Calculations

1. Air flow rate measurement
   a. Use anemometer to measure the velocity \( v_{air} \), temperature, and relative humidity of air.
   b. Use the psychrometric chart to obtain the air density \( \rho_{air} \).
   c. Compute the volumetric flow rate of air \([\text{m}^3/\text{s}]\):
      \[
      \dot{V}_G = v_{air} A_X, \tag{5.1}
      \]
      where \( A_X = 0.020 \text{ m}^2 \) is the area of cross-section of the measurement slit.
   d. Compute the mass flow rate of air \([\text{kg/s}]\):
      \[
      \dot{m}_G = \dot{V}_G \rho_{air} \tag{5.2}
      \]

2. Cooling capacity (Energy Balance)
   Under adiabatic conditions the cooling capacity \( \dot{Q}_L \) is the sum of the heat of evaporation \( \dot{Q}_E \), and the heat \( \dot{Q}_c \) transferred by convection,
   \[
   \dot{Q}_L = \dot{Q}_E + \dot{Q}_c \tag{5.3}
   \]
   The heat of evaporation is
   \[
   \dot{Q}_E = \dot{m}_E \lambda, \tag{5.4}
   \]
   where \( \lambda \) is the latent heat of evaporation of water and
   \[
   \dot{m}_E = \dot{m}_G (h_{out} - h_{in}) \tag{5.5}
   \]
   is the rate of water evaporation. In Eq. (5.5), \( \dot{m}_G \) is the mass flow rate of air, and \( h \) is the absolute humidity of air.
   The heat transferred by convection is
   \[
   \dot{Q}_c = \dot{m}_G C_{G,p} (T_{G,out} - T_{G,in}), \tag{5.6}
   \]
   Here, \( C_{G,p} \) is the constant-pressure specific heat of air.
   The values of \( \lambda \) at different temperatures are given in Table 5.1. Recall that the temperature is not constant throughout the column. Therefore, \( \lambda \) is approximated by its value at the mean temperature of water inlet and outlet streams.
   Ideally,
   \[
   \dot{Q}_W = \dot{Q}_L \tag{5.3}
   \]
where $\dot{Q}_W$ is the heat load computed using Eq. (2.12) of the Theory section.

Table 5.1. Latent heat of evaporation for water at various temperatures.

<table>
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<tr>
<th>Latent heat of evaporation</th>
<th>t in °C</th>
<th>r in kJ/kg</th>
<th>t in °C</th>
<th>r in kJ/kg</th>
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</table>

**Report Requirements**

Plot the following variables as a function of air and water flow rates for the columns used in the experiment:

a) Cooling range
b) Cooling coefficient
c) Cooling capacity and heat load
d) Water Loss
e) Overall mass transfer coefficient