585.615 Mathematical Methods for Applied Biomedical Engineering

Syllabus

Instructor Contact

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I prefer that students contact me via email. Please be sure to include the course number in the subject line. I will make every effort to respond to your inquiry within 48 hours or earlier. If an issue is urgent, please indicate "urgent" within the subject line of the email and I will respond as soon as is practical. If the question(s) pertains to particular material in the class it may sometimes be easier and more expedite to have a direct conversation with students. In that case (if possible) I may request that you contact me by phone or alternatively use the weekly office hours available (with Zoom - see below) if you can wait.

Office Hours via Zoom

For more information regarding Zoom, please see the Zoom Information page after you click on office hours on the left menu.

This course will use Zoom to facilitate weekly, synchronous office hours. You are not required to participate in office hours; however, you may find them very beneficial for receiving more timely answers to questions related to the course content and assignments.

During the first week of the course I may conduct a student survey to determine the best day and time of the week to schedule the office hours, however I usually pick Thursday evenings 8PM EST. Once the day and time have been determined I will set up office hours links each week in Announcements and email everyone a link. Students can click that link to access the meeting and participate in the office hours. You are encouraged to post any questions you would like to have answered during the live office hour sessions to the "Office Hours Discussion" by Wednesday at 5:00 PM. Recorded office hour sessions will be posted to the Discussions Announcements area of the course for any students who were unable to participate in the "live" sessions or for students who like to listen to them again.

Course Description

The course covers mathematical techniques needed to solve advanced problems encountered in applied biomedical engineering. Fundamental concepts are presented with emphasis placed on applications of these techniques to biomedical engineering problems. Topics include solution of ordinary differential equations using the Laplace transformation, Fourier series and integrals, solution of partial differential equations including the use of Bessel functions and Legendre polynomials and an introduction to complex analysis.

Prerequisites

Familiarity with multi-variable calculus, linear algebra, and ordinary differential equations.

Course Goals

The goal of this course is to insure that all students in the biomedical program have experience with advanced mathematical procedures that they may be exposed to in taking additional course work or more importantly during their career. It also serves as a refresher course on some mathematical topics students have previously been exposed to as an undergraduate.

Course Objectives

By the end of the course, you will be able to:

- Represent functions in terms of Fourier series and perform Fourier integral transforms.
- Apply methods of Fourier series and Fourier or Laplace integral transforms in the solution of engineering and/or biomedical engineering problems.
- Solve ordinary differential equations or system of equations with initial values using Laplace integral transform and apply this technique to solve engineering and/or biomedical engineering problems.
- Solve non-homogenous differential equations using he methods of variation of parameters and Green's functions.
- Find series solutions to second-order ordinary differential equations
- Identify and solve Strum-Liouville equations, especially those for "special" functions (e.g. Legendre and Bessel functions).
- Develop and use special functions in the solution of engineering and/or biomedical engineering problems.
- Derive and solve some important partial differential equations (PDEs) (especially that for the wave and heat equation in one and two spatial dimensions and time) that arise in engineering and/or biomedical engineering problems.
- Perform computations and graph functions of a complex variable that involve powers, nth roots and circular functions such as exponentials and trigonometric functions.
- Compute derivatives of functions of a complex variable and apply the Cauchy-Riemann equations to check functions for analyticity.
- Compute complex line integrals a number of ways, including the following methods: antiderivatives, parametrization of the path of integration, application of Cauchy's theorems and formulas and application of the theory of residues.
- Apply the techniques of complex variables to compute an inverse Laplace transform via the Bromwich inversion formula and solve Laplace's 2-dimensional PDE equations for complex potentials that are applicable to the computation of electrical potentials or steady state fluid flow.

Course Structure

The course materials are divided into modules which can be accessed by clicking Course Modules on the left menu. A module will have several sections including the overview, content, readings, discussions, and assignments. You are encouraged to preview all sections of the module before starting. Most modules run for a period of seven (7) days, exceptions are noted on the Course Outline page. You should regularly check the Calendar and Announcements for assignment due dates.

Textbook

Required

Riley, K. F., Hobson M. P. (2011) Essential Mathematical Methods for the Physical Sciences, Cambridge University Press

ISBN-10: 0-521-76114-X
ISBN-13: 978-0-521-76114-7

Textbook information for this course is available online through the appropriate bookstore website: For online courses, search the MBS website at http://ep.jhu.edu/bookstore.

Optional

Kreyszig, E. (2011) Advanced Engineering Mathematics, 10th ed., Wiley

ISBN-10: 9780470458365
ISBN-13: 978-0470458365

Additionally, any of the following texts or other texts that you may have from previous courses may be useful for this course if you find yourself struggling with specific skills:

- Tenenbaum, M., Pollard, H. (1985) Ordinary Differential Equations, Revised ed., Dover Books
- Strang, G. (2009) Introduction to Linear Algebra, Fourth Edition 4th ed., Wellesley Cambridge Press

Required Software

MATLAB

You will need access to a recent version of MATLAB. The MATLAB Total Academic Headcount (TAH) license is now in effect. This license is provided at no cost to you. Send an email to software@jhu.edu to request your license file/code. Please indicate that you need a standalone file/code. You will need to provide your first and last name, as well as your Hopkins email address. You will receive an email from Mathworks with instructions to create a Mathworks account. The MATLAB software will be available for download from the Mathworks site.

Technical Requirements

You should refer to Help & Support on the left menu for a general listing of all the course technical requirements.

Student Coursework Requirements

It is expected that each module will take approximately 8–12 hours per week to complete. Here is an approximate breakdown: reading the assigned sections of the texts (approximately 3–4 hours per week) as well as some outside reading, listening to the audio annotated slide presentations (approximately 1–2 hours per week), and writing assignments (approximately 4–6 hours per week).

This course will consist of four basic student requirements:

1. **Interactive Assignments** (12% of Final Grade Calculation)

Participation in interactive assignment discussions is an essential part of your grade for this course. Most weeks a set of homework problems will be assigned to the entire class. A portion of these problems will also be chosen and assigned to some students (chosen on a weekly basis) so that they can post their initial attempt at a solution. If you are the initial presenter then it is expected that you have worked on the solution to the problem you have been assigned and made it presentable to the class. Posting your initial answer in the interactive assignment discussion by day 5 (at the latest, i.e. Timeliness) for that module week.

Another part of your grade for module discussion is your interaction (i.e., responding to classmate postings with thoughtful responses, i.e., Critical Thinking). Just posting your response to a discussion question is not sufficient; we want you to interact with your classmates. Be detailed in your postings and in your responses to your classmates' postings. Feel free to agree or disagree with your classmates. Please ensure that your postings are civil and constructive.

I will monitor module discussions and will respond in the discussions in some instances, I will also summarize the overall discussions and post my corrected answers if necessary.

Evaluation of preparation and participation is based on contribution to discussions.

Preparation and participation in homework discussions is evaluated by the following grading elements:

1. Timeliness (50%)
2. Critical Thinking (30%)
3. Correctness of posted analysis either in initial answer or follow up discussion (20%)

Preparation and participation is graded as follows:

100–90 = A—Timeliness [regularly participates; all required postings; early in discussion; throughout the discussion]; Critical Thinking [correct technique; insightful critic or added value]; Correctness.

89–80 = B—Timeliness [frequently participates; all required postings; some not in time for others to read and respond]; Critical Thinking [substantially correct technique; some relevant critic]; Correctness.

79–70 = C—Timeliness [infrequently participates; all required postings; most at the last minute without allowing for response time]; Critical Thinking [some initial attempt; some critic]; Correctness.

<70 = F—Timeliness [rarely participates; some, or all required postings missing]; Critical Thinking [rudimentary and superficial attempt; no critic]; Correctness.

Again, note that late initial submissions of homework problems for the discussion will be graded as F (no exceptions without prior coordination with the instructor).

2. **Submission of completed Homework Assignments** (8% of Final Grade Calculation)

Submission of completed homework (twice during the semester):

1. Timeliness of completed homework (50%)
2. General quality of completed homework (50%)

Completed Homework Assignments should consist of all homework problems assigned for that portion of the semester. Homework submitted should be reasonably detailed and show all appropriate steps. In the case where homework problems have already been presented and discussed online make sure that you show all **your own details and steps in solving them** since it is expected that your answer will be correct. Remember that while problems often require the same steps to solve that solution styles and details can differ significantly from person to person! I also recognize the fact that for some problem there is little latitude in the technique for working out the problem - just make an honest attempt to provide your own work. Also include your name and a page number indicator (i.e., page x of y) on each page of your submissions. Each problem should be identified by book chapter and number of the problem in the book chapter. All Figures and Tables if appropriate should be captioned and labeled appropriately.

Completed homework (twice during the semester) is graded as follows:

100–90 = A—Timeliness [All homework was turned in when due]; General quality [neat, shows all steps with attention to details when necessary and answers are almost all correct].

89–80 = B—Timeliness [Most homework was turned in when due]; General quality [mostly neat, shows all steps and has mostly correct answers].

79–70 = C—Timeliness [Some homework not turned in when due]; General quality [not very neat, steps missing and many answers not supported by work or not correct].

<70 = F—Timeliness [Most homework not turned in when due]; General quality [sloppy, most steps are missing and many answers are not correct].

3. **Course Individual Projects** (30% of Final Grade Calculation)

Three course project will be assigned.

The course projects will be evaluated by the following grading elements:

1. General organization of project answers (10%)
2. Mathematical setup and assumptions (if necessary) are correctly and clearly presented for project questions (20%)
3. Each part of questions is answered (20%)
4. Appropriateness of mathematical techniques, including major and intermediate steps are included (30%)
5. Correctness of answers and associated mathematics (20%)

Course Projects are graded as follows:

100–90 = A— General organization [Clear, neat and well organized work]; Mathematical setup and assumptions [Correct setup and assumptions presented]; Appropriateness of mathematical techniques [Appropriate, detailed and correct techniques are used]; Correctness.

89–80 = B— General organization [Mostly Clear, neat and well organized work]; Mathematical setup and assumptions [Generally correct setup and assumptions presented]; Appropriateness of mathematical techniques [Mostly appropriate, some detailed and techniques missing or not correct]; Correctness.

79–70 = C— General organization [Not very clear or neat and organized poorly]; Mathematical setup and assumptions [Some incorrect setup and assumptions presented]; Appropriateness of mathematical techniques [Many details missing and some major techniques inappropriate]; Correctness.

<70 = F— General organization [Sloppy and disorganized work]; Mathematical setup and assumptions [Mostly incorrect setup and assumptions not presented]; Appropriateness of mathematical techniques [Most details missing and major techniques inappropriate]; Correctness.

4. **Exam[s]** (25% of Final Grade Calculation, combined from 25% for Midterm and 25% for Final)

The midterm exam will be available in Module 8 and the final exam will be available in the final Module (14). You will have one week to complete the exams and they will be due by 5PM exactly one week from their release. You may use all course materials to complete the exams.

The exams are evaluated by the following grading elements:

1. General organization or presentation of answers (20%)
2. Each part of questions is answered (20%)
3. Appropriateness of mathematical techniques, including major and intermediate steps are included (30%)
4. Correctness of answers and associated mathematics (30%)

Exams are graded as follows:

100–90 = A— General organization or presentation of answers; Writing Quality/ Rationale/ Examples/ Outside References [rich in content; full of thought, insight, and analysis].

89–80 = B—All parts of the question are addressed; Writing Quality/ Rationale/ Examples/ Outside References [substantial information; thought, insight, and analysis has taken place].

79–70 = C—Majority of parts of the question are addressed; Writing Quality/ Rationale/ Examples/ Outside References [generally competent; information is thin and commonplace].

<70 = F—Some parts of the question are addressed; Writing Quality/ Rationale/ Examples/ Outside References [rudimentary and superficial; no analysis or insight displayed].

Grading

Assignments are due according to the dates posted in your Blackboard course site. You may check these due dates in the Course Calendar or the Assignments in the corresponding modules. I will post grades one week after assignment due dates.

A grade of A indicates achievement of consistent excellence and distinction throughout the course—that is, conspicuous excellence in all aspects of assignments and discussion in every week.

A grade of B indicates work that meets all course requirements on a level appropriate for graduate academic work. These criteria apply to both undergraduates and graduate students taking the course.

100–98 = A+
97–94 = A
93–90 = A−
89–87 = B+
86–83 = B
82–80 = B−
79–70 = C <70
= F

Final grades will be determined by the following weighting:

Item	% of Grade
Preparation, Participation in Homework Discussions	12%
Homework Assignments	8%
Course Projects	30%
Exam[s] (Midterm + Final)	50% (25% + 25%)

Help & Support

You should refer to Help & Support on the left menu for a listing of all the student services and support available.

Policies and Guidelines

Academic Integrity

Academic Integrity Course

You will be enrolled in the EP Orientation Course and are required to take the Academic Ethics Assessment quiz. You will be enrolled in this course after registering for your first class at Johns Hopkins Engineering for Professionals. This course covers the fundamental values of academic integrity, as well as information related to our academic misconduct policy. You will receive guidance on proper citation, and learn how to avoid mistakes like plagiarism and other violations of academic misconduct.

Academic Misconduct Policy

All students are required to read, know, and comply with the Johns Hopkins University Krieger School of Arts and Sciences (KSAS) / Whiting School of Engineering (WSE) Procedures for Handling Allegations of Misconduct by Full-Time and Part-Time Graduate Students.

This policy prohibits academic misconduct, including but not limited to the following: cheating or facilitating cheating; plagiarism; reuse of assignments; unauthorized collaboration; alteration of graded assignments; and unfair competition. You may request a paper copy of this policy at this by contacting jhep@jhu.edu.

Collaborations and discussions between students are key ingredients to success in a graduate course. You are encouraged to discuss the course material with each other as you sort through concepts that may be difficult to comprehend or controversial. However, the line between collaboration and cheating needs to be carefully delineated. Whenever you turn in work with your name on it to be evaluated, graded and included in your record it must represent an individual effort by you alone. If you include direct quotes from any source in your discussions, written assignments, the final exam, or any other submission for which you will receive a grade you must provide attribution. Students using published material without reference, or copying the work of another individual will receive a warning at the first incident. Any further incidents will result in the student receiving a zero on the assignment and the matter will be referred to the Associate Dean. Contact us if you have any questions, no matter how slight, about this policy, or if you have questions about a particular assignment.

Plagiarism

Plagiarism is defined as taking the words, ideas or thoughts of another and representing them as one's own. If you use the ideas of another, provide a complete citation in the source work; if you use the words of another, present the words in the correct quotation notation (indentation or enclosed in quotation marks, as appropriate) and include a complete citation to the source. See the course text for examples.

Policy on Disability Services

Johns Hopkins University (JHU) is committed to creating a welcoming and inclusive environment for students, faculty, staff and visitors with disabilities. The University does not discriminate on the basis of race, color, sex, religion, sexual orientation, national or ethnic origin, age, disability or veteran status in any student program or activity, or with regard to admission or employment. JHU works to ensure that students, employees and visitors with disabilities have equal access to university programs, facilities, technology and websites.

Under Section 504 of the Rehabilitation Act of 1973, the Americans with Disabilities Act (ADA) of 1990 and the ADA Amendments Act of 2008, a person is considered to have a disability if c (1) he or she has a physical or mental impairment that substantially limits one or more major life activities (such as hearing, seeing, speaking, breathing, performing manual tasks, walking, caring for oneself, learning, or concentrating); (2) has a record of having such an impairment; or (3) is regarded as having such an impairment class. The University provides reasonable and appropriate accommodations to students and employees with disabilities. In most cases, JHU will require documentation of the disability and the need for the specific requested accommodation.

The Disability Services program within the Office of Institutional Equity oversees the coordination of reasonable accommodations for students and employees with disabilities, and serves as the central point of contact for information on physical and programmatic access at the University. More information on this policy may be found at the Disabilities Services website or by contacting (410) 516-8075.

Disability Services

Johns Hopkins Engineering for Professionals is committed to providing reasonable and appropriate accommodations to students with disabilities.

Students requiring accommodations are encouraged to contact Disability Services at least four weeks before the start of the academic term or as soon as possible. Although requests can be made at any time, students should understand that there may be a delay of up to two weeks for implementation depending on the nature of the accommodations requested.

Requesting Accommodation

New students must submit a Disability Services Graduate Registration Form along with supporting documentation from a qualified diagnostician that:

- Identifies the type of disability
- Describes the current level of functioning in an academic setting
- Lists recommended accommodations

Questions about disability resources and requests for accommodation at Johns Hopkins Engineering for Professionals should be directed to:

EP Disability Services
Phone 410-516-2306
Fax 410-579-8049
E-mail ep-disability-svcs@jhu.edu