42.13 What is the viscosity of $150°F$ water?

A. $5 \times 10^{-6} \frac{lb_m}{ft \cdot hr}$

B. $9 \times 10^{-6} \frac{lb_m}{ft \cdot hr}$

C. $3 \times 10^{-4} \frac{lb_m}{ft \cdot hr}$

D. $1 \frac{lb_m}{ft \cdot hr}$

The question is ambiguous in terms of whether the Absolute i.e. Dynamic Viscosity is to be used or the Kinematic Viscosity. Look up the values in the table Properties of Water and note the units:

$$\mu = .905 \times 10^{-5} \frac{lb_f \cdot sec}{ft^2}$$

$$\nu = .476 \times 10^{-5} \frac{ft^2}{sec}$$

Note the answer choices have units of $\frac{lb_m}{ft \cdot hr}$. Choose to work with the dynamic viscosity as it is best suited for conversion to the desired units.

Recall from physics the relationship between force, mass, and acceleration due to gravity:

$$F = mg$$

where g is the constant acceleration due to gravity and the typical units are:

$$[1lb_f] = [1lb_m] \left[32.2 \frac{ft}{sec^2} \right]$$

Make a substitution for lb_f in the units of μ, evaluate, and simplify:

$$\mu = .905 \times 10^{-5} \frac{sec}{ft^2} \left(32.2 \frac{lb_m \cdot ft}{sec^2} \right) = .000291 \frac{lb_m}{ft \cdot sec}$$

Convert seconds to hours for alignment with answer choice units:

$$\mu = .000291 \frac{lb_m}{ft \cdot sec} \left(\frac{60sec}{1min} \right) \left(\frac{60min}{1hr} \right) = 1.05 \frac{lb_m}{ft \cdot hr}$$

Answer D

42.14 An uninsulated hot water pipe runs horizontally through a room. The water entering the pipe is $130°F$. Where the pipe leaves the room, the water temperature is $110°F$. The room temperature is $70°F$. What is the film temperature?

A. $90°F$

B. $95°F$

C. $100°F$

D. $120°F$

The film temperature of a tube is the average of the bulk temperature of the ambient space, T_∞, and the average surface temperature, T_s. Note this represents the mean boundary layer condition i.e. film condition, for which the coefficient of heat transfer may be specified, if needed.

In this case only the film temperature needs to be calculated. Since the pipe is uninsulated, assume the surface temperature is the same as the hot water temperature, which is the average of the entering and leaving hot water temperature:

$$T_s = \frac{T_e + T_l}{2} = \frac{130°F + 110°F}{2} = 120°F$$

Calculate the film temperature:

$$T_f = \frac{T_s + T_\infty}{2} = \frac{120°F + 70°F}{2} = 95°F$$

Answer B

42.15 How much heat does a $3in$ horizontal hot water pipe lose to the ambient space per unit length by natural convection if the surrounding room has an average temperature of $70°F$, the surface temperature of the pipe is $100°F$, and the coefficient of thermal expansion for air is $1.79 \times 10^{-3} \, per \, °F$.

A. $19 \frac{Btu}{hr \cdot ft}$

B. $29 \frac{Btu}{hr \cdot ft}$

C. $45 \frac{Btu}{hr \cdot ft}$

D. $72 \frac{Btu}{hr \cdot ft}$

For convection problems in general, a reasonable starting point is always Newton's Law of Cooling:

$$\dot{Q} = hA\Delta T$$

where h is the convection heat transfer coefficient.