Syllabus
Physics 273 – Advanced Honors Physics III
Fall 2022

Instructor: Prof. Jed Pixley; jed.pixley@physics.rutgers.edu
Lectures: Located in the Physics Lecture Hall (PLH) on Tuesdays and Thursday 2:00PM to 3:20PM.
Office hours: By appointment only

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

Grader and study group leader: Wenbo Ge; email: wenbo.ge@rutgers.edu
Location and time of study group: To be determined

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 Tuesday and Thursday 2-3:20pm in the Physics lecture Hall. These lectures will cover the concepts and techniques in depth while the study groups will have more of a focus on problem solving and 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 in the mailbox of the grader (Wenbo Ge) or to their email address (wenbo.ge@rutgers.edu). The mailbox room can be found on the 2nd floor of Serin across from the Chair's office. Homework not turned in by the specified time **will count as zero, NO late homework will be accepted**. Solutions are posted online at the course website.

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.

Mask Mandate

In order to protect the health and well-being of all members of the University community, masks must be worn by all persons on campus when in the presence of others (within six feet) and in buildings in non-private enclosed settings (e.g., common workspaces, workstations, meeting rooms, classrooms, etc.). Masks must be worn during class meetings; any student not wearing a mask will be asked to leave.

Masks should conform to CDC guidelines and should completely cover the nose and mouth.
`https://www.cdc.gov/coronavirus/2019-ncov/prevent-getting-sick/about-face-coverings.html`

Each day before you arrive on campus or leave your residence hall, you must complete the brief survey on the My Campus Pass symptom checker self-screening app.

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

- (T&R) *Modern Physics*, 5th edition by Stephen Thornton and Andrew Rex is the required textbook for this class. We will not be using Webassign, so there is no need to purchase a Webassign account.
- (K&K) *An Introduction to Mechanics*, 2nd edition by Daniel Kleppner and Robert Kolenkow (the primary textbook of 271) will be used as the primary source of discussion for special relativity.
- (Purcell) *Electricity and Magnetism*, 3rd edition by Edward Purcell and David Morin (the primary textbook of 272) will be used to further supplement the discussion on special relativity.
- (Griffiths) *Introduction to Quantum Mechanics* by David Griffiths will be relied on for the discussion on quantum mechanics.
- (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, 9/5-9/9

   - **Tu 9/6**: Introduction, Michelson-Morley Experiment.
     Reading: TR 2.1-2.2; K&K 12.1-12.3
     Demo: MM experiment
   - **Th 9/8**: Postulates of SR and Lorentz transformations
     Reading: TR 2.3-2.4; K&K 12.4-12.7

2. Week 2, 9/12-9/16

   - **Tu 9/13**: Lorentz contraction, time dilation, velocity transformations
     Reading: TR 2.5-2.6; K&K 12.8-12.9
     HW # 1 Due
   - **Th 9/15**: Doppler shift, Twin "paradox"
     Reading: TR 2.8, 2.10; K&K 12.10-12.11
     Demo: Cosmic ray chamber

3. Week 3, 9/19-9/23

   - **Tu 9/20**: Momentum and Energy, massless particles
     Reading: TR 2.11-2.12; K&K 13.1-13.4
     HW # 2 Due
   - **Th 9/22**: Minkowski spacetime, four-vectors, four momentum, metric tensor
     Reading: TR 2.9, 2.11-2.12; K&K 14.1-14.5

4. Week 4, 9/26-9/30

   - **Tu 9/27**: Magnetism as a relativistic effect
     Reading: TR 2.14; Purcell 5.1-5.4
     HW # 3 Due
     Demo: Relativity with Magnet and Coil
   - **Th 9/29**: Magnetism as a relativistic effect (cont.), exam review
     Reading: 5.5-5.9

5. Week 5, 10/3-10/7

   - **Tu 10/4**: **Exam I**
     HW # 4 Due
   - **Th 10/6**: Experimental basis of quantum physics: X-rays and the electron, line spectra, Black-body radiation
     Reading: TR 3.1-3.5
     Demo: Diffraction and atomic spectra

6. Week 6, 10/10-10/14

   - **Tu 10/11**: Experimental basis of quantum physics: Blackbody radtiation continued, start the Photoelectric effect
     Reading: T&R 3.6-3.9; K&K 13.5-13.6
     Demo: The photoelectric effect

- **Th 10/13**: Experimental basis of quantum physics: Photoelectric effect, x-ray production, Compton scattering
  Reading: 3.8-3.9

7. Week 7, 10/17-10/21

   - **Tu 10/18**: Finish Experimental basis of quantum physics: with pair production and annihilation; started Structure of the atom: Rutherford scattering
     Reading: T&R 4.1-4.3; K&K 10.5.1
     HW # 5 Due
   - **Th 10/20**: Finish Rutherford scattering; The Bohr model of the hydrogen atom
     Reading: 4.4-4.7

8. Week 8, 10/24-10/28

   - **Tu 10/25**: Wave nature of matter: De-Broglie wavelength, X-ray and electron diffraction
     Reading: T&R 5.1-5.3
     HW # 6 Due
   - **Th 10/27**: Wave nature of matter: Double slit experiment, Heisenberg's uncertainty principle
     Reading: T&R 5.4-5.7

9. Week 9, 10/31-11/4

   - **Tu 11/1**: Quantum Mechanics: The Schrodinger Equation
     Reading: T&R 6.1-6.2 and Griffiths Chapter 1
     HW # 7 Due
   - **Th 11/3**: Quantum Mechanics: The infinite square well and the harmonic oscillator.
     Reading: T&R 6.3 6.6, Griffiths 2.1-2.2 and 2.6

10. Week 10, 11/7-11/11

    - **Tu 11/8**: Quantum Mechanics: Harmonic oscillator continued, finite square well
      Reading: T&R 6.4; Griffiths 2.6
      HW # 8 Due
    - **Th 11/10**: Quantum Mechanics: Barriers and tunneling, 3D Schrödinger equation
      Reading: T&R 6.5; Griffiths 4.1

11. Week 11, 11/14-11/18

    - **Tu 11/15**: Hyrdogen atom
      Reading: T&R 7.1-7.2; Griffiths 4.2
      HW # 9 Due
    - **Th 11/17**: Exam Review

12. Week 12, 11/21-11/25

    - **Tu 11/22**: (Thursday class technically) **Midterm Exam II**
      HW # 10 Due
    - **Th 11/24**: NO CLASS, Happy Thanksgiving!

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

14. **Tu 11/29**: Quantum Mechanics: Angular momentum and spin
    Reading: T&R 7.3; FL3 19.4-19.5; Griffiths 4.3

15. **Th 12/1**: Zeeman effect and atomic orbitals
    Reading T&R 7.4-7.6; Griffiths 4.4

Week 14, 12/5-12/9

- **Tu 12/6**: Quantum Statistical Mechanics: Identical Particles, the periodic table
  Reading: Griffith 5.1-5.2, T&R Chapter 8
  HW # 11 Due
- **Th 12/18**: Quantum Statistical Mechanics: Bose-Einstein and Fermi-Dirac distributions

Week 16, 12/12-12/16 **Last day of class 12/14**

- **Tu 12/12**: Statistical Mechanics: Bose-Einstein condensation, Superfluidity and superconductivity
  HW # 12 Due
  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.