



Assume a solid ball of mass  $m$  and radius  $r_b$  at radius  $r$  from a pivot point attached by a massless arm with length  $r$ . The angle of the arm is  $\theta$ , a function of time. The torque applied to the arm is  $\tau$ , positive in the counterclockwise direction. By the parallel axis theorem, the moment of inertia is given by

$$I = m \left( r^2 + \frac{2}{5} r_b^2 \right).$$

The angular version of Newton's second law is

$$\tau = I\ddot{\theta}.$$

The torque due to gravity, assuming it is applied only at the center of the ball, is given by

$$\tau_g = -mrg \cos \theta,$$

where  $g = 9.81 \text{ m/s}^2$  is the acceleration of gravity at sea level. Hence, we have:

$$\ddot{\theta} = \frac{\tau + \tau_g}{I} = \frac{\tau - mrg \cos \theta}{m \left( r^2 + \frac{2}{5} r_b^2 \right)}$$