13. A 6200-kg satellite is in a circular earth orbit that has a radius of 3.3 x 10^7 m. A net external force must act on the satellite to make it change to a circular orbit that has a radius of 7.0 x 10^6 m. What work *W* must the net external force do? Note that the work determined here is *not* the work W_{lift} done by the satellite's engines to change the orbit. Instead, the work *W* is $W = W_{lift} + W_{gravitational}$, where $W_{gravitational}$ is the work done by the gravitational force.

Work – Energy Theorem

$$\sum W = \Delta K = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_0^2$$

Consider the sum of the forces when the satellite is in a stable gravitational orbit

$$\sum F_R = F_G = \frac{GM_EM_S}{r^2} = \frac{mv^2}{r}$$

Solving for v^2

$$v^2 = \frac{GM_E}{r}$$

Plug this into Work-Energy

$$\sum W = \Delta K = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_0^2 = \frac{M_s}{2}(v_f^2 - v_0^2)$$

$$\sum W = \frac{M_s}{2}(v_f^2 - v_0^2) = \frac{M_s}{2}\left(\frac{GM_E}{r_f} - \frac{GM_E}{r_0}\right) = \frac{GM_EM_S}{2}\left(\frac{1}{r_f} - \frac{1}{r_0}\right)$$

$$W = \frac{GM_EM_s}{2}\left(\frac{1}{r_f} - \frac{1}{r_0}\right)$$

$$W = \frac{\left(6.67\ x\ 10^{-11}\,Nm^2/kg^2\right)(5.98\ x\ 10^{24}kg)(6200\ kg)}{2}\left(\frac{1}{r_f} - \frac{1}{r_0}\right)$$

$$W = 1.236\ x\ 10^{18}J\,m\left(\frac{1}{r_f} - \frac{1}{r_0}\right)$$

$$W = 1.236\ x\ 10^{18}J\,m\left(\frac{1}{7.0\ x10^6m} - \frac{1}{3.3\ x10^7m}\right)$$

$$W = 1.236\ x\ 10^{18}J\,m(1.126\ x\ 10^{-7}m^{-1}) = +1.392\ x\ 10^{11}J$$

$$\boxed{W = +1.4\ x\ 10^{11}J}$$

Dr. Donovan's Classes Page	**Dr. Donovan's PH 201 Homework Page**
NMU Physics Department Web Page	**NMU Main Page**

Please send any comments or questions about this page to ddonovan@nmu.edu

This page last updated on November 12, 2021