Physics (Giancoli) Ch 6 E1B1a

\# 13, 14, 28, 47, 57, 60 due Tues 3 feb 04

a m

13. (II) At what distance from the Earth will a spacecraft on the way to the Moon experience zero net force due to these two bodies because the Earth and Moon pull with equal and opposite forces?

EARTH Sat moon

$M_\otimes$ s $M_\odot$

$\leftarrow a \rightarrow \leftarrow b \rightarrow$

$\leftarrow d \rightarrow$

$a + b = d = 3.84 \times 10^5$ km

Force between earth & satellite : $F_a = G m M_\otimes / a^2$

Force between moon & satellite : $F_b = G m M_\odot / b^2$

Equal strengths : $F_a = F_b$

simplify $\frac{G m M_\otimes}{a^2} = \frac{G m M_\odot}{b^2} \rightarrow$

Sub in $b = d - a$: $\frac{M_\odot}{M_\otimes} = \frac{b^2}{a^2} = \frac{(d-a)^2}{a^2} =$

Solve for a :

1[2]

3

28. (II) (*a*) Show that if a satellite orbits very near the surfa[ce] of a planet with period T, the density (= mass per unit vo[l]ume) of the planet is $\rho = m/V = 3\pi/GT^2$. (*b*) Estimate th[e] density of the Earth, given that a satellite near the surfa[ce] orbits with a period of about 90 minutes.

$$F = \frac{GmM}{R^2} = \frac{mv^2}{R}$$

$$\frac{GM}{R} = v^2 = \left(\frac{2\pi R}{T}\right)^2 = \frac{4\pi^2 R^2}{T^2}$$

$$\frac{GM}{R^3} = \frac{4\pi^2}{T^2}$$ and density = mass/volume

$$\rho = M \Big/ \tfrac{4}{3}\pi R^3$$

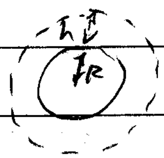
$$\frac{4}{3}\pi\rho = \frac{M}{R^3} = \frac{4\pi^2}{GT^2}$$

a

b

47. How far above the Earth's surface will the acceleration of gravity be half what it is at the surface?

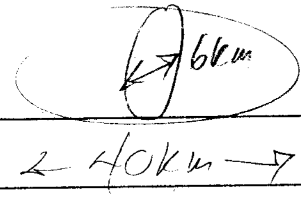
$R = 6.4 \times 10^6$ m



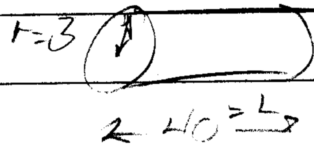
$d = h + R$

$$F(d) = \frac{GmM}{d^2} = \frac{1}{2}\frac{GmM}{R^2}$$

57. NASA launched the Near Earth Asteroid Rendevous (NEAR), which, after traveling 1.3 billion miles, is meant to orbit the asteroid Eros at a height of about 15 km. Eros is potato-shaped: 40 km × 6 km × 6 km. Assume Eros has a density (mass/volume) of about 2.3×10^3 kg/m^3. (*a*) What will be the period of NEAR as it orbits Eros? (*b*) Suppose Eros to be a sphere with the same mass and density. What would its radius be? (*c*) What would *g* be at the surface of this spherical Eros?



Approximate Eros as a cylinder:



Volume = area × length = $\pi r^2 \cdot L$

$V =$ ________ m^3

mass = $\frac{\text{mass}}{\text{volume}}$ × volume

= $\rho \times V$

(b) If Eros was a sphere with the same mass & density, it would have $V = \frac{4}{3}\pi R^3 = \frac{\text{mass}}{\text{mass}/\text{volume}} = \frac{m}{\rho}$

$$R^3 = \frac{3m}{4\pi\rho} = \frac{3(2.65\times10^{15}\ \text{kg})}{4\pi \cdot 2.3\times10^3\ \text{kg/m}^3} = 2.75\times10^{11}$$

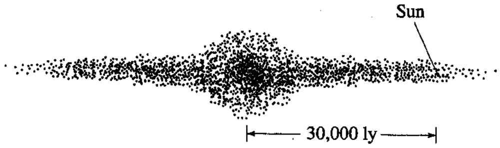
$$R = 6.5\times10^3\ \text{m} = 6.5\ \text{km}$$

(c) To find g at the surface of this sphere, recall that

$$F = mg = \frac{GmM}{R^2} \longrightarrow g = \frac{GM}{R^2}$$

$$g = \frac{GM}{R^2} = \frac{6.67\times10^{-11}\ \frac{\text{m}^3}{\text{kg}\cdot\text{s}^2}\ (2.65\times10^{15}\ \text{kg})}{(6.5\times10^3\ \text{m})^2} = 4.2\times10^{-3}\ \frac{\text{m}}{\text{s}^2}$$

60. The Sun rotates about the center of the Milky Way Galaxy (Fig. 6–25) at a distance of about 30,000 light years from the center $(1\text{ ly} = 9.5 \times 10^{15}\text{ m})$. If it takes about 200 million years to make one rotation, estimate the mass of our Galaxy. Assume that the mass distribution of our galaxy is concentrated mostly in a central uniform sphere. If all the stars had about the mass of our Sun $(2 \times 10^{30}\text{ kg})$, how many stars would there be in our Galaxy?



$R = 3\times10^{4}\,ly \left| \dfrac{9.5\times10^{15}\,m}{ly} \right| =$

$T = 2\times10^{8}\,yrs \left| \dfrac{\pi\times10^{7}\,s}{yr} \right| =$

$\boxed{12}$

By Kepler's 3^{d} law,

$$M = \frac{4\pi^2 R^3}{GT^2} =$$

galaxy's mass = Number of stars × mass per star

$M = N \cdot M_{\odot}$

$N =$