3. Walker3 15.P.041. [565914]

To water the yard, you use a hose with a diameter of 3.9 cm. Water flows from the hose with a speed of 1.2 m/s. If you partially block the end of the hose so the effective diameter is now 0.55 cm, with what speed does water spray from the hose?

60.3 m/s

41. **Picture the Problem**: Water flows through a hose at a constant volume flow rate. When the diameter of the hose is decreased by partially blocking the end, the speed through the end increases so the same volume flows in the same time.

Strategy: We wish to find the speed through the partially blocked end. Write the continuity equation (15-12) in terms of the diameters of the hose and solve for the speed at the end.

Solution: 1. Write the continuity equation in terms of the diameters of the hose:

$$A_1 v_1 = A_2 v_2$$

$$\left(\pi d_1^2/4\right)v_1 = \left(\pi d_2^2/4\right)v_2$$

2. Solve for the end velocity:

$$v_2 = \left(\frac{d_1}{d_2}\right)^2 v_1 = \left(\frac{3.4\text{ cm}}{0.57\text{ cm}}\right)^2 (1.1\text{ m/s}) = \boxed{39\text{ m/s}}$$

Insight: The ratio of the speeds is inversely proportional to the square of the diameters. If the diameter were to be cut in half, the speed would increase by a factor of four.

4. Walker3 15.P.043. [565725]

To fill a child's inflatable wading pool you use a garden hose with a diameter of 2.8 cm. Water flows from this hose with a speed of 1.1 m/s. How long will it take to fill the pool to a depth of 22 cm if it is circular and has a diameter of 2.4 m?

24.5 min

Picture the Problem: A child's pool is filled from a garden hose. The volume flow rate through the hose is equal to the rate at which the pool fills.

Strategy: In this problem we wish to calculate the time necessary to fill the pool. Use the volume continuity equation (equation 15-11) to calculate the speed at which the water rises in the pool. Divide the depth of the pool by the speed of the rising water to determine the time necessary to fill the pool.

Solution: 1. Solve the continuity equation for the speed at which the pool fills:

$$v_{\text{pool}} = \frac{A_{\text{hose}}}{A_{\text{pool}}} v_{\text{hose}} = \frac{\pi d_{\text{hose}}^2/4}{\pi d_{\text{pool}}^2/4} v_{\text{hose}} = \left(\frac{d_{\text{hose}}}{d_{\text{pool}}}\right)^2 v_{\text{hose}}$$

$$= \left(\frac{0.028\text{m}}{2.0\text{m}}\right)^2 (1.1\text{ m/s}) = \underline{\underline{2.16\times10^{-4}\text{ m/s}}}$$

2. Divide the height of the pool by the water speed to find the required fill time:

$$t = \frac{h}{v_{\text{pool}}} = \frac{0.26\text{ m}}{2.16\times10^{-4}\text{m/s}} = 1200\text{ s}\times\left(\frac{1\text{ min}}{60\text{ sec}}\right) = \boxed{20\text{ min}}$$

Insight: To decrease the time necessary to fill the pool, either the diameter of the hose or the speed of the water should be increased.

6. HRW7 14.P.047. (me) [764067]

A water pipe having a 2.0 cm inside diameter carries water into the basement of a house at a speed of 0.85 m/s and a pressure of 165 kPa. The pipe tapers to 1.8 cm and rises to the second floor 7.4 m above the input point.

(a) What is the speed at the second floor?

1.05 m/s

(b) What is the water pressure at the second floor?

92.3 kPa

First, The thinner the pipe the higher the speed. $A_1v_1=A_2v_2$, due to the continuity, the total flow rate is the same. When pipe becomes wide at a location, flow speed reduces. When pipe becomes narrower flow speed is high. Pipe area is proportional to diameter square. $A=3.14*D^2/4$, here D is diameter.

$\mathbf{A_1v_1=A_2v_2}$; **So,** $\mathbf{A_1v_1/A_2 = v_2}$ **, So,** $\mathbf{D_1^2\, v_1 / D_2^2 = v_2}$

So, at narrower location: $v_2 = (0.02^2 /0.018^2)*0.85 = 1.05$ m/s

The change of the speed is due to the change of pipe diameter.

Once we know the speed and height at the new location we can use the Bernoulli's equation $\mathbf{P_1+1/2\, \rho v_1^2+ \rho g\, y_1 = P_2+1/2\, \rho v_2^2+ \rho g\, y_2}$

To find out the pressure P_2 at the new location.

$165*10^3+0.5*1.0*10^3*0.85^2+1.0*10^3*9.8*0=P_2+0.5*1.0*10^3*1.05^2+1.0*10^3*9.8*7.4$

or

$P_2= P_1+1/2\, \rho v_1^2+ \rho g\, y_1 -1/2\, \rho v_2^2-\rho g\, y_2$

$=165*10^3+0.5*1.0*10^3*0.85^2-0.5*1.0*10^3*1.05^2-1.0*10^3*9.8*7.4$

$=92290$ Pa = 92.3 kPa

Pay attention to units. Use SI unit for density, pressure and everything, then you can just use the numbers an avoid units calculation, and get SI unit for pressure, Pa at the end, directly.

7. Walker3 15.P.055. [565923]

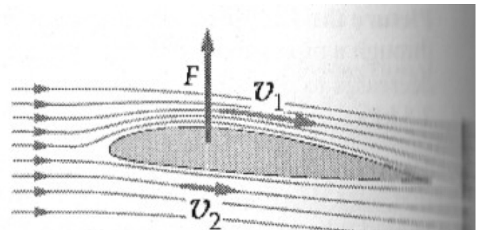
(a) Find the pressure difference on an airplane wing where air flows over the upper surface with a speed of 128 m/s, and along the bottom surface with a speed of 103 m/s.

3.72 kPa

(b) If the area of the wing is 33 m^2, what is the net upward force exerted on the wing?

123 kN

55. **Picture the Problem**: The diagram shows an airplane wing. The air velocity over the wing is $v_1 = 115$ m/s and the air velocity under the wing is $v_2 = 105$ m/s. The difference in wind speeds produces a pressure difference and a resulting upward force.



Strategy: Apply Bernoulli's equation (15-14) between a point on the upper surface and a point on the lower surface. We can neglect the difference in height between the two surfaces since the difference in static pressures between these points is negligible. Multiply the pressure difference by the wing area to calculate the net force on the wing.

Solution: 1. (a) Solve equation 15-14 for the pressure difference:

$$P_2+\tfrac{1}{2}\rho v_2^2 = P_1+\tfrac{1}{2}\rho v_1^2$$
$$P_2-P_1=\tfrac{1}{2}\rho\left(v_1^2-v_2^2\right)$$
$$=\tfrac{1}{2}\left(1.29\text{ kg/m}^3\right)\left[\left(115\text{ m/s}\right)^2-\left(105\text{ m/s}\right)^2\right]=\boxed{1.42\text{ kPa}}$$

2. (b) Multiply by the area of the wings:

$$\Delta F=\left(\Delta P\right)A=\left(1.42\times10^3\text{ Pa}\right)\left(32\text{ m}^2\right)=\boxed{45\text{ kN}}$$

Insight: If the weight of the airplane is less than 45 kN, the net vertical force will be upward and the plane will rise in the air.

Notice that ρgh is not considered here. Because the h difference is at most a few meters. And ρ of air is very small (1/1000 of water), so that ρgh for a few meters of height difference do not change pressure noticeably.

Problem 5, When you blow across the opening of a partially filled two-liter soda pop bottle you hear a tone. If you take a sip of the pop and blow across the opening again, does the tone you hear have a higher frequency, a lower frequency, or the same frequency as before?

○ higher frequency ○ lower frequency ○ the same frequency

Key: The sound produced after taking a sip is lower in frequency. This is because the vibrating column of air is now longer, which means that the wavelength of the sound is longer as well. Since the speed of sound is the same in air, it follows that the frequency is reduced. frequency = speed of wave/ wavelength, $f = v/\lambda$,