Physics 303K Handout 9

1. **Chapter 9.5 to end: Rotational Dynamics**

   (a) Equilibrium Analysis Procedure (from Resnick Halliday and Krane pg 188)

      i. Draw boundary of system.

      ii. Draw Free-Body Diagram. Treat all forces that act across system boundary as external forces.

      iii. Choose coordinate system.

      iv. Choose axes for torques.

      Note: any choice of coordinate system and axes will work, but some may simplify the solution.

   (b) Overdetermined equations have more equations than unknowns. It can fall under two cases:

      i. The equations are all consistent, and one of the relations is redundant.

      ii. The equations are inconsistent, so the problem is ill-defined.

   (c) Underdetermined equations have fewer equations than unknowns. The problem cannot be solved unless another condition, relation, or equation is found.

   (d) In general, there are no restrictions on the relation between angular velocity and translational velocity. Think of a hockey puck sliding across ice. However, in rolling motion without slipping, the translational velocity and the angular velocity must be related: $v_{cm} = \omega R$.

2. **Chapter 10.1 to 10.3 Angular Momentum**

   (a) The angular momentum of a single particle is $\vec{l} = \vec{r} \times \vec{p}$. The magnitude is $|\vec{l}| = |\vec{r}||\vec{p}|sin\theta$. The direction is found using the Right Hand Rule.

   (b) The relation between angular momentum and torque is $\frac{d\vec{l}}{dt} = \sum \vec{\tau}$.

   (c) For a system of particles, the relations are $\vec{L} = \sum_n \vec{l_n}$ and $\frac{d\vec{L}}{dt} = \sum \vec{\tau_{ext}}$. This assumes the strong form of Newton's third law:

      i. $|\vec{F_{12}}| = |\vec{F_{21}}|$

      ii. $\hat{\vec{F_{12}}} = -\hat{\vec{F_{21}}}$

      iii. The forces only act along the line connecting them.

   (d) Note 1: This works for a rigid body or a loose collection of particles!

   (e) Note 2: $\vec{L} = I\vec{\omega}$ is only true for axially symmetric bodies. In other words, $\vec{L}$ and $\vec{\omega}$ are not generally parallel.

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