The ocean is dynamic and how it transports and stores tracers in marine environments plays a crucial role in many aspects of marine sciences. Following on from the compulsory descriptive oceanography course OCES 2003 that largely focuses on the qualitative aspects of dynamics, the elective physical oceanography course focuses on the *quantitative* aspects of dynamics. In some sense there is no new science in this course, as everything you will learn has been talked over in OCES 2003. We are essentially going to redo all the things highlighted in OCES 2003 (see `https://github.com/julianmak/academic-notes/tree/master/OCES2003_descriptive_phys_ocean`) but within a mathematical framework, so that we can start doing quantification and prediction, which cannot be achieved satisfactorily in a purely descriptive approach.

!!! Important notes !!!

- This course is technical and quantitative, and no apologies are made for this. In the first four lectures I will essentially teach all the mathematical techniques I think you will need, and then the rest of the course we will use it to describe and analyse the relevant ocean relevant features and dynamical processes (mostly via pen and paper approaches, maybe some basic scientific computing). If you think you cannot tolerate (emphasis on the word *tolerate*) the maths that I go through within that first two weeks, then you should drop the course, because you will most likely fail. Note it is not a coincidence that the maths bits are scheduled to be within the add/drop period.

- On the other hand, if you are a student from say maths/physics/engineering, this might actually be a reasonable elective to take. You will probably need to work a bit for the physical interpretation as I am not going to spend that much time on it (see above link for notes from the descriptive course for that).

- I might be amenable to overlooking the OCES 2003 prerequisite for this course, but the maths prerequisites are non-negotiable. Substitutes of the maths prerequisites might be allowed (e.g. some physics/engineering courses).

- The assessment and course structure will depend on the enrolment each year. If the numbers are low (say less than or equal to around three) then we will take a guided study approach, otherwise it will be a standard lecture course. See later for methods of assessment and proposed syllabus depending on method of delivery.

- Your best bet is probably to arrange to talk to me (`jclmak@ust.hk`) before you enrol on the course, to find out more about it. Contacting me in advance is essential if you want to audit this course or for me to consider overlooking some prerequisites; without prior contact, I will reject all requests by default.

Assessment

If lecture course: 40% midterm, 60% finals

If guided study: 80% continuous assessment, 20% *viva voce* at the end (interview style assessment)
<u>NOTE</u>: I make the assessment questions mostly on what I would regard as “book work” material, but there will always be “hard + challenging” content. If you do all the “book work” you can expect to be getting around a B+. For those who want an A grade, you actually have to attempt the “hard” stuff.

Learning outcomes

- advanced knowledge of concepts and terminology in physical oceanography
- be able to carry out quantification in relation to the ocean relevant physical principles
- be able to analyse, predict and quantify features relevant to physical oceanography

Supplementary book list

(Keyword being "supplementary")

- Vallis (2006), "Atmospheric and oceanic fluid dynamics" 1st edn, Cambridge University Press
  - has details (waves + instabilities in Part 1, ocean circulation in Part 3)
  - 2nd edition longer, shorter version just as good (book title is "essentials of ...")
  - probably be using this book extensively if this course is proceeding in the guided study format
- Knauss (1997), "Introduction to physical oceanography", 2nd edn., Waveland Press Inc.
  - reasonable all rounder
- Wunsch (2015), "Modern observational physical oceanography", Princeton University Press
  - plenty of detail, with the over arching theme being on observations
- Talley et al. (2011), "Descriptive physical oceanography", 6th edn., Academic Press
  - more for background reading
- Williams & Follows (2012), "Ocean dynamics and the carbon cycle", Cambridge University Press
  - one of my favourite books, supposed to target physicists who want to learn some biology and carbon chemistry, and biologists/chemists who want to learn some physics
- Karnauskas (2020), "Physical oceanography and climate", Cambridge University Press
  - more climate focus (suitable for OCES 4001), great explanations of the physical processes and circulation

Proposed Syllabus

[Some slack/flexibility in timing and pace of lectures]

L01 Basic geometry and some linear algebra

L02 Basics of vector calculus

L03 Basics of differential equations

L04 Basics of complex numbers and Fourier transforms

How the course continues depends on the enrolment and delivery format. The choice of topics are essentially the same:

- equations of state, equations of motion, dimensional analysis, and approximations
- geostrophic theory, Ekman theory, models of large-scale circulation
- waves and tides
- instabilities

If this is continuing as a **lecture course**, then there will be two 90 mins lectures a week, with about four lectures on each topic listed above (not necessarily in order), and assessment through exams.

If this is continuing as a **guided study**, then contact time will instead be once a week for around 90 mins, but each week all students get the same pre-assigned reading, all students should prepare the material, but one person "teaches" what they learned that week at the weekly meeting; the preparation can be as a group or as an individual, but the "teaching" is per person. Assessment is through performance during the "teaching" session, involvement in class through question and answer, and a final individual *viva voce*.