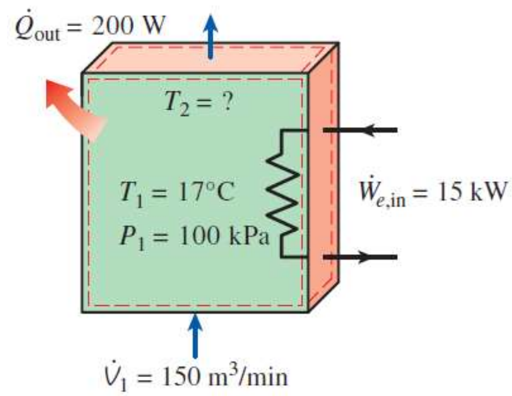
Given:
The electrical heating systems used in many houses consist of a simple duct with resistance heaters. Air is heated as it flows over the resistance wires. Consider a 15 kW electric heating system where air enters at 100 kPa and 17°C with a flow rate of $150 \frac{m^3}{min}$.



$Q'_{out} := 200\ W$ $\quad T_1 := 17\ °C$ $\quad P_1 := 100\ kPa$

$W'_{e,in} := 15\ kW$ $\quad V'_1 := 150 \frac{m^3}{min}$

Required:
If the rate of heat loss from the air duct to the surroundings is 200 W, determine the final temperature of the air.

Solution:
1st Law (for rigid, steady flow device with no changes in kinetic and potential energy)

$$\frac{d}{d\ t} E_{sys} = \Sigma E'_{in} - \Sigma E'_{out}$$

$$E'_{in} = E'_{out}$$

$$W'_{in} + m' \cdot h_{in} = m' \cdot h_{out} + Q'_{out}$$

Rearranging yields

$$W'_{in} - Q'_{out} = m' \cdot \left(h_{out} - h_{in}\right)$$

Assuming the air behaves as an ideal gas in the process region and has a constant specific heat the first law becomes

$$W'_{in} - Q'_{out} = m' \cdot c_p \cdot \left(T_{out} - T_{in}\right)$$

Solving for the outlet temperature yields

$$T_{out} = \frac{W'_{in} - Q'_{out}}{m' \cdot c_p} + T_{in}$$

Using the ideal gas law, the mass flow rate may be found by

$$m' = \frac{P \cdot V'}{R \cdot T}$$

Going to Table A-2(a) @ air shows

$R := 0.287 \frac{kJ}{kg\ K}$ $\quad c_p := 1.005 \frac{kJ}{kg\ K}$

The mass flow rate is then

$$m' := \frac{P_1 \cdot V'_1}{R \cdot T_1} = 3.002 \frac{kg}{s}$$

The outlet temperature is then

$\boxed{T_2 := \frac{W'_{e,in} - Q'_{out}}{m' \cdot c_p} + T_1 = 295.1\ K}$ $\quad \boxed{T_2 = 21.91\ °C}$