# **New York City College of Technology**

## The City University of New York

## PHYSICS DEPARTMENT

**SYLLABUS Interdisciplinary Course Phys 2443**

Principles of Modern Physics

**Physics 3.3 PHYS 2443.**

This semester the course is taught by the following faculty and by guest lecturers.

**Oleg Berman - Part 1 - Quantum Theory**

**Giovanni Ossola - Part 2 - Nuclei, Radioactivity, Elementary Particles**

**Darya Krym - Part 3 - Relativity and Cosmology**

**Roman Kezerashvili - Lab component of the course.**

**Office Hours \_\_\_\_\_\_\_\_\_ email: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Phone \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

1. **Welcome to PHYS 2443.**

This is the third of a sequence of three Physics 3 courses (Physics 3.3).

In this course we learn about the paradigm shifting discoveries of 20th century physics. These discoveries had far reaching implications not only for physics, but for other areas of science, for technology, and for society in general. We explore these topics in guest lectures by experts in these fields.

We expect that your aim is not only to pass this course, but also to learn something in the process. Our aim is to do all in our power to ensure that you enjoy doing this, that you successfully complete this course, and come to appreciate what physics has to offer. In order to help you plan your study schedule for this course, we have listed in these sheets the syllabus outlining the texts required, topics covered, reading and homework assignments and laboratory schedule for the whole semester. They also summarize the general rules that we expect you to follow.

1. **Attendance**

The Department adheres to the College Attendance policy.

1. **Examinations**

The department guideline is two examinations plus a Final examination. The Final examination is **cumulative.** All examinations must be taken. There will be **no make-ups**. In the event of an extreme personal emergency, each case will be deal with individually.

1. **Grading**

Your final grade is based on the following: an average of the two 1 hour 40 min examinations will count 35% toward your total **PHYS 2443** grade, your laboratory grade will count 25% of your total **PHYS 2443** grade, your research project will count 10% of your total **PHYS 2443** andfinal examination will count 20% toward your total **PHYS 2443** grade. Essays and/or short projects that explain a problem, experiment, or application related to the topic or methodology discussed in guest lectures. Students must integrate their knowledge of the related physics concepts and the other disciplines, and bring both skillsets to bear on the problem. These essays and/or short projects will count 10% of your grade.

* Two Exams = 35%
* Laboratory Grade = 25%
* Research project = 10%
* Final examination = 20%
* Essays/Short Projects = 10%
* **Academic dishonesty is strictly forbidden and will be dealt with according to College and University policy.**

1. **Laboratory**

This course is based on doing computer-based experiments in physics and traditional experiments. Although the experiments are done in-group, each student must write and type his own individual laboratory report. It consists of a title page, data sheet, computations, graphs, discussions and questions.

Each week you will get a grade based on 100. If you do the experiment, you get a 60. The laboratory report is graded from 60 to 100. The laboratory report is due at the beginning of the following laboratory session. If it is handed in afterwards, the late penalty is 10 point per week. We will do 10 experiments. Students are allowed one excused absence. You may not make up an experiment that you have missed. The average of your laboratory grade is based on the 9 best laboratory reports and an oral presentation.

**6. Textbooks**

* **Physics for Scientists & Engineers with Modern Physics, Volume III**

by Giancoli, 4th Edition. Pearson- Prentice Hall.

* **Laboratory Experiments in College Physics; Electricity. Magnetism. Optics. Modern Physics** by Roman Kezerashvili
* Departmental handout materials
* **Other resources**

Many of the topics covered in this class will seem counter-intuitive, since we are unable to observe the movement of subatomic particles, for example, with our own eyes. It is very important that you take the time to digest these new ideas. If the explanations in the book are unclear, you might find it helpful to seek an alternative point of view from another book. Also, there are a growing number of animations and applets available on the web. We will sometimes use some of these in the lectures, and we will post links to web resources on the course website. You are encouraged to take a look at these on your own. Sometimes a picture really is worth a thousand words.

Note the table below is a list of the lectures, organized by week. Weeks 6, 7, 10, 14 have two lectures and no lab. Other weeks have one lecture and one lab.

|  |  |  |  |
| --- | --- | --- | --- |
| Week | Topic & Chapter | Chapter | Problems |
| **Part 1: Quantum Theory** | | | |
| 1 | **Early Quantum Theory and Model of the Atom**   1. Electromagnetic waves 2. Planck’s Quantum Hypothesis 3. Photon Theory; Photoelectric Effect 4. Photon Energy, Mass and Momentum    1. Wave – Particle Duality; the Principle of Complementarity    2. Wave Nature of Matter    3. Early Models of the Atom and the Bohr Model | 37 | All related Sample problem from the chapter |
| 2 | **Quantum Mechanics**   1. The Wave Function and the Heisenberg Uncertainty Principle 2. The Schrödinger Equation and examples of its solution in one dimension 3. Tunneling through a Barrier | 38 | All related Sample problem from the chapter |
| 3 | **Quantum Mechanics**   1. Hydrogen Atom: Schrödinger Equation and Wave Function 2. Complex Atoms: the Exclusion Principle and Periodic Table of Elements | 39 | All related Sample problem from the chapter |
| 4 | **Quantum Mechanics**   1. X-Ray Spectra 2. Lasers and Holography   **Quantum Mechanics of Solids**   1. Bonding in Molecules and Potential-Energy Diagrams for Molecules 2. Molecular Spectra 3. Bonding in Solids | 39-40 | All related Sample problem from the chapter |
| 5 | **Quantum Mechanics of Solids**   1. Drude Free-Electron Theory of Metals; Fermi Energy 2. Band Theory of Solids 3. Semiconductors and Doping 4. Applications: Semiconductor Diodes, Transistors and Chips (Integrated Circuits)   **Exam 1** | 40 | All related Sample problem from the chapter |
| 6 | **Guest Lecture: Alberto Martinez: Quantum Chemistry: Bounds and Periodic Table of Elements** | | |
| 6 | **Guest Lecture: Xiangdong Li: Quantum Computer and Quantum Computations** | | |
| **Part 2: Nuclei, Radioactivity, Elementary Particles** | | | |
| 7 | **Nuclear Physics and Radioactivity**   1. Structure and Properties of the Nucleus 2. Binding Energy and Nuclear Forces 3. Radioactivity: Alpha, Beta and Gamma Decays 4. Conservation Laws in Nuclear Physics   e. Detection and application of Radiation | 41 | All related Sample problem from the chapter |
| 7 | **Nuclear Energy; Effects and Uses of Radiation**   1. Nuclear Reactions and the Transmutation of Elements 2. Nuclear Fission; Nuclear Reactors   c. Nuclear Fusion  d. Application of Nuclear Physics: Dosimetry, Radiation Therapy, Tracers in Research and Medicine, Imaging by Tomography: CAT Scans and Emission Tomography, Nuclear Magnetic Resonance (NMR), Magnetic Resonance Imaging (MRI) | 42 | All related Sample problem from the chapter |
| 8 | **Elementary Particle Physics**   1. High-Energy Particles and Accelerators 2. Particles and Antiparticles 3. Particle Interactions and Conservations Laws 4. Neutrinos 5. Particle Classification 6. Particle Stability and Resonances | 34 | All related Sample problem from the chapter |
| 9 | **Elementary Particle Physics**   1. Strangeness? Charm? Towards a New Model 2. Quarks 3. The Standard Model: QCD and Electroweak Theory, Strings and supersymmetry | 43-44 | All related Sample problem from the chapter |
| 10 | d. Grand Unified Theories  e. Strings and supersymmetry  **Exam 2** |  |  |
| 10 | **Guest Lecture: Kyle Cuordileone: The Political and Social Implications of Nuclear Weapons in Historical Perspective.** | | |
| **Part 3: Relativity and Cosmology** | | | |
| 11 | **Special Theory of Relativity**   * 1. Galilean – Newtonian Relativity & speed of light   2. Postulates of the Special Theory of Relativity   Time Dilation and Length Contraction | 36 | All related Sample problem from the chapter |
| 12 | **Special Theory of Relativity**   1. Lorentz Transformations 2. Relativistic Momentum and Mass   c. E = mc2; Mass and Energy  Doppler Shift for Light | 36 | All related Sample problem from the chapter |
| 13 | **Astrophysics and Cosmology**   1. Stars and Galaxies 2. Stellar Evolution: Nucleosynthesis, and the Birth and Death of Stars   c. Distance Measurements  d. General Relativity: Gravity and the Curvature of Space | 44 | All related Sample problem from the chapter |
| 14 | **c**  a. The Expanding Universe: Redshift and Hubble’s Law  b. The Big Bang and the Cosmic Microwave Background  c. The Standard Cosmological Model: The Early Universe | 44 | All related Sample problem from the chapter |
| 14 | **Guest Lecture: Shalva Tsiklauri: Relativity and it application for the Global Positioning System (GPS).** | | |
| 15 | **Astrophysics and Cosmology**  a. Inflation  b. Dark Matter and Dark Energy  c. Large-Scale Structure of the Universe  **Final Exam** | 44 | All related Sample problem from the chapter |

*Additional Problems may be assigned by the instructor.*

Topic of a research project will be assigned by the instructor

The table below is a list of the laboratory experiments, organized by week. Note that there is no lab during weeks 6, 7, 10, and 14 and instead there are two lectures on those weeks. The last class is half oral presentations and half guest lecture.

|  |  |
| --- | --- |
| Week | Laboratory Experiments. |
| 1. | Property of electromagnetic waves: Interference, Polarization and Dispersion of light |
| 2. | Property of electromagnetic waves: Interference, Polarization and Dispersion of microwaves |
| 3. | 1. Photons: Photoelectric Effect |
| 4 | 1. Charge of electron |
| 5 | 1. Measurements of e/m for Electron and mass of electron |
| 8 | Diffraction of electrons |
| 9 | 1. Study of Spectral lines and Rydberg Constant |
| 11 | 1. Holography and an open cavity laser: He-Ne laser |
| 12 | 1. andRadiation: Radiation detection and absorption |
| 13 | 1. Principles of acceleration of elementary particles: electron |
| 15 | 1. **Guest Lecture: David Kagan – Philosophical Implications of Quantum Mechanics** |
| 1. Oral presentation of the Research project |