Gravitational Potential Energy

1] List and describe the formula used to find the gravitational potential energy of an object, **relative to infinity,** a certain distance (r) from a planet.

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

Calculate the gravitational potential energy, relative to infinity, of a 2.0×10^4 kg mass which is on the earth's surface.

-1.25×10^{12} J

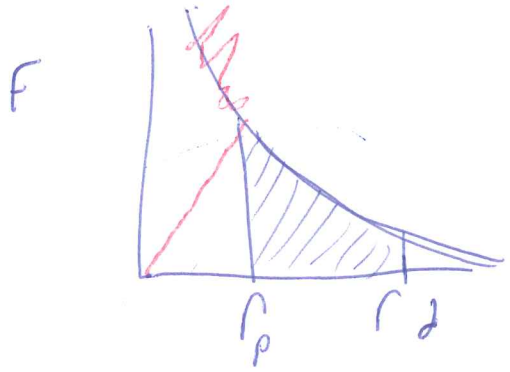
2] List and describe the formula used to find the work done lifting a mass well away from a planet.

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

Calculate the work required to lift a 5.0×10^3 kg mass from the earth's surface to a spot 1000.0 km above the earth's surface.

$$-Gm_em_3\left(\frac{1}{(6.38\times10^6 + 1\times10^6)} - \frac{1}{6.38\times10^6}\right) = 4.2\times10^{10}\ \text{J}$$

Illustrate the work being done on a force-distance graph.



3] List and describe a formula used to calulate how high a mass will go when it is fired from the earth with some initial speed.

$E_{p_f} = E_{p_0} + E_{k_0}$

$-\frac{Gm_1m_2}{r_f} = -\frac{Gm_1m_2}{r_0} + \frac{1}{2}m_1v^2$ Solve for r_f, then $r_f - r_0 = h$

An object is fired vertically into space from the surface of the moon at speed of 6.0×10^2 m/s. How far from the center of the moon will the object travel?

$E_{p_f} = E_{p_0} + E_{k_0}$

$-\frac{Gm_m m}{r_f} = -\frac{Gm_m m}{r_m} + \frac{1}{2}mv^2$

$-\frac{(+6.67\times10^{-11})(7.35\times10^{22})}{r_f} = -6.67\times10^{-11}\left(\frac{7.35\times10^{22}}{1.74\times10^6} + \frac{1}{2}(600)^2\right)$

$-4.9\times10^{12} = -2.82\times10^6 + 1800$

$\frac{+4.9\times10^{12}}{r} = +2.82\times10^6$

$r = 1.74\times10^6$ m

$r = 1.85\times10^6$ m

An asteroid has a radius of 5150 m and a mass of 3.00×10^{15} kg. With what speed would a person on its surface have to jump straight upward to reach a height of 2150 m above the surface?

$r_f = r_a + h$

$-\frac{Gm_A m}{r_f} = -\frac{Gm_A m}{r_a} + \frac{1}{2}mv^2$

$-Gm_A\left(\frac{1}{r_f} - \frac{1}{r_a}\right) = \frac{1}{2}v^2$

$11.44 = \frac{1}{2}v^2$

$v = 4.78\ \frac{m}{s}$

4] A stone with a mass of 12 kg is dropped from a very high 3.0 km tower on the asteroid Blob. Blob has a mass of 3.4×10^{10} kg and a radius of 8.6×10^4 m. At what speed will the rock strike Blob?

$E_p = E_p + E_k$

$-\frac{Gmm}{r_0} = -\frac{Gmm}{r_f} + \frac{1}{2}mv^2$

$-\frac{Gm}{(3000 + 8.6\times10^4)} = -\frac{Gm}{8.6\times10^4} + \frac{1}{2}v^2$

$-Gm\left(\frac{1}{8.9\times10^4} - \frac{1}{8.6\times10^4}\right) = \frac{1}{2}v^2$

$8.89\times10^{-7} = \frac{1}{2}v^2$

$v = 1.33\times10^{-3}\ \frac{m}{s}$