

**47.61** Olive oil has a dynamic viscosity of  $40cP$  and a specific gravity of **0.92**. What is the kinematic viscosity?

- A.  $4.3 \times 10^{-5} \frac{ft^2}{s}$
- B.  $4.7 \times 10^{-4} \frac{ft^2}{s}$
- C.  $2.0 \times 10^{-3} \frac{ft^2}{s}$
- D.  $1.7 \frac{ft^2}{s}$

Use the **Specific Gravity** to determine the density of the oil.

$$SG = \frac{\rho_{oil}}{\rho_{water}}$$

$$\rho_{oil} = SG \cdot \rho_{water} = (0.92) \left( 62.4 \frac{lb_m}{ft^3} \right) = 57.4 \frac{lb_m}{ft^3}$$

Use the relation between **Kinematic Viscosity** and **Absolute Viscosity** i.e. 'Dynamic Viscosity'. Use **Measurement Relationships** for required unit conversions to align with the answer choices.

$$\nu = \frac{\mu}{\rho}$$

$$\nu = \frac{(40cP) \left( 2.412 \frac{lb_m}{hr \cdot ft \cdot cP} \right) \left( \frac{1hr}{3600s} \right)}{57.4 \frac{lb_m}{ft^3}} = 4.7 \times 10^{-4} \frac{ft^2}{s}$$

**Answer B**

**47.62**  $900gpm$  of a fluid flows through  $500ft$  of a  $8in$  pipe. The Reynolds number is  $80,000$  and the relative roughness is  $0.0003$ . What is the total pressure drop?

- A.  $2.5ft$
- B.  $3.5ft$
- C.  $5.8ft$
- D.  $8.2ft$

The pressure drop is calculated with the **Darcy-Weisbach Equation**.

$$h_f = \frac{fLv^2}{2Dg}$$

The Reynolds number and relative roughness are given. Use the Moody diagram to obtain the friction factor.

$$Re = 80,000$$

$$\frac{\epsilon}{D} = 0.0003$$

$$f = f\left(Re, \frac{\epsilon}{D}\right) \approx 0.021$$

Use the **Steel Pipe Friction Tables** to obtain the velocity and exact diameter based on the *gpm* and nominal pipe size.

$$v = 5.77 \frac{ft}{s}$$

$$D = 7.981in$$

Substitute into the Darcy Equation and solve. Keep the final result with units of *ft*.

$$h_f = \frac{(0.021)(500ft)\left(5.77 \frac{ft}{s}\right)^2}{2\left(\frac{7.981in}{12 \frac{in}{ft}}\right)\left(32.2 \frac{ft}{s^2}\right)} = 8.2ft$$

**Answer D**

**47.63**  $50^\circ F$  water enters a steam boiler with a capacity 200 boiler horsepower. The boiler has an operating pressure of 10psig. What is the required flow rate of feedwater at maximum capacity?

- A. 12gpm
- B. 180gpm
- C. 290gpm
- D. 700gpm

The feedwater must first be heated sensibly from its initial temperature,  $T_1 = 50^\circ F$ , to the boiling point. Use the table **Properties of Saturated Water and Steam** (Pressure) to obtain the saturation temperature i.e. boiling point of water at the operating pressure. Also obtain the latent heat of vaporization,  $h_{fg}$ , from the same line in the steam table.

$$P = 10psig + 14.7psi \approx 25psia$$

$$T_{sat} = 240^\circ F$$

$$h_{fg} = 952 \frac{Btu}{lb}$$

Use **Measurement Relationships** to convert the heating capacity of the boiler from *boiler hp* to  $\frac{Btu}{hr}$ .