# 270.626 Ocean General Circulation

## Fall Term 2025.

Prof. Thomas Haine, Thomas.Haine@jhu.edu

and

Dr. Prajvala Kurtakoti, pkurtak1@jh.edu

Tuesdays & Thursdays 9:00–10:20am, Olin 145

## Synopsis

This course is on the low-frequency global ocean general circulation. The treatment is mainly phenomenological, but intuitive physical explanations are attempted almost everywhere, and there are some more detailed mathematical models too. The course is designed for graduate students with interests in oceans, atmospheres, climate dynamics, geophysics, and/or fluids. Basic familiarity with fluid mechanics is required, and a solid grounding in physics, and mathematical methods for physics, at undergraduate level is assumed. The course may be accessible to you without these requirements, but expect to do some remedial work to catch up. Prior exposure to physical oceanography (or atmospheric dynamics) is an advantage, but is not required. Again, expect to do some background reading if necessary.

**Format:** The course will be taught as 80min in-person classes twice a week. There will be a few lecture presentations and some traditional note-taking as we lecture. More importantly, there will often be chance to discuss ideas and work on problems together during class. We will make computations and display data, for example in MATLAB or Python (or Julia, or something else). There will also be student discussion of homework. Class materials will be posted to Canvas. You are expected to review materials (presentation pdfs, textbook reading) beforehand, so that during class we can focus on problems. We plan to use Panopto to capture lectures and post to Canvas. We don't hold regular office hours, but feel free to talk to us after class or email to setup a meeting.

We're excited to teach Ocean General Circulation! This subject is fascinating!

## Topics

We will study the following topics (these are chapters in *Klinger and Haine* 2019):

- Physical Oceanography: Methods and Dynamical Framework (Chapter 1)

- Rotating and Shallow-Water Flow (Chapter 2)
- Two-Dimensional Horizontal Circulation (Chapter 3)
- Gyre-Scale Structures and Depth-Dependent Geostrophic Circulation (Chapter 5)
- Deep Meridional Overturning (Chapter 8)
- Heat Flux, Freshwater Flux, and Climate (Chapter 11)

Each of these topics/chapters consist of sections on Observations, Concepts, and Theory.

## Learning Goals

- Demonstrate proficiency in understanding and interpreting observations of physical oceanography with relevance to ocean general circulation.
- Learn, understand, and demonstrate proficiency in: observations, conceptual explanations, and theoretical models of select, key phenomena in ocean general circulation (such as: subtropical gyre, western intensification, hydrographic structure,deep and abyssal circulation, meridional overturning circulation, ocean's role in climate).
- Develop ability to understand both intuitive physical explanations and the corresponding mathematical arguments. Students will learn to be adept at switching between approaches.
- Increase expertise in using computers to analyze and present oceanographic data, perform numerical calculations (e.g. in MATLAB or python), and prepare clear written assignments with mathematical arguments and quantitative data (e.g. in latex).
- Increase expertise in collaborative team-work (e.g. on assignments) and informal presentations (e.g. "chalk & talk").

## Textbooks

The course is based on the required textbook *Ocean Circulation in Three Dimensions* (OC3D) by *Klinger and Haine* (2019), which is at the bookstore and on reserve at the library (an electronic version is also available). The topics above are the chapters in this book. The following are also good for reference, at least on the more theoretical aspects:

- Basic principles: *Marshall and Plumb* (2008); *Cushman-Roisin* (1994). (A new edition of Cushman-Roisin's book was published in 2011, and is much updated.)
- At the level of the class: *Vallis* (2019) (although we only cover a fraction of this material).
- Advanced reading: *Pedlosky* (1996); *Salmon* (1998).

## Assessment

The final grade in this class will depend on the following input data:

1. 30%: Class participation, including informal discussion, and presenting material,
2. 70% Six homeworks in total (see Schedule below), weighted equally.

There will be no final exam (the last assignment will probably be due on the day of the final exam, which is 11 December). Attendance at each class is expected, and is essential for good performance. Please inform us ahead of time if you cannot attend class, or as soon as is practicable. We will adhere to the University guidelines on illness (including COVID, available here): don't worry about catching up with class until you're well again. You will not be academically penalized for following the advice of health professionals! Similarly, religious holidays are valid reasons to be excused from class, but please inform us in advance.

## Ethics

The following guidelines are taken seriously in this class:

The strength of the university depends on academic and personal integrity. In this course, you must be honest and truthful. Ethical violations include cheating on exams, plagiarism, reuse of assignments, improper use of the Internet and electronic devices, unauthorized collaboration, alteration of graded assignments, forgery and falsification, lying, facilitating academic dishonesty, and unfair competition.

In addition, the specific ethics guidelines for this course are: *Homework assignments must be completed without any collaboration with anyone else and without use of generative artificial intelligence, such as large-language models. We encourage you to discuss homework problems with other students, but you must write up your own answers unless told otherwise. All printed and online information source should be accurately cited. There may also be some assignments where you work together.*

Report any violations you witness to the instructor or Renee Seitz rseitz5@jh.edu. The policy can be found here.

## Students with Disabilities - Accommodations and Accessibility

Johns Hopkins University is committed to providing welcoming, equitable, and accessible educational experiences for all students. If disability accommodations are needed for this course, students should request accommodations through Student Disability Services (SDS) as early as possible to provide time for effective communication and arrangements. For further information about this process, please refer to the SDS Website or email SDS Homewood: studentdisabilityservices@jhu.edu .

## Inclusivity

Johns Hopkins University is committed to creating a classroom environment that values the diversity of experiences and perspectives that each student brings. Everyone deserves to be treated with dignity and respect. Fostering an inclusive climate is important because research and experience show that students who interact with peers who are different from themselves learn new things and experience tangible educational outcomes. We invite you to help create a welcoming, vibrant and intellectually engaging classroom climate. Note that you should expect to be challenged intellectually by the instructors, and your peers, and at times this may feel uncomfortable. Indeed, growth often requires being pushed beyond your comfort zone. However, at no time in this learning process should someone be singled out or treated unequally based on any aspect of their identity (visible or invisible). If you ever have concerns in this course about harassment, discrimination, or any unequal treatment, or if you seek accommodations or resources, please reach out to your instructors, who will take your communication seriously and seek mutually acceptable resolutions and accommodations. Reporting will never impact your course grade. You may also share concerns with the department chair (Ben Zaitchik, zaitchik@jhu.edu), the Director of Undergraduate Studies (Emmy Smith, efsmith@jhu.edu), the KSAS Assistant Dean for Diversity and Inclusion (Arielle Frias afrias3@jhu.edu) or the Office of Institutional Equity (oie@jhu.edu). In handling reports, people will protect your privacy as much as possible, but faculty and staff are required to officially report information for some cases (e.g., sexual harassment).

## References


Cushman-Roisin, B. (1994), *Introduction to geophysical fluid dynamics*, Prentice-Hall, Inc., Englewood Cliffs, NJ, USA.

Klinger, B. A., and T. W. N. Haine (2019), *Ocean Circulation in Three Dimensions*, 1st ed., Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Marshall, J., and R. A. Plumb (2008), *Atmosphere, Ocean, and Climate Dynamics: An Introductory Text*, 319 pp., Elsevier Inc.

Pedlosky, J. (1996), *Ocean circulation theory*, Springer-Verlag, doi:10.1007/978-3-662-03204-6.

Salmon, R. (1998), *Lectures on geophysical fluid dynamics*, Oxford University Press, doi:10.1093/oso/9780195108088.001.0001.

Vallis, G. K. (2019), *Essentials of Atmospheric and Oceanic Dynamics*, Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, doi:10.1017/9781107588431.

## Schedule

We will meet twice a week for two 80 minute classes in Olin 145. Our schedule is: Tuesdays and Thursdays at 09:00–10:20. The tentative schedule is as follows:

Week 1. 26, 28 August

- Introduction to the Class
- Physical Oceanography: Methods and Dynamical Framework (Observations: 1.1.1–1.1.6)

Week 2. 2, 4 September

- Physical Oceanography: Methods and Dynamical Framework (Concepts: 1.2.1–1.2.3)

Week 3. 9, 11 September

- Physical Oceanography: Methods and Dynamical Framework (Theory: 1.3.1–1.3.3)

Homework 1: OC3D Exs. 1.1–1.14

Week 4. 16, 18 September

- Rotating and Shallow-Water Flow (Concepts: 2.1.1–2.1.5)

Week 5. 23, 25 September

- Rotating and Shallow-Water Flow (Theory: 2.2.1–2.2.5)

Homework 2: OC3D Exs. 2.4, 2.7, 2.8, 2.10, 2.11

Week 6. 30 September, 2 October. **Drop deadline**

- Two-Dimensional Horizontal Circulation (Observations: 3.1.1–3.1.4)

Week 7. 7, 9 October

- Two-Dimensional Horizontal Circulation (Concepts: 3.2.1–3.2.5)

Week 8. 14 October, Fall Break

- Two-Dimensional Horizontal Circulation (Theory: 3.3.1–3.3.3)

Homework 3: OC3D Exs. 3.1, 3.2, 3.3, 3.6, 3.7

Week 9. 21, 23 October

- Depth-Dependent Gyre Circulation (Observations: 5.1.1–5.1.3)

Week 10. 28, 30 October

- Depth-Dependent Gyre Circulation (Concepts: 5.2.1–5.2.5)

Week 11. 4, 6 November

- Depth-Dependent Gyre Circulation (Theory: 5.3.1–5.3.3)

Homework 4: OC3D Exs. 5.1, 5.2, 5.7, Bonus: 5.14

Week 12. 11, 13 November

- Deep Meridional Overturning (Observations: 8.1.1–8.1.4)

Week 13. 18, 20 November

- Deep Meridional Overturning (Concepts: 8.2.1–8.2.5)

Homework 5: OC3D Exs. 8.3, 8.4, 8.5, 8.6

Week 14. 25. 27 November Thanksgiving vacation

Week 15. 2, 4 December

- Heat Flux, Freshwater Flux, and Climate (Observations: 11.1.1–11.1.5)
- Heat Flux, Freshwater Flux, and Climate (Concepts: 11.2.3)
- Heat Flux, Freshwater Flux, and Climate (Theory: 11.3.2)

Homework 6: OC3D Exs. 11.3, 11.4, 11.9