# *PHYS222: Modern Physics*
# *Spring 2010*

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| Teacher: Dr. Kelly Krieble | Classroom: CHS 107 M,W,F 7:50-8:40<br>Th 7:50-8:40 |
| Office: Room 109, Collier Hall of Science | Lab: CHS 107 M 1:15-4:15 |
| Phone: ext. 1437 | Office Hours: By appointment |
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**Course Texts**: **Modern Physics for Scientists and Engineers**, 3rd ed., Thornton and Rex.
**Introduction to Relativity**, Kogut
**An Introduction to Error Analysis**, 2nd ed., John R. Taylor

**Course Objectives**: The primary aim of this course is to provide students with a working knowledge of the concepts leading to the breakdown of classical physics and the emergence of modern quantum theory. The course material follows an historical approach, and contains a substantial experimental and writing component. Students will learn and develop mathematical and physical techniques for solving a wide range of problems. In the laboratory portion of the course students will learn about experimental design and gain experience using a variety of equipment for conducting physical measurements. This course satisfies the Writing Across the Curriculum requirement.

**Course Content and Schedule of Topics**:

| *Topic* | *Approximate Time Span* | *Readings* |
|---|---|---|
| Relativity | 4 weeks | Chapter 2 |
| Scattering and diffraction<br>a. Photon interactions<br>b. Bragg diffraction<br>c. Rutherford scattering | 2 weeks | |
| Bohr Theory | 1 week | Chapter 4 |
| Quantization<br>a. X-rays<br>b. Franck-Hertz<br>c. Wilson-Sommerfeld<br>d. Harmonic oscillator | 1.5 weeks | Chapter 3 |
| Wave-Particle Duality<br>a. DeBroglie wavelength<br>b. Complimentarity<br>c. Uncertainty principle | 2 weeks | Chapter 5 |
| Quantum numbers<br>a. Schroedinger equation<br>b. Angular momentum<br>c. Energy splitting (Zeeman effect, etc.) | 2 weeks | Chapters 6, 7, 8 |
| Elementary particles and conservation laws | 1.5 weeks | Chapter 14 |
| Nuclear physics and radioactivity | 2 weeks | Chapters 12, 13 |

**Grading Policy:**

A = 90%-100%
B = 80%-89%
C = 70%-79%
D = 60%-69%
F = below 60%

| **Assessment:** | **% Weight** |
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| Homework Problems | **20** |
| Lab Journal and Reports | **20** |
| Paper and Presentation | **10** |
| Exams | **30** |
| Final Exam | **20** |

**Homework Problems:**

As illustrated above, the problem sets constitute a significant portion of your grade. Your work on these problem sets, as well as on lab reports and your paper, is subject to the Moravian College Policy on Academic Honesty. Refer to the Student Handbook or ask your instructor if you have any doubts or questions about any submitted work.

*Due dates and late policy*: Work submitted after the due date will receive a zero.

**Labs:**

To augment your overall learning experience and provide an experimental aspect to the course, you will be required to perform a lab each week during the term. To instill good laboratory report writing skills, lab reports will be submitted throughout the semester according to a prescribed format that follows the style of popular physics journals, using LaTeX software. Use of the Bedford writing handbook will be encouraged, and a copy will be available in the modern physics lab. Unless otherwise stated, the Physical Review Letters style will be used for all citations.

*Schedule of experiments:*

| Week | Experiments: |
|---|---|
| 1 | Interferometer |
| 2 | Radioisotopes, Shielding, and the MCA |
| 3 | Relativistic Energy |
| 4 | Coincidence |
| 5 | Photoelectric Effect |
| 6 | Compton Effect |
| 7 | Balmer Series in H and D |
| 8 | X-Ray Diffraction |
| 9 | Electron diffraction |
| 10 | Photon Counting |
| 11 | Zeeman Effect |
| 12 | TBD - Mossbauer Effect or NMR |

Students will also have the opportunity to peer review each other's work. For each lab report turned in, students must supply a second copy for peer review (comments and suggestions/corrections on grammar, format, content, style, and readability). Both copies will be returned and a revised report will be re-submitted by the student with the lab journal at the end of the semester. All originals and revisions shall be included in the portfolio. The student will also keep a laboratory journal throughout the semester, which includes notes, raw data, and calculations on the experiments performed during the course.

**Paper and Presentation:**

In addition to the lab reports, throughout the semester students will be researching a topic in physics and will write a formal research paper (approximately 10-15 pages long). Assignments throughout the term will include: selecting a topic, producing a preliminary and final annotated bibliography, rough drafts, and writing the final draft of the paper. A 10-15 minute presentation will be given on this work during the last week of class.

**Exams:** At least three (in-class) one-hour exams during the semester.

**Final comprehensive exam:** An exam covering all material introduced during the semester.

**Attendance Policy:**

Students are expected to come to class, however sometimes issues beyond the student's control arise. Excused absences include but are not limited to medical problems, family emergencies, participation in sporting events, and the like. The instructor reserves the right to lower the student's grade should more than two unexcused absences accrue during the semester.

Good luck in the coming semester. Should you have any comments about the class during the semester, please feel free to discuss them with me.

*Subject to Revision*

# *PHYS222: Modern Physics*

| Date | | Scheduled Topic/Lab |
|---|---|---|
| Monday | 1/18 | Introduction, Galilean Transform<br>**Lab #1 – Interferometer** |
| Wednesday | 1/20 | Michelson-Morley experiment |
| Thursday | 1/21 | Einstein's postulates, simultaneity, train paradox |
| Friday | 1/22 | Lorentz Transformations |
| Monday | 1/25 | Length Contraction and Time Dilation<br>**Lab #2 – Radioisotopes, Shielding, MCAs** |
| Wednesday | 1/27 | Relative Velocity |
| Thursday | 1/28 | Problem Session |
| Friday | 1/29 | Twin paradox, Space-time diagrams |
| Monday | 2/1 | ***Relativistic momentum and mass-energy***<br>**Lab #3 – Relativistic Energy** |
| Wednesday | 2/3 | Collisions |
| Thursday | 2/4 | Problem Session |
| Friday | 2/5 | Threshold energy |
| Monday | 2/8 | Doppler effect, decay, and binding energy<br>*Muon decay demo*<br>**Lab #4 – Coincidence** |
| Wednesday | 2/10 | J.J Thompson, Millikan, and Planck<br>*Oil-drop experiment demo*<br>*Planck radiation law demo* |
| Thursday | 2/11 | Problem Session |
| Friday | 2/12 | Photoelectric effect |
| Monday | 2/15 | Photon interactions<br>**Lab - Exam #1 (Relativity)**<br>**Lab #5 – Photoelectric Effect** |
| Wednesday | 2/17 | Compton effect |
| Thursday | 2/18 | Problem Session |
| Friday | 2/19 | Crystal structure |

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|---|---|---|
| Monday | 2/22 | Bragg diffraction<br>**Lab #6 – Compton Effect** |
| Wednesday | 2/24 | Rutherford scattering |
| Thursday | 2/25 | Problem Session |
| Friday | 2/26 | Rutherford scattering |
| Monday | 3/1 | Bohr Theory<br>**Lab #7 – Balmer Series in H and D** |
| Wednesday | 3/3 | Spectral Lines and reduced mass |
| Thursday | 3/4 | Problem Session |
| Friday | 3/5 | Correspondence principle |

**SPRING BREAK**

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|---|---|---|
| Monday | 3/15 | X-rays and energy level quantization<br>*Franck-Hertz experiment demo*<br>**Lab #8 – X-ray diffraction** |
| Wednesday | 3/17 | Wilson-Sommerfeld quantization |
| Thursday | 3/18 | Problem Session |
| Friday | 3/19 | De Broglie wavelength |
| Monday | 3/22 | Complimentarity<br>**Lab - Exam #2 (Particle/Wave Physics)**<br>**Lab #9 – Electron diffraction** |
| Wednesday | 3/24 | Phase and group velocity |
| Thursday | 3/25 | Problem Session |
| Friday | 3/26 | Uncertainty principle |
| Monday | 3/29 | Schroedinger equation<br>**Lab #10 – Photon Counting** |
| Wednesday | 4/1 | Infinite square well |

**Easter Break**

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|---|---|---|
| Wednesday | 4/7 | Hydrogen Atom, Angular momentum & quantum numbers |
| Thursday | 4/8 | Problem Session |
| Friday | 4/9 | Energy splitting and the g factor |
| Monday | 4/12 | Zeeman effect<br>**Lab #11 – Zeeman Effect** |
| Wednesday | 4/14 | Anomalous Zeeman effect and Lande g |
| Thursday | 4/15 | Problem Session |
| Friday | 4/16 | Elementary Particles |
| Monday | 4/19 | Conservation Laws<br>**Lab - Exam #3 (Quantum Physics)**<br>**Lab #12 – TBD (Mossbauer or NMR)** |
| Wednesday | 4/21 | Nuclear Physics |
| Thursday | 4/22 | Problem Session |
| Friday | 4/23 | Radioactive Decay |
| Monday | 4/26 | Fission<br>**LAB – paper presentations** |
| Wednesday | 4/28 | Fusion |
| Thursday | 4/29 | Problem Session |
| Friday | 4/30 | Semester Review |