Contents

1 Surface Tension

1.1 12.38

$$A_0 v_0 = 0.750\,\mathrm{m^3\,s^{-1}}$$

(a)

$$d = 4.50\,\mathrm{cm} = 0.0450\,\mathrm{m}$$

$$\begin{aligned} A_0 v_0 &= A_1 v_1 \\ v_1 &= \frac{A_0 v_0}{A_1} \\ v_1 &= \frac{0.750\,\mathrm{m^3\,s^{-1}}}{\pi\left(\frac{0.0450\,\mathrm{m}}{2}\right)^2} \\ v_1 &= 472\,\mathrm{m\,s^{-1}} \end{aligned}$$

(b)

$$\begin{aligned} A_0 v_0 &= A_1 v_1 \\ \pi\left(\frac{3(0.0450\,\mathrm{m})}{2}\right)^2 v_0 &= 0.750\,\mathrm{m^3\,s^{-1}} \\ v_0 &= 52.4\,\mathrm{m\,s^{-1}} \end{aligned}$$

1.2 12.39

$$\begin{aligned} A_0 v_0 &= A_1 v_1 \\ \pi(0.008\,\mathrm{m})^2(3.0\,\mathrm{m\,s^{-1}}) &= \pi[20(0.001\,\mathrm{m})^2]v_1 \\ v_1 &= 9.6\,\mathrm{m\,s^{-1}} \end{aligned}$$

2 Bernoulli's Equation

$$\begin{aligned}
\text{Work} &= \mathbf{F} \cdot \Delta\mathbf{x} = F\Delta x\cos(\theta) \\
\text{Work} &= \Delta KE \\
\text{Work} &= -\Delta PE
\end{aligned}$$

$$\begin{aligned}
\text{Work} &= \Delta KE + \Delta PE \\
F_0 ds_0 - F_1 ds_1 &= \left[\frac{1}{2}mv_1^2 - \frac{1}{2}mv_0^2\right] + [mgh_1 - mgh_0] \\
F_0 ds_0 + \frac{1}{2}mv_0^2 + mgh_0 &= F_1 ds_1 + \frac{1}{2}mv_1^2 + mgh_1 \\
P_0 A_0 ds_0 + \frac{1}{2}mv_0^2 + mgh_0 &= P_1 A_1 ds_1 + \frac{1}{2}mv_1^2 + mgh_1 \\
P_0 V + \frac{1}{2}[\rho V]\, v_0^2 + [\rho V]\, gh_0 &= P_1 V + \frac{1}{2}[\rho V]\, v_1^2 + [\rho V]\, gh_1 \\
P_0 + \frac{1}{2}\rho v_0^2 + \rho gh_0 &= P_1 + \frac{1}{2}\rho v_1^2 + \rho gh_1
\end{aligned}$$

2.1 12.45

$$\begin{aligned}
y_1 &= 11.0\,\text{m} \\
p_0 &= 3.00\,\text{atm}
\end{aligned}$$

$$\begin{aligned}
p_0 + 0 + \rho gh_0 &= p_1 + \frac{1}{2}\rho v_1^2 + 0 \\
v_1 &= \sqrt{2\left[\frac{p_0 - p_1}{\rho} + gh_0\right]} \\
v_1 &= \sqrt{2\left[\frac{3.039\times10^5\,\text{Pa} - 0}{1.00\times10^3\,\text{kg m}^{-3}} + (10.0\,\text{m s}^{-2})(11.0\,\text{m})\right]} \\
v_1 &= 26.7918\,\text{m s}^{-1} = 26.8\,\text{m s}^{-1}
\end{aligned}$$

2.2 12.49

$$\begin{aligned}
v_0 &= 2.50\,\text{m s}^{-1} \\
p_0 &= 1.80\times10^4\,\text{Pa}
\end{aligned}$$

$$\begin{aligned}
A_0 v_0 &= A_1 v_1 \\
v_1 &= \frac{A_0}{2A_0}v_0 \\
v_1 &= \frac{2.50\,\text{m s}^{-1}}{2} \\
v_1 &= 1.25\,\text{m s}^{-1}
\end{aligned}$$

$$p_0 + \frac{1}{2}\rho v_0^2 + \rho g h_0 = p_1 + \frac{1}{2}\rho v_1^2 + \rho g h_1$$
$$p_0 + \frac{1}{2}\rho v_0^2 + 0 = p_1 + \frac{1}{2}\rho v_1^2 + 0$$
$$p_1 = p_0 + \frac{1}{2}\rho v_0^2 - \frac{1}{2}\rho v_1^2$$
$$p_1 = 1.80 \times 10^4\,\mathrm{Pa} + \frac{1}{2}(1.00 \times 10^3\,\mathrm{kg\,m^{-3}})\left[(2.50\,\mathrm{m\,s^{-2}})^2 - (1.25\,\mathrm{m\,s^{-1}})^2\right]$$
$$p_1 = 20\,343.8\,\mathrm{Pa} = 2.03 \times 10^4\,\mathrm{Pa}$$

2.3 12.50

$$v_0 = 3.00\,\mathrm{m\,s^{-1}}$$
$$p_0 = 5.00 \times 10^4\,\mathrm{Pa}$$
$$y_0 = 11.0\,\mathrm{m}$$
$$p_1 = ?$$
$$2d_1 = d_0$$

$$A_0 v_0 = A_1 v_1$$
$$\left[\pi\left(\frac{d}{2}\right)^2\right] v_0 = \left[2\pi\left(\frac{d}{2}\right)^2\right] v_1$$
$$v_1 = 4v_0$$
$$v_1 = 4(3.00\,\mathrm{m\,s^{-1}})$$
$$v_1 = 12.0\,\mathrm{m\,s^{-1}}$$

$$p_0 + \frac{1}{2}\rho v_0^2 + \rho g h_0 = p_1 + \frac{1}{2}\rho v_1^2 + \rho g h_1$$
$$p_0 + \frac{1}{2}\rho v_0^2 + \rho g h_0 = p_1 + \frac{1}{2}\rho v_1^2 + 0$$

$$p_1 = p_0 + \frac{1}{2}\rho v_0^2 + \rho g h_0 - \frac{1}{2}\rho v_1^2$$
$$p_1 = 5.00 \times 10^4\,\mathrm{Pa} + \frac{1}{2}(1.00 \times 10^3\,\mathrm{kg\,m^{-3}})(3.00\,\mathrm{m\,s^{-1}})^2 + (1.00 \times 10^3\,\mathrm{kg\,m^{-3}})(10.0\,\mathrm{m\,s^{-2}})(11.0\,\mathrm{m})$$
$$- \frac{1}{2}(1.00 \times 10^3\,\mathrm{kg\,m^{-3}})(12.0\,\mathrm{m\,s^{-1}})^2$$
$$p_1 = 158\,500\,\mathrm{Pa} = 1.59 \times 10^5\,\mathrm{Pa}$$

2.4 12.51

$$
\begin{aligned}
Q_0 &= 7200\,\mathrm{cm^3\,s^{-1}} = 7.20 \times 10^{-3}\,\mathrm{m^3\,s^{-1}} \\
r_0 &= 0.0400\,\mathrm{m} \\
p_0 &= 2.40 \times 10^5\,\mathrm{Pa} \\
r_1 &= 0.0200\,\mathrm{m}
\end{aligned}
$$

$$
\begin{aligned}
A_0 v_0 &= A_1 v_1 \\
Q_0 &= \pi r_1^2 v_1 \\
v_1 &= \frac{Q_0}{\pi r_1^2} \\
v_1 &= \frac{7.20 \times 10^{-3}\,\mathrm{m^3\,s^{-1}}}{\pi (0.0200\,\mathrm{m})^2} \\
v_1 &= 5.73\,\mathrm{m\,s^{-1}}
\end{aligned}
$$

$$
\begin{aligned}
v_0 &= \frac{Q_0}{A_0} \\
v_0 &= \frac{7.20 \times 10^{-3}\,\mathrm{m^3\,s^{-1}}}{\pi (0.0400\,\mathrm{m})^2} \\
v_0 &= 1.43\,\mathrm{m\,s^{-1}}
\end{aligned}
$$

$$
\begin{aligned}
p_0 + \frac{1}{2}\rho v_0^2 + \rho g h_0 &= p_1 + \frac{1}{2}\rho v_1^2 + \rho g h_1 \\
p_0 + \frac{1}{2}\rho v_0^2 + 0 &= p_1 + \frac{1}{2}\rho v_1^2 + 0 \\
p_1 &= p_0 + \frac{1}{2}\rho \left[v_0^2 - v_1^2 \right] \\
p_1 &= 2.40 \times 10^5\,\mathrm{Pa} + \frac{1}{2}(1.00 \times 10^3\,\mathrm{kg\,m^{-3}}) \left[(1.43\,\mathrm{m\,s^{-1}})^2 - (5.73\,\mathrm{m\,s^{-1}})^2 \right] \\
p_1 &= 224\,606\,\mathrm{Pa} = 2.25 \times 10^5\,\mathrm{Pa}
\end{aligned}
$$

2.5 Problem

$$
\begin{aligned}
A_0 &= 1.00\,\mathrm{m^2} \\
y_0 &= 5.00\,\mathrm{m} \\
A_1 &= 0.500\,\mathrm{m^2}
\end{aligned}
$$

$$
\begin{aligned}
A_0 v_0 &= A_1 v_1 \\
v_0 &= \frac{1}{2} v_1
\end{aligned}
$$

$$
\begin{aligned}
p_0 + \frac{1}{2}\rho v_0^2 + \rho g h_0 &= p_1 + \frac{1}{2}\rho v_1^2 + \rho g h_1 \\
0 + \frac{1}{2}\rho \left[\frac{1}{2} v_1\right]^2 + \rho g h_0 &= 0 + \frac{1}{2}\rho v_1^2 + 0 \\
v_1^2 \left[\frac{1}{2}\rho - \frac{1}{8}\rho\right] &= \rho g h_0 \\
v_1 &= \sqrt{\frac{g h_0}{\frac{1}{2} - \frac{1}{8}}} \\
v_1 &= \sqrt{\frac{(10.0\,\mathrm{m\,s^{-2}})(5.00\,\mathrm{m})}{\frac{1}{2} - \frac{1}{8}}} \\
v_1 &= 11.547\,\mathrm{m\,s^{-1}}
\end{aligned}
$$