Lecture 17: Potential Energy

Warm-Up Activity

Question?

(A) Answer?

A Deeper Model for Interactions

- Quantities
  - Energy E
  - Work $W = \int_{r_i}^{r_f} \vec{F} \cdot d\vec{r}$
  - Kinetic Energy $K = \frac{1}{2}mv^2$
- Laws
  - Work-energy theorem $W_{\text{net,ext}} = \Delta E_{\text{total}}$

Potential Energy

- Potential energy is present when there is an *internal* interaction between objects within a system.
- How do we figure out how much potential energy something has?
  - We can look at the work that the internal interaction would have done if it were external.
- For special kinds of internal forces (called *conservative* forces):

$$\Delta U = -W_{\text{internal}}$$

Questions	System 1: Tennis Ball	System 2: Tennis Ball + Earth
External forces?	Gravity	None
$W_{\text{net,ext}}$	$+mgh$	0
ΔE_{total}	$+mgh$	0
What kinds of E are there and how have they changed?	Kinetic energy increases.	Kinetic energy increases. Potential energy decreases.

L17-1: Gravitational Potential Energy

You drop a tennis ball (mass m) off the top of a tall building (height h).

Questions	System 1: Tennis Ball	System 2: Tennis Ball + Earth
External forces?		
$W_{\text{net,ext}}$		
ΔE_{total}		
What kinds of E are there and how have they changed?		

Gravitational Potential Energy

When a mass m in a system changes its height by an amount Δh:

(A) If we don't include the Earth in the system, then the Earth does work on the system equal to

$$W_g = -mg\Delta h.$$

This changes the total energy of the system.

(B) If we include the Earth in the system, then the potential energy of the system changes by an amount

$$\Delta U_g = mg\Delta h.$$

This does not change the total energy of the system.

Other Kinds of Energy

In PH 212, you will work with rotational kinetic energy and the energy carried by different types of waves, and in PH 213, you will work with electric potential energy.

There are other kinds of energy. To name just a few, you might deal with chemical energy in some situations, or perhaps you could think about the energy stored in pressurized gas (thermodynamics will teach you a lot about how changes in pressure and volume will affect the temperature of a gas).

A Deeper Model for Interactions

- Quantities
  - Energy E
  - Work $W = \int_{r_i}^{r_f} \vec{F} \cdot d\vec{r}$
  - Kinetic Energy $K = \frac{1}{2}mv^2$
  - Potential Energy $U =$ depends on interaction

    You have to tell everyone where zero PE is!
    - Gravity $U_g = mgy$
    - Spring $U_{sp} = \frac{1}{2}kx^2$
- Laws
  - Work-energy theorem $W_{\text{net,ext}} = \Delta E_{\text{total}}$

(B) 600 J
The displacement is squared ($U_{sp} = \frac{1}{2}kx^2$), so it doesn't matter if it is positive or negative. The same amount of stretch or compression stores the same amount of energy.

L17-2: Stretch vs. Compression

- A spring's potential energy is 0 J at $x = 0$ (equilibrium).
- When you stretch the spring to the right ($x = +3$ cm), the spring's potential energy is 600 J.
- What is the spring's potential energy when you compress the spring to the left ($x = -3cm$)?

(A) 1200 J
(B) 600 J
(C) 0 J
(D) -600 J
(E) -1200 J

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(D) −600 J

If you can change to a lower height, you can always decrease gravitational potential energy. There is always more energy to access, even if you start at zero. The choice of zero is arbitrary; the change in potential energy is what matters.

L17-3: Second Floor vs. Basement

- An object's gravitational potential energy with the Earth is 0 J on the **first floor**.
- On the **second floor**, 3 meters above the first floor, the gravitational potential energy is 600 J.
- What is the gravitational potential energy when the object is in the basement (3 meters underground)?

(A) 1200 J

(B) 600 J

(C) 0 J

(D) −600 J

(E) −1200 J

Main Ideas

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