Faculty of Science
School of Mathematics and Statistics

MATH2111

HIGHER SEVERAL VARIABLE CALCULUS

2013
MATH2111 – Course Outline

Information about the course

Course Authority: Dr William McLean

Lecturers: Dr Jonathan Kress RC–4102 j.kress@unsw.edu.au
Dr William McLean RC–2085 w.mclean@unsw.edu.au.

Dr Kress will lecture weeks 1–5 and week 12 and Dr McLean will lecture weeks 6-11.

Consultation: Consultation times will be arranged in week 2 and announced in lectures and on Moodle.

Credit: 6 Units of Credit (6UOC).

Prerequisites: MATH1231 or MATH1241 or MATH1251 each with a mark of at least 70.

Exclusions: MATH2019, MATH2049, MATH2069, MATH2100, MATH2110. MATH2011, MATH2039, MATH2510, MATH2610

Lectures: The lecture times as stated on myUNSW are:

- Monday 1pm–2pm Electrical Engineering G24
- Tuesday 4pm–5pm Biomedical Theatre C
- Thursday 1pm–2pm Old Main Building 149
- Friday 9am–10am Old Main Building 149

The locations are subject to change. Two of this semester’s lectures fall on public holidays and so an additional 1 or 2 lectures may be scheduled in week 13. Details will be announced towards the end of the semester.

Tutorials: The Monday tutorials will begin in week 2 and the Thursday tutorials will begin in week 1. This is to compensate for Thursday tutorial that will be missed due to the ANZAC day public holoday in week 7. There may need to be some rearrangement of tutorial times and groups. Tutorial problem sheets will be posted on Moodle. You should attempt the problems before attending your tutorial.

About this course

This 6UOC course is the Higher Version of the core second year mathematics topic, Several Variable Calculus. Either this course or its ordinary level version MATH2011 is required for completion of a mathematics major. It also forms a compulsory or recommended
component of several other programs. MATH2111 is highly recommended for students intending to proceed to Honours.

Course Aims
The aim of this course is to deepen your understanding of the ideas and techniques of integral and differential calculus for functions of several variables. These ideas and techniques are crucial to mechanics, dynamics, electromagnetism, fluid flow and many other areas of pure and applied mathematics. The course combines and extends ideas from one variable calculus and linear algebra to establish the calculus of vector–valued functions: from differentiation through multiple integration to integration over curves and surfaces and the classical Stokes’ and Divergence Theorems. The emphasis is on understanding fundamental concepts, developing spatial understanding and acquiring the ability to solve concrete problems.

Higher or Ordinary?
Formally, entry to MATH2111 requires a mark of 70 in first year. Past experience indicates that students who have not achieved this grade struggle with the course. MATH2111 contains a significant amount of extra, theoretical, material compared to MATH2011. Apart from the extra understanding that this brings, the reward for this is that the examination marks are scaled to make sure that the grades are comparable. Many more Distinctions and High Distinctions are awarded in MATH2111 than in MATH2011. The pass rate in MATH2111 is traditionally very high (as it should be with the quality of students in the course). Gaining a high mark in MATH2111 requires that a student understands a reasonable amount of this extra material. Passing requires (as it does in MATH2011) that the student can at least do the most important computational parts of the course.

Student Learning Outcomes

Students taking this course will

- develop an understanding of the main ideas of calculus in higher dimensions,
- develop proficiency in performing computations arising in higher dimensional calculus,
- become acquainted with the central concepts of mathematical analysis, and of classical applied mathematics that will be used in later years.

Through regularly attending lectures and applying themselves in tutorial exercises, students will develop competency in mathematical presentation, written and verbal skills.

Relation to graduate attributes
The above outcomes are related to the development of the Science Faculty Graduate Attributes, in particular: 1. Research, inquiry and analytical thinking abilities, 4. Communication.
Teaching strategies underpinning the course

New ideas and skills are introduced and demonstrated in lectures, then students develop these skills by applying them to specific tasks in tutorials and assessments.

Rationale for learning and teaching strategies
We believe that effective learning is best supported by a climate of enquiry, in which students are actively engaged in the learning process. To ensure effective learning, students should participate in class as outlined below.

We believe that effective learning is achieved when students attend all classes, have prepared effectively for classes by reading through previous lecture notes, in the case of lectures, and, in the case of tutorials, by having made a serious attempt at doing for themselves the tutorial problems prior to the tutorials.

Furthermore, lectures should be viewed by the student as an opportunity to learn, rather than just copy down lecture notes. Effective learning is achieved when students have a genuine interest in the subject and make a serious effort to master the basic material.

The art of logically setting out mathematics is best learned by watching an expert and paying particular attention to detail. This skill is best learned by regularly attending classes.

Assessment

<table>
<thead>
<tr>
<th>Assessment</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Writing Assignment</td>
<td>5%</td>
</tr>
<tr>
<td>Class Test 1 (week 5)</td>
<td>15%</td>
</tr>
<tr>
<td>Class Test 2 (week 10)</td>
<td>15%</td>
</tr>
<tr>
<td>Final Examination</td>
<td>65%</td>
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</tbody>
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Writing Assignment

The first assessment task will be a writing assignment. The aim of this task is to develop your ability to present your mathematics in a professional way, paying attention to neatness, grammar, clarity of argument, use of notation and so forth. Work that is not up to standard will be returned for resubmission — repeatedly if necessary! You should start work on this assignment as soon as possible, since your mark for this task will depend on the number of weeks that you take to produce an acceptable submission.

The writing assignment will incorporate a peer review process that will be administered using Moodle. Further details of what is expected, including submission dates for the peer review and final submissions, will be announced in lectures and on Moodle.
Tests

The class tests are designed to give you a chance to assess your mastery of the course material, including both the theoretical and computational aspects of the course.

Each of the 2 class tests will last about 40 minutes. They will NOT take place in tutorials. They will be held in the lecture theatre during the Tuesday lecture in weeks 5 and 10. Announcements will be made in lectures about the topics that will be covered in each of the tests.

You must bring your STUDENT ID card to each test.

Normal exam conditions apply in tests. In particular, you must not bring any kind of written material into the test and you must not try to get assistance from or give assistance to any other person.

You will need to provide your own writing paper for the test.

You will NOT be allowed to use a calculator in class tests.

If illness (or some other circumstance beyond your control) affects your attendance at or performance in a class test do NOT make an official application for Special Consideration, just show a medical certificate (or other appropriate documentation) to the lecturer in charge. If this documentation is accepted, your final mark will be calculated using an increased weighting for the remaining assessment tasks.

You should keep all marked tests until the end of semester in case an error has been made in recording the marks. Your marks will be available online, and you should check these well before the end of semester.

Final exam

The final exam is the major assessment task. Its purpose is to determine the level of student mastery of both the theoretical and computational course material. The duration of the final exam will be two hours.

If your attendance at, or performance in, the final exam is affected by circumstances beyond your control, you may be able to apply for special consideration. See the ”Administrative Matters” section for further information. You should read this information NOW so that you are aware of the rules and procedures for additional assessment.

Calculator Information

For end of semester UNSW exams student must supply their own calculator. Only calculators on the UNSW list of approved calculators may be used in the end of semester
exams. This list is similar to the list of calculators approved for HSC examinations.

BEFORE the exam period calculators must be given a UNSW approved calculator sticker, obtainable from the School of Mathematics and Statistics Office, and other student or Faculty centres.

The UNSW list of calculators approved for use in end of semester exams is available at


Resources for students

Moodle

This course will use Moodle rather than UNSW Blackboard. Use your zID and zPass to log in to Moodle at the following URL.

http://moodle.telt.unsw.edu.au

Texts

The text for the course is Vector Calculus (Fifth Edition, 2003) by Marsden and Tromba and published by W. H. Freeman and Company, New York. In particular, there is a webpage to complement the book where you will find further resources, http://bc.s.wfreheman.com/marsdenvc5e/.

For the more abstract material you should consult more widely. Recommended texts are

- Williamson, Crowell and Trotter, Calculus of Vector Functions, P517.5/23.

The first year text Calculus by Salas, Hille and Etgen published by Wiley (any recent edition) has material relevant to much of this course.

Lecture Notes. Lecture notes will be provided as a PDFs on Moodle. The Moodle site will also contain a significant amount of additional material that may be of use to students. These web notes should be thought of as an alternative source of information rather than as a description of what will be covered in the lectures this year.

Problem sets. The tutorial exercises will be provided as PDFs on Moodle.

Sample exams. Moodle will contain a number of sample exams.
Videos

Some videos of the weeks 1 to 6 lectures in 2011 are available on UNSW TV. Most of this is very similar to this year’s lectures. To view these videos go to [http://tv.unsw.edu.au](http://tv.unsw.edu.au) and search for math2111. You will need to log in with your zPass to view the videos. If you have trouble logging in, try resetting your zPass with the UNSW Identity Manager [http://idm.unsw.edu.au](http://idm.unsw.edu.au).

Course Evaluation and Development

The School of Mathematics and Statistics evaluates each course each time it is run. We carefully consider the student responses and their implications for course development. Feedback is very important to us, so please don’t leave it to the end of the course to pass on any ideas.

Administrative matters

Important information on

- Additional Assessment
- School Rules and Regulations
- Plagiarism and academic honesty

can be found on the School’s website at


Please carefully read this page and the documents two which it links.

Syllabus

The references shown against each topic are to the textbook by Marsden and Tromba [MT] and the two addition texts listed above, Morgan [M] and Williamson, Crowell and Trotter [WCT].

These references are not a definition of what is covered in this course — they are just a guide to finding relevant material. Some parts of the course are not covered in the references and many parts of the references (even in the sections mentioned below) are not included in this course.
1. Curves and Surfaces in $\mathbb{R}^n$ [MT, Sections 2.4, 7.3]

Curves in $\mathbb{R}^n$.
Surfaces in $\mathbb{R}^n$.

2. Introduction to Analysis and Topology in $\mathbb{R}^n$
[Web notes; M, Parts I and II; MT, Section 2.2]

Topology of $\mathbb{R}^n$.
Limits and continuity for functions $\mathbb{R}^m$ to $\mathbb{R}^n$.
Compact and connected sets
Images of compact and connected sets

3. Differential Calculus [MT, Sections 2.3, 2.5, 2.6, 3.2–3.5]

Partial derivatives.
Differentiability.
The Chain Rule
Scalar fields
  Directional derivatives and the gradient
  Normals and tangents
  Taylor’s Theorem, higher order differentials
  Maxima and minima, Lagrange multipliers
Solubility of systems of non-linear equations
  The Inverse and Implicit Function Theorems

4. Integral Calculus [MT, Sections 5.1–5.5, 6.2]

Double and triple integrals
Iterated integrals and Fubini’s Theorem
Differentiation under the integral sign
Change of variables
Integrals in polar, cylindrical and spherical coordinates

5. Dot and Cross Products [MT, Sections 1.2, 1.3]

Examples
Summation convention
Dot and cross products
Scalar and vector triple products
6. Path Integrals [MT, Sections 4.2, 7.1, 7.2]

- Path integral of a scalar field
- Path integral of a vector field
- Work and energy
- Properties of path integrals

7. Surface Integrals [MT, Sections 7.3–7.6]

- Parametric surface
- Surface integral of a scalar field
- Orientation of a surface
- Surface integral of a vector field


- Gradient
- Curl
- Divergence
- Two key identities

9. Vector Integral Theorems [MT, Sections 8.1–8.5]

- Two concepts of boundary
- Green’s theorem
- Stokes’ theorem
- Divergence theorem
- Applications of the integral theorems

10. Orthogonal Curvilinear Coordinates [MT, Sections 8.2, 8.4]

- General curvilinear coordinates
- Scale factors
- Path and surface integrals
- Grad, curl, divergence
- Laplacian

11. Fourier Series [WCT, Sections 5.5–5.8; M, Sections 7, 22, 28]
Inner products of functions
Function norms and metrics
Piecewise-continuous functions
Fourier coefficients
Piecewise-differentiable functions
Pointwise convergence
General periodic functions
Uniform convergence
Mean-square convergence
Applications to partial differential equations