

# Syllabus for PHY493/803, Spring 2018

## Intro to Elementary Particle Physics

Instructor: Wade Fisher  
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Lecture: Monday, Wednesday, Friday: 11:30AM - 12:20 PM  
Office hours: Fridays 1-2pm (or by appointment)  
Lecture Room: BPS 1415

### **Course Summary:**

This course is intended as an introduction to elementary particle physics for advanced undergraduate students. The course is taught from the phenomenological and experimental perspectives, covering details of the underlying theory and the experimental techniques. We will also cover the physics of quarks, leptons and gauge bosons, including the weak, electromagnetic and strong forces. This course will also include a focus on experimental techniques, particle accelerators and modern experimental measurements. The mathematical rigor will be minimal, but students should have a background in quantum mechanics and special relativity.

### **Required Textbook:**

*"Introduction to Elementary Particles"* (Second Edition) D. Griffiths, Wiley-VCH  
ISBN: 978-3-527-40601-2

### **Recommended References:**

- For those who will go on to study particle physics:  
*"Particle Physics"* (Third Edition) B.R. Martin & G. Shaw, WILEY; ISBN 978-0-470-03294-7
- Classic & concise book on special relativity:  
*"Theory of Relativity"* (Third Edition) W. Pauli, Dover; ISBN: 978-0-486-64152-2
- Convenient & free summary of particle physics measurements and reviews of methods:  
*"Review of Particle Physics"*, Particle Data Group
  - Print, read or order for free at <http://pdg.lbl.gov>

## **Reading Assignments, Homework, Quizzes and Exams:**

There is a reading assignment listed in the Course Schedule that is associated with each lecture. There are suggested chapters from the books listed above. Reading is not mandatory, but the homework, in-class quizzes and exams will be based heavily on the reading and not all the material on the homework, quizzes and exams will be covered in the lectures. It is the student's responsibility to be well versed in the assigned reading material.

There will be 7 homework assignments. The homework will be collected at the beginning of class and the **due dates are indicated in the Course Schedule**. Homework handed in late will only be graded in approved circumstances. Questions about homework grading must be brought to the attention of the grader within one week after the homework is returned. No adjustments will be made after one week has elapsed. Disputes about the homework grading will be addressed first by the grader, with any unresolvable issues handled by Prof. Fisher. If you have a documentable reason for not finishing the homework on time (eg, extended illness) you must contact Prof. Fisher immediately to request an extension. Extension of more than one homework assignment is in general not permitted and will only be considered in extreme circumstances.

There will be in-class quizzes (*OPEN book and notes*), which will be administered at the beginning of the class period on a roughly weekly basis. These quizzes will be 10-15 min in duration and will be based on the recommended reading for each class period (which is outlined in the Course Schedule) and on any material covered previous to that week. There are no make-ups for the in-class quizzes. If you miss several quizzes due to a documentable reason, your quiz grade will be assigned as the average of the remaining quizzes. This consideration will only be taken in extreme circumstances.

Three, 50-minute midterm exams (*CLOSED book and notes*) will be given on Feb. 9 (Fri), March 14 (Weds) and April 13 (Fri) (**see the Course Schedule**). The exams will be based on quiz questions, homework, and material presented in the lectures. **There is no final exam**. You may miss one exam due to a documented medical emergency. Make-up exams are not guaranteed and I will determine on a case-by-case basis how to assign a grade for any missed exam. Missing two or more exams will result in a score of zero points for the relevant exams, and exceptions will be considered only in extreme circumstances. In any event that you will miss an exam with a legitimate excuse, you should first inform Prof. Fisher by email in advance.

This class has a strict ban on cellular phones during class and exams. Students who are found to have a cellular phone in their possession for any reason during an exam will receive a score of zero for that assignment. Students are advised to store their cellular phones in the off position in their backpacks or purses for the duration of the class session.

**Please note:** I expect that senior physics majors may be busy visiting and selecting graduate schools in the spring semester. Thus, if you are frequently going to be missing in-class quizzes due to your travels, please communicate that with me as soon as possible in advance. Quizzes are not fixed to any particular day of the week, so please contact me with questions or concerns. Students will not be penalized in their grade for visiting graduate schools.

## **Tier II Writing Assignment (PHY 493):**

Physics 493 is intended to fulfill the Tier II writing requirement for physics majors. Therefore a term paper is assigned. This year we will allow for two options for your paper, which are described in more detail below: (1) a review of an important measurement or (2) an original proposal to improve an existing experimental measurement or theoretical technique. The paper should include necessary equations, figures and a full list of citations. It will be graded on style and grammar as well as physics content and presentation of the material. **The grading rubric to be used is included on page 7 of the syllabus.** The paper should be on a topic from particle physics, at the content level of a Scientific American article, scientifically literate but not too technical. The paper must be an original work, wherein plagiarism is strictly forbidden and is considered a violation of academic honesty.

The first step is to choose a topic for your paper. The topic should be narrow enough so that you can focus on the salient material in the paper length limits. For example, you should not embark on presenting the history of particle physics. If you already have a topic of interest for you in particle physics, you may ask for it to be approved. A list of possible topics is provided on page 6 of the syllabus. Other possible sources of topics include: the textbooks, research seminars, Annual Review of Particle Physics, etc.

Students who choose to write a review of a measurement or theoretical concept should produce a paper 10-13 pages in length. The paper should include an introduction of the topic and a summary of the historical context in which the concept was developed or the measurement was made (eg, the state of particle physics at the time of the discovery of the muon). The paper should discuss the importance of the topic and how it applies to our modern understanding of the relevant field. If the topic involves experimental measurements, the paper should include a discussion of the existing measurements and their uncertainties.

Students who choose to write a proposal to improve an existing measurement should produce a paper 6-8 pages in length. The paper should be in the style of a proposal to a funding agency, wherein the motivation for the improved measurement should be clearly defined. The format should be a description of the related physics, a review of the existing measurements, the proposal for the new measurement and a description of the impact of the improved measurement on our understanding of the relevant physics topic. At least one page must be devoted to a description of the costs associated with the improved measurement (ie, the funds which need to be awarded to perform the measurement). This estimate of the costs should be based on a thoroughly researched and documented concept (ie, it should attempt to be realistic and not imaginary or a "guess"). For example, if you use a number to support costs, you should reference it.

The paper milestones are listed below in the Course Schedule (**See page 5 of the syllabus**). Your topic choice must be approved by Prof. Fisher by February 16 and an outline must be handed in by March 2. A complete first draft is due March 30 and the deadline for the final draft is April 25.

The paper format should be 1-inch margins, 12 pt font and double-spaced lines. Single-spacing and smaller fonts can be utilized when it makes sense to do so or improves readability (eg, figure captions, tables, lists, etc).

## **PHY 803 Students**

Students enrolled in PHY 803 are required to have additional course breadth to qualify for graduate-level credit. This will be achieved in two parts. First, PHY 803 students will have one additional problem for each homework assignment and each exam.

Second, students enrolled in PHY 803 are not required to complete the Tier-II writing requirement. In lieu of the paper students will write an original synopsis of a detailed research paper in particle physics. Specifically, students will choose a paper of at least 20 pages from an approved, peer-reviewed physics journal and summarize the work in a short, letter-format paper of 5-7 pages. This exercise will serve to solidify students' scientific writing skills and awareness of salient aspects in the communication of physics results via publications. Approved journals are Physical Review D ([prd.aps.org](http://prd.aps.org)), Physics Letters B (<http://www.journals.elsevier.com/physics-letters-b/>) or the Journal of High Energy Physics (<http://www.springer.com/physics/particle+and+nuclear+physics/journal/13130>). Examples of short, letter-format papers can be found in Physics Review Letters ([prl.aps.org](http://prl.aps.org)). The paper milestones are listed below in the Course Schedule (**See page 5 of the syllabus**). Your original paper choice must be approved by Prof. Fisher by February 16 and an outline must be handed in by March 2. A complete first draft is due March 30 and the deadline for the final draft is April 25.

## **Grading Policy:**

Your grade will be determined based on your scores on the two exams, your homework, the in-class quizzes and your term paper. A full score for the homework will be based on 90% of the total points, wherein a score of 90% will receive full points and scores below 90% will be prorated accordingly. In the same fashion, the in-class quiz scores will be based on 80% of the total quiz points (allowing for intermittent absences from class). The exams will be graded on a curve determined by the class average. Final grade assignments will be determined based on the mean score in the course after adjusting for corrections and/or documented student absences.

The cumulative grade will be calculated as follows:

Each Midterm Exam:	15% (total 45%)
Homework:	25%
Quizzes:	15%
Paper:	15%

## **Grader:**

The grader for PHY493/803 for Spring 2018 is Kyle Krowpman. His email address is [krowpman@msu.edu](mailto:krowpman@msu.edu). Questions about grading and requests for meetings should be first communicated with Kyle via email with Prof. Fisher copied on the email. Kyle will not have fixed office hours and students can schedule in-person meeting times as needed.

## PHY 493/803 Schedule, Spring 2018

W	D	Date	Subjects Covered	Reading	HW Due	Paper Milestone
1	M	1/8	Intro	Griffiths, Ch1		
	W	1/10	Particles	Griffiths, Ch1		
	F	1/12				
2	M	1/15	MLK Day, No Class!			
	W	1/17	No Class!			
	F	1/19	Particle Dynamics	Griffiths, Ch2		
3	M	1/22				
	W	1/24	Relativity	Griffiths, Ch3	#1	
	F	1/26				
4	M	1/29				
	W	1/31	Symmetries	Griffiths, Ch4		
	F	2/2				
5	M	2/5				
	W	2/7	Bound States	Griffiths, Ch5	#2	
	F	2/9	Exam #1			
6	M	2/12	Feynman Rules	Griffiths, Ch6		
	W	2/14				
	F	2/16				Select Topic
7	M	2/19	Particle Accelerators	PDG Review, Ch 29	#3	
	W	2/21				
	F	2/23	Particle Interactions with Matter	PDG Review, Ch 32		
8	M	2/26				
	W	2/28	Particle Detectors	PDG Review, Ch 33 & 34		
	F	3/2			#4	Outline Due
		3/5-3/9	Spring Break: No Class!			
9	M	3/12	Modern HEP Experiments			
	W	3/14	Exam #2			
	F	3/16	QED	Griffiths, Ch7		
10	M	3/19				
	W	3/21				
	F	3/23	Quark Dynamics	Griffiths, Ch8		
11	M	3/26			#5	
	W	3/28				
	F	3/30	Weak Interactions	Griffiths, Ch9		First Draft Due
12	M	4/2				
	W	4/4				
	F	4/6	Gauge Theories	Griffiths, Ch10		
13	M	4/9			#6	
	W	4/11				
	F	4/13	Exam #3			
14	M	4/16	Neutrinos	Griffiths, Ch11		
	W	4/18				
	F	4/20				
15	M	4/23	The Future!	Griffiths, Ch12		
	W	4/25			#7	Final Draft Due
	F	4/27				
			4/30-5/4: No Final Exam!			

### **Example Research Paper Topics (PHY 493):**

1. Strong CP violation, axions
2. Dark Matter and/or Dark Energy
3. New detector developments
4. Future accelerators & accelerator technology
5. Linear colliders
6. Neutrino-less Double beta decay
7. The discovery of the bottom/top/strange/charm quark
8. The discovery of the positron
9. The discovery of the Higgs boson
10. The discovery of beta decay
11. The discovery of electroweak gauge bosons
12. The discovery of the neutrino
13. The observation of neutrinos from supernova 1987a
14. Neutrino masses and neutrino oscillations
15. Neutrino mixing measurements
16. The “solar neutrino puzzle” and its impact on understanding neutrino oscillations
17. Measurements of the strong coupling constant
18. Tests of parity violation in atomic systems
19. The quark-gluon plasma
20. The search for proton decay
21. The discovery of parity violating weak charged and neutral currents
22. The discovery of time reversal violation and CP violation in neutral kaon systems
23. The discovery of the  $J/\Psi$  vector particle and its impact on the quark model
24. Is the neutrino a Majorana particle?
25. Is the Higgs boson truly responsible for mass generation?

Grading Rubric for the Final Paper

**PHY493, Spring 2018  
Paper Grading Form**

Name:

Paper Format & Length: 20 pts

Spelling & Grammar: 10 pts

Overall Writing Style: 10 pts

Physics Content & Understanding: 50 pts

Originality: 10pts

Demonstration of Physics Understanding: 15 pts

Explanation of Physics Concepts: 15 pts

Clarity and organization of Material: 10 pts

Citations & Accuracy: 10 pts

**Total: \_\_\_\_\_ / 100 pts**