### Problem 1

On a summer day, the air within a well-sealed house has the following properties:

- mass \( m = 800 \text{ kg} \)
- temperature: \( T = 35^\circ C \)
- specific heats: \( c_v = 0.72 \text{ kJ/kg} \cdot ^\circ C \) and \( c_p = 1.0 \text{ kJ/kg} \cdot ^\circ C \)

The air conditioner is turned on and the air temperature decreases to \( 20^\circ C \) in 30 minutes.

1. If the air conditioner has a COP of 2.8, calculate the power drawn by the air conditioner \( P_{in} \).
2. Using Matlab or Excel, plot the required power input as a function of the air conditioner COP over the range \( 1.5 < \text{COP} < 4.5 \).

### Problem 2

Refrigerant R-134a enters the condenser of a residential heat pump at 800 kPa and \( 35^\circ C \) at a rate of 0.018 kg/s, and leaves at 800 kPa as a saturated liquid. The compressor unit consumes 1.2 kW of power.

1. Calculate the COP of the heat pump
2. Calculate the rate of heat absorption from the outside air

**Solution:**

\( \dot{Q} = 1.96 \text{ kW} \)

### Problem 3

A heat engine operates between a source at \( 477^\circ C \) and a sink at \( 25^\circ C \).

1. If heat is supplied to the heat engine at a steady rate of 65,000 kJ/min, calculate the maximum power output of this heat engine.
2. Using Matlab or Excel, plot the power produced and the cycle efficiency against the source temperature for sink temperatures of \( 0^\circ C \), \( 25^\circ C \) and \( 50^\circ C \).

### Problem 4

A commercial refrigerator with refrigerant R-134a as the working fluid is used to keep the refrigerated space at \(-35^\circ C\) by rejecting waste heat to cooling water that enters the condenser at \( 18^\circ C \) at a rate of 0.25 kg/s and leaves at \( 26^\circ C \). The refrigerator enters the condenser at \( 1.2 \text{ MPa} \) and \( 50^\circ C \), and leaves at the same pressure subcooled by \( 5^\circ C \). The compressor consumes 3.3 kW of power.

1. Calculate the mass flow rate of refrigerant, \( \dot{m} \)
2. Calculate the refrigeration load, \( \dot{Q}_L \)
3. Determine the COP of the refrigerator
4. Calculate the minimum power input to the compressor for the same refrigeration load, \( \dot{W}_{in, min} \)