Flipping Physics Lecture Notes:

AP Physics C: Rotational Kinematics Review (Mechanics)
https://www.flippingphysics.com/apc-rotational-kinematics-review.html

- Angular velocity: $\vec{\omega}_{average} = \frac{\Delta\vec{\theta}}{\Delta t}$ & $\vec{\omega}_{instantaneous} = \frac{d\vec{\theta}}{dt}\left(\frac{rad}{s}\, or \frac{rev}{\min}\right)$
- Angular acceleration: $\vec{\alpha}_{average} = \frac{\Delta\vec{\omega}}{\Delta t}$ & $\vec{\alpha}_{instantaneous} = \frac{d\vec{\omega}}{dt}\left(\frac{rad}{s^2}\right)$
- Uniformly Angularly Accelerated Motion: $U\alpha M$ (when $\alpha = constant = \#$)
  - 5 variables, 4 equations, If you know 3 variables, you can find the other 2, which leaves you with 1 …
  - $\omega_f = \omega_i + \alpha\Delta t\,; \Delta\theta = \omega_i\Delta t + \frac{1}{2}\alpha\Delta t^2\,;\ \ \omega_f^2 = \omega_i^2 + 2\alpha\Delta\theta\,;\ \ \Delta\theta = \frac{1}{2}\left(\omega_i + \omega_f\right)\Delta t$
- Arc length, s, is the linear distance travelled when moving along a circle or part of a circle. In other words it is the linear length when traveling along an arc.
  - $s = r\Delta\theta$: arc length equals the radius of the object times the angular displacement of the object.
    - Must use radians when using this equation.
    - $1\ revolution = 360^\circ = 2\pi\ radians$
    - The equation for circumference is an example of this equation where the angular displacement is one revolution or 2π radians: $C = r\left(2\pi\right)$
    - Arc length is a linear dimension, so its units are linear: meters, etc.
    - Not on equation sheet
    - I use a lowercase cursive s for arc length, because my s looks like a 5. Sorry.
- $s = r\Delta\theta \Rightarrow \frac{d}{dt}\left(s = r\Delta\theta\right) \Rightarrow \frac{ds}{dt} = r\frac{d\theta}{dt} \Rightarrow v_t = r\omega$ (is on the AP equation sheet)
- $v_t = r\omega \Rightarrow \frac{d}{dt}\left(v_t = r\omega\right) \Rightarrow \frac{dv_t}{dt} = r\frac{d\omega}{dt} \Rightarrow a_t = r\alpha$ (not on the AP equation sheet)
  - Both of these equations assume the radius stays constant.
  - Must use radians when using both of these equations.
  - v_t is tangential velocity, or the linear velocity of an object moving in a circle. $\left(\frac{m}{s}\right)$
  - a_t is tangential acceleration, or the linear acceleration of an object moving in a circle. $\left(\frac{m}{s^2}\right)$
    - Both tangential quantities are tangent to the circle the object is moving along. This also means they are perpendicular to the radius of the circle the object is moving along.
- Uniform Circular Motion is where objects move in a circle with an angular acceleration of zero.
  - $\alpha = 0$ (The symbol for angular acceleration is alpha, α .)
  - Even though the magnitude of the object's velocity does not change, the direction of the velocity does, that means the velocity is not constant, therefore there must be an acceleration. The acceleration responsible for this change in the direction of the velocity is called centripetal acceleration, a_c.

- $a_c = \frac{v_t^2}{r} = r\omega^2$ in $\left(\frac{m}{s^2}\right)$
- Centripetal means “center seeking” because the centripetal acceleration is **always** toward the center of the circle the objects path describes.

- According to Newton’s 2nd law, where there is an acceleration, there must be a net force. Therefore, if an object is moving in a circle, there is a centripetal acceleration and there must be a centripetal force.
    - Centripetal force: $\sum F_{in} = ma_c$
    - Centripetal force is the net force in the in direction.
        - It is not a new force.
        - It is never in a free body diagram
        - The “in” direction is positive. (The “out” direction is negative.)
    - See “conical pendulum” example from AP Physics 1 Kinematics Review.
- Non-Uniform Circular Motion will have an angular acceleration which is nonzero. $\alpha \neq 0$
    - This means there will also be a *tangential* acceleration, a_t, which is parallel to the tangential velocity and normal to the centripetal acceleration.
    - The net acceleration of an object in Non-Uniform Circular Motion is: $\vec{a}_{net} = \vec{a}_c + \vec{a}_t$
- The period, T, of an object moving in a circle is the time it takes for one revolution. Therefore:
    - $\omega = \frac{\Delta\theta}{\Delta t} = \frac{2\pi}{T} \Rightarrow T = \frac{2\pi}{\omega}$: Period is in seconds