In Atwood's Machine two masses (m_1 & m_2), connected by a string, hang off opposite ends of a frictionless pulley (radius R; moment of inertia I). If m_1 moves up a distance x the pulley turns an angle $\phi = x/R$ (why?) and the mass m_2 falls a distance x. Careful consideration of forces and torques in 191 showed that the acceleration ($\ddot{x}$) was given by:

$$\ddot{x} = \frac{(m_2 - m_1)g}{m_1 + m_2 + I/R^2}$$

1. Make three free body diagrams showing and naming (a) all the forces on m_1, (b) all the forces on m_2, and (c) all the torques on the pulley. (Use the pulley's center as the origin for all torques.)
2. Write down the energy (KE+PE) of the entire system in terms of x and $\dot{x}$.
3. Since gravity is a conservative force the above energy should be a constant and hence its time derivative should be zero. Take the time derivative of your (2) result and derive the above formula for the acceleration $\ddot{x}$.
4. Is there a gravitational torque on m_1 (as always, use the pulley's center as the origin)? If the gravitational torque is non-zero, report its direction.
5. Does m_1 have angular momentum (use the pulley's center as the origin)? If the angular momentum is non-zero report the direction of its angular momentum (assume $\dot{x} > 0$).
6. Now consider the net external torque on the entire system and the time derivative of the total angular momentum (i.e., the angular momentum of m_1, m_2, and the pulley together). Use this to again derive the top equation for $\ddot{x}$.