From second order to first order

Once you have your differential equations, you'll want to transform them into a set of first order DE's that will be compatible with an ODE solver. Do so!

This should be pretty straightforward: we just need to do some relabeling here.

As noted in our state variables, we have θ and ω, and r and v_r. Clearly two of our DE's are the simple definitional ones:

$$\frac{dr}{dt} = v_r$$

$$\frac{d\theta}{dt} = \omega$$

We obtain our other two DE's for ω and v_r by substituting these in the equation above:

$$\frac{d\omega}{dt} = \frac{-mgr\cos\theta - 2mrv_r\omega}{mr^2 + I}$$

and finally

$$\frac{dv_r}{dt} = -g\sin\theta + r\omega^2$$