PHY370 Advanced Mathematical Methods of Physics

Gustavus Adolphus College Spring 2018

Instructor: Dr. Steven Mellema

Office: Olin Hall 210 **Office Hours:** MTWRF 8:30-9:50am

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Textbooks:
Mathematical Methods for Physicists 7th Edition, by Arfken, Weber and Harris, Academic Press, ©2013

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 11:30AM-12:20PM 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.

3. **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.

4. **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.

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

6. **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.

7. **Evaluation** :

Homework	25%
Group Problems	7.5%
In-Class Problem Presentations	7.5%
Hour Exams	10% each
Final Exam	20%

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%	

8. **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*).

9. **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. 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. (The full text of the Gustavus Academic Honor Code Policy may be found at: https://gustavus.edu/general_catalog/current/acainfo).

10. **Disability Services**: Gustavus Adolphus College is committed to ensuring the full participation of all students in its programs. If you have a documented disability (or you think you may have a disability of any nature) and, as a result, need reasonable academic accommodation to participate in class, take tests or benefit from the College's services, then you should speak with the Disability Services Coordinator, for a confidential discussion of your needs and appropriate plans. Course requirements cannot be waived, but reasonable accommodations may be provided based on disability documentation and course outcomes. Accommodations cannot be made retroactively; therefore, to maximize your academic success at Gustavus, please contact Disability Services as early as possible. Disability Services (https://gustavus.edu/advising/disability/) is located in the Center for Academic Resources & Enhancement (CARE). Disability Services Coordinator Kelly Karstad (kkarstad@gustavus.edu or x7138) can provide further information.

11. **Help for Students Whose First Language is not English**: Support for Multilingual students is available via the Multilingual and Intercultural Program Coordinator. Please schedule appointments by phone at x7545 or by email to Carly Overfelt (coverfel@gustavus.edu).

FEBRUARY2018

Subject PHY370 Period 4

	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SAT/SUN
				1	2	3/4
	5	6	7	8	9	10/11
WEEK 1	12 Syllabus; Introduction Infinite Series Section 1.1	13 Series of Functions Section 1.2	14 Binomial Theorem Sections 1.3, 1.6	15 Dirac Delta Function Section 1.11	16 Gamma Function; Error Function Sections 13.1, 13.6	17/18
WEEK 2	19 Elliptic Integrals Section 18.8	20 Problem Presentations on Series and Special Functions	21 Determinants **Homework 1 Due** Section 2.1	22 Matrices Section 2.2	23 Dirac Notation Section 2.2	24/25
WEEK 3	26 3D Vector Spaces Sections 3.1-3.2	27 Coordinate Transformations Section 3.3	28 Rotations Section 3.4			

MARCH2018

Subject PHY370

WEEK	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SAT/SUN
3				1 Problem Presentations on Matrices and Vector Spaces	2 Function Spaces **Homework 2 Due**	3/4
					Section 5.1	
4	5 Gram-Schmidt Orthogonal-ization	6 **Hour Exam 1: Series, Special Functions; Vectors**	7 Operators	8 Operator Transformations	9 Problem Presentations on Vector Spaces	10/11
	Section 5.2		Section 5.3	Sections 5.4.5.5		
5	12 Eigenvalue Problems **Homework 3 Due**	13 Matrix Diagonalization	14 Normal Matrices	15 Applied Eigenvalue Problems	16 Problem Presentations on Linear Algebra	17/18
	Sections 6.1-6.2	Sections 6.3-6.4	Section 6.5	McQuarrie 10.3		
6	19 Linear, First-Order ODE's **Homework 4 Due**	20 Linear, Second-Order ODE's	21 Numerical Solutions to ODE's	22 Numerical Solutions to ODE's	23 Frobenius' Method	24/25
	Sections 7.1-7.2	Sections 7.3-7.4			Section 7.5	
7	26 Frobenius' Method	27 Problem Presentations on Linear ODE's	28 Sturm-Liouville Theory **Homework 5 Due**	29 **Hour Exam 2: Linear Algebra, ODE's**	30 **No Class: Spring Break**	31
	Section 7.5		Sections 8.1-8.2			

APRIL2018

Subject PHY370

	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SAT/SUN
						1
WEEK 8	2 **No Class: Spring Break**	3 **No Class: Spring Break**	4 **No Class: Spring Break**	5 **No Class: Spring Break**	6 **No Class: Spring Break**	7/8
WEEK 9	9 Eigenvalue Problems Revisited Section 8.3	10 Fourier Series Section 19.1	11 Applications of Fourier Series Sections 19.2-19.3	12 Problem Presentations on Sturm-Liouville Theory	13 The Logistic Map **Homework 6 Due** Section 33.1	14/15
WEEK 10	16 Phase Space Section 33.2	17 Autonomous Differential Equations Section 33.4	18 Chaos in Dynamical Systems Section 33.5	19 Problem Presentations on Nonlinear Diff. Equations	20 First and Second Order PDE's Sections 9.1-9.3	21/22
WEEK 11	23 Separation of Variables Section 9.4	24 Laplace, Poisson, and Wave Equations Sections 9.5-9.6	25 Helmholtz and Heat Equations Section 9.7	26 Problem Presentations on PDE's	27 Green's Functions **Homework 7 Due** Section 10.1	28/29
	30 Bessel Functions Sections 14.1-14.2					

MAY2018

Subject PHY370

	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SAT/SUN
WEEK 11		1 **Hour Exam 3: Sturm-Liouville Theory; PDE's**	2 Neumann and Hankel Functions	3 Spherical Bessel Functions	4 Problem Presentations: Bessel Functions	5/6
			Sections 14.3-14.4	Section 14.7		
WEEK 12	7 Legendre Functions **Homework 8 Due**	8 Multipole Expansion	9 Spherical Harmonics	10 More Special Functions	11 Problem Presentations: Special Functions	12/13
	Sections 15.1-15.2	Section 15.3	Sections 15.4-15.5	Sections 18.1-18.3		
WEEK 13	14 Fourier Transforms **Homework 9 Due**	15 Fourier Transforms	16 Laplace Transforms	17 Laplace Transforms	18 Properties of Laplace Transforms	19/20
	Sections 20.1-20.2	Sections 20.3-20.4	Section 20.7	Section 20.7	Section 20.8	
WEEK 14	21 Properties of Laplace Transforms	22 Problem Presentations: Integral Transforms	23 **Hour Exam 4: Special Functions; Integral Transforms**	24 **No Class: Reading Day**	25 **Final Exam: 8:00-10:00 AM (Compre-hensive)**	26/27
	Section 20.8		**Homework 10 Due**			
	28	29	30	31		