

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.

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

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.

$$\dot{m} = \rho Q = \left(1 \frac{kg}{L}\right) \left(500,000 \frac{L}{s}\right) = 500,000 \frac{kg}{s}$$

Substitute and solve for power.

$$\dot{W} = mgh = \left(500,000 \frac{kg}{s}\right) \left(9.81 \frac{m}{s^2}\right) (30m) = 1.47 \times 10^8 \frac{kg \cdot m^2}{s^3}$$

To get the final answer in MW , use the following unit conversions.

$$1N = 1 \frac{kg \cdot m}{s^2}$$

$$1J = 1N \cdot m = 1 \frac{kg \cdot m^2}{s^2}$$

$$1W = 1 \frac{J}{s} = 1 \frac{kg \cdot m^2}{s^3}$$

$$1MW = 10^6 W = 10^6 \frac{kg \cdot m^2}{s^3}$$

Finally, solve for power, \dot{W} , in MW .

$$\dot{W} = \left(1.47 \times 10^8 \frac{kg \cdot m^2}{s^3}\right) \left(\frac{1MW}{10^6 \frac{kg \cdot m^2}{s^3}}\right) = 147MW$$

Answer B

47.37 An air handling unit uses a hot water coil to produce 20,000cfm of 120°F supply air. The entering air is composed of 5000cfm of 25°F outside air and 15,000cfm of 75°F return air. The hot water supply and return temperatures to and from the coil are 135°F and 105°F, respectively. What volume flow rate of hot water is required?

- A. 14gpm
- B. 83gpm
- C. 119gpm
- D. 345gpm

Use the sensible heating rule of thumb for air to quantify the amount of heat added to the air.

$$\dot{Q}_{s,air} = 1.08cfm\Delta T$$

The discharge air temperature is given, but the entering air is a mixture of outside air and return air. Perform a mixing calculation to find the temperature of the air entering the coil. For