Given:

A garden hose with a nozzle is used to fill a 10 gal bucket. The inner diameter of the hose is 2 cm and the diameter of the nozzle exit is 0.8 cm.

$$V_b := 10\ \text{gal} = 0.03785\ \text{m}^3 \qquad D_h := 2\ \text{cm} \qquad D_n := 0.8\ \text{cm}$$

Required:

If it takes 50 seconds to file the bucket, determine

(a) the volume and mass flow rates of water through the hose,

(b) the average velocity of water inside the hose, and

(c) the average velocity of water at the nozzle exit.

Solution:

The time it takes to fill the bucket is defined as

$$\Delta t := 50\ \text{s}$$

The volumetric flow rate of the hose is

$$\boxed{V' := \frac{V_b}{\Delta t} = 0.7571\ \frac{\text{L}}{\text{s}}} \qquad \text{(a1)} \qquad V' = 7.571 \cdot 10^{-4}\ \frac{\text{m}^3}{\text{s}}$$

Assuming the density of water is 1 kg/L, the mass flow rate of the hose is then

$$\boxed{m' := \left(1\ \frac{\text{kg}}{\text{L}}\right) \cdot V' = 0.7571\ \frac{\text{kg}}{\text{s}}} \qquad \text{(a2)}$$

The cross sectional area of the flow at the hose section is

$$A_h := \frac{\pi}{4} \cdot D_h^{\,2} = 3.1416 \cdot 10^{-4}\ \text{m}^2$$

The average velocity of the water at the hose section is then

$$\boxed{V_{avg\_h} := \frac{V'}{A_h} = 2.4099\ \frac{\text{m}}{\text{s}}} \qquad \text{(b)}$$

The cross sectional area of the flow at the nozzle section is

$$A_n := \frac{\pi}{4} \cdot D_n^{\,2} = 5.0265 \cdot 10^{-5}\ \text{m}^2$$

The average velocity of the water at the nozzle section is then

$$\boxed{V_{avg\_n} := \frac{V'}{A_n} = 15.0617\ \frac{\text{m}}{\text{s}}} \qquad \text{(c)}$$