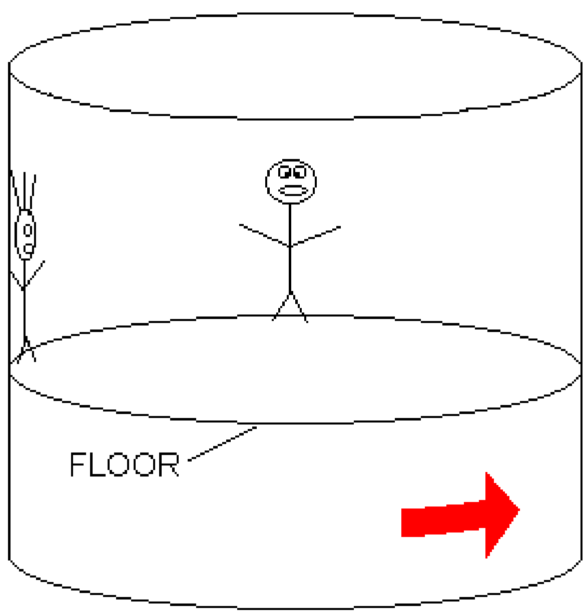
Name:_______________________________ Date:_______________

Weight No More

If you travel in space, you could stay in a weightless environment like the astronauts who inhabit the International Space Station, or you could stay on the circumference of a rotating space station that simulates the feeling of weight you have on Earth. You can calculate the gravitational pull necessary to keep you grounded in space.

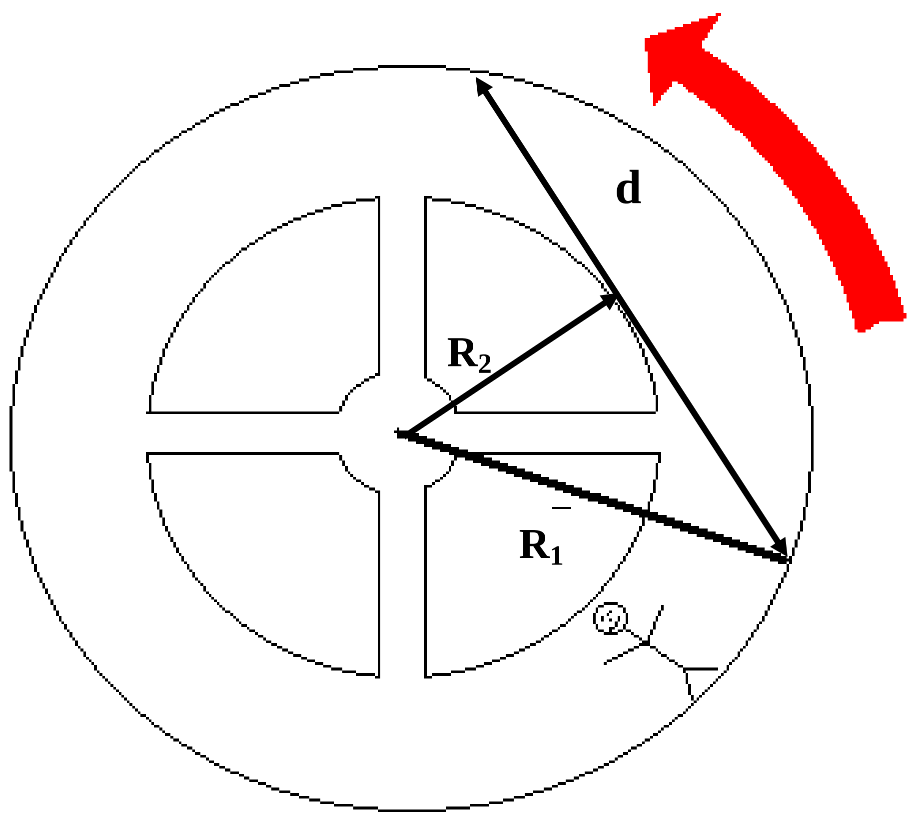
How does artificial gravity work? Remember, in orbit there is still gravity (otherwise the spacecraft would fly off away from Earth on a straight line), but since gravity is making everything fall toward Earth at the same rate, the effect is the same as *weightlessness*.

- Spinning creates *centripetal force*, which increases with faster spin rates.
- A popular amusement park ride consists of a cylinder that spins around a vertical axis. People stand with their backs to the inside wall and the cylinder spins up. Once it's going fast enough, the floor drops away and everyone is stuck to the wall by the *artificial gravity*. What's really happening is that the cylinder wall is exerting a force (*centripetal force)* to keep everyone moving on a curved path (in this case, a circular path). But to the people or any other object in the cylinder, the effect is the same as if there were a force pushing them *outward* (called the centrifugal force) -- that's the artificial gravity.



The same principle applies to a space station. It's just Newton's First Law: an object will maintain constant speed and direction (i.e. a straight line) unless some external force acts on it. Here, the external force is provided by the walls of the space station.

As the space station rotates, your body wants to move in a straight line. The outside rim of the space station pushes on the bottoms of your feet to keep you moving in a circular path. If the size and rotational speed of the space station are chosen carefully, this push, called the *centripetal force*, can make you feel the same "weight" that you experience on Earth.

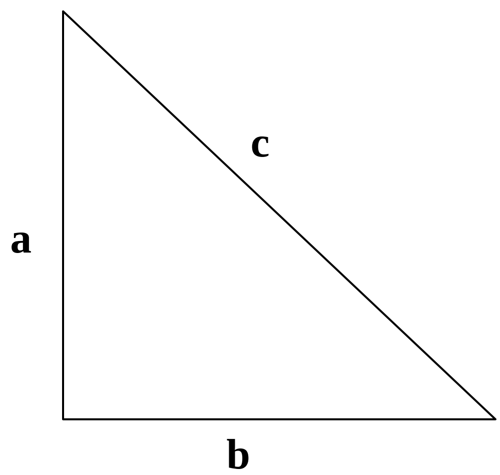


Here $\mathbf{R_1}$ and $\mathbf{R_2}$ are radii. Their difference is the height of living space.

The station's curvature limits how far inhabitants can see as they walk. In the diagram, the distance **d** is a measure of the viewing distance.

Questions:

1. How can we calculate the distance **d**? Hint: use Pythagorean Theorem.



<u>Pythagorean Theorem:</u>

$$\mathbf{a^2 + b^2 = c^2}$$

2. Select $\mathbf{R_1}$ and $\mathbf{R_2}$ so that the height of the living space makes sense for humans. Use your formula **d** fond in question 1 to calculate the distance for your values of $\mathbf{R_1}$ and $\mathbf{R_2}$.

3. If the viewing distance is too short, the inhabitants may feel claustrophobic. Keep the height of the living space the same as in question 2, but adjust your values of $\mathbf{R_1}$ and $\mathbf{R_2}$ so that **d** is at least 80 feet.

The equation $F = \frac{1}{8}\pi^2 WN^2 R$ describes the centripetal force you would feel between your feet and the floor as a circular space station rotates.

In the equation above: W = your weight on Earth in pounds
N = rotational speed of the station in revolutions/second
R = the radius of the station in feet at the bottom of your shoes.

Questions:

1. Calculate the rotational speed necessary so that the force beneath the feet of a 150-lb person is his or her usual weight. Convert your answers to rotations per hour.

2. Use your answer from a previous question to find how many seconds it takes to make one revolution.

3. Calculate the rotational speed necessary for a 20-lb dog to experience its usual weight. Convert your answers to rotations per hour. What do you notice?