

PHYS 373 Special Topics: Theoretical Physics

Application of mathematical methods to classical, statistical, relativistic, and quantum mechanics, as well as electromagnetic theory. Emphasis is on revealing fundamental structure and connections. The powerful theoretical techniques learned serve as excellent preparation for graduate study in physics, astrophysics, and related fields such as engineering.

Prerequisite: Calculus II (MATH 192) or permission of the instructor.

Instructor: Michael J. Ruiz, Ph.D. in theoretical physics from the University of Maryland.

January 2021

Monday	Tuesday	Wednesday	Thursday	Friday
				1 
4	5	6	7	8
11	12	13	14	15
18 	19 First Class Video: Intro Physics	20	21	22 A. Rotation Matrix, Groups
25 B. What is e? Integral Tricks	26	27	28	29 C. Special Relativity

Text: [Theoretical Physics](#) by Michael J. Ruiz

Lectures: [YouTube](#) (doctorphys)



February 2021

Monday	Tuesday	Wednesday	Thursday	Friday
1 D. Integral Maxwell Equations	2 	3	4	5 E. Differential Maxwell Equations
8 F. Let There Be Light	9 UNCA Break Day	10	11	12 G. Ideal Gas Law
15 H. Statistical Mechanics	16	17	18	19 I. Schrödinger Equation
22 Exam 1 (A-G) 6:00 pm – 7:30 pm	23	24	25	26 J. Spinors



Class Responsibilities and Resources

1. **Website:** <http://www.doctorphys.com/courses/theoretical/>
2. **Text:** [Theoretical Physics](#) (same website location as above)
3. **Videos:** Links www.doctorphys.com/courses/theoretical and at [YouTube](#)
4. **Homework:** Homework sets are due 11:59 pm on the date that is two class letters beyond. For example, Homework for Class A is due the day of Class C; Class B is due Class D, etc. Late Policy: Grace Period until 12 noon the day after the due date; then 10% off per hour until 10 pm, at which point homework cannot be accepted and solutions will be posted. **Name homework files as follows (sample student Marie Curie): 0_Curie.pdf, A_Curie.pdf, B_Curie.pdf, etc. and email to me using my UNCA email address.**
5. **Office Hours:** Zoom Office hours by demand.
6. **Email Help:** Email me questions and I will respond to the class. You will remain anonymous.
7. **Gingerbread Math (2004):** Best Decorated [Gingerbread Prize](#) for Rhoades-Robinson Hall.

Insight into three important math-physics formulas.

$$A = \pi r^2 \quad E = mc^2 \quad e^{i\pi} + 1 = 0$$

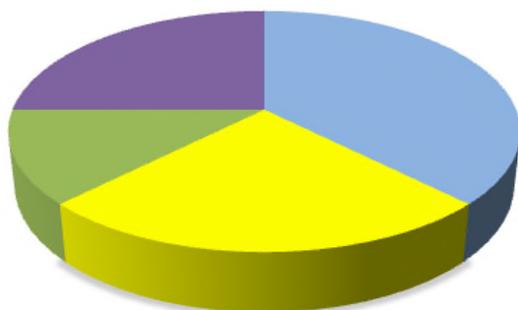


March 2021

Monday	Tuesday	Wednesday	Thursday	Friday
1 K. Pauli Equation	2	3	4	5 L. Dirac Equation
8 M. Orthogonal Functions	9	10 UNCA Break Day	11	12 N. Dirac Delta Function
15 O. Fourier Series	16	17 	18	19 P. Fourier Transforms
22 Exam 2 (H-N) 6:00 pm – 7:30 pm	23	24	25	26 Q. Laplace Transforms
29 R. Convolution	30	31		



Grading



■ Exams ■ Final ■ Best Exam PCT ■ Homework

Borderline Cases: If your grade is near the borderline (10 points away), I will consider helping you if you have come to 90% of the classes and have turned in 90% of the homework. In addition, I may look for a strong performance on the Final Exam, depending on the grade sought after.

100 Exam 1
 100 Exam 2
 100 Exam 3
 200 Final
 100 Best Exam Percentage
200 Homework
 800 **Total** (No ± Grades, See Right)

A (740-800) - apply knowledge in new areas
 B (660-739) - apply knowledge in familiar areas
 C (580-659) - apply knowledge in easy areas
 D (500-579) - misconceptions in principles
 F (0-499) - serious gaps in understanding

April 2021



Monday	Tuesday	Wednesday	Thursday	Friday
			1 	2 S. Cauchy Integral Formula
5 T. Residue Theorem and Poles	6	7	8 UNCA Break Day	9 U. Green's Functions
12 V. Transfer Functions	13	14	15	16 W. Principle of Least Action
19 Exam 3 (O-T) 6:00 pm – 7:30 pm	20	21	22 	23 X. General Relativity & Mercury
26 Y. Feynman: Schrödinger Equation	27 Z. Final Exam Guide	28 Reading Day	29 Final Exam Week Begins	30 UNCA Finals

How to Succeed in Theoretical Physics

1. **Time.** Reserve at least 3 hours (organizing your notes, study, working practice problems, doing homework, etc.) for every hour of class. This amounts to at least 9 hours per week in addition to class time. If you are a full-time student and have a job, you should NOT work more than 15-20 hours per week.

2. **Instructor.** Email me a question if you are confused or would like to call a zoom office hour.

3. **Peers.** You are encouraged to work together as long as you write up your own solutions and they look sufficiently original as your own. You master the material when you are challenged to discuss and explore it with someone else.

4. **Physics.** Watch every class and take notes. Do not fall behind! As my senior high school math teacher once said, the best way to study math is with pencil in hand. Same goes for physics. Write things out. If your notes are sloppy, recopy them. Consult and study the eBook, which has all the material in print form posted for each class. Otherwise, you can quickly get lost.

5. **Homework.** Always state the problem in some way, be neat, do on scrap paper first, never cross out on the version you turn in, and explain your steps so a fellow student can follow. Make sure you write dark and large enough for easy reading. For each question you get +4 for stating the problem and showing all steps with occasional comments, +4 for mathematical and notational accuracy, +2 for neatness (which includes proper handwriting size and legibility).

May 2021

Monday	Tuesday	Wednesday	Thursday	Friday
3 Final Exam Covers A-Z 6:30 pm–9pm	4 Other Finals at UNCA	5 Other Finals at UNCA	6  	7
10	11	12	13	14
17	18	19	20	21
24	25 	26	27	28
31 				



Theoretical Physics (Math Physics)

A general *Theoretical Physics* course is sometimes called Mathematical Physics or Math Physics. Such a course focuses on the mathematical methods employed across many areas of physics, engineering, and related fields. We learn the "tools of the trade" and how to use them. This aim makes our course very powerful as these mathematical tools are used in so many fields, even those outside physics such as economics. A graduate with such knowledge has the power to work in diverse fields.



Richard Feynman (1918-1988)
 Courtesy nobelprize.org

Finally, *theoretical physics* teaches you elegant tricks and offers you deep insight into physics. Richard Feynman, America's most colorful physicist for many years, often pointed out the importance of theoretical physics and using innovative mathematical methods to see things from different points of view. He was often described as a magician when it came to applying mathematics to physics.

This course follows in this spirit, teaching you "magical" math tricks and shortcuts. We also present elegant formulations of the laws of physics, giving you a better appreciation of the power and beauty of physics.