Determine the mass flow rate of water being added to the air.

$$\dot{m}_w = \left(152.7\frac{lb_{da}}{min}\right)\left(0.0155\frac{lb_{h2o}}{lb_{da}} - 0.0037\frac{lb_{h2o}}{lb_{da}}\right) = 1.8\frac{lb_m}{min}$$

Answer A

46.14 Water traveling at $2fps$ in a nominal $5in$ pipe is combined with water traveling at $5fps$ in a nominal $3in$ pipe at a tee connection. Downstream of the tee, the piping has a nominal $6in$ diameter. What is the velocity downstream of the tee?

A. $1.3fps$

B. $1.9fps$

C. $2.7fps$

D. $3.9fps$

Sketch and label the tee connection with the given information. Designate the entering flows as 1 & 2 and the exiting flow as 3. The volume flow rate exiting the tee is equal to the sum of the volume flow rates entering the tee.

$$Q_1 + Q_2 = Q_3$$

Apply the Continuity Equation and replace the volume flow rates with the products of their respective velocities and areas.

$$Q = Av$$

$$A_1v_1 + A_2v_2 = A_3v_3$$

Solve for the the velocity downstream of the tee, v_3.

$$v_3 = \frac{A_1v_1 + A_2v_2}{A_3}$$

Express area as a function of internal diameter for each connection to the tee and substitute accordingly, cancelling the $\frac{\pi}{4}$ which is common to all terms.

$$A = \frac{\pi}{4}D^2$$

$$v_3 = \frac{\frac{\pi}{4}D_1^2v_1 + \frac{\pi}{4}D_2^2v_2}{\frac{\pi}{4}D_3^2} = \frac{D_1^2v_1 + D_2^2v_2}{D_3^2}$$

Gather inside diameter values from the table by searching Schedule 40 Steel Pipe. Substitute and solve for the velocity, v_3.

$$v_3 = \frac{(5.047in)^2\left(2\frac{ft}{s}\right) + (3.068in)^2\left(5\frac{ft}{s}\right)}{(6.065in)^2} = 2.66\frac{ft}{s}$$

Answer C

46.15 A $100lb_m$ mass rests on 4 springs, each with a spring constant of $15\frac{lb_f}{in}$. The mass is initially displaced from its equilibrium position, then released. What is the resulting period of oscillation?

A. $0.03s$

B. $0.1s$

C. $0.4s$

D. $2.3s$

Refer to the section on Free Vibration. Recognize that the spring constant for springs in parallel add linearly, therefore the total spring constant for the system can be determined as follows.

$$k_{total} = 4\left(k_{spring}\right) = (4)\left(15\frac{lb_f}{in}\right) = 60\frac{lb_f}{in}$$

Find the natural frequency, which is a function of the total spring contant and the mass. The relevant formula may be found by searching undamped natural circular frequency. Note g_c must be included to change lb_m to lb_f for consistency of units. This is not given in the reference handbook and must be inferred by the inconsistency of the units if not addressed. Also note the appearance of radians in the result for this application. Be assured this is valid and expected with analysis of vibrating sytems.

$$\omega_n = \sqrt{\frac{kg_c}{m}} = \sqrt{\frac{\left(60\frac{lb_f}{in}\right)\left(32.2\frac{lb_m \cdot ft}{lb_f \cdot s^2}\right)\left(\frac{12in}{ft}\right)}{100lb_m}} = 15.2\frac{rad}{s}$$

Find the period. The relevant formula may be found by searching undamped natural period of vibration.

$$\tau_n = \frac{2\pi}{\omega_n} = \frac{2\pi\, rad}{15.2\frac{rad}{s}} = 0.4s$$

Answer C