Flipping Physics Lecture Notes:

A Tale of Three Accelerations
or
The Differences between Angular, Tangential, and Centripetal Accelerations

An object moving in a circle can have three different types of accelerations:

- Angular Acceleration: $\alpha = \frac{\Delta\omega}{\Delta t}$ in $\frac{rad}{s^2}$ is an *angular* quantity.
- Tangential Acceleration: $a_t = r\alpha$ in $\frac{m}{s^2}$ is a *linear* quantity.
- Centripetal Acceleration: $a_c = \frac{v_t^{\,2}}{r} = r\omega^2$ in $\frac{m}{s^2}$ is a *linear* quantity.

Angular acceleration separates itself from the others:

1) Because it is an *angular* quantity, whereas the other two are linear quantities.
2) Because angular acceleration applies to the whole rigid object, however, tangential acceleration and centripetal acceleration are for a specific radius.

A major difference between tangential acceleration and centripetal acceleration is their direction.

- Centripetal means “center seeking”. Centripetal acceleration is always directed inward.
- Tangential acceleration is always directed tangent to the circle.
    - By definition, tangential acceleration and centripetal acceleration are perpendicular to one another.

Another major difference between tangential acceleration and centripetal acceleration is that circular motion cannot exist without centripetal acceleration.

- No centripetal acceleration means the object is not moving in a circle.
    - Centripetal acceleration results from the change in direction of the tangential velocity. If the tangential velocity is not changing directions, then the object is not moving in a circle.
- Tangential acceleration results from the change in magnitude of the tangential velocity of an object. An object can move in a circle and not have any tangential acceleration. No tangential acceleration simply means the angular acceleration of the object is zero and the object is moving with a constant angular velocity.
    - $\alpha = \frac{\Delta\omega}{\Delta t} = \frac{0}{\Delta t} = 0 \Rightarrow a_t = r\alpha = r\left(0\right) = 0$