SMS-303: Integrative marine sciences III.

Lab 3, Motion on a rotating planet (The Coriolis effect).

We will divide the class into two groups. Each group will see demos in different rooms (it takes time to spin the experiments and we have a limited number of rotating tables). We will have a few hands-on activities to do by the groups.

Demos in Room 1 (large lab)

Rotating table 1:
I. Rotating flow over topography, Taylor columns (from: http://www.ocean.washington.edu/courses/oc512/lab2-2004.pdf also in introduction to GFD, by Cushman-Roisin).

Put some dye (a permanganate crystal) on top of the 'sea mount' and a different dye around it. Observe the fluid at rest relative to the rotating fluid. You are about to change the rotation rate. What do you think will happen to the fluid?

Decrease a little the rotation rate (by decreasing the voltage). Observe the fluid flowing towards the 'seamount'. Does it climb over it?
What is happening to the dyed fluid?
The fluid in the tank has a specific angular momentum based on its motion, distance from the center and depth. If it were to climb the 'seamount' it will need to changed its height (and become fatter); if it did that, its velocity will need to change prompting it to stay away from the seamount. This rigidity of the fluid is a particular property of rotating fluids.

II. Coriolis in a fluid
A syringe with dye is attached to a rotating tank at solid body rotation. What do you think will happen when you skirt fluid into the tank at mid depth in direction of its center? Do it, and observe what happens to the fluid (Is it deflected?).
How does it compare to an analogue setup that does not rotate? Compare the fluid in both setups. Do they develop differently following the injection?

III. Inertial oscillations
Using a surface designed to be a geopotential for a given rotation rate, observe a ball at rest in the rotating frame of reference (via the camera). Perturb the ball and observe the motions in both rotating and nonrotating reference frames. These motions are called inertial oscillations and occur often in the oceans in response to a sudden impulse on it.

IV. Faucualt's pendulum:
Observe how a pendulum is seen from a rotating frame (camera) and a frame at rest. This is one of the most striking experiments proving the Earth rotation that can be done without ever leaving ones room!

Demos in Room 2 (small lab)

Rotating table 2.
I. Taylor sheets.
Put dye in a rotating tank and a non rotating tank. Observe how the dye spread. Why is it different between the two?

Rotating table 3.
I. Ekman pumping.
Have a tank with a viscous fluid come to solid body rotation by spinning about 5min. Once in solid body rotation put a stationary beaker on top generating stress on the upper surface of the fluid. What direction is the stress (plot it) ? How would such a stress affect a fluid on the ocean? Using dye observe the motion within the fluid. Is it consistent with what you learned about Ekman pumping?

Station for individual groups:

I. Ekman dynamics.

Stirr a tank with tea leaves on the bottom. How are the tea leaves moving as they slow down? Why?

II. Rotating table Coriolis:
Rotate the table by hand and release the bead on the duct. How is the trajectory changing with rotation intensity, and direction? How does it compare with what you learned on Coriolis? How will it change if you insert the ball in from a non-rotating source? Try it.

III: Computer exercise. Coriolis applet
http://profhorn.meteor.wisc.edu/wxwise/kinematics/testwind2.html
Geostrophic balance: when no friction is present, the force due to pressure differences (or gradient) is balanced by Coriolis and the resultant winds are parallel to lines of constant pressure (isobars).
Explore geostrophy at different latitude.

- For a given pressure gradient how does the magnitude of the velocity changes as you go closer to the poles compared to the equator?
- Now add friction. Predict what will happen and compare to what happens.
- In the ocean and atmosphere, where would you expect friction to be most important? How will it vary vertically?

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