PHY225 The Quantum Universe

Gustavus Adolphus College Spring 2023

Instructor: Dr. Steven Mellema **Office:** Olin Hall 210

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Textbook: *Modern Physics for Scientists and Engineers* (2nd Edition), by Taylor, Zafiratos and Dubson

Course Policy and Evaluation:

1. **Class Meetings and Reading Assignments**: The class will meet five days a week from 11:30 am-12:20 pm. Class meetings will be either in person or online via Zoom meeting. Usually, four periods per week will be used for lecture, recitation or homework review. Class periods on the fifth day will be used for group problem-solving sessions or for exams. Attached is a daily calendar of all activities and reading assignments 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. "**Lectures":** The lectures for this course **will not** be used simply to repeat material covered in the textbook. I will assume that each student is capable of reading and understanding the textbook, which has been chosen for its clarity and completeness of presentation. (Of course, questions about areas that were unclear when you read the textbook are always encouraged during class time!) Class time will be spent exploring in greater depth the concepts introduced in the textbook using demonstrations, discussion, and "Conceptests". We will also devote time to examining and developing problem-solving techniques through additional worked examples.

3. **Pre-class, Online Reading Quizzes:** On each class day for which a reading assignment is given on the calendar, each student is required to take an online quiz to demonstrate that he/she has read and obtained a basic understanding of the material in the textbooks for the next lecture.

   These quizzes will be conducted using the WebAssign program (accessible at **webassign.net**). The day's reading quiz may be accessed at least 24 hours in advance, and **must be completed 15 minutes before class starts, i.e. at 11:15 am.**

   You will need to purchase a WebAssign code, either from the Book Mark or online at webassign.net. The WebAssign class key for this course is: **gustavus 5759 6807. (**You can use WebAssign for 10 days before purchasing and entering the registration code.)

   Each student should self-enroll at webassign.net for the course PHY225-001 using that class key.

4. **Use of Moodle:** The course Moodle site is the main communications platform for this class, and should be accessed several times a week. Students will be held responsible for informing themselves of all announcements/assignments made via Moodle.

5. **Homework**: Homework problems will be due approximately once per week, and written solutions are due at the beginning of class on the assigned date. (See the complete list of homework assignment due dates in the calendar below.) Late homework may be accepted at the discretion of the instructor with a reduction in credit of 20% per week.

6. **Group Problem Solving:** Approximately once per week, students will work in assigned groups of three or four to solve difficult problems in a cooperative-learning setting. These sessions will require each group to submit a solution in a particular format, using the five-step physics problem-solving method previously taught. The entire group will receive one grade for their solution, with the grade depending on adherence to the problem-solving method.

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

8. **Exams:** There will be four one-hour exams and a two-hour final exam. The date for each of the exams is given in 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.

9. **Evaluation** :

Homework	25%
Online Reading Quizzes	10%
Group Problem Solutions	10%
Hour Exams	10% each
Final Exam	15%
Total	100%

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.

11. **Alignment with MN Teacher Education Standards**: This course fulfills some of the requirements for a MN Teaching License. A list of these standards, and the content within this course can be found at https://gustavus.edu/physics/Syllabi.php

12. **Academic Honesty**: Having signed and agreed to abide by the College's Honor Code, students thereby pledge that, in all academic exercises and examinations, 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. Furthermore, seeking outside assistance during exams is expressly

forbidden. A full description of the Academic Honesty Policy and the Honor Code can be found in the Academic Catalog (online at:www.gustavus.edu/general_catalog/current/acainfo).

13. **Requesting Accommodations**: 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. Students with a documented elevated risk of COVID-19 may also request academic accommodations. 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/asc/accessibility/) (x7138). Accessibility Resources Coordinator, Corrie Odland, (codland@gustavus.edu), can provide further information.

14. **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), Pam Pearson (ppearson@gustavus.edu). Pam 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 Pam 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.

15. **Departmental Expectations:** As is expected in any course in the physics department, each student is asked to work, along with the instructor and their student peers, to develop a culture of cooperation and inclusion within our department. The physics major can be challenging, and we all need the respect and support of others. While it would be unreasonable to assume that every single person will develop a close working relationship with every other, it is expected that each individual will be supportive of, and a positive influence on, every member of the departmental community that they encounter.

FEBRUARY2023

subject QUANTUM UNIVERSE **period** 4

	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SAT/SUN
			1	2	3	4/5
WEEK 1	6 Classes begin; Syllabus and Introduction Read: Sections 1.1-1.6	7 Time Dilation Sections 1.7-1.9	8 Length Contraction Sections 1.10-1.12	9 Velocity Addition Sections 1.13-1.14	10 Group Problem: Relativistic Kinematics	11/12
WEEK 2	13 Relativistic Momentum Chapter 1 Homework due Read: Sections 2.1-2.4	14 Relativistic Mass-Energy Sections 2.5-2.7	15 Classical Limits Sections 2.8-2.9	16 General Relativity Sections 2.10-2.11	17 Group Problem: Relativistic Dynamics	18/19
WEEK 3	20 *World Within World* Chapter 2 Homework due Read: Sections 3.1-3.5	21 Atomic Theory Sections 3.6-3.9	22 Experimental Confirmation Sections 3.10-3.11	23 The Nuclear Atom Sections 3.12-3.13	24 **Hour Exam #1 (Chapters 1-2)**	25/26
WEEK 4	27 Quantization Chapter 3 Homework due Read: Sections 4.1-4.5	28 Wave-Particle Duality Sections 4.6-4.7				

MARCH2023

subject QUANTUM UNIVERSE period 4

	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SAT/SUN
WEEK 4			1 Atomic Spectra	2 Other Evidence for Quantization	3 Group Problem: Quantization	4/5
Read:			Sections 5.1-5.6	Sections 5.7-5.10		
WEEK 5	6 Matter Waves Chapters 4-5 Homework due	7 Wave Functions	8 Wave Packets and Uncertainty	9 Velocity of a Wave Packet	10 Group Problem: Matter Waves	11/12
Read:	Sections 6.1-6.3	Sections 6.4-6.6	Sections 6.7-6.8	Sections 6.9-6.10		
WEEK 6	13 Schrödinger Equation Chapter 6 Homework due	14 One-Dimensional Examples	15 Harmonic Oscillator	16 **Hour Exam #2 (Chapters 3-6)**	17 Quantum Tunneling	18/19
Read:	Sections 7.1-7.5	Sections 7.6-7.7	Sections 7.8-7.9		Sections 7.10-7.11	
WEEK 7	20 Three Dimensions Chapter 7 Homework due	21 Central Force Problem in Three Dimensions	22 The Hydrogen Atom	23 Atomic Shells	24 Group Problem: Quantum Mechanics	25/26
Read:	Sections 8.1-8.3	Sections 8.4-8.5	Sections 8.6-8.8	Sections 8.9-8.10		
WEEK 8	27 Electron Spin Chapter 8 Homework due	28 The Zeeman Effect	29 Multielectron Atoms	30 The Periodic Table	31 Group Problem: Atomic Physics	
Read:	Sections 9.1-9.5	Sections 9.6-9.8	Sections 10.1-10.5	Sections 10.6-10.9		

APRIL2023

subject QUANTUM UNIVERSE **period** 4

	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SAT/SUN
						1/2
	..					
	3 **No Class: Spring Break**	4 **No Class: Spring Break**	5 **No Class: Spring Break**	6 **No Class: Spring Break**	7 **No Class: Spring Break**	8/9
	Read:					
WEEK 9	10 Atomic Transitions Chapters 9-10 Homework due	11 Time-Dependent Perturbation Theory	12 Selection Rules	13 Lasers	14 Group Problem: Atomic Transitions	15/16
	Read: Sections 11.1-11.4	Section 11.5	Sections 11.6-11.8	Sections 11.9-11.10		
WEEK 10	17 Molecules Chapter 11 Homework due	18 Semi-conductors	19 Super-conductors	20 Group Problem: Atoms, Molecules and Solids	21 **Hour Exam #3 (Chapters 7-11)**	22/23
	Read: Sections 12.1-12.5	Sections 14.1-14.4	Sections 14.7-14.8			
WEEK 11	24 *Knowledge or Certainty* Chapters 12-14 Homework due	25 Nuclear Properties	26 The Liquid Drop Model	27 The Shell Model	28 Radioactivity	29/30
	Read:	Sections 16.1-16.4	Sections 16.5-16.7	Sections 16.8-16.9	Sections 17.1-17.4	

MAY2023

subject QUANTUM UNIVERSE **period** 4

	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SAT/SUN
WEEK 12	1 Nuclear Reactions Chapter 16 Homework due	2 *The Manhattan Project*	3 Fission and Fusion **MayDay! Schedule (12:10-12:40)**	4 Radiation Safety	5 Group Problem: Nuclear Physics	6/7
	Read: Sections 17.5-17.6	Sections 17.7-17.9	Sections 17.10-17.11	Sections 17.12-17.13		
WEEK 13	8 Elementary Particles Chapter 17 Homework due	9 The Fundamental Forces	10 Quantum Exchange Models	11 Particle Accelerators	12 Group Problem: Elementary Particles	13/14
	Read Sections 18.1-18.3	Sections 18.4-18.7	Sections 18.8-18.9	Sections 18.10-18.11		
WEEK 14	15 Chapter 18 Homework due Looking Back: The Cosmic Universe	16 Looking Forward: Supersymmetry?	17 **Hour Exam #4 (Chap. 12-18)**	18 Final Exam Review	19 **No Class: Reading Day**	20/21
	Read					
	22 **Final Exam: 1:00-3:00 pm**	23	24	25	26	27/28
	29	30	31			