

46.53 Air exits a nozzle at $500 \frac{ft}{s}$ into a $70^\circ F$ room at atmospheric pressure. What is the Mach number?

- A. 0.39
- B. 0.44
- C. 2.3
- D. 2.5

The **Mach Number** is the velocity of the air divided by the speed of sound in air. The speed of sound in air can be determined in at least three ways. First, it can be memorized. $c \approx 1130 \frac{ft}{s}$

Second, it can be looked up in the **Properties of Air at Low Pressure** table. Interpolate or estimate as necessary.

Third, it can be calculated using the equation below. However, to make the units work, the gravitational constant, g_c , must also be included for US customary units. Substitute the ratio of specific heats for air, the **Specific Gas Constant** for air, and the absolute temperature in degrees Rankine.

$$c = \sqrt{kRT}$$

$$c = \sqrt{kRTg_c}$$

$$c = \sqrt{(1.4) \left(53.35 \frac{ft \cdot lb_f}{lb_m \cdot R} \right) (530R) \left(32.2 \frac{lb_m \cdot ft}{lb_f \cdot s^2} \right)} = 1128 \frac{ft}{s}$$

Calculate the Mach number.

$$M = \frac{V}{c}$$

$$M = \frac{500 \frac{ft}{s}}{1128 \frac{ft}{s}} = 0.44$$

Answer B

46.54 20gpm of oil with specific gravity 0.88 flows through a valve with a valve coefficient of 4.5. What is the pressure drop across the valve?

- A. 3.9psi
- B. 4.4psi
- C. 17psi
- D. 20psi

The **Valve Flow Coefficient** for a fluid other than water is given by the equation below which accounts for the specific gravity. The volume flow rate must be in *gpm* and the pressure drop must be in *psi*. Rearrange to isolate ΔP , substitute, and solve.

$$C_v = Q \sqrt{\frac{SG}{\Delta P}}$$

$$C_v^2 = Q^2 \frac{SG}{\Delta P}$$

$$\Delta P = \left(\frac{Q}{C_v}\right)^2 SG = \left(\frac{20}{4.5}\right)^2 (0.88) = 17.4psi$$

Answer C

46.55 1000gpm of water is pumped up an incline of 200ft. The suction pressure is 50psig and the pressure at the extent of the discharge piping is 250psig. The head loss through the discharge piping is 40ft, and losses through the suction piping are negligible. The suction and discharge piping diameters are 12in and 8in, respectively. How much horsepower is supplied by the pump?

- A. 111hp
- B. 132hp
- C. 177hp
- D. 410hp

Use the modified **Bernoulli Equation** for head added by a pump.

$$h_A = \frac{P_2 - P_1}{\gamma} + \frac{v_2^2 - v_1^2}{2g} + z_2 - z_1 + h_f$$

Neglect the velocity term. Use the rule of thumb conversion factor to convert the differential static pressure from *psi* to *ft*.