Artificial Gravity and Satellites

On Earth we usually measure weight by measuring normal force (often with a bathroom scale or the like).

This weight, in turn, allows us to find mass (by dividing by 9.8).

This is called gravitational mass.

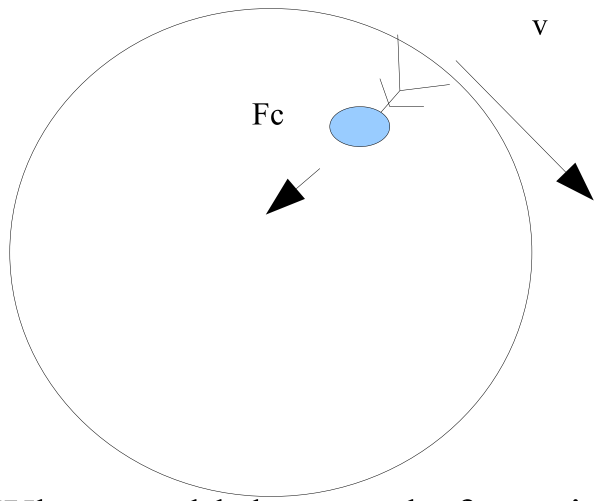
When an astronaut is orbitting the Earth, he/she has no normal force. In order to find the mass of such a person, we must find "inertial mass", using newton's 2nd law:

- Exert a known force on an object
- Measure the displacement and time interval for the object's motion
- Calculate the object's acceleration using $\Delta d = v_1\Delta t + \frac{1}{2} a\Delta t^2$
- Calculate mass using $F_{net} = ma$

If we wanted people in outer space to experience "artificial gravity", we could generate some sort of normal force. How can we do this?

- Rotate the spacecraft/station in which the astronauts are housed
- The inner wall of the craft pushes inwards on the objects inside
- The objects inside the spacecraft undergo centripetal acceleration
- For people, this "feels" like standing on Earth as long as their $a_c = 9.8\ m/s^2$

Rotating Spacecraft:



1. What would the speed of rotation have to be for a space station of radius 82 m in order create an "Earth-like artificial gravity"?

$F_c = mv^2/r$

$mg = mv^2/r$

$9.8 = v^2/82$

$v = 28.3$ m/s

2. What would an astronaut experience if they walked "down" a hallway towards the centre of the space station? What would they experience at the very centre? Why?

While climbing towards the centre, the force required to stay in position decreases. At the very centre, the force acting on the astronaut is zero.

$F_c = 4\pi^2 mrf^2$ ---> r decreases but everything else is constant!

Satellites

Satellites orbitting large objects in space (such as planets or stars) are influenced ONLY by gravity, so

$F_c = F_g$

$$\frac{mv^2}{r} = \frac{GmM}{r^2} \quad \text{-->} \quad v^2 = \frac{GM}{r}$$

m = mass of satellite
M = mass of planet or star

$$v = \sqrt{\frac{GM}{r}}$$

3. What is the speed and period for a space shuttle orbitting thr Earth at an altitude of 600 km?

$$v = \sqrt{\frac{GM}{r}} \quad \text{-->} \quad v = \sqrt{\frac{(6.67 \times 10^{-11})(5.98 \times 10^{24})}{6.38 \times 10^6 + 6 \times 10^5}}$$

= 7559.4 m/s

and $T = \dfrac{\Delta d}{v} = \dfrac{2\pi r}{v} = \dfrac{2\pi(6.38 \times 10^6 + 6 \times 10^5)}{7559.4}$

= 5801.6 s or 96.7 minutes