Homework #1
Introduction to physical oceanography

1. Suppose the trajectories of fluid elements are given by

$$\begin{aligned} x &= x_0 e^{-\alpha t} \\ y &= y_0 e^{\alpha t} \\ z &= z_0 \end{aligned}$$

where x_0, y_0, z_0 are the position coordinates of the element at $t = 0$. Find the Eulerian velocity field. Find the streamlines and sketch them.

2. "Abyssal recipes": plot the vertical temperature profile using the Ingrid ocean data home page at Columbia University
(`http://iridl.ldeo.columbia.edu/SOURCES/.LEVITUS94/.ANNUAL/.temp/figviewer.html?plottype=line`)
at three (longitude, latitudes) locations: middle of the equatorial Pacific Ocean; the North Atlantic ocean at 60N; in the Southern Ocean south of Australia. Find and plot (not using Ingrid, but using excel, Matlab, or a pocket calculator and a graphing paper) an exponential profile that seems to fit each of the profiles reasonably well at depth ranges from 500m to the ocean bottom. Assume the vertical velocity is $w = 10^{-4} cm/sec$, and find the appropriate vertical mixing coefficients. Can you fit all locations with the same value of κ, w? What do you conclude from this?

3. Material derivative: (a) Use the above Ingrid home page
`http://iridl.ldeo.columbia.edu/SOURCES/.LEVITUS94/`
in order to plot contours of the annual mean ocean temperature as function of depth (0 to 1500m) and latitude (20N to 60N), along 40W. (b) Evaluate the gradient $\partial T/\partial y$ at the ocean surface from the plot. (c) Assume the ocean velocity in the north-south direction is 0.1 m/s. What is the Lagrangian rate of change for a fluid parcel following the above section at the surface? give you answer in units of degree per day.

4. Read Knauss 2nd edition chapter 3.

5. **Challenge problem: optional**. Suppose the Eulerian velocity field (u, v, w) in the Cartesian coordinate system (x, y, z) is

$$\begin{aligned} u &= -\mu x - \Omega y \\ v &= \mu y + \Omega x \\ w &= 0 \end{aligned}$$

Calculate the fluid trajectories for elements which at $t = 0$ have coordinates x_0, y_0, z_0. Consider the cases $\Omega > \mu$ and $\Omega < \mu$ explicitly in your final discussion.