



## UNSW Course Outline

# MATH2241 Introduction to Atmosphere and Ocean Dynamics - 2024

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## General Course Information

Course Code : MATH2241

Year : 2024

Term : Term 1

Teaching Period : T1

Is a multi-term course? : No

Faculty : Faculty of Science

Academic Unit : School of Mathematics & Statistics

Delivery Mode : In Person

Delivery Format : Standard

Delivery Location : Kensington

Campus : Sydney

Study Level : Undergraduate

Units of Credit : 6

### Useful Links

[Handbook Class Timetable](#)

## Course Details & Outcomes

### Course Description

This course introduces students to mathematical models for the circulation of the atmosphere

and oceans. The equations of motion are exploited to provide simplified models for phenomena including the effects of the Earth's rotation, large-scale balanced flows, waves and potential vorticity, and the energy balance in the climate system. Some fundamentals of geophysical fluid dynamics are developed first and then allied to the oceans, to the atmosphere, and to the role of both in the climate system.

## Course Aims

The aim of this course is to introduce mathematical models that describe the circulation of the ocean and atmosphere. Students will gain a basic understanding of the physical processes and forcing mechanisms in the ocean and atmosphere. After successfully completing this course students will be able to identify the relevant physical approximations and mathematical techniques needed to model a range of commonly occurring geophysical flows. Students will also gain an understanding of the limitations involved in the modelling process as applied to atmosphere and ocean dynamics.

## Relationship to Other Courses

Prerequisites: MATH1231 or MATH1241 or MATH1251

# Course Learning Outcomes

Course Learning Outcomes
CLO1 : Apply key concepts of geophysical fluid dynamics to observed weather and climate phenomena in the atmosphere and ocean.
CLO2 : Interpret the predictions of simple mathematical models in terms of the corresponding geophysical phenomena.
CLO3 : Construct simple mathematical models, and to apply relevant simplifying physical approximations, for a range of commonly occurring geophysical flows.
CLO4 : Explain the key roles of the atmosphere and ocean in the global climate system.

Course Learning Outcomes	Assessment Item
CLO1 : Apply key concepts of geophysical fluid dynamics to observed weather and climate phenomena in the atmosphere and ocean.	<ul style="list-style-type: none"><li>• Tutorial Problems</li><li>• Final Exam</li></ul>
CLO2 : Interpret the predictions of simple mathematical models in terms of the corresponding geophysical phenomena.	<ul style="list-style-type: none"><li>• Tutorial Problems</li><li>• Final Exam</li></ul>
CLO3 : Construct simple mathematical models, and to apply relevant simplifying physical approximations, for a range of commonly occurring geophysical flows.	<ul style="list-style-type: none"><li>• Tutorial Problems</li><li>• Final Exam</li></ul>
CLO4 : Explain the key roles of the atmosphere and ocean in the global climate system.	<ul style="list-style-type: none"><li>• Tutorial Problems</li><li>• Final Exam</li></ul>

## Learning and Teaching Technologies

Moodle - Learning Management System

## Learning and Teaching in this course

You should attend all classes. Failure to do so may compromise your chances of understanding the material.

It is anticipated that you will also have to do substantial work outside of class contact hours on practice problems and assessed assignments.

Online Content: Lecture notes and slides will be made available online (moodle) at the end of each week.

Solutions to assessed problems and most tutorial problems will be covered in the weekly tutorial sessions.

Solutions to assessed problems will *not* be made available online.

Solutions to non-assessed tutorial problems will be made available online.

## Additional Course Information

This course provides an introduction to the mathematical and physical models of atmospheric and oceanic flows.

The equations of motion for geophysical fluids are developed and subjected to physical approximations to provide simplified models for large-scale fluid flow in the atmosphere and ocean.

Focus is mainly on phenomena that are important in the climate system.

Topics covered include balanced flows (geostropic/thermal-wind), waves, large-scale vorticity dynamics, parcel theory, Ekman layers, Sverdrup theory, energy and angular momentum constraints.

## Assessments

### Assessment Structure

Assessment Item	Weight	Relevant Dates
Tutorial Problems Assessment Format: Individual	50%	Start Date: Not Applicable Due Date: Not Applicable
Final Exam Assessment Format: Individual	50%	Start Date: Not Applicable Due Date: Not Applicable

### Assessment Details

#### Tutorial Problems

##### Assessment Overview

You will complete a set of problems to be worked on outside of class times with a selection submitted in weeks 3, 5, 8, and 10. Fully engaging with these problems is essential for understanding and learning the course material. The submitted problems will be carefully graded with feedback provided on the marked-up problems. These problems provide an important foundation for the exam.

##### Course Learning Outcomes

- CLO1 : Apply key concepts of geophysical fluid dynamics to observed weather and climate phenomena in the atmosphere and ocean.
- CLO2 : Interpret the predictions of simple mathematical models in terms of the corresponding geophysical phenomena.

- CLO3 : Construct simple mathematical models, and to apply relevant simplifying physical approximations, for a range of commonly occurring geophysical flows.
- CLO4 : Explain the key roles of the atmosphere and ocean in the global climate system.

### Detailed Assessment Description

There will be a set of about 14 substantial problems to be worked on outside of class time throughout the term. The problems will be released in four installments as the relevant material is covered in class. The problems will be assessed according to a fixed schedule, with each installment counting for 12.5% of the grade for a summative weight of 50\%.

The assessment of the problems is based on individual written worked solutions that the student submits by the deadlines provided in the course schedule.

Assessed problems are due anytime before 23:50 on the due date.

Assessed problems part A: released Fri 23 Feb, due Fri 1 Mar.

Assessed problems part B: released Fri 1 Mar, due Fri 15 Mar.

Assessed problems part C: released Fri 15 Mar, due Fri 5 Apr.

Assessed problems part D: released Fri 5 Apr, due Wed 17 Apr.

### Assessment Length

About 14 problems spread over the term.

### Submission notes

The problem solutions can be handwritten. The student is asked to submit a high-quality pdf document via Moodle by the deadline specified for each of the four installments.

### Assessment information

Standard late submission penalties apply.

### Assignment submission Turnitin type

Not Applicable

## **Final Exam**

### Assessment Overview

The exam is designed to test your understanding of the course material covered across the term in both lectures and tutorials. The exam questions will be similar in format to those of the assessed problems (assessment 1) that you will work on throughout the term. . A selection of

questions will be presented to you during a 50 minute oral examination and you will provide an answer through verbal explanation and by solving problems and showing your written workings. The exam will be closed book and count for 50% of your grade.

Feedback is available through inquiry with the course convenor.

#### **Course Learning Outcomes**

- CLO1 : Apply key concepts of geophysical fluid dynamics to observed weather and climate phenomena in the atmosphere and ocean.
- CLO2 : Interpret the predictions of simple mathematical models in terms of the corresponding geophysical phenomena.
- CLO3 : Construct simple mathematical models, and to apply relevant simplifying physical approximations, for a range of commonly occurring geophysical flows.
- CLO4 : Explain the key roles of the atmosphere and ocean in the global climate system.

#### **Detailed Assessment Description**

The exam will cover the content of the lectures, tutorials, and assigned problems.

The exam will be comprehensive covering the entire course from the first to the last lecture, inclusive.

#### **Assessment Length**

2 hours

#### **Submission notes**

School-run sit-down exam. Solutions to be written in exam booklets to be collected by the course authority at the end of the exam.

#### **Assessment information**

A UNSW approved calculator is allowed.

A formula sheet will be provided with the exam. A copy of the formula sheet is made available toward the end of the course.

#### **Assignment submission Turnitin type**

Not Applicable

## **General Assessment Information**

There are two assessments: (1) a set of problems to be worked on outside of class time and (2) a comprehensive exam at the end of the semester during the exam period.

The problems will be assessed according to the schedule below, with a summative weight of 50%. The exam accounts for the remaining 50% of the course grade.

The assessment of the problems is based on the written worked solutions that the student submits by the deadlines provided in the course schedule (and with the problems).

The exam will cover the content of the lectures, tutorials, and assigned problems.

The exam will be comprehensive covering the entire course from the first to the last lecture, inclusive.

Marks will be awarded for approach and appropriate explanations and not just for the final answer.

#### **Grading Basis**

Standard

#### **Requirements to pass course**

A total grade or 50% or more.

# Course Schedule

Teaching Week/Module	Activity Type	Content
Week 1 : 12 February - 18 February	Lecture	Introduction, equations of motion for fluids geophysical fluids, geometry of the atmosphere and ocean equations of state, hydrostatic balance, barotropic and baroclinic pressure, exponential atmosphere (review of partial derivatives, gradient, vector cross-product) Newton's 2nd law for non-rotating fluid and transformation to rotating frame Coriolis and centrifugal acceleration, effective geopotential
	Tutorial	Weekly tutorial to work on sample problems for the material covered
Week 2 : 19 February - 25 February	Lecture	Balanced flow: geostrophy, Taylor-Proudman columns local Cartesian coordinates, scaling Rossby number and geostrophy Taylor-Proudman theorem/columns thermal wind (height and pressure coordinates)
	Tutorial	Weekly tutorial to work on sample problems for the material covered
	Assessment	Part A of assessed problems released Friday 23 February 2024, due Friday 1 March 2024 (any time before 23:50).
Week 3 : 26 February - 3 March	Lecture	Shallow-water systems, waves and vorticity Continuity and subgeostrophic flow in weather systems shallow-water equations linearization for small-amplitude perturbations waves
	Tutorial	Weekly tutorial to work on sample problems for the material covered
	Assessment	Part A of assessed problems due Friday 1 March 2024 (any time before 23:50). Part B of assessed problems released Friday 1 March 2024, due Friday 15 March 2024 (any time before 23:50).
Week 4 : 4 March - 10 March	Lecture	Ocean: geostrophic flow and density structure parcel theory, buoyancy and internal waves potential vorticity conservation, Rossby waves geostrophic flow near the surface, satellite altimetry geostrophic flow at depth, slope of density surfaces, "dynamic method"
	Tutorial	Weekly tutorial to work on sample problems for the material covered
Week 5 : 11 March - 17 March	Lecture	Ocean: wind-driven circulation wind stress and Ekman layer layer-integrated Ekman transport, Ekman pumping/suction coastal up/down welling
	Tutorial	Weekly tutorial to work on sample problems for the material covered
	Assessment	Part B of assessed problems due Friday 15 March 2024 (any time before 23:50). Part C of assessed problems released Friday 15 March 2024, due Friday 5 April 2024 (any time before 23:50).
Week 6 : 18 March - 24 March	Other	No lectures or tutorial in week 6.
Week 7 : 25 March - 31 March	Lecture	Ocean: depth-integrated circulation Taylor-Proudman on the sphere Sverdrup theory western boundary currents
	Tutorial	Weekly tutorial to work on sample problems for the material covered
Week 8 : 1 April - 7 April	Lecture	Atmosphere: radiation balance radiation balance and emission temperature IR-opaque and IR-leaky layer models of the atmosphere Green-house effect
	Tutorial	Weekly tutorial to work on sample problems for the material covered
	Assessment	Part C of assessed problems due Friday 5 April 2024 (any time before 23:50). Part D of assessed problems released Friday 5 April 2024, due Wednesday 17 April 2024 (any time before 23:50).
Week 9 : 8 April - 14 April	Lecture	Atmosphere: stability, potential temperature 1st law of thermodynamics and adiabatic processes, dry static energy dry adiabatic lapse rate and stability, potential temperature humidity effects on stability
	Tutorial	Weekly tutorial to work on sample problems for the material covered
Week 10 : 15 April - 21 April	Lecture	Atmosphere: general circulation angular momentum transport, subtropical jets and Hadley circulation midlatitude eddies and westerly jet baroclinic instability and maintenance of the general circulation
	Tutorial	Weekly tutorial to work on sample problems for the material covered
	Assessment	Part D of assessed problems due Wednesday 17 April 2024 (any time before 23:50).

# **Attendance Requirements**

Students are strongly encouraged to attend all classes and review lecture recordings.

## **General Schedule Information**

We will meet for two 2-hr lectures and one 1-hr tutorial each week (except week 6):

2-hr lecture on Tuesdays, 9:00-11:00, Old Main Building G32

2-hr lecture on Thursdays, 11:00-13:00, Old Main Building G32

1-hr tutorial on Fridays, 13:00-14:00, UNSW Business School 107

Tentative: Consultation hour Fridays 14:00-15:00, Anita B. Lawrence Centre (formerly The Red Centre) Rm 4107

## **Course Resources**

### **Prescribed Resources**

None.

### **Recommended Resources**

J. Marshall and R. A. Plumb

*Atmosphere, Ocean and Climate Dynamics, An Introductory Text*

Academic Press, ISBN: 978-0-12-558691-7

This is an excellent book that the course will follow to a significant degree.

The UNSW library has a hardcopy and an electronic copy.

### **Additional Costs**

None.

## **Course Evaluation and Development**

The School of Mathematics evaluates each course each time it is run.

Feedback on the course is gathered, using among other means, through UNSW's myExperience online survey.

Student feedback is taken seriously, and continual improvements are made to the course based in part on such feedback.

# Staff Details

Position	Name	Email	Location	Phone	Availability	Equitable Learning Services Contact	Primary Contact
	Mark Holzer		Anita B. Lawrence Centre - Room 4107	9385 7109	weekly consultation hour, email, by appointment	No	Yes

## Other Useful Information

### Academic Information

Upon your enrolment at UNSW, you share responsibility with us for maintaining a safe, harmonious and tolerant University environment.

You are required to:

- Comply with the University's conditions of enrolment.
- Act responsibly, ethically, safely and with integrity.
- Observe standards of equity and respect in dealing with every member of the UNSW community.
- Engage in lawful behaviour.
- Use and care for University resources in a responsible and appropriate manner.
- Maintain the University's reputation and good standing.

For more information, visit the [UNSW Student Code of Conduct Website](#).

### Academic Honesty and Plagiarism

**Referencing** is a way of acknowledging the sources of information that you use to research your assignments. You need to provide a reference whenever you draw on someone else's words, ideas or research. Not referencing other people's work can constitute plagiarism.

Further information about referencing styles can be located at <https://student.unsw.edu.au/referencing>

**Academic integrity** is fundamental to success at university. Academic integrity can be defined as a commitment to six fundamental values in academic pursuits: honesty, trust, fairness, respect, responsibility and courage. At UNSW, this means that your work must be your own, and others' ideas should be appropriately acknowledged. If you don't follow these rules, plagiarism may be detected in your work.

Further information about academic integrity, plagiarism and the use of AI in assessments can

be located at:

- The [Current Students site](#),
- The [ELISE training site](#), and
- The [Use of AI for assessments](#) site.

The Student Conduct and Integrity Unit provides further resources to assist you to understand your conduct obligations as a student: <https://student.unsw.edu.au/conduct>

## Submission of Assessment Tasks

### Penalty for Late Submissions

UNSW has a standard late submission penalty of:

- 5% per day,
- for all assessments where a penalty applies,
- capped at five days (120 hours) from the assessment deadline, after which a student cannot submit an assessment, and
- no permitted variation.

*Any variations to the above will be explicitly stated in the Course Outline for a given course or assessment task.*

Students are expected to manage their time to meet deadlines and to request extensions as early as possible before the deadline.

### Special Consideration

If circumstances prevent you from attending/completing an assessment task, you must officially apply for special consideration, usually within 3 days of the sitting date/due date. You can apply by logging onto myUNSW and following the link in the My Student Profile Tab. Medical documentation or other documentation explaining your absence must be submitted with your application. Once your application has been assessed, you will be contacted via your student email address to be advised of the official outcome and any actions that need to be taken from there. For more information about special consideration, please visit: <https://student.unsw.edu.au/special-consideration>

**Important note:** UNSW has a “fit to sit/submit” rule, which means that if you sit an exam or submit a piece of assessment, you are declaring yourself fit to do so and cannot later apply for Special Consideration. This is to ensure that if you feel unwell or are faced with significant circumstances beyond your control that affect your ability to study, you do not sit an examination

or submit an assessment that does not reflect your best performance. Instead, you should apply for Special Consideration as soon as you realise you are not well enough or are otherwise unable to sit or submit an assessment.

## Faculty-specific Information

### Additional support for students

- [The Current Students Gateway](#)
- [Student Support](#)
- [Academic Skills and Support](#)
- [Student Wellbeing, Health and Safety](#)
- [Equitable Learning Services](#)
- [UNSW IT Service Centre](#)
- Science EDI Student [Initiatives](#), [Offerings](#) and [Guidelines](#)

### School-specific Information

#### School of Mathematics and Statistics and UNSW Policies

The School of Mathematics and Statistics has adopted a number of policies relating to enrolment, attendance, assessment, plagiarism, cheating, special consideration etc. These are in addition to the Policies of The University of New South Wales. Individual courses may also adopt other policies in addition to or replacing some of the School ones. These will be clearly notified in the Course Initial Handout and on the Course Home Pages on the Maths Stats web site. Students in courses run by the School of Mathematics and Statistics should be aware of the School and Course policies by reading the appropriate pages on the web site starting at: [The School of Mathematics and Statistics assessment policies](#)

The School of Mathematics and Statistics will assume that all its students have read and understood the School policies on the above pages and any individual course policies on the Course Initial Handout and Course Home Page. Lack of knowledge about a policy will not be an excuse for failing to follow the procedure in it.

#### Special Consideration - Short Extension Policy

The School of Mathematics and Statistics has carefully reviewed its range of assignments and projects to determine their suitability for automatic short extensions as set out by the UNSW Short Extension Policy. Upon comprehensive examination of our course offerings that incorporate these types of assessments, we have concluded that our current deadline structures

already accommodate the possibility of unexpected circumstances that may lead students to require additional days for submission. Consequently, the School of Mathematics and Statistics has decided to universally opt out of the Short Extension provision for all its courses, having pre-emptively integrated flexibility into our assessment deadlines. The decision is subject to revision in response to the introduction of new course offerings. Students may still apply for Special Consideration via the usual procedures.

## Computing Lab

The main computing laboratory is room G012 of the Anita B.Lawrence Centre (formerly Red Centre). You can get to this lab by entering the building through the main entrance to the School of Mathematics (on the Mezzanine Level) and then going down the stairs to the Ground Level. A second smaller lab is Room M020, located on the mezzanine level through the glass door (and along the corridor) opposite the School's entrance.

For more information, including opening hours, see the [computing facilities webpage](#). Remember that there will always be unscheduled periods when the computers are not working because of equipment problems and that this is not a valid excuse for not completing assessments on time.

## School Contact Information

### School Contact Information

Please visit the [School of Mathematics and Statistics website](#) for a range of information.

For information on Courses, please go to "Student life & resources" and either Undergraduate and/or Postgraduate and respective "Undergraduate courses" and "Postgraduate courses" for information on all course offerings.

All school policies, forms and help for students can be located by going to the "Student Services" within "Student life & resources" page. We also post notices in "Student noticeboard" for your information. Please familiarise yourself with the information found in these locations. If you cannot find the answer to your queries on the web you are welcome to contact the Student Services Office directly.

### Undergraduate

E: ug.mathsstats@unsw.edu.au

P: 9385 7011 or 9385 7053

**Postgraduate**

E: pg.mathsstats@unsw.edu.au

P: 9385 7053

Should we need to contact you, we will use your official UNSW email address of in the first instance. **It is your responsibility to regularly check your university email account. Please use your UNSW student email and state your student number in all emails to us.**