Unit 5: Forces

Newton's Universal Law of Gravitation

Gravity.. attracts any two objects depending on their masses and their distance apart.

Newton's Law of Universal Gravitation states:

$$F_g = \frac{GMm}{r^2}$$

Where:

G = gravitational Constant = $6.67 \times 10^{-11}\ Nm^2/kg^2$

M = mass of 1st object

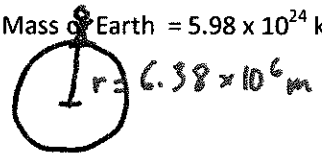
m = mass of 2nd object

r = distance between centers of mass

Ex 1: What is the force of gravity exerted on a 70.0 kg astronaut that is standing on Earth's surface?

Radius of Earth = 6.38×10^6 m

Mass of Earth = 5.98×10^{24} kg

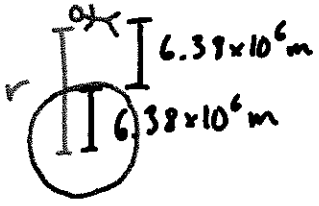


$$F_g = \frac{GMm}{r^2}$$

$$\frac{(6.67\times10^{-11})(5.98\times10^{24})(70.0)}{(6.38\times10^{6})^2}$$

$$= \boxed{686\ N}$$

Ex 2: What is the force of gravity acting on a 70.0 kg astronaut who is at an ***altitude*** of 6.38×10^6 m?



$$F_g = \frac{GMm}{r^2}$$

$$= \frac{(6.67\times10^{-11})(5.98\times10^{24})(70.0)}{(1.276\times10^{7})^2}$$

$$= \boxed{171\ N}$$

Ex 3: Two physics lab partners sit side by side. One has a mass of 55 kg and the other a mass of 65 kg. If they sit 50.0 cm apart, what is the irresistible force of attraction between them?

$$F_g = \frac{GMm}{r^2}$$

$$= \frac{(6.67\times10^{-11})(55)(65)}{(0.50)^2}$$

$$= \boxed{9.5\times10^{-7}\ N}$$

A typical problem type...

An astronaut weighs 800 N on Planet X. How much would she weigh if she was at an altitude equal to the radius of Planet X?

$$F_{g_1} = \boxed{\frac{GMm}{r^2}} = 800N$$

$$F_{g_2} = \frac{GMm}{(2r)^2} = \frac{GMm}{4r^2} = \frac{800N}{4}$$

$$= \boxed{200\ N}$$

A spaceship orbits a planet at radius, r and weighs 10 000N. How much would it weigh if it orbits a planet twice as massive at half the radius?

$$F_{g_1} = \boxed{\frac{GMm}{r^2}} = 10000N$$

$$F_{g_2} = \frac{G(2M)m}{(\frac{1}{2}r)^2} = \frac{2}{\frac{1}{4}}\boxed{\frac{GMm}{r^2}}$$

$$= \boxed{80\ 000\ N}$$