DEVIL PHYSICS
THE BADDEST CLASS ON CAMPUS

AP PHYSICS

LSN 6-4: POTENTIAL ENERGY
LSN 6-5: CONSERVATIVE AND NONCONSERVATIVE FORCES

Questions From Reading Activity?

- Can’t help you with recipes or how to twerk.

Big Idea(s):

- The interactions of an object with other objects can be described by forces.
- Interactions between systems can result in changes in those systems.
- Changes that occur as a result of interactions are constrained by conservation laws.

Enduring Understanding(s):

- All forces share certain common characteristics when considered by observers in inertial reference frames.
- Classically, the acceleration of an object interacting with other objects can be predicted by using .

Enduring Understanding(s):

- Interactions with other objects or systems can change the total energy of a system.
- The energy of a system is conserved.

Essential Knowledge(s):

- An observer in a particular reference frame can describe the motion of an object using such quantities as position, displacement, distance, velocity, speed, and acceleration.
  - A choice of reference frame determines the direction and the magnitude of each of these quantities.

Essential Knowledge(s):

- Free-body diagrams are useful tools for visualizing forces being exerted on a single object and writing the equations that represent a physical situation.
  - An object can be drawn as if it was extracted from its environment and the interactions with the environment identified.
  - A force exerted on an object can be represented as an arrow whose length represents the magnitude of the force and whose direction shows the direction of the force.
  - A coordinate system with one axis parallel to the direction of the acceleration simplifies the translation from the free-body diagram to the algebraic representation.

Essential Knowledge(s):

- The energy of a system includes its kinetic energy, potential energy, and microscopic internal energy. Examples should include gravitational potential energy, elastic potential energy, and kinetic energy.
- Classically, an object can only have kinetic energy since potential energy requires an interaction between two or more objects.

Essential Knowledge(s):

- A system with internal structure can have potential energy. Potential energy exists within a system if the objects within that system interact with conservative forces.
  - The work done by a conservative force is independent of the path taken. The work description is used for forces external to the system. Potential energy is used when the forces are internal interactions between parts of the system.
  - Changes in the internal structure can result in changes in potential energy. Examples should include mass-spring oscillators, objects falling in a gravitational field.

Learning Objective(s):

- The student is able to create and use free-body diagrams to analyze physical situations to solve problems with motion qualitatively and quantitatively.
- The student is able to calculate the total energy of a system and justify the mathematical routines used in the calculation of component types of energy within the system whose sum is the total energy.

Learning Objective(s):

- The student is able to predict changes in the total energy of a system due to changes in position and speed of objects or frictional interactions within the system.
- The student is able to set up a representation or model showing that a single object can only have kinetic energy and use information about that object to calculate its kinetic energy.

Learning Objective(s):

- The student is able to translate between a representation of a single object, which can only have kinetic energy, and a system that includes the object, which may have both kinetic and potential energies.
- The student is able to describe and make qualitative and/or quantitative predictions about everyday examples of systems with internal potential energy.

Learning Objective(s):

- The student is able to make quantitative calculations of the internal potential energy of a system from a description or diagram of that system.
- The student is able to apply mathematical reasoning to create a description of the internal potential energy of a system from a description or diagram of the objects and interactions in that system.

Introductory Video:

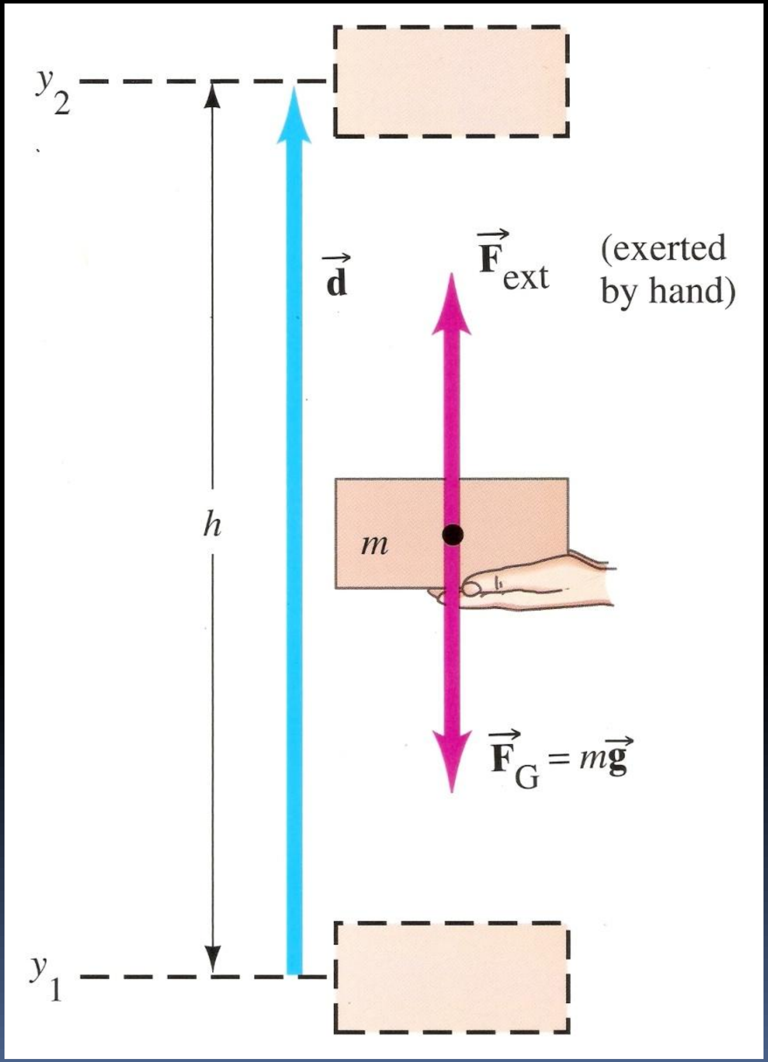
Potential and Kinetic Energy

Potential Energy

- *". . . energy associated with forces that depend on the position or configuration of a body (or bodies) and the surroundings."*
- Two main types:
  - Gravitational potential energy
  - Elastic potential energy
  - (Electrical potential energy)
  - (Chemical potential energy)

Gravitational Potential Energy

- The energy of position
- If we hold a brick at some height above an object, the brick has energy because it has the ability to do work
- That ability to do work is because of gravity which exerts a force on the brick



Gravitational Potential Energy

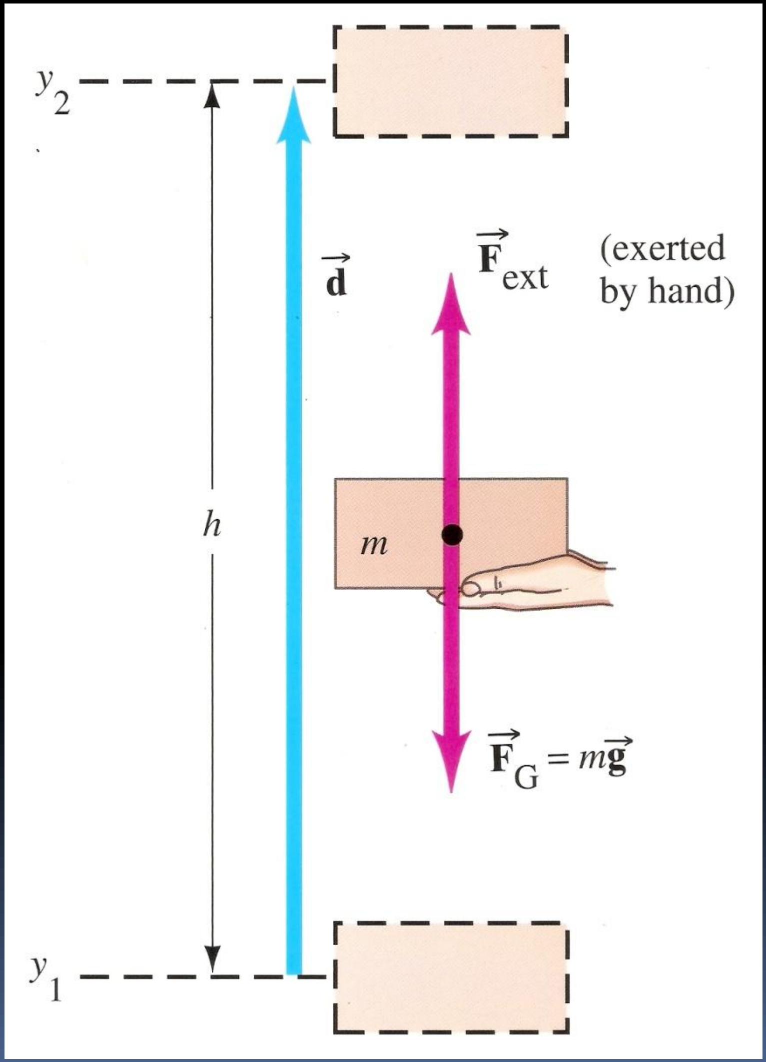
- In order to raise the brick (at constant velocity to height y_2, we had to do work

$$W = Fd$$

$$F = mg$$

$$d = h$$

$$W = mgh$$



Gravitational Potential Energy

- This work is stored as gravitational potential energy

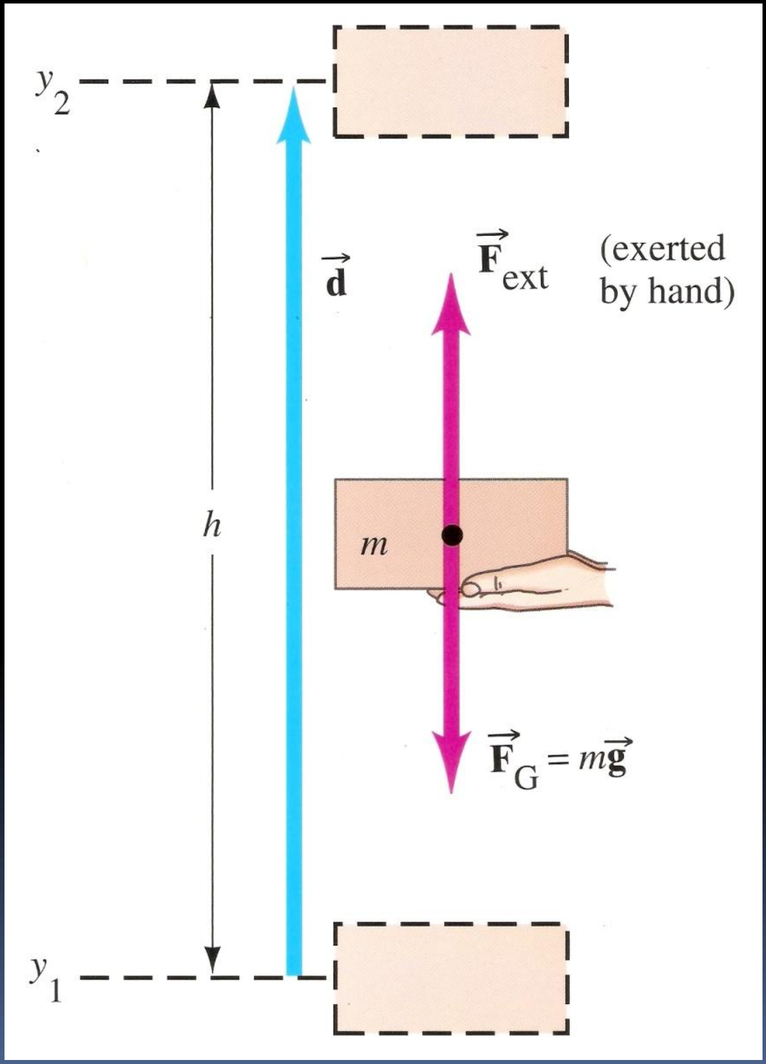
$$W = mgh$$

$$h = y_2 - y_1$$

$$W = mgy_2 - mgy_1$$

$$PE_{grav} = mgy$$

$$W = \Delta E = \Delta PE$$

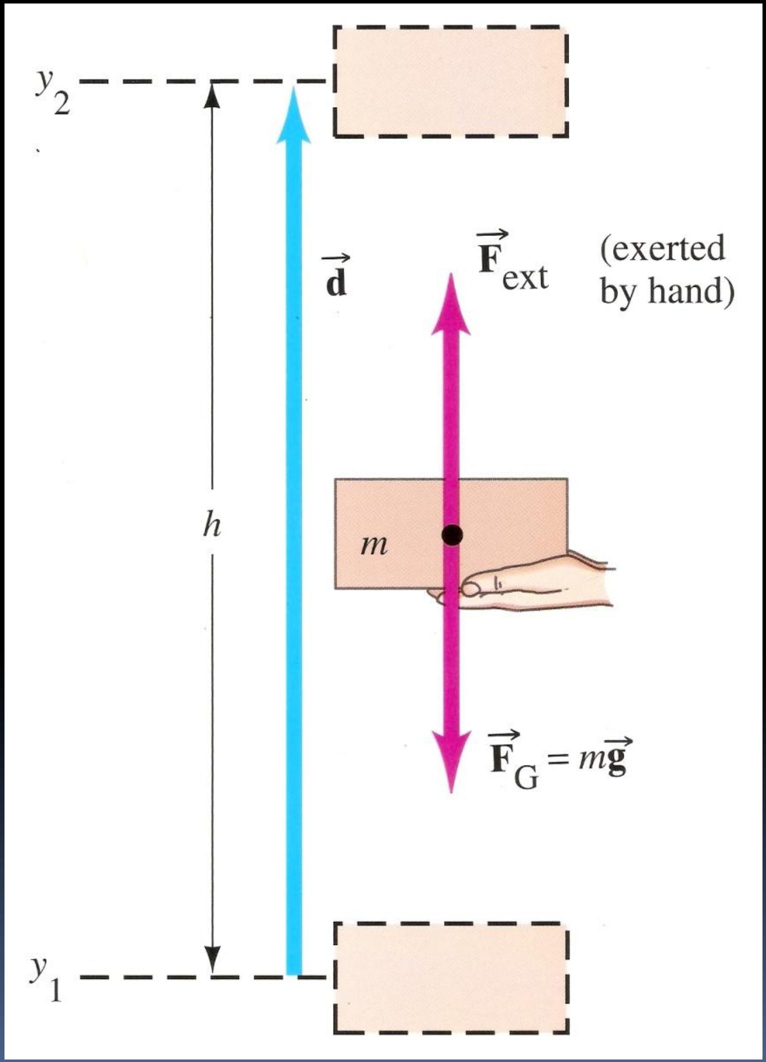


Gravitational Potential Energy

- Potential Energy is dependent on the reference level
  - y_2 with respect to y_1
  - y_1 with respect to y_2
  - y_2 with respect to present
  - y_1 with respect to present

$$PE_{grav} = mgy$$

$$W = \Delta PE$$

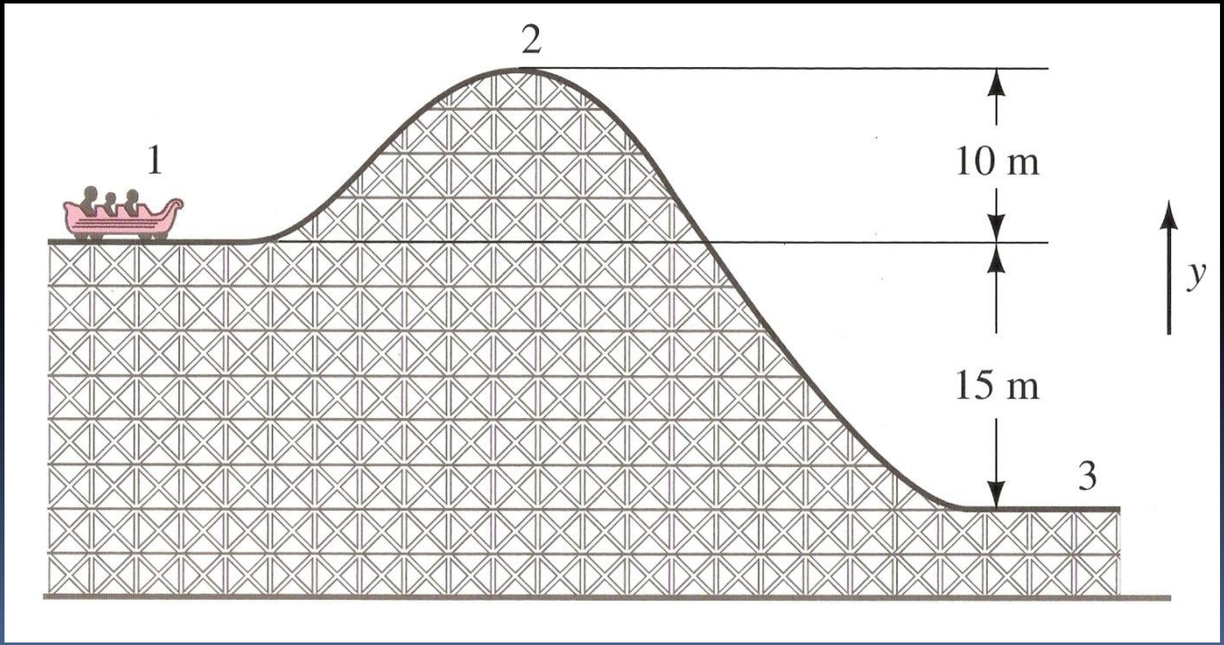


Gravitational Potential Energy

- Potential Energy is dependent on the reference level
- Think in terms of work equal to the change in potential energy

$$PE_{grav} = mgy$$

$$W = \Delta PE$$

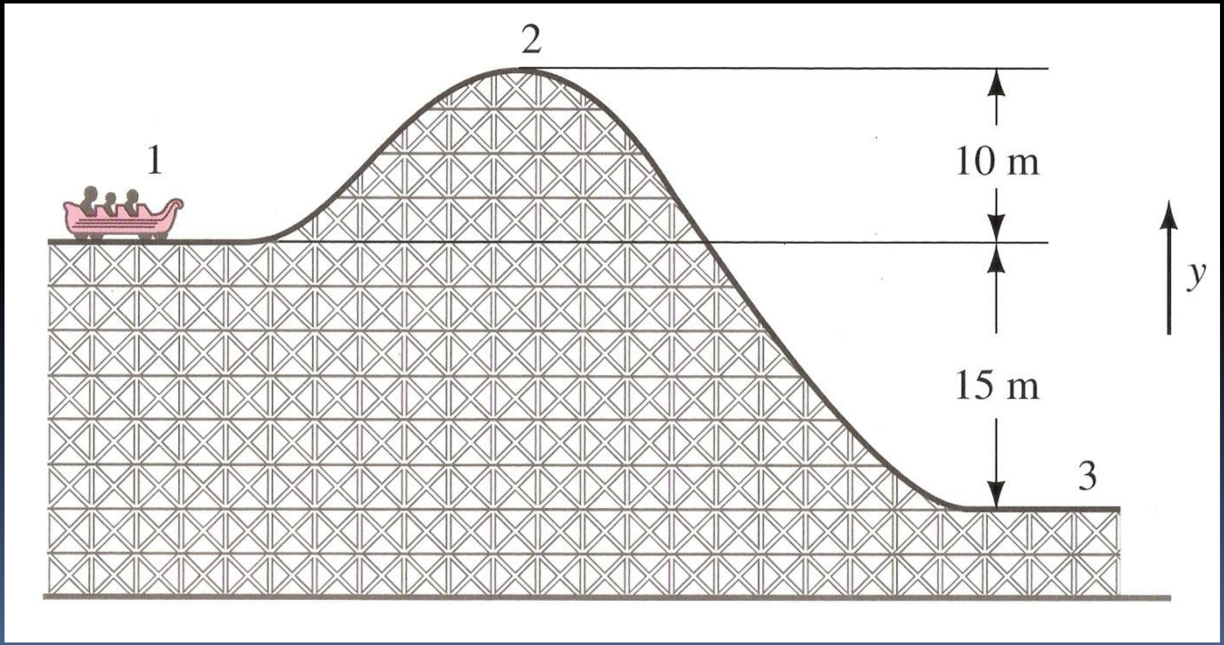


Gravitational Potential Energy

- *If the weight of the cart is 1000 N, what is its potential energy at 1, 2 and 3?*

$$PE_{grav} = mgy$$

$$W = \Delta PE$$



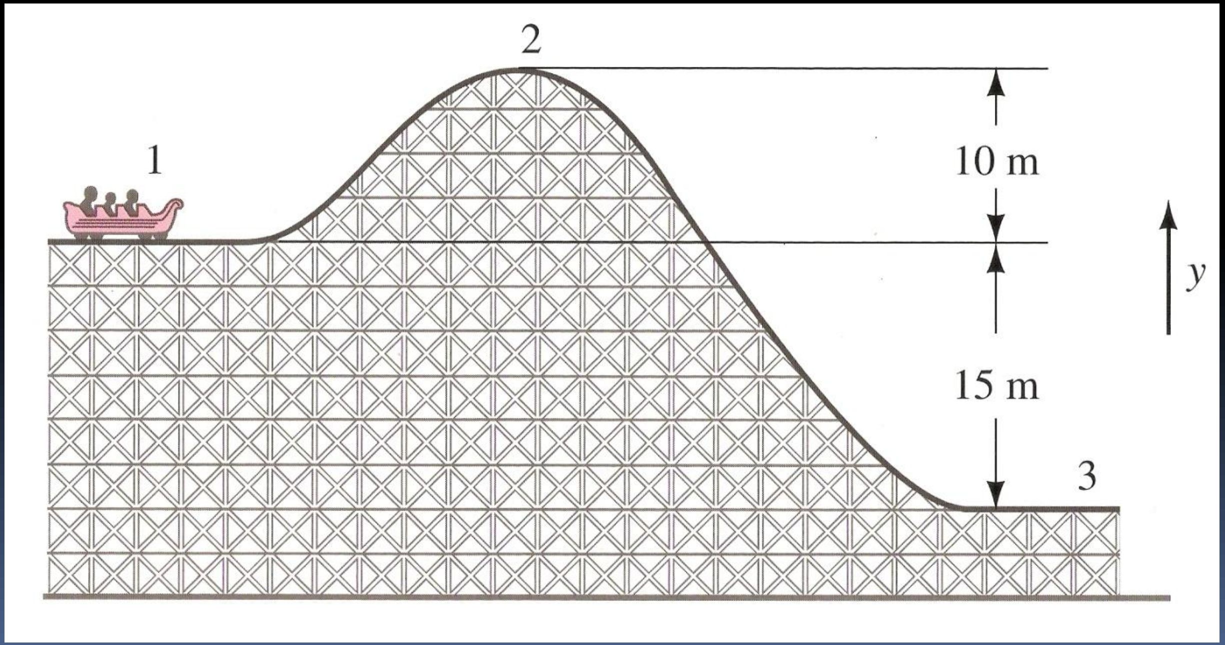
Gravitational Potential Energy

- *If the weight of the cart is 1000 N, what is its potential energy at 1, 2 and 3?*
  - **1. 15,000 J**
  - **2. 25,000 J**
  - **3. 0 J**

If we use y = 0 at point #3

$$PE_{grav} = mgy$$

$$W = \Delta PE$$

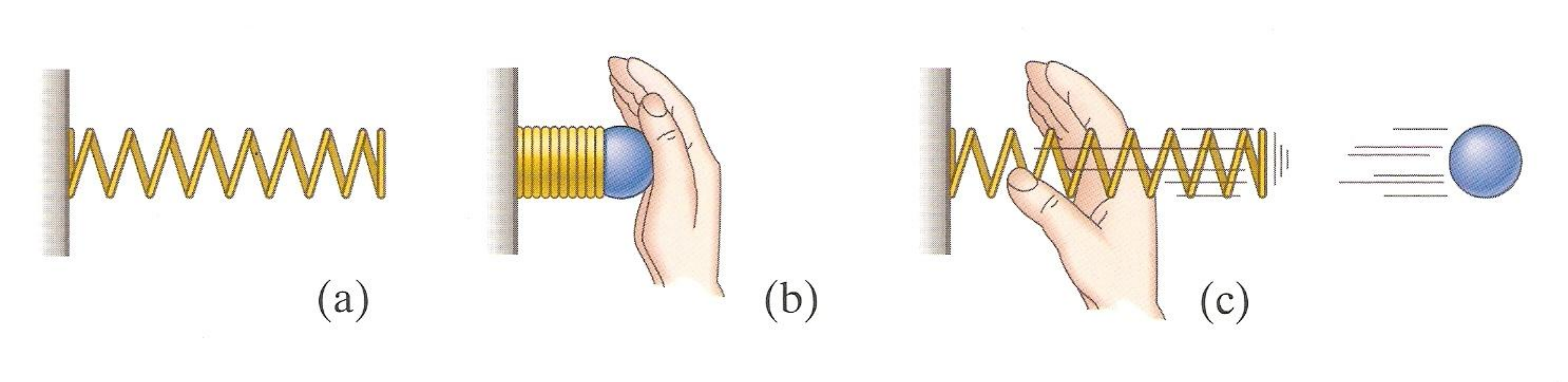


Potential Energy

- *" . . . change in potential energy associated with a particular force, is equal to the negative of the work done by that force if the object is moved from one point to a second point."*
- *" . . . change in potential energy is the work required of an external force to move the object without acceleration between the two points."*

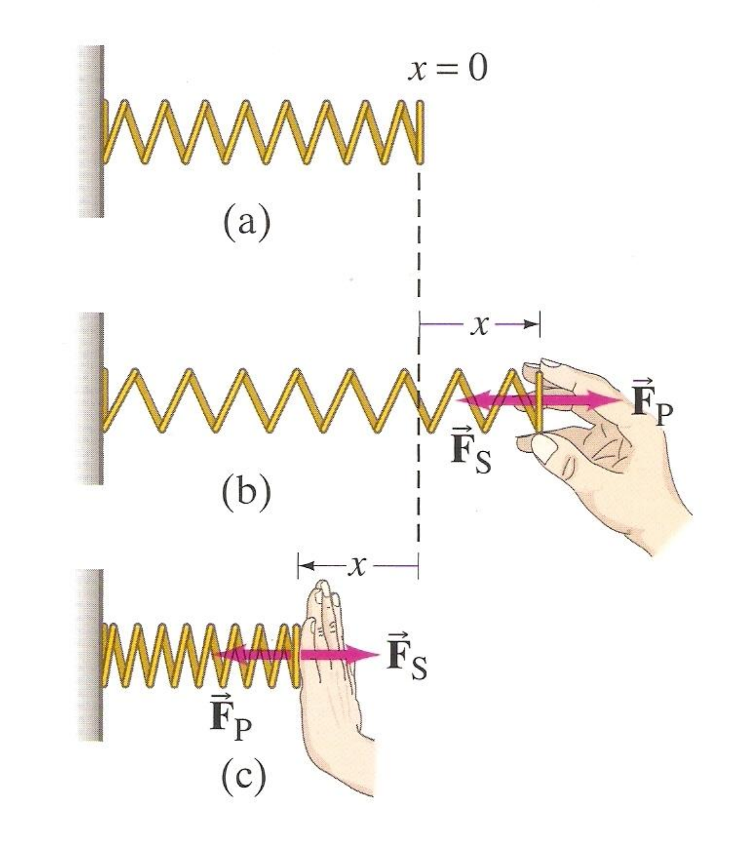
Elastic Potential Energy

- It takes work to compress a spring
- A compressed spring has the ability to do work so,
- The work done in compressing a spring is saved as potential energy



Elastic Potential Energy

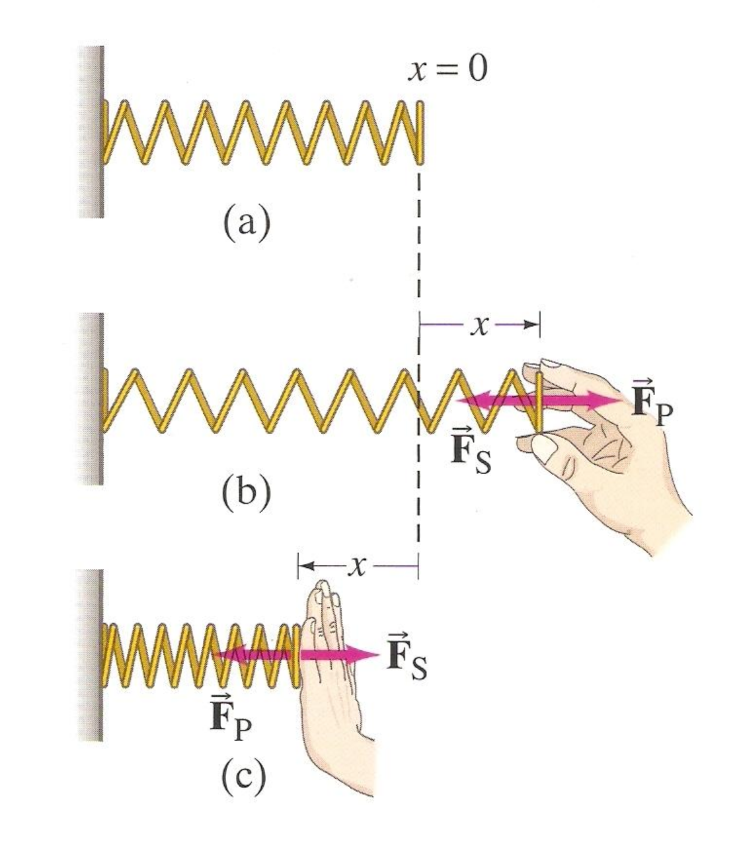
- A bi-directional spring works in both stretching and pushing
- We find that it takes the same amount of work (Fd) to stretch a spring a given distance as it does to push the spring the same distance



$$F_{stretch}d = F_{push}d$$

Elastic Potential Energy

- We also find that the further we stretch or compress a spring, the more force it takes
- In fact, the force required is directly proportional to the distance ***x*** the spring is displaced

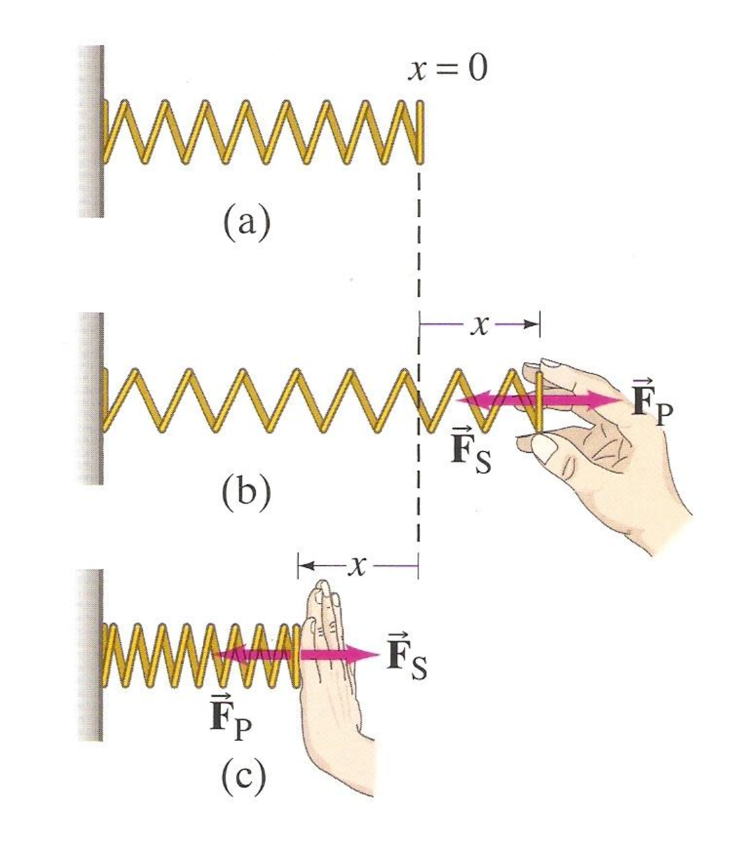


$$F = kx$$

k **is called the *spring constant* (N/m)**

Elastic Potential Energy

- In order to find the potential energy of a stretched or compressed spring, we need to find the work needed to stretch or compress it

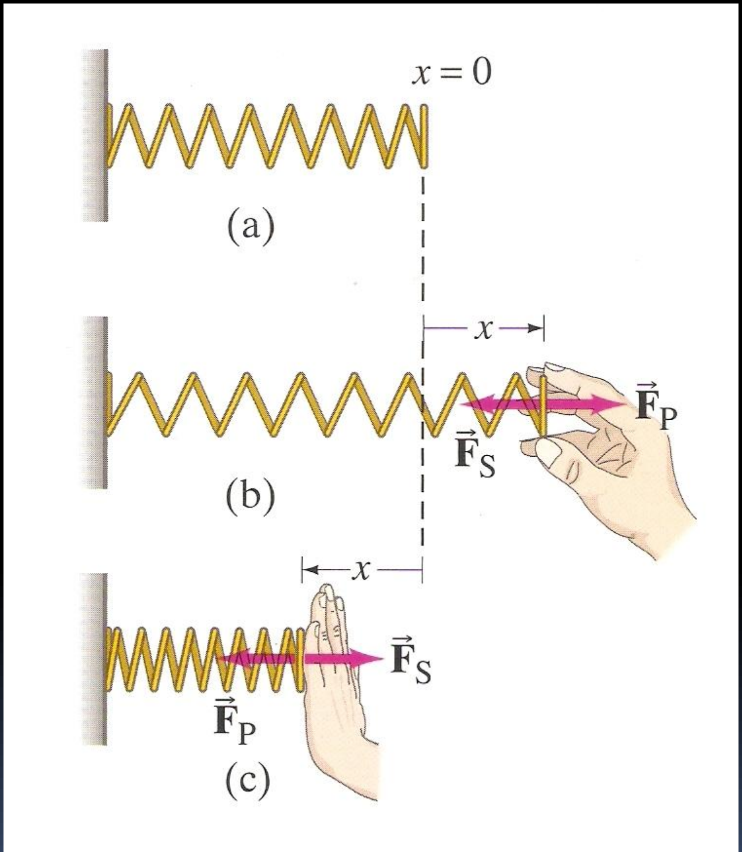


$$F = kx$$

Elastic Potential Energy

- You might think that

$$F = kx$$
$$W = Fd$$
$$d = x$$
$$W = kx^2$$



- ***But this is not the case***

$$W \neq kx^2$$

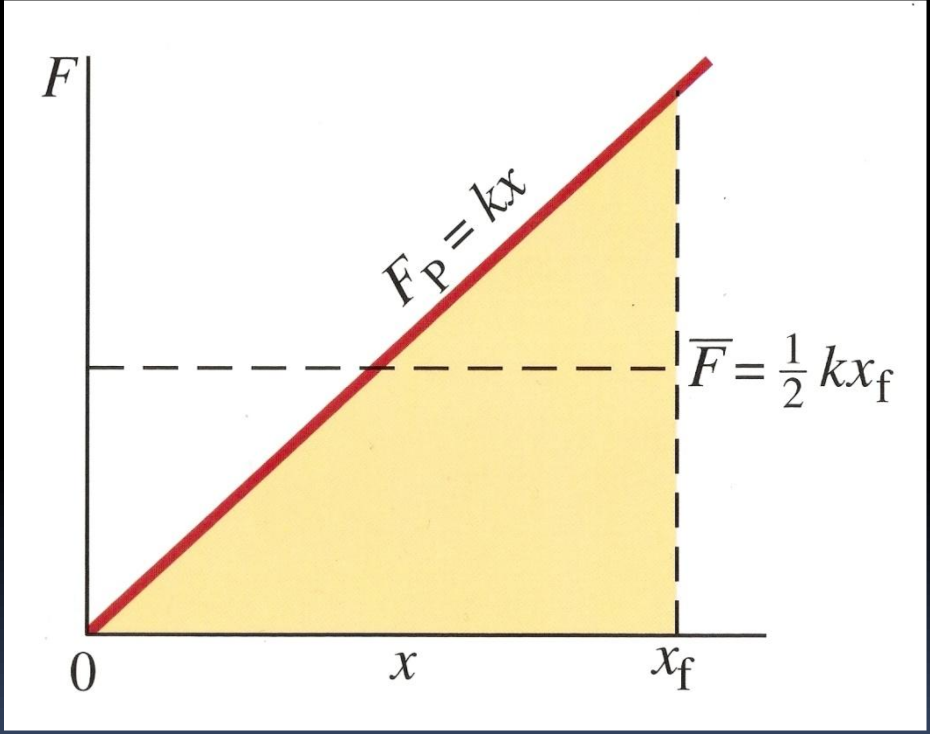
Elastic Potential Energy

- The force required constantly changes as the distance increases
- So, we have to use the average force,

$$\overline{F} = \frac{kx_i + kx_f}{2}$$

$$kx_i = 0$$

$$\overline{F} = \frac{1}{2}kx_f$$



Elastic Potential Energy

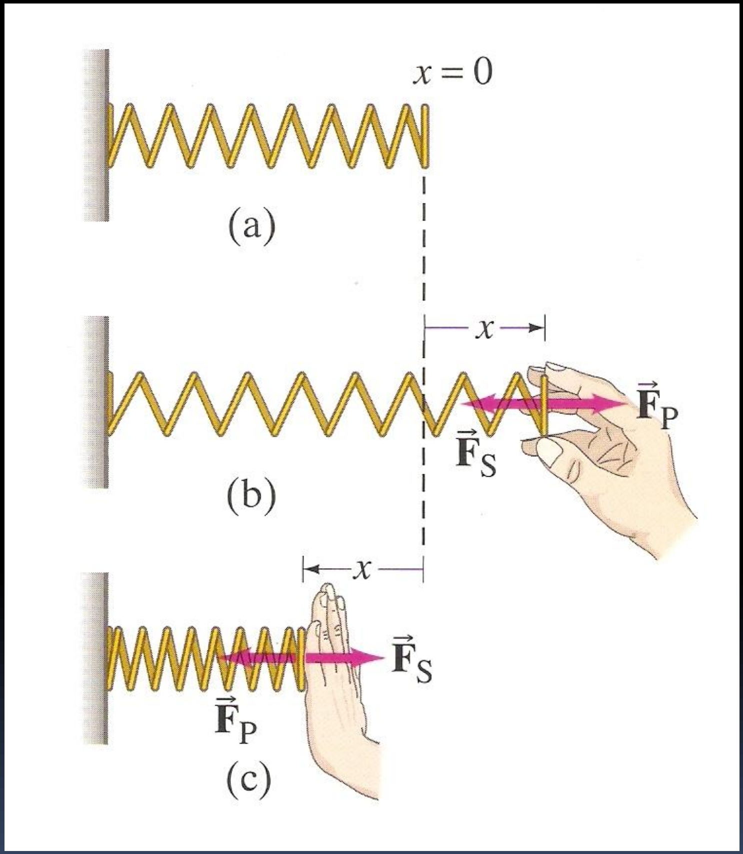
- Now we can find the elastic potential energy

$$\overline{F} = \frac{1}{2}kx_f$$

$$W = \Delta PE = \overline{F}d$$

$$PE_{elas} = \left(\frac{1}{2}kx\right)(x)$$

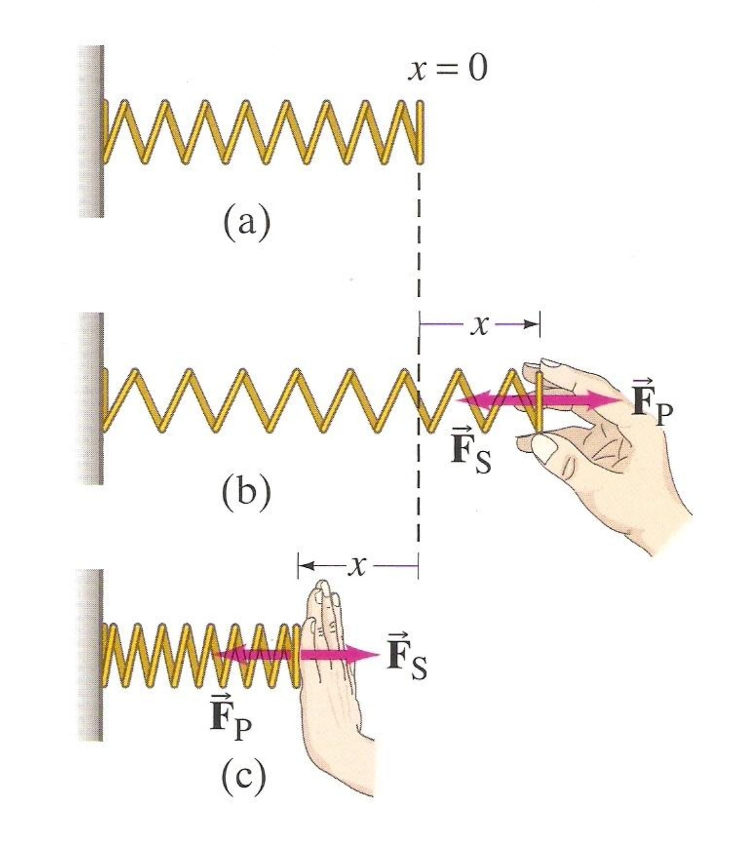
$$PE_{elas} = \frac{1}{2}kx^2$$



Elastic Potential Energy

- This is called Hooke's Law or the spring equation
- ***k*** is known as the spring constant

$$PE_{elas} = \frac{1}{2}kx^2$$



Conservative and Nonconservative Forces

- What are the characteristics of conservative forces?

- What are the characteristics of nonconservative forces?

Conservative and Nonconservative Forces

- What are the characteristics of conservative forces?
  - Does work
  - Allows progress, i.e. movement forward
  - Generally produces positive energy
- What are the characteristics of nonconservative forces?

Conservative and Nonconservative Forces

- What are the characteristics of conservative forces?
  - Does work
  - Allows progress, i.e. movement forward
  - Generally produces positive energy
- What are the characteristics of nonconservative forces?
  - Opposes work
  - Inhibits progress
  - Generally produces negative or wasteful energy

Conservative and Nonconservative Forces

- Conservative Forces
  - The work done ***does not*** depend on the path taken, but only on the initial and final positions (displacement)
  - It doesn’t matter what route you take to get up a hill, the work depends on the change in height (PE)
- Nonconservative Forces
  - The work done ***does*** depend on the path taken
  - Friction constantly opposes motion throughout the path taken

Conservative and Nonconservative Forces

TABLE 6–1 Conservative and Nonconservative Forces

Conservative Forces	Nonconservative Forces
Gravitational	Friction
Elastic	Air resistance
Electric	Tension in cord
	Motor or rocket propulsion
	Push or pull by a person

Conservative and Nonconservative Forces

- Potential Energy
  - Since potential energy is dependent on a difference of positions, potential energy can only be defined for a conservative force

Work-Energy Principle

- Net Work is equal to the sum of the work done by conservative and nonconservative forces

- Work done by nonconservative forces is equal to the sum of the changes in PE and KE

$$Work_{Net} = W_C + W_{NC}$$

$$Work_{Net} = \Delta KE$$

$$W_C = -\Delta PE$$

$$\Delta KE = -\Delta PE + W_{NC}$$

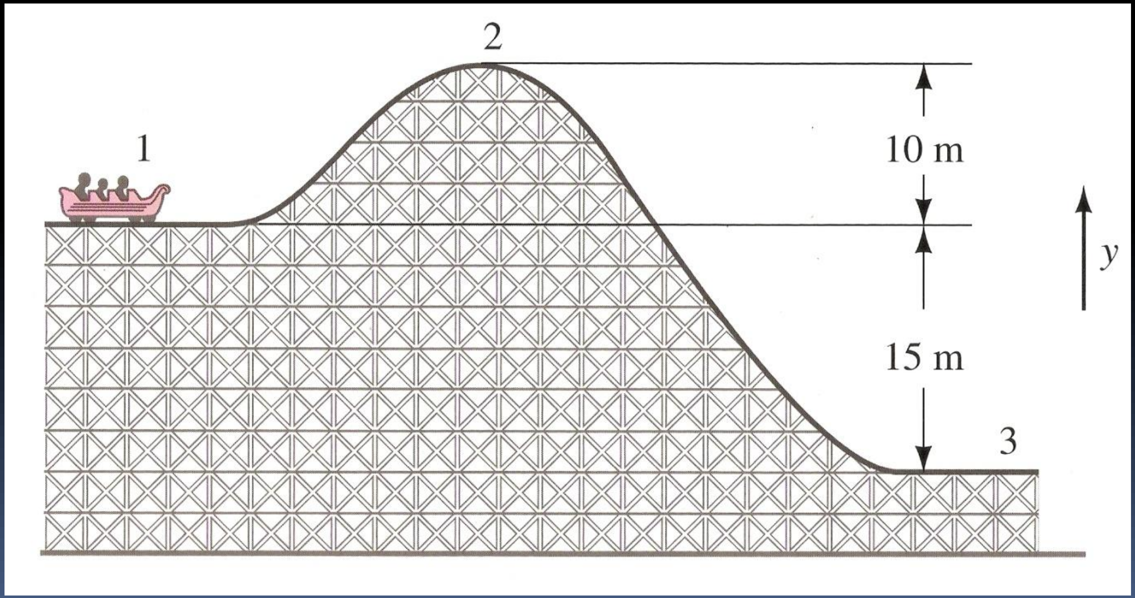
$$W_{NC} = \Delta KE + \Delta PE$$

Work-Energy Principle

- Work done by nonconservative forces is equal to the sum of the changes in PE and KE
- ***If energy is lost, it is due to work done by nonconservative forces***

$$W_{NC} = \Delta KE + \Delta PE$$

$$KE_1 + PE_1 = KE_2 + PE_2 + W_{NC}$$



Summary: Wiley Coyote Demonstrates Potential, Gravitational and Elastic Energy

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QUESTIONS?

Homework

#26-32