5.25

5.25 Air at standard conditions enters the compressor shown in Fig. P5.25 at a rate of 10 ft³/s. It leaves the tank through a 1.2-in.-diameter pipe with a density of 0.0035 slugs/ft³ and a uniform speed of 700 ft/s. (a) Determine the rate (slugs/s) at which the mass of air in the tank is increasing or decreasing. (b) Determine the average time rate of change of air density within the tank.

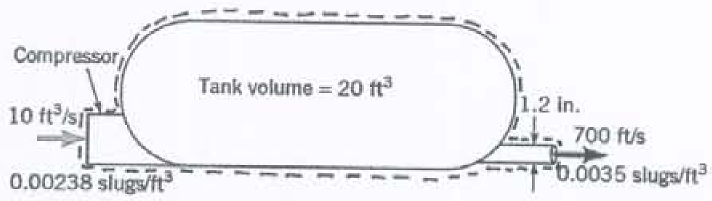

FIGURE P5.25

Use the control volume within the broken lines.

(a) From the conservation of mass principle we get

$$\frac{DM_{sys}}{Dt} = \dot{m}_{in} - \dot{m}_{out} = \rho_{in} Q_{in} - \rho_{out} A_{out} V_{out}$$

$$\frac{DM_{sys}}{Dt} = \left(0.00238\ \frac{slug}{ft^3}\right)\left(10\ \frac{ft^3}{s}\right) - \left(0.0035\ \frac{slug}{ft^3}\right)\frac{\pi\,(1.2\ in.)^2}{\left(144\ \frac{in^2}{ft^2}\right)}\left(700\ \frac{ft}{s}\right)$$

$$\frac{DM_{sys}}{Dt} = \underline{\underline{0.00456}}\ \frac{slug}{s} \quad \text{increasing}$$

(b) $$\frac{DM_{sys}}{Dt} = \frac{D(\rho V_{sys})}{Dt} = V_{sys}\frac{D\rho}{Dt} = 0.00456\ \frac{slug}{s}$$

so

$$\frac{D\rho}{Dt} = \frac{0.00456\ \frac{slug}{s}}{V_{sys}} = \frac{0.00456\ \frac{slug}{s}}{20\ ft^3} = \underline{\underline{2.28 \times 10^{-4}}}\ \frac{slug}{ft^3\, s}$$