Department: PHYS

Course No.: 140Q

Credits: 4

Title: Introduction to Modern Physics

Contact: G. Rawitscher

Content Area: CA 3 Science and Technology- Lab

WQ: Q

Catalog Copy: -140Q. Introduction to Modern Physics First semester. Four credits. Three class periods, one recitation period, and one 3-hour laboratory. Recommended preparation: MATH 101 or the equivalent and MATH 109, which may be taken concurrently, or a pass on the Calculus Readiness Test. Qualitative and quantitative exploration of the structure of atoms and the concept of quantization. Topics include gas laws, kinetic theory, the electron, the photon, light waves, matter waves, relativity, the Heisenberg Uncertainty Principle. This course is recommended for prospective Physics majors and others interested in a general introduction to modern issues in physics.

Course Information: -a. This course offers students with a strong interest in science an introduction into modern themes in physics and the study of matter. The major goal is to give students an understanding of the nature of the questions driving modern physics research and a familiarity with ideas beyond the classical theories of physics. We hope that it will inspire students to further study in the physical sciences. b. The course requires the reading and assimilating of approximately one chapter (30 pages) per week, although the class is primarily based upon material presented in lectures, labs, and recitation sections. Weekly problem sets are required and graded. Typically two or three in-class midterm examinations are given along with a comprehensive final examination. The laboratory sections include a weekly laboratory write up and at least one extensive lab report. Further requirements are at the discretion of the instructor and may include such items as a weekly quiz concerning the reading assignments. c. Physics 140 explores the idea of quantization in physics, with an emphasis on historically evolving theories of the atom. We discuss how scientific theories evolve and become accepted or rejected. This is particularly important for understanding models for things that we cannot see and abstract concepts that appear to contradict our daily experiences. Topics include the historical development of the atomic theory of matter and of atoms themselves, special relativity, the dual wave/particle nature of both light and matter, the Rutherford-Bohr atom including its deficiencies.

Meets Goals of Gen Ed: Acquire intellectual breadth and versatility. For most students this is their first exposure to ideas extending beyond the classical models of Isaac Newton and Galileo Galilei. Much of modern science cannot be appreciated, even at the level of newspaper articles, without some appreciation of the ideas behind quantum mechanics and relativity. A student successfully completing Physics 140 will have the background to appreciate the concepts of modern physics and follow discussions of current topics. Acquire critical judgement. Much of the emphasis of Physics 140 is to discuss how scientists know what they know – how theories are developed and the role of experiment in determining the validity of any theory. Many different famous experiments are discussed, and some reworked in the laboratory, as an avenue for discussing what science deems as truth. These ideas should be applied to any class or issue in science. Acquire a working understanding of the processes by which they can continue to acquire and use knowledge. As mentioned above, an emphasis of the class is on understanding how we know what we know. This process will be important to consider for any science class or science discussion. The class also provides the necessary conceptual framework for further discussion of modern scientific issues.

CA3 Criteria: 1. Explore an area of science or technology by introducing students to a broad, coherent body of knowledge and contemporary scientific or technical methods; The course probes many specific topics of physics grouped around two interwoven themes, theories of the atom and the idea of quantization in nature. Students are encouraged to understand how a particular theory was developed and its relationship to scientific knowledge at the time of discovery. Laboratories include a variety of contemporary elements and equipment including vacuum systems, lasers, exploration of individual electron motion, etc.

2. Promote an understanding of the nature of modern scientific inquiry, the process of investigation, and the interplay of data, hypotheses, and principles in the development and application of scientific knowledge; Students are encouraged to understand how a particular theory was developed and its relationship to scientific knowledge at the time of discovery. The text for this course is “Modern Introductory Physics” by Holbrow and Amato

3. Introduce students to unresolved questions in some area of science or technology and discuss how progress might be made in answering these questions; A major theme of the course is how classical theories of the physical world were both completely reasonable but also incorrect when pushed to new limits. We study the developing theories as they developed, including both what proved to be correct as well as some of what proved to be incorrect, and how such conclusions were reached. Where the same questions exist today, they are discussed in an exactly analogous context.

4. Promote interest, competence, and commitment to continued learning about contemporary science and technology and their impact upon the world and human society. That is THE point of Physics 140. This course provides the necessary background to discuss or further explore modern questions in physics. Added interest is achieved by demonstrating surprising consequences of the physics we discuss at the frontiers of knowledge. Some examples are behavior of matter at extremely low temperatures using liquid nitrogen, using lasers to show the diffractive nature of waves, demonstrating the ability of superconductors to levitate magnets.

CA3 Lab Criteria: The laboratory section of the course includes the following three hour experiments. All of the labs consist of a physical apparatus that the students must adjust or reconfigure during the course of the lab, actual measurements must be made, and real data analyzed. Computers are used when appropriate to assist in taking and analyzing data, but do not run simulations of experiments. The labs are performed in groups. Each week a short lab write-up must be submitted and at least one more extensive report. The specific experiments may vary somewhat year to year depending on the discretion of the instructor. The experiments pursued in fall of 2003 were, 1. Fundamentals of measurement 2. Boyle's Law and the use of spreadsheets 3. Kinetic Theory 4. Statistics and error analysis 5. Electron charge to mass ratio, part I 6. Electron charge to mass ratio, part II 7. Electrolysis and the charge to mass ratio of an electron 8. Interference of Light 9. Interference of Waves 10. Radiation 11. Bohr model and atomic spectra 12. Bragg Scattering

Q Criteria: 1. Include mathematics and/or statistics at or above the basic algebra level as an integral part of the course which is used throughout the course. 2. Include use of basic algebraic concepts such as: formulas and functions, linear and quadratic equations and their graphs, systems of equations, polynomials, fractional expressions, exponents, powers and roots, problem solving and word problems. Formal abstract structures used in symbolic logic and other algebraic analyses are acceptable. 3. Require the student to understand and carry out actual mathematical and/or statistical manipulations, and relate them to whatever data might be provided in order to draw conclusions. Merely feeding numerical data into a program on a computer or a calculator to obtain a numerical result does not satisfy this requirement. Technology should be viewed as a tool to aid understanding and not as a driver of content. The course cannot be presented without using the basic mathematics cited above. Only a few advanced calculus derivations are used, but extensive use is made of algebraic derivations, symbolic solutions, and solving equations through graphing. Emphasis both in homework and on lectures is put on translating between mathematical descriptions and English descriptions based on a conceptual model. Problem solving is promoted through context rich word problems. Numerical solutions are constantly discussed in the context of whether an answer is reasonable and understanding what a particular value for a solution means. Finally, most formulas are derived and discussed in terms of predictions that can be made for actual physical measurements, and how such data is properly analyzed.

Role of Grad Students: -A graduate student teaching assistant runs the laboratory section under the supervision of both the instructor of record and the physics department manager of laboratory services. A typical laboratory section involves a brief introduction to the topic at hand, an explanation of the requirements for each session, followed by student exploration of the weeks experiments with the TA available to provide assistance as needed. The TA administers and grades the laboratory reports and provides a final