

Course Description:

Ch 6 Functions of a Complex Variable I

I'll probably omit section 6.1 on the algebra of complex numbers and begin our discussion of functions of a complex variable with section 6.2. Roughly speaking, analytic functions are those functions that have derivatives. Series expansions of complex functions are developed.

Ch 7 Functions of a Complex Variable II

The ideas of the previous chapter are explored further. In particular, a useful method of integration is developed using ideas first found in expansions of functions of a complex variable.

Ch 8 Gamma Function

I'll do this chapter in two pieces. I'll begin with section 8.1 (Gamma Function or generalized factorial function) and 8.4 (Beta function) which we'll need to deal with the second solution of Bessel's equation. Later, I'd like us to look at look at 8.2 and 8.3 before we look at Probability. However, we may not have time to do this in class.

Ch 11 Bessel Functions

We have seen the first two sections of this chapter in math methods I but couldn't do the rest until we had seen some complex analysis. Section 11.3 looks at the second solution to Bessel's equation. Section 11.4 introduces linear combinations of the independent solutions that have interesting asymptotic properties. Bessel functions are modified in section 11.5. I don't propose to look at asymptotic expansions but will treat Spherical Bessel Functions in 11.7.

Ch 2 Curved Coordinates and Tensors

We will begin with rotations and develop Cartesian Tensors as a tool to deal with these transformations. We looked at the algebra of Cartesian Tensors in Math Methods I when we talked about 'index notation'. We can use this notation to talk about 'rotations' in general (also called 'coordinate transformations').

Ch 19 Probability

I'll say as much about this as time allows. I'd like to develop these ideas from the beginning. The sections at the end show how analysis of errors (in experimental data) arises.

Student Learning Objectives/Outcomes:

- Given a function of a complex variable, students will carry out operations that can lead to the evaluation of the integral of the function over a given contour.
- Given a relation between Cartesian coordinates and a new set of orthogonal coordinates, students will find unit (tangent) vectors for the new coordinates in terms of Cartesian unit vectors
- Given some experimental data, students will analyze it using ideas from Probability & Statistics to either fit the data to a curve or propagate error from the experimental data through to quantities calculated from it

At least 65% of students will get a grade of 65% or more in questions that assess these learning objectives.

More broadly, I hope that students will;

- increase their familiarity with a variety of mathematical techniques
- increase in confidence in setting-up a problem so that it can be solved mathematically

It is worth remembering that you will stop taking classes at some stage and focus all of your effort on research. By then, you will need to be able to suggest questions to yourself as the subject of your work. I don't expect you to come up with research questions during this course! I do expect that you begin to ask questions about the topic as you review/rewrite your lecture notes.¹ You might want to ask yourself some of the 'big picture' questions such as how a certain topic fits in with other things that you know; how the topic might be approached differently etc. You might want to ask me about such questions but I expect you to begin answering them yourself. In this spirit, we might add another aim of the course;

- Ability to consider open-ended questions.

Required & Suggested Textbooks and Materials:

This course uses questions similar to those in *Mathematical Methods for Physicists* (6th edition; 2005) by G. Arfken and H. Weber. This book is well-known and is comprehensive. The 'Additional Readings' at the end of every chapter are useful bibliographies. (The actual text of homework questions will be posted on WebCT.)

I liked the book *Mathematics for Physicists* by Susan Lea. It is a (smaller) textbook covering many areas of the course and seems very readable.

In my undergraduate class, I use *Mathematical Methods in the Physical Sciences* by Mary L. Boas. Like S. Lea. She covers much of the same ground that Arfken & Weber cover. While it is

¹ I hope that the reference to 'reviewing/rewriting your notes didn't surprise you. By 'reviewing' I don't mean just checking that you actually have notes, handouts etc. I mean working through the algebra (pencil in hand) and following up on any questions that either I mention or that you think are worth considering.

not (nominally) a graduate textbook, it is an excellent book to have. (By the way, the third edition came out in July 2005. That should mean that there are cheap second editions to be had...)

I require that you get/continue to use one of these. Personal taste is important to your choice. Do get a book soon!

Some students that have done this course liked “Mathematical Physics” by Sadri Hassani. I am less familiar with “Mathematical Methods of Physics” by J. Matthews and R. L. Walker but this book is frequently used for courses in math methods. “Modern Mathematical Methods for Physicists and Engineers” by C.D. Cantrell looks to be a very nice book.

Personally, I think that you should use as many useful sources as you can get your hands on. I do. There is always something right/wrong with every textbook. There is always some emphasis that you like/don't like. However, it is imperative that you **identify something that you can use** (at least for now) **and get down to work quickly**.

You should have a **scientific** calculator, pencil and pen at all meetings of the class and at all tests.

Assignments & Academic Calendar:

Homework in this class takes the form of doing sets of questions. Most of the question numbers below are from Arfken's book though a couple of questions are my own. I intend to send you an e-mail (on WebCT) on Tuesday evenings. This will have the numbers of questions whose answers are **due at the beginning of class on the **Thursday nine days later****. However, please don't wait for me to formally assign homework before you begin on the questions. ***As soon as we finish section 6.1, consider problem 6.1.23 to have been assigned etc.*** (You will usually be right!). The ***text of the homework questions is already on the WebCT site. The version of the questions on WebCT is the one that I want you to work on.***

A tentative list of homework questions follows. The questions that are assigned for homework are those posted on WebCT. Several changes from questions in the book have been made.

Section	Questions
6.1	23
6.2	3, 8, 12
6.3	4
6.4	5, Derivatives of Analytic functions
6.5	8
6.6	1
7.1	1[a b c d], 15, 19, 20
8.1	4, 11 (a)
8.3	[iff we do this section!] 6
8.4	6
11.3	1
11.4	2
11.5	1
11.7	19, 10Extra credit
2.4	1, 7, 11
2.5	1
2.6	Orthogonality relation in \mathbb{R}^2 .
2.7	3
2.8	1
2.9	3, 13
19.1	MacAlevey #4
19.2	7
19.3	MacAlevey #5, 3
19.4	3
19.5	1, 3
19.6	1, 2, 3

The TA will collect the homework that is due and return graded homework. I intend to post solutions on the WebCT site after the due date. **Late homework is not accepted after solutions to questions have been posted on the WebCT site.**

To use WebCT, you have to have a login ID/WebCT ID and password. The WebCT server is at <http://webct6utdallas.edu>. The solutions are protected with a password and can be opened with Acrobat 5 or later <http://www.adobe.com/products/acrobat/readstep2.html>. The password is **methods**. It is intended that the solutions get you 'on the right track' that you can follow to produce a complete solution. **If you have any hard-copy solutions to problems in Arfken's book, then I suggest that you destroy them.** Using solutions as a substitute for doing a problem yourself **almost guarantees poor performance on exams.**

You will also need to **check the preferences used by your browser** from the 'check browser' link on the first page that you get after log-into WebCT. (WebCT uses pop-ups intensively. Use your internet options to make the site a 'trusted site'.)

Tentative Schedule:

Date	Meeting	Aims
Tuesday Jan 13	1	6.1, 6.2
Thursday Jan 15	2	6.2 (Plus singularity from 6.6)
Tuesday Jan 20	3	6.3
Thursday Jan 22	4	6.4
Tuesday Jan 27	5	6.5, 7.1
Thursday Jan 29	6	7.1 continued
Tuesday Feb 3	7	7.2
Thursday Feb 5	8	7.2 continued
Tuesday Feb 10	9	7.2 continued
Thursday Feb 12	10	8.1 Gamma function
Tuesday Feb 17	11	8.4 Beta Function
Thursday Feb 19	12	11.3 Bessel Functions of the second kind (Neumann functions)
Tuesday Feb 23	13	11.4 (Hankel Functions)
Thursday Feb 26	14	Midterm I
Tuesday March 3	15	11.4 continued +Airy
Thursday March 5	16	11.7 (Spherical Bessel Functions)
Tuesday March 10	17	11.5 (Modified Bessel Functions)
Thursday March 12	18	2.4, 2.5 (Contravariant components [Basis of Tangents] & their relation to Physical components)
Tuesday March 17		<i>Spring Break!</i>
Thursday March 19		<i>Spring Break!</i>
Tuesday March 24	19	2.2, Gradient in OT systems (giving a Basis of Normals and Covariant components).
Thursday March 26	20	Extended example on Parabolic Cylindricals. Divergence in Orthogonal Coordinates
Tuesday March 31	21	Reciprocal bases, lowering and raising by metric (first subsection of 2.10), 2.7, 2.6
Thursday April 2	22	Tensors of arbitrary rank, 2.8
Tuesday April 7	23	2.9
Thursday April 9	24	19.1
Tuesday April 14	25	19.2
Thursday April 16	26	Midterm II
Tuesday April 21	27	19.3 Binomial
Thursday April 23	28	19.4 Poisson: Binomial to Poisson limit.
Tuesday April 28	29	19.4 Binomial to Gauss' limit
Thursday April 30	30	19.5 (up to use of tables)
		19.5 (from use of tables),
		19.6
Tuesday May 12		Comprehensive final
		The University arranges the final exam. Please check the UTD web page to check the scheduled time just before this exam. http://www.utdallas.edu/student/registrar/finals/

sections help with the development of Probability in chapter 19.

5.9 Euler-Maclaurin integration formula
8.2 to get as far as (8.41)
8.3 Stirling

Test dates won't change. Content of tests may change but will not include material in chapters/sections that have not been treated in class.

By the way, **I intend to present some material in the text in a slightly different fashion to the text and intend to include material that is not in the text when I think it relevant.** (This extra material may be included in lectures, in hard-copy 'handouts' to the class or in postings to the WebCT site.) **It is your responsibility to use these sources in addition to the textbook.**

Grading Policy:

The University calculates a GPA for graduate students based on the grades A (4.0), A- (3.67), B+ (3.33), B (3.00), B- (2.67), C (2.00), C+ (2.33), P, F and I (incomplete). However, the Physics department calculates a GPA based on grades A+, A, A-, B+, B, B-, etc. (If you are a PhD student in the Physics dept. and want to make a research proposal, then you need a GPA that corresponds to B+ in your courses at UTD.) Ask Margie for more details. I intend to use a grade scale similar to the following:

If x is a score then,

$x \geq 95$	A+
$95 > x \geq 90$	A
$90 > x \geq 85$	A-
$85 > x \geq 75$	B+
$75 > x \geq 65$	B
$65 > x \geq 60$	B-
$60 > x \geq 55$	C+
$55 > x \geq 50$	C
$50 > x \geq 45$	C-
$45 > x$	F

Weighting:	Homework	30%
	Midterm tests	20% each
	Final Exam	30%

I do not intend to use a curve in my grading of individual tests. A grade of X (incomplete) is awarded if an unforeseen, non-academic emergency prevents a student from completing the work in a course. If a student wants to discontinue the course because a poor grade is expected, it is nearly always more appropriate for the student to withdraw from the course and re-register in another semester. If an incomplete is given, the course must be completed within eight weeks of the first class day of the next long semester.

In general my tests are 'closed book' and 'closed notes'. I tend to embed reference material and some long equations in my tests. I have found that the main difficulty with tests is not with remembering equations but in knowing how to use them. **All books, notes, backpacks, cell**

phones etc. are to be placed by the sides of the room during a test. (By the way, don't spend too long erasing mistakes when writing answers to **test** questions. Begin again and **label the correct version** so that I can find it. Versions that you can't get to work may tell me something.)

Use of scientific calculators is allowed on tests. However, graphing and programmable calculators are not allowed. None of the test questions that I ask will involve lots of number crunching. **Valid UT-D student cards must be available if requested during tests.** (You can get one made and stamped/validated at the info depot in the student union building; SU 2.204.)

Missed tests can only be made up in the case of documented, extenuating circumstances. Such circumstances include medical emergencies and work-related travel that cannot be re-scheduled.

Course & Instructor Policies

Doing homework is an important part of the learning process. **Feel free to form study groups etc.** However, it is important to **hand in work that is your own.** When writing an answer to a question, it is important to write comments that explain both what you are trying to do and how you are trying to achieve it. In addition to the homework problems that are handed in for grading, I may suggest that you work problems other than homework problems. These are worth looking at as they improve your ability to solve problems.

In addition to helping you become familiar with the material, the homework will include problems that have longer solutions than problems on a test. Begin your homework when it is assigned; many problems are too difficult for a last-minute effort. When grading your work, the grader will be trying to understand your reasoning. Help him/her by saying what you are trying to do! Homework with no comments or partly scratched out answers don't help you show this. For grading, present neat versions of your solutions to the TA. Answers that are indecipherable will not attract much credit. If needed, **I may ask any student to explain their work to me.**

Dishonesty:

I would like to emphasize a point about the use of secondary sources etc. I do not object to people discussing problems that they have already attempted. I do not object to the use of any other textbooks that you come across. I object strongly to any verbatim, unacknowledged work done by anyone other than you and presented as part of your work. **(This includes any passages from textbooks, any solutions that you come across in hard copy or on WebCT etc. It also includes work produced by any member of the class [past or present]).** Every student in the course agrees to this limitation. **Further, all students agree to tell me the source of any solution to problem assigned in PHYS 5401 that they know about. No materials posted on the WebCT site become the property of the student. At the conclusion of the course, all students undertake to keep all course materials for their exclusive use. Any distribution of course materials to third parties constitutes academic dishonesty and will be reported to the Dean of Students**

In order to further the objective of eliminating scholastic dishonesty, the University has a policy on scholastic dishonesty. This policy is clearly articulated in Subchapter F section 49.36 of the policy on student discipline & conduct adopted by the University and used in this course. The full chapter 49 is at <http://www.utdallas.edu/student/slife/chapter49.html> Students enrolling in the course are bound by this policy and are encouraged to read it. Any questions about this

policy can be asked of the Dean of Students. **Any suspected cases of scholastic dishonesty will be passed along to the Dean of Students.**

Students are welcome to ask questions of my TA or me about homework problems. However, I do not authorize these students to communicate such discussions to other students. These other students are welcome to ask me questions too.

The WebCT site contains postings exclusively for the use of the person with the privilege accessing the site. Materials on this site form another secondary source that is intended to help students in my class during the semester that the posting is made. No materials posted on the WebCT site become the property of a student. **Students acknowledge that distribution/transmission of any posting made on the WebCT site constitutes scholastic dishonesty.** (See parts (d) 1 and (d) 5 of section 49.36 of the policy on student discipline & conduct.)

The question about WebCT can be extended. I will treat in the same way any pre-existing solution to a problem assigned as homework in a previous semester, a solution to a problem asked on a test, or any problem from the book. As soon as any student in PHYS this class comes across any kind of pre-existing solution, that student must inform me of its existence and source. To do otherwise is to aid copying. (See part d (1) of section 49.36.) In order to maintain privacy, I can be contacted by e-mail if desired.

At the conclusion of the course, all students undertake to keep **all** course materials (posted solutions, graded homework etc.) for their exclusive use.

A note about missing classes

First of all, please try not to! **If something arises that prevents you from attending class, please inform me as to why by e-mail.** Not everything that we do in class is covered in any single textbook. If there were an ideal textbook for us then there would be little or no need for classes. An ideal textbook does not exist. By missing class, you will miss either something not covered by the book that you are reading, or you will miss 'intermediate steps' in an author's argument that will help you follow along. You also pass up the opportunity to ask questions of your own and miss out on hearing the questions of others. (This latter point is significant. Other students may ask questions that haven't occurred to you yet and hence develop your understanding of the subject.) If you **have** to miss class for some reason then it is your responsibility to get class notes or handouts given in class. (I'm not keeping tabs on your attendance and leave some of the responsibility to you.) Please do this quickly after your absence. In order to understand the next lecture given, you will need to have obtained and worked through any notes etc. from the previous lecture. I give lectures from 'outline notes' that are probably not what you want to read. If you miss a lecture then your best source of class notes is another student who wrote down exactly what we actually did. I return graded homework and tests primarily in class. Again, you'll miss this if you are absent from class. After I have tried to return the graded work to you a class from which you were absent, the responsibility for getting it from me becomes yours.

Student Conduct & Discipline

The University of Texas System and The University of Texas at Dallas have rules and regulations for the orderly and efficient conduct of their business. It is the responsibility of each student and each student organization to be knowledgeable about the rules and regulations which govern student conduct and activities. General information on student conduct and discipline is contained in the UTD publication, *A to Z Guide*, which is provided to all registered students each academic year.

The University of Texas at Dallas administers student discipline within the procedures of recognized and established due process. Procedures are defined and described in the *Rules and Regulations, Board of Regents, The University of Texas System, Part I, Chapter VI, Section 3*, and in Title V, Rules on Student Services and Activities of the university's *Handbook of Operating Procedures*. Copies of these rules and regulations are available to students in the Office of the Dean of Students, where staff members are available to assist students in interpreting the rules and regulations (SU 1.602, 972/883-6391).

A student at the university neither loses the rights nor escapes the responsibilities of citizenship. He or she is expected to obey federal, state, and local laws as well as the Regents' Rules, university regulations, and administrative rules. Students are subject to discipline for violating the standards of conduct whether such conduct takes place on or off campus, or whether civil or criminal penalties are also imposed for such conduct.

Academic Integrity

The faculty expects from its students a high level of responsibility and academic honesty. Because the value of an academic degree depends upon the absolute integrity of the work done by the student for that degree, it is imperative that a student demonstrate a high standard of individual honor in his or her scholastic work.

Scholastic dishonesty includes, but is not limited to, statements, acts or omissions related to applications for enrollment or the award of a degree, and/or the submission as one's own work or material that is not one's own. As a general rule, scholastic dishonesty involves one of the following acts: cheating, plagiarism, collusion and/or falsifying academic records. Students suspected of academic dishonesty are subject to disciplinary proceedings.

Plagiarism, especially from the web, from portions of papers for other classes, and from any other source is unacceptable and will be dealt with under the university's policy on plagiarism (see general catalog for details). This course will use the resources of turnitin.com, which searches the web for possible plagiarism and is over 90% effective.

Email Use

The University of Texas at Dallas recognizes the value and efficiency of communication between faculty/staff and students through electronic mail. At the same time, email raises some issues concerning security and the identity of each individual in an email exchange. The university encourages all official student email correspondence be sent only to a student's U.T. Dallas email address and that faculty and staff consider email from students official only if it originates from a UTD student account. This allows the university to maintain a high degree of confidence in the identity of all individual corresponding and the security of the transmitted information. UTD furnishes each student with a free email account that is to be used in all communication with university personnel. The Department of Information Resources at U.T. Dallas provides a method for students to have their U.T. Dallas mail forwarded to other accounts.

Withdrawal from Class

The administration of this institution has set deadlines for withdrawal of any college-level courses. These dates and times are published in that semester's course catalog. Administration procedures must be followed. It is the student's responsibility to handle withdrawal requirements from any class. In other words, I cannot drop or withdraw any student. You must do the proper paperwork to ensure that you will not receive a final grade of "F" in a course if you choose not to attend the class once you are enrolled.

Student Grievance Procedures

Procedures for student grievances are found in Title V, Rules on Student Services and Activities, of the university's *Handbook of Operating Procedures*.

In attempting to resolve any student grievance regarding grades, evaluations, or other fulfillments of academic responsibility, it is the obligation of the student first to make a serious effort to resolve the matter with the instructor, supervisor, administrator, or committee with whom the grievance originates (hereafter called "the respondent"). Individual faculty members retain primary responsibility for assigning grades and evaluations. If the matter cannot be resolved at that level, the grievance must be submitted in writing to the respondent with a copy of the respondent's School Dean. If the matter is not resolved by the written response provided by the respondent, the student may submit a written appeal to the School Dean. If the grievance is not resolved by the School Dean's decision, the student may make a written appeal to the Dean of Graduate or Undergraduate Education, and the dean will appoint and convene an Academic Appeals Panel. The decision of the Academic Appeals Panel is final. The results of the academic appeals process will be distributed to all involved parties.

Copies of these rules and regulations are available to students in the Office of the Dean of Students, where staff members are available to assist students in interpreting the rules and regulations.

Incomplete Grade Policy

As per university policy, incomplete grades will be granted only for work unavoidably missed at the semester's end and only if 70% of the course work has been completed. An incomplete grade must be resolved within eight (8) weeks from the first day of the subsequent long semester. If the required work to complete the course and to remove the incomplete grade is not submitted by the specified deadline, the incomplete grade is changed automatically to a grade of **F**.

Disability Services

The goal of Disability Services is to provide students with disabilities educational opportunities equal to those of their non-disabled peers. Disability Services is located in room 1.610 in the Student Union. Office hours are Monday and Thursday, 8:30 a.m. to 6:30 p.m.; Tuesday and Wednesday, 8:30 a.m. to 7:30 p.m.; and Friday, 8:30 a.m. to 5:30 p.m.

The contact information for the Office of Disability Services is:
The University of Texas at Dallas, SU 22
PO Box 830688
Richardson, Texas 75083-0688
(972) 883-2098 (voice or TTY)

Essentially, the law requires that colleges and universities make those reasonable adjustments necessary to eliminate discrimination on the basis of disability. For example, it may be necessary to remove classroom prohibitions against tape recorders or animals (in the case of dog guides) for students who are blind. Occasionally an assignment requirement may be substituted (for example, a research paper versus an oral presentation for a student who is hearing impaired). Classes enrolled students with mobility impairments may have to be rescheduled in accessible facilities. The college or university may need to provide special services such as registration, note-taking, or mobility assistance.

It is the student's responsibility to notify his or her professors of the need for such an accommodation. Disability Services provides students with letters to present to faculty members to verify that the student has a disability and needs accommodations. Individuals requiring special accommodation should contact the professor after class or during office hours.

Religious Holy Days

The University of Texas at Dallas will excuse a student from class or other required activities for the travel to and observance of a religious holy day for a religion whose places of worship are exempt from property tax under Section 11.20, Tax Code, Texas Code Annotated.

The student is encouraged to notify the instructor or activity sponsor as soon as possible regarding the absence, preferably in advance of the assignment. The student, so excused, will be allowed to take the exam or complete the assignment within a reasonable time after the absence: a period equal to the length of the absence, up to a maximum of one week. A student who notifies the instructor and completes any missed exam or assignment may not be penalized for the absence. A student who fails to complete the exam or assignment within the prescribed period may receive a failing grade for that exam or assignment.

If a student or an instructor disagrees about the nature of the absence [i.e., for the purpose of observing a religious holy day] or if there is similar disagreement about whether the student has been given a reasonable time to complete any missed assignments or examinations, either the student or the instructor may request a ruling from the chief executive officer of the institution, or his or her designee. The chief executive officer or designee must take into account the legislative intent of TEC 51.911(b), and the student and instructor will abide by the decision of the chief executive officer or designee.

These descriptions and timelines are subject to change at the discretion of the Professor.