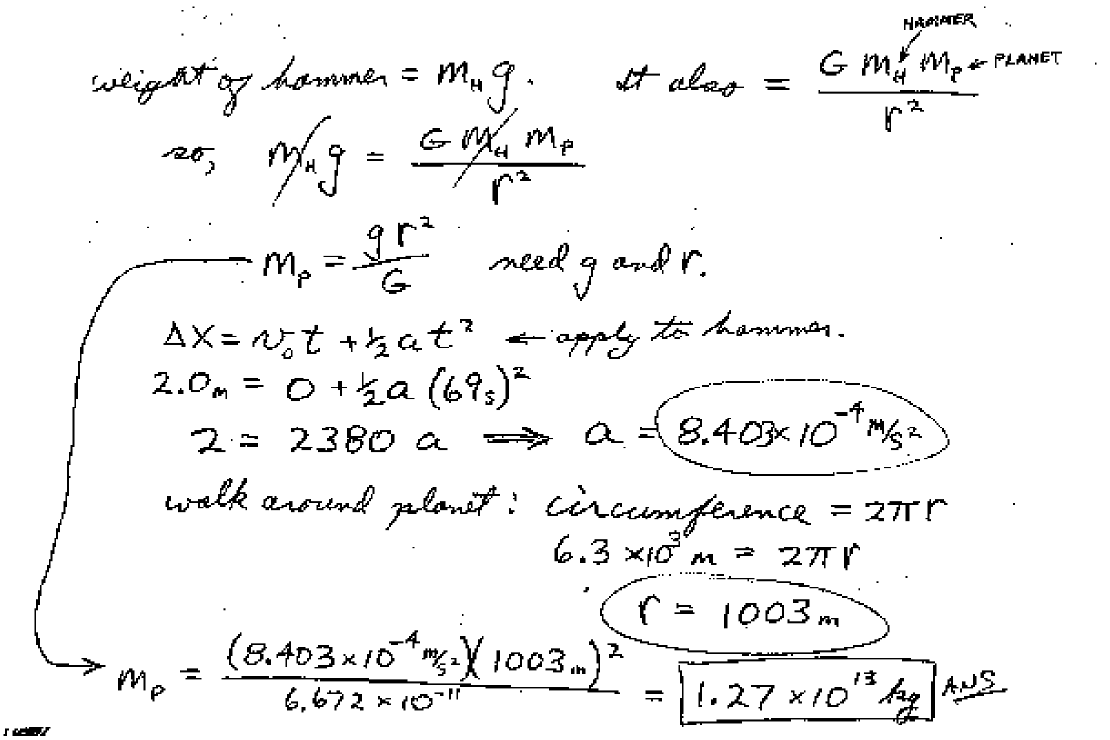
Phy 131 - Assignment 12

A.



weight of hammer = $m_H g$. it also = $\frac{G \overset{\text{HAMMER}}{m_H} M_P \leftarrow \text{PLANET}}{r^2}$

so, $\cancel{m_H} g = \frac{G \cancel{m_H} M_P}{r^2}$

$M_P = \frac{g r^2}{G}$ need g and r.

$\Delta X = v_0 t + \frac{1}{2} a t^2$ ← apply to hammer.

$2.0_m = 0 + \frac{1}{2} a (69_s)^2$

$2 = 2380\, a \Rightarrow a = 8.403\times10^{-4}\, m/s^2$

walk around planet: circumference $= 2\pi r$

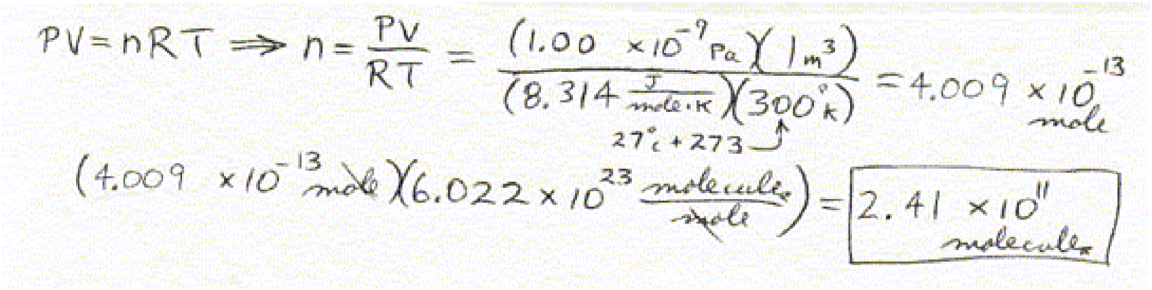
$6.3\times10^3\, m = 2\pi r$

$r = 1003_m$

$M_P = \frac{(8.403\times10^{-4}\, m/s^2)(1003_m)^2}{6.672\times10^{-11}} = \boxed{1.27\times10^{13}\, kg}$ ANS

B. 1. PV = nRT. The question says n and T are the same and R is a universal constant, so PV = a constant. That is, pressure is inversely proportional to volume. The container with three times the volume has one third the pressure: $P_A = (1/3)P_B$.

2.



$PV = nRT \Rightarrow n = \frac{PV}{RT} = \frac{(1.00\times10^{-9}\, Pa)(1\, m^3)}{(8.314 \frac{J}{mole\cdot K})(\underset{27^\circ C + 273}{300\, K})} = 4.009\times10^{-13}$ mole

$(4.009\times10^{-13}\, \cancel{mole})(6.022\times10^{23} \frac{molecules}{\cancel{mole}}) = \boxed{2.41\times10^{11}\, molecules}$

C. a. The tire's volume stays approximately constant:

$$P_1V = nRT_1 \text{ and } P_2V = nRT_2 \Rightarrow \frac{P_2\cancel{V}}{P_1\cancel{V}} = \frac{\cancel{n}\cancel{R}T_2}{\cancel{n}\cancel{R}T_1} \Rightarrow P_2 = P_1\frac{T_2}{T_1}$$

You have to have absolute pressure and temperature: 31 lb/in$^2$ + 14.7 lb/in$^2$ = 45.7 lb/in$^2$. 45°C + 273 = 318 K. 11°C + 273 = 284 K.

$$P_2 = (45.7)\frac{284}{318} = 40.8\,\frac{\text{lb}}{\text{in}^2}$$

So, the gauge reads 40.8 – 14.7 = $\boxed{26.1\,\frac{\text{lb}}{\text{in}^2}}$

b. This time, the temperature stays constant.

$$P_1V_1 = nRT \quad \text{and } P_2V_2 = nRT \quad \Rightarrow \quad P_1V_1 = P_2V_2$$

$$V_2 = \frac{P_1}{P_2}V_1 = \frac{40.8}{14.7}(20\text{ L}) = \boxed{55.5\text{ L}}$$

D.

Kepler's 3rd Law: $T^2 = \frac{4\pi^2}{G(m_1+m_2)}a^3$

$$a = \sqrt[3]{\frac{G(m_1+m_2)T^2}{4\pi^2}}$$

$$= \sqrt[3]{\frac{(6.67\times10^{-11})\left[2\times10^{30}\text{kg} + (.2)(2\times10^{30}\text{kg})\right]\left[(3\times10^{7}\text{y})\left(\frac{3.16\times10^{7}\text{s}}{1\text{y}}\right)\right]^2}{4\pi^2}}$$

$$= \sqrt[3]{\frac{(6.67\times10^{-11})(2.4\times10^{30}\text{kg})(8.987\times10^{29}\text{s}^2)}{4\pi^2}} = \sqrt[3]{3.64\times10^{48}}$$

$$= \boxed{1.54\times10^{16}\text{m}}$$

E.

$$\vec{F}_{64} = \frac{G\,m_6 m_4}{r_{64}^2}(-\hat{i}) = \frac{(6.672 \times 10^{-11})(6\text{ kg})(4\text{ kg})}{(4\text{ m})^2}(-\hat{i})$$

$$= -10.0 \times 10^{-11}\,\hat{i}\text{ N}$$

$$\vec{F}_{24} = \frac{G\,m_2 m_4}{r_{24}^2}(\hat{j}) = \frac{(6.672 \times 10^{-11})(2\text{ kg})(4\text{ kg})}{(3\text{ m})^2}(\hat{j})$$

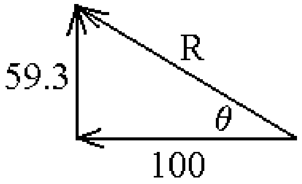
$$= 5.93 \times 10^{-11}\,\hat{j}\text{ N}$$

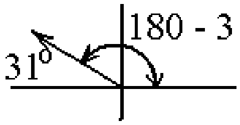
Total force: $\vec{F} = \vec{F}_{64} + \vec{F}_{24} = -100\,\hat{i} + 59.3\,\hat{j}$ pN

To find magnitude and direction:

$$R = \sqrt{100^2 + 59.3^2} = 116$$

$$\theta = \arctan\left(\frac{59.3}{100}\right) = 31^\circ$$





$180 - 31 = 149^\circ$

ans: $\boxed{116\text{ pN at }149^\circ}$

F. 1. Because the gravitational force on the satellite points directly toward the Earth (along the $\vec{r}$ vector, making $\theta = 0°$ in $\tau = r F \sin\theta$), gravity produces no torque. Therefore, angular momentum is conserved. (Kepler's second law follows from conservation of $\vec{L}$.)

$$r_P(\cancel{m}\,v_P) = r_A(\cancel{m}\,v_A)$$

P = perigee
A = apogee

$$\frac{v_P}{v_A} = \frac{r_A}{r_P} = \frac{2289 + 6.37 \times 10^3\text{ km}}{459 + 6.37 \times 10^3\text{ km}} = \frac{8659\text{ km}}{6829\text{ km}} = \overset{\text{ANS}}{\boxed{1.27}}$$

↑

Add the altitude to the radius of the Earth, from the formula sheet, to get the radius of the orbit. It doesn't matter if you use m or km, but it has to be the same on all distances, so something needs to be converted. The 6762 s period is irrelevant.)

2. Kepler’s third law: $T^2 = \frac{4\pi^2}{G(m_1+m_2)}a^3$

Jupiter is thousands of times as massive as any of its moons, so $m_1$+$m_2$ is, to a good approximation, equal to just Jupiter’s mass, which I’ll call m.

$$m = \frac{4\pi^2}{GT^2}a^3 = \frac{4\pi^2}{(6.67\times10^{-11})(1.53\times10^5)^2}(4.22\times10^8\ m)^3 = 1.90\times10^{27}\ kg$$