AP Physics C

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March 23, 2022

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Part I

Mechanics

Chapter 1

Rotations

1.1 Rotation

A **rigid body** rotates as a unit.
The axis about which an object rotates is the **axis of rotation**. The **angular position** $\boldsymbol{\theta}$ of this line is taken relative to a fixed direction, the **zero angular position**.

> Although its can be changed (if specified), positive angles are conventionally **counterclockwise** from the zero angular position.

Angular dimension is measured using **radians** (**rad**), which are dimensionless.

$$\theta = \frac{s}{r}$$

A **revolution** is equal to 360° which is also equal to 2π rad.

1.2 Rolling, Torque, and Angular Momentum

For an object to **roll** is for it to move rotationally and translationally along a surface. For an object to roll **smoothly** is for it not to leave the ground while it is rolling.

> Smooth rolling can be thought of as pure rotation and pure translation or as rotation about a moving contact point.

The center of mass of a rolling object moves parallel to the surface. The rest of the object rotates about the center of mass.
The **arc distance** $\boldsymbol{S}$, the distance covered on the surface, and the velocity about the center of mass are defined as linear variables:

$$S = \theta r \qquad v_{\text{com}} = \omega r$$

As rolling objects move both translationally and rotationally, they have both translational and rotational kinetic energy.

$$K = \frac{1}{2} I_{\text{com}} \omega^2 + \frac{1}{2} M v_{\text{com}}^2$$

If no slipping occurs, then energy is conserved (even with friction). The acceleration about the center of mass follows the pattern of position and velocity.

$$a_{\text{com}} = \alpha r$$

For an object to roll smoothly on a slope, three things are required are required:

1. The gravitational force must be vertically down.
2. The normal force must be perpendicular to the slope.
3. The force of friction must point up the slope.

The acceleration of a body rolling smoothly down a slope can be found as such:

$$a_{\text{com},x} = \frac{-g \sin\theta}{I + \frac{I_{\text{com}}}{Mr^2}}$$