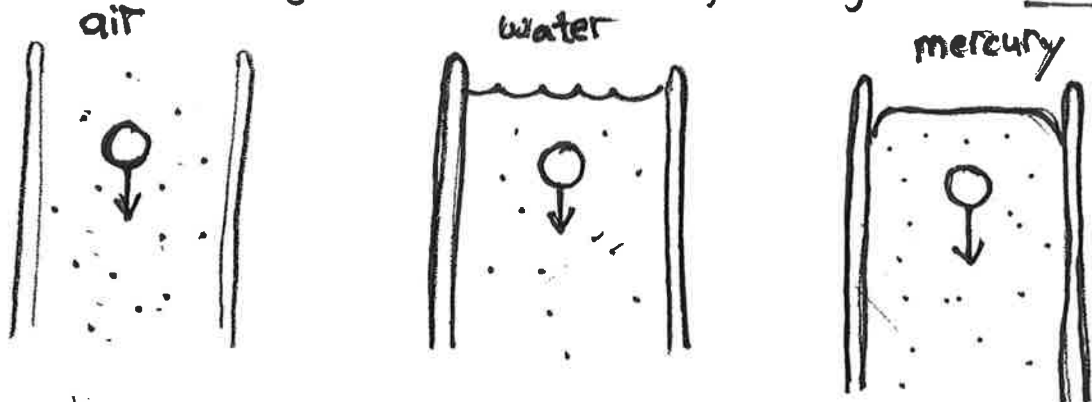
ASG v2 EX 3.2 (Falling gold balls)

Consider 3 gold balls (identical) falling in different media.



The acceleration, a, of each ball is determined by its weight as measured in the surrounding medium. More specifically, its acceleration in a medium is reduced from its acceleration in a vacuum by the ratio of the density of the fluid to that of the ball. So if the ball would fall with an acceleration of 1 unit of speed per second in a vacuum, then it would fall with an acceleration of

$$a_{air} = 1 - \frac{\rho_{air}}{\rho_{gold}} \approx 1 - \frac{1}{15200} = \boxed{0.9999} \text{ in air}$$

$$a_{water} = 1 - \frac{\rho_{water}}{\rho_{gold}} \approx 1 - \frac{1}{19} = \boxed{0.95} \text{ in water}$$

$$a_{mercury} = 1 - \frac{\rho_{mercury}}{\rho_{gold}} = 1 - \frac{14}{19} = \boxed{0.26} \text{ in mercury}$$

From the perspective of <u>forces</u>, we can find that

- weight − buoyant force = mass × acceleration

$$W_{ball} - B = m_{ball}\, a \quad \leftarrow \text{Newton's 2nd law}$$

(we'll come to this later)

$$\rho_{ball} \cancel{V_{ball}}\, g - \rho_{fluid} \cancel{V_{ball}}\, g = \rho_{ball} \cancel{V_{ball}}\, a$$

$$g\left(\rho_{ball} - \rho_{fluid}\right) = \rho_{ball}\, a$$

$$g\left(1 - \frac{\rho_{fluid}}{\rho_{ball}}\right) = a$$

- This formula shows that the ball's acceleration is just $g = 9.8\ m/s^2$ reduced by a factor of

$$\left(1 - \frac{\rho_{fluid}}{\rho_{ball}}\right)$$

as used by Galileo.

- This, of course, neglects any drag forces caused at the surface of the ball.