Academic Year	AY2020/21	**Semester**	2
Course Coordinator	Patrick Martin		
Course Code	ES4901		
Course Title	Oceanography		
Pre-requisites	ES1007 Climate Change or CY1007 Climate Change		
No of AUs	3		
Contact Hours	39 (39 h lectures)		
Proposal Date	August 2019		

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 11 combined lecture + tutorial classes 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 two mid-term exams.

Assessment (includes both continuous and summative assessment)

Component	Course LO Tested	Related Programme LO or Graduate Attributes	Weighting	Team/ Individual	Assessment Rubrics
1. Take-home problem sets	All	Knowledge; Intellectual flexibility and critical thinking; Problem solving	25% (6.25% each)	Individual	
2. End-of-semester test	All	Knowledge; Intellectual flexibility and critical thinking	40%	Individual	
3. Participation in discussions during class	All	Knowledge; Intellectual flexibility and critical thinking; Formulating questions	10%	Individual	
4. Project presentation	All	Knowledge, Problem solving; Passion and communication	25%	Individual	
5. Total			100%		

Formative feedback

You will receive feedback on your understanding during lectures by participating in discussions and doing practical exercises. The take-home problem sets will be graded and returned to you promptly. You will receive qualitative feedback on your project presentation.

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.
Take-home problem sets	Problem sets will allow you to test your knowledge and understanding, and will make you think deeply about the subject matter.
End-of-semester test	The test will examine your knowledge and ability to solve oceanographic problems. You will be allowed to bring in any hand-written notes and diagrams that you have prepared yourself to refer to during the test.
Final project	The project will allow you to do independent background research and solve a problem based on the data you are given. The presentation is an opportunity to practice your communication 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:

1) Emerson & Hedges 2009, "Chemical Oceanography and the Marine Carbon Cycle", ISBN 978-0-521-83313-4
2) Ocean Circulation (Open University Press, 2001), ISBN 978-0-08-053794-8
3) Seawater: Its Composition, Properties and Behaviour (Open University Press), ISBN 978-1-48-325707-5
4) Libes 2011 "Introduction to Marine Biogeochemistry", 2nd Edition, ISBN 978-0-12-088530-5
5) Garrison 2007, Oceanography: An Invitation to Marine Science (Brooks and Cole), ISBN-13: 978-1305105164

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	Why is the ocean salty? Geochemical mass balance	1,2,4,5	
6	Ocean and climate	1,2,4,5	
7	Biological oceanography	3,4,5	
8	Primary production and organic carbon cycling	1,2,3,4,5	
9	Macro- and micronutrient cycles	1,2,3,4,5	
10	Oxygen, gas exchange, and oceanographic tracers	1,2,3,4,5	
11	The carbonate system	1,2,3,4,5	
12	Optical oceanography	1,2,3,4,5	
13	Project presentations	1,2,3,4,5	

Appendix 1: Assessment Criteria for final Project Presentation

Marks	Criteria
A+ (Exceptional) A (Excellent)	Correct identification of the water parcel. Excellent and concise presentation of the evidence, ruling out other possibilities where appropriate. Technically an excellent presentation in terms of slide design and oratory. Selection of highly relevant papers with an excellent and concise summary of their content. No inaccuracies in the presentation.
A- (Very good) B+ (Good)	Correct identification of the water parcel. Very good presentation of the evidence, with some degree of irrelevant points being raised or not excluding other possibilities where appropriate. Technically a less refined presentation, possibly with some tangents being raised, and less refined oratory. Selection of papers is possibly somewhat tangential to the issue of the water masses, with a good summary of their content. Some inaccuracies and errors in the presentation.
B (Average) B- (Satisfactory) C+ (Marginally satisfactory)	Possibly misidentification of the water parcel with a water mass that has similar (but not totally different) properties. Passable presentation of the evidence, with varying degrees of inaccuracy in the interpretation and irrelevant points being raised. Technically not more than an acceptable presentation. Selection of papers is perhaps not very relevant, or summary of their content is only average and not concise (e.g. either considerably too brief or considerably too verbose and going into lots of irrelevant detail). Increasing number and severity of inaccuracies and errors, indicating a more limited grasp of oceanographic concepts.
C (Borderline unsatisfactory) C- (Unsatisfactory)	Water parcel is misidentified with a water mass of very different properties. Poor presentation of the evidence, with serious inaccuracies in interpretation and possibly omitting important pieces of evidence. Technically a poor presentation, with relevant evidence omitted and/or a lot of irrelevant points discussed. Poor selection of papers that are not really relevant to the topic, or relevant papers but a poor summary of their content. Significant errors, and clear evidence of a poor grasp of even basic oceanographic concepts.
D, F (Deeply unsatisfactory)	Rudimentary attempt at a presentation that does not attempt to properly identify the water parcel or present evidence to support the conclusion.