Centripetal vs. Centrifugal Force

Knowledge/Understanding Goals:
- the difference between centripetal and centrifugal force

Skills:
- calculate the centripetal force of an object moving in a circle

Notes:
Suppose an object is moving at a constant speed around a circle. Although its speed is constant, its direction keeps changing as it goes around. Because velocity is a vector (speed and direction), this means its velocity is constantly changing. (To be precise, the magnitude is staying the same, but the direction is changing.

Because a change in velocity over time is acceleration, this means the object is constantly accelerating. The continuous change in velocity is toward the center of the circle, which means there is continuous acceleration toward the center of the circle.

Finally, because acceleration is caused by a net force (Newton’s second law of motion), if there is continuous acceleration toward the center of the circle, then there must be a continuous force toward the center of the circle.

This force is called “centripetal force”.

**centripetal force**: the inward force that keeps an object moving in a circle. If the centripetal force were removed, the object would fly away from the circle in a straight line that starts from a point tangent to the circle.

The formula for centripetal acceleration ($\alpha$) is:

$$\alpha = \frac{v^2}{r}$$

Given that $F = ma$, the equation for centripetal force is therefore:

$$F_c = ma = \frac{mv^2}{r}$$
Centrifugal “force”: the apparent outward force felt by an object that is moving in a circle.

Centrifugal “force” is technically not a force as we would define it in physics. Centrifugal “force” is actually the inertia of objects resisting motion as they are continuously pulled toward the center of a circle by centripetal acceleration.

As an analogy, imagine that you are standing in an elevator. While the elevator is accelerating upward, the force between you and the floor of the elevator increases. An increase in the normal force from the floor because of the upward acceleration of the elevator feels like the same as an increase in the downward force of gravity.

Similarly, a sample being spun in a centrifuge is subjected to the force from the bottom of the centrifuge tube as it is accelerated toward the center. The faster the rotation, the stronger the force. Again, an increase in the normal force from the bottom of the centrifuge tube would “feel” the same as a downward force toward the bottom of the centrifuge tube.