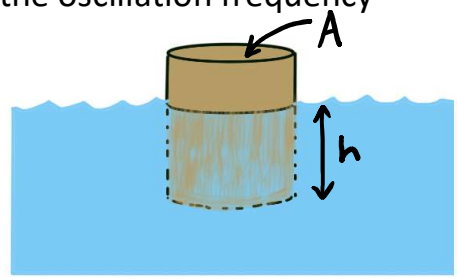
Physics 157 oscillations worksheet: determining the oscillation frequency

1) A cylindrical object of mass M and cross-sectional area A is placed in some water. We'd like to predict the oscillation frequency for the bobbing motion.



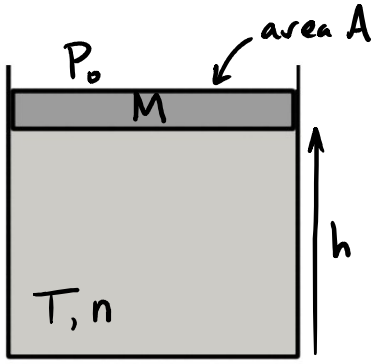
a) Draw a free body diagram for the object showing the vertical forces.

b) Calculate the magnitude of the net downwards force on the object as a function of the depth h that the object is in the water. (*Hint: the upward buoyant force is the net force from the water and air. Its magnitude is equal to the weight mg of the "missing" water displaced by the object).*

Answer in terms of h, A, M, g, and ρ_{water}

c) Graph the downward force as a function of h, for positive values of h up to the height of the object, assuming the object is less dense than water.

d) What is the oscillation frequency ω in terms of h, A, M, g, and ρ_{water}? (*Hint: what is k in the equation $F_{NET} = - k \Delta x$?)*



2) A cylinder with gas at constant temperature T has a piston of mass M which can move freely up and down. We would like to calculate the oscillation frequency of the piston if it is displaced up or down.

a) Draw a free body diagram for the piston showing the vertical forces. Calculate the magnitude of the net upwards force on the object as a function of the height h of the piston.

Answer in terms of h, n, T, A, M, g, R, and P_0

c) Sketch a graph of the net upward force on the piston vs the height of the piston

d) What is the equilibrium height of the piston?

Answer in terms of h, n, T, A, M, g, R, and P_0

e) What is the oscillation frequency ω? (Hint: to find k here, you need to think about small oscillations about the equilibrium position)