FREEHOLD REGIONAL HIGH SCHOOL DISTRICT

OFFICE OF CURRICULUM AND INSTRUCTION

INTERNATIONAL BACCALAUREATE PROGRAM

PHYSICS SL, YEAR 1

Grade Level: 11

Credits: 5

BOARD OF EDUCATION ADOPTION DATE:

AUGUST 29, 2016

SUPPORTING RESOURCES AVAILABLE IN DISTRICT RESOURCE SHARING
APPENDIX A: ACCOMMODATIONS AND MODIFICATIONS
APPENDIX B: ASSESSMENT EVIDENCE
APPENDIX C: INTERDISCIPLINARY CONNECTIONS

FREEHOLD REGIONAL HIGH SCHOOL DISTRICT

Curriculum Writing Committee

Mr. Paul Reardon

Supervisor

Ms. Mary Hough

IB PHYSICS SL, YEAR 1
COURSE PHILOSOPHY
The International Baccalaureate Organization provides the following philosophy for the teaching of Physics SL: *“Physics is the most fundamental of the experimental sciences, as it seeks to explain the universe itself from the very smallest particles—currently accepted as quarks, which may be truly fundamental—to the vast distances between galaxies. . .* *Despite the exciting and extraordinary development of ideas throughout the history of physics, certain aspects have remained unchanged. Observations remain essential to the very core of physics, sometimes requiring a leap of imagination to decide what to look for. Models are developed to try to understand observations, and these themselves can become theories that attempt to explain the observations. Theories are not always directly derived from observations but often need to be created. These acts of creation can be compared to those in great art, literature and music, but differ in one aspect that is unique to science: the predictions of these theories or ideas must be tested by careful experimentation. Without these tests, a theory cannot be quantified. A general or concise statement about how nature behaves, if found to be experimentally valid over a wide range of observed phenomena, is called a law or a principle. . .* *At the school level both theory and experiments should be undertaken by all students. They should complement one another naturally, as they do in the wider scientific community. The Diploma Programme physics course allows students to develop traditional practical skills and techniques and increase their abilities in the use of mathematics, which is the language of physics. It also allows students to develop interpersonal and digital communication skills which are essential in modern scientific endeavour and are important life-enhancing, transferable skills in their own right.”*
COURSE DESCRIPTION
The International Baccalaureate Organization provides the following description for Physics SL: *“IB Physics SL covers the core topics of measurements and uncertainties, mechanics, thermal physics, waves, electricity and magnetism, circular motion and gravitation, atomic, nuclear and particle physics, and energy production. Optional topics such as relativity, engineering physics, imaging, and astrophysics will also be covered. Through studying physics, students should become aware of how scientists work and communicate with each other. While the scientific method may take on a wide variety of forms, it is the emphasis on a practical approach through experimental work.”*

COURSE SUMMARY	
COURSE GOALS	
CG1: Within a global context, students will craft and execute inquiry-based labs by problem-solving, gathering existing research, analyzing data, and utilizing laboratory skills. CG2: Students will communicate and justify everyday phenomena using their understanding of content, scientific techniques, methods, and experimentation. CG3: Students will effectively communicate and collaborate during scientific activities and communicate their findings through multiple representations.	
COURSE ENDURING UNDERSTANDINGS	COURSE ESSENTIAL QUESTIONS
CEU1: Scientists perform investigative experiments in order to develop new theories and conclusions that lead to real-world global innovation.	CEQ1: Why do we still experiment?
CEU2: Physics concepts, techniques, and methods are used to explain and describe experiences in the world around us.	CEQ2: To what extent can we predict the physical world around us or are the events that we experience completely random?
CEU3: Scientific ideas must be effectively communicated across various cultures and various disciplines in order to advance scientific understanding, technology, and innovation.	CEQ3: To what extent does communication impact scientific advancements across the globe?

UNIT GOALS & PACING		
UNIT TITLE	**UNIT GOALS**	**RECOMMENDED DURATION**
Unit 1: Mechanics	Students will use their understanding of energy, forces, and momentum to construct graphical and mathematical representations, analyze interactions, and make predictions about the resulting motion of objects.	13 weeks
Unit 2: Thermal Physics	Students will use their understanding of solids, liquids, gasses, and the ideal gas laws to model thermal energy transfer at a microscopic and macroscopic level.	4 weeks
Unit 3: Oscillations and Waves	Students will use their understanding of period behaviors and oscillating motion to describe the types, characteristics, and behaviors of travelling waves.	6 weeks
Unit 4: Electricity and Magnetism	LG1: Students will use their understanding of electric charges, forces and fields to arrange electrical components on a circuit for desired outcomes. LG2: Students will sketch and interpret magnetic field patterns to determine magnetic forces, currents, and charges.	11 weeks

IB PHYSICS SL, YEAR 1 UNIT 1: Mechanics	SUGGESTED DURATION: 13 WEEKS

UNIT OVERVIEW	
UNIT LEARNING GOALS	
Students will use their understanding of energy, forces, and momentum to construct graphical and mathematical representations, analyze interactions, and make predictions about the resulting motion of objects.	
UNIT LEARNING SCALE	
4	In addition to score 3 performances, the student can create, defend, and/or peer teach complex problems with real-world applications.
3	The student can: • apply vector component addition to displacements, velocities, and forces; • determine and solve problems for instantaneous and average velocities, speed and acceleration using equations of motion; • sketch and interpret motion through graphical methods; • experimentally determine the acceleration of free-fall; • analyze projectile motion by exploring both horizontal and vertical components; • qualitatively model the effect of fluid resistance on projectiles or falling objects, including when an object reaches terminal velocity; • sketch and interpret free-body diagrams; • quantitatively and qualitatively use Newton's three laws of motion to describe interactions; • describe static and dynamic friction by use of coefficients of friction; • investigate the conservation of total energy within a system; • sketch and interpret force-distance graphs; • calculate the work done on an object including scenarios involving resistive forces; • compare power output and efficiency of various systems involving energy transfers; • apply conservation of momentum to explosions, collisions, water jets, or other isolated systems; • determine impulse in various real-world scenarios; • sketch and interpret force-time graphs; • compare both quantitatively and qualitatively situations involving inelastic collisions, elastic collisions, and explosions; and • apply Newton's second law to scenarios in which mass is not constant.
2	The student can identify and define: • distance, displacement, speed, velocity, acceleration, projectile motion, fluid resistance, and terminal speed; • net force and free-body diagrams; • Newton's laws of motion; • static and dynamic friction; • kinetic, potential, and elastic energy; • work, power, efficiency; • conservation of energy and conservation of momentum; and • elastic collisions, inelastic collisions, and explosions.
1	The student needs assistance to avoid major errors in attempting to reach score 3 performances.
0	Even with assistance, the student does not exhibit understanding of the performances listed in score 3.

ENDURING UNDERSTANDINGS	ESSENTIAL QUESTIONS
EU1: Motion can be described using a graphical analysis or kinematic equations.	EQ1: How can you tell that an object is in motion?
EU2: In the real-world, you must account for friction, fluid resistance and terminal velocity when describing motion.	EQ2: To what extent are our predictions valid and accurate when we consider the assumptions that need to be made?
EU3: Newton's three laws of motion can be used to predict the resulting changes in motion caused by a force.	EQ3: Can we accurately predict the changes in motion of an object?
EU4: Conservation laws of energy and momentum can be used to predict the outcome of interactions and collisions of objects.	EQ4: To what extent can knowledge of the present give us knowledge of the future?

COMMON ASSESSMENT	
ALIGNMENT	DESCRIPTION
LG1 EU 1, 2, 3, EQ 1, 2, 3 HS-PS2-1 11-12.RST.1, 4 11-12.WHST.1.A DOK 3	Students will be given a set of data recorded from a projectile motion experiment. The data will include various applied forces to get an object to begin moving and various angles at which the object was launched. Students must analyze the data using graphical and mathematical analysis in order to determine a relationship between an applied force and distance travelled after being launched, as well as a relationship between launch angle and distance travelled after being launched. Students must use evidence from their graphs and kinematic equations to justify the relationships. In addition, students should explain how the data might be affected by the presence of air resistance.
LG1 EU 4, EQ 4 HS-PS2-2 11-12.RST.3, 11-12.WHST.2 DOK 4	Students will design and run a collision simulation lab in order to record data in the form of diagrams, charts, and graphs. Students must analyze the data from the collisions to justify the laws of conservation of energy and conservation of momentum. Students must be able to clearly explain how their simulation is used to justify the conservation laws and must cite evidence from multiple representations.

TARGETED STANDARDS		
DECLARATIVE KNOWLEDGE	PROCEDURAL KNOWLEDGE	STANDARDS
vector quantities scalar quantities vector component addition resultant vector	Determine the magnitude and direction of the sum of two vectors given the magnitude and direction of each (DOK 2) Understand that the magnitude of a sum of two vectors is typically not the sum of the magnitudes (DOK 2) Apply vector component addition to a real-world scenario using displacements, velocities, or forces (DOK 3)	*HSN.VM.B.4b Given two vectors in magnitude and direction form, determine the magnitude and direction of their sum.

DECLARATIVE KNOWLEDGE	PROCEDURAL KNOWLEDGE	STANDARDS
distance displacement speed velocity acceleration projectile terminal speed $v = u + at$ $s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$ $s = \frac{(v+u)t}{2}$	Calculate the speed, velocity, displacement, acceleration of an object in motion using the kinematic equations (DOK 1) Create motion graphs of an object (DOK 2) Formulate an experiment to determine the acceleration of free-fall (DOK 3) Analyze motion graphs to support the relationships of the kinematic equations (DOK 3) Predict the landing location of a projectile and hypothesize about the effect of air resistance (DOK 3)	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. 11-12.RST.3 Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.
equilibrium force free body diagram friction $F = ma$ $F_f \leq \mu_s R$ $F_f = \mu_d R$	Calculate net force and resulting acceleration of objects in 1 and 2 dimensions (DOK 1) Sketch and interpret free body diagrams (DOK 2) Differentiate between the effects of kinetic and static friction (DOK 2) Analyze data related to net force, mass, and acceleration (DOK 3) Support the claim that Newton's second law of motion describes a mathematical relationship between net force, mass, and acceleration (DOK 3) Create and analyze a scenario in which an object is in translational equilibrium (DOK 4)	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. 11-12.WHST.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes. 11-12.RST.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account
conservation of energy efficiency elastic potential energy gravitational potential energy kinetic energy power work $W = Fs\,cos\theta$ $E_k = \frac{1}{2}mv^2$ $\Delta E_p = mg\Delta h$	Calculate the change in mechanical energy of a system (DOK 2) Sketch and interpret force distance graphs (DOK 2) Apply concepts of power to analyze the work done during everyday activities (DOK 3)	HS-PS3-1 Create a computational model to calculate the change in the 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. 11-12.RST.4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to *grades 11-12 texts and topics*.

DECLARATIVE KNOWLEDGE	PROCEDURAL KNOWLEDGE	STANDARDS
$E_p = \frac{1}{2} k\ \Delta x^2$ $Power = Fv$ $Efficiency = \frac{useful\ work\ out}{total\ work\ in}$	Develop a model that illustrates that energy will transfer from gravitational energy into kinetic energy and elastic potential energy (DOK 3)	HS-PS3-2 Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as either motions of particles or energy stored in fields.
conservation of momentum elastic/inelastic collision impulse momentum $p = mv$ $F = \frac{\Delta p}{\Delta t}$ $E_k = \frac{p^2}{2m}$ $Impulse = F\Delta t = \Delta p$	Use mathematical representation to support the claim that total momentum is conserved (DOK 3) Compare the energy and momentum associated with inelastic collisions, elastic collisions, and explosions (DOK 3)	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.
	Sketch and interpret force-time graphs (DOK 2) Use mathematical representation to compare the impulse and change in momentum of objects including but not limited to car safety and sports (DOK 3) Design a device that minimizes force during a collision (DOK 4) Evaluate a device that minimizes force during a collision (DOK 3) Refine a device that minimizes force during a collision (DOK 3)	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. 11-12.WHST.1.A Introduce precise, knowledgeable claim(s), establish the significance of the claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that logically sequences the claim(s), counterclaims, reasons, and evidence.

IB PHYSICS SL, YEAR 1 UNIT 2: Thermal Physics	SUGGESTED DURATION: 4 WEEKS

UNIT OVERVIEW

UNIT LEARNING GOALS

Students will use their understanding of solids, liquids, gasses, and the ideal gas laws to model thermal energy transfer at a microscopic and macroscopic level.

UNIT LEARNING SCALE

4	In addition to score 3 performances, the student can create, defend, and/or peer teach complex problems with real-world applications.
3	The student can: • describe temperature change in terms of internal energy; • describe temperature scales and convert between Kelvin and Celsius temperature scales; • experimentally apply the concepts of latent heat and specific heat capacity; • describe phase change with respect to the behavior of molecules within the substance; • sketch and interpret phase change graphs; • predict energy changes involving latent heat and specific heat capacity; • solve problems using the ideal gas laws; • sketch and interpret the following graphs for an ideal gas: pressure-volume, pressure-temperature, and volume-temperature; and • experimentally investigate at least one ideal gas law.
2	The student can identify and define: • molecular theory of solids, liquids, and gases; • temperature and absolute temperature; • internal energy; • specific heat capacity; • latent heat of fusion and vaporization; • phase change; • pressure; • ideal gas laws; and • kinetic model of an ideal gas.
1	The student needs assistance to avoid major errors in attempting to reach score 3 performances.
0	Even with assistance, the student does not exhibit understanding of the performances listed in score 3.

ENDURING UNDERSTANDINGS	ESSENTIAL QUESTIONS
EU1: Energy is transferred through the form of thermal processes until thermal equilibrium is reached.	EQ1: If we can’t see thermal energy, how do we know it’s there or being transferred?
EU2: The rate at which thermal energy is absorbed or released depends on the chemical makeup of the material.	EQ2: How can some materials be heated, but not hot?
EU3: The ideal gas law can be used to describe the pressure, volume, and temperature changes of a gas at a macroscopic level.	EQ3: How can studying theoretical laws help us understand the real-world around us?
EU4: The kinetic model of an ideal gas can be used to describe the kinetic energy of a gas at a microscopic level.	EQ4: To what extent can we predict the energy of tiny microscopic particles of gas, if we can’t even see their motion with our eyes?

COMMON ASSESSMENT	
ALIGNMENT	DESCRIPTION
LG 1 EU 1,2,3,4, EQ 1,2,3,4 HS-PS3-1,2,4 11-12 RST.4, 7 11-12 WHST.1.B DOK 4	Students will be given data collected from an experiment involving thermal energy transfer. They must plan an investigation which could result in the provided data and draw conclusions about the significance of the experiment to the laws of thermodynamics. They must be able to write a clear and detailed procedure which could be replicated and demonstrates how the data could have been collected.

TARGETED STANDARDS		
DECLARATIVE KNOWLEDGE	PROCEDURAL KNOWLEDGE	STANDARDS
absolute temperature phase change solid, liquid, gas specific heat capacity specific latent heat $Q = mc\Delta T$ $Q = mL$	Sketch and interpret phase change graphs to determine specific latent heat (DOK 2) Determine the specific heat and latent heat required to change temperature, phase, or both (DOK 2) Design and carry out an experiment to measure the specific heat capacity of an unknown material (DOK 3) Use data to provide evidence supporting the second law of thermodynamics (DOK 3)	HS-PS3-4 Plan and conduct an investigation to provide 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-PS3-1 Create a computational model to calculate the change in the 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. 11.12.RST.4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to *grades 11-12 texts and topics*.
ideal gas kinetic model molar mass mole pressure $P = \frac{F}{A}$ $n = \frac{N}{N_A}$ $PV = nRT$ $E_k = \frac{3}{2}k_s T = \frac{3}{2}\frac{R}{N_A}T$	Solve problems using the equation of state for an ideal gas (DOK 2) Sketch and interpret diagrams which represent changes of states of ideal gasses in terms of pressure-temperature, pressure-volume, and temperature-volume (DOK 2) Compare and contrast the differences between an ideal gas and a real gas and critique the value of assuming a gas to be ideal in an everyday application citing technical texts to provide evidence (DOK 3) Experimentally investigate the ideal gas laws, using data as evidence to draw conclusions and justify the relationships between pressure, volume, and temperature (DOK 3)	HS-PS3-2 Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as either motions of particles or energy stored in fields. 11-12.RST.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. 11-12.WHST.1.B Develop claim(s) and counterclaims fairly and thoroughly, supplying the most relevant data and evidence for each while pointing out the strengths and limitations of both claim(s) and counterclaims in a discipline-appropriate form that anticipates the audience's knowledge level, concerns, values, and possible biases.

IB PHYSICS SL, YEAR 1 UNIT 3: Oscillations and Waves	SUGGESTED DURATION: 6 WEEKS

UNIT OVERVIEW	
UNIT LEARNING GOALS	
Students will use their understanding of period behaviors and oscillating motion to describe the types, characteristics, and behaviors of travelling waves.	
UNIT LEARNING SCALE	
4	In addition to score 3 performances, the student can create, defend, and/or peer teach complex problems with real-world applications.
3	The student can: • qualitatively describe the changes in energy that take place during one cycle of an oscillation; • sketch and interpret graphs for objects experiencing simple harmonic motion; • explain and describe the conditions necessary for simple harmonic motion; • sketch and interpret diagrams for wavefronts and rays; • solve problems using the relationship between amplitude, intensity, and the inverse square law; • use the law of superposition to sketch and interpret the interaction of waves and pulses; • describe and explain the methods and applications of polarizing a wave; • sketch and interpret diagrams which illustrate reflected and transmitted beams, and polarized waves; • calculate a resulting intensity using Malus' law; • sketch and interpret incident, refracted, and reflected waves at the boundary of media; • solve problems using the laws of reflection and refraction (Snell's law); • experimentally determine the index of refraction for a material; • qualitatively describe the diffraction pattern formed when plane waves are incident normally on a single-slit; • quantitatively describe interference patterns for waves diffracting through a double-slit; • apply the concept of superposition to describe the formation of standing waves; • differentiate between travelling waves and standing waves; • observe, sketch, and interpret standing waves in pipes and strings; and • solve problems involving the frequency of a harmonic, length of the standing wave and the speed of the wave.
2	The student can identify and define: • simple harmonic oscillations, time period, frequency, amplitude, displacement and phase difference; • travelling waves, wavelength, frequency, period, wave speed, transverse and longitudinal waves; • electromagnetic waves and sound waves; • wavefronts and rays; • amplitude and intensity; • superposition and polarization; • reflection, refraction, Snell's law, total internal reflection, and critical angle; • single-slit and double slit diffraction and interference and interference patterns; and • path difference.
1	The student needs assistance to avoid major errors in attempting to reach score 3 performances.
0	Even with assistance, the student does not exhibit understanding of the performances listed in score 3.

ENDURING UNDERSTANDINGS	ESSENTIAL QUESTIONS
EU1: Isochronous oscillations and simple harmonic motion are repeatable behaviors which have many modern applications.	EQ1: How has our society benefited from studying naturally occurring oscillations?
EU2: All waves exist as either transverse or longitudinal which can be distinguished by the direction of the energy pulse.	EQ2: Some types of waves can't be seen; how do we know they exist?
EU3: Numerous modern technologies rely on wave characteristics like polarization for their operation.	EQ3: By understanding characteristics of waves, how are we able to predict and use waves to advance technologies?
EU4: Waves behave in a predictable way when they interact with other waves or boundaries between media.	EQ4: To what extent are we able to predict the resulting behavior of wave when it interacts with another wave?

COMMON ASSESSMENT	
ALIGNMENT	DESCRIPTION
LG 1 EU 1,2, EQ 1,2 HS-PS4-1 11-12.RST.6, 11-12.WHST.4 DOK 4	Students will design and execute an experiment in which an object is experiencing simple harmonic motion (e.g., mass on a spring, simple pendulum, motion on a curved air track). Students will analyze the objects motion and represent it graphically through displacement-time, velocity-time, acceleration-time, and acceleration-displacement graphs. Students must use evidence from their graphs to justify that their object is experiencing simple harmonic motion according to its definition.
LG 1 EU 3, 4, EQ 3, 4 HS-PS4-3, 5 11-12.RST.3, 11-12. WHST.6 DOK 4	Students will design a series of experiments to demonstrate the various ways in which waves behave at boundaries including, reflection, refraction, and diffraction. Students should be able to clearly explain the procedures and data which would be collected. They must also explain how the data could be analyzed to provide evidence for the various wave behaviors.

TARGETED STANDARDS		
DECLARATIVE KNOWLEDGE	PROCEDURAL KNOWLEDGE	STANDARDS
amplitude frequency period phase difference simple harmonic oscillations $T = \frac{1}{f}$	Identify the period, frequency, amplitude for objects in simple harmonic motion (DOK 2) Compare the energy at different points of motion for an object experiencing SHM (DOK 3) Given a displacement-time graph, draw conclusions about the oscillations an object is experiencing (DOK 3) Construct a velocity-time and acceleration-time graph for an object in SHM (DOK 3) Develop a process for determining the phase difference between two given waves (DOK 3)	HS-PS4-1. Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media. 11-12.WHST.4 Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

DECLARATIVE KNOWLEDGE	PROCEDURAL KNOWLEDGE	STANDARDS
electromagnetic waves longitudinal waves sound waves transverse waves travelling waves wave speed wavelength $c = f\lambda$	Identify the period, frequency, amplitude, and wavelength or travelling waves (DOK 2) Create a demonstration to explain the difference between the motion of particles for longitudinal and transverse waves (DOK 3) Graphically analyze displacement-distance and displacement-time graphs to explain the motion of waves (DOK 3) Research a possible experiment to determine the speed of sound in air, analyze the procedure, identify important issues in the experiment, and use the research develop a procedure with equipment available to experimentally determine the speed of sound (DOK 4) Research one region of the electromagnetic spectrum and create a presentation to relate this region to applications in modern technologies (DOK 3)	HS-PS4-1 Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media. 11-12.RST.6 Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, identifying important issues that remain unresolved. 11-12.WHST.4 Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience
intensity polarization rays superposition wavefronts $I = I_o \cos^2 \theta$	Diagram a wave distinguishing between the wavefront and the ray (DOK 2) Perform calculations for the intensity of a wave as it propagates away from a source (DOK 2) Determine the resultant wave at points in time using the law of superposition (DOK 2) Given specific parameters about two waves, create a scenario in which the waves will superpose into a resulting wave with desired characteristics (DOK 3) Research the phenomena of polarization and create a presentation showing detailed diagrams of the behavior of polarized light and how this technology is used in modern applications (DOK 3)	HS-PS4-1 Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media. HS-PS4-5 Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy. 11-12.WHST.6 Use technology, including the Internet, to produce, publish, and update individual or shared writing products in response to ongoing feedback, including new arguments or information.

DECLARATIVE KNOWLEDGE	PROCEDURAL KNOWLEDGE	STANDARDS
diffraction double-slit interference interference pattern reflection refraction Snell's law total internal reflection Path difference $\frac{n_1}{n_2} = \frac{sin\theta_2}{sin\theta_1} = \frac{v_2}{v_1}$ $s = \frac{\lambda D}{d}$ Constructive interference: $path\ diff = n\lambda$ Destructive interference: $path\ diff = \left(n + \frac{1}{2}\right)\lambda$	Perform calculations using the laws of reflection and refraction (DOK 2) Using a block of glass, follow a detailed procedure and use graphical analysis techniques to estimate the refractive index of the material (DOK 3) Use the concept of reflection and refraction to draw conclusions about the critical angle which would produce the phenomena of total internal reflection (DOK 3) Design and conduct an experiment to create a diffraction pattern of a single-slit and double-slit grating (DOK 3)	HS-PS4-5 Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy. 11-12.RST.3 Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.
antinodes boundary conditions nodes standing waves	Compare and contrast standing waves to travelling waves (DOK 2) Perform calculations to determine the harmonics of standing waves and apply their findings to real-world applications (DOK 3)	HS-PS4-5 Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.

IB PHYSICS SL, YEAR 1 UNIT 4: Electricity and Magnetism	SUGGESTED DURATION: 11 WEEKS

UNIT OVERVIEW	
UNIT LEARNING GOALS	
LG1: Students will use their understanding of electric charges, forces and fields to arrange electrical components on a circuit for desired outcomes. LG2: Students will sketch and interpret magnetic field patterns to determine magnetic forces, currents, and charges.	
UNIT LEARNING SCALE: LG 1	
4	In addition to score 3 performances, the student can create, defend, and peer teach complex problems with real-world applications.
3	The student can: • predict the direction of a force between two different types of charge; • solve problems using Coulomb's law and involving electric fields; • calculate the work done in an electric field taking into account units of joules and electronvolts; • calculate the drift speed of charge carries in a metal; • solve problems involving current, potential differences, and charge; • draw and interpret circuit diagrams; • solve problems involving, resistance and resistivity, potential difference, charge, current, Kirchhoff's circuit laws, and power; • use V/I characteristic graphs to distinguish ohmic and non-ohmic conductors; • investigate the outcome of combining resistance in parallel and series circuits; • describe real-world uses of potential divider circuits and compare to series resistors when controlling a simple circuit; • describe ideal and non-ideal ammeters and voltmeters; • experimentally investigate one or more of the factors that affect resistance; • investigate practical electric cells; • describe the discharge characteristic of a simple cell; • explain the importance of the direction of current flow required to recharge a cell; • experimentally determine the internal resistance; and • solve problems involving internal resistance and emf.
2	The student can identify and define: • charge, electric field, Coulomb's Law, and drift speed; • Electric current, direct current, and potential difference; • circuit diagrams and Kirchhoff's circuit laws; • Ohm's law; • resistivity, power dissipation, cells, internal resistance, and secondary cells; • terminal potential difference; and • Emf.
1	The student needs assistance to avoid major errors in attempting to reach score 3 performances.
0	Even with assistance, the student does not exhibit understanding of the performances listed in score 3.

UNIT LEARNING SCALE: LG 2	
4	In addition to score 3 performances, the student can create, defend, and peer teach complex problems with real-world applications.
3	The student can: • determine the direction of the force a charge experiences when moving in a magnetic field; • determine the direction of the force a current carrying wire experiences due to a magnetic field; • sketch and interpret magnetic field patterns; • determine the direction of a magnetic field based on the direction of a current; and • solve problems involving magnetic fields, forces, current, and charges.
2	The student can identify and define: • magnetic fields and forces; and • current and charge.
1	The student needs assistance in order to reach the learning goal(s).
0	Even with assistance, the student does not exhibit understanding of the performances listed in score 3.

ENDURING UNDERSTANDINGS	ESSENTIAL QUESTIONS
EU1: The electric force between two charges, which can ultimately result in the movement of charges known as a current, can be determined using Coulomb's law.	EQ1a: People say that "opposites attract." Can physics be used to support this claim? EQ1b: Why do the lights turn on in a room when you flick the switch?
EU2: The geometrical arrangement of resistors and capacitors in a circuit can affect its electrical properties.	EQ2: Why can't you just plug the USB from your cell phone charger directly into a wall outlet as you would your computer?
EU3: Electric cells allow us to store energy in chemical form for future use.	EQ3: In what other ways besides mechanical potential energy are we able to store energy for future uses?
EU4: A method for creating magnetism which has led to numerous technological applications involves a charge moving in the vicinity of another moving charge.	EQ4: How has the relationship between electricity and magnetism helped to advance technologies?

COMMON ASSESSMENT	
ALIGNMENT	DESCRIPTION
LG 1 EU 1, 2, 3, EQ 1a, 1b, 2, 3 HS-PS2-4 11-12.RST.3, 11-12.WHST.2 DOK 4	Students will design a circuit which will run three different devices each requiring a different amount of current. The circuit must be able to store energy for a time at which a power source is unable to provide voltage to the circuit. Students will create a diagram and perform all calculations in order to provide evidence that their circuit would provide the proper current, voltage, resistance, and capacitance.
LG 2 EU 4, EQ 4 HS-PS2-5 11-12.RST.3 11-12.WHST.1.A, 2, 5 DOK 4	Students will design and carry out an experiment which will provide evidence of the relationship between a current carrying wire and a magnetic field. Students must explain how their experiment and findings could be applied to an everyday real-world application.

TARGETED STANDARDS		
DECLARATIVE KNOWLEDGE	PROCEDURAL KNOWLEDGE	STANDARDS
charge coulomb's law direct current electric current electric field potential difference $I = \frac{\Delta q}{\Delta t}$ $F = \frac{kq_1q_2}{r^2}$ $k = \frac{1}{4\pi\varepsilon_o}$ $V = \frac{W}{q}$ $E = \frac{F}{q}$ $I = nAvq$	Predict the direction of forces between positive and negative charges in different combinations (DOK 2) Use mathematical representations of Coulomb's Law and electric fields to predict the effect of the electrostatic forces between objects (DOK 2) Identify and calculate the drift speed of particles which carry a charge (DOK 2) Construct a physical representation of the electric field lines around charged particles and parallel plates and use the diagrams to make a claim about the resulting motion of the particles (DOK 3)	HS-PS2-4 Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects. 11-12.WHST.1.A Introduce precise, knowledgeable claim(s), establish the significance of the claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that logically sequences the claim(s), counterclaims, reasons, and evidence.
magnetic fields magnetic force $F = qvB\ sin\theta$ $F = BIL\ sin\theta$	Sketch and interpret magnetic field patterns (DOK 2) Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field (DOK 3) Plan and conduct an investigation to provide evidence that a changing magnetic field can produce an electric current (DOK 3) Analyze data to develop a relationship between the direction of a magnetic force, a magnetic field, and a current or moving charge (DOK 3)	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-PS3-5 Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction. 11-12.RST.3 Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text. 11-12.WHST.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.

DECLARATIVE KNOWLEDGE	PROCEDURAL KNOWLEDGE	STANDARDS
cells circuit diagrams Emf heating effect of current internal Resistance Kirchhoff’s circuit laws Ohm’s law power dissipation resistivity terminal potential difference $R = \frac{V}{I}$ $P = VI = I^2R = \frac{V^2}{R}$ $R_{Total} = R_1 + R_2 + \cdots$ $\frac{1}{R_{Total}} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots$ $\rho = \frac{RA}{L}$ $\varepsilon = I(R + r)$	Draw and interpret circuit diagrams (DOK 2) Solve complex problems using potential difference, resistance, current, charge, Kirchoff’s laws, and power (DOK 2) Describe ideal and non-ideal ammeters and voltmeters, and apply them to common everyday applications (DOK 3) Explain the practical uses and compare the advantages of a potential divider circuit over a series resistor when controlling a simple circuit (DOK 3) Experimentally investigate and draw a conclusion as to the various factors which affect resistivity (DOK 3)	HS-PS2-4. Use mathematical representations of Newton’s Law of Gravitation and Coulomb’s Law to describe and predict the gravitational and electrostatic forces between objects. 11-12 WHST.5 - Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.