Here comes the long awaited lecture on rotational dynamics.

1 | Torque

Ok at this point most of us know what torque is: it is the *force* that causes rotation without any translation. It is "force" in the rotational sense.

For translational motion, we know that the defining Newton's Second Law expression is:

$$\vec{F_{net}} = M\vec{a} \tag{1}$$

A similar thing works for torque:

$$\vec{\tau_{net}} = I\vec{\alpha} \tag{2}$$

where I is the rotational inertia and $\vec{\alpha}$ would be the angular acceleration. This is actually not that entirely true, it only applies in limited cases where we are estimating a rigid body in circular motion.

1.1 | Rotational Inertia

For a simple particle going in circular motion, we know that:

$$I = Mr^2 \tag{3}$$

that the rotational inertia is equal to the mass multiplied by the radius. We can see that inertia depends on the object about which things are rotating.

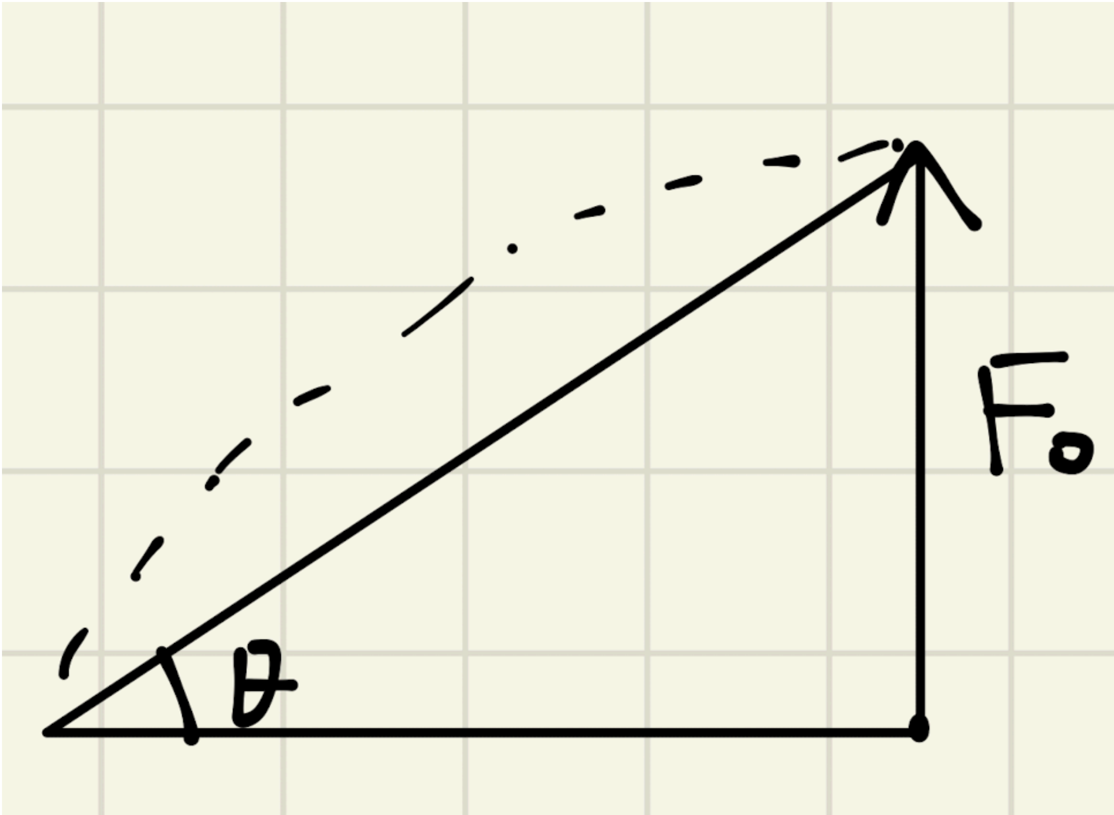
1.2 | Fixing origin

It is much easier to solve for rotation about a fixed origin. Therefore, for the expression we describe as something $r \times \vec{F}$, this r is really necessarily about a fixed origin.

1.3 | Torque is Porp. to Force Applied

$$|\vec{\tau}| \propto |\vec{F}|^\gamma \tag{4}$$

We believe that the magnitude of torque should be proportional to the force applied. Why?



The circumference changes at every step can be measured that:

$$R\Delta\theta = \Delta S \tag{5}$$

if we take the second derivative on both sides:

$$R\frac{d^2\theta}{dt^2} = a = R\ddot{\theta} \tag{6}$$

We can see angular acceleration is proportional to the vertical acceleration, which is proportional to the force. Therefore, torque is porp. to force applied.