Physics 4A
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Center Of Gravity

In many situations one of the forces acting on the rigid body is gravity. The weight of the body is distributed over entire body ⇒ need to be able to calculate torque due to weight

\[ \vec{\tau} = \sum_i \vec{\tau}_i = \sum_i \vec{r}_i \times \vec{w}_i = \sum_i \vec{r}_i \times m_i \vec{g} \]

⇒ \[ \vec{\tau} = \left( \sum_i m_i \vec{r}_i \right) \times \vec{g} = \left( \sum_i \frac{m_i \vec{r}_i}{M} \right) \times M \vec{g} \]

⇒ \[ \vec{\tau} = \vec{r}_{cm} \times \vec{w} \]

Total \( \tau_{grav} \) is same as if total weight was acting at \( \vec{r}_{cm} \).

Define CG as the point at which gravity can be considered to act.

If \( \vec{g} \) has same value over entire body then CG=CM
Conditions for Equilibrium:

CM of rigid body has $\ddot{a}=0 \implies \sum \vec{F} = 0$

can't have tendency to start rotating about any point

$\implies \sum \vec{\tau} = 0$
Stability & Balance

Body in static equilibrium, if left undisturbed, will undergo no translational or rotational acceleration.

If object disturbed, 3 outcomes possible:

1. **Stable equilibrium**: Object returns to its original position.

2. **Unstable Equilibrium**: Object moves even further away from its original position.

3. **Neutral Equ.**: Object stays in new position (like a sphere on a flat table).