Academic Year	AY2023/24	**Semester**	1
Course Coordinator	Patrick Martin		
Course Code	ES4901		
Course Title	Oceanography		
Pre-requisites	ES1007 or CY1007		
No of AUs	3		
Contact Hours	39 (39 h lectures)		
Proposal Date	May 2023		

Course Aims

The oceans cover 75% of our planet's surface area, and consequently play a major role in the Earth System. They also present a fascinating environment that is physically, chemically, and biologically different from the land environment we humans are used to. The objectives of this course are to provide a strong foundation in the principles of oceanography, with a primary focus on physical and chemical oceanography at a global scale, and throughout the full depth of the ocean. The course will begin by considering physical ocean circulation, including interactions between the ocean and climate. We will then examine ocean chemistry and its interactions with ocean biology, especially nutrient cycling, biological production and decomposition, and ocean carbon uptake. As part of that, we will consider how chemical tracers can shed light on oceanographic processes, and we will wrap up with a look at optical oceanography.

Intended Learning Outcomes (ILO)

By the end of this course, you (as a student) will be able to:

1. Explain global patterns of ocean circulation, and identify and trace different water masses based on their physical and chemical properties;
2. Interpret distributions of oceanographic tracers to diagnose processes and estimate their rates;
3. Analyse the coupling between the ocean biogeochemical cycles of carbon and several nutrient elements;
4. Analyse and interpret real-world oceanographic data;
5. Explain the connections and interactions between physical, chemical, and biological oceanographic processes;

Course Content

The course will consist of 12 lectures and tutorials that will explain the content, and will involve a lot of interactive discussion of oceanographic data and practical exercises. You will deepen your knowledge by solving take-home problem sets, and by tackling a project and presenting your results at the end of the course to the class. Your knowledge and understanding will further be tested through a final exam.

Assessment (includes both continuous and summative assessment)

Component	Course LO Tested	Related Programme LO or Graduate Attributes	Weighting	Team/ Individual	Assessment Rubrics
1. Final exam	All	Knowledge; Intellectual flexibility and critical thinking	40%	Individual	

2. Water mass project oral presentation	All	Knowledge, Problem solving; Passion and communication	20%	Individual	Appendix 1
3. Water mass project write-up	All	Knowledge; Intellectual flexibility and critical thinking	40%	Individual	Appendix 2
4. Total			100%		

Formative feedback

All classes will include in-class discussions and practical exercises (pen-and-paper or computer exercises). Participating in these exercises and discussions will give you feedback on your understanding. These exercises will be analogous to the problems you will be set in the final exam (short-answer questions with calculation exercises or data interpretation tasks).
You will present the results of your water mass project in the week following recess week. You will be given feedback on the presentation, and on the accuracy of your identification.
You will be given written feedback on your water mass project write-up to help improve your writing and highlight any inaccuracies in your understanding.

Learning and Teaching approach

Approach	**How does this approach support students in achieving the learning outcomes?**
Lectures	Lectures will efficiently outline the knowledge you are expected to acquire during the course, and will involve discussion of oceanographic data.
Tutorial exercises and discussions	Discussing data and concepts, and doing practical exercises will deepen your knowledge of the subject.
Final exam	The exam will test your knowledge and ability to solve oceanographic problems.
Water mass project	The project will allow you to do independent research on different water masses and their physicochemical properties to track down your water mass. The presentation is an opportunity to practice your communication skills, while the written report is an opportunity to practice your technical writing skills.

Reading and References

There will not be required reading set for this course, but the following books provide detailed background information for additional reading and research:

Emerson & Hedges 2009, “Chemical Oceanography and the Marine Carbon Cycle”, ISBN 978-0-521-83313-4
Ocean Circulation (Open University Press, 2001)
Seawater: Its Composition, Properties and Behaviour (Open University Press)
Libes 2011 “Introduction to Marine Biogeochemistry”, 2nd Edition, ISBN 978-0-12-088530-5
Garrison 2007, Oceanography: An Invitation to Marine Science (Brooks and Cole)

Course Policies and Student Responsibilities

(1) General
You are expected to attend all lectures punctually and take all scheduled assignments and tests by due dates. You are expected to take responsibility to follow up with course notes, assignments, and course related announcements for classes you have missed. You are expected to participate in all clicker questions during class.

(2) Absenteeism
Absences from lectures will likely affect your overall course grade, so you are strongly encouraged to attend all lectures. If you miss a mid-term exam without a valid reason (e.g., illness as supported by a medical certificate), you will be given zero marks for it. If you have a valid reason for missing a mid-term exam, you need to inform me as soon as possible, and you will need to sit a make-up exam. Since you will have longer to prepare, any make-up exams will be harder than the ordinary exams.

(3 Compulsory Assignments
You are required to submit the video presentation by the due date, and no extensions will be granted. Exceptions may be made if you have a valid reason, e.g. a long illness as supported by a medical certificate. If you do need an extension for a valid reason, you must inform me as soon as possible by e-mail (pmartin@ntu.edu.sg). Any extension is at the instructor's discretion.

Academic Integrity

Good academic work depends on honesty and ethical behaviour. The quality of your work as a student relies on adhering to the principles of academic integrity and to the NTU Honour Code, a set of values shared by the whole university community. Truth, Trust, and Justice are at the core of NTU's shared values.

As a student, it is important that you recognize your responsibilities in understanding and applying the principles of academic integrity in all the work you do at NTU. Not knowing what is involved in maintaining academic integrity does not excuse academic dishonesty. You need to actively equip yourself with strategies to avoid all forms of academic dishonesty, including plagiarism, academic fraud, collusion, and cheating. If you are uncertain of the definitions of any of these terms, you should go to the academic integrity website for more information. Consult your instructor(s) if you need any clarification about the requirements of academic integrity in the course.

Course Instructors

Instructor	Office Location	Phone	Email
Patrick Martin	N2-01C-46	6513 8683	pmartin@ntu.edu.sg

Planned Weekly Schedule

Week	Topic	Course LO	Readings/ Activities
1	Introducing the ocean, properties of seawater, concept of salinity	1,2,4,5	

2	Surface ocean circulation (and atmospheric circulation)	1,2,4,5	
3	Deep ocean circulation and water masses	1,2,4,5	
4	Forces and geostrophic motion	1,2,4,5	
5	Biological carbon and nutrient cycling	2,3,4,5	
6	Biological carbon and nutrient cycling	2,3,4,5	
7	ODV practical	1,2,3,4,5	
8	Water mass project oral presentations	1,2,3,4,5	
9	Tracers and the conveyor-belt circulation	1,2,3,4,5	
10	ODV practical	1,2,3,4,5	
11	Why is the ocean salty? Geochemical mass balance	2,4,5	
12	The carbonate system	2,3,4,5	
13	Optical oceanography	1,2,3,4,5	

Appendix 1: Assessment criteria for oral project presentation

Marks	Criteria
A+ (Exceptional) A (Excellent)	Excellent and concise presentation of the evidence for identifying the water mass, ruling out other possibilities where appropriate. Selected a suitable paper to discuss and provides a comprehensive summary that is very easy to understand while not sacrificing technical accuracy. Presenter clearly understands the paper well in all major aspects, without missing major aspects of the purpose. Technically an excellent presentation in terms of slide design and oratory. Excellent responses to questions: concise but complete and correct.
A- (Very good) B+ (Good)	Presents the evidence for identifying the water mass in good detail, but maybe structured or presented in a way that is a bit hard to follow. Selected a suitable paper to discuss and provides a fairly comprehensive summary that is broadly understandable, but perhaps with some inaccuracies or omissions that are not too major. Presenter understands most of the main aspects of the paper but maybe misunderstanding or simply not understanding some parts that ought to be understandable. Technically an good presentation in terms of slide design and oratory but all round not quite as polished as for a genuinely excellent effort. Overall good responses to questions with no major errors, but possibly somewhat limited or somewhat rambling.
B (Average) B- (Satisfactory) C+ (Marginally satisfactory)	Presents evidence for identifying the water mass in an increasingly unclear manner or omitting important aspects of the evidence. Paper summary increasingly limited and/or hard to understand, shows increasing degrees of inaccuracy, with the presenter perhaps showing clear evidence of not understanding key aspects of the paper themselves. Technically just a passable presentation in terms of slide design and oratory. Limited responses to questions or responding with completely irrelevant answers that miss the point of the question, with clear inaccuracies.
C (Borderline unsatisfactory) C- (Unsatisfactory)	Provides only a cursory discussion of the evidence identifying the water parcel rather than properly discussing all the properties given. Provides a very limited and discussion of the paper, with significant gaps, so the listener cannot properly understand the purpose of what the paper is attempting to do. Clear evidence that the presenter does not understand the paper, with basic errors in oceanographic understanding.
D, F (Deeply unsatisfactory)	Presentation does not attempt to develop an argument to identify the water mass, and no proper summary of the paper is provided.

Appendix 2: Assessment criteria for written project report

Marks	Criteria
A+ (Exceptional) A (Excellent)	Correctly identified the water mass and provided an excellent and exhaustive written argument that is logically structured, possibly including relevant diagrams. Cites relevant literature to provide logical examples in a concise but accurate way. No significant inaccuracies in the content.
A- (Very good) B+ (Good)	Correct identification of the water parcel, with a written argumentation that is good but not necessarily completely exhaustive or structured in a way that makes it harder to follow. Cites some relevant literature but doesn't always make clear and logical points, or papers are rather tangentially related to the topic. Some inaccuracies and errors in content.
B (Average) B- (Satisfactory) C+ (Marginally satisfactory)	Possibly misidentification of the water parcel with incomplete reasoning in the argument identifying the water mass. Evidence to support the identification of the water mass is not clearly presented, writing is poorly structured so as to be hard to follow, and irrelevant points are discussed. Literature is not cited or irrelevant. Significant errors in the content.
C (Borderline unsatisfactory) C- (Unsatisfactory)	Water parcel is misidentified with a water mass of very different properties. Poorly written and poorly structured argument to present the evidence, with serious inaccuracies in interpretation and possibly omitting important pieces of evidence. No or only irrelevant papers cited. Major errors, and clear evidence of a poor grasp of even basic oceanographic concepts.
D, F (Deeply unsatisfactory)	Rudimentary attempt preparing a written report, with no proper argument to identify the water mass based on presented evidence.