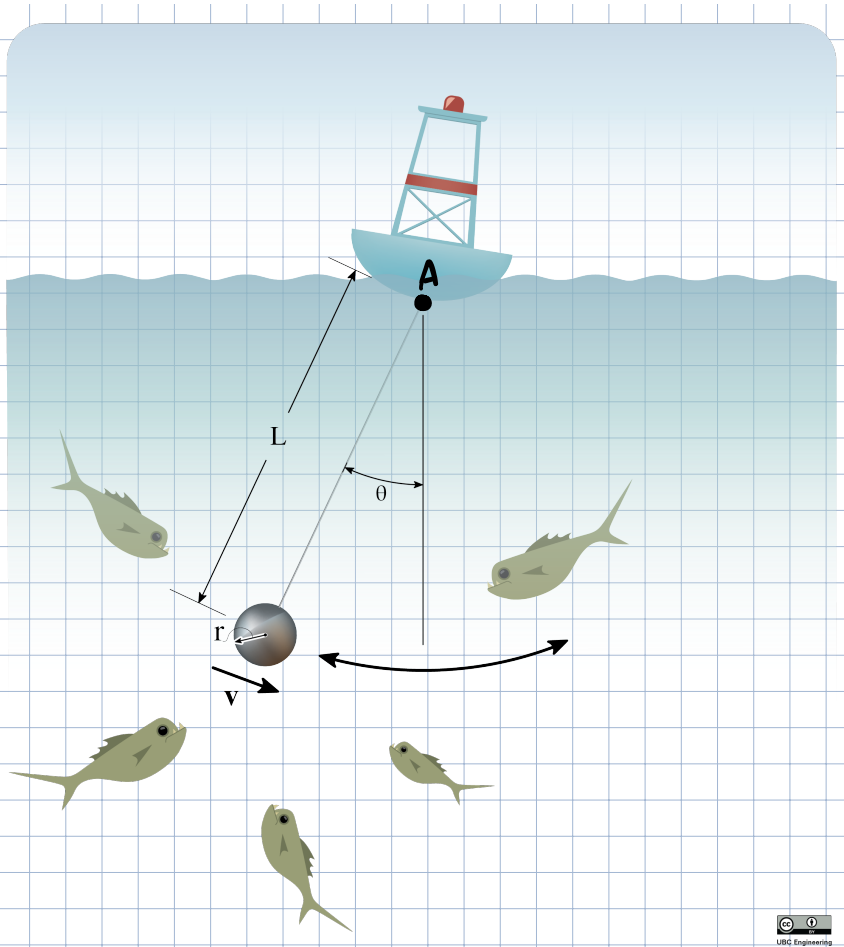
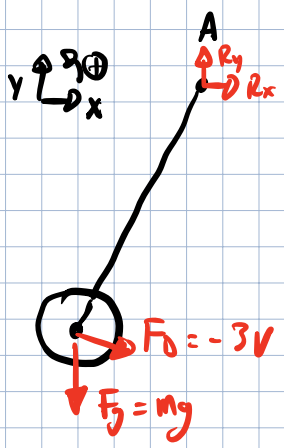
A new fish species discovered in the Fraser River has been observed to be attracted to swinging pendulums as depicted above. You want to observe this phenomenon, so you take a spherical metal ball of mass m = 0.585 kg attached to a rope of length L = 1.5 m and tie it to a buoy as shown. If the drag force of the ball is modelled by $F_d = -3v$, what radius must the ball be for oscillation to occur?

(Use g = 9.81 m/s^2 and assume that sin θ = θ. Ignore the buoyancy force in your calculations.)





$$\sum M_A = I_A \alpha \quad \rightarrow \quad I_A = \frac{2}{5}mr^2 + mL^2$$

$$-3vL - mgL\sin\theta = \left(\frac{2}{5}mr^2 + mL^2\right)\alpha$$

$\sin\theta = \theta$

$v = L\dot{\theta}$

$\alpha = \ddot{\theta}$

$$-3L^2\dot{\theta} - mgL\theta = \left(\frac{2}{5}mr^2 + mL^2\right)\ddot{\theta}$$

$$\left(\frac{2}{5}mr^2 + mL^2\right)\ddot{\theta} + 3L^2\dot{\theta} + mgL\theta = 0$$

need char. sol. to be imaginary $\rightarrow$ oscillate

$$3L^2 - 4\left(\frac{2}{5}mr^2 + mL^2\right)mgL \leq 0$$

$$\rightarrow \quad r^2 \geq \frac{3L^4 - 4m^2L^3g}{\frac{8}{5}(m^2gL)}$$

$$\rightarrow \boxed{r \geq 0.05\,m}$$