AP Physics C

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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:

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

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

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

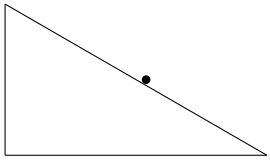
If no slipping occurs, then energy is conserved (even with friction). The acceleration about the center of mass follows the pattern of position and velocity.

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

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 frictional and normal forces are applied to the point of contact rather than the center of mass.



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

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