Gravitational Potential Energy (12-4 & 12-5)

Gravitational potential energy close to the Earth is:

$$E_g = mgh$$

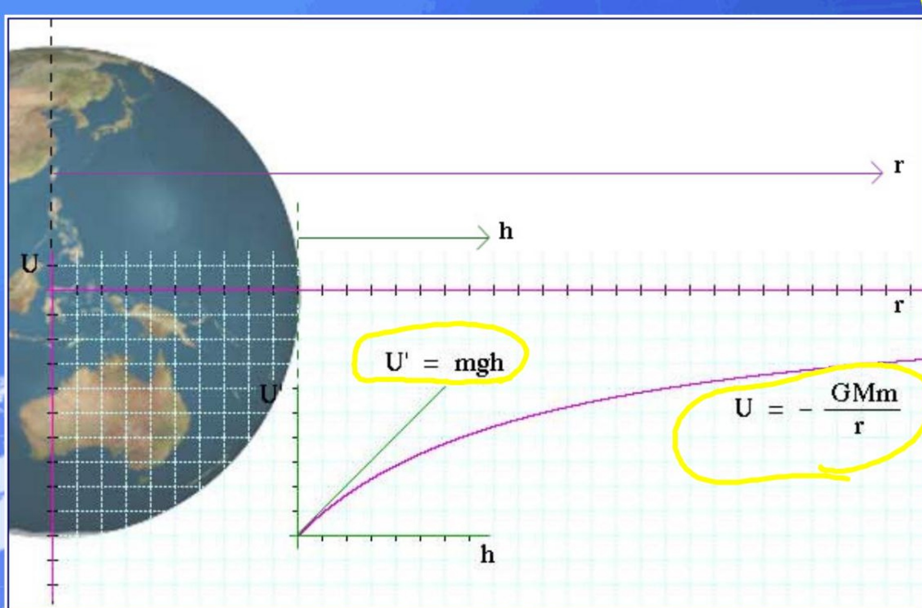
But, when the object is further away from the Earth, the acceleration of gravity is not 9.8 m/s^2.

So, we consider that the work needed to put something into space is: Work = Force x distance

$$Work = G\frac{mM_E}{r^2}\times r = G\frac{mM_E}{r}$$

The work done on the object is positive. That makes the potential energy that the object then has negative.

Potential Energy Well



What is the gravitational potential energy of a 12.0 kg meteorite when it is one Earth radius above the surface of the Earth?

$$U = -G\frac{m M_E}{r}$$

$m = 12\text{ kg}$, $M_E = 5.97 \times 10^{24}\text{ kg}$

$r = 2(6.37 \times 10^{6}\text{ m})$

$U = -3.75 \times 10^{8}\text{ J}$

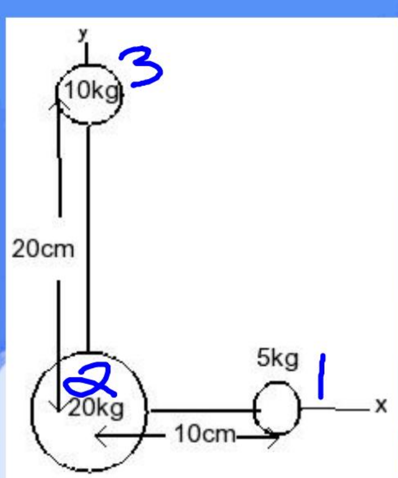
$E_g = mgh$

$= (12\text{ kg})(9.8\text{ m/s}^2)(6.37 \times 10^{6}\text{ m})$

$7.49 \times 10^{8}\text{ J}$

E_g?

This same concept applies to the total potential energy of a group of objects. What is the total potential energy of the configuration below? (Is direction important?)



$U_{12} = 6.67 \times 10^{-8}$

$+$

$U_{23} = 6.67 \times 10^{-8}$

$+$

$U_{13} = 1.5 \times 10^{-8}$

$$\frac{G m_1 m_2}{r}$$

Now, we have a new part to our conservation of energy equation,

$$E = K + U = \frac{1}{2}mv^2 - G\frac{mM_E}{r}$$

How can this be used?

We can find the speed at which an asteroid might have if it were to hit the Earth.

Assume the initial speed in space is 0. And, the gravitational potential energy in space, at infinity, is 0 as well.

Remember that $E_i = E_f$.

What would the initial speed need to be in order for an object to escape Earth's gravitational pull? This is called the escape velocity.

(If a rocket barely escapes Earth's gravity, its speed would decrease to zero. Also, its gravitational potential energy would approach zero as r approaches ∞.)

There are many other examples in the book that you can look at as you do your assignment.

Read P. 394 - 404

Do P. 411 - 412 (41, 43, 47, 51, 57)