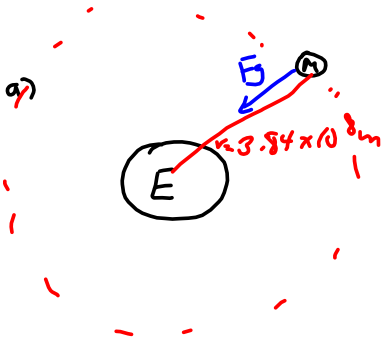
$M_E = 5.98 \times 10^{24}$ kg

1. The moon has a mass of 7.35 x 10^{22} kg and orbits the Earth at a radius of 3.84 x 10^{8} m.
a) What is the gravitational potential energy of the Moon-Earth system?
b) What is the Moon's kinetic energy and speed in circular orbit?
c) What is the Moon's binding energy to Earth?



a) $PE = -\frac{GMm}{r}$

$= -\frac{(6.67 \times 10^{-11})(5.98 \times 10^{24})(7.35 \times 10^{22})}{3.84 \times 10^{8}}$

$= -7.63 \times 10^{28}$ J

b) $F_g = F_c$

$\frac{1}{2}|PE| = \frac{1}{2}\frac{GMm}{r^2} = \frac{1}{2}\frac{mv^2}{r} = KE$

In orbit $\frac{1}{2}|PE| = KE$

$KE = \frac{1}{2}(7.63 \times 10^{28}$ J$)$

$= 3.82 \times 10^{28}$ J

$KE = \frac{1}{2}mv^2$

$3.82 \times 10^{28} = \frac{1}{2}(7.35 \times 10^{22})$

$1.2 \times 10^{6} = v^2$

$v = 1.1 \times 10^{3}$ m/s

c) What is binding energy?

It is the energy that is required to separate 2 objects.

To separate the moon from the Earth we are taking it to $r = \infty$ where

$PE = 0$

$KE = 0$

In orbit

$E_T = PE + KE$

$= -7.63 \times 10^{28} + 3.82 \times 10^{28}$ J

$= -3.81 \times 10^{28}$ J

To make $E_T = 0$ we need to add $+3.81 \times 10^{28}$ J

$BE = +3.81 \times 10^{28}$ J

2. What is the total energy needed to place a 2000 kg satellite into circular orbit around Earth at an altitude of 5.0 x 10^2 km?

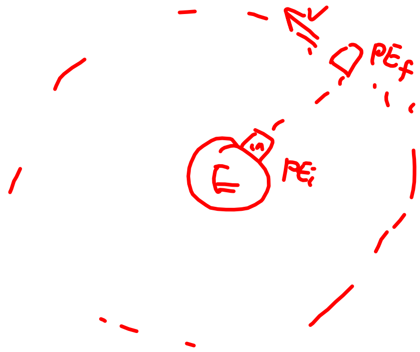
$M_E = 5.98 \times 10^{24}$ kg

$r_E = 6.38 \times 10^6$ m

$W = \Delta PE + KE$

$= PE_f - PE_i + \frac{1}{2}|PE_f|$

$= \frac{1}{2}PE_f - PE_i$



Gravitational Potential Energy

1. What is the gravitational potential energy of a satellite of mass 1000 kg at a radius of orbit of 2×10^7 m relative to infinity? Relative to the surface of the Earth? (-1.99×10^{10} J, 4.26×10^{10} J)
2. A satellite of mass 1500 kg is placed in orbit at a radius of $4r_E$ (r_E is Earth's radius).
   (a) How much potential energy does the satellite gain if launched from Earth's surface? (7.02×10^{10} J)
   (b) What kinetic energy does the satellite require to be in orbit at this height? (1.17×10^{10} J)
   (c) What is the total energy required to put the satellite in this orbit? (8.19×10^{10} J)
3. What is the escape velocity of a rocket from the surface of the Earth? (11.2 km/s)
4. What velocity would the Earth have to obtain to escape the sun? (42.2 km/s)