

### ASGV3 Ex 3.3 (Sinking ball of wax)

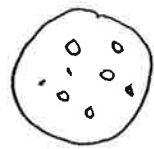
The ball of wax will sink when there is enough

sand in it so that its density is equal to that of water (or just greater). When  $N$  grains of sand are in it, it will have a mass given by

$$M = N \rho_s V_s + \rho_w V_w$$

where  $\rho_s$  and  $\rho_w$  are the densities of the sand and wax, and  $V_s$  and  $V_w$  are the volumes of the sand (grain) and wax ball. The overall density of the sand and wax ball is given by

$$\rho = \frac{M}{V} = \frac{N \rho_s V_s + \rho_w V_w}{N V_s + V_w}$$



When the numerator & denominator are equal, the ball just begins to sink:

$$N \rho_s V_s + \rho_w V_w = N V_s + V_w$$

$$V_s N (\rho_s - 1) = V_w (1 - \rho_w)$$

$$N = \frac{V_w}{V_s} \frac{(1 - \rho_w)}{(\rho_s - 1)} = \frac{\left(\frac{1}{2} \text{ cm}\right)^3 (1 - 0.93)}{\left(\frac{1}{4} \text{ mm}\right)^3 (2 - 1)} = \boxed{560}$$