$$\dot{Q}_{rad} = \sigma\varepsilon A\left(T_s^4 - T_\infty^4\right)$$

$$\dot{Q}_t = \dot{Q}_{conv} + \dot{Q}_{rad} = hA\Delta T + \sigma\varepsilon A\left(T_s^4 - T_\infty^4\right)$$

Calculate the heat transfer resulting from radiation. Be sure to use absolute temperatures i.e. degrees Rankine.

$$\dot{Q}_{rad} = \sigma\varepsilon A\left(T_s^4 - T_\infty^4\right)$$

$$\dot{Q}_{rad} = \left(0.1713 \times 10^{-8}\frac{Btu}{hr \cdot ft^{2\circ}R}\right)(0.8)\left(10ft^2\right)\left[(540^\circ R)^4 - (500^\circ R)^4\right] = 308.8\frac{Btu}{hr}$$

Subtract the radiation from the total heat gain to determine the heat gain from convection.

$$\dot{Q}_{conv} = \dot{Q}_t - \dot{Q}_{rad} = 1000\frac{Btu}{hr} - 308.8\frac{Btu}{hr} = 691.2\frac{Btu}{hr}$$

Solve for the convection coefficient.

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

$$h = \frac{\dot{Q}_{conv}}{A\Delta T} = \frac{\left(691.2\frac{Btu}{hr}\right)}{\left(10ft^2\right)(80^\circ F - 40^\circ F)} = 1.7\frac{Btu}{hr \cdot ft^{2\circ}F}$$

Answer A

47.35 A hot water heat exchanger is supplied with $55^\circ C$ LTHW which is used to heat $2\frac{L}{s}$ of domestic water from $20^\circ C$ to $50^\circ C$. The return LTHW temperature is $47^\circ C$. What is the volume flow rate of LTHW required?

A. $0.5\frac{L}{s}$

B. $3.0\frac{L}{s}$

C. $7.5\frac{L}{s}$

D. $11.0\frac{L}{s}$

Assuming 100% efficiency, the heat supplied to the domestic hot water is removed from the low temperature hot water (LTHW). Set these quantities equal and represent each using $Q = \dot{m}c_p\Delta T$.

$$\dot{Q}_{LTHW} = \dot{Q}_{DHW}$$

$$\left[\dot{m}c_p\Delta T\right]_{LTHW} = \left[\dot{m}c_p\Delta T\right]_{DHW}$$

Substitute the product of density and volume flow rate for the mass flow rate on both sides.

$$\dot{m} = \rho Q$$

$$[\rho Q c_p \Delta T]_{LTHW} = [\rho Q c_p \Delta T]_{DHW}$$

Since both sides of the heat exchanger are using liquid water as a medium, the density and specific heat capacity cancel out.

$$[Q \Delta T]_{LTHW} = [Q \Delta T]_{DHW}$$

Rearrange for the volume flow rate on the LTHW side. Substitute and solve.

$$Q_{LTHW} = Q_{DHW}\left(\frac{\Delta T_{DHW}}{\Delta T_{LTHW}}\right) = \left(2\frac{L}{s}\right)\left(\frac{50°C - 20°C}{55°C - 47°C}\right) = 7.5\frac{L}{s}$$

Answer C

47.36 $500,000\frac{L}{s}$ of water is discharged from a reservoir and falls $30 meters$. How much power is released due to the change in elevation?

A. $60MW$

B. $150MW$

C. $310MW$

D. $480MW$

Power is released when the potential energy stored in the water is converted into kinetic energy as the water descends from high elevation. Search for Potential Energy and use the formula for potential energy due to gravity.

$$PE = mgh$$

Work is a form of energy, and power is work per unit time. On the left side, potential energy, PE, can be replaced with work, $\dot{W}$, and on the right side use the mass flow rate, $\dot{m}$, instead of the mass, m. Both sides then have time in the denominator.

$$\dot{W} = \dot{m}gh$$

$1L$ of water has a mass of $1kg$. This can be confirmed by searching Properties of Water at Standard Conditions which states that $\rho_{water} = 1000\frac{kg}{m^3}$. Since $1000L = 1m^3$, then converting the density to $\frac{kg}{L}$.

$$\rho_{water} = 1000\frac{kg}{m^3}\left(\frac{1m^3}{1000L}\right) = 1\frac{kg}{L}$$

Apply the Continuity Equation to determine the mass flow rate as a function of density and volume flow rate.