Ocean 420 Physical Processes in the Ocean
Project 9: Internal waves, inertial oscillations and Kelvin waves
Due: Thursday, March 8rd

To get started

1. Login
   Username: Ocean Class (click on the icon)
   Password: *ocwaves*
2. Start up MATLAB
3. At the MATLAB prompt, type: *cd c:\classes\ocean420* to change to the Ocean 420 directory
4. Type: *ocean420* to begin running program – you will see a small window pop up with Ocean 420 in the title bar, from here you can choose a demonstration.

Turn in problems 2 and 3 only.

1. Internal wave phase propagation and particle trajectories

Go to the MATLAB demonstrations once again. Under *Wave Phase Propagation* choose *Internal Wave*. You are looking at an *x-z* plot. The color is the density anomaly and the white lines are contours of density. You can vary the frequency, the amplitude and the horizontal and vertical wave numbers. Note because you are varying all three at the same time, you are in effect changing the buoyancy frequency as well because the relationship between the wave numbers and the frequency are fixed by the dispersion relation. $\omega^2 = N^2 \cos^2 \varphi$ where φ is the angle that the wave number vector makes with the horizontal.

a) Pick a k=m=0.2 and ω of 2.5. Examine the phase propagation. What direction is it propagating (what is φ) ? What direction is the energy propagating?
b) Double the wave number in the horizontal and vertical directions. How does the picture change? What direction is the phase propagating (what is φ)? How does this compare to your answer in part (a)?
c) Using the wave number values in (a) lower the frequency. How does the picture change?
d) Using the parameters in (a) change the sign of the vertical wave number. What direction is the phase propagation? What direction is the energy propagating?

Now choose the internal wave case under *Wave Particle Trajectory*.

e) Using the same values as in (a) examine the wave particle trajectories. When in the cycle of the wave is the velocity maximum (i.e. what is the density anomaly when the velocity of the particle is maximum)?
f) By following particles at different levels, make a sketch of horizontal velocity as a function of depth.
g) Now set *k=0.02* and *m=0.5*. Describe the wave particle trajectories. How do the trajectories compare to those in shallow water gravity waves that we talked about several weeks ago?
h) Now set *k=0.5*, and *m=0.02*. Describe the wave particle trajectories. How do the wave particle trajectories compare to the buoyancy oscillations that we described in class.

2. A mysterious oscillation…

Go to my web site in the projects section once again and down load the data for this homework **uv.txt**. It contains 80 numbers in two columns. Once again, load it into Excel or Matlab. It is current meter data from a location off the Washington coast at 47N in units of m/s. The first column is the East-West velocity, and the second column is the North-South velocity. The data is taken every hour. You suspect that the observations will show a nearly constant current. Instead you find significant variability.

a) To begin your analysis, plot u versus time and v versus time.
b) Next, plot a progressive vector diagram. A progressive vector diagram shows the displacement that a parcel would experience if it were in the velocity field. To do this, integrate u and v with respect to time, and plot the results against each other. To integrate, start the integration at x=y=0, then for t=1 hour, the location is 1 hour times the velocity at 1 hour. For hour two, the location will be the location at hour 1 plus the velocity at hour 2 times one hour etc.
c) You decide that the time series represents a constant current superimposed on an oscillation with a fixed period. Estimate both the constant current and the period.
d) What is the oscillation?

3. A two layer internal wave in the coastal region.

We are going to examine a similar internal wave that you studied in problem set 8, but this time with rotational effects. Let the upper layer depth be 100m, the lower layer depth be 1000m. The upper layer density is 1028 kg/m3, and the density is 1029 kg/m3 in the lower layer. We are at 30N.

a) A wind event generates an upwelling internal wave at 30N with a positive deviation in interface height of size 30m at the coast. What would the sea surface height deviation be associated with this wave? Give sign and magnitude.
b) If the period of the wave were 24 hours, what would the wavelength of the internal (baroclinic) wave be?
c) Calculate the internal deformation radii at 30N.
d) Sketch the sea surface height and interface height associated with this wave. Write down a formula for the sea surface height as a function of distance from the coast.
e) Write down a formula for the velocity of the wave as a function of distance from the coast. What would the velocity perturbation in the upper layer be at the coast associated with the internal wave? Give the direction and magnitude.