

PROGRESSIVE SCIENCE INITIATIVE

ALGEBRA BASED PHYSICS

I. Course Description

This course represents the first year in a comprehensive two year sequence of Algebra/Trigonometry based physics. This first course is comprised of Mechanics, which is studied for the first 40% of the year; Electricity and Magnetism, which is studied for the next 40%; and, finally, Simple Harmonic Motion, Waves, Light and the Bohr model of the Hydrogen atom for the last 20%.

The order of the topics has been geared to use and reinforce the mathematics that the students are studying. For this reason, this first year course is geared towards reinforcing skills in algebra and requires no trigonometry. This is accomplished by restricting the first year course to problems that can be simplified to one-dimensional form. While vectors are introduced, they are only added and subtracted in one dimension at a time. This allows students to do about 90% of the Physics AP B topics. Connections are also developed between the analysis of motion and graphical analysis, collision problems and the solving of systems of equations, etc.

The second year course, AP Physics B, begins with a brief review of that same material while introducing multi-dimensional problems, through the addition and subtraction of vectors in two and three dimensions. This is coordinated with the student's study of trigonometry.

Throughout both years, students will be involved in problem-solving activities on an individual, small group and large group basis. Through this process the ability to read and understand problems, break them down into their component parts and then create and present solutions will be developed.

Students who have successfully completed this course may elect to move onto Physics AP B.

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II. Course Outline

1. One- Dimensional Kinematics

- a. Motion in one dimension
- b. Vectors vs. scalars
- c. Displacement vs. Distance
- d. Velocity vs. Speed
- e. Using the four kinematics equations to solve problems:
 - a. $x = x_0 + v_0 t + \frac{1}{2} a t^2$
 - b. $v = v^0 + at$
 - c. $v^2 = v_0^2 + 2a\Delta x$
 - d. $v_{avg} = (v + v_0)/2$
- f. Graphical interpretation of motion

2. Dynamics

- a. Aristotelian World View
- b. Galilean view
- c. Newton's Laws
- d. Free body Diagrams
- e. Gravity near the earth's surface and "g"
- f. Mass versus weight ($W = mg$)
- g. Use $\Sigma F = ma$ and free body diagrams to solve problems in one dimension
- h. Surface Forces: Normal Force and Friction
- i. Apparent weight
- e. Static and Kinetic Friction

3. Circular Motion

1. Net force required for circular motion ($a = mv^2/r$)
2. Application of Free Body diagrams and Newton's Laws to circular motion problems
3. Universal gravitation
4. Solve problems with universal gravitation ($F = GMm/r^2$)
5. Satellites and 'weightless'
6. Kepler's Laws and Newton's Synthesis

5. Linear Momentum

- a. Momentum ($p = mv$)
- b. Impulse ($I = F\Delta t = \Delta p$)
- c. Momentum and its relation to force ($F = \Delta p/\Delta t$)
- d. Conservation of momentum ($\Sigma p = \Sigma p'$)
- e. Collision and Impulse Problems
- f. Elastic collisions in one dimension ($v_1 - v_2 = v_2' - v_1'$)
- g. Perfectly inelastic collisions in one dimension ($m' = m_1 + m_2$)
- h. Inelastic collisions in one dimension

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6. Work and Energy

- a. Work done by a constant force ($W = Fd_{\text{parallel}}$)
- b. Conservation of Energy ($E_o + W = E_f$)
- c. Kinetic Energy ($KE = \frac{1}{2} mv^2$)
- d. Gravitational Potential Energy ($GPE = mgh$)
- e. Elastic Potential Energy ($EPE = \frac{1}{2} kx^2$)
- f. Internal Energy and Joule's Principle
- g. Conservative and non-conservative forces
- h. Problem solving with the Principle of Conservation of Energy.

7. Electric Charge and Electric Field

- a. Electric charge and its conservation
- b. Interactions of charges
- c. Induced charges; the electroscope
- d. Coulomb's Law ($F = kq_1q_2/r^2$)
- e. Electric field ($E = kq/r^2$)
- f. Superposition of forces
- g. Superposition of electric fields
- h. Calculation of net force and/or field due to multiple charges

8. Electric Potential

- a. Electric potential and potential difference ($V = kq/r$)
- b. Relation between electric potential and field ($V = Ed$)
- c. Equipotential lines
- d. Calculation of net electric potential due to multiple charges
- e. Calculation of potential energy of a charge in at a voltage
- f. Calculation of the potential energy of an assembly of charges

9. Electric Currents

- a. The electric battery
- b. Electric current ($I = \Delta q/\Delta t$)
- c. Ohm's Law ($I = V/R$)
- d. Resistivity $R = \rho L/A$
- e. Superconductivity
- f. Joule's Law and Electric Power ($P=V^2/R = IV = I^2R$)

10. DC Circuits

- a. Resistors in series ($R_{\text{series}} = R_1 + R_2 + \dots$)
- b. Adding resistors in parallel ($1/R_{\text{parallel}} = 1/R_1 + 1/R_2 + \dots$)
- b. Equivalent Circuit resistance
- c. Calculating current in circuits and circuit branches
- d. Calculating power in circuits and circuit branches
- e. EMF and terminal voltage ($V_T = \mathcal{E} - Ir$)
- f. EMF's in series and in parallel

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11. Magnetism

- a. Magnets and magnetic fields
- b. Electric currents produce magnetic fields
- c. Force on an electric current in a magnetic field ($F = LI B_{\text{perpendicular}}$)
- d. Force on a charged particle in a magnetic field ($F = qv B_{\text{perpendicular}}$)
- e. Magnetic field due to a current carrying wire $B = \mu_0 I / 2\pi r$
- f. Force between parallel wires $F = \mu_0 I_1 I_2 / 2\pi r$
- g. Direction of force between two parallel wires
- h. Mass spectrometry ($r = mv / (qB)$)
- i. Velocity selection ($v = E/B$)

12. Electromagnetic Induction

- a. Magnetic Flux ($\phi_B = BA_{\text{parallel}}$)
- b. Magnitude of Induced EMF ($\mathcal{E} = -N \Delta \phi / \Delta \tau$)
- c. Lenz's Law
- d. EMF induced in a moving conductor $\mathcal{E} = BvL_{\text{perpendicular}}$
- e. Changing magnetic flux produces an electric field
- f. Electric generators
- g. Conversion of mechanical to electric energy and its importance

13. Simple Harmonic Motion; Vibrations; and Waves

- a. Period and frequency
- b. Mass-spring systems
- c. The simple pendulum
- d. Wave Motion
- e. Wavelength, frequency and wave velocity
- f. Interference
- g. Refraction
- h. Diffraction
- i. Standing Waves

14. Electromagnetic Radiation and the Wave Nature of Light

- a. Changing electric fields produce magnetic fields
- b. Production of EM Waves
- c. The Wave Nature of Light
- d. Visible Spectrum
- e. Dispersion
- f. The Speed of Light
- g. The Double slit Experiment

15. Atomic and Nuclear Physics

- a. Alpha particle scattering and the Rutherford model of the atom
- b. Photons and the photoelectric effect
- c. Wave-particle duality
- d. Bohr model of the atom

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III. Required Labs

1. Graphical analysis of the motion of an object
2. Position, velocity, acceleration
3. Kinetic friction
4. Inertia
5. Centripetal force
6. Conservation of momentum
7. Electric charge
8. Electric field
9. Ohm's Law
10. Series and parallel circuits
11. Resistivity
12. Magnetic field maps
13. SHM spring-mass oscillating system

IV. Course Assessment

Formative assessments are done by the teacher in order to assure that the students understand the material that has been taught. These occur during class and divide into two categories. The first category is ungraded and consists of student participation, student responses to questions, observed student-student interactions and homework completion.

The second type of formative assessment is graded and consists of quizzes, based on previously discussed homework assignments; quests, which are full period assessments that check a broader set of problems at the same level of difficulty as quizzes; and reading quizzes, which check to see if students have been completing reading assignments. Altogether these assessments represent about 20 - 30 % of the marking period grade.

Summative assessments take the form of chapter tests, midterms and finals. These are all given in the same form as the AP exam; half multiple choice and half free response. The multiple choice questions are conceptual in nature while the free response section involves solving multistep problems; often taken from prior AP exams. Chapter tests comprise about 50 - 60% of each marking period grade. The midterm and final exam each represent 10% of the full year grade; combined they equal a marking period grade.

The intention is for identical summative assessments to be given to all the students in the course on the same day, regardless of their teacher. This is to encourage students to study together in groups, with or without a teacher, to advance their skill and understanding.

Laboratory work is graded and typically represents about 20% of each marking period grade. The grade is divided evenly between the work done in the lab, based on teacher observation, and the lab report.

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V. Methodology

Lecture

Use of this method will be limited to the introduction of new topics and will be of short duration, no more than 10 minutes in one class period. Many classes will not include this component at all. The students will need to use their visual, listening, writing skills and organization skills to benefit from this part of the course. Students will be required to keep complete and organized notebooks

Large group Problem Solving and Discussion Sessions

The teacher will lead these sessions where students will actively participate in raising questions, answering questions and expanding upon topics. The entire class will work together to solve complex problems which test their understanding of the ideas being developed. The teacher will coordinate these sessions to ensure that all the students participate. This is vital in that this gives each student the opportunity to expand their understanding. By increasing the Zone of Proximal Development (ZPD) for all the students, they will be able to quickly advance their understanding.

Small Group Problem Solving Sessions

In these sessions a few problems will be given to the entire class and they will work in groups of 2 to 4 students to solve them. Once most of the problems have been solved, each group will present a solution to one of the problems to the rest of the class. Disputes and different approaches will be discussed in the Large Group format with the class taking the lead in determining the best approach. The teacher serves to chair the discussion. Once again this activity is designed to allow the students to quickly learn in an environment where their ZPD has been expanded.

Hands On Activities / Laboratory / Discovery

Students participate in labs on alternate weeks. Each lab period is 86 minutes long, giving students the time necessary to take all data and begin analysis in groups.

Students need to not only solve problems analytically but also apply those solutions to real hands on problems. These sessions are generally, but not exclusively, held in the physics laboratory and involve two to four students working together. The students will be asked to conduct experiments that either apply or develop new understandings. These will not be cookbook experiments, where the students simply walk through a procedure. Rather, these experiments involve gathering data and making analyses where the results are unknown to them, and sometimes even to the instructor.

These labs will use actual physical apparatus, often with electronic probes to

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gather data and computers to conduct analysis. Whenever possible, they will be performed towards the beginning of each unit, affording the student the experience of discovering the concepts before they are formally taught by the instructor. One objective of each lab exercise is for each student to analyze their data using data and error analysis techniques in order to judge the accuracy and meaning of their results.

Reading

Students will be encouraged to develop the self-confidence and techniques required to learn directly from the text. The techniques needed to accomplish that will be discussed in class and reviewed from time to time. Readings will be assigned to either introduce or reinforce topics. In this way, classroom time is not spent reviewing every fact and detail for which the students will be responsible. Students will then be better prepared to participate and engage in active classroom discussion. The skill of being able to read and understand a text is so critical that great effort will be made to encourage students to develop it. In this vein, reading quizzes will be given from time to time to determine that students are completing their reading assignments.

Homework problems

Problems will be assigned every night so that students can apply the learning that was done during class that day. This will be checked by periodic homework quizzes that will be given the day after the assignment was due. In that way, student who made an honest effort but need to ask questions in class to reach a correct solution are not penalized. The homework quizzes are designed to test that students are learning how to do these problems. This contrasts with collecting assignments, which can lead to copying rather than understanding.

Field Trips

Appropriate trips out of the school environment are an excellent way to show students that what they learn in classroom definitely relates to the world at large. Students are given a chance to see how ideas develop into real life situations and have real life applications.