Syllabus
Physics 273 – Advanced Honors Physics III
Fall 2023

Instructor: Prof. Jed Pixley; jed.pixley@physics.rutgers.edu
Lectures: Located in the Science and Engineering Resource Center (SEC) 210 on Mondays and Thursday 10:35am to 11:30am.
Office hours: Tuesday 3:00pm-4:00pm

Course Canvas Site: To be determined
Use Canvas email for course communication.

Course Description

Course 01:750:273 or Advanced Honors Physics III is a 3-credit course that completes the Honors Physics sequence. It covers the topics of Modern Physics, i.e. the physics that was developed in the 20th and 21st centuries. We will cover special relativity, quantum mechanics, atomic physics, and statistical mechanics. We will meet Monday and Thursday 10:35-11:30am in SEC 210. These lectures will cover the concepts and techniques in depth while the sections will have more of a focus on problem solving and advanced homework.

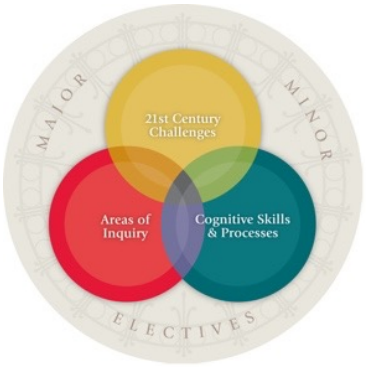
Learning Goals

- Understand the principles of special relativity and how they change the kinematic and dynamical description of matter and light.
- Be able to compute properties of particles moving and scattering at relativistic speeds.
- Understand the experimental evidence for special relativity and non-relativistic quantum mechanics.
- An introduction to the principles of quantum mechanics, with a large focus on explaining relevant experimental observations and atomic theory.
- The ability to compute physical properties of a single quantum mechanical particle based on their wavefunction.

This supports 3 of the 4 learning goals of the Physics and Astronomy department.

- Top 25 % of our Physics majors demonstrate mastery of basic Physics and the ability to solve essential problems appropriate for beginning graduate study in Physics.
- All Physics majors demonstrate knowledge of fundamental Physics principles and are able to quantitatively analyze a broad spectrum of problems presented in a range of undergraduate Physics courses.
- Students who complete our introductory sequence of Physics courses demonstrate an understanding of Physics principles at a basic level.

As well as two aspects of the Core Curriculum Learning Goals of Rutgers University shown in the Venn diagram.



- Areas of inquiry, Natural Sciences.
  NS-1. Understand and apply basic principles and concepts in the physical or biological sciences.
  NS-2. Explain and be able to assess the relationship among assumptions, method, evidence, arguments, and theory in scientific analysis.
- Cognitive Skills and Proceeses, Quantitative and Formal Reasoning.
  QQ. Formulate, evaluate, and communicate conclusions and inferences from quantitative information. (includes various quantitative methods courses as well as 640 courses)
  QR. Apply effective and efficient mathematical or other formal processes to reason and to solve problems. (includes 640 courses and formal reasoning courses)

Prerequisites

- Students are expected to have taken 01:750:271 and 01:750:272 (Honors Physics I and II) the previous year.
- Calculus I and II are required. Mastery of the basic concepts of calculus (differentiation and integration) will be assumed.
- Enrollment in an honors program or permission of the department undergraduate advisor is required.

Assesment

Breakdown of grade contributions

- Homework 25%
- Midterm I 25%
- Midterm II 25%
- Final 25%

Homework

It is expected you are reading the course material specified in the content below prior to class. We will have weekly homework assignments due at the end of the day to be turned into the grader. In working on the problems, you are encouraged to talk with others in the class, but you must write up your own solution. Always show your work. You will not receive full credit if you do not show your work. In general, I am not looking for a specific answer; rather, I am always looking for the reasoning behind the answer.

Homework will be **due by 5:00pm on the day specified in the assignment**. Please submit them via **Canvas that links to WileyPlus**. Homework not turned in by the specified time **will count as zero, NO late homework will be accepted**. Solutions are posted online.

Exams

Two in-class midterms will be held on dates as specified in the syllabus timeline. The final will be held on Dec. 20th from 12-3pm in the PLH. You should bring a scientific calculator for each exam. For the midterms, you are allowed one 8.5x11" formula sheet (both sides) and for the final you are allowed two formula sheets.

Policies

The course schedule and guidelines are subject to change. I will communicate any changes promptly and clearly. Still, it is your responsibility to make yourself aware of any and all changes by attending class and maintaining communication with me.

Students with Disabilities

Please consult the professor as early as possible if you have a disability that might interfere with learning. We will help you as much as possible. The University has coordinators for students with disabilities.

Absences

Students are expected to attend all classes; if you expect to miss one or two classes, please use the University absence reporting website to indicate the date and reason for your absence. An email is automatically sent to your instructors. If you have been told to quarantine, or are experiencing symptoms of any transmissable disease, please do not attend in-person class meetings. Contact me to make arrangements for handling such absences.

Books: required and suggested

- Fundamentals of Physics, 11th Edition by Halliday, Resnick, and Walker is the **required textbook** for this class.
- (T&R) *Modern Physics*, 5th edition by Stephen Thornton and Andrew Rex.
- (K&K) *An Introduction to Mechanics*, 2nd edition by Daniel Kleppner and Robert Kolenkow.
- (Purcell) *Electricity and Magnetism*, 3rd edition by Edward Purcell and David Morin.
- (Griffiths) *Introduction to Quantum Mechanics* by David Griffiths.
- (FL3) Feynman Lectures Vol. III (available online for free by Caltech) will supplement the discussion on quantum mechanics.

Course Content

Tentative homework assignment due dates marked in red and in class demos in blue.

1. Week 1, 9/4-9/8
    - **Th 9/7** : Introduction, Michelson-Morley Experiment.
2. Week 2, 9/11-9/15
    - **M 9/11** Postulates of SR and Lorentz transformations
      Reading: HRW 37-1,37-3
      Demo: MM experiment
    - **Th 9/14**: Lack of simultaneity in SR, time dilation, Lorentz contraction
      Reading: HRW 37-1,37-2,37-3
      HW # 1 Due
3. Week 3, 9/18-9/22
    - **M 9/18**: Lifetime of μ, Velocity transformations
      Reading: HRW 37-1,37-2
      Demo: Cosmic ray chamber

- **Th 9/21**: Doppler shift, twin "paradox"
  Reading: HRW 37-6
  HW # 2 Due

4. Week 4, 9/25-9/29

   - **M 9/25**: Momentum and Energy
     Reading: HRW 37-6
   - **Th 9/28**: Finish momentum and energy, massless particles, start 4-vectors
     Reading: HRW 37-6
     HW # 3 Due

5. Week 5, 10/2-10/6

   - **M 10/2**: four-vectors, Minkowski spacetime, Exam review
   - **Th 10/5**: **Exam I**
     HW # 4 Due

6. Week 6, 10/9-10/13

   - **M 10/9**: Experimental basis of quantum physics: discovery of X-rays and the electron, line spectra
     Reading: HRW 38-1,38-3
     Demo: Diffraction and atomic spectra
   - **Th 10/12**: Experimental basis of quantum physics: Blackbody radiation
     Reading: HRW 38-4

7. Week 7, 10/16-10/20

   - **M 10/16**: Experimental basis of quantum physics: Photoelectric effect
     Reading: HRW 38-4
     Demo: The photoelectric effect
     HW # 5 Due
   - **Th 10/19**: Experimental basis of quantum physics: x-ray production, Compton scattering
     Reading: HRW 38-3

8. Week 8, 10/23-10/29

   - **M 10/23**: Finish Experimental basis of quantum physics: with pair production and annihilation
     HW # 6 Due
   - **Th 10/26**: Wave nature of matter: De-Broglie wavelength, X-ray and electron diffraction
     Reading: HRW 38-5

9. Week 9, 10/30-11/3

   - **M 10/30**: Wave nature of matter: Double slit experiment, Heisenberg's uncertainty principle
     Reading: HRW 38-7
     HW # 7 Due
   - **Th 11/2**: Quantum Mechanics: The Schrodinger Equation
     Reading: HRW 38-6

10. Week 10, 11/6-11/10

    - **M 11/6**: Quantum Mechanics: The infinite square well.
      Reading: HRW 39-1, 39-2
      HW # 8 Due

- **Th 11/9**: Quantum Mechanics: The finite square well
  Reading: HRW 39-3

11. Week 11, 11/13-11/17

    - **M 11/13**: Quantum Mechanics: Barriers and tunneling
      Reading: HRW 38-8, 38-9
      HW # 9 Due
    - **Th 11/16**: 2D and 3D Schrödinger equation, Exam Review
      Reading: HRW 39-4

12. Week 12, 11/20-11/24

    - **M 11/20**: **Midterm Exam II**
      HW # 10 Due
    - **Th 11/23**: NO CLASS, Happy Thanksgiving!

13. Week 13, 11/28-12/2

    - **Mo 11/27**: Bohr's model of the Hydrogen atom
      Reading: HRW 39-5
    - **Th 11/30**: Quantum mechanical solution of the Hydrogen atom
      Reading HRW 39-5

14. Week 14, 12/4-12/8

    - **M 12/4**: Angular momentum and spin
      Reading: HRW 40-1
      HW # 11 Due
    - **Th 12/7**: Zeeman effect and atomic orbitals

15. Week 15, 12/12-12/16 **Last day of class 12/13**

    - **Mop 12/11**: identical particles and the periodic table
      HW # 12 Due ON LAST DAY OF CLASS 12/13
      Demo: The Meissner effect

Resources for Students

The faculty and staff at Rutgers are committed to your success. Students who are successful tend to seek out resources that enable them to excel academically, maintain their health and wellness, prepare for future careers, navigate college life and finances, and connect with the RU community. Helpful resources include the Rutgers Learning Centers and school-based advising (for SAS, SOE, SEBS, and RBS). Additional resources that can help you succeed and connect with the Rutgers community can be found at https://success.rutgers.edu.

Please visit the Rutgers Student Tech Guide for resources available to all students. If you do not have the appropriate technology for financial reasons, please email the Dean of Students (deanofstudents@echo.rutgers.edu) for assistance. If you are facing other financial hardships please visit the Office of Financial Aid.

Academic Integrity

Rutgers University takes academic dishonesty very seriously. By enrolling in this course, you assume responsibility for familiarizing yourself with the Academic Integrity Policy and the possible penalties (including suspension and expulsion) for violating the policy. As per the policy, all suspected violations will be reported to the Office of Student Conduct. Academic dishonesty includes (but is not limited to):

1. Cheating
2. Plagiarism
3. Aiding others in committing a violation or allowing others to use your work
4. Failure to cite sources correctly
5. Fabrication
6. Using another person's ideas or words without attribution–re-using a previous assignment Unauthorized collaboration
7. Sabotaging another student's work

If in doubt, please contact me. Also review the Academic Integrity Policy and Academic Integrity Resources for Students. Use of external website resources (such as Chegg.com or others) to obtain solutions to homework assignments or exams is cheating and a violation of the University Academic Integrity policy. Cheating in the course may result in grade penalties, disciplinary sanctions or educational sanctions. Posting homework assignments or exams to external sites without the instructor's permission may be a violation of copyright and may constitute the facilitation of dishonesty, which may result in the same penalties as cheating.

The Rutgers honor pledge will be included on all major assignments for you to sign: *On my honor, I have neither received nor given any unauthorized assistance on this examination/assignment.*

Almost all original work is the intellectual property of its authors. This includes not just books and articles, but the syllabi, lectures, slides, recordings, course materials, presentations, homework problems, exams, and other materials used in this course, in either printed or electronic form. **You may not copy this work, post it online, or disseminate it in any way without the explicit permission of the instructor**. Respect for an author's efforts and intellectual property rights is an important value that members of the university community are expected to take seriously.

Student Wellness Services

The university provides a number of resources to support your physical and mental well-being. I list several valuable resources here and encourage you to contact me for more guidance about university resources.

- **Report a Bias Incident**: If you experience or witness an act of bias or hate, report it to someone in authority. You may file a report online and you will be contacted within 24 hours. The bias reporting page is here. Bias is defined by the University as an act, verbal, written, physical, psychological, that threatens, or harms a person or group on the basis of race, religion, color, sex, age, sexual orientation, gender identity or expression, national origin, ancestry, disability, marital status, civil union status, domestic partnership status, atypical heredity or cellular blood trait, military service or veteran status.

  Click here to report a bias incident.

- **Counseling, ADAP Psychiatric Services (CAPS) (848) 932-7884 / 17 Senior Street, New Brunswick, NJ 08901**, http://health.rutgers.edu/medical-counseling-services/counseling/
  CAPS is a University mental health support service that includes counseling, alcohol and other drug assistance, and psychiatric services staffed by a team of professionals within Rutgers Health services to support students' efforts to succeed at Rutgers University. CAPS offers a variety of services that include: individual therapy, group therapy and workshops, crisis intervention, referral to specialists in the community, and consultation and collaboration with campus partners.

- **Crisis Intervention**: http://health.rutgers.edu/medical-counseling-services/counseling/crisis-intervention/
  Report a Concern: http://health.rutgers.edu/do-something-to-help/

- **Violence Prevention Victim Assistance (VPVA) (848) 932-1181 / 3 Bartlett Street, New Brunswick, NJ 08901**,
  http://vpva.rutgers.edu/
  The Office for Violence Prevention and Victim Assistance provides confidential crisis intervention, counseling and advocacy for victims of sexual and relationship violence and stalking to students, staff and faculty. To reach staff during office hours when the university is open or to reach an advocate after hours, call 848-932-1181.

- **Disability Services (848) 445-6800 / Lucy Stone Hall, Suite A145, Livingston Campus, 54 Joyce Kilmer Avenue, Piscataway, NJ 08854**,
  https://ods.rutgers.edu/
  Rutgers University welcomes students with disabilities into all of the University's educational programs. In order to receive consideration for reasonable accommodations, a student with a disability must contact the appropriate disability services office at the campus where you are officially enrolled, participate in an intake interview, and provide documentation: https://ods.rutgers.edu/students/documentation-guidelines. If the documentation supports your request for reasonable accommodations, your campus's disability services office will provide you with a Letter of Accommodations. Please share this letter with your instructors and discuss the accommodations with them as early in your courses as possible. To begin this process, please complete the Registration form on the ODS web site at: https://ods.rutgers.edu/students/registration-form.