Physics of Astronomy - week 1 HW due wk 2 - Zita

ESTIMATES ARE FINE. Try using your brain, not your calculator.

Phys.A: Giancoli 1, Introduction # 16, 23, 24, 38, 50, 54, 56 and drill on many odd #

(16) (I) The Sun, on average, is 93 million miles from the Earth. How many meters is this? Express (*a*) using powers of ten, and (*b*) using a metric prefix.

done in class

93×10^6 mi $= 1.5 \times 10^{11}$ m $= 150$ Gm

(23) (II) A *light-year* is the distance light (speed = 2.998×10^8 m/s) travels in one year. (*a*) How many meters are there in 1.00 light-year? (*b*) An astronomical unit (AU) is the average distance from the Sun to Earth, 1.50×10^8 km. How many AU are there in 1.00 light-year? (*c*) What is the speed of light in AU/h?

$$\text{year} \left| \frac{365\,d}{yr} \right| \frac{24\,hr}{d} \left| \frac{60\,min}{hr} \right| \frac{60\,sec}{min} \right| = 3.65 \times 10^2 \cdot 2.4 \times 10^1 \cdot 3600 \text{ sec}$$

$$t = 1 \text{ year} = 3.65 \cdot 2.4 \cdot 3.6 \cdot 10^{2+1+3} = 3.16 \times 10^7 \text{ s} \simeq \pi \times 10^7 \text{ sec}$$

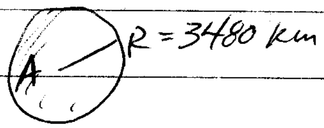
$$\text{Speed} = \frac{\text{distance}}{\text{time}} \qquad \text{Speed of light} = c = 3 \times 10^8 \text{ m/s}$$

(a) $c = \frac{x}{t} \rightarrow x = ct = 3 \times 10^8 \frac{m}{s} \cdot \pi \times 10^7 \text{ sec} \simeq 9 \times 10^{15}$ m

(b) $ly \simeq 9 \times 10^{15} \text{ m} \left| \frac{AU}{1.5 \times 10^8 \text{ km}} \right| \frac{km}{10^3 \text{ m}} \Big| \simeq 6 \times 10^4$ AU

(c) $c = 3 \times 10^8 \frac{m}{s} \left| \frac{1 \text{ AU}}{1.5 \times 10^{11} \text{ m}} \right| \frac{3.6 \times 10^3 \text{ s}}{hr} \Big| \simeq 7 \frac{AU}{hr}$

(24) (II) The diameter of the moon is 3480 km. What is the surface area, and how does it compare to the surface area of the Earth?



$$A_{MOON} = 4\pi R_M^2 = 4\pi (3480 \text{ km})^2$$

$$= 4\pi \left(\frac{3480}{2}\right)^2 \text{km}^2 \simeq 3.8 \times 10^7 \text{ km}^2$$

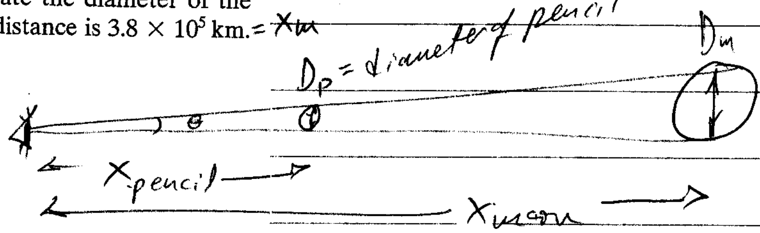
$$\frac{A_E}{A_M} = \frac{4\pi R_E^2}{4\pi R_M^2} = \left(\frac{R_E}{R_M}\right)^2 = \left(\frac{6.38 \times 10^3 \text{ km}}{3.48/2 \times 10^3 \text{ km}}\right)^2 = \frac{(= 7.4 \times 10^{-4})^{-1}}{1.3 \times 10^3}$$

*38. (II) Three students derive the following equations in which x refers to distance traveled, v the speed, a the acceleration (m/s^2), t the time, and the subscript ($_0$) means a quantity at time $t = 0$: (*a*) $x = vt^2 + 2at$, (*b*) $x = v_0t + \frac{1}{2}at^2$, and (*c*) $x = v_0t + 2at^2$. Which of these could possibly be correct according to a dimensional check?

done in class

50. Hold a pencil in front of your eye at a position where its blunt end just blocks out the Moon (Fig. 1–11). Make appropriate measurements to estimate the diameter of the Moon, given that the Earth–Moon distance is 3.8×10^5 km. $= X_m$

FIGURE 1–11 Problem 50. How big is the Moon?



Solve for D_m ALGEBRAICALLY

Similar triangles: $\frac{D_p}{X_p} = \frac{D_m}{X_m} \rightarrow D_m = \frac{X_m D_p}{X_p}$

I used my finger & arm:

Measure $x_p = 19''$ $D_p = \frac{1}{4}''$

Calculate $D_m = 3.8 \times 10^5\ km \left(\frac{\frac{1}{4}''}{19''}\right) = \frac{0.2}{4} \times 10^5\ km = 5 \times 10^3\ km$ ($\pm \sim 20\%$)

54. One liter ($1000\ cm^3$) of oil [volume tot] is spilled onto a smooth lake. If the oil spreads out uniformly until it makes an oil slick just one molecule thick, with adjacent molecules just touching, estimate the diameter of the oil slick. Assume the oil molecules have a diameter of 2×10^{-10} m. $= D$

$\text{volume}_{tot} \simeq N_{molecules} \times V_{mol}$

$\text{Volume}_{\text{one molecule}} = V_m = \frac{4}{3}\pi R^3$ where $D = 2R_m = 2 \times 10^{-10}$ m

$R_m =$

Calculate $V_m =$

Number of molecules $N_m = \frac{V_{tot}}{V_m} =$ (not necessary after all)

p. 2) Radius of oil slick $= R_o$

Volume of oil slick $= V_o$ = Area of slick × thickness of mol. $= \pi R_o^2 \times D$

$$V_{tot} = 10^3\,cm^3 \left| \frac{m}{10^2\,cm} \right|^3 = \frac{10^3\,cm^3\,m^3}{10^6\,cm^3} = 10^{-3}\,m^3$$

Volume of oil slide = volume tot

$$V_o = V_{tot} = \pi R_o^2 \cdot D$$

$$R_o^2 = V_{tot}/\pi D$$

Solve algebraically for $R_o^2 = \frac{10^{-3}\,m^3}{\pi \times 2\times10^{-10}\,m} = \frac{10^{-3+10}\,m^2}{6} = \frac{10^7}{6}\,m^2$

Then plug in numbers for V_{tot} and D to solve for

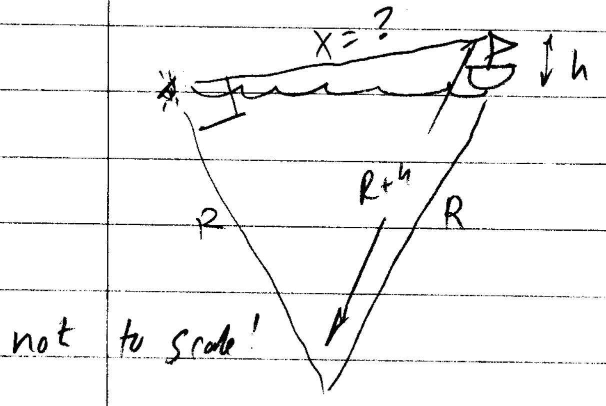
$$R_o^2 \simeq \frac{1}{60}\times 10^8\,m^2 \rightarrow R \simeq \frac{1}{8}\times10^4\,m = \frac{1}{8}\times 10\,km$$

$$D_{oil\,slick} = 2R_o = \frac{2}{8}\times 10\,km \sim \frac{1}{4}\times 10\,km \sim \underline{2.5\,km}$$

That seems reasonable

(56) You are lying on the sand at the edge of the sea, watching a sailboat. If you know (or measured) that the distance from the water to the top of the boat hull is 2.5 m, estimate how far away the boat is when (using binoculars) you can no longer see the hull. The radius of the Earth is 6.38×10^6 m. = R

done in class – write it up neatly. (Miranda + Julie – Jeff)



$$R^2 + X^2 = (R+h)^2$$

$$R^2 + X^2 = R^2 + 2Rh + h^2 \quad (h^2 \text{ small})$$

$$X^2 \simeq 2Rh$$

$$= 2(6.38\times10^6\,m)(2.5\,m)$$

$$X^2 = \underline{3.2\times10^7}\,m^2$$

$$X \simeq \underline{5.6\times10^3\,m} = \underline{5.6\,km}$$