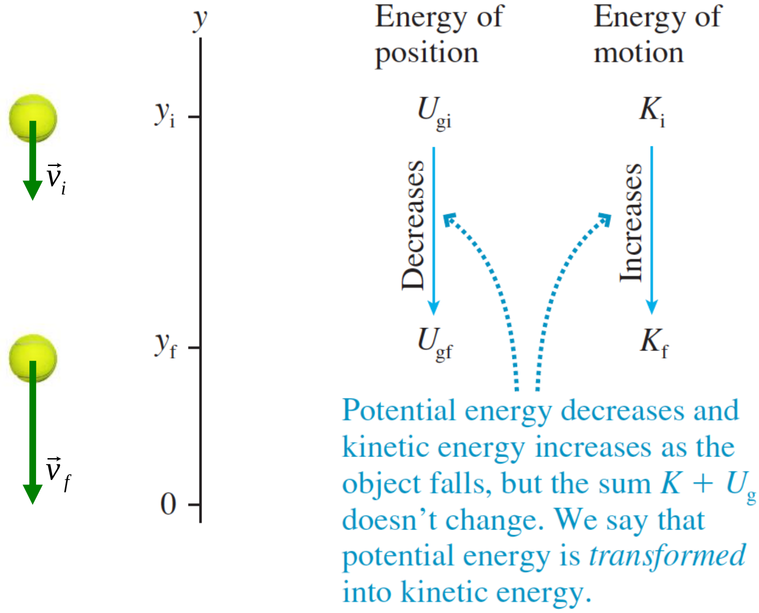
Gravitational Potential Energy

- **Gravitational potential energy** stores the work done against gravity:

$$\Delta U = mg\ \Delta y$$

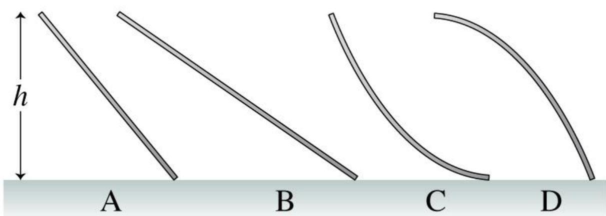
  - Gravitational potential energy increases linearly with height y.
  - This reflects the *constant* gravitational force near Earth's surface.

Another way of looking at freefall:



Learning Catalytics Question

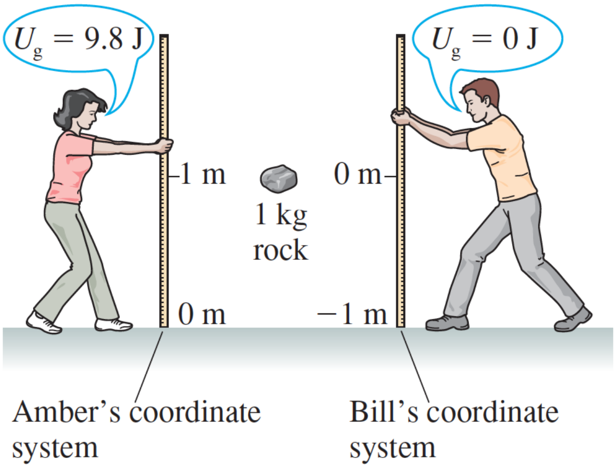
A small child slides down the four frictionless slides A–D. Each has the same height, and the child always starts from rest. Rank in order, from largest to smallest, her speeds v_A to v_D at the bottom.



A. $v_C > v_A = v_B > v_D$
B. $v_C > v_B > v_A > v_D$
C. $v_D > v_A > v_B > v_C$
D. $v_A = v_B = v_C = v_D$
E. $v_D > v_A = v_B > v_C$

NOTE: The Zero of Potential Energy

- You can place the origin of your coordinate system, and thus the "zero of potential energy," wherever you choose and be assured of getting the correct answer to a problem.
- The reason is that only ΔU_g has physical significance, not U_g itself.



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Ch.7 Example. I hold a ball at a distance of 5 m above the ground and release it from rest. How fast is it going just before it hits the ground?

Sketch and translate

Represent mathematically

Simplify and diagram

Solve and Evaluate

Ch.7 Example. Zainab runs forward with her sled at 2.0 m/s. She hops at the top of a very slippery slope. The slope is 7.0° below the horizontal, and extends down a total vertical distance of 5.0 m. What is her speed at the bottom?

Sketch and translate

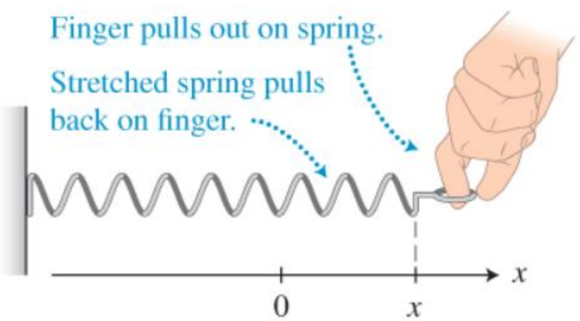
Represent mathematically

Simplify and diagram

Solve and Evaluate

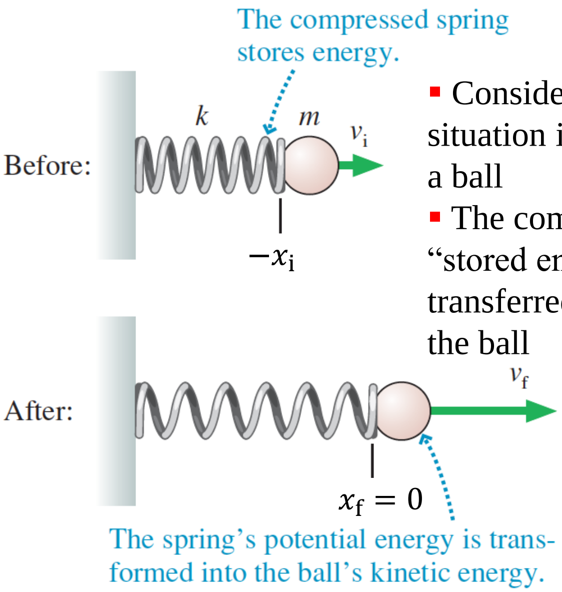
Elastic Potential Energy

- What is the work done when an Object stretches a Spring, originally at equilibrium, out to a distance x?



  - Work = Force × distance
  - Hooke's Law for a spring is: $F_{\text{O on S}} = kx$
  - Work should be (kx) × distance = kx^2
  - But keep in mind that the force the object exerts actually starts at zero (at spring equilibrium) and then increases to kx, so the average is half.
  - Therefore, the correct equation for the work done is $W = \frac{1}{2}kx^2$
  - The work done on the spring is equal to the energy you put into that spring – this is a form of Potential Energy

Elastic Potential Energy



- Consider a before-and-after situation in which a spring launches a ball
- The compressed spring has "stored energy," which is then transferred to the kinetic energy of the ball
- We define the **elastic potential energy** U_s of a spring to be:

$$U_s = \frac{1}{2}kx^2$$

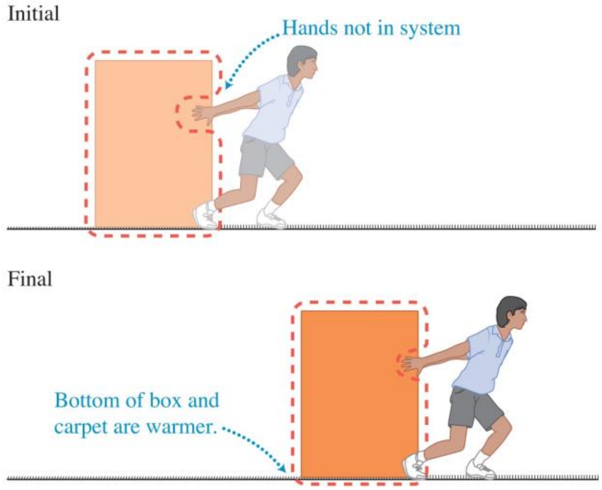
Learning Catalytics Question

A spring-loaded gun shoots a plastic ball with a speed of 4 m/s. If the spring is compressed twice as far, the ball's speed will be

A. 1 m/s.
B. 2 m/s.
C. 4 m/s.
D. 8 m/s.
E. 16 m/s.

Internal energy

- If a object slides on a surface, the surfaces in contact can become warmer.
- Structural changes in an object can occur when an external force is applied.
- The energy associated with both temperature and structure is called internal energy (symbol U_{int}).



Learning Catalytics Question

A car starts with speed v_i, but the driver puts on the brakes and the car slows to a stop. As the car is slowing down, its kinetic energy is transformed to

A. stopping energy.
B. gravitational potential energy.
C. energy of motion.
D. internal thermal energy.
E. energy of rest.

Learning Catalytics Question

A child is sliding down a playground slide at ***constant speed***.

While sliding, the energy transformation is

A. $U_g \rightarrow K$
B. $U_g \rightarrow U_{int}$
C. $K \rightarrow U_g$
D. $K \rightarrow U_{int}$
E. There is no transformation because energy is conserved.