

Elementary Particles (PHY 290)

Spring 2017

Dr. Scott N. Walck

Contact Information

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Course Description

What is matter ultimately made of at the smallest scale? What are mesons, neutrinos, quarks, leptons, baryons, and intermediate vector bosons? This course will explore elementary particles and their interactions. Topics include symmetries, conservation laws, Feynman diagrams, and quantum electrodynamics. 3 credits.

Learning Objectives

It is expected that students will

1. describe physical situations using the language of Feynman diagrams
2. describe light as a photon
3. interpret the behavior of elementary particles in terms of their fundamental interactions
4. apply special relativity and Feynman diagrams to specific physical situations
5. apply Feynman diagrams to calculate particle lifetimes
6. apply Feynman diagrams to calculate scattering cross sections
7. calculate decay rates and scattering cross sections
8. explain the interactions at play in elementary particle reactions

IDEA Objectives

1. Learning fundamental principles and theories, in particular quantum electrodynamics
2. Gaining factual knowledge and terminology, especially properties of elementary particles
3. Learning to apply Feynman diagrams to calculate decay rates and cross sections

Textbook

The textbook for the course is *Introduction to Elementary Particles* (second edition), by David Griffiths, Wiley-VCH (year), ISBN 978-3-527-40601-2.

Exams

There will be three 50-minute exams during the normal class time. There will also be a comprehensive final exam. No computers, cell phones, music players, or any electronic devices with wireless or network capability are allowed during exams. You will be allowed to use a calculator during exams.

Homework

The homework is the centerpiece of this course. It is in doing the homework problems that you will begin to understand elementary particle theory. Give the homework problems the time they deserve. I expect that many of the problems I am asking you to work will take about one hour each. I would not ask you to do these problems if I didn't believe that the process was worth your time. You cannot succeed with this subject if you wait until the day before the homework is due to start. Start the homework a week before the due date by reading the problems and seeing if you can do any of them. Come to me with questions, or if you get stuck.

You may work together on the homework, talking about how to solve the problems, but you must write your homework solutions independently. Do not copy homework solutions from the web, from your classmates, or from a white board in which you have worked together on a problem. If you work together on a white board, stare at the white board until you understand the process, then go somewhere alone and see if you can do it yourself.

Copying another person's homework solutions is an act of cheating and plagiarism. Submitting your own work for the homework will cause you to learn elementary particle theory. Everything that you write in your homework solutions you should be able to explain to me if I were to ask. This does not mean that your homework needs to be perfect, only that it must have come from your mind.

If you can't finish some of the problems before the due date, turn in what you have done. It is still worth trying to do the remaining problems, because they all have a purpose. If you know in advance that you will have trouble finishing the homework by the deadline, come and talk to me.

Class Participation

A portion of your grade is determined by class participation. Obviously, attendance is a prerequisite for participation in class. If you attend every class, and participate by preparing summaries, asking questions, writing problems, answering questions, and taking your turn in doing problems at the board, you will have a perfect score for this area. If you need to miss a class, see me in advance and I'll give you an alternative assignment.

Grading

Your grade will be determined by a weighted average as indicated in the table below.

Exams	45%
Homework	30%
Class Participation	10%
Final Exam (comprehensive)	15%

Your letter grade for the course is determined by the weighted average. The minimum weighted average (out of 100) required for each letter grade is indicated below.

A	93
A-	90
B+	87
B	83
B-	80
C+	77
C	73
C-	70
D+	67
D	63
D-	60
F	0

Office Hours

Please feel free to stop by my office any time to chat. I will make a special effort to be in my office during the office hours posted on my door (also listed on my web page). We can also make an appointment to get together if that is convenient for you.

Disabilities Services Syllabus Statement

If you have a physical, medical, psychological, or learning disability that is going to impact your attendance or require accommodation, please let me know. In order to ensure that your learning needs are appropriately met, you will need to provide documentation of your disability or medical condition to the Director of Disability Services. The Office of Disability Services will then provide a letter of verification of disability that describes the accommodations needed for this class. This office is located in the Humanities Building, room 04, and the Director may be reached by phone at 717-867-6071.

Academic Honesty

Any student who submits plagiarized work will be subject to the penalties described in the Student Handbook and outlined in LVC's "Academic Honesty Policy" (<http://www.lvc.edu/catalog/acad-reg-procedures.aspx>). This code asks each student to do his/her own work in his/her own words.

A student shall neither hinder nor unfairly assist the efforts of other students to complete their work. All individual work that a student produces and submits as a course assignment must be the student's own. Cheating and plagiarism are acts of academic dishonesty.

Cheating is an act that deceives or defrauds. It includes, but is not limited to, looking at another's exam or quiz, using unauthorized materials during an exam or quiz, colluding on assignments without the permission or knowledge of the instructor, and furnishing false information for the purpose of receiving special consideration, such as postponement of an exam, essay, quiz or deadline of an oral presentation.

Plagiarism is the act of submitting as one's own the work (the words, ideas, images, or compositions) of another person or persons without accurate attribution. Plagiarism can manifest itself in various ways: it can arise from sloppy note-taking; it can emerge as the incomplete or incompetent citation of resources; it can take the form of the wholesale submission of other people's work as one's own, whether from an online, oral or printed source.

Students who take part in violations such as cheating or plagiarism are subject to a meeting with the Associate Dean of Academic Affairs, who has the authority to take further action, up to and including expulsion from the College.

Civility, Respect, Community

LVC aims to be a community of inclusive excellence. We affirm the rights of all persons to a superior educational experience that is characterized by respect for and tolerance of others. This class is a place where our core values of inclusiveness, civility, and appreciation of difference are affirmed.

Class Schedule

Date	Topic	Read before class	Due
01/16	Welcome		
01/18	Mesons	Intro, 1.1 to 1.3	
01/20	Antiparticles	1.4 to 1.7	
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01/23	Quarks	1.8 to 1.11	
01/25	Four Forces	2.1 to 2.3	HW 1
01/27	Weak Interactions	2.4	
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01/30	Conservation Laws	2.5 to 2.6	
02/01	Four-vectors	3.1 to 3.2	HW 2

02/03	Energy and Momentum	3.3	
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02/06	Collisions	3.4	
02/08	Examples	3.5	
02/10	Symmetries	4.1	HW 3
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02/13	Angular Momentum	4.2	
02/15	Exam 1 (Chapters 1 to 3)		
02/17	Flavor Symmetries	4.3	
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02/20	Discrete Symmetries	4.4	
02/22	Schrödinger Equation	5.1	HW 4
02/24	Hydrogen	5.2	
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02/27	Positronium	5.3	
03/01	Quarkonium	5.4	
03/03	Light Quark Mesons	5.5	
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03/06	Spring vacation		
03/08	Spring vacation		
03/10	Spring vacation		
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03/13	Baryons	5.6	
03/15	Decay Rates	6.1	HW 5
03/17	Cross Sections	6.1	
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03/20	Exam 2 (Chapters 4 to 5)		
03/22	Golden Rule	6.2	
03/24	Golden Rule	6.2	
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03/27	Feynman Rules	6.3	
03/29	Feynman Rules	6.3	
03/31	Dirac Equation	7.1 to 7.2	HW 6
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04/03	The Photon	7.3 to 7.4	
04/05	QED	7.5	
04/07	Examples	7.6	
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04/10	Casimir's Trick	7.7	
04/12	Lifetimes	7.8	
04/14	Easter vacation		
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04/17	Easter vacation		
04/19	Renormalization	7.9	
04/21	ValleyFest Weekend		
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04/24	Review		HW 7

04/26 Problems
04/28 **Exam 3 (Chapters 6 to 7)**
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05/01 Review
05/03 Problems