Unit 3: Dynamics

3.0 Gravity & Weight

Gravity is an attractive force that acts between any two bodies and depends on their mass and the distance separating them.

Newton's Law of Universal Gravitation is:

$$F_g = \frac{Gm_1m_2}{r^2}$$

where F_g = Force due to gravity (in Newtons)

G = universal gravitational constant

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

m_1 = mass of first body

m_2 = mass of second body

r = dist. between centres of mass

Mass is the stuff that an object is made of and does not change regardless of the object's position in the universe.

Weight on the other hand, is the gravitational pull on an object towards the centre of Earth (or another object). Weight is a force measured in Newtons... not kg or lbs.

ex. What is the force of gravity between a sumo wrestler of mass 300 kg and Mr. Grottoli (75 kg) if they are standing 50 cm apart?

50 cm → 0.5 m

$$F_g = \frac{Gm_1m_2}{r^2}$$

$$= \frac{(6.67\times10^{-11}\ Nm^2/kg^2)(300\ kg)(75\ kg)}{(0.5\ m)^2}$$

$$= 0.000006003$$

with one sig fig. $F_g \doteq 6\times10^{-6}$ N

$\vec{g}$ is the gravitational field strength at a given distance from the centre of a celestial object. As long as an object is at or near the surface of the celestial body (earth, moon...) and we know the value of *g*, we can calculate the weight of a object with:

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

To find *g* for any planet use: $\vec{g} = \dfrac{Gm_{planet}}{r_{planet}^2}$ Note: m_2 doesn't matter here

ex. Find the weight of a 100 kg Vampire by using the equation above as well as Newton's Law of Universal Gravitation. → on earth ($\vec{g} = 9.8\ m/s^2$)

easy:

$F_g = mg$

$= (100\ kg)(9.8\ m/s^2)$

$= 980\ kg\ m/s^2 = N$

$= 980\ N$

I like easy.

difficult:

$F_g = \dfrac{Gmm}{r^2}$

$= \dfrac{(6.67\times10^{-11}\ N\ kg^2 m^2)(100\ kg)(5.98\times10^{24}\ kg)}{(6.38\times10^{6}\ m)^2}$

$= 979.9\ N$

very close

ex. A person weighs 735 N on earth's surface. Use a ratio to describe their weight at 3 times the distance from centre of the Earth. What is the gravitational field strength at that distance?

$$\frac{\text{field strength}_{far}}{\text{field strength}_{near}} = \frac{\frac{Gm_1m_2}{r^2_{far}}}{\frac{Gm_1m_2}{r^2_{near}}} = \frac{\frac{1}{r_{far}^2}}{\frac{1}{r_{near}^2}} = \frac{r_{near}^2}{r_{far}^2} = \frac{(1)^2}{(3)^2} = \frac{1}{9}$$

$\therefore \vec{g} = \frac{1}{9}$ of that on earth's surface.

$\therefore \vec{g} = \frac{1}{9}(9.8\ m/s^2)$ or $\vec{g} \doteq 1.09\ m/s^2$

practice: pg. 181 #20ac, 21-24, 26, 29, 30