1. By Pascal’s principle, the pressure needed to lift the mass is distributed throughout the hydraulic fluid. The pressure is

\[
P_{\text{out}} = \frac{F_{\text{out}}}{A_{\text{out}}} = \frac{mg}{\pi(r_{\text{out}})^2} = \frac{(1250\text{kg})(9.8\text{m/s}^2)(1000\text{km})}{\pi((6\text{in})(2.54\times10^{-2}\text{m/in}))^2} = 1.68\times10^5\text{ Pa}
\]

By Pascal’s principle, \(P_{\text{out}} = P_{\text{in}}\).

\[
P_{\text{in}} = \frac{F_{\text{in}}}{A_{\text{in}}}
\]

\[
F_{\text{in}} = P_{\text{in}}A_{\text{in}} = (1.68\times10^5\text{ Pa})(\pi((1\text{in})(2.54\times10^{-2}\text{m/in}))^2 = 340\text{N}
\]

2. The pressure at the bottom of the tube is due to the weight of the water, the weight of the oil, and the atmosphere.

\[
P_z = P_i + \rho_o g h_o + \rho_w g h_w
\]

\[
= 1.01\times10^5\text{ Pa} + (800\text{kg/m}^3)(9.8\text{m/s}^2)(15\text{m}) + (1000\text{kg/m}^3)(9.8\text{m/s}^2)(12.5\text{m})
\]

\[
= 3.4\times10^5\text{ Pa}
\]

3. There two ways to solve the problem. One is to use the density of steel to find the volume of the bolt. First find the mass of the bolt

\[
W = mg
\]

\[
m = \frac{W}{g} = \frac{0.770\text{N}}{9.8\text{m/s}^2} = 0.0786\text{kg}
\]

Use the density to find the volume,

\[
\rho = \frac{m}{V}
\]

\[
V = \frac{m}{\rho} = \frac{0.0786\text{kg}}{7860\text{kg/m}^3} = 1.0\times10^{-5}\text{ m}^3
\]

The other way to solve this problem is to use Archimedes’ principle. The buoyant force is the difference in the actual weight and the apparent weight,

\[
F_B = W - W_{\text{app}} = 0.770\text{N} - 0.672\text{N} = 0.098\text{N}
\]
Now use Archimedes’ principle

\[ F_n = \rho g V \]

\[ V = \frac{F}{\rho g} = \frac{0.098 \text{N}}{(1000 \text{kg/m}^3)(9.8 \text{m/s}^2)} = 1.0 \times 10^{-3} \text{ m}^3 \]

4. The volume flow rate is related to the speed of the water,

\[ \frac{\Delta V}{\Delta t} = Av \]

\[ v = \frac{1}{A} \frac{\Delta V}{\Delta t} = \frac{1}{\pi r^2} \frac{\Delta V}{\Delta t} = \frac{1}{\pi((0.0254 \text{m})/2)^2} \frac{0.08 \text{m}^3}{12 \text{s}} = 13.2 \text{ m/s} \]

This velocity is created as the water flows from down from the tower. Using Bernoulli’s equation

\[ P_1 + \rho g y_1 + \frac{1}{2} \rho v_1^2 = P_2 + \rho g y_2 + \frac{1}{2} \rho v_2^2 \]

Associate the 1 subscript with the tower and the 2 subscript with the faucet. Since the tower and the faucet are open to the atmosphere, \( P_1 = P_2 = P_{atm} \). The tower has such a large volume and its level falls very slowly, \( v_1 = 0 \).

\[ P_{atm} + \rho g y_1 + \frac{1}{2} \rho (0)^2 = P_{atm} + \rho g y_2 + \frac{1}{2} \rho v_2^2 \]

\[ \rho g (y_1 - y_2) = \frac{1}{2} \rho v_2^2 \]

\[ y_1 - y_2 = \frac{v_2^2}{2g} = \frac{(13.2 \text{ m/s})^2}{2(9.8 \text{ m/s}^2)} = 8.8 \text{ m} \]

5. Use Poiseuille’s law

\[ \frac{\Delta V}{\Delta t} = \frac{\pi \Delta P / L}{r^4} \]

\[ \Delta P = \frac{\Delta V}{\pi r^4} \frac{8 L \eta}{\Delta t} = \frac{4.5 \times 10^{-4} \text{ m}^3/\text{s}}{\pi} \frac{8 (1900 \text{ m})(0.20 \text{ Pa} \cdot \text{s})}{(0.15 \text{ cm})^4} = 860 \text{ Pa} \]

6. The stress in the cable is

\[ \text{stress} = \frac{F}{A} = \frac{mg}{\pi r^2} = \frac{(250 \text{ kg})(9.8 \text{ m/s}^2)}{\pi(0.012 \text{ m})^2} = 5.42 \times 10^6 \text{ Pa} \]

Young’s modulus is
\[ Y = \frac{\text{stress}}{\text{strain}} \]
\[ \text{strain} = \frac{\text{stress}}{Y} = \frac{5.42 \times 10^6 \text{ Pa}}{2.0 \times 10^{11} \text{ Pa}} = 2.7 \times 10^{-5} \]

Since strain = \( \Delta L/L \) this is the fractional increase in length.

7. The volume compresses 0.10% = 0.001. The relationship defining the bulk modulus,
\[ \Delta P = -B \frac{\Delta V}{V} = (90 \times 10^9 \text{ Pa})(0.001) = 9.0 \times 10^7 \text{ Pa} \]

8. The spring constant is
\[ k = \frac{mg}{x} = \frac{(3 \text{ kg})(9.8 \text{ m/s}^2)}{0.25 \text{ m}} = 118 \text{ N/m} \]

The period of a simple harmonic oscillator is
\[ T = 2\pi \sqrt{\frac{m}{k}} = 2\pi \sqrt{\frac{(3 \text{ kg})}{(118 \text{ N/m})}} = 1.0 \text{ s} \]

9. The period of a pendulum is
\[ T = 2\pi \sqrt{\frac{L}{g}} \]

Forming a ratio
\[ \frac{T_M}{T_E} = \frac{2\pi \sqrt{\frac{L}{g_M}}}{2\pi \sqrt{\frac{L}{g_M}}} = \sqrt{\frac{g_E}{g_M}} \]
\[ T_M = T_E \sqrt{\frac{g_E}{g_M}} = (2.0 \text{ s}) \sqrt{\frac{9.8 \text{ m/s}^2}{3.8 \text{ m/s}^2}} = 3.2 \text{ s} \]

10. Use the conservation of energy
\[ U_1 + K_1 = U_2 + K_2 \]
\[ \frac{1}{2} kA^2 + 0 = \frac{1}{2} kx^2 + K_2 \]
The amplitude is $A = 0.25 \text{ cm}$. Solving for $K_2$,

$$K_2 = \frac{1}{2} kA^2 - \frac{1}{2} kx_2^2 = \frac{1}{2} k(A^2 - x_2^2) = \frac{1}{2}(50 \text{ N/m})(0.25 \text{ m})^2 - (0.10 \text{ m})^2) = 1.3 \text{ J}$$

11. Since $v_m = A \omega$, the amplitude can be found,

$$A = \frac{v_m}{\omega} = \frac{4 \text{ m/s}}{6 \text{ rad/s}} = 0.667 \text{ m}$$

The position function for the given velocity function is

$$y = A \sin \omega t = (0.667 \text{ m}) \sin[(6 \text{ rad/s})(3 \text{ s})] = -0.50 \text{ m}$$

Your calculator must be in radian mode to get this result.

12. The intensity is a function of distance,

$$I = \frac{P}{4\pi r^2}$$

Forming a ratio

$$\frac{I_2}{I_1} = \left(\frac{r_1}{r_2}\right)^2$$

Solving for $r_2$

$$\frac{I_2}{I_1} = \left(\frac{r_1}{r_2}\right)^2$$

$$\frac{r_1}{r_2} = \sqrt{\frac{I_2}{I_1}}$$

$$r_2 = r_1 \sqrt{\frac{I_1}{I_2}} = (2 \text{ m}) \sqrt{\frac{0.1 \text{ W/m}^2}{0.01 \text{ W/m}^2}} = 6.3 \text{ m}$$

13. The speed of a wave in string is
\[ v = \sqrt{\frac{F}{\mu}} \]
\[ v^2 = \frac{F}{\mu} \]
\[ \mu = \frac{F}{v^2} \]
\[ \frac{m}{L} = \frac{F}{v^2} \]
\[ m = \frac{F}{v^2} L = \frac{75 \text{ N}}{(140 \text{ m/s})^2} (5 \text{ m}) = 0.019 \text{ kg} \]

14. The velocity of the wave is related to the wavenumber and angular frequency

\[ v = \frac{\omega}{k} \]
\[ \omega = vk = (60 \text{ m/s})(3.0 \text{ rad/m}) = 180 \text{ rad/s} \]

The general equation of a wave traveling in the \(-x\) direction is

\[ y = A \cos(\omega t + kx) \]

Substituting the values above,

\[ y = A \cos((180 \text{ rad/s})t + (3.0 \text{ rad/m})x) \]

15. Since the end of the rope is a free end, the reflected pulse will have the same orientation as the incident pulse. Both pulses will point upward when they meet and

\[ A = A_1 + A_2 = (3 \text{ cm}) + (4 \text{ cm}) = 7 \text{ cm} \]

16. The speed of the wave can be found

\[ v = \sqrt{\frac{\mu}{F}} = \sqrt{\frac{mg}{\mu}} = \sqrt{\frac{(2.10 \text{ kg})(9.8 \text{ m/s}^2)}{3.55 \times 10^{-3} \text{ kg/m}}} = 761 \text{ m/s} \]

For the lowest frequency, the wavelength is twice the length of the string, \( \lambda = 2L = 4 \text{ m} \). The frequency is

\[ f = \frac{v}{\lambda} = \frac{761 \text{ m/s}}{4 \text{ m}} = 190 \text{ Hz} \]
17. The decibel scale is defined as

$$\beta = 10 \log \left( \frac{I}{I_0} \right)$$

Solving for I,

$$\beta = 10 \log \left( \frac{I}{I_0} \right)$$

$$\beta / 10 = \log \left( \frac{I}{I_0} \right)$$

$$\frac{I}{I_0} = 10^{\beta/10}$$

$$I = I_0 10^{\beta/10} = (1.0 \times 10^{-12} \text{ W/m}^2) 10^{70/10} = 1.0 \times 10^{-5} \text{ W/m}^2$$

18. The frequencies for a pipe open at both ends is given by

$$f_n = n \frac{v}{2L}$$

where $n = 1, 2, 3$, etc.

$$f_1 = \frac{1}{2L} \frac{v}{2(1\text{m})} = 170\text{Hz}$$

The next frequency corresponds to $n = 2$

$$f_2 = \frac{2}{2L} \frac{v}{1\text{m}} = 340\text{Hz}$$

The frequencies are 170 Hz and 340 Hz.

19. Two waves with similar frequencies create beats.

20. The vehicles are traveling in different directions

\[\text{Diagram of two vehicles traveling in opposite directions.}\]
The sound travels in the same direction as the sound. Therefore $v_s > 0$. The car moves against the sound waves and $v_o < 0$. Using the equation for the Doppler effect

$$f_o = f_s \left( \frac{1 - \frac{v_o}{v}}{1 - \frac{v_s}{v}} \right) = (550\text{Hz}) \left( \frac{1 - \left( \frac{-25\text{m/s}}{340\text{m/s}} \right)}{1 - \left( \frac{35\text{m/s}}{340\text{m/s}} \right)} \right) = 660\text{Hz}$$