Due Monday, May 15 12:00 p.m.
Turn Exams in to Prof. Cowen in Ho 119

General Information
You may work on this assignment with each other but you are each to turn in your own separate problem set solution. If you choose to work with other people list who you have collaborated with and on which problems you worked with that (those) people.

State any assumptions not given in the problems.

Each problem is worth the same number of points.

Note: For those who performed projects in the DeFrees Lab you MUST clean up your experiment before a grade will be issued!

Good Luck!

1) You plan on using an ADV to make measurements beneath a water wave. The velocity vector at the particular point you are measuring is well described by:

\[ u = 4\cos(\pi t) + 5 \]
\[ v = 0 \]
\[ w = 4\sin(\pi t) \]

i) The flow is uniformly seeded with small neutrally buoyant particles. You are interested in verifying that the mean flow is unaffected by the presence of the waves and hence you elect to sample the flow at 0.5 Hz (e.g., you report a velocity for each wave period.). You collect hundreds of wave periods of data and average the results to determine the mean. To your surprise \( \bar{u} \neq 5 \), what is it and why?

ii) What is \( \bar{w} \), and why?

iii) Describe a method to remove the bias in your results.

2) You are running an experiment on breaking waves and want to ensemble average a number of individual breaking events together to determine the turbulent statistics beneath the breaking wave. It is important that each individual wave be generated under the same conditions, which you have decided to be a wave breaking in quiescent water (e.g., no background level of turbulence). You decide to monitor the region where the wave breaks with an LDV to see when the turbulence has decayed. You determine that when \( \sqrt{\bar{u}^2} < 0.1 \text{ cm/s} \) you will consider the tank quiescent and initiate the generation of the next wave. As you do not want to wait around for a long time to get lot’s of independent samples you have decided to sample for only 30 seconds at 0.5 Hz (which you assume is sufficiently slow that the samples are independent). Develop an algorithm for checking when the tank is quiescent at the 95% confidence level.
3) Download the data set from the web site (in the sample data link) *final_signal.dat*. This data was sampled uniformly over 1 second. What are the amplitude and frequency as a function of time for this signal?

4) You deployed a fluorometer in an autonomous underwater vehicle (AUV) for a field experiment to measure the concentration of a fluorescent dye emanating from the wastewater treatment plant outfall in Cayuga Lake. The AUV is recovered and the data from the fluorometer is downloaded (download the data set from the web *final_auv.dat*). The fluorometer was sampled as an analog signal and clearly there was some sort of noise source in the data.

   i) Do your best to remove the noise source from the data, plot your result.
   ii) Report the standard deviation of the signal before and after you post-process the data.
   iii) What do you think the noise source might have been?

5) The temperature was sampled once a minute for 10 minutes at opposite corners of Hollister 314 during the final presentations. The data set can be found on the web as *final_7.dat* (two columns of 10 temperatures each). At the 95% confidence level was the average temperature in each corner the same? At about what confidence level is the dividing line between being able to say that the average temperatures are the same and they are different?

6) You are designing a BSA type LDV system. You will use an FFT approach to determine the Doppler frequency. You have a dual Bragg cell based 1-component optical system that you intend to operate in a mode such that you know the Doppler frequency will be between 1 and 2 MHz. Your budget is limited and you are trying to avoid spending more money than you need to on an ADC to sample the photomultiplier tube output. What is the slowest ADC you can get away with? Describe your algorithm for determining the Doppler frequency.

7) You are the TA in CEE 636 – Environmental Fluid Mechanics. We go out to Cayuga Lake in September to take a temperature profile of the lake on a late summer day. You take a boat out on the lake to a depth of 35m and lower a digital thermometer that returns an 8-bit number for the temperature. The thermometer has a range of -40°C - +120°C. You log the data on your laptop as you lower the probe. The returned values as a function of depth are:

<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>0</th>
<th>5</th>
<th>10</th>
<th>15</th>
<th>20</th>
<th>25</th>
<th>30</th>
<th>35</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temp (C)</td>
<td>25</td>
<td>24</td>
<td>20</td>
<td>5</td>
<td>0</td>
<td>7</td>
<td>6</td>
<td>5</td>
</tr>
</tbody>
</table>

Now, at this time of the year the water temperature should always be above 4°C so you know something is up, besides, this temperature profile implies unstable conditions (the water temperature at 15 – 20 m should be less the water temperature at 30 m!). At first
you think you have found some unusual physics (light water sitting below heavy water) but then you remember that back in the laboratory this thermometer had been behaving strangely – what is the problem? What are the actual temperatures that most likely should have been recorded?