P20 Unit B: UA pt B - Gravity

1. Newton's formula for determining gravitational field strength:

$\vec{g} = \frac{Gm}{r^2}$

gravitational field strength: $\vec{g}$

m ← mass of gravity producting object

r^2 ← center to center separation

G ← Universal Gravitational constant

Step ① Replace $\vec{a}$ in $\vec{F} = m\vec{a}$ with $\vec{g}$.

$\vec{F} = m\vec{g}$

Step ② Replace $\vec{g}$ with $\frac{Gm}{r^2}$

$\vec{F}_g = \frac{GmM}{r^2}$ ← force of gravity; m, M ← mass of each object

2. $\vec{F}_g = \frac{Gm_1m_2}{r^2}$

$= \frac{(6.67\times10^{-11}\ \frac{Nm^2}{kg^2})(70kg)(50kg)}{(4.0m)^2}$

$\vec{F}_g = 1.5\times10^{-8}\ N$

$\vec{F}_g \propto \frac{Gm_1m_2}{r^2}$

$\vec{F}_g \propto \frac{(1)(1)(1)}{(\frac{1}{4})^2}$ ← because the separation is 4 times smaller than before

$\vec{F}_g \propto$ 16 times larger.

3. a.) $\vec{g} = \frac{Gm}{r^2}$

$\vec{g} = \frac{(6.67\times10^{-11}\ \frac{Nm^2}{kg^2})(1.5\times10^{24}kg)}{(18\,000\,000m)^2}$

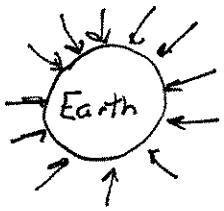
$\vec{g} = 0.309\ N/kg$

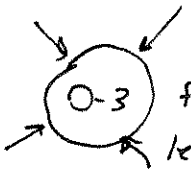
b.) $\vec{F}_g = m\vec{g}$

$\vec{F}_g = (60kg)(0.309\ N/kg)$

$\vec{F}_g = 18.5N$

c.)





* A weaker field means less field lines.

4. a.) $\vec{F}_g = m\vec{g}$

$200N = m(9.81m/s^2)$

$m = 20.4kg$

b.) $\vec{g} \propto \frac{Gm}{r^2}$

$\vec{g} \propto \frac{(1)(4)}{(3)^2}$

$\vec{g} \propto \frac{4}{9}$

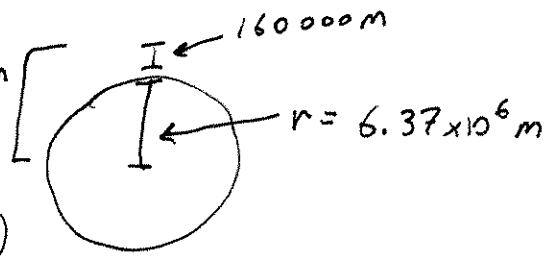
$9.81m/s^2 \times \frac{4}{9} = 4.36m/s^2$

$\vec{F}_g = m\vec{g}$

$= (20.4kg)(4.36m/s^2)$

$= 88.9N$

5. $\vec{F}_g = \frac{G m_1 m_2}{r^2}$



$\vec{F}_g = \frac{(6.67 \times 10^{-11} \frac{Nm^2}{kg^2})(20kg)(5.97 \times 10^{24} kg)}{(6.53 \times 10^6 m)^2}$

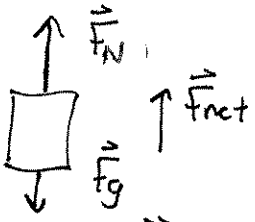
$\vec{F}_g = \underline{187N}$

6. $\vec{F}_g = \frac{G m_1 m_2}{r^2}$ $\quad 5.44 \times 10^{-8} N = \frac{(6.67 \times 10^{-11} \frac{Nm^2}{kg^2})(m)(m)}{(0.75m)^2}$ $\quad *(m)(m) = m^2$

$457.96 = m^2$

$\underline{21.4kg = m}$

7. a.)



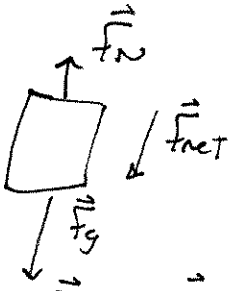
$\vec{F}_{net} = \vec{F}_N + \vec{F}_g$

$(70kg)(2.5m/s^2) = \vec{F}_N + (70kg)(-9.81m/s^2)$

$\vec{F}_N = 862N$

$\vec{F}_{apparent} = \underline{862\,N\ [down]}$

b.)



$\vec{F}_{net} = \vec{F}_N + \vec{F}_g$

$(70kg)(-2.5m/s^2) = \vec{F}_N + (70kg)(-9.81\frac{m}{s^2})$

$\vec{F}_N = 512N$

$\vec{F}_{apparent} = \underline{512N\ [down]}$

8. ① "Weighs one-sixth as much" means "$\vec{F}_g$ is 6 times smaller".

② The radius of the moon's 0.273 times that of Earth's radius. → $\frac{1.74 \times 10^6 m}{6.37 \times 10^6 m} = 0.273$

$\vec{F}_g = \frac{G m_1 m_2}{r^2}$

$(\frac{1}{6}) \propto \frac{(1)(1)\,m}{(0.273)^2}$

$m \propto 0.0124$

$m_{moon} = 0.0124 \times 5.97 \times 10^{24} kg = \underline{7.4 \times 10^{22} kg}$

(m_{earth})