Department: PHYS

Course No.: 101Q

Credits: 4

Title: Elements of Physics

Contact: G. Rawitscher

Content Area: CA3 Science and Technology- Lab

WQ: Q only

Catalog Copy: 101Q. Elements of Physics Either semester. Four credits. Three class periods and one 2-hour laboratory period. Recommended preparation: MATH 101 or the equivalent. Not open for credit to students who have passed PHYS 121, 131, 141 or 151. Basic concepts and applications of physics for the non-science major. Scientific principles and quantitative relationships involving mechanics, energy, heat and temperature, waves, electricity and magnetism, and the theory of the atom. Laboratory provides hands-on experience with the principles of physics.

Course Information:
a) Course goals and objectives: The goal of this course is to introduce non-science majors to the concepts and methods of physics. The webpage about the course lists the following specific goals:

1. To begin to see that physics is all around us, all the time 2. To learn to think logically in order to solve problems 3. To learn to complete and analyze measurements 4. To develop and expand your physical intuition 5. To learn how things work 6. To begin to understand that the universe is predictable rather than magical 7. To articulate thoughts, ideas and relationships using mathematics 8. To obtain a perspective on the history of science and technology

b) Course requirements: Attendance and participation in the three hours of lecture and two hours of laboratory instruction per week. During the semester there are three in-class hour exams and a cumulative final, weekly homework assignments and online quizzes, reading assignments from the text and course notes and completion of the weekly laboratory exercise. Problems on the homework, quizzes and exams are word problems with either numerical answers or quantatative reasoning. Most problems require at least some algebra to obtain the solution.

c) Major Themes
Week 1: Mathematical Introduction and Description of Motion
Units, Graphs, Formulas, Scientific Notation
One Dimension Kinematics, Displacement, Velocity and Acceleration

Week 2: Newton's Laws of Motion

Inertia, Net Force, Newton's Second Law, Free Fall Revisited
Air Drag, Friction, Newton's Third Law

Week 3: Momentum and Energy
Momentum Changes, Momentum-Impulse Theorem
Kinetic Energy, Work, Potential Energy, Energy Conservation

Week 4: Circular Motion and Gravity
Uniform Circular Motion, Centripetal Acceleration
Newtonian Gravity, Inverse-Square Relationships, Satellites and Planets

Week 5: Structure of Matter
Atoms, Macroscopic and Microscopic Properties, Pressure
Temperature, Ideal Gas Law

Week 6: State of Matter
Density, Fluids, Atmospheric Pressure
Pressure vs. Depth, Archimedes' Principle

Week 7: Thermal Energy
Temperature, Internal Energy, Heat, Work, First Law of Thermodynamics
Specific Heat, Change of State, Heat Transfer, Greenhouse Effect

Week 8: Electricity
Electric Charge, Charge Conservation, Polarization, Coulomb's Force Law
Electric Field, Electric Potential Energy, Capacitors, Voltage, Van de Graff Generator

Week 9: Electric Circuits
Voltage Sources, Resistance, Ohm's Law
Series and Parallel Circuits, Electrical Power and Energy

Week 10: Magnetism
Magnetic Fields, Atomic and Nuclear Magnets, The Magnetic Force
Earth's Magnetic Field, MRI, Biomagnetism, Faraday's Law, Transformers

Week 11: Vibrations and Waves
Vibrations and Oscillations, Natural Frequency, Resonance, Waves
Transverse & Longitudinal Waves, Electromagnetic Waves, Standing Waves

Week 12: The Early Quantum Theory
Emission of Light from Atoms, Incandescence, Photoelectric Effects
Rutherford Model, Bohr Model, Periodic Table, X-rays

Week 13: Modern Quantum Theory
Wave-Particle Duality for Light, Matter Waves, Wave Interference
Wave Function and Probability, The Uncertainty Principle, Complimentarity Principle

Week 14: Nuclear Physics
Nuclear Structure, Elements & Isotopes, Radioactivity, Half-life
Activity, Radioactive Dating, Biological Effects of Radiation, Antimatter, PET scans

Meets Goals of Gen Ed: Acquire intellectual breadth and versatility. There are several levels of "intellectual breadth" that are relevant to Physics 101Q. The course touches on all the major pillars of physics and has a very broad list of topics within the discipline. There is also a historical breadth, where physics is developed starting from the ancient Greeks and ends with antimatter and modern theories of the big bang. There is a breadth of application, where specific physics examples related to health, medicine, sports, theater, music, philosophy, archeology, and other aspects of human endeavor are presented in the course.

Acquire critical judgment. To recognize the fact that the physical world can be studied and understood in a quantitative mathematical framework should help students realize that there is a difference between good science and the pseudoscience of popular culture and the media that covers it. This is especially true in the medical and health related topics of magnetism and nuclear physics covered in Physics 101Q. Students also learn the importance of precise meanings of words and concepts in the expression of scientific statements and evaluations.

Acquire a working understanding of the processes by which they can continue to acquire and use knowledge. An important goal of this course has been "to learn how to think logically in order to solve problems". It is the scientific method and logical problem solving techniques that form the basis of the most important and successful way of generating new knowledge and also applying this knowledge to problems facing the individual and society at large. The students acquire the understanding in the laboratory and it is reinforced in lecture examples and the homework/quiz assignments.

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 topics of this course discussed above cover all of the general aspects of physics (mechanics, electricity and magnetism, heat, wave, quantum and nuclear physics) and their interrelationships.

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; These points are covered in an active way during the student laboratory, and also reinforced during the lecture part of the course.

3. Introduce students to unresolved questions in some area of science or technology and discuss how progress might be made in answering these questions; and Unresolved questions involving the health effects of magnetic fields (and more generally, electromagnetic fields), ionizing radiation, and the

environmental impact of greenhouse emissions are presented and we point out how the answers to these question effect quality of life and resource allocation issues.

4. Promote interest, competence, and commitment to continued learning about contemporary science and technology and their impact upon the world and human society. One of the goals of this course is "to see that physics is all around us, all the time". We make special use of news headlines and current events to bring relevancy to the physical principles we teach. Examples such as magnetic resonance imaging, PET scans, carbon-14 dating, superconductivity, and magnetic levitation are presented to foster the kind of interest in physics that we hope serves the student long after their graduation.

CA3 Lab Criteria: The laboratory section of the course includes the following ten 2-hour labs plus a lab final. All of the labs consist of a physical apparatus that the students must adjust or reconfigure during the course of the lab. The labs are performed in groups of three students, while the lab final is done individually, so that each student is required to show mastery of the experimental techniques. Each student fills out a worksheet with data analysis and observations that is turned in at the end of the lab section.

1. The Scientific Method
2. Space and Matter
3. Forces
4. Motion
5. Fluids
6. Heat and Calorimetry
7. Illumination
8. Electricity and Magnetism
9. Sound and Standing Waves
10. Atomic Spectra
11. Lab Final

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. Almost all of the homework, quiz, exam, and laboratory problems and exercises require either numerical or algebraic answers, or quantitative reasoning involving scaling relationships.

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. The course material requires the use of formulas and functional relationships, linear equations, systems of equations, exponents, powers and roots, problem solving and word problems. The lab also emphasizes graphical relationships between measured quantities. Scaling relationships include simple linear, inverse, and powers (integer and fractional).

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 quantitative techniques mentioned above require careful thought and analysis and the assigned problems and questions cannot be properly answered by simply "plugging" numbers into an equation.

Role of Grad Students: Graduate student assistants are responsible for the laboratory section of the course. This involves giving a brief presentation (~15 min) at the beginning of the lab section on the content and methodology of the experiments and the data analysis. The TA then assists and guides the students as they perform the experiments and then collects and grades the worksheet-style lab reports. Our teaching assistants participate in a special training session during the summer just prior to the start of classes and are supervised by the instructor of record and the department Manager of Laboratory Services.