Physics 9, February 7, 2008

Collect Assignment #1

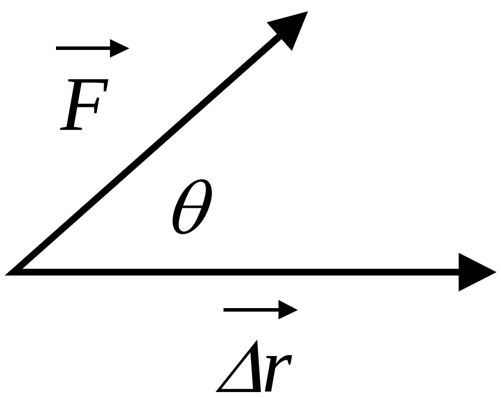
Conservation of Energy

Examples of Conservation of Energy

A Laboratory Test of Conservation of Energy

Work - Physics Definition

$$W = \vec{F} \cdot \Delta\vec{r} = F\Delta r\cos(\theta)$$



Why do we use this peculiar definition of Work?

This definition yields the Work-Kinetic energy theorem.

Total Work done on an object
= Change in the Kinetic energy.

$$\boxed{W = \Delta K = K_{final} - K_{initial}}$$

Note: This theorem can be derived from Newton's Laws

Gravity - an important example

$F = m\,g$ = weight (downward)

Newton's 2nd => $F = m\,a = mg$

=> $a = g = 9.8\ m/s^2 = 32\ ft/s^2$

All things freefall with the same acceleration! (Galileo)

How much work is done by gravity?

If we move up from an initial position to a final position, the force opposes the motion.

$$\text{Work} = -F\Delta z = -mg\,(z_{final} - z_{initial})$$

$$\text{Work} = mg\,(z_{initial} - z_{final})$$

If gravity is the only force doing work on an object, what does the Work - KE theorem have to say?

$$W = \Delta K = K_{final} - K_{initial}$$

$$W = mg\,(z_{initial} - z_{final}) = K_{final} - K_{initial}$$

$$K_{initial} + mg\,z_{initial} = K_{final} + mgz_{final}$$

Hmmm - Something looks to be the same at both positions (it is conserved).

Gravitational Potential

Define the gravitational potential to be
$U = mgz$

$$K_{initial} + U_{initial} = K_{final} + U_{final}$$

So $E = K + U$ is a conserved quantity.
We call it the Mechanical Energy

$$E_{initial} = E_{final}$$

Example 1: drop a ball from a height h_0.

Mechanical Energy = mgh_0

Conservation of Energy implies that at any distance h above the surface

$$E = K + U$$

$$mgh_0 = \tfrac{1}{2}mv^2 + mgh$$

$$\tfrac{1}{2}mv^2 = mgh_0 - mgh = mg(h_0 - h)$$

$$v^2 = 2g(h_0 - h)$$

How fast does the ball hit the floor if I drop it from 1 m?

$$v^2 = 2g(h_0 - h)$$

$$v = \sqrt{2g(h_0 - h)} = \sqrt{2gh_0}$$

$$v = \sqrt{2gh_0} = \sqrt{2 \times (9.8m/s^2) \times 1m}$$

$$v = \sqrt{19.6(m^2/s^2)} = 4.4m/s$$

Throw a ball up.

How much does the balls speed change between when I release the ball and when I catch it?

$$E = K_0 + U_0 = K + U$$

$$\tfrac{1}{2} m v_0{}^2 + mgh_0 = \tfrac{1}{2} m v^2 + mgh$$

$$\tfrac{1}{2} m v^2 - \tfrac{1}{2} m v_0{}^2 = mgh_0 - mgh$$

$$v^2 - v_0{}^2 = 2g(h_0 - h)$$

So if $h = h_0$ then the speeds are equal.

(not the velocities!)

Alligator

What forces do work on the alligator?

What is the speed of the alligator at various points along the track?

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$$v^2 = 2g(h_0 - h)$$

$$v = \sqrt{2g(h_0 - h)}$$

Pendulum

What forces do work on the pendulum?

What is the speed of the pendulum at various points along its trajectory?

The equations are identical to before!

$$v = \sqrt{2g(h_0 - h)}$$

What happens when $h > h_0$?

The velocity squared is negative?

This can't happen. Conservation of energy implies that the height will never exceed the initial height.

Do I really believe in

Conservation of Energy?