PHYS 461 Modern Physics Lab, Fall 2020

University of Tennessee, Knoxville

Meeting Time and Place: Nielsen 303 MW 9:15 – 12:15 (6 contact hours)
Course Credit Hours: 3

Pandemic Relevant Information: This semester is not going to look like any previous semester. We will endeavor to keep this class in person, for as long as it is safe to do so, and allowed by University rules. We will keep the number of people in the laboratory to a minimum, and spread the equipment out over two rooms. There will be a lot of scheduling required, so that we can introduce experiments to you the students, and allow time for you to work on the experiments with your lab partner outside of the stated class times. We recommend six hours a week working in the laboratory with your partner, but recognize that some experiments take more time taking data, and some take more time to analyze data. Most of the data can be analyzed on your own personal laptops outside of the laboratory. Each experiment should take two weeks to complete, although again, some will go faster and some will take more time. We will work together to try to keep everyone on track, but there will be a degree of independent working needed. More information specific to this semester is included throughout this syllabus (highlighted in green). Please read carefully.

Faculty Contact Information

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Dr. Kate Jones: Nielsen 407B
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Course Description/Information: Introduction to fundamental and modern techniques in experimental physics and to the theory and practice of measurement and data analysis. Selected experiments in nuclear, atomic, molecular and solid state physics, and modern optics. Prerequisites: PHYS 361and either PHYS 250, or PHYS 411.

Value Proposition: This course is essentially the capstone experimental experience for physics majors. The laboratory includes specialized equipment for performing experiments to investigate diverse physical phenomena. The experiments rely on knowledge garnered from across the undergraduate curriculum. This course is a research experience, going beyond simply following detailed step-by-step instructions. Together, we consider different approaches and improvements to the experiments, as well as sources of uncertainty. We take responsibility for ourselves, others, and the equipment when trouble shooting, or considering improvements. There is also a focus on scientific communication through short reports, leading into a longer written report and oral presentation at the end of the semester.

Student Learning Outcomes/Objectives: After successful completion of this course, you will be able to:
1) Make measurements with complex equipment, including making and applying calibrations. You will be able to use your own judgement in making observations and reading results, for example, from oscilloscopes.
2) Analyze data, including making error estimates and propagating these to the final results.
3) Communicate the physics motivation, experimental methods including descriptions of equipment used, and results, in writing and through oral presentations.
4) Illustrate results using graphs with error bars, and in clear tables.
5) Extract information from graphs using fits.
6) Keep a laboratory journal that includes notes about the physical concepts being studied and progress in taking data.

Learning Environment: The laboratory is a collaborative environment. It is important that everyone respects each other, as well as the health and safety rules in place to protect all of us. Students typically work in pairs, and it is usual for pairs to help other pairs with an experiment that they have already performed, for example with trouble shooting. Saying this, each pair will present their own data (unless we are required to go fully online, or there is special permission given in exceptional circumstances) and each student will write their own reports. Graphs and tables, can be shared between students working together in a pair, but the text of reports and sketches of the equipment must be unique to the individual student.

Course Communications: Communication will be in-person in the laboratories, through email, through Canvas, and via Zoom. Any sessions that include all students, for example the first session of semester, will be via Zoom. Grading will be communicated through grading slips and comments on laboratory reports. Read these carefully and contact us with any questions. Please monitor your email and Canvas regularly. For technical issues, contact the OIT HelpDesk via phone (865) 974-9900 or online at http://help.utk.edu/.

How to Be Successful in This Course: This course requires the completion of seven experiments. These are typically the seven experiments listed below, but one, or two, may be replaced with other experiments, usually those listed as "other experiments". Usually these alternates are brought in later in the semester.

The best way to be successful in the course is to perform the experiments carefully, taking time with calibrations where needed, or for the temperature to equilibrate where needed. Most of the experiments will give poor results if rushed. Therefore, in order to complete all the experiments before the end of semester, when final exams become a priority, it is important to spend sufficient time in the laboratory and/or analyzing the data throughout the semester. The class is allocated six hours a week. Especially this semester, those six hours may not be during the normal class time, but you should endeavor to spend at least six hours a week working toward completing experiments and analyzing data. As we will be scheduling meetings with pairs of students, it is important that you come to those sessions prepared. This means that you should have read the handout for the experiment that you are starting. All the handouts can be found here: http://www.phys.utk.edu/physlabs/modern-physics/index.html

Handing reports in on time is essential to getting early feedback on your work. These reports take significant time to grade. We, the instructors, usually grade and return reports within a week of receiving them, especially for the first reports, but this may sometimes be closer to two weeks. We use a rubric for grading, so students know where they lost points, and we also write comments on the report. Not all the comments will result in lost points, some are grammatical corrections, or suggestions of a stylistic nature.

Safety first: We have tried to minimize electrical and radiation hazards, but there are always possibilities for injury. Follow all safety procedures for handling lasers, the x-ray machine, radioactive materials, and high voltage sources. **Be careful with the equipment**. Don't make connections unless you understand what you're doing. **Don't play with the equipment with "Idle Hands."** Read the equipment manuals.

Be courteous: Return tools, equipment, etc. to their proper place. Don't remove equipment from someone else's experiment for use on your own (without asking first).
Texts/Resources/Materials:
Students are required to purchase a laboratory notebook. A hardbacked version is recommended as there are few open hard surfaces that students can use for writing. If you prefer to keep a digital laboratory notebook that will also be acceptable. You may want to make sketches, so think about using software that allows text and drawings.

Experiments: The experiments that are available to be performed this semester are as follows:

Experiments

1. Zeeman Effect
2. Compton Scattering
3. X-Ray Bragg Diffraction
4. Temperature Dependent Lifetimes of Fluorescence from a Phosphor
5. Nuclear magnetic resonance

6. Hall Effect
7. The Speed of Light--Rotating Mirror Version

Other Experiments that may be available

1. Cavendish Experiment--Determination of Gravitational Constant
2. Muon lifetime
3. Cesium Heatpipe Experiment

Course Requirements, Assessments, and Evaluations:

1. One experiment will be selected in consultation with the instructor to be reported on in depth. This will be both written and a presentation to the class.

2. Reports for the remaining experiments will be **brief reports** which consist of the following:
    a. A title page listing the course name and number, name of the experiment, the date performed, and the experiment collaborators.
    b. A short introduction **including a few sentences on the physical process being investigated** and what you want to find. It should be clear that you understand the experimental process and the underlying physics.
    c. An **original** diagram of the experiment with all the associated instrumentation and wiring. This should be clear, whether drawn by hand (with a ruler etc.) or on a computer.
    d. Raw data should be available to instructors upon request (you do not need to append pages of tabulated data).
    e. Graphs of representative data and analysis of data.
    f. A summary of the analysis, final results, and error analysis—identify the sources of errors and their significance in the analysis of results. Calculate/estimate the expected errors in the final quantity, where appropriate.

3. **Detailed report** will consist of the following:
    a. A title page listing the course name and number, name of the experiment, the date performed, and the experiment collaborators.
    b. An introduction section in which the overall experiment and its objectives are described.
    c. A description and derivation of the pertinent theory that supports the experiment to demonstrate your understanding of the principles being studied.
    d. A description of the experimental apparatus and instrumentation, complete with a schematic diagram and description of the purposes of each piece of equipment.
    e. Presentation of results section. This should include graphs and/or tables of the data.
    f. Analysis of Results—Description of the analysis of results including calculations and graphical analyses.
    g. Discussion of results with error analysis—identify the sources of errors and their significance in the analysis of results. Calculate/estimate the expected errors in the final quantity, where appropriate.

4. Presentations
    a. Presentations will be during the final exam period. All students will attend the presentation session.
    b. The presentations will be given in pairs. Each student will contribute equally, typically the time is split evenly between students.
    c. Each presentation will be 10 minutes, with approximately 2-5 minutes for questions.
    d. Students should expect basic physics questions relating to any of the experiments performed during the semester during the presentation session.
    e. A handout on presentation skills will be provided near the end of the semester.

5. Final grades will be calculated as follows:
    a. Performance of experiment—proper use of equipment, use of time, use of good experimental techniques, good experimental note taking, care of equipment--7 points per experiment for 7 experiments, a total of 49 points. ***Data and analysis should be submitted for all 7 experiments.***
    b. Results and analysis of experiments—the 5 experiments with brief reports--5 points per experiment for the 5 experiments for a total of 25 points.
    c. Detailed report 14 points.
    d. Presentation 12 points.
    e. In all cases, good results are paramount. All the experiments are capable of producing good results, but depend on the care and diligence that the experimenter gives to the experiment.

Notes on Written Reports

You should write your report for a physicist who understands the physics behind your work, but needs to be told exactly what went on and how it turned out.

A short introduction should explain what you tried to do and why. Little credit will be given for long histories of the experiment or theoretical derivations that can be found in the references or handouts. Give a brief explanation of the formulae you used and how you used them. Describe any unique characteristics of the experiment and present derivations of non-standard formulas. Do NOT copy the writeup or other sources. That is plagiarism and unacceptable. Use your own words. You should not look at the writeup while you write your introduction or you will be tempted to just paraphrase the writeup.

The experimental section should give enough information to enable someone to reproduce your results. **This should NOT take the form of a list of** instructions, but should be in the **past** tense, describing what was done. You should: Show the equipment used and their interconnections, Explain the data acquisition procedures, Describe the statistical uncertainties and an explanation of how they were assigned. Discuss possible sources of systematic error and how you handled them.

The analysis section should show how the data and their uncertainties (random and systematic) produce the final results and their uncertainties. Present graphs or tables of derived quantities with their associated uncertainties. Show how the errors were assigned.

The results section should give a concise listing of the major findings of the experiment. Comparisons between your results and theoretical expectations or other experimental values should be made. You may also want to comment on how the experiment could be improved. We do not use percentage error in this class. We discuss agreement to within 1 sigma, or 2 sigma.
The final grade will be assigned from the weighted average based on the following *provisional* grading scale.

A	90 and above
A-	87 and above
B+	83 and above
B	80 and above
B-	77 and above
C+	73 and above
C	70 and above
C-	67 and above
D+	63 and above
D	60 and above
D-	57 and above
F	below 57

Major Assignments and Exams
Students are expected to attend class at least 6 hours per week summed over the scheduled class times and outside of these times. Students should arrive promptly for scheduled sessions. The laboratory time can be used for background reading, as well as taking data and graphing results. However, this semester we request that students prioritize working on lab-based tasks in the lab, work on reading and writing tasks outside of the laboratory, where possible. While collecting data, it is reasonable that students work on **writing reports, although generally these should be worked on outside of lab time**. Laboratory reports are due on the day shown in the table below. Any student who is delinquent by two reports cannot move on to their next experiment. The grading takes into account laboratory performance, written reports, and a major power point presentation on one of the experiments performed.

Below you will find a list of due dates for the short reports. Reports handed in after the due date will have half a point taken off per week late. That means, a report handed in up to a week late will be graded out of 4.5 instead of 5.

Course Feedback:
Each short report will be graded using the grading slip copied below. Note that the report is graded out of a total of 5, so the individual elements are summed and divided by 4. Please note, if you do not include something that is on the grading slip, we cannot give you points for that item. Please hand in notes with your short reports. You can scan, or take a photo of the relevant pages of your notebook and email them to us with your report. Please make sure that the file size is not excessively large.

Day	Date	Note
Wednesday	8/19/20	First day of class. Zoom session
Monday	8/24/20	
Wednesday	8/26/20	
Monday	8/31/20	
Wednesday	9/2/20	
Monday	9/7/20	Labor Day. No class.
Wednesday	9/9/20	
Monday	9/14/20	First Report Due
Wednesday	9/16/20	
Monday	9/21/20	
Wednesday	9/23/20	
Monday	9/28/20	Second Report Due
Wednesday	9/30/20	
Monday	10/5/20	
Wednesday	10/7/20	
Monday	10/12/20	Third Report Due
Wednesday	10/14/20	
Monday	10/19/20	
Wednesday	10/21/20	
Monday	10/26/20	Fourth Report Due
Wednesday	10/28/20	
Monday	11/2/20	
Wednesday	11/4/20	
Monday	11/9/20	Fifth Report Due
Wednesday	11/11/20	
Monday	11/16/20	
Wednesday	11/18/20	
Monday	11/23/20	Last Scheduled Class Session

Example Grading Slip for Short Reports

Report	
Physical mechanism being investigated and background	/5
Description of major equipment	/3
Description of experimental procedure	/2
Original diagram of equipment	/2
Description of data analysis	/3
Representative data graph	/2
Summary graph or Table	/3
TOTAL	**/5**
Experimental	
Careful measurement and analysis resulting in high quality data	/3
Error estimation propagated to final results	/2
TOTAL	**/5**
Notes	
Makes notes about the physics concept behind experiment	/1
Makes notes to track progress of the experiment	/1
TOTAL	**/2**

University Policies:
Academic Integrity: "An essential feature of the University of Tennessee, Knoxville is a commitment to maintaining an atmosphere of intellectual integrity and academic honesty. As a student of the university, I pledge that I will neither knowingly give nor receive any inappropriate assistance in academic work, thus affirming my own personal commitment to honor and integrity."

University Civility Statement: Civility is genuine respect and regard for others: politeness, consideration, tact, good manners, graciousness, cordiality, affability, amiability and courteousness. Civility enhances academic freedom and integrity, and is a prerequisite to the free exchange of ideas and knowledge in the learning community. Our community consists of students, faculty, staff, alumni, and campus visitors. Community members affect each other's well-being and have a shared interest in creating and sustaining an environment where all community members and their points of view are valued and respected. Affirming the value of each member of the university community, the campus asks that all its members adhere to the principles of civility and community adopted by the campus: http://civility.utk.edu/.
Disability Services: "Any student who feels s/he may need an accommodation based on the impact of a disability should contact Student Disability Services in Dunford Hall, at 865-974-6087, or by video relay at, 865-622-6566, to coordinate reasonable academic accommodations."

Your Role in Improving Teaching and Learning Through Course Assessment:
At UT, it is our collective responsibility to improve the state of teaching and learning. During the semester, you may be requested to assess aspects of this course either during class or at the completion of the class. You are encouraged to respond to these various forms of assessment as a means of continuing to improve the quality of the UT learning experience.

Key Campus Resources for Students:

- Center for Career Development (Career counseling and resources; HIRE-A-VOL job search system)
- Course Catalogs (Listing of academic programs, courses, and policies)
- Hilltopics (Campus and academic policies, procedures and standards of conduct)
- OIT HelpDesk (865) 974-9900
- Schedule of Classes/Timetable
- Student Health Center (visit the site for a list of services)
- Student Success Center (Academic support resources)
- Undergraduate Academic Advising (Advising resources, course requirements, and major guides)
- University Libraries (Access to library resources, databases, course reserves, and services)

Syllabus language regarding masks and social distancing

Students are required to wear face masks at all times and maintain social distancing (6 feet between individuals in traditional classrooms, or, in instructional laboratories and similar settings, only a few minutes in closer proximity when absolutely necessary to achieve learning objectives). Students who are feeling ill or experiencing symptoms such as sneezing, coughing, or a higher than normal temperature will be excused from class and should stay at home.
Instructors have the right to ask those who are not complying with these requirements to leave class in the interest of everyone's health and safety. In the event that a student refuses to comply with these requirements, the instructor has the right to cancel class.
Additionally, following other simple practices will promote good health in and out of the classroom, such as frequent and thorough hand washing, wiping down desks and seats with disinfectant wipes whenever possible, not sharing personal items such as pens and cell phones, and avoiding crowded hallways and other enclosed spaces.
The Volunteer Creed reminds us that we bear the torch in order to give light to others. As Volunteers, we commit to caring for one another and for the members of the communities in which we live, work, and learn. This semester, the University asks that we all demonstrate the Volunteer spirit by following these and other health guidelines and requirements.
Updated June 16, 2020
The instructor reserves the right to revise, alter or amend this syllabus as necessary. Students will be notified in writing / email of any such changes.