Never Stand Still | Science | School of Mathematics and Statistics

COURSE OUTLINE

MATH2621

HIGHER COMPLEX ANALYSIS

Semester 2, 2016

MATH2621 – Course Outline

Information about the course

Course Authority and Lecturer: Professor Michael Cowling

Contact details: room: RC-5113, email: `m.cowling@unsw.edu.au`.

Consultation: Tuesday mornings from 11.00 to 12.30, and Thursday mornings from 10.30 until 12.00, in RC-5113. If these times are unsuitable, please contact the lecturer before or after lectures or by email, to arrange an appointment.

Credit, Prerequisites, Exclusions:

This course counts for 6 Units of Credit (6UOC).

The formal prerequisite for this course is a mark of at least 70 in MATH1231 or MATH1241 or MATH1251. Material in these courses is assumed knowledge. A "Lecture 0" summarising relevant material has been placed on the UNSW Moodle web-site; this should be read before the first lecture.

MATH2621 is an expanded version of the old 3 UOC course MATH2620 Higher Complex Analysis, which last ran in 2013. There is a ordinary equivalent of this course, MATH2521 Complex Analysis, also a 6 UOC course, which replaces the previous 3 UOC course MATH2520 Complex Analysis.

Exclusions: MATH2069, MATH2520, MATH2521, MATH2620

Lectures: There will be three lectures per week for the first twelve weeks of the session. Here is the timetable.

Tuesday	9–10	Old Main Building OMB-G32
Tuesday	10–11	Old Main Building OMB-G32
Thursday	12–1	Red Centre Theatre RC-G001

Tutorials: There will be one tutorial per week from Week 2 to Week 13. Possible tutorial times are Thursday 1–2 and Friday 11-12. You may try and alter your tutorial times yourself via `myUNSW` up to the end of week 1. Attendance at tutorials will be recorded.

No tutorials will be lost to Public Holidays this semester.

Syllabus and Course Schedule: A Syllabus and Course schedule is located at the end of this handout.

On-line information: Further information, lecture notes, tutorial problems, and other material will be provided via the UNSW Moodle web-site for MATH2621, which may be accessed at
`http://moodle.telt.unsw.edu.au`,

or by following the UNSW Moodle links on the School of Mathematics and Statistics web-pages at
`http://www.maths.unsw.edu.au`.

Course aims

This course aims to extend our understanding of differential and integral calculus from functions of one real variable to functions of one complex variable. The differences between the two are often surprising. The theory of complex functions gives us many new insights into the real variable theory, such as why integration of rational functions sometimes gives logarithms and sometimes inverse trigonometric functions, as well as the ability to perform entirely new calculations. One feature of the higher version of Complex Analysis is that it is an introduction to Pure Mathematics, and students will be expected to deal with some of the theoretical aspects of the subject as well as perform computations.

Relation to other mathematics courses

Pure mathematics may be divided into the broad categories of analysis (calculus), algebra, geometry and logic. This subject fits into the analysis category and follows on from material learnt in first year algebra and calculus. This course is part of the compulsory core aimed at those majoring in Mathematics.

It is worthwhile to try to explain the similarities and differences with MATH2521 Complex Analysis. First and foremost, in MATH2621, the higher version of the course, more emphasis is placed on theory—appropriate use of definitions, statements of theorems, and proofs—leading to a different kind of understanding of the material. Some students find this very challenging, and prefer to learn formulae and apply them to solving problems; they are advised to take MATH2521 Complex Analysis. Others find the theory interesting and (on occasion) easier than the exercises; such students should take MATH2621 Higher Complex Analysis.

A secondary difference is that in MATH2621, we assume a greater degree of familiarity with first year material, especially on complex numbers, and spend less time doing easier problems and more time on harder problems. Students who are very comfortable with the easier problems will find that the greater exposure to harder problems during the teaching session is helpful with the harder problems on the final examination paper; students who are having difficulties with the easier problems during the teaching session should probably take MATH2521 to concentrate on these in order to be sure of passing the course.

Student Learning Outcomes

Students taking this course will gain an understanding of the basic theory of functions of a complex variable. They will:

- understand the main properties and examples of analytic functions;
- be able to compute and manipulate series expansions for analytic functions;
- know and be able to use the major integral theorems;
- be able to identify and classify zeros and poles of functions and find their residues;
- be able to calculate certain real improper and trigonometric integrals using complex analytic methods;
- be able to compute some Laplace transforms and know how to apply these to solve ordinary differential equations;
- understand how conformal mappings make it possible to solve partial differential equations;
- understand the relationship between complex function theory and the theory of functions of a real variable.

Moreover, they will improve their general mathematical and problem-solving skills, and their ability to communicate a logical argument.

New ideas and techniques will be introduced in lectures and then applied to specific tasks in tutorials. Effective learning is achieved and these outcomes are attained when students attend all classes, prepare for classes by reading through the lecture notes before the lectures, make a serious attempt at doing the tutorial problems before the tutorials, and engage actively with lectures and tutorials by asking and replying to questions.

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,
6. Information literacy

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. Assessment in this course will use problem-solving tasks of a similar form to those practiced in tutorials, to encourage the development of the core analytical and calculation skills underpinning this course. In the marking of class tests, students will also be evaluated and given feedback on their communication skills, which will also be important in the final examination.

Rationale for learning and teaching strategies

Experience suggests that effective learning is best supported by active engagement in the learning process. Hence this course is structured with an emphasis on problem-solving tasks in tutorials and in assessment tasks, and students are expected to devote a large part of their study time to problem-solving.

The art of logically setting out a mathematical argument is best learned by watching an expert and paying attention to detail.

Success in this course is achieved by regularly attending classes, completing all assessment tasks, and looking carefully at the feedback.

Assessment

UNSW assesses students under a standards-based assessment policy. For how this policy is applied in the School of Mathematics and Statistics, see
`http://www.maths.unsw.edu.au/currentstudents/assessment-policies`.

Assessment in this course rewards students for working consistently at the tutorial problems throughout the session. It encourages the development of analytical thinking and the ability to understand and solve problems and to express mathematics clearly in written form.

Final mark: The final mark in MATH2621 is an aggregate mark based on:

- three short (25 minute) class tests, to be held in the tutorials in weeks 5, 8 and 11, each worth 10%,
- the final two hour examination (70%) covering all of the course.

Aspects of assessment in MATH2621 will be organised in conjunction with the ordinary version of this course, MATH2521 Complex Analysis, and will reflect the greater difficulty of the higher course. The presentation of material in MATH2621 will put more emphasis on harder questions, and students who have difficulty with easier questions are strongly advised to take MATH2521, where they will find more support appropriate to their mathematical level.

Knowledge and abilities assessed: All assessment tasks will assess the learning outcomes outlined above, specifically, the acquisition of relevant knowledge, the ability to present logical and coherent mathematical arguments and to solve mathematical problems by choosing appropriate methods and applying them accurately.

Assessment criteria: The main criteria for marking all assessment tasks will be *clear and logical presentation of mathematically correct solutions*; creativity will also be valued.

Class Tests

Rationale: The class tests allow students to evaluate their mastery of the course material and to prepare for the final examination. They are especially useful for students who are not familiar with the evaluation criteria adopted in the School of Mathematics and Statistics.

Sample Tests will appear on the UNSW Moodle web-pages for MATH2521 about one week prior to the test. Students may bring their own nonprogrammable hand-held scientific calculator to the tests. Calculators will not be necessary, and will not be provided.

Class Test Schedule: These will be held in tutorials in weeks 5, 8 and 11.

Weighting: Each class test will count for 10% of the final mark. Students who miss a class test will be given a mark of 0 unless they provide a medical certificate (or other appropriate reason) for their absence. When a medical certificate is provided, the remaining class tests will still count for 10% of the final mark, but the weighting of the examination will increase by 10% for each missed class test.

Examination

Duration: Two hours.

Rationale: The final examination will assess mastery of the material covered in the lectures, and the ability to extend it to solve new problems.

Weighting: 70% of the final mark, unless class tests have been missed, as explained above.

The final examination will take place in the examination period, which is normally in November. Additional assessment is usually held just after the examination period, in late November or early December. More details will be provided when these are available. Students who plan overseas trips before the additional assessment increase their chances of failing the course.

The UNSW library has past examination papers for MATH2620, but these do not cover the whole syllabus of MATH2621. Past exam papers for MATH2621 will be placed on the UNSW Moodle web-site.

Additional resources and support

Tutorial Exercises

A set of tutorial exercises will be made available through the UNSW Moodle web-site. These problems are to enhance mastery of the course. Some of these problems will require computation, and some will require some theoretical knowledge.

Some of the problems will be done in tutorials, but students will learn a lot more and be better prepared for the final examination if they try to do them before the tutorial.

Worked solutions for all problems are not provided, though numerical answers to some problems with numerical solutions will be. Students can find out whether their solutions are correct by attending tutorials.

Textbooks

The textbook for this course is J.W. Brown and R.V. Churchill, *Complex Variables and Applications*; McGraw Hill, 2008. New copies are expensive, but second-hand copies may be available. Acquiring a copy is not compulsory. This and other textbooks on the same subject are available in the University Library.

The course content is defined by the material presented in lectures, not by the textbook.

Lecture notes

Incomplete lecture notes will be provided through the web-site on Moodle. These contain spaces for solutions of problems, parts of proofs, comments, and so on. Students are advised to print these out and read them before lectures, and attempt to fill in the blanks during and after lectures. Attending lectures is essential in order to fill in all the gaps.

Moodle

All course materials and handouts will be available on Moodle. These will be revised, to reflect, for example, any major changes in the lecture timetable. Students should check regularly for new and updated material.

Maple

The course has no formal MAPLE component. However, students may find MAPLE useful for visualisation, and for checking calculations, for instance, using the `series` and `residues` commands to check Taylor and Laurent series and residues. All students enrolled in Mathematics courses have access to MAPLE through UNSW. The lecturer can provide for more information if requested.

Course Evaluation and Development

The School of Mathematics and Statistics evaluates each course each time it is run. We carefully consider student responses and their implications for course development. It is common practice to discuss informally with students in the course how the course and their mastery of it are progressing. Especially with a new course, feedback is highly valued in order to improve the course for future years.

Administrative matters

Additional Assessment

See the handout **Important Information for Undergraduate Students**, which may be found on the School of Mathematics and Statistics Web page at `http://www.maths.unsw.edu.au/currentstudents/additional-assessment.` Please read this document carefully. Students have failed this and other higher year courses because they did not understand these rules. In particular note the last section on Concessional Additional Assessment. Any student in second or later year mathematics courses who receives a preliminary final mark—which includes the exam mark—in the range 40–49 is automatically entitled to take the Additional Assessment exam and have a second chance at passing the course. The maximum final mark after Concessional Additional Assessment is 50.

As already stated, the preliminary final mark includes the exam mark. The class tests amount to only 30% of the final mark, so even with full marks in all of these, a student who misses the final exam and does not put in a request for Special Consideration with a medical certificate for illness (or other appropriate reason) is not eligible for additional assessment and will fail the course.

Students who miss the final exam due to illness or misadventure must ask for special consideration and submit supporting documents such as a medical certificate through UNSW Student Central. If this excuse is acceptable and pre-exam assessment is at least 40% and tutorial attendance at least 70% then normal additional assessment will be granted. It is up to each student to find out where and when the additional exams are held. See Section 7 of the document.

School Rules and Regulations

Fuller details of the general rules regarding attendance, release of marks, special consideration etc are available via the School of Mathematics and Statistics Web page at
`http://www.maths.unsw.edu.au/students/current/policies/studentpolicy.html`.

Plagiarism and academic honesty

Plagiarism is the presentation of the thoughts or work of another as one's own. Issues to be aware of regarding plagiarism and the university's policies on academic honesty and plagiarism may be found at
`http://www.lc.unsw.edu.au/plagiarism`
and
`http://www.lc.unsw.edu.au/plagiarism/plagiarism_STUDENTBOOK.pdf`.

Detailed course schedule

Here is a rough guide to the proposed teaching schedule. Because this is a new course, we reserve the right to modify the following schedule somewhat if circumstances require it. Major variations from this schedule will be indicated by the lecturer and posted on the course Moodle web-site.

Some parts of the notes are not in the text, such as the links with several variable calculus at various points and the discussion of the Fourier transformation in Week 10.

Week	Topic	Sections in text
1	Revision, basic topology, complex functions	1–14
2	Limits, continuity, and differentiation; Cauchy–Riemann equations	15–23
3	Power series; analytic and harmonic functions	55–56, 24–27
4	Exponentials, logarithms, roots, and related functions	29–36
5	Contour integrals; antiderivatives; the Cauchy–Goursat theorem	37–46
6	The Cauchy integral formula; Morera's theorem	47–53
7	Taylor and Laurent series; singularities	57–68, 72–77
8	Residues, and evaluating integrals	69–71, 78–85
9	Winding number, Rouché's theorem, and consequences	86–87
10	The Fourier and Laplace transformations	88–89
11	The Dirichlet problem	90–106
12	Various, including review	