MATH3084/MATH6162

Integral Transform Methods, 2022/23

Module information sheet

Overview

MATH3084 is an optional third year module for engineers and mathematicians. The prerequisite is one of MATH2038, MATH2047, MATH2048 or MATH2015. Mathematicians should find some of the material on complex analysis familiar while engineers will have more prior knowledge of some of the material on Fourier and Laplace transforms. MATH6162 is a code share for 4th-year MMath students only.

Aims and Course Synopsis

The aim of this module is to provide a systematic treatment of integral transforms and their applications in applied mathematics and engineering. Many classes of problems are difficult to solve in their original domain. An integral transform maps the problem from its original domain into a new domain in which it can more easily be solved. The solution can then be mapped back to the original domain with the inverse integral transform.

In the first half of the course we will study complex variable theory and learn how to evaluate almost any definite integral over the real line or half-line, using the method of residues.

In the second half we will discuss the theory of infinite integral transforms includind Fourier, sine and cosine, Laplace and Hankel transforms. We will learn how to use them in solving PDEs in two variables by transforming them into ODEs in one variable. This second part of the course relies crucially on the techniques and ideas developed in the first part.

As an important application of Laplace transforms, we will use Nyquist theory to determine the stability of systems described by ODEs.

Lecturer

Professor Carsten Gundlach, c.j.gundlach@soton.ac.uk.

Teaching materials

The module will be delivered through **30 pre-recorded lectures** (pen capture and voiceover) in the first 10 teaching weeks. You will find those lectures on the "Recorded Sessions" tab on Blackboard.

There are **30 homework problems**. Each of these is designed to reenforce what you have just learned in the lecture of the same number, and so you should attempt it right after that lecture. The homework problems will require both time and original thought, and are an integral part of the teaching.

You will be given full **printed lecture notes**. These were written by me in 1999/2000 and expanded by David Schley in 2005/06. Since 2021/22, I have re-ordered them and added a few short sections to follow the current pre-recorded lectures more closely. Please point out any errors, or make requests for any gaps to be filled.

The **lecture plan** tells you which parts of the printed notes are covered in each lecture.

This **module information sheet** tells you exactly how the module is taught and assessed.

Note that the MATH6162 Blackboard site will remain empty. All materials are on the MATH3084 site.

Assessment

If you have already taken MATH3084, you cannot take MATH6162. Both modules have the same syllabus and homework problems, but the MATH6162 coursework and exam will have some harder questions.

20% of the final mark is from self-marking 30 homework questions, submitted and self-marked in 10 weekly chunks. These marks are for engaging with the material, see below for details.

20% of the final mark is for two pieces of coursework, one on complex variables due at the end of Week 7, **Friday 17 March 2023, 23.59h**, and one on integral transforms due at the end of Week 11, **Friday 12 May 2023, 23.59h**. The usual late penalty applies: 10% per working day, down to 50%.

60% of the final mark is from the final exam. Questions will be roughly similar to previous years. All material in the pre-recorded lectures and printed notes is examinable except where announced. On Blackboard you will find previous exams with model answers.

Teaching methods

Teaching is via pre-recorded lectures, plus 4 in-person sessions in all 12 teaching weeks. There is one **tutorial** to go with each pre-recorded lecture, so three per week, and there is one **problem class** each Friday.

Please **watch each lecture before attending the corresponding tutorial.** A good plan, if you can fit it in, is to watch it on the same day. If taking notes in in-person lectures has helped you in the past, you should try doing this also in recorded lectures. You will probably need to stop or rewind the recording to take notes, think something through, or check a calculation. (It is easier to see when I need to pause in a lecture when I have a live audience.)

At the beginning of each **tutorial** I will summarise the lecture material, and take questions. You then work on the homework problem for that lecture, and that may bring up further questions. I will record those parts of the tutorial where I speak to the whole class.

Self-marking

To encourage you to engage with the course, and in particular with the homework problems, day by day, we will use self-marking. **The plan for the problem classes** on Fridays is that I go over the three homework problems in that week, and that you mark your own work during the session. You are still encouraged to ask questions! You should normally be able to self-mark your work during the problem class. If you had serious problems or errors, it may be more instructive to work that part of the problem again in your own time after the tutorial, and attach it to your original solution.

You will get 0, 1 or 2 marks per week. These are not for the correctness of your work, but for engaging with the material: **You will get the first mark for submitting a reasonable effort at a solution, and the second mark for accurate self-marking**. This means finding where you went wrong, and explaining to yourself what you should have done.

If you have not submitted something before the problem class, you can still get a single mark for submitting a correct complete solution by the self-marking deadline. The idea behind this is that you will learn something by attending the problem class and taking notes, although not as much as if you first try on your own. A model answer will then be released after the self-marking deadline, to assist with revision.

How to submit weekly homework, self-marking and coursework

Each Friday you will be asked to submit a scan of your handwritten solutions for the three homework questions of that week, mark them on paper using a red pen during the problem class, and submit a scan of your marked homework again. You must mark and resubmit the pages you originally submitted. If necessary, insert or add extra pages. (The idea is that you find and correct any errors in your own work, rather than just copy out the correct answers.)

You must submit a scan of your work as a single PDF file, containing all pages the right way

up and in the right order. On Blackboard there is a document written by James Vickers explaining how to do this on an Android phone. If you have a computer scanner or iphone, you probably know what to do. If you repeatedly submit scans that are hard to read I will subtract marks.

You submit on the Assignments tab of the Bb pages. Only the relevant upload points will be visible at any time.

Weekly workplan

In Week 0: Familiarise yourself with the structure of the course and the lecture notes, watch Lecture 1 (if you do not have time to do it on Monday morning).

In Week 1:

Monday	Watch L1, read corresponding sections in the notes
	Attend T1 and attempt H1
Tuesday	Watch L2, read corresponding sections in the notes
	Attend T2 and attempt H2
Thursday	Watch L3, read corresponding sections in the notes
	Attend T3 and attempt H3
	Scan and submit your solutions to H1-3 by the beginning of problem class, **Friday 10.00**
Friday	Attend PC1, self-mark your homework
	Scan and submit your self-marked solutions to H1-3 by **Friday 23.59**

Weeks 2-10 continue in the same way. **Weeks 11-12** are for revision: all 4 sessions in those weeks will be tutorials.

Getting help

Please ask questions in the online tutorials and problem classes! In Tn we will focus on your questions about Ln and solving Hn, and in the problem class we focus on self-marking, but there is always time for additional questions.

If there is something you do not understand, it is very likely you are not the only one, so it makes sense to ask in class. However, if you want to talk to me alone, email me to make an appointment.

Suggested Reading

The lecture notes will cover all that you need so no book purchase is required. Any book whose title contains “complex variable theory” or “complex analysis” or “engineering mathematics” or ”mathematical methods for physics” is likely to cover the topics discussed in this module. Below is a list of suggested books (along with their location in the University Library).

1. H A Priestley, *An introduction to complex analysis*, Oxford UP [QA 331]
2. M R Spiegel, *Theory and problems of complex variables* (Schaum), McGraw Hill [QA 331]
3. R V Churchill and J W Brown, *Complex variables and applications*, McGraw Hill [QA 331]
4. C Wylie and L C Barrett, *Advanced engineering mathematics*, McGraw Hill [QA 100]
5. G Stephenson and P M Radmore, *Advanced mathematical methods for engineering and science students*, Cambridge UP [QA 100]
6. E Kreyszig, *Advanced engineering mathematics*, Wiley [TA 150]
7. M D Greenberg, *Advanced engineering mathematics,* Cambridge UP [QA 100]