THE UNIVERSITY OF MICHIGAN - DEARBORN
ME 379 – Thermal Fluids Laboratory
Fall 2010

QUIZ

(100 pts. - Total)

(10 pts.) 1) Explain the thermal fluids principle behind the operation of a pitot tube and how the instrument is used to measure fluid velocity.

(10 pts.) 2) Explain the physical principle behind the operation of a thermocouple and how it is used to measure temperature.

(10 pts.) 3) Explain the fluids principle behind a laminar flow element and how it is used to measure flowrate.

(30 pts.) 4) First read the theory section and then solve the problem following.

Theory

To calculate the humidity ratio [kg(v)/kg(a)] of moist air one would use the following equation.

$$\omega = \frac{(2501 - 2.381T_{wb})\omega_{s,wb} - 1.006(T_{db} - T_{wb})}{2501 - 1.805T_{db} - 4.186T_{wb}}$$

where T_{db} is the dry bulb temperature [C] and T_{wb} is the wet bulb temperature [C]. $\omega_{s,wb}$ is the saturated humidity ratio evaluated at wet bulb temperature. It is determined by

$$\omega_{s,wb} = 0.62198\left(\frac{P_{sat}(T_{wb})}{P_{atm} - P_{sat}(T_{wb})}\right)$$

where $P_{sat}(T_{wb})$ is the water saturation pressure at wet bulb temperature. An approximation is the following.

$$P_{sat}(T) = 6.11 * 10^{(7.5T)/(237.7+T)}$$

where P_{sat} is in millibars. (1 mb = 100 Pa) and T is the temperature [C].

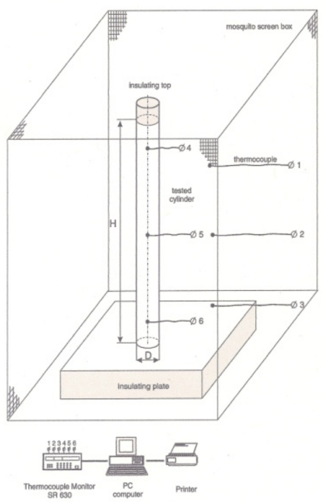
Problem

For a moist air flow the dry bulb and wet bulb temperatures are measured to be 40.0 C and 25.5 C, respectively. The atmospheric pressure is 1 atm or 1013 mb.

a) Determine the humidity ratio considering significant digits. Show work. Intermediate results must also show significant digits.

b) Estimate the uncertainty of the humidity ratio assuming a temperature uncertainty of ± 0.5 C. Also assume the saturated humidity ratio at wet bulb temperature has an uncertainty of 2%.

(40 pts.) 5) An experiment is designed to measure the natural convection heat transfer from a vertical small-diameter cylinder. Below is a figure of the experimental setup.



An aluminum rod is mounted vertically and is shrouded in a screen box. The screen allows air to pass through but protects the rod from external room air currents. Thermocouples are attached to the cylinder to measure its temperature. In addition the air temperature is measured. Knowing the amount of power to heat the rod and its surface area the heat transfer coefficient is calculated from Newton's law of cooling equation. Below are the experimental data for the Nusselt number with an uncertainty of 3.5% for a range of Rayleigh numbers.

Table 1: Heat transfer data for vertical rod.

Nusselt Number, Nu	99	112	121	126	128	130
Rayleigh Number, Ra	1×10^8	2×10^8	4×10^8	6×10^8	8×10^8	9×10^8

The following correlation has been developed for this heat transfer process.

$$Nu = ARa^n$$

Where A and n are 7.39 and 0.14, respectively.

(a) On the graph page, plot the data (ln Nu vs. ln Ra) and correlation based on the rules presented in this course. The format of the plot should be what one would present in a lab report. Provide caption.

(b) In addition, write an abstract that would be placed in a lab report.