The physics of the atmosphere & ocean

Exercise 5

1. Computer assignment for equation of state:

Use MATLAB/Python "seawater_ver3_0" package (or the more accurate package http://www.teos-10.org/ package).

  a) Plot the T-S diagram (theta_sdiag.m) for temperature range 0C to 28C and salinity range 34ppt to 42ppt. From this estimate the difference between the minimum and maximum density in this range. How small is this difference compare to the average density? What happens when the temperature is close to 0C?
  b) Estimate the thermal and haline coefficients (sw_alpha.m, sw_beta.m) around T=14C and S=38ppt and write down linear equation of state.
  c) Density of sea water depends also on pressure. Using the matlab software, plot the density (sw_dens.m) of homogeneous water with T=14C and S=38ppt as a function of depth (up to 4000m) assuming that the water are at rest.

2. Data processing:

Use the oceanographic measurements of the Gulf of Eilat of the cruise station A – copy the file "20181114 A cast1_6580.cnv" from the moodle and open it as a text file and extract the data table. Note the difference between the temperature and the potential temperature.

  a) Using Matlab (or any alternative softwarte) plot the profiles of the temperature, salinity, fluorescence, irradiance, and density. ***Using the pressure as the depth scale*** estimate the depth of the thermocline.
  b) Using seawater matlab package (sw_bfrq.m) estimate the Brunt-Väisälä frequency (look at explanation in Question 3).

     Does it make any sense to you? Now smooth the data and estimate again the stratification frequency. At what depth the frequency is maximal? Is there any relation between this depth and the depth of the thermocline?
  c) Calculate the thermal and haline coefficients (sw_alpha.m, sw_beta.m) for the cruise data set and plot the Density profile using the linear equation.
  d) Now use the UNESCO equation of state to estimate the density (sw_dens.m) of sea water using the measured salinity, temperature, and pressure. Compare these density profiles to the one you calculate at the previous section and the ones given in the datasets. Do you see any difference? How big are these differences and what is the reason for them? How good is the linear equation of state compare to the more accurate nonlinear one?
  e) Plot on the same graph the potential density using the matlab (sw_pden.m). and the graph you plot at (c). Explain the effect of pressure on density.

3. <u>Brunt-Väisälä frequency</u>

A parcel which is neutrally buoyant inside a stratified liquid (with different densities at different heights) will have a restoring force – buoyancy will push it up when it is lowered, and gravity will pull it down when it is raised. Therefore, a vertical displacement of the parcel will cause it to oscillate.
The oscillation frequency, marked N, is called the "Brunt-Väisälä frequency" and is given by:

$$N^2 = -\frac{g}{\rho_0}\frac{d\rho}{dz},$$

where ρ_0 is the density of the oscillating parcel.
In a laboratory experiment an egg that has density $\rho_0 = (\rho_1 + \rho_2)/2$ was placed between two layers of fluid, the bottom layer with density ρ_2 and the upper layer with density ρ_1 where $\rho_1 < \rho_2$. The egg then was displaced a distance A downward and then released. When assuming that the size of the "egg" is infinitesimal, the egg feels constant buoyancy force within each layer.

a) Find the time that the egg returns to its original releasing point. Describe the motion within each layer.

b) Now assume that the density increases linearly with depth such that the density is ρ_2 at depth A downward relative to the interface between the two layers and ρ_1 at height A upward relative to the interface between the two layers. Find the time that the egg returns to its original release point.

c) If the students in the lab measured a time period of 4 seconds, what is ρ_2, for the two scenarios described above, when assuming that upper layer is a freshwater layer? Assume g=10 m/s^2 and A=10 cm.