Instructor: Professor Robert Hetland  
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Office hours: By appointment

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Description:
This course is an introduction to geophysical fluid dynamics as it relates to oceanic flows. The goal of the course is to develop conceptual tools used by oceanographers to understand oceanic flow. Topics will include basic concepts in GFD, such as constructing the equations of motion, Lagrangian vs. Eulerian motion, vorticity dynamics, Ekman dynamics, rotating waves, basin scale circulation and quasi-geostrophic dynamics, the effects of stratification and the use of layer models, instability theory, and turbulent mixing.

Prerequisites:
OCNG 608, Calculus, Differential equations

Course Outline:
The equations of motion:

Kinematics:  
- Conservation of mass  
- The Boussinesq approximation  
- Tracer equations  
- Lagrangian vs. Eulerian views  
- The equation of state  
- Streamfunction definition

Dynamics:  
- Forces in fluids  
- Conservation of momentum  
- Equations of motion on a rotating plane  
- The hydrostatic assumption

Effects of rotation:  
- The Coriolis force  
- Ball on a rotating plane  
- Temporal Rossby number  
- Inertial oscillations

Unstratified flow:

Shallow water theory:  
- Aspect ratios  
- Absence of vertical shear

Steady flow:  
- The Rossby number  
- Geostrophy

The Rossby adjustment problem:  
- Potential vorticity conservation  
- The deformation radius

Waves in unstratified flow:  
- Kelvin waves  
- Poncaré (inertia-gravity) waves  
- The $\beta$-plane  
- Rossby (planitary)/topographic waves  
- Wave dispersion

Viscous effects in unstratified flow:  
- The Ekman layer  
- The Ekman number  
- Ekman transport
### Stratified Flow:

- **Steady flow:**
  - Baroclinic pressure gradients
  - Thermal wind

- **Waves in stratified flow:**
  - Internal waves
  - The Brunt-Väisälä frequency
  - Flow over topography
  - The Burger number

- **Layer models:**
  - Layer model assumptions
  - The reduced gravity model

### Large-Scale Flows:

- **Western boundary currents:**
  - Sverdrup transport
  - Westward intensification

### Nonlinear Flows:

- **Unstable flow:**
  - Shear instability
  - The Richardson number
  - Barotropic instability

- **Hydraulic control:**
  - Flow through a constriction
  - The Froude number
  - Form drag

- **Mixing and turbulence:**
  - Scales of turbulent motions
  - The closure problem
  - Turbulent kinetic energy equation
  - Second moment closure

### Grading:

You will be expected to understand the material presented, derive basic results independently, and be able to present these results to your peers. Homework will be assigned approximately every other week, and will account for 30% of your grade. Homework will be due two weeks from the date of assignment, and your grade will be reduced if the homework is not completed on time. Two take-home exams (mid-term and final exams) will each count for 30% of your grade. Exams will be on new problems that extend work done in class. Class participation will account for 10% of your grade. A: 90% – 100%, B: 80% – 90%, etc.

### Text:

*Introduction to Geophysical Fluid Dynamics, Physical and Numerical Aspects* by Benoit Cushman-Roisin and Jean-Marie Beckers. (See also, *Atmosphere-Ocean Dynamics* by Adrian E. Gill, *Geophysical Fluid Dynamics* by Joseph Pedlosky, and *Fluid Mechanics* by Pijush K. Knundu.)

### Attendances

Please inform me before any planned absences, and I will try to be accommodating. University excused absences are always accepted.

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