Complex Variables
MAT 3730                    Spring 2016

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University and Departmental Mission: Seattle Pacific University seeks to be a premier Christian university fully committed to engaging the culture and changing the world by graduating people of competence and character, becoming people of wisdom, and modeling grace-filled community. The mathematics department at Seattle Pacific University seeks to provide excellent instruction to enable our students to be competent in the mathematics required for their chosen fields, and to share our expertise with the community through service and leadership. Hence, common goals for students in mathematics courses include 1) becoming competent in the topics covered in the course, 2) demonstrating skills and attitudes which contribute to professional, ethical behavior, 3) the ability to communicate mathematically, in both written and verbal form, and 4) learning to appreciate the beauty and utility of mathematics.

Prerequisites: MAT 3238. Mastery of calculus and vector calculus (MAT 1234, 1235, 1236, and 3238) is essential. Some basic familiarity with Maple will also be expected.

Course Goals: The aim of this course is to introduce students to the algebra and geometry of complex numbers and to the calculus of functions of a complex variable. The emphasis will be on gaining a geometric understanding of complex analytic functions as well as developing computational skills in employing the powerful tools of complex analysis for solving theoretical and applied problems.

Learning Objectives: By the end of the course, students should be able to:
- perform basic arithmetic and algebraic operations (including powers and roots) with complex numbers;
- work with complex numbers in both rectangular and polar form;
- describe the geometry of complex numbers and complex arithmetic;
- describe the extensions of elementary functions (including polynomial, reciprocal, exponential, trigonometric, and logarithmic) to complex numbers, and perform basic computations involving these functions;
- state and apply the Cauchy-Riemann equations, determine where a complex function is differentiable and where it is analytic, and compute its derivative;
- describe how basic analytic functions act as conformal mappings of regions in the plane;
- determine basic mapping properties of elementary functions, including how functions transform simple shapes in the plane such as lines and circles;
- compute complex contour integrals in several ways: directly using parameterization, using Cauchy’s theorem and deformation of contour, using the fundamental theorem for line integrals, and by Cauchy’s integral formula; and
- compute Taylor series expansions for analytic functions and determine where the series converges.

In addition to the specific content oriented objectives above, students should be able to:
- state and prove basic theorems related to the concepts above;
- provide written explanations of the ideas behind key concepts from the course;
- clearly present and explain solutions to problems in both written and verbal form;
- apply mathematical reasoning and the theory of complex variables to solve theoretical and applied problems.

Students should also gain an increased appreciation of mathematics as part of the language of science and as a study in itself. Finally, I hope that you will have fun accomplishing all of these objectives, even if the material is difficult and the course takes a lot of time and effort.

Textbook: The primary textbook is *A First Course in Complex Analysis* (Version 1.5) by Matthias Beck, Gerald Marchesi, and Dennis Pixton, which is available for free online at http://math.sfsu.edu/beck/papers/complex.pdf. I’ll also occasionally refer to other free online resources, including the following:
- http://mathfaculty.fullerton.edu/mathews/c2003/ComplexUndergradMod.html, an online version of nearly the entire textbook *Complex Analysis for Mathematics and Engineering* by Mathews and Howell.

Finally, I highly recommend the book *Visual Complex Analysis* by Tristan Needham. It is one of the best math books that I have ever read, but it has way too much content for a 3-credit one-quarter introductory course. If you want to dig more deeply into the subject, this is a great book to read.

Calculators & Computers: Calculators will be permitted on all exams. Any basic scientific calculator or a graphing calculator such as the TI-81, TI-82, or TI-85 will be allowed. However, calculators such as the TI-89 or TI-92 which are capable of symbolic manipulation will NOT be permitted. We will also use computer software in this course, including Maple and Matlab, primarily for visualization of complex functions as mappings of the plane.
Grading and Course Expectations

Exams: There will be two exams: a midterm and a cumulative final exam. Both exams will have a take-home component. The in-class portion of the midterm is tentatively scheduled for Monday, May 2, but the date is subject to change. The in-class final exam is scheduled for Wednesday, June 8 from 8:00 to 10:00 am.

Homework: The only way to truly learn mathematics is to work as many exercises as possible. You cannot learn to do mathematics by watching someone else do mathematics or listening to someone else talk about mathematics – you must actually do it yourself and practice, practice, practice. Furthermore, the material each class period builds on what came before, so it is essential to keep up with the work every day. As a result, there will be homework assignments given virtually every class period which will often be collected at the next class meeting.

General homework policies:
- Homework must be turned in by 9:30 (not 9:31) on the day it is due; late homework will not be accepted for any reason. If you have an excused absence and make arrangements with me before class starts, the homework score will be dropped.
- Not all written homework exercises will be graded. A few exercises will be selected for grading, and your grade for the assignment will be based on those exercises only.
- You are strongly encouraged to come to my office to ask me questions about the homework.
- You are also encouraged to work with other students on the homework, but unless otherwise indicated for a particular assignment, you must individually write up and submit your own solutions.
- You are required to list on your paper all other individuals that you worked with or who gave you assistance with the homework – failure to do so will be considered cheating (turning in someone else’s work as your own).
- Homework must be neat and easily readable or you will receive NO credit.
- You must show all of your work – a correct answer with no justification will receive NO credit.
- All homework assignments will be posted online; however, you are also responsible for all announcements made in class, whether or not they are posted on the web.
- Your lowest homework score will be dropped from your final grade.

Presentations: All students may be asked occasionally to present and explain solutions to homework problems in class. These presentations will count as part of the homework grade.

Group Assignments: You will occasionally be asked to work in groups on problems (either in or outside of class). Some of these assignments may involve computer lab activities using Maple, Matlab, or other software. For group assignments, you will only need to turn in one copy of your solutions for the entire group. Group assignments will be counted as a part of your homework grade.

Attendance: Attendance will be taken regularly and will count toward your homework grade. If you expect to succeed in this course, it is essential that you come to class every day. Unless you have an acceptable excuse and make special arrangements with me before class begins, missing an exam or failing to turn in an assignment on time will result in a grade of zero. Late homework will not be accepted for any reason, but if you have an acceptable excuse and contact me before class, I will drop the homework score.

NOTE: Things such as oversleeping or lack of preparation are NOT acceptable excuses. Acceptable excuses include illness, a death in your immediate family, and official SPU athletic trips. If requested, you are responsible for providing me with documentation of your excuse.

Course Grades: Homework assignments will be worth 35% of your course grade, the midterm exam will be worth 30%, and the final exam will count for 35%. Course grades will be based on the following scale:

- 93-100% A
- 90-92% A-
- 87-89% B+
- 83-86% B
- 80-82% B-
- 77-79% C+
- 73-76% C
- 70-72% C-
- 67-69% D+
- 60-66% D
- Below 60% E

A grade of I (incomplete) is only given for non-academic reasons such as a severe illness that prevents you from completing the course. You must have a passing grade on the material that you have completed in order to receive an incomplete.

Academic Dishonesty: The current edition of the SPU Undergraduate Catalog describes the University’s commitment to academic integrity, which is breached by academic dishonesty of various kinds. Examples of academic dishonesty include copying another’s work on an exam, bringing concealed answers to an exam, turning in another person’s work as your own, committing plagiarism, assisting another student in cheating, or lying to the instructor. The minimum penalty for academic dishonesty in any form will be a zero for the assignment or exam in question; in severe cases, academic dishonesty will result in a failing grade for the course. In addition, all students have an obligation to make efforts to prevent other students from cheating and to report incidents of cheating or plagiarism.
Office Hours: My regular office hours will be posted on the course web pages. You are strongly encouraged to drop by my office to ask questions, discuss problems, and just to get to know me better. If you are unable to meet with me during my scheduled office hours, I am available at other times by appointment. I also maintain an “open door” policy at my office – any time that my door is open you are welcome to drop in to talk to me, even if it is not during my scheduled office hours. Please note that I am generally not available at all on campus on Tuesdays. Please plan accordingly.

Additional Notes

E-mail: All SPU students have an SPU e-mail address. I will occasionally make use of these SPU e-mail addresses to send information to all members of the class, so you should check your e-mail regularly. If you do not use your SPU e-mail account, there is a utility available through Banner to set up your SPU e-mail account to forward messages to some other e-mail address. I strongly recommend doing this so that you do not miss any important messages.

Please note that while it can be a great tool for quick communication (such as scheduling an appointment to talk with me face-to-face), e-mail is rarely a good substitute for face-to-face conversations and is very poorly suited for answering mathematical questions. When you come to my office to ask me questions, I engage you in a discussion about the problem, ask questions about what ideas you have for approaching the problem, explore various possible approaches (and what goes wrong with some of them), etc. In the process, I can usually find out precisely where your difficulties lie and help you to learn how to get past them. Such a conversation is impossible by e-mail. Furthermore, typing and e-mailing mathematical symbols is very time consuming, and the resulting equations in the e-mail e-mails often come out garbled (or even completely missing).

Students with Disabilities: In accordance with Section 504 of the Rehabilitation Act of 1973 and the Americans with Disabilities Act of 1990, students with specific disabilities that qualify for academic accommodations need to contact Disabled Student Services in the Center for Learning. Disabled Student Services in turn will send a Disability Verification Letter to me indicating what accommodations have been approved.

Once you have done this, you should also make an appointment to meet with me as early as possible in the quarter to discuss the details of how we will implement the accommodations in this course.

Inclement Weather: SPU maintains an Emergency Closure Hotline (206-281-2800). In the event of inclement weather or an emergency that might close the university, please call the Hotline for the most up-to-date closure information or check the SPU website. Both will be updated before 6:00 a.m.

Emergency Procedure: A one-page summary of SPU’s emergency procedures is attached at the end of this syllabus. Please note the emergency procedures posted in the classroom and note all emergency exits. In case of an emergency requiring evacuation of the building, the class will leave via the rear exit to the right when exiting the classroom and then will gather in the Alumni Center parking lot on the Nickerson Street side of Otto Miller Hall. Please try to stay together so that we can check that everyone has made it safely out of the building.

Modifications to the course requirements (such as the addition of quizzes) can be made at any time. It is your responsibility to know all course requirements as described here or announced in class.
**Tentative Class Schedule**

The table below provides a very tentative schedule of topics to be covered in class. The exact dates on which material will be covered will almost certainly vary somewhat from this list. Topics may be added to or removed from this list at any time.

<table>
<thead>
<tr>
<th>Date</th>
<th>Topics Covered</th>
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<tbody>
<tr>
<td>March 30</td>
<td>Introduction and history of complex numbers</td>
</tr>
<tr>
<td>April 1</td>
<td>No class – Dr. Gill attending a conference</td>
</tr>
<tr>
<td>April 4</td>
<td>Complex numbers, arithmetic, and geometry (1.1, 1.2, 1.3)</td>
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<tr>
<td>April 6</td>
<td>More on arithmetic and geometry of complex numbers (1.2, 1.3)</td>
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<tr>
<td>April 8</td>
<td>Sets in the complex plane; elementary topology of the plane (1.4)</td>
</tr>
<tr>
<td>April 11</td>
<td>Complex functions and limits (2.1)</td>
</tr>
<tr>
<td>April 13</td>
<td>Differentiation and holomorphicity (2.2)</td>
</tr>
<tr>
<td>April 15</td>
<td>Cauchy-Riemann equations (2.4)</td>
</tr>
<tr>
<td>April 18</td>
<td>Mobius transformations (3.1)</td>
</tr>
<tr>
<td>April 20</td>
<td>Infinity and the cross ratio (3.2)</td>
</tr>
<tr>
<td>April 22</td>
<td>Stereographic projection (3.3)</td>
</tr>
<tr>
<td>April 25</td>
<td>Exponential and trigonometric functions (3.4)</td>
</tr>
<tr>
<td>April 27</td>
<td>The logarithm and complex exponentials (3.5)</td>
</tr>
<tr>
<td>April 29</td>
<td>Review/catch-up</td>
</tr>
<tr>
<td>May 2</td>
<td><strong>Midterm</strong></td>
</tr>
<tr>
<td>May 4</td>
<td>Contour integrals (4.1)</td>
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<tr>
<td>May 6</td>
<td>Antiderivatives (4.2)</td>
</tr>
<tr>
<td>May 9</td>
<td>Cauchy’s theorem (4.3)</td>
</tr>
<tr>
<td>May 11</td>
<td>Cauchy’s integral formula (4.4)</td>
</tr>
<tr>
<td>May 13</td>
<td>Consequences of Cauchy’s formula (5.1)</td>
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<tr>
<td>May 16</td>
<td>Antiderivatives Again (5.2)</td>
</tr>
<tr>
<td>May 18</td>
<td>Taking Cauchy’s formula to the limit (5.3)</td>
</tr>
<tr>
<td>May 20</td>
<td>Sequences and series (7.1, 7.2)</td>
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<tr>
<td>May 23</td>
<td>Sequences and series of functions; region of convergence (7.3, 7.4)</td>
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<tr>
<td>May 25</td>
<td>Power series and holomorphic functions (8.1)</td>
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<tr>
<td>May 27</td>
<td>Classification of zeros and the identity principle (8.2)</td>
</tr>
<tr>
<td>May 30</td>
<td><strong>No Class</strong> – Memorial Day</td>
</tr>
<tr>
<td>June 1</td>
<td>Laurent Series (8.5)</td>
</tr>
<tr>
<td>June 3</td>
<td>Review/wrap-up</td>
</tr>
<tr>
<td>June 8</td>
<td><strong>Final exam</strong>, 8:00-10:00</td>
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Emergency Preparedness Information

Report an Emergency or Suspicious Activity
Call the Office of Safety and Security to report an emergency or suspicious activity by dialing 206-281-2911 or by pressing the call button on a campus emergency phone. SPU Security Officers are trained first responders and will be dispatched to your location. If needed, the SPU Dispatcher will contact local fire/police with the exact address of the location of the emergency.

SPU-Alert System
The SPU-Alert System is SPU’s emergency notification system. It can send information via text message, email, electronic reader board, computer pop-ups (for SPU computers), loudspeaker, and recorded cell phone messages. Text messaging has generally proven to be the quickest way to receive an alert about a campus emergency. In order to receive text messages from SPU-Alert, you must provide SPU with your cell phone number through the Banner Information System on the web, https://www.spu.edu/banweb/. Select the Personal Menu then choose the Emergency Alert System tab. Contact the CIS Help Desk if you have questions about entering your personal contact information into the Banner Information System. Emergency announcements may also be made by SPU staff members serving as Building Emergency Coordinators (“BECs”).

Lockdown / Shelter in Place – General Guidance
The University will lock down in response to threats of violence such as a bank robbery or armed intruder on campus. You can assume that all remaining classes and events will be temporarily suspended until the incident is over. Lockdown notifications are sent using the SPU-Alert System.

If you are in a building at the time of a lockdown:
• Stay inside and await instruction, unless you are in immediate visible danger.
• Move to a securable area (such as an office or classroom) and lock the doors.
• Close the window coverings then move away from the windows and get low on the floor.
• Remain in your secure area until further direction or the all clear is given (this notification will be sent via the SPU-Alert System).

If you are outside at the time of a lockdown:
• Leave the area and seek safe shelter off campus. Remaining in the area of the threat may expose you to danger.
• Return to campus after the all clear is given (this notification will be sent via the SPU-Alert System).

Evacuation – General Guidance
Students should evacuate a building if the fire alarm sounds or if a faculty member, a staff member, or the SPU-Alert System instructs building occupants to evacuate. In the event of an evacuation, gather your personal belongings quickly and proceed to the nearest exit. Most classrooms contain a wall plaque or poster on or next to the classroom door showing the evacuation route and the assembly site for the building. Do not use the elevator.

Once you have evacuated the building, proceed to the nearest evacuation assembly location. The “Stop. Think. Act.” booklet posted in each classroom contains a list of assembly sites for each building. Check in with your instructor or a BEC (they will be easily recognizable by their bright orange vests). During emergencies, give each BEC your full cooperation whenever they issue directions.

Additional Information
Additional information about emergency preparedness can be found on the SPU web page at http://www.spu.edu/info/emergency/index.asp or by calling the Office of Safety and Security at 206-281-2922.