Gravitational Ep and infinity

In past Ep = mgh. No more. Because g changes as distance from a mass changes the definition of Ep must also change.

Ep= mgh works ONLY when the entire situation occurs close to a planet's surface.

The Law of Conservation of Energy still applies:
Epo + Eko = Epf +Ekf + Eh but

E_p at $\infty = 0$

Ep is NOT ~~mgh~~ any more. BAD

E_p closer than ∞ must be < 0

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

E_p will be $-$ or zero

The gravitational potential energy of some object (m_1) is zero Joules when infinitely far from some planet (m_2)

$$E_p = -\frac{Gm_1m_2}{r}$$

r ← distance from centre

All Ep measured in relation to infinity will be less than zero (negative).

Ep = - Gm_1m_2 / r   r is the distance to the centre of the mass (planet).

*Calculate your Ep, relative to infinity at the surface of the moon if your mass is 100 kg.

$$E_p = -\frac{Gm_1m_2}{r}$$

$$= -\frac{6.67\times10^{-11}(100)\,7.35\times10^{22}}{1.74\times10^{6}} = -2.81\times10^{8}\,J$$

You are now lifted to a radius of 8.0 x 10 ^{9} m from the moon's centre. What Was the work done?

$W = \Delta E_p$

$W = E_{...} - E_{p...}$

$W = \Delta U_p$

$W = E_{pf} - E_{po}$

$= -\frac{G m_1 m_2}{r_f} - -\frac{G m_1 m_2}{r_o}$

$W = -\frac{6.67\times10^{-11} \; 100 \; 7.35\times10^{22}}{8\times10^{9}} - -\frac{6.67\times10^{-11} \; 100 \; 7.35\times10^{22}}{1.74\times10^{6}}$

$W = -61280 + 2.82\times10^{8}$

$= 2.82\times10^{8}\ J$

An asteroid of mass 1x 10 ^{4} kg can be considered infinitely far from Earth. It is moving though space at 1 km / s & heads to Earth, with what speed will it impact us?

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

$\frac{1}{2}\cancel{m_a} V_o^2 = -\frac{G \cancel{m_a} m_e}{r_e} + \frac{1}{2}\cancel{m_a} V_f^2$

$\frac{1}{2} \; 1000^2 = -\frac{6.67\times10^{-11} \; 5.98\times10^{24}}{6.38\times10^{6}} + \frac{1}{2} V_f^2$

$500000 = -6.25\times10^{7} + \frac{1}{2} V_f^2$

$\sqrt{\frac{6.30\times10^{7}}{\frac{1}{2}}} = V_f = 1.1\times10^{4}\ \frac{m}{s}$

Escape Velocity: this is the minimum velocity to escape a planet's gravitational pull. This means that you make it to infinity, but are at rest when you get there.

surface $\qquad\qquad\qquad \infty$

$$E_{po} + E_{ko} = E_{pf} + E_{kf} + \cancel{E_H}$$

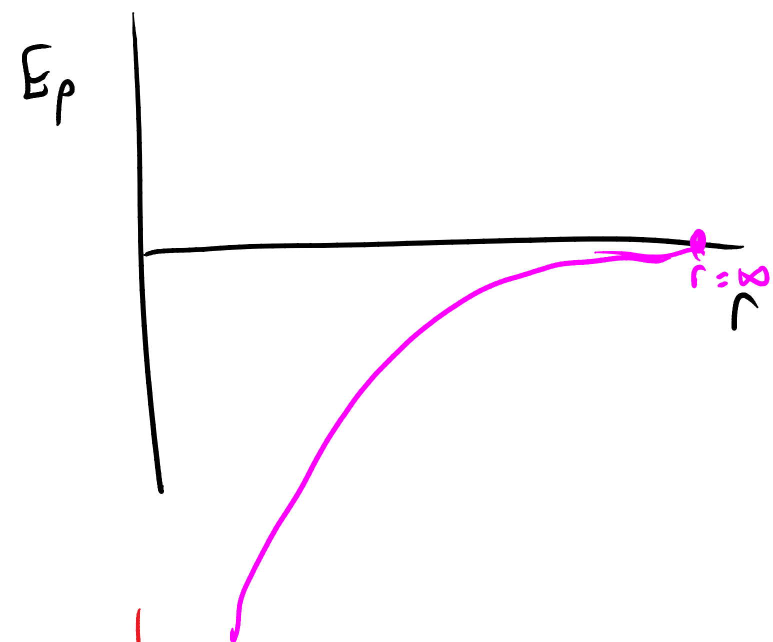
$$-\frac{Gm_o m_e}{r_e} + \frac{1}{2} m_o v_o^2 = 0 + 0$$

$$\frac{1}{2}\cancel{m_o} v_o^2 = \frac{G\cancel{m_o} m_e}{r_e}$$

$$v_o = \sqrt{\frac{2(6.67\times10^{-11})(5.98\times10^{24})}{6.38\times10^{6}}} = 1.12\times10^{4}\ \frac{m}{s}$$

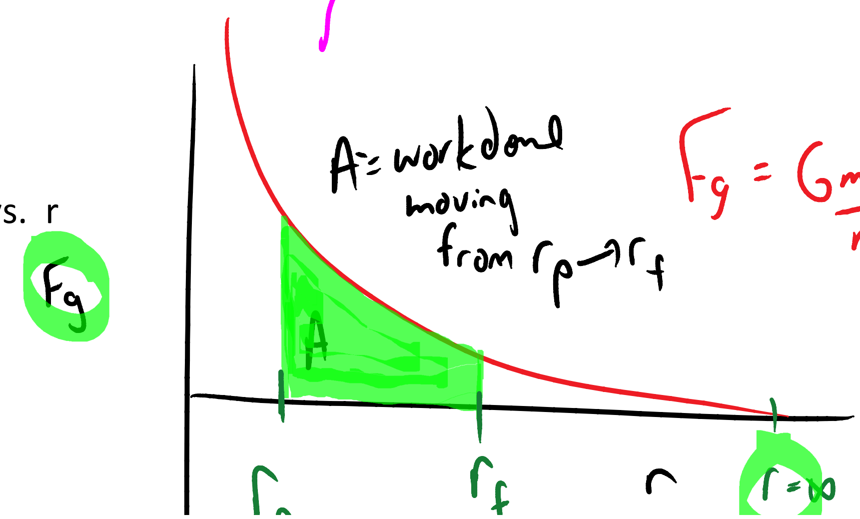
Graphs of Ep vs. r

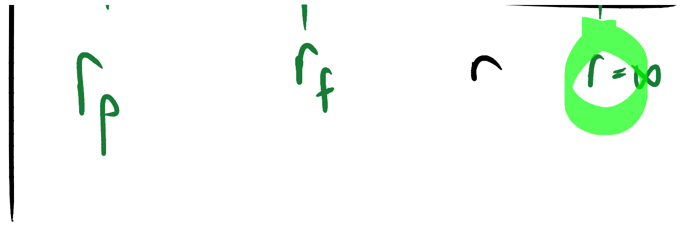
$$E_p = -\frac{Gmm}{r}$$



Graphs of Fg vs. r

$$F_g = \frac{Gmm}{r^2}$$





Escape: rockets like to escape the planet they are on.

If you escape you must be free of a gravitational field g, and you can stop.
This means Epf = 0 and Ekf = 0

So:

By the Law of Conservation of Energy:

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