Science Curriculum

Course Title: AP Physics I

Grade Level: High School

Board Approved: January 5, 2022

AP PHYSICS 1 SYLLABUS

TEXTBOOK

Urone, Paul, and Hinrichs, Roger. College Physics. Houston, TX: Rice University, 2013. [CR1]

TEACHING RESOURCES

Hieggelke, Curtis, David Maloney, and Stephen Kanim. *Newtonian Tasks Inspired by Physics Education Research: nTIPERs*. Upper Saddle River, NJ: Pearson, 2012.

Hieggelke, Curtis, David Maloney, Thomas O'Kuma, and Stephen Kanim. *E&M TIPERs: Electricity & Magnetism Tasks.* Upper Saddle River, NJ: Pearson, 2006.

O'Kuma, Thomas, David Maloney, Hieggelke, Curtis. *Ranking Task Exercises in Physics*. Boston: Pearson/Addison Wesley, 2008.

Hieggelke, Curtis, Steve Kanim, D P Maloney, T. L. O'Kuma. *TIPERs: Sensemaking Tasks for Introductory Physics*, Upper Saddle River, NJ: Pearson, 2013.

Knight, Randall D., Brian Jones, and Stuart Field. College Physics: A Strategic Approach. 3rd ed., AP® ed. Boston: Pearson, 2014.

Etkina, Eugenia, Michael Gentile, and Alan Van Heuvelen. College Physics. San Francisco, CA: Pearson, 2014.

INSTRUCTIONAL STRATEGIES

This AP Physics 1 course is conducted using an inquiry-based modeling approach. Most units begin with a teacher-led demonstration of a paradigm, in the sense of a typical example, for the unit. Students suggest variables that influence the paradigm, and then experiment to investigate the variables. A consensus-building discussion follows in which the class constructs a conceptual model that describes the physics of the paradigm. The majority of the unit is spent using and expanding the ideas introduced in the paradigm lab. As a result of this approach, the students construct and use multiple representations of physical processes, design investigations, critically analyze data, and participate in classroom discourse and writing on the nature of science.

Students are engaged in hands-on guided inquiry laboratory work for at least 25% of instructional time throughout the school year. In addition to paradigm labs, students engage in open-ended “Exploration Labs”. In these activities, they work with lab equipment but don’t collect a complete data set. Instead, they answer questions and explore concepts. Many units include a lab practicum activity. In these students are proposed a problem and given a set of available equipment, but are not given a solution. Lab groups work together to devise and attempt a solution to the practicum. An example is “Rolls in Sync”, in which the problem is: Predict the ratio of heights that will cause a dropped toilet paper roll and an unrolling toilet paper roll to hit the ground at the same time.

Instructional technology is used throughout the course. Most hands-on labs are conducted using Vernier LabQuest 2 probeware technology for data acquisition. PhET simulation software is used for visualization of physics principles and some virtual labs. Much homework and some formative assessment is conducted using the MasteringPhysics platform. Other formative assessment occurs with implementation of TIPERS, or Peer Instruction using Socrative. Students have access to tablet computers and graphing calculators in the classroom.

Students have many opportunities to meet learning objectives across Enduring Understandings. For example, in Unit 4, Interactions I, students are questioned about Normal Force interactions, to elicit their ideas. In an interactive lecture demonstration they are led through a series of reasoning steps to recognize that even "rigid" real objects have an internal structure, leading to their ability to exert a Normal Force equivalent to the force exerted on them.

Learning Objectives: 1.A.5.1, 3.A.3.1, 3.A.3.3, 3.C.4.1, 3.C.4.2

Students also have opportunities to relate their learning to Real World situations. A key component of each paradigm lab conclusion is that students must relate the model investigated to a Real World example. Most units include a practicum that relates the physics principles in the unit to a Real World situation. For instance, in the kinematics units, students are asked to predict a collision point between two vehicles theoretically, and then model it with lab equipment. In the sound unit, students will be asked to describe how what they have learned about standing waves describes the production of sound in a simple Real World instrument, such as a guitar or a recorder.

Scientific Argumentation is a key component of the course. For example, in the modified Atwood's machine paradigm lab (Unit 5), students first observe a demonstration of the modified Atwood's machine. Then they engage in a whole-class discussion about apparatus. They propose governing variables, and make claims about the effect of those variables. Groups are assigned to investigate those claims in an experiment, and the whole class evaluates the claims made in light of the data from the lab. Other paradigm labs follow this pattern.

The TIPERs and other resources are used in a Peer Instruction-inspired method to promote discourse in the classroom. Students are asked to answer the TIPER individually. They then compare answers with others in the group, and evaluate each group member's reasoning. The groups are given a few minutes to reach consensus, and then a whole-class discussion follows. Each group is prepared to present an argument for their answer. A group is selected to present, other groups evaluate the physics of the presentation, and eventually a whole-class consensus about the correct answer is reached.

Semester 1 [Estimated 82 class days]

Unit 1: Motion I – Constant Velocity [est. 10 days]
Big Idea 3 – Constant Velocity in one dimension, vectors and multiple representations
Learning Objectives: 3.A.1.1, 3.A.1.2, 3.A.1.3

Unit 2: Interactions I – Balanced Forces [est. 13 days]
Big Ideas 1, 2, 3, 4 – The force concept, Newton's First and Third Laws, modeling systems where Σ F = 0
Learning Objectives: 3.A.1.1, 3.A.1.2, 3.A.1.3, 3.A.2.1,3.A.3.A,3.C.4.1,3.C.4.2,3.A.4.1,3.A.4.3

Unit 3: Motion II – Constant Acceleration [est. 10 days]
Big Idea 3 – Constant acceleration in one dimension, vectors and multiple representations
Learning Objectives: 3.A.1.1, 3.A.1.2, 3.A.1.3, 4.A.2.1,4.A.2.3

Unit 4: Interactions II – Unbalanced Forces [est. 10 days]
Big Ideas 1, 2, 3, 4 – Newton's Second Law, modeling systems where Σ F≠ 0
Learning Objectives: 1.C.1.1, 1.C.3.1, 3.B.1.1, 3.B.1.2, 3.B.1.3, 3.B.2.1, 4.A.1.1, 4.A.2.2, 4.A.3.1 ,4.A.3.2

Unit 5: Motion III – 2-d Motion (Projectiles; Rotational Kinematics) [est. 9 days]
Big Ideas 2, 3 – Kinematics in two-dimensions: projectiles, applying representations of kinematics to rotational motion
Learning Objectives: 2.B.1.1, 3.A.1.1, 3.A.1.2, 3.A.1.3, 4.A.2.1,4.A.2.3

Unit 6: Interactions III - Dynamics of Circular Motion; Gravitation [est. 9 days]
Big Ideas 1, 2, 3, 4 – Centripetal acceleration and circular motion, universal gravitation, circular orbits
Learning Objectives: 1.C.3.1, 2.B.1.1, 2.B.2.1, 2.B.2.2, 3.C.1.1, 3.C.1.2, 3.G.1.1, 4.A.2.2

Unit 7: Work, Energy and Power [est. 11 days]

Big Ideas 3, 4, 5 – Work, energy, power, conservation of energy (incl. rotational kinetic energy)
Learning Objectives: 3.E.1.1, 3.E.1.2, 3.E.1.3, 3.E.1.4, 4.C.1.1, 4.C.1.2, 4.C.2.1, 4.C.2.2, 5.A.2.1, 5.B.1.1, 5.B.1.2, 5.B.2.1, 5.B.3.1, 5.B.3.2, 5.B.3.3, 5.B.4.1, 5.B.4.2, 5.B.5.1, 5.B.5.3, 5.B.5.4, 5.B.5.5, 1.A.5.1, 5.B.5.2
Unit 8: Linear Momentum and Impulse [est. 10 days]
Big Ideas 3, 4, 5 – Impulse, linear momentum, collisions, conservation of momentum
Learning Objectives: 3.D.1.1, 3.D.2.1, 3.D.2.2, 3.D.2.3, 3.D.2.4, 4.B.1.1, 4.B.1.2, 4.B.2.1, 4.B.2.2, 5.A.2.1, 5.D.1.1, 5.D.1.2, 5.D.1.3, 5.D.1.4, 5.D.1.5, 5.D.2.1, 5.D.2.3, 5.D.2.4, 5.D.2.5, 5.D.3.1, 5.D.1.4, 5.D.2.2

Semester 2 [Estimated 63 class days]

Unit 9: Rotational Motion [est. 15 days]
Big Ideas 3, 4 – Rotational statics, dynamics, energy, and momentum
Learning Objectives: 3.F.1.1, 3.F.1.2, 3.F.1.3, 3.F.1.4, 3.F.1.5, 3.F.2.1, 3.F.2.2, 3.F.3.1, 3.F.3.2, 3.F.3.3, 4.D.1.1, 4.D.1.2, 4.D.2.1, 4.D.2.2, 4.D.3.1, 4.D.3.2, 5.E.1.1, 5.E.2.1

Unit 10: Simple Harmonic Motion and Oscillation [est. 7 days]
Big Idea 3, 4, 5 – Simple pendulum, mass on a spring, multiple representations of oscillation, energy in oscillation
Learning Objectives: 3.B.3.2, 3.B.3.1, 3.B.3.3, 3.B.3.4, 5.B.2.1, 5.B.3.1, 5.B.3.2, 5.B.3.3, 5.B.4.1, 5.B.4.2

Unit 11: Mechanical Waves and Sound [est. 12 days]
Big Idea 6 – Wave pulses, interference and superposition, wave speed, reflection, representations of waves, traveling waves, standing waves. Sound, harmonics in strings, open and closed tubes, musical instruments Learning Objectives: 6.A.1.1, 6.A.1.2, 6.A.2.1, 6.A.3.1, 6.A.4.1, 6.B.1.1, 6.B.2.1, 6.B.4.1, 6.B.5.1, 6.D.1.1, 6.D.1.2, 6.D.1.3, 6.D.2.1, 6.D.3.1, 6.D.3.2, 6.D.3.3, 6.D.3.4, 6.D.4.1, 6.D.4.2, 6.D.5.1

Unit 12: Electricity [est. 15 days]
Big Ideas 1, 2, 3, 5 - *Conservation of Charge, two-charge model, electrostatic force, Ohm's Law, Kirchhoff's Loop and Junction Laws for simple DC circuits, potential and energy in circuits*
Learning Objectives: 1.B.1.1, 1.B.1.2, 1.B.2.1, 1.B.3.1, 1.E.2.1, 3.C.2.1, 3.C.2.2, 5.A.2.1, 5.B.9.1, 5.B.9.2, 5.B.9.3, 5.C.3.1, 5.C.3.2, 5.C.3.3

Review for AP Test: [est. 14 days]

SCIENCE PRACTICES

Students have regular opportunities to work with the Science Practices, and develop Enduring Understandings. **All labs are designed as guided inquiry**, as described above, and all labs include a conceptual component, either in the pre-lab questions, the post-lab questions, or in the required conclusion. Students are expected to estimate the uncertainty of their measurements and evaluate the significance of uncertainty on their lab results. In addition to the activities listed below, each unit may include one or more Exploration Labs, Lab Practicum, or Interactive Demonstration, all of which require student writing, to be graded by the instructor. **All lab work is recorded by the students in a lab notebook.**

MAJOR LAB ACTIVITIES BY UNIT
Unit 1: Motion I – Constant Velocity
Lab 1 - "Blinky Buggy" Constant Velocity Cart - (Guided Inquiry)
Given setups with different initial and final conditions, student groups produce multiple representations of constant velocity motion
Science Practices: 1.1, 1.2, 1.3, 1.4, 1.5, 7.1

Unit 2: Interactions I – Balanced Forces
Labs 2,3,4 - "Frictionless" Hover Puck, Bowling Ball and Rubber Mallet, Force Table designed to demonstrate Newton's First and Third Laws - (Guided Inquiry)
Students view and interact with demos, make predictions, produce and refine explanations using the force concept and Newton's Laws
Science Practices: 6.1, 6.2, 6.3, 6.4, 6.5, 7.1, 7.2

Unit 3: Motion II – Constant Acceleration
Lab 5 - Dynamics Cart on an Incline - (Guided Inquiry)
Students use video analysis to produce multiple representations of accelerated motion
Science Practices: 1.1, 1.2, 1.3, 1.4, 1.5, 7.1

Unit 4: Interactions II – Unbalanced Forces
Lab 6 - Modified Atwood's Machine (Newton's Second Law - (Guided Inquiry)
Students derive Newton's Second Law from lab data
Science Practices: 5.1, 5.2, 5.3

Unit 5: Motion III – 2-d Motion (Projectiles; Rotational Kinematics)
Lab 7 - Horizontal Projectile - (Guided Inquiry)
Students analyze the motion of a projectile using video analysis.
Science Practices: 1.1, 1.2, 1.3, 1.4, 1.5, 7.1
Lab 8 - Falling Mass Accelerates an Rotating Object (kinematics only) - (Guided Inquiry)
Students design an experiment to confirm that constant acceleration equations translate to a rotational situation
Science Practices: 3.1, 3.2, 3.3

Unit 6: Interactions III - Dynamics of Circular Motion; Gravitation
Lab 9 - Flying Pig - (Guided Inquiry)
Students are challenged to produce an accurate estimate of the speed of and forces acting on the pig
Science Practices: 4.1, 4.2, 4.3, 4.4
Lab 10 - PhET Simulation: Gravity Force Lab (Newton's Universal Gravitation) - (Guided Inquiry)
Students derive Newton's Law of Universal Gravitation
Science Practices: 5.1, 5.2, 5.3
Lab 11 - PhET Simulation Gravity and Orbits (Connecting Universal Gravitation and Circular Motion) - (Guided Inquiry)
Science Practices: 4.1, 4.2, 4.3, 4.4

Unit 7: Work, Energy, and Power
Lab 12 - Elastic Potential Energy- Kinetic Energy Conservation - (Guided Inquiry)
Students use a spring cart launcher to derive the relationship between spring stretch and cart speed, and derive formulae for elastic potential energy and kinetic energy from the data
Science Practices: 5.1, 5.2, 5.3
Lab 13 - Work and Gravitational Potential Energy - (Guided Inquiry)
Students derive relationships for work and gravitational potential energy from multiple representations while working with a cart on a ramp
Science Practices: 1.1, 1.2, 1.3, 1.4, 5.1, 5.3

Unit 8: Linear Momentum and Impulse
Lab 14 - Cart and Force Sensor Collisions – Impulse and Change in Momentum - (Guided Inquiry)
Students derive the mathematical relationship between impulse and change in momentum from data of a dynamics cart colliding with a force sensor, describe the utility of the relationships, and then estimate values for collisions in other contexts
Science Practices: 2.1, 2.2, 2.3
Lab 15 - Conservation of Linear Momentum - (Guided Inquiry)
Students design a lab to use momentum conservation to find the value of an unknown mass
Science Practices: 3.1, 3.2, 3.3

Unit 9: Rotational Motion
Lab 16 - Balanced Torques with Meter Stick Lever Apparatus - (Guided Inquiry)
Students design a plan and derive the rules for static equilibrium
Science Practices: 4.1, 4.2, 4.3
Lab 17 - Falling Mass Accelerates an Rotating Object (dynamics) - (Guided Inquiry)
Science Practices: 3.F.1.1, 3.F.1.2, 3.F.1.3, 3.F.2.1, 3.F.2.2, 4.D.1.1, 4.D.1.2
Lab 18 - Conservation of Angular Momentum - (Guided Inquiry)
Students investigate angular momentum conservation using probeware, and then generalize their findings to other domains
Science Practices: 7.1, 7.2

Unit 10: Simple Harmonic Motion and Oscillation
Lab 19 - Simple Pendulum - (Guided Inquiry)
Students design a lab to determine the factors that affect the period of a pendulum
Science Practices: 3.1, 3.2, 3.3, 4.1, 4.2, 4.3, 5.1
Lab 20 - Mass on a Spring Oscillations - (Guided Inquiry)
Students design a lab to determine the factors that affect the period of a mass-spring oscillator, then investigate the behavior of the system at different angles, and finally learn to represent the energy partitioning of the oscillator
Science Practices:

Unit 11: Mechanical Waves and Sound
Lab 21 - Snakey and Slinky Investigations - (Guided Inquiry)
Students use large springs to investigate wave pulses, interference, reflection, wave speed, and generalize the behavior to other situations
Science Practices: 6.1, 6.2, 6.3, 7.1, 7.2
Lab 22 - Standing Waves on a String - (Guided Inquiry)
Students will apply wave equations and pictorial representations to model the behavior of standing waves

Science Practices: 1.4, 2.1, 2.2
Lab 23 - Kundt's Tube - (Guided Inquiry)
Students produce standing waves in the tube using a frequency generator and speaker, represent them, and then relate them to sound production in other contexts
Science Practices: 1.4, 1.5, 7.1, 7.2

Unit 12: Electricity
Lab 24 - Sticky Tape Interaction - (Guided Inquiry)
Students investigate the interactions of charged sticky tape to demonstrate Conservation of Charge and the two-charge model
Science Practices: 1.1, 1.2, 1.3, 1.4
Lab 25 – Electrostatic Force - (Guided Inquiry)
Students derive Coulomb's law by measuring force between two charged metallized spheres using an electronic balance
Science Practices: 4.2, 4.3, 5.1, 5.3,
Lab 26 - Ohmic and Non-Ohmic Behavior - (Guided Inquiry)
Students predict graphs of potential vs. current for a bulb and a resistor, then derive Ohm's Law from their data
Lab 27 - Mapping a Circuit - (Guided Inquiry)
Finding Kirchhoff's Laws through analysis and multiple representations of a simple circuit
Science Practices: 1.4, 6.2

Amistad Law: N.J.S.A. 18A 52:16A-88 Every board of education shall incorporate the information regarding the contributions of African-Americans to our country in an appropriate place in the curriculum of elementary and secondary school students.
Holocaust Law: N.J.S.A. 18A:35-28 Every board of education shall include instruction on the Holocaust and genocides in an appropriate place in the curriculum of all elementary and secondary school pupils. The instruction shall further emphasize the personal responsibility that each citizen bears to fight racism and hatred whenever and wherever it happens.
LGBT and Disabilities Law: N.J.S.A. 18A:35-4.35 A board of education shall include instruction on the political, economic, and social contributions of persons with disabilities and lesbian, gay, bisexual, and transgender people, in an appropriate place in the curriculum of middle school and high school students as part of the district's implementation of the New Jersey Student Learning Standards (N.J.S.A.18A:35-4.36) A board of education shall have policies and procedures in place pertaining to the selection of instructional materials to implement the requirements of N.J.S.A. 18A:35-4.35.