PHY370 Advanced Mathematical Methods of Physics

Gustavus Adolphus College Spring 2020

Instructor: Dr. Steven Mellema

Office: Olin Hall 210 **Office Hours:** MTWRF 11:30am-12:20pm

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Textbooks:

Mathematical Methods for Scientists and Engineers, by Donald McQuarrie, University Science Books, ©2003

Mathematical Handbook of Formulas and Tables, by Murray R. Spiegel (Schaum's Outline Series)

Course Description and Objectives:

In this course we extend the development of mathematics to topics essential in advanced physics and engineering. The course includes topics in linear algebra, differential equations, Sturm-Liouville theory, and special functions, and explores both analytical and numerical techniques. Practical objectives are:

1. to expose the student to the formalism of the theories and involve them in handling the operational techniques of problem solving;

2. to prepare students for the study of quantum mechanics in their senior year, using Dirac notation to connect both the matrix and eigenfunction representations; and

3. to build upon the mathematical techniques introduced in previous mathematics and physics courses, and to prepare the student for the mathematical level of introductory graduate courses in physics and engineering.

Course Policy and Evaluation:

1. **Class Meetings and Reading Assignments**: The class will meet five days a week from 9:00-9:50AM for lecture, small-group problem solving, homework review and, occasionally, for exams. Attached is a daily calendar of activities for the course. When reading assignments are made for a class session, the reading is expected to be completed **before** coming to the class.

2. **Homework**: Homework problems will be assigned according to topics from the textbook, and are due at the beginning of class on the due date listed on the calendar. Late homework may be accepted at the discretion of the instructor with a reduction in credit of 20% per week.

3. **Use of Computers for Homework**: Occasionally homework problems will be assigned which require a numerical solution. These problems will be specifically assigned as computer problems. For the solutions of these computer problems, you may use any computational tools with which you are familiar, including Mathematica, Python, MATLAB, etc. However, **for non-numerical problems involving algebra and calculus, the use of Mathematica or other Computer Algebra/Calculus Systems is forbidden**. **No credit for such problems will be given for solutions done by Mathematica.**

4. **Group Problems**: Frequently in class, students will work together, in assigned groups of 3-4 members, to cooperatively solve problems. A group solution will be submitted, with all group members receiving the same grade. There will be no make-up for group problems missed due to absence.

5. **Problem Presentations**: After completing the lectures for each topic in the textbook, we will take one day to have example problem solutions presented to and discussed by the class. These problems will be assigned to specific student presenters approximately one week in advance, and all students will take turns to present problem solutions. Students will earn credit both for their presentations and for their thoughtful discussion of others' presentations.

6. **Attendance** : Regular attendance at all class meetings is expected. Students will be held responsible for informing themselves of all announcements/assignments made in class.

7. **Use of Electronic Devices in Class:** The use of cellular phones, tablets, and laptop computers during the lectures is prohibited. Exceptions may be made to accommodate student accessibility.

8. **Exams :** There will be four hour exams and a two-hour final exam (see the calendar below). Students must arrange **in advance** to take an exam at other than the scheduled time, and may do so **only** for a valid health or school-related reason. (It is the responsibility of the student to inform the instructor during the first week of the semester regarding any anticipated absences due to required field trips, athletic events, musical performances, or other extra-curricular activities.) Exams missed without pre-arrangement are entered as zero credit and cannot be made up.

9. **Evaluation** :

Homework	25%
Group Problems	10%
In-Class Problem Presentations	10%
Hour Exams	10% each
Final Exam	15%

Assignment of final letter grades will be based upon the following guidelines:

	B+ = 86-90%	C+ = 74-78%	D+ = 62-66%
A = 94-100%	B = 82-86%	C = 70-74%	D = 58-62%
A- = 90-94%	B- = 78-82%	C- = 66-70%	

10. **Incompletes** : A grade of incomplete will **only** be given for work not completed due to circumstances beyond the control of the student (*this is the College policy*).

11. **Academic Honesty**: Having signed and agreed to abide by the College's Honor Code, students thereby pledge that, in all academic exercises, examinations, papers, and reports, they shall submit their own work. Footnotes, or some other acceptable form of citation must accompany any use of another's words or ideas. In the context of this course, students are expected to collaborate and to discuss their out-of-class assignments. However, submitting under one's own name work that is merely copied from another is a violation of the Honor Code. (Full descriptions of the Academic Honesty Policy and the Honor Code can be found in the Academic Catalog, online at https://gustavus.edu/general_catalog/current/acainfo. For more information about the Honor Code, contact Dean Valerie Banschbach (vbanschbach@gustavus.edu or x7541).

12. **Accessibility Resources:** Gustavus Adolphus College is committed to ensuring equitable and inclusive learning environments for all students. If you have a disability and anticipate or experience barriers to equal access, please speak with the accessibility resources staff about your needs. A disability may include mental health, attentional, learning, chronic health, sensory, physical, and/or short-term conditions. When appropriate, staff will guide students and professors in making accommodations to ensure equal access. Accommodations cannot be made retroactively; therefore, to maximize your academic success at Gustavus, please contact them as early as possible. Accessibility resources staff are located in the Academic Support Center (https://gustavus.edu/care/accessibility/). Accessibility Resources Coordinator, Katy Clay, (clayk@gustavus.edu) (x7227), can provide further information.

13. **Help for Multilingual Students:** Some Gusties may have grown up speaking a language (or languages) other than English at home. If so, we refer to you as "multilingual." Your multilingual background is an incredible resource for you, and for our campus, but it can come with some challenges. You can find support through the Center for International and Cultural Education's (https://gustavus.edu/cice/) Multilingual and Intercultural Program Coordinator (MIPC), Carly Overfelt (overfelt@gustavus.edu). Carly can meet individually for tutoring in writing, consulting about specific assignments, and helping students connect with the College's support systems. If you want help with a specific task (for example, reading word problems on an exam quickly enough or revising grammar in essays), let your professor and Carly know as soon as possible. In addition, the Writing Center (https://gustavus.edu/writingcenter/) offers tutoring from peers (some of whom are themselves multilingual) who can help you do your best writing.

FEBRUARY2020

SUBJECT Advanced Math Methods PERIOD 2

	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SAT/SUN
						1/2
	3 No Class – Touring Week	4 No Class – Touring Week	5 No Class – Touring Week	6 No Class – Touring Week	7 No Class – Touring Week	8/9
WEEK 1	10 Classes begin; Syllabus and Introduction to Infinite Series Sections 2.1-2.3	11 Alternating Series Sections 2.4-2.5	12 Power Series Sections 2.6-2.8	13 The Gamma and Beta Functions Sections 3.1-3.2	14 The Error Function and Elliptic Integrals Sections 3.3, 3.5	15/16
WEEK 2	17 The Dirac Delta Function Section 3.6	18 Problem Presentations: Chapters 2&3	19 Determinants Chapters 2-3 Homework due Section 9.1	20 Gaussian Elimination Section 9.2	21 Matrices Section 9.3	22/23
WEEK 3	24 The Rank of a Matrix Section 9.4	25 Vector Spaces Sections 9.5-9.7	26 Problem Presentations: Chapter 9	27 Transformations Chapter 9 Homework Due Section 10.1	28 Eigenvalues and Eigenvectors Section 10.2	29

MARCH2020

SUBJECT Advanced Math Methods PERIOD 2

	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SAT/SUN
						1
WEEK 4	2 Applied Eigenvalue Problems Section 10.3	3 **Hour Exam #1 (Ch. 2,3,9)**	4 Change of Basis Section 10.4	5 Matrix Diagonalization Section 10.5	6 Quadratic Forms Section 10.6	7/8
WEEK 5	9 Problem Presentations: Chapter 10	10 First-Order ODE's Chapter 10 Homework due Section 11.1	11 First-Order ODE's Section 11.2	12 Second-Order ODE's with Constant Coefficients Section 11.3-11.4	13 Systems of Linear Differential Equations Section 11.6	14/15
WEEK 6	16 Numerical Solutions to ODE's	17 Problem Presentations: Chapter 11	18 Frobenius' Method Chapter 11 Homework due Sections 12.1-12.2	19 Legendre's Equation Section 12.3	20 Singularities Section 12.4	21/22
WEEK 7	23 Bessel's Equation Section 12.5	24 Bessel Functions Section 12.6	25 Problem Presentations: Chapter 12	26 Phase Plane Chapter 12 Homework due Section 13.1	27 Critical Points Section 13.2	28/29
WEEK 8	30 Stability of Critical Points Section 13.3	31 **Hour Exam #2 (Ch. 10-12)**				

APRIL2020

SUBJECT Advanced Math Methods PERIOD 2

	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SAT/SUN
WEEK 8			1 Nonlinear Oscillators Section 13.4	2 Population Dynamics Section 13.5	3 Problem Presentations: Chapter 13	4/5
	6 No Class – Spring Break	7 No Class – Spring Break	8 No Class – Spring Break	9 No Class – Spring Break	10 No Class – Spring Break	11/12
WEEK 9	13 No Class – Spring Break	14 Legendre Polynomials Chapter 13 Homework due Section 14.1	15 Orthogonal Polynomials in General Section 14.2	16 Sturm-Liouville Theory Section 14.3	17 Eigenfunction Expansions Section 14.4	18/19
WEEK 10	20 Green's Functions Techniques Section 14.5	21 Problem Presentations: Chapter 14	22 Fourier Series Chapter 14 Homework due Section 15.1	23 Fourier Sine/Cosine Series Section 15.2	24 Convergence of Fourier Series Section 15.3	25/26
WEEK 11	27 Fourier Series and ODE's Section 15.4	28 Problem Presentations: Chapter 15	29 Partial Differential Equations Chapter 15 Homework due Sections 16.1-16.2	30 The One-Dimensional Wave Equation Section 16.3		

MAY2020

SUBJECT Advanced Math Methods PERIOD 2

	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SAT/SUN
WEEK 11					1 Two-Dimensional Wave Equation Section 16.4	2/3
WEEK 12	4 **Hour Exam #3 (Ch. 13-15)**	5 The Heat Equation Section 16.5	6 The Schrödinger Equation Section 16.6	7 Problem Presentations: Chapter 16	8 Laplace Transforms Chapter 16 Homework due Section 17.1	9/10
WEEK 13	11 Laplace Inverse Transforms Section 17.2	12 Laplace Transforms and ODE's Section 17.3	13 Laplace Transforms and PDE's Section 17.4	14 Fourier Transforms Section 17.5	15 Fourier Transforms and PDE's Section 17.6	16/17
WEEK 14	18 Problem Presentations: Chapter 17	19 Chapter 17 Homework due	20 **Hour Exam #4 (Ch. 16-17)**	21 No Class – Reading Day	22	23/24 **Final Exam Saturday 1:00-3:00 PM**
	25	26	27	28	29	30/31