a-g Physics

Basic Course Information

Title: a-g Physics

Transcript abbreviations: a-g Physics A / 6E1007 , a-g Physics B / 6E1014

Length of course: Full Year

Subject area: Laboratory Science ("d") / Physics

UC honors designation? No

Prerequisites: Algebra 2 and Biology and/or Chemistry (Required)

Co-requisites: None

Integrated (Academics / CTE)? No

Grade levels: 10th, 11th, 12th

Course learning environment: Classroom Based

Course Description

Course overview:

a-g Physics is a standards-based course focused on the Next Generation Science Standards. This course is designed to educate the student in fundamental physics topics. Students study mechanics, kinematics, energy, momentum, light, electricity, relativity, and sound, among other topics. This course equips students with the ability to recognize physical concepts and laws in the natural world and in day-to-day events, and increases their critical and creative thinking skills, using them to solve a wide variety of problems in a laboratory setting. This course is taught using multiple methods, including lecture, laboratory work, inquiry, technology, critical reading, research, and engineering applications. Performance Expectations emphasize students demonstrating an understanding and ability to use Science and Engineering Practices, Crosscutting Concepts, and selective disciplinary Core ideas in HS Physical Science; HS Engineering, Technology, and Applications of Science.

Course content:

The shaded background of the following field indicates this course was approved by UC for the 2014-15 school year or earlier. Please refer to the current "a-g" course criteria and guidelines when completing your course submission form.

Unit 1 – Science and Engineering Practices

Description:

This unit is designed to build upon foundational skills in scientific inquiry and strengthen mathematical skills needed to analyze data, Excel and word-processing skills to present data, and refine their understanding of engineering principles needed to develop a solution to a problem within given constraints. These skills will be called up and further developed throughout the course. Topics of study and course work will include: scientific method, systems and system models, accuracy and precision, types of data, using math in physics, recording results, transforming raw data to Excel spreadsheets, constructing tables (Excel and Microsoft Word), drawing graphs (paper and Excel), describing statistics and the spread of data, engineering principles (define, develop, optimize), engineering drawings, and the engineering notebook.

NGSS Core Performance expectations emphasized:

HS-ETS1-2 Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

Disciplinary Core Ideas in this Segment:

PS2.A: Forces and Motion

ETS1.A: Defining and Delimiting Engineering Problems

ETS1.C: Optimizing the Design Solution

Unit Assignment(s):

Summary of sample assignment – **Accuracy Versus Precision (Circle of Pong)**

This is an introductory activity that involves measuring and manipulating data. Data is gathered; statistically analyzed for precision and accuracy; and presented in Microsoft Word tables, Excel graphs, and histograms. Students are then encouraged to pose further questions on the effect of increasing distance from the target on both precision and accuracy. Patterns are a crosscutting concept emphasized.

Unit Lab Activities:

Summary of sample lab – **Roto-Copter**

This lab helps to remind students of the processes of science, i.e., making an observation, asking a question, developing a hypothesis, constructing experiments to test the hypothesis, experimenting, collecting, analyzing data, and communicating their findings. These processes help one to better understand a science concept or principle. Students will learn some analysis techniques that can be used throughout any study of science. Graphing data is a good way to understand relationships between independent variables and dependent variables, and that changing the independent variable affects the dependent variable. Students also learn that it is important to exercise caution in how an experiment is designed and how the results are graphed. Students gain experience in interpolation, reading a graph between data points and predicting the results and extrapolation, reading a graph beyond the data points, assuming that the trend continues as graphed, and predicting the results.

To begin the lab, students are instructed to make several Roto-Copter devices of different sizes and materials (types of paper) per directions provided. Next, students select one of the devices they have made and, holding it as high as possible, their partner measures this height and records it in the data table. Once the measurement is recorded, the student then drops the Roto-Copter while their partner uses a stopwatch to time how long it takes the Roto-Copter to fall. This data is recorded. Students repeat this process two more times. Students then vary conditions (size of blades, size of stem, paper stiffness, mass, etc.) and collect data for each of the changes selected. Once all of the data is collected, students construct graphs and analyze the graphed data. Students write a formal lab report for the lab and create a 2-3 minute visual (PowerPoint, iMovie, etc.) presentation to share their findings with the class.

Unit 2 – Motion and Stability – Forces and Interactions

Description:

Students will begin this unit with a series of guided inquiries designed to review the effects of unbalanced forces on an object. Using technology, graphical representations of constant and accelerated motion will be analyzed and patterns identified. Newton's Laws are then applied to describe and predict changes in motion. Mathematical, physical, and simulated models are used with the support of analog and digital tools of measurement. Field forces are further explored in how energy is transferred between objects in electrical and magnetic fields.

NGSS Core Performance expectations emphasized:

HS-PS2-1 Analyze data to support the claim that Newton’s second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.

HS-PS2-2 Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system.

HS-PS2-3 Apply scientific and engineering ideas to design, evaluate and refine a device that minimizes the force on a macroscopic object during a collision.

HS-PS2-4 Use mathematical representations of Newton’s Law of Gravitation and Coulomb’s Law to describe and predict gravitational and electrostatic forces between objects.

HS-PS2-6 Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.

Disciplinary Core Ideas in this segment:

PS1.A: Structure and Properties of Matter

PS2.A: Forces and Motion

PS2.B: Types of Interactions

ETS1.A: Defining and Delimiting Engineering Problems

Unit Assignment(s):
Unit Assignment :

Summary of sample assignment - **Hover Craft**

This assignment is designed to help students gain a better understanding of how friction works and how it can be used to design moving objects so they can be controlled. Students learn that some design materials increase the friction while other design materials reduce the friction. Snow tires may have metal studs that poke into snow and ice, creating more friction than rubber alone. Rollerblade wheels must be sticky enough for control, but not so soft that they create too much drag or wear out too fast. Engineers also reduce friction between moving parts so that they run smoothly and do not wear down as quickly.

Students are given the task of designing and testing a Hover Craft that will slide 2 meters across a hard surface. Students receive a box of materials that can be used to construct the device, and then work as teams to build and test and revise the model as needed. Students sketch and describe their original design and all subsequent design changes made to the Hover Craft. Students record performance data and construct graphs that are analyzed as they work toward a final design that is officially tested in the class. Students write a report that summarizes their project, and create a PowerPoint presentation or iMovie (2-3 minute) that is shared with the class.

Unit Lab Activities:

Summary of lab assignment - **Acceleration on an Inclined Plane**

In this lab, students examine the forces acting on a cart on an inclined plane. If friction is neglected, the forces on the cart are the weight of the cart plus the force from the ramp. Gravity is a downward force that can be resolved into a force normal (perpendicular) to the ramp and a force parallel to the ramp. Using geometry, an angle α equals angle β since their respective sides are perpendicular. In this lab, the force parallel to the ramp will be the accelerating force. First, students use a balance to measure the mass of a Hall's cart, recording the mass in a data table. Next, students place the ramp on a level table top and use blocks to raise one end of the ramp to about 20 cm. Then they attach the spark timer and timing tape to the raised end of the ramp so that the tape will go down the ramp. Next, students measure the length of the ramp and the height of the raised end, and use these measures to calculate and record the angle of incidence of the ramp. Students next put 150 g in the cart and measure and record the total mass of the cart. Now they are ready to determine the velocity of the Hall's cart using the spark timer and tape. Students run the trial, record the data, and use the data collected to calculate the velocity of the cart. Students repeat several trials using different masses in the cart and different ramp angles. Students develop Excel or Word graphs of the data they collect, analyze them to see patterns, and form conclusions based on data. Finally, students calculate the expected acceleration using Newton's second law, the mass of the cart, and the force parallel to the ramp, and compare this calculation to the accepted value of the acceleration of gravity (9.8 m/s2). Students then ,write a lab report summarizing the lab.

Unit 3 – Energy

Description:

Students will review the definition of energy both kinetic and potential and the ways in which energy is transferred. Students will also review the conversion of energy from one form to another. Building upon their knowledge, they will begin to describe and predict transfers of energy between systems, and apply the principle of conservation of energy within a system. Students begin with a physical model they use to ask questions and predict cause and effect. Students will then address computational models, using a computer simulation. Finally, students are given a design challenge in which they can refine and apply gained knowledge.

NGSS Core Performance expectations emphasized:

HS-PS3-1 Create a computational model to calculate the change in energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.

HS-PS3-2 Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative position of particles (objects).

HS-PS3-3 Design, build, and refine a device that works to convert one form of energy into another form of energy.

HS-PS3-4 Plan and conduct an investigation to provided evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).

HS-ETS1-2 Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

HS-ETS1-3 Evaluate a solution to a complex real-world problem based on prioritized criteria and trade- offs that account for a range of constraints.

Disciplinary Core Ideas in this segment:

PS3.A: Definitions of Energy

PS3.B: Conservation of Energy and Energy Transfer

ETS1.A: Defining and Delimiting Engineering Problems

Unit Assignment(s):

Summary of sample assignment - **Pump It Design Challenge**

In this design challenge, student groups design, build, test, and improve devices to pump water as if they were engineers helping a rural village meet their drinking water supply. Students can choose whether they want to design and build a displacement-type pump or a centrifugal pump. The objective is build a pump that will pump water from a 5-gallon bucket into another bucket located on a table. Pumps will be judged on design creativity, materials cost, and power usage. Students keep track of their materials costs, and calculate power and cost efficiencies of the prototype pumps. They also learn about different types of pumps, how they work, and useful applications. At the end of this assignment, students should be able to explain how centrifugal pumps and displacement pumps work, calculate the power output of a pump, and covert lb-ft/s into watts and horsepower.

Unit Lab Activities:

Summary of a sample lab - **Is Energy Conserved?**

Students work with a partner and use a spring scale to measure the force required to pull a block up and lower it down an inclined plane. They also use the measured forces to determine the friction force of the inclined surface on the block. Finally, students calculate the net non-conserved work done on the block when it is pulled against the friction up the slope, and compare it to the expected gravitational potential energy that the block gains.

Students begin by measuring and recording the mass of the block. They next set up the inclined plane at an angle such that the block will just begin to slide down without being pushed down the ramp. Students are to record this angle. Once the inclined plane is set up, one student hooks the spring scale to the block and pulls the block up the inclined plane with a constant speed while the other student reads the value on the spring scale and records the data. This process is repeated with the student lowering the block down the inclined plane and recording the value on the spring scale. Additional trials are run of the procedure using different angles and block masses. Students then solve a system of equations of pulling and lowering forces for the friction force for each trial and record the data. Students use the collected data to calculate the net force of pulling and friction for each trial. Finally, students calculate the non-conserved work done that would be done if the blocks were pulled a distance of 1 meter and compare the non-conserved work in pulling the block up the incline to the gravitational potential energy gained by the block.

Unit 4 – Waves

Students learn about the characteristics of mechanical and electromagnetic waves and their behavior, beginning with a simple exploration of harmonic motion in a pendulum where patterns of cause and effect are identified. Students are then encouraged to identify types of waves, wavelength, speed, amplitude, and frequency in various other mediums. Through inquiry, mathematical relationships among these properties will be identified. Once performance expectations of a mechanical wave are met, a guided inquiry of the particle and wave properties of electromagnetic waves is explored. Finally, students investigate wave behavior through a set of hands-on inquiry labs and pen and pencil activities.

As students work through this unit, they have the opportunity of putting into practice what they learn by building a working solar cell and designing a solution to aid color blind people in distinguishing colors. The historical development of instrumentation is discussed and debated, as well as the critical discussion of the potential risks of electromagnetic radiation, through a series of online discussion boards.

NGSS core performance expectations emphasized:

HS-PS4-1 Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.

H5-PS4-2 Evaluate questions about the advantages of using digital transmission and storage of information.

H5-PS4-3 Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or particle model, and that for some situations, one model is more useful than another.

HS-PS4-4 Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter.

HS-ETS1-1 Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.

HS-ETS1-2 Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

Disciplinary Core Ideas In this segment:
PS4.A: Wave Properties
PS4.B: Electromagnetic Radiation
PS4.C: Information Technologies and Instrumentation
ETS1.A: Defining and Delimiting Engineering Problems

Unit Assignment(s):

Summary of sample assignment - **Soda Straw Wave Machine**

Students work independently or with a partner to build a soda straw wave machine that they can use to investigate models of a variety of waves and analyze factors that affect wave characteristics and behaviors. To build the device, students use drinking straws, paper clips, transparent tape, and a meter stick or metric tape measure. Students begin by inserting a paper clip into each end of each straw. Next, they measure out about 1 meter of transparent tape and stick a straw across the tape about every 3 cm so the middle of the straw lies on the tape. Once this is done, students stick a second identical length of tape over the top of the straws to cover the sticky part of the first tape. Now students can hang the straw strip from a desk or table and pull it taut. They then give one of the straws at the top or bottom a tap to start a wave and observe and record what happens. Students increase the tension on the strip of straws, or decrease it and observe how this affects the wave frequency and amplitude, recording their observations. Next, students can remove the paper clips from the end of each straw in the wave machine, or add a second paper clip to each straw end and repeat the process of changing the tension on the strip, comparing the behavior of the waves when the paper clips are removed or added.

Once the initial investigation is complete, students are encouraged to construct two or three more 1-meter straw wave machines, then tape them together to make a longer wave machine and compare how the waves that are created compare to the waves of the shorter wave machine. They can continue to investigate waves by choosing additional variables and observing how they affect wave characteristics and behavior.

Finally students design a data table in which to record their observations and write a complete lab report for the investigation and submit and slide program or short video that project to the class.

Unit Lab Activities:

Summary of a sample lab - **Speed of Sound**

In this inquiry investigation, students work as a team and use the frequency and wavelength of the sound to calculate the speed of sound by using the equation . To begin, students tape a 100 mL graduated cylinder to the table with masking tape and fill it with 90 mL of water. Next they put a 20 cm tube plastic tube with a scale on it into the graduated cylinder with the zero end of the scale up. Now students strike a tuning fork on a firm object (do not strike on a metal object). Holding the end of the tuning fork over the end of the plastic tube, they move the fork with the tube up and down. When the sound is the loudest, they measure the length of the tube that is out of the water and record this measurement. This produces a standing wave with 1/4 of a wave. Next they use masking tape to fasten a 15 cm section of plastic tube to the end of the 20 cm section so that the zero end of the scale is next to an end of the 15 cm tube. Now they repeat the process with the longer tube, measuring and record the length of the standing wave. This produces a standing wave with 3/4 of a wave. Now they repeat the process a third time, extending the tube length by fastening the second 15 cm tube to the first 15 cm tube with masking tape. This produces a standing wave with 5/4 of a wave. Students subtract the lengths of the standing waves to find the wavelengths of sound, they organize their data into a data table and complete the related calculations. Finally, they compare their experimental measurement of the speed of sound with the known value and analyze any differences they see. Students write and submit a formal lab report for the lab.

Unit 5 – Electricity

This unit will cover a variety of topics related to electricity, magnetism, and electronics. Students begin by investigating static electricity and learn that like electrical charges repel and unlike charges attract. They will extend this understanding as they study electric fields of force, learning that this property of the space around a charged object exerts forces on other charged objects, and that electrical potential (sometime called voltage) is the electric potential energy per unit charge. Next, students will learn that electric current is the flow of electric charges and that electrical energy can be transformed to other forms of energy including radiant energy, thermal energy, and mechanical energy. Continuing their study of electricity, students will investigate parallel and series circuits. In the process, they will gain an understanding that a series current follows a single path, while a parallel current follows more than one path. They will also learn that most circuits are combinations of series and parallel circuits. Students will next examine the topics of fields of magnetic energy and inducing currents through magnetic fields. Students will learn that magnets and electric currents produce magnetic fields, and that many devices, including ear buds and electric motors rely on forces from magnetic fields in order to work. Additionally, students will gain an understanding that an electric current can be induced through a changing magnetic field, and that a changing magnetic field induces an EMF in a wire, and the EMF, in turn, generates current when the wire is in a circuit. Through inquiry activities they will understand that these induced magnetic fields are crucial to the operation of generators, motors, and transformers. In the later part of the unit, students will investigate electromagnetism and will learn that deflection of moving particles in electric and magnetic fields can be used to find properties of those particles. They will also learn that electromagnet waves are oscillating electric and magnetic fields that move through space and interact with matter. Solid state electronics will be studied as the final part of the unit. Students will learn that electronic devices can be created by controlling the conductivity of the materials used to make them, and that a material's conductivity depends on the energy difference between the valence and conducting bands. Students will build a simple electronic device to gain an understanding of how diodes and transistors are fundamental components in modern electronic circuits.

NGSS core performance expectations emphasized:

HS-PS2-5 Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current.

HS-PS3-1 Create a computational model to calculate the charge in energy of one component in a system when the change in energy of the other component(s) and the energy flows in and out of the system are known.

HS-PS4-2 Evaluate questions about the advantages of using digital transmission and storage of information.

HS-PS4-3 Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or particle model, and that for some situations, one model is more useful than another.

HS-PS4-4 Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter.

HS-ETS1-2 Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

Disciplinary Core Ideas in this segment:

PS2.B: Types of Interactions

PS3.A: Definitions of energy

PS4.A: Wave Properties

PS4.B: Electromagnetic Radiation

PS4.C: Information Technologies and Instrumentation

Unit Assignment(s):

Summary of sample assignment - **Series and Parallel Circuits**

Students complete a set of activities designed to promote deep understanding of series and parallel circuits through modeling and guided exploration of mathematical relationships. The activities challenge students to do the following tasks: 1) Use mathematics to calculate values for change in voltage, current, and resistance; 2) Rewrite equations to highlight specific variables of interest; 3) Apply their knowledge to show the validity of an equation as it relates to circuit analysis.

Unit Lab Activities:

Summary of a sample lab - **Making an Electronic Breadboard**

In this lab, students construct an electronic breadboard to show electrical circuits. The face of the electronic breadboard has fourteen vertical columns, with seven on the left side and seven on the right side. Students will plug the lead wires from various resistors into designated sockets and use a multimeter to measure the resistance. They will use this data to gauge the quality of the circuits. To begin, students take a 2.2 kΩ, a 4.7 kΩ, and a 10 kΩ resistor out of their respective packages. They then use pliers to shorten the leads on these resistors to about 1 cm. A color code key is provided for students to use in order to determine the resistance of each resistor. Students record this information. Next, students bend the leads of the specified resistors and insert them into designated sockets to form a series circuit. They use the multimeter to measure the actual resistance of the circuit, compare it to the calculated resistance, and determine the percent difference between the measured sum (Ω) and the calculated sum (Ω). Students build a second circuit by inserting another set of specified resistors into designated sockets to form a parallel circuit. Students again use a multimeter to measure the actual resistance of the circuit, compare it to the calculated resistance, and determine the percent difference between the actual resistance and the calculated resistance. Students organize the data into an appropriately designed chart and make detailed diagrams of both circuits, then write a formal lab report of their investigation.

Course Materials

Textbooks

Title	Author	Publisher	Edition	Website	Primary
CA Standards-based textbook (This course is aligned to the 2009 edition of Glencoe McGraw-Hill Physics: Principles and Problems textbook, but it will work with any CA standards aligned textbook)	Paul W. Zitzewitz, Todd George Elliott, David G. Hass, Kathleen A. Harper, Michael R. Hertzog, Jane Bray Nelson, Jim Nelson, Charles A. Schuler, Margaret	Glenco-McGraw	2009		Yes

	K. Zorn				

Manuals

Title	Author	Publisher	Edition	Website	Read In Entirety
Argument-Driven Inquiry in Physics, Volume 1, Mechanics Lab Investigations for Grades 9-12	Victor Sampson, Peter Carafano, Patrick Enderle, Steve Fannin, Jonathan Grooms, Sherry A. Southerland, Carol Stallworth, Kiesha	NSTA Press – National Science Teachers Association	2017	www.nsta.org	No

Websites

Title	Author(s)/Editor(s)/Compiler(s)	Affiliated Institution or Organization	URL
The Physics Classroom	The Physics Classroom	The Physics Classroom	
Teach Engineering STEM Curriculum for K-12	College of Engineering & Applied Science, University of Colorado, Boulder	University of Colorado	www.teachengineering.org/
PhET Interactive Simulations – Official Site	University of Colorado	University of Colorado	https://phet.colorado.edu/
Physics.org – Your Guide to Physics on the Web	Institute of Physics	Physics in Society	www.physics.org
American Association of Physics Teachers – Resources for High School, Undergraduate, and Graduate Students	American Association of Physics Teachers	American Association of Physics Teachers	