Using Torque and Rotational Kinetic Energy

Pre-Lecture Questions

Problem Set #27 (due next time)

Lecture Outline

1. Applications of the Second Law
2. Rolling Motion
3. Rotational Kinetic Energy

Pre-Class Summary:

The forces explain the motion of the center-of-mass while the torques explain the rotational motion.

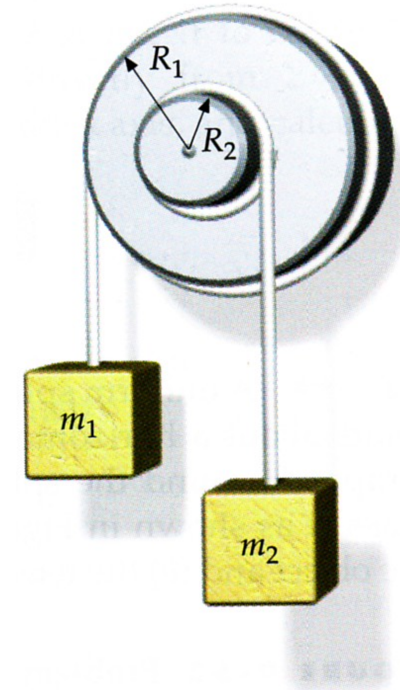
When an object rolls without slipping there are special relationships between the motion of the center-of-mass and the rotational motion:

$$x_{cm} = r\theta \qquad v_{cm} = r\omega \qquad a_{cm} = r\alpha$$

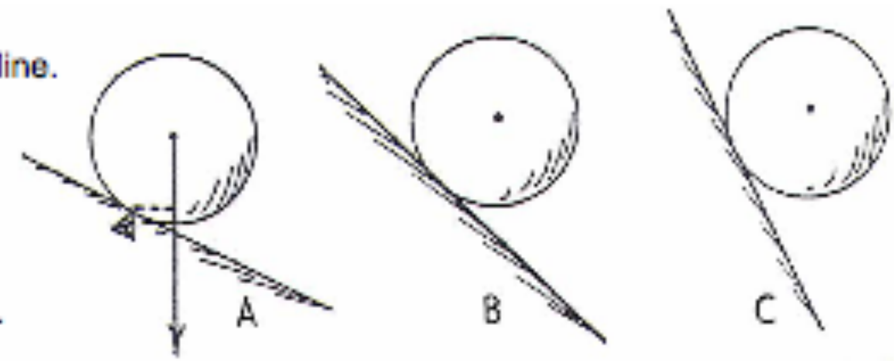
We can still use the Law of Conservation of Energy if we include the rotational kinetic energy.

The Rotational Kinetic Energy $K = \frac{1}{2} I\omega^2$.

Example 1: The device shown rotates about its axis with an angular acceleration of 1.37rad/s^2 when m_1 = 36.0kg, m_2 = 72.0kg, R_1 = 1.20m, and R_2 = 0.400m. Find the tension in each rope and the rotational inertia of the device.



. We all know that a ball rolls down an incline. But only a few people know that the reason a ball picks up rotational speed is because of a torque. In sketch A, we see a torque acting on a ball. Note the force due to gravity and the lever arm to the point where surface contact is made.



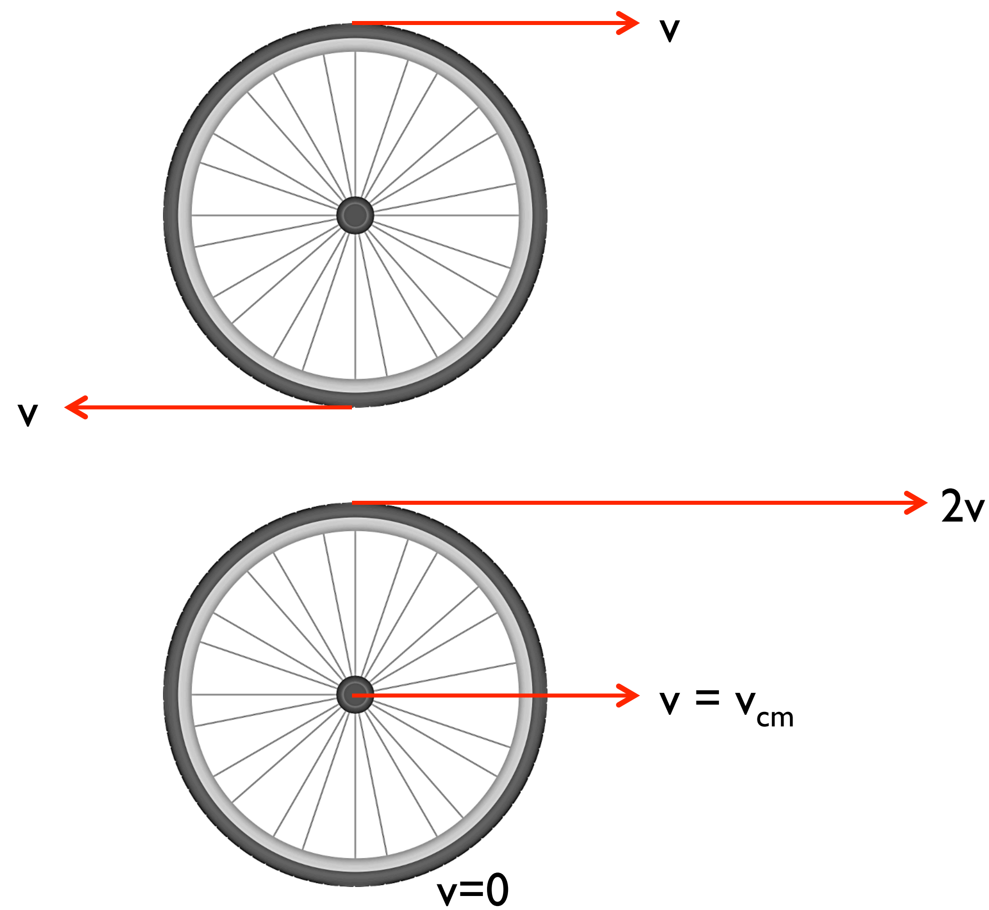
a. Construct the lever arms for positions B and C.

b. As the incline becomes steeper, the torque [increases] [decreases] [remains the same].

Rolling Without Slipping

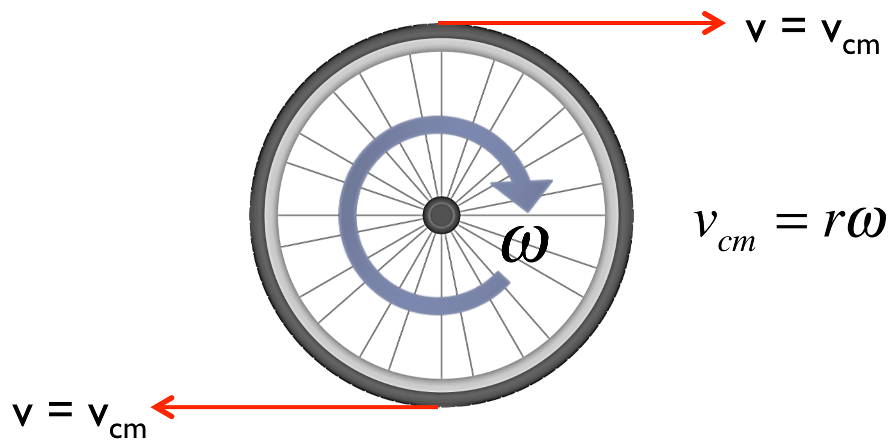
Bicycle rider's reference frame

Pedestrian's reference frame



Rolling Without Slipping

Bicycle rider's reference frame



$$v_{cm} = r\omega$$

Rolling Without Slipping

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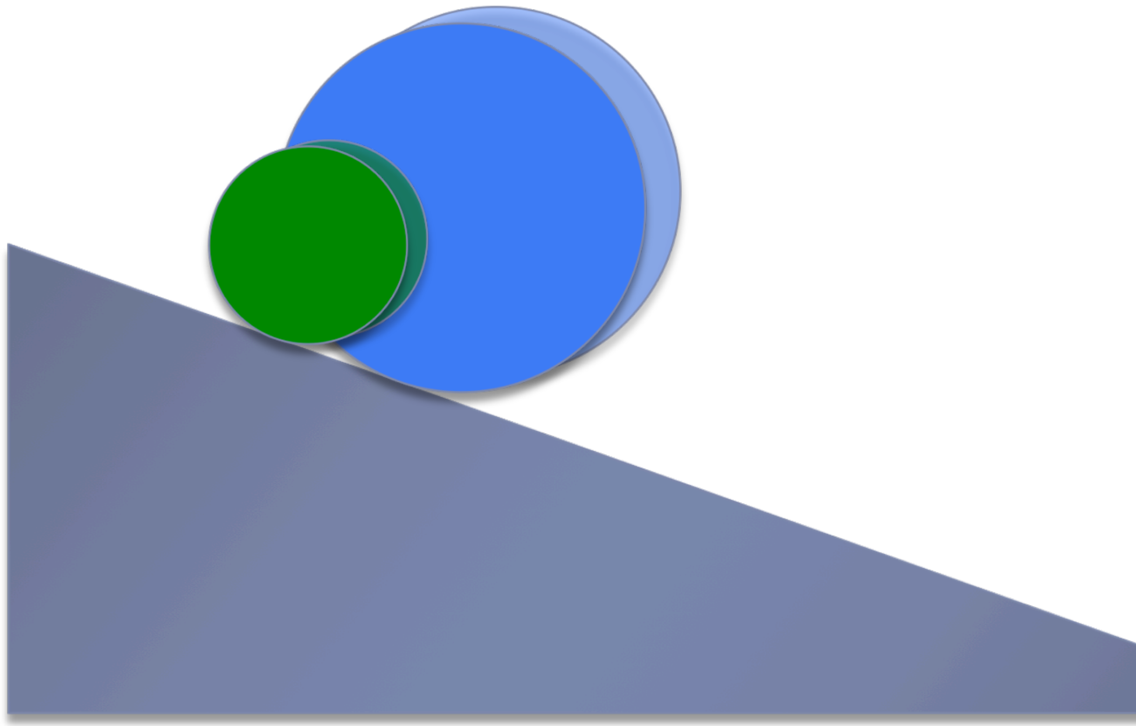
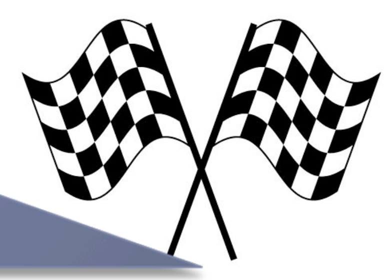
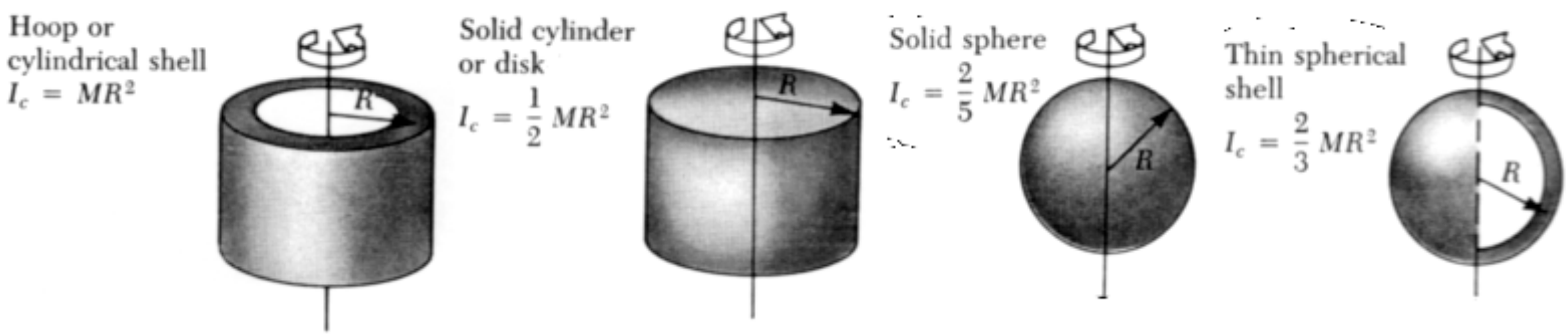
Example 2: A bowling ball is rolling without slipping. Find the fraction of its kinetic energy that is rotational.

Example 3: An object with mass, m, radius, r, and rotational inertia, I, starts from rest rolls down a hill of height, h. Find the speed at the bottom.

Incline Plane Races







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