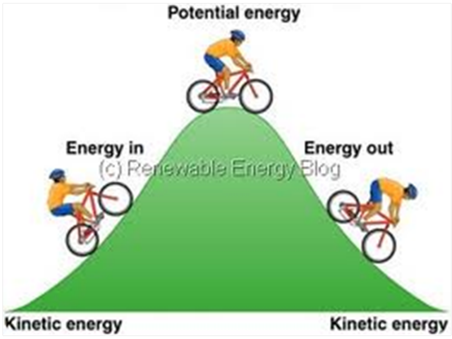
AP Phys 1 Unit 7.4 Notes - Potential Energy

7.4 – Potential Energy



1. Review

What kinetic energy does a 1.4 kg steel sphere have when traveling 15 m/s?

$$K = \frac{1}{2}mv^2$$
$$= \frac{1}{2} \bullet 1.4\,kg \bullet (15\,m/s)^2$$
$$= 160\,J$$

2. Review!

If a 1.4 kg sphere has 160 J of kinetic energy when traveling 15 m/s, how much work is done on the sphere if it is slowed to 9.5 m/s?

$$W = \Delta K = K_2 - K_1$$
$$= \frac{1}{2}mv^2 - 160\,J$$
$$= \frac{1}{2} \bullet 1.4\,kg \bullet (9.5\,m/s)^2 - 160\,J$$
$$= 63.2\,J - 160\,J = -97\,J$$

Potential Energy (U)

Energy of position or configuration can be thought of as "stored work".

Different types include:
- Mechanical: a flexed stick, extended spring
- Electrical: a charged capacitor
- Gravitational: a lifted mass
- Chemical: batteries, gunpowder
- Nuclear: fission or fusion releases energy

Potential Energy Rabbit Hole!

Why is the symbol for potential energy "U"? Yahoo says:

The concept of potential energy took a while to be accepted.

Thermodynamics began considering heat as energy, and substances contained "internal heat". Changes to "internal heat" equaled heat (ΔQ) & work (ΔW) added to the substance.

At the time, scientists were using symbols clustered from capital P to capital W for thermodynamic quantities.

It was an early convention to use the symbol V, so the equation was ΔV = ΔQ + ΔW, because it looked like W: and could be likened to "potential work".

Later, since V was used elsewhere (volume, voltage, velocity), the symbol U was adopted.

Springs

The work done on a spring equals potential energy stored in it.

You can release the spring and it'll do work!

Mousetrap/ping pong ball Demo.

$W_s =$	$U_s = \frac{1}{2}kx^2$ AP Equation	k = spring constant (N/m) x = displacement (m)

Gravitational Potential Energy

The potential energy of gravity equals the work done on an object by lifting it some height (h, or y):

$\Delta U_g = mg\Delta y$ AP Equation	m = mass (kg) g = 9.81 m/s^2 Δy = elevation change (m)

3. Example

A 77 kg man climbs 2.5 meters up a ladder.
How much potential energy does he have there?

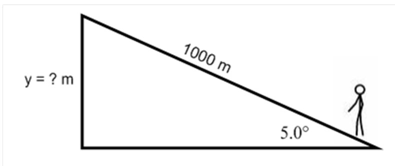
U_g = mgy = 77 kg (9.81 m/s^2) (2.5 m)
= 1900 J

4. Example

A 60.0 kg man walks up a 5.00°, 1000.0 m slope.

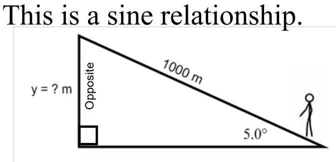
How much gravitational potential energy does he have at the end of his walk?

Sketch:



Example 4: Solution

Since U_g = mgh, we need to find the total elevation gained.
Trig time.
This is a sine relationship.



S = O/H
sin 5.00° = opposite/1000.0 m
opposite = 1000.0 m X sin 5.00 °
= 87.2 m

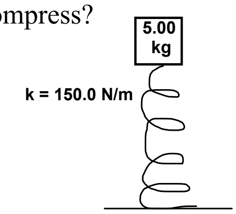
Example 4: Solution

So:

$$U_g = mg\Delta y$$
$$= 60.0\,kg \bullet 9.81\,m/s^2 \bullet 87.2\,m$$
$$= 51{,}000 J = 51 kJ$$

5.A - Spring Example

A 5.00 kg mass is set on a spring with a constant of 150.0 N/m, and is gently lowered to rest.
A. How much does the spring compress?



$$F_g = F_s$$
$$mg = kx$$
$$x = \frac{mg}{k} = \frac{5.00\,kg \bullet 9.81\,m/s^2}{150.0\,N/m}$$
$$= 0.327 m$$

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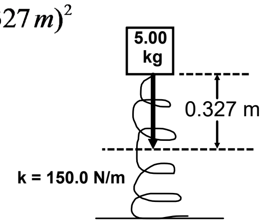
Example 5.B

A 5.00 kg mass is set on a spring (k = 150.0 N/m), and is lowered 0.327 m.

How much potential energy is in the spring?

$$U_s = \frac{1}{2}kx^2 = \frac{1}{2} \bullet 150.0\,n/m \bullet (0.327\,m)^2$$

$$= 8.02\,J$$



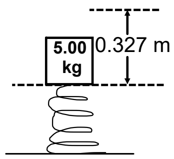
Physics Democracy!

The 5.00 kg mass, lowered 0.327 m, gives the spring 8.02 J of potential energy.

How much gravitational potential energy is lost?

Ballot

None 0.00 J	**Same** 8.02 J	**1.5 X More** 12.03 J	**Double** 16.04 J

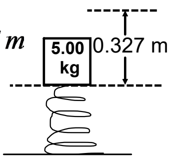


Example 5.C

The 5.00 kg mass, lowered 0.327 m:

$$U_g = mg\Delta y = 5.00\,kg \bullet 9.81\,m/s^2 \bullet 0.327\,m$$

$$= 16.0\,J$$



Spring energy does not equal gravitational energy! What happened? What about energy conservation?

Answer: in lowering the mass gently, work was done as force was exerted over the 0.327 meters to lower the mass **gently.**

6. Last Example - ADD to Booklet!!

How far would the mass go, if allowed to fall on the spring, rather than being lowered gently?

Hint: it is where spring and gravitational energy are equal.

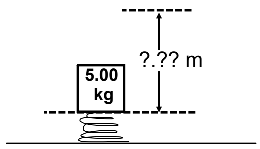
$$U_s = U_g$$

$$\frac{1}{2}ky^2 = mg\Delta y$$

$$\frac{y^2}{\Delta y} = \frac{2mg}{k}$$

Vertical displacement: use y instead of x.

$$y = \frac{2 \bullet 5.0\,kg \bullet 9.81\,\frac{m}{s^2}}{150\,N/m} = 0.654\,m$$



Homework

Read 5.5 in your book
7.4 Problems in your Booklet
Due: next class

Work Quiz Tomorrow