King Fahd University of Petroleum & Minerals

Department of Physics.

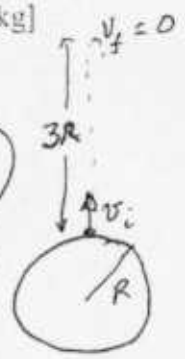
Student's Name : Solution ID: _____ Sect.: _____.

Quiz #9.

Q1. (5 marks)

A rocket is fired from the surface of the Earth and reaches a maximum altitude above the surface of the Earth equal to three Earth radii. What is the initial speed of the rocket?

[R (Earth) = $6.4\times10^{6}$ m; G = $6.67\times10^{-11}$ N.m$^2$/kg$^2$; M (Earth)=$6.0\times10^{24}$ kg]




$$E_i = E_f$$

$$\frac{1}{2}m v_i^2 + \left(-\frac{GmM}{R}\right) = 0 + \left(-\frac{GmM}{4R}\right)$$

$$\therefore \frac{1}{2}v_i^2 = \frac{GM}{R}\left(1 - \frac{1}{4}\right) = \frac{3}{4}\frac{GM}{R}$$

$$\therefore v_i = \sqrt{\frac{3}{2}\left(\frac{GM}{R}\right)}$$

$$= \sqrt{\frac{3}{2}\times\frac{6.67\times10^{-11}\times6\times10^{24}}{6.4\times10^{6}}}\ \text{m/s} = 9.68\times10^{3}\ \text{m/s}$$

$$= 9.68\ \text{km/s}$$

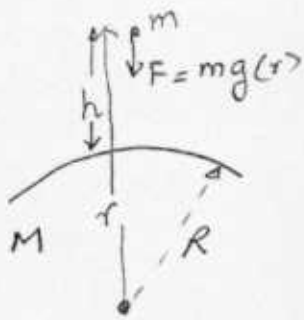
Q2. (5 marks)

At what altitude (in Earth's radii) above the surface of the Earth would the acceleration due to gravity be 1/9 of that on the surface?

[R (Earth) = $6.4\times10^{6}$ m; G = $6.67\times10^{-11}$ N.m$^2$/kg$^2$; M (Earth)=$6.0\times10^{24}$ kg]

$$F = \frac{GmM}{r^2} = m\,g(r)$$

$$\therefore g(r) = \frac{GM}{r^2}$$




If $g(r) = \frac{1}{9}g_s$, then

$$\frac{\frac{1}{9}g_s}{g_s} = \frac{GM}{r^2}\cdot\frac{R^2}{GM}$$

$$r^2 = 9R^2 \Rightarrow r = 3R$$

$$\therefore h = 3R - R = 2R = 12.8\times10^{6}\ \text{m}$$