# Practice Problem Set 9

November 22, 2016

## Rotational Motion

A solid disk of mass 5 kg and radius 0.5 m is spinning at a speed of 100 rad/s. A torque is applied at the edge of the disk to slow it down. What torque is required to stop the disk in under 10 rotations?

## Wolfson, Ch. 10 Q.65

## Rotational and Kinetic Energy

A solid ball of mass M and radius R starts at the top of a ramp at height H. What is the final speed of the ball at the base of the ramp assuming it rolls without slipping and no energy is lost to friction? How does this compare with an equivalent mass that isn't rolling and is sliding instead?

## Challenge Problem: Tsiolkovsky Rocket Equation

A rocket in space works by ejecting a part of its mass (the propellant) backwards, so that it can move forward by conservation of momentum. The Tsiolkovsky rocket equation describes the change in velocity resulting from a change in mass and can be used to calculate how much fuel is needed to launch a rocket into space. The Tsiolkovsky rocket equation is:

$$\Delta v = v_e ln(\frac{m_i}{m_f}) \tag{1}$$

where $\Delta v$ the change of velocity of the rocket (with no external forces acting).
$m_i$ is the initial total mass, including propellant.
$m_f$ is the final total mass without propellant.
$v_e$ is the exhaust velocity relative to the rocket.

Derive the Tsiolkovsky rocket equation using momentum conservation. Hint: Find the momentum at time $\Delta t$, where the rocket has lost mass $\Delta m$ and gained speed $\Delta V$ and take the limit where $\Delta t$ goes to zero and integrate your equation.