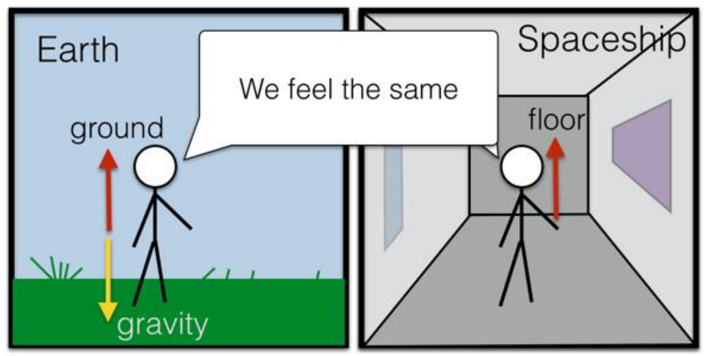
DESIGN A ROTATING SPACE STATION, WHY DO SPACECRAFT SPIN?

Here are the key points:

- There is still gravity in space.
- Astronauts feel weightless when both they and their spacecraft are accelerated only by gravity.
- To the astronauts, it feels just like there is no gravity.
- Humans don't even really feel the gravitational force since it pulls on all parts of our body. Instead, we associate weight with the external contact forces such as that of the ground pushing up on us. We call this force the "apparent weight".

Here are two astronauts. On the left, an astronaut standing on Earth and on the right one in a spaceship. If the astronaut is in a location with very little gravity (like in deep space), then the only way to "feel weight" would be to have a force from the floor pushing up. In this case, both astronauts would feel the same.



So how do you make this force on the astronaut in space? It all depends on the nature of force. Perhaps you are familiar with this equation:

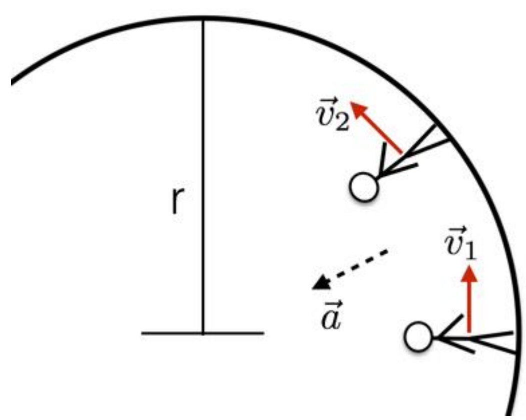
$$\vec{F}_{\text{net}} = m\vec{a}$$

This says that the total (net) force on an object makes it accelerate. Both force and acceleration are vectors – this will be important in a little bit. But for now, let's say that I look at some short time interval. Over this time interval, the average acceleration would be:

$$\vec{a}_{\text{avg}} = \frac{\Delta\vec{v}}{\Delta t} = \frac{\vec{v}_2 - \vec{v}_1}{\Delta t}$$

If you change the velocity of the spacecraft, you will have an acceleration. If this acceleration is in the direction from the feet to head of the astronaut, there will also be a force from the floor pushing up and the astronaut will feel an apparent weight. Of course it would be quite difficult to continue to accelerate by speeding up for a significant time (but not impossible).

There is another way to have an acceleration for an astronaut and it has to do with the vector nature of velocity. The acceleration depends on the change in velocity. Since velocity is a vector, changing either the magnitude or the direction of the velocity will result in an acceleration. If you just move in a circle (at a constant speed), you will change direction all the time and be accelerating.



Moving in a circle means you have to accelerate. Every time you turn your car, you can feel the forces on you that go along with this circular acceleration. A spinning spacecraft does essentially the same thing. The apparent weight an astronaut feels depends on just two things (in a spinning spacecraft): the radius of the circle and the rotation speed. Bigger spaceships (larger r) don't have to spin as fast. If you have a smaller spacecraft, you have to spin faster.

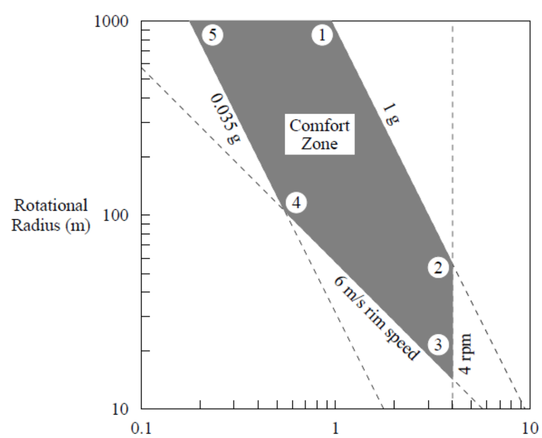
Now that we have a relationship for the apparent weight, we can use this on a spinning spacecraft. The spacecraft spins "to generate 1g of gravity". If the spacecraft has an apparent weight of 1 g and I know how fast it spins, then I can calculate the radius.

$$a_c = \frac{4\pi^2 r}{T^2} = \frac{v^2}{r}$$

You need to figure out the rotational speed of the spacecraft. If you make the origin the center of the ship, then you get the angular position by choosing some position on the outer rim of the station.

For your assignment, design a rotating spacecraft. Measure the rotational speed and use that to calculate the size of the radius by assuming it will produce 1 g of apparent weight. Keep in mind that too great of a difference between the rate at which your head spins relative to your feet will cause nausea due to the Coriolis effect. To minimize this effect make sure that the rotational speed is around 2rpm.

The Coriolis effect gives an apparent force that acts on objects that move relative to a rotating reference frame. This apparent force acts at right angles to the motion and the rotation axis and tends to curve the motion in the opposite sense to the habitat's spin. If an astronaut inside a rotating artificial gravity environment moves towards or away from the axis of rotation, he or she will feel a force pushing him or her towards or away from the direction of spin. These forces act on the inner ear and can cause dizziness, nausea and disorientation. Lengthening the period of rotation (slower spin rate) reduces the Coriolis force and its effects. It is generally believed that at 2 rpm or less, no adverse effects from the Coriolis forces will occur,



[Theodore W. Hall]

Rotating Space Station Criteria

- Each table will draw a model version of a rotating space station
- Show and explain the physics of how it works. Size of the station, diameter, rotational speed, apparent gravity at various locations from the center to the outer rim..
- Describe the layout and function of the space station. (How will it keep a crew alive with food, water, energy, etc be re-using, reducing, and recycling)
- Show how and where people would stand, work, live, and sleep in the space station.
- Look up others ideas on rotating space stations as depicted by NASA, SciFi movies like Armageddon, Interstellar, or 2001, etc. to help you design your own.

Grade will be based on:

- Quality of diagrams
- Completeness and correctness of calculations including units and showing work
- Descriptions about life aboard the space station.