MAE126A/171A Winter Quarter 2006

ENVIRONMENTAL AND MECHANICAL ENGINEERING LABORATORY
Turbulent plume – Week 1.
CALIBRATION AND PLUME BUOYANCY FLUX

General description

The experiment consists of a plume produced by a source of salt water at the top of a tank of fresh water. The flow to the plume is controlled by a peristaltic pump, which pumps salt water from the beaker to the plume nozzle.

The density of the plume is determined by a conductivity probe that measures the resistance of the solution that is, in turn, a function of the salt concentration. The probe measures the salinity of water drawn in through the tip by the second peristaltic pump. The location of the probe is controlled by labview.

Objectives

1. To determine the buoyancy flux of the plume
2. To determine the flow rate of the peristaltic pump
3. To calibrate the conductivity probe

Procedures

1. The determination of the plume buoyancy flux

The plume buoyancy flux is determined by the product of the flow rate Q and the reduced gravity g' of the supply salt solution. The salt concentration of the source solution will be 1100 kgm^{-3}.

Measure the flow rate for the pump setting at 6 rpm and 20 rpm, using the graduated cylinder and a stopwatch. Repeat each measurement at least 3 times, and determine the average flow rate and standard deviation for each setting. Calculate the expected buoyancy flux of the plume.

2. Calibration of the conductivity probe
The conductivity probe measures the salinity of the fluid, and this provides a measure of the density of the sample. It requires a flow through the probe driven by the peristaltic pump.

The probe is delicate! The peristaltic pump MUST be switched off whenever the tip is not under water.
Start with 2l of de-ionized water. Place the conductivity probe in the water and measure the voltage recorded by the conductivity probe. Dissolve 5 g of NaCl in the water and immerse the conductivity probe. Record the output voltage. Dissolve further NaCl in units of 5 g until a total of 40 g is reached. Measure the probe voltage for each solution (9 readings). Note both the mean and rms of the probe output, and use the latter to plot the results with error bars.
Use the table to convert the amount of dissolved salt to density.
Plot the output from the conductivity probe against the solution density and determine the least squares fit to the data.

Error analysis

1. Calculate any systematic errors in the measurements you take.
2. Determine random errors from repeated samples.
3. Plot all data with appropriate error bars.

Definitions
The **reduced gravity** is given by

$$g' \equiv g\frac{\rho_s - \rho_f}{\rho_f},$$

where $g = 9.81$ ms^{-2} is the acceleration due to gravity and ρ_s is the density of the salt solution and ρ_f is the density of fresh water.
The **buoyancy flux** is

$$B = g_0' Q,$$

where g_0' is the reduced gravity of the plume supply fluid.