Gravitational Ep and infinity

We need a new place to define Ep, that place is infinity <= infinitely far from all masses.

$$E_p = -\frac{G m_1 m_2}{r}$$

New formula for Ep based on Ep = 0 J at infinity

Calculate the Ep of a 5000 kg cat at a distance of 3.0 x 10^7 m from Earth's centre.

$$E_p = -\frac{G m_1 m_2}{r} = -\frac{6.67\times10^{-11}(5000)(5.98\times10^{24})}{3.0\times10^{7}}$$

$$= -6.65\times10^{10}\ \text{J}$$

Work done:
USE THE WORK ENERGY THEOREM!!

$$W = \Delta E = E_{pf} - E_{po}$$

$$= -\frac{G m_1 m_2}{r_f} - \left(-\frac{G m_1 m_2}{r_0}\right) = \frac{G m_1 m_2}{r_0} - \frac{G m_1 m_2}{r_f}$$

A mass of 5000 kg is moved from 2.0x 10^7m distance to 3.0 x 10^7 m distance (all distances are from centre of Earth), find the work done.

$m = 5000$ $\quad 2\times10^7 \rightarrow 3\times10^7$ $\quad \hookrightarrow W = ?$

$$W = \Delta E = E_{pf} - E_{po} = -\frac{6.67\times10^{-11}(5000)(5.98\times10^{24})}{3\times10^{7}} + \frac{6.67\times10^{-11}(5000)\,5.98\times10^{24}}{2\times10^{7}}$$

$$= 3.32\times10^{10}\ \text{J}$$

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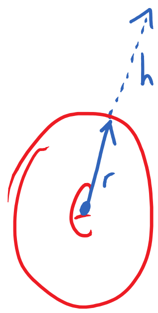

$$W = \Delta E = Gm_1m_2\left(\frac{1}{r_0} - \frac{1}{r_f}\right)$$

x^{-1}

$$4\times10^{8} = 6.67\times10^{-11}(10)(5.98\times10^{24})\left(\frac{1}{6.38\times10^{6}} - \frac{1}{r_f}\right)$$

$$\frac{4\times10^{8}}{6.67\times10^{-11}(10)(5.98\times10^{24})} - \frac{1}{6.38\times10^{6}} = -\frac{1}{r_f}$$

$r_f = 17.7$ Mm.

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height $= r_f - r_e$

$= 17.7\times10^{6} - 6.38\times10^{6}$

$= 11.3$ Mm.

The Law of Conservation of Energy still applies:

Epo + Eko = Epf +Ekf + Q but Q= 0J

Typical situations involve:

a) An object moving in space crashing into the Earth (any planet)
b) An object moving in space to some closer distance to the Earth (any planet)
c) An object on the Earth moving into space

comet/meteor/asteroid

A comet of mass 1.0×10^{7} kg is 4.0×10^{9} m from Earth's centre, it is moving at 2500 m/s and crashes into the Earth's surface, what is the impact speed? ↳ V_f

Conservation of Energy.

$$E_{po} + E_{ko} = E_{pf} + E_{kf}$$

$$-\frac{Gm_1\cancel{m_2}}{r_0} + \frac{\cancel{m}v_0^2}{2} = -\frac{Gm_1\cancel{m_2}}{r_f} + \frac{\cancel{m}V_f^2}{2}$$

$$-\frac{6.67\times10^{-11}(5.98\times10^{24})}{4\times10^{9}} + \frac{2500^2}{2} = -\frac{6.67\times10^{-11}(5.98\times10^{24})}{6.38\times10^{6}} + \frac{V_f^2}{2}$$

$V_f = 11.4$ km/s

A cat is blasted off of the moon at 1.3 km/s from the surface, to what height
Will it rise before coming to rest?

$h = ?$

$E_{po} + E_{ko} = E_{pf} + E_{kf}$

$$-\frac{6.67\times10^{-11}(7.35\times10^{22})}{1.74\times10^{6}} + \frac{(1.3\times10^{3})^2}{2} = -\frac{6.67\times10^{-11}(7.35\times10^{22})}{r}$$

$r = 2.49\ Mm$

$h = 2.49\times10^6 - 1.74\times10^6$

$= 750\ km.$

Escape Velocity: is defined as the velocity at a planet's surface necessary
To ESCAPE to infinity, you can stop when you reach infinity. Escape Velocity
Is found using Conservation of Energy

$$E_{po} + E_{ko} = E_{pf} + E_{kf}$$

$$-\frac{Gm_1\cancel{m_2}}{r_0} + \frac{\cancel{m}v^2}{2} = 0 + 0$$

$$\frac{v^2}{2} = \frac{Gm_1}{r_0}$$

$$v = \sqrt{\frac{2Gm}{r_0}}$$

$$= \sqrt{\frac{2(6.67\times10^{-11})(5.98\times10^{24})}{6.38\times10^{6}}}$$

$$= 11.2\ km/s$$

In ORBIT there is a relationship between

E_p and E_k.

$F_c = F_g$

$$E_k = \frac{mv^2}{2} = \frac{m}{2}\boxed{\frac{Gm}{r}}$$

$$F_c = F_g$$

$$m\left(\frac{v^2}{r}\right) = \frac{G m_1 m_2}{r^2}$$

$$\boxed{v^2 = \frac{Gm}{r}}$$

$$E_k = \frac{mv^2}{2} = \frac{m}{2}\,\frac{Gm}{r}$$

$$= \frac{G m_1 m_2}{2r}$$

$$E_p = -\frac{Gmm}{r}$$

$$\therefore \quad E_k = -\frac{1}{2} E_p \quad \square$$

mind = blown