Course: Modern Physics
PEIMS Code: N1120041 *Abbreviation:* MODPHY
Number of credits that may be earned: 1/2-1

Brief description of the course (150 words or less):

Most physics courses effectively end their study at the year 1900. For students to be educated in a field it is important they have some sort of knowledge of the current state of the field. In physics this necessitates some knowledge of relativity and quantum mechanics and their applications and implications. Beyond this students will gain an understanding of how science works; what motivates it, how initially promising ideas are refuted by continued research, and the consequences of science on other fields and society in general.

Essential Knowledge and Skills of the course:

(a) General Requirements

This course is recommended for 11th or 12th graders. The recommended prerequisites are first year physics , precalculus, and geometry. Calculus concurrent would be beneficial but not required.

(b) Introduction

(1) In Modern Physics, students will conduct field and laboratory investigations using scientific methods to study a variety of topics related to relativity and quantum mechanics, the fundamental concepts written down by 1930 continuing to applications and consequences throughout the 20th century, including particle physics, unification, and cosmology.

(2) Science is a collaborative process that is affected by the historical context in which it is pursued. Students will study the historical context around the advances of 20th century physics and understand the influences that shape the development of the science.

(3) Science presents a model for understanding how the natural world works. Students will have an understanding of the fundamental picture of the natural world, both in elementary particles and fundamental forces, and cosmology.

(4) Hypotheses, postulates, and conjectures drive science research and direct scientific efforts. Students will gain knowledge and some degree of understanding of many of the most cutting edge ideas in physics, ideas trying to answer some of the most difficult

unanswered questions. Examples include but are not limited by string theory, loop quantum gravity, etc., understanding their promises as well as limitations.

(c) Knowledge and Skills

(1) Scientific Processes. The student, for at least 40% or the time, conducts field and laboratory investigations using safe, appropriate scientific practices, planning experimental procedures, making quantitative measurements, and interpreting and evaluating data to reach and communicate valid conclusions.

(1) Science Concepts. The student is expected to understand the historical context of research leading to special relativity. The student is expected to demonstrate:

(a) the historical basis and result of the Michelson-Morley experiment;

(b) the conflict between the Galilean Transformation and Maxwell's Equations; and

(c) the concept of the aether and preferred frames of reference.

(2) Science Concepts. The student is expected to identify the basic postulates, and demonstrate the consequences of special and general relativity including the quantitative effects on space and time. The student is expected to:

(a) demonstrate length contraction, time dilation, lorentz transformations, gravitational redshift, Doppler effect; and

(b) demonstrate the Equivalence Principle, bending of space and time, and other consequences of general relativity.

(3) Science Concepts. The student is expected to understand the historical context of research leading to the first quantum ideas. The student is expected to:

(a) describe photoelectric effect, blackbody radiation, and the models of the atom; Thomson, Rutherford, and Bohr.

(4) Science Concepts. The student is expected to analyze historical experimental data relating to emission spectra and evaluate the strengths and weakness of various atomic models designed to explain the spectra, including the advent of the four quantum numbers.

(5) Science Concepts. The student is expected to analyze the development of the concept of wave-particle duality. The student is expected to:

(a) understand de Broglie's relations, Compton effect;

(b) know Heisenberg's Uncertainty Principle;

(c) describe both Schrödinger's Equation and Heisenberg's Matrix Mechanics;

(d) demonstrate solutions to the Schrödinger Equation for simple cases; infinite square well, finite square well, and harmonic oscillator; and

(e) evaluate the results for the hydrogen atom.

(6) Science Concepts. The student is expected to identify the applications of quantum mechanics to technologies; including electrical conductivity, superconductivity, semiconductors, and newer nanotechnologies.

(7) Science Concepts. The student is expected to identify the historical context for our theoretical understanding of fundamental forces and elementary particles and demonstrate the classification and properties of the fundamental elementary particles, various models of unification of the forces, and the workings of the standard model.

(8) Science Concepts. The student is expected to identify and analyze current knowledge in cosmology, including the expansion of the universe, the big bang, time scale of the evolution and fate of the universe, and size and geometry of the universe.

(9) Science Concepts. The student is expected to identify and describe fields at the forefront of contemporary physics, including string theory, various competing paths toward unification, and complexity and chaos theory.

Description of the specific student needs this course is designed to meet:

The student will benefit in three ways. First and most important a much more sophisticated level of understanding of physical science will be achieved which will benefit the student in physics, chemistry, and many engineering fields in future study. Second, the student will see an incredible array of mathematical applications in science that aren't found in any other high school science course. Third, the student will further their familiarity with research in science, both in universities and industry.

Major resources and materials to be used in the course:

The course will draw from several texts, periodical literature, web-based sources, and individual student research of various sources. 40% of the coursework will be devoted to laboratory investigations, including traditional lab work, virtual investigations, and survey of current research from the physics community, when appropriate. Also guest lectures from university professors or attendance at lectures and symposiums will be encouraged.

Required activities and sample optional activities to be used:

Several components will make up the coursework. 1) Traditional text sources and exercises. 2) Lab work and student research of historical and current physics research. 3) Student papers and in-class presentations on various topics. 4) A student journal of readings and personal reflections of academic progress.

Methods for evaluating student outcomes:

Evaluation will be traditional testing over course work, both quantitatively and qualitatively, and evaluation of the students' quality of participation in presentations and projects.

Teacher qualifications:

Certified in physics or composite science with additional coursework in physics is preferred. An advanced degree is also preferable so the instructor has first-hand experience with graduate work and research.

Additional information (optional):

Topics in this course may vary year to year. Since the purpose of the course is to study cutting edge science, the curriculum should constantly be updated. This allows flexibility and opportunity to adjust both the content and the methods to student interests and abilities.

Original course creator: Austin Independent School District