AP Physics I

Energy – Conservation of Energy

Today…Tuesday

- Review Work-Energy Homework
- Mechanical Energy
- Conservative Forces
- Conservation of Energy

Last 7 Days

- Wednesday: Non Conservative Forces
- 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

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

Mechanical Energy

- Total mechanical energy in a system to be kinetic energy plus potential energy.

$$\mathrm{TME} = \mathrm{PE} + \mathrm{KE}$$

- Energy possessed by an object due to its motion or position.
- Non-mechanical energy includes chemical potential, nuclear and thermal.

Conservative Forces

Two types of forces; conservative forces and non-conservative forces.

- In short, conservative forces are derived from a potential, while non-conservative forces are not.
- Conservative forces are also path independent and conserve mechanical energy (thus the name conservative force),
- while non-conservative forces are path dependent and do not conserve mechanical energy.

Comarison Table

Conservative Forces	Non-Conservative Forces
Derived from a potential	Not derived from any particular quantity
Conserve mechanical energy	Do not conserve mechanical energy
Path independent	Path dependent
Examples: gravitational forces, magnetic forces	Examples: friction, air resistance, viscous forces

Law of Conservation of Energy

Energy can be changed into different forms, and transferred from system to system, but it never magically disappears or reappears.

In the world of physics, we can never truly destroy energy. The understanding that the total amount of energy in the universe remains fixed is known as the **law of conservation of energy**.

Total energy is always conversed in any closed system.

If you neglect effects of friction – can state it is a constant.

Formula

$$ME_i = ME_f$$

When $W_{friction} = 0$
and $W_{Fa} = 0$

$$E_i = E_f$$

OR

$$KE_i = KE_f$$

$$KE_i + PE_i = KE_f + PE_f$$

Conservative forces only!

Class Problem

F/A-18 Hornet jet fighter with a mass of 20,000 kg flying at an altitude of 10,000 m above the Earth's surface with velocity of 250 m/s.

What is the total mechanical energy of the jet fighter?

$$\mathrm{TME} = \mathrm{PE_g} + \mathrm{KE}$$

$$\mathrm{TME} = \mathrm{mgh} + \frac{1}{2}mv^2$$

$$= (20000\mathrm{kg})(9.81\ \mathrm{m/s^2})(10000\mathrm{m}) + ½(20000\mathrm{kg})(250\mathrm{m/s})^2$$

$$= 2.59\ \mathrm{x10_9J}$$

Part 2

The Hornet dives down to an altitude of 2,000 meters above Earth’s surface.

Total mechanical energy remains constant, and the gravitational potential energy of the fighter decreases, therefore the kinetic energy of the fighter must increase.

The fighter's velocity goes up as a result of flying closer to the Earth!

For this reason, a key concept in successful dogfighting taught to military pilots is that of energy conservation.

Find New Velocity

It has a new height but its total mechanical energy must remain constant.

$$\mathrm{TME} = \mathrm{PE_g} + \mathrm{KE}$$

$$\mathrm{TME} = \mathrm{mgh} + \frac{1}{2}mv^2$$

$$\frac{1}{2}mv^2 = \mathrm{mgh} + \mathrm{TME}$$

$$\mathrm{v} = \sqrt{\frac{2(TME - mgh)}{m}} = \sqrt{\frac{2(2.59\ \mathrm{x}109\mathrm{J} - (20000\mathrm{kg})(9.81\ \mathrm{m/s^2})(20000\mathrm{m}))}{20000kg}}$$

$$= 4.69\ \mathrm{m/s}$$

The Hornet has almost doubled its speed by "trading in" 8000m of altitude!

Class Problem 2

We are going to take another look at free fall but we are going to solve it two ways: Kinematics approach and Conservation of Energy Approach.

Ready?

An object falls from a height of 10m above the ground. Neglecting air resistance, find its velocity the moment before the object strikes the ground.

Two Approaches

Object falls from a height of 10m above the ground. Neglecting air resistance, find velocity moment before strikes gro

Conservation of Energy

Energy of objects at its highest point must equal energy of object at lowest point:

$$ME_{top} = Me_{bottom}$$

$$PE_{top} = Ke_{bottom}$$

$$mgh_{top} = \frac{1}{2} m v_{bottom}^{\ 2}$$

$$V_{bottom} = \sqrt{2gh}$$

$$= \sqrt{2(9.81\ m/s^2)(10m)}$$

$$= 14\text{m/s}$$

Kinematics

Given:

$v_i = 0$

$d = 10\text{m}$

$a = 9.81\ \text{m/s}^2$

Find:

v

For an object in free fall, its initial velocity must be zero, its displacement is 10m, & the acceleration due to gravity is 9.81 m/s². Choosing down as the positive direction:

Use: $\boldsymbol{v^2 = v_0^{\ 2} + 2a_x(x - x_0)}$

$$v = \sqrt{v_o^{\ 2} + 2ad}$$

$$v = \sqrt{2(9.81\ m/s^2)(10m)}$$

$$v = 14\text{m/s}$$

Homework

- Finish Work-Energy Theorem homework from Monday.
- Attempt all problems on Conservation of Energy homework from Today.
- Read Nonconservative Forces in OpenStax - https://openstax.org/books/college-physics-ap-courses/pages/7-5-nonconservative-forces