FACULTY OF SCIENCE

SCHOOL OF MATHEMATICS & STATISTICS

MATH3261/5285
Fluids, Oceans & Climate

Semester 2 2012
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1 Location of Course

Red Centre Central Wing 4082 (K-H13-4082)
Lectures: Tuesdays 9:00–11:00 and Fridays 11:00–12:00, weeks 1–7, 8–12
Tutorials: Fridays 12:00–13:00, weeks 2–7, 8–13

2 Staff Contact Details

convener and lecturer: Prof. Trevor McDougall
    room: 4071, Red Centre
    phone: 02 9385 3498
    email: Trevor.McDougall@unsw.edu.au

Consultation times will be announced in class and posted on the course's Blackboard site. Additional consultation appointments may be made via email.

3 Course Details

Units of credit: 6
Prerequisites: 12 units of credit in Level 2 Math courses including MATH2011 or MATH2111, and MATH2120 or MATH2130, or both MATH2019(DN) and MATH2089, or both MATH2069(DN) or MATH2099.

Course Description (handbook entry):
The mathematical modelling and theory of problems arising in the flow of fluids, the oceans and the global climate; Cartesian tensors, kinematics, mass conservation, vorticity, Navier-Stokes equation; topics from inviscid and viscous fluid flow, gas dynamics, sound waves, water waves.
The dynamics underlying the circulation of the atmosphere and oceans are detailed using key concepts such as geostrophy, the deformation radius and the conservation of potential vorticity. The role of Rossby waves, shelf waves, turbulent boundary layers and stratification is discussed. The atmosphere-ocean system as a global heat engine for climate variability is examined using models for buoyant forcing, quasi-geostrophy and baroclinic instability.

Course Aims:
The course aims to provide a solid foundation for the analysis of geophysical flows that arise in the study of the ocean, the atmosphere, and their interactions in the climate system. This course introduces the equations of motion and conservation laws that govern the fluid dynamics of the atmosphere and the ocean. These equations are then systematically simplified and solved to quantitatively model key phenomena selected from the enormously rich variety of atmospheric and oceanic flows. Emphasis is on large-scale phenomena important in the global climate system and on physically relevant approximations.
Student Learning Outcomes.
By the end of this course you will be able to:

- Model and describe common dynamical processes in the ocean and atmosphere using appropriately approximated dynamical equations and their solutions.
- Communicate discipline specific information in a written form with appropriate referencing.

4 Rationale and Strategies Underpinning the Course

Lectures are used to deliver the bulk of the content of the course and tutorials include the opportunity for guided problem solving. We believe that effective learning is best supported by a climate of inquiry in which students are actively engaged in the learning process. Hence this course is structured with a strong emphasis on problem-solving tasks in lectures, tutorials, and assessments. Students are expected to devote the majority of their study time to the solving of such tasks. New ideas and skills are first introduced in the lectures, and then students develop these skills by applying them to specific tasks in tutorials and assessments. This course has a major focus on research, inquiry and analytical thinking as well as information literacy. An exam tests the ability of the students to integrate and apply the facts, concepts, and theory discussed in lectures.
5 Assessment

The course grade will be assigned based on the assessments detailed in the tables below. The assessment of the assignments is based on the written worked solutions that the student submits according to the timetable below. The exam will cover the content of the lectures/tutorials and assigned work. 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 the final answer.

5.1 Assessment Timetable

Note that the 3rd-year component, MATH3261, and the graduate component, MATH5285, have different assessments: MATH5285 has an additional assignment and the weighting of assignments and exam is different.

<table>
<thead>
<tr>
<th>Assessment 3261</th>
<th>Weight</th>
<th>Release Date</th>
<th>Due Date</th>
</tr>
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<tbody>
<tr>
<td>Assignment 1</td>
<td>15%</td>
<td>Tue., Aug. 7</td>
<td>Thur., Aug. 23</td>
</tr>
<tr>
<td>Assignment 2</td>
<td>15%</td>
<td>Tue., Aug. 28</td>
<td>Thur., Sep. 20</td>
</tr>
<tr>
<td>Assignment 3</td>
<td>15%</td>
<td>Tue., Sep. 25</td>
<td>Thur., Oct. 11</td>
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<tr>
<td>3-hour Final Exam</td>
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<table>
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<th>Weight</th>
<th>Release Date</th>
<th>Due Date</th>
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<tbody>
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<td>Assignment 1</td>
<td>12%</td>
<td>Tue., Aug. 7</td>
<td>Thur., Aug. 23</td>
</tr>
<tr>
<td>Assignment 2</td>
<td>12%</td>
<td>Tue., Aug. 28</td>
<td>Thur., Sep. 20</td>
</tr>
<tr>
<td>Assignment 3</td>
<td>12%</td>
<td>Tue., Sep. 25</td>
<td>Thur., Oct. 11</td>
</tr>
<tr>
<td>Assignment 4</td>
<td>12%</td>
<td>Tue., Oct. 2</td>
<td>Thur., Oct. 18</td>
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<tr>
<td>3-hour Final Exam</td>
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</tr>
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</table>

These release dates are tentative; the assignments are due two weeks after the release date on the Thursday. All assignments must be submitted to the School Office by 12 noon on the due date. Assignments handed in late will incur a 10% reduction in the mark per day. Assignments handed in more than 7 days late will not receive a mark.
6 Course Schedule

There will be three hours of lectures (Tue., 9:00-11:00 and Fri., 11:00-12:00) per week followed by a one-hour tutorial the following week (Fri., 12:00-13:00). (See also item 1 of this outline.) All lectures and tutorials are scheduled to take place in room RC 4082. You will also have to do work outside class contact hours on practice problems and assessed assignments.

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

6.1 Course Syllabus

The following list is an approximate guide to the topics covered in this course. The course content is ultimately defined by the material covered in the lectures.

- **Basic concepts and mathematics of fluid mechanics**
  Material and field representations, Navier-Stokes equation, conservation laws, equations of state, non-dimensionalization and scaling

- **Effects of rotation and stratification**
  Equations of motion in a rotating reference frame, pressure coordinates, hydrostatic balance, geostrophic balance, thermal-wind balance, Boussinesq approximation, static stability and gravity waves, Ekman layers

- **Shallow-water systems**
  Potential vorticity conservation, Poincaré and Kelvin waves, geostrophic adjustment, available potential energy

- **Vorticity and potential vorticity**
  Vorticity dynamics, circulation theorem, PV conservation

- **Approximations and simplifications for the ocean and atmosphere**
  Planetary-geostrophic and quasi-geostrophic equations, Rossby waves

- **General circulation of the ocean**
  Observations, wind-driven circulation, Sverdrup balance, overturning circulation, Stommel-Arons model

- **General circulation of the atmosphere**
  Observations, overturning circulations, jets, baroclinic instability
7 Resources for Students

7.1 Recommended Reading

- G. K. Vallis
  Excellent somewhat encyclopedic text on geophysical fluid dynamics.

- J. Marshall and R. A. Plumb
  Excellent mid-level text.

- P. K. Kundu, I. M. Cohen and D. R. Dowling
  Very good text on the fundamentals of fluid mechanics.

8 Other Matters

8.1 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, UNSW’s Course and Teaching Evaluation and Improvement (CATEI) Process.

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

8.2 Additional Assessment

For information about Additional Assessments and other Administrative matters relating to your course please consult the School of Mathematics and Statistics web page at


8.3 Plagiarism

Plagiarism is the presentation of the thoughts or work of another as one’s own. Issues you must be aware of regarding plagiarism and the university’s policies on academic honesty and plagiarism can be found at

http://www.maths.unsw.edu.au/students/current/policies/Plagiarism_statement.pdf