Physics: Embedded Inquiry

Conceptual Strand:

Understandings about scientific inquiry and the ability to conduct inquiry are essential for living in the 21st century.

Guiding Question:

What tools, skills and knowledge are needed to conduct scientific inquiry?

Course Level Expectations	Checks for Understanding	State Performance Indicators
CLE 3231.Inq.1 Recognize that science is a progressive endeavor that reevaluates and extends what is already accepted. **CLE 3231.Inq.2** Design and conduct scientific investigations to explore new phenomena, verify previous results, test how well a theory predicts, and compare opposing theories. **CLE 3231.Inq.3** Use appropriate tools and technology to collect precise and accurate data. **CLE 3231.Inq.4** Apply qualitative and quantitative measures to analyze data and draw conclusions that are free of bias. **CLE 3231.Inq.5** Compare experimental evidence and conclusions with those drawn by others about the same testable question. **CLE 3231.Inq.6** Communicate and defend scientific findings.	✓**3231.Inq.1** Trace the historical development of a scientific principle or theory. ✓**3231.Inq.2** Conduct scientific investigations that include testable questions, verifiable hypotheses, and appropriate variables to explore new phenomena or verify the experimental results of others. ✓**3231.Inq.3** Select appropriate independent, dependent, or controlled variables for an experiment. ✓**3231.Inq.4** Analyze the components of a properly designed scientific investigation. ✓**3231.Inq.5** Perform an experiment to test a prediction. ✓**3231.Inq.6** Select appropriate tools and technology to collect precise and accurate quantitative and qualitative data. ✓**3231.Inq.7** Determine if data supports or contradicts a hypothesis or conclusion.	**SPI 3231.Inq.1** Select a description or scenario that reevaluates and/or extends a scientific finding. **SPI 3231.Inq.2** Analyze the components of a properly designed scientific investigation. **SPI 3231.Inq.3** Determine appropriate tools to gather precise and accurate data. **SPI 3231.Inq.4** Evaluate the accuracy and precision of data. **SPI 3231.Inq.5** Defend a conclusion based on scientific evidence. **SPI 3231.Inq.6** Determine why a conclusion is free of bias. **SPI 3231.Inq.7** Compare conclusions that offer different, but acceptable explanations for the same set of experimental data.

	✓**3231.Inq.8** Recognize, analyze, and evaluate alternative explanations for the same set of observations. ✓**3231.Inq.9** Evaluate the accuracy and precision of data. ✓**3231.Inq.10** State a conclusion in terms of the relationship between two or more variables. ✓**3231.Inq.11** Defend a conclusion based on scientific evidence. ✓**3231.Inq.12** Analyze experimental results and identify possible sources of bias or experimental error. ✓**3231.Inq.13** Compare the results of an experiment with what is already known about the topic under investigation. ✓**3231.Inq.14** Suggest alternative explanations for the same set of observations. ✓**3231.Inq.15** Formulate and revise scientific explanations and models using logic and evidence. ✓**3231.Inq.16** Compare conclusions that offer different, but acceptable explanations for the same set of experimental data.	

Physics: Embedded Technology and Engineering

Conceptual Strand:

Society benefits when engineers apply scientific discoveries to design materials and processes that develop into enabling technologies.

Guiding Question:

How do science concepts, engineering skills, and applications of technology improve the quality of life?

Course Level Expectation	Checks for Understanding	State Performance Indicators
CLE 3231.T/E.1 Explore the impact of technology on social, political, and economic systems. **CLE 3231.T/E.2** Differentiate among elements of the engineering design cycle: design constraints, model building, testing, evaluating, modifying, and retesting. **CLE 3231.T/E.3** Explain the relationship between the properties of a material and the use of the material in the application of a technology. **CLE 3231.T/E.4** Describe the dynamic interplay among science, technology, and engineering within living, earth-space, and physical systems.	✓**3231.T/E.1** Select appropriate tools and procedures best suited to conduct a specified scientific inquiry. ✓**3231.T/E.2** Apply the engineering design process to construct a prototype that meets developmentally appropriate specifications. ✓**3231.T/E.3** Evaluate a protocol to determine the degree to which an engineering design process was successfully applied. ✓**3231.T/E.4** Explore how the unintended consequences of new technologies can impact human and non-human communities. ✓**3231.T/E.5** Evaluate the overall benefit to cost ratio of a new technology. ✓**3231.T/E.6** Present research on current engineering technologies that contribute to improvements in our daily lives. ✓**3231.T/E.7** Design a series of multi-view	**SPI 3231.T/E.1** Distinguish among tools and procedures best suited to conduct a specified scientific inquiry. **SPI 3231.T/E.2** Evaluate a protocol to determine the degree to which an engineering design process was successfully applied. **SPI 3231.T/E.3** Evaluate the overall benefit to cost ratio of a new technology. **SPI 3231.T/E.4** Use design principles to determine if a new technology will improve the quality of life for an intended audience.

	drawings that can be used by others to construct an adaptive design and test its effectiveness.	

Physics: Embedded Mathematics

Conceptual Strand:

Physics applies mathematics to investigate questions, solve problems, and communicate findings.

Guiding Question:

What mathematical skills and understandings are needed to successfully investigate physics?

Course Level Expectation	Checks for Understanding	State Performance Indicators
CLE.3231.Math.1 Graph relationships and functions between manipulated (independent) variables and responding (dependent) variables. **CLE.3231.Math.2** Solve for variables in an algebraic formula. **CLE.3231.Math.3** Apply statistical techniques to manipulate data. **CLE.3231.Math.4** Investigate trigonometric connections to physics. **CLE.3231.Math.5** Utilize calculus to understand physics principles.	✓**3231.Math.1** Plot points on the Cartesian coordinate graphing system. ✓**3231.Math.2** Graph basic relations and functions. ✓**3231.Math.3** Determine the slope of a linear function. ✓**3231.Math.4** Determine the frequency, range, mode, median, and mean from a list of data. ✓**3231.Math.5** Utilize a graphing calculator to enter data and find basic statistics: frequency, range, means, mode, median, and standard deviation. ✓**3231.Math.6** Solve for all variables based on a formula. ✓**3231.Math.7** Solve for the *t* – value, *p* (probability), and % of confidence between two lists of data (manipulated variables and responding variables).	**SPI.3231.Math.1** Graph basic physics relations and functions. **SPI.3231.Math.2** Determine the slope of a linear function that represents physics data. **SPI.3231.Math.3** Given a graph of a physics relationship, recognize the type of function that relates to that graph: ie. $y = x^2$. **SPI.3231.Math.4** Utilize a graphing calculator to enter physics data and find basic statistics: frequency, range, mean, mode, median, and standard deviation. **SPI.3231.Math.5** Solve for the *t* – value, *p* (probability), and % of confidence between two lists of physics data (manipulated variables and responding variables). **SPI.3231.Math.6** Reject or accept a null hypothesis based on statistical analysis. **SPI.3231.Math.7** Find the regression line

	✓**3231.Math.8** Reject or accept a null hypothesis based on statistical analysis. ✓**3231.Math.9** Find the regression line (equation) between data for manipulated and responding variables. ✓**3231.Math.10** Utilize trigonometric functions (sine, cosine, and tangent) to solve simple vector problems. ✓**3231.Math.11** Apply the laws of sine and cosine to solve vector problems. ✓**3231.Math.12** Solve mechanics problems using the quadratic formula. ✓**3231.Math.13** Find the derivative (velocity function) of a distance (displacement) function. ✓**3231.Math.14** Find the derivative (acceleration function) of a velocity function. ✓**3231.Math.15** Link various calculus procedures to solve physics problems.	(equation) between physics data for manipulated and responding variables. **SPI.3231.Math.8** Find the first derivative of a function that describes the position of an object moving along a straight line. **SPI.3231.Math.9** Find the first derivative of a function that describes the velocity of an object moving along a straight line.

Physics: Standard 1 - Mechanics

Conceptual Strand

Laws of mechanics are the foundations of classical physics.

Guiding Question

How do the laws of mechanics govern the basic understanding of classical physics?

Course Level Expectation	Checks for Understanding	State Performance Indicators
CLE 3231.1.1 Investigate fundamental physical quantities of length, mass, and time. **CLE 3231.1.2** Analyze and apply Newton's three laws of motion. **CLE 3231.1.3** Understand work, energy, and power. **CLE 3231.1.4** Investigate kinematics and dynamics. **CLE 3231.1.5** Investigate and apply Archimedes's Principle. **CLE 3231.1.6** Explore Pascal's Principle. **CLE 3231.1.7** Develop an understanding of Bernoulli's Principle and its applications.	✓**3231.1.1** Explore displacement, velocity, and acceleration Average Velocity: $v_{av} = (d_f-d_i)/(t_f-t_i)$; Final Velocity: $v_f = v_i+a\Delta t$; Final Velocity of Falling object: $v_f = v_i+g\Delta t$; Average Acceleration: $a_{av} = (v_f-v_i)/(t_f-t_i)$; Displacement of Falling object: $d = v_i \Delta t+(1/2) a\Delta t^2$; Displacement of Falling object: $\Delta d = v_i \Delta t +(1/2)g \Delta t^2$. ✓**3231.1.2** Analyze vector diagrams and solve composition and resolution problems for force and momentum. ✓**3231.1.3** Explore characteristics of rectilinear motion and create displacement-time graphs (velocity), velocity-time graphs (acceleration and distance). ✓**3231.1.4** Investigate the characteristics of centripetal motion and centripetal acceleration	**SPI.3231.1.1** Identify mass and weight data using units in the SI system. **SPI.3231.1.2** Given various examples of quantities, categorize them as scalar or vector quantities. **SPI.3231.1.3** Given Newton's laws of motion, analyze scenarios related to inertia, force, and action-reaction. **SPI.3231.1.4** Solve motion and conceptual problems regarding velocity, acceleration, and displacement using displacement-time graphs and velocity-time graphs. **SPI.3231.1.5** Evaluate and describe the phenomena related to Archimedes' Principle, Pascal's Principle, and Bernoulli's Principle. **SPI.3231.1.6** Given the static and kinetic friction coefficients (μ_s and μ_k); select the appropriate coefficient of friction and calculate the force necessary to move the object.

	Centripetal Force: $F_c = (mv^2)/r$; Angular Velocity: $\omega = \Delta\theta/\Delta t$; Angular Acceleration: $\alpha = \Delta\omega/\Delta t$. ✓**3231.1.5** Evaluate the dynamics of systems in motion including friction, gravity, impulse and momentum, change in momentum, and conservation of momentum. Coefficient of Friction: $\mu = F_f/F_N$; Law of Universal Gravitation: $F_G = (G\, m_1 m_2)/d^2$; Impulse: $F\Delta t = m\Delta t$. ✓**3231.1.6** Investigate projectile motion. Parabolic Equations with the Quadratic Formula: $$X = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$ ✓**3231.1.7** Apply mathematics to solve motion problems. ✓**3231.1.8** Experiment with elastic and inelastic collisions. ✓**3231.1.9** Experiment with pendulums Pendulum period: $T = 2\pi \sqrt{l/g}$ ✓**3231.1.10** Utilize trigonometry and vector analysis to solve force and momentum problems [Sine, Cosine, Tangent Functions, Law of Sines, and Law of Cosines]. ✓**3231.1.11** Apply elementary calculus to solve motion problems: Velocity = derivative of position Acceleration = derivative of velocity.	**SPI.3231.1.7** Select the correct vector diagram to illustrate all forces on an object affected by gravity, friction and an applied force. **SPI.3231.1.8** Given an inclined plane, the required coefficient of friction and an object of a specific mass, select the appropriate trigonometry functions to determine whether the object will slide down the plane or not. **SPI.3231.1.9** Given the mass, velocity and time it takes to stop an object in an inelastic collision, determine the momentum and impulse of the collision. **SPI.3231.1.10** Analyze and solve problems related to elastic and inelastic collisions related to change in momentum. **SPI.3231.1.11** Given a projectile launched at an angle, select the correct equation from a list for calculating: the maximum height of travel, time of flight and/or the maximum horizontal distance covered. **SPI.3231.1.12** Given a scenario where a projectile is being launched at an angle, answer the following conceptual questions. • What is the velocity in the y direction when the projectile is at maximum height? • What acceleration does the projectile have in the x direction after launched. • What forces are acting on the projectile in the y direction before it reaches maximum height? **SPI.3231.1.3** Analyze and solve pendulum problems using the pendulum period formula:

	✓**3231.1.12** Experiment with elastic and inelastic collisions Elastic : $m_1v_1 + m_2v_2 = m_1v_3+m_2v_4$; Inelastic: $m_1v_1+m_2v_2 = (m_1+m_2)v_3$ ✓**3231.1.13** Distinguish between mass and weight using base units in the SI system. ✓**3231.1.14** Associate time with the independent variable in most experiments. ✓**3231.1.15** Relate inertia, force, or action-reaction forces to Newton's three laws of motion. ✓**3231.1.16** Compare, contrast, and apply characteristic properties of scalar and vector quantities. ✓**3231.1.17** Investigate the definitions of force, work, power, kinetic energy, and potential energy. Force: $F = ma$; Work: $W = Fd$; Power: $P = (F\Delta d)/ \Delta t$; Kinetic Energy: $E_K = 0.5mv^2$; Potential Energy: $E_P = mg\Delta h$. ✓**3231.1.18** Analyze the characteristics of energy, conservation of energy including friction, and gravitational potential energy [Gravitational Potential Energy: $E_p=mg\Delta h$]. ✓**3231.1.19** Relate work and power to various simple machines, mechanical advantage of different machines, and recognize simple machines that are combined to form compound machines Work: $W= F\Delta d$;	$T = 2\pi \sqrt{l/g}$ **SPI.3231.1.14** Relate the variables of work, power, kinetic energy, and potential energy to mechanical situations and solve for these variables. **SPI.3231.1.15** Calculate the gravitational attraction between two objects. **SPI.3231.1.16** Calculate the tangential velocity of a satellite's motion given the angular speed. **SPI.3231.1.17** Solve problems for centripetal force, and angular acceleration. **SPI.3231.1.18** Analyze and solve problems related to rotational motion and torque.

	Power: $P = (F\Delta d)/\Delta t$; Efficiency = $(W_{OUT}/W_{IN})x100\%$. ✓**3231.1.20** Describe rotational equilibrium and relate this factor to torque Rotational Inertia: $T = I\alpha$; Torque: $T = Fr$ ✓**3231.1.21** Determine the magnitude of the buoyant force exerted on a floating object or a submerged object ($F_B = m_f g = \rho_f V_f g$). ✓**3231.1.22** Investigate the apparent weight of an object submerged in a fluid ($F_{net} = F_B - F_g$). ✓**3231.1.23** Explain, in terms of force and/or density, why some objects float and some objects sink. ✓**3231.1.24** Calculate the pressure exerted by a fluid according to Pascal's Principle ($P_{inc} = F_1/A_1 = F_2/A_2$). ✓**3231.1.25** Calculate how pressure varies with water depth ($P = P_0 + \rho gh$). ✓**3231.1.26** Examine the motion of a fluid using the continuity equation ($A_1 v_1 = A_2 v_2$). ✓**3231.1.27** Recognize the effects of Bernoulli's principle on fluid motion and its applications (i.e. lift, curve balls, and wind around/over object).	

Physics: Standard 2 - Thermodynamics

Conceptual Strand:

The principles and laws of thermodynamics are essential for understanding the concept of energy.

Guiding Question:

How do the laws of thermodynamics relate to understanding the conservation of energy?

Course Level Expectation	Checks for Understanding	State Performance Indicators
CLE 3231.2.1 Develop an understanding of temperature, heat, and internal energy. **CLE 3231.2.2** Compare Celsius, Kelvin and the Absolute temperature scales. **CLE 3231.2.3** Investigate exchanges in internal energy.	✓**3231.2.1** Investigate temperature in relationship to kinetic energy. ✓**3231.2.2** Identify the characteristics of internal energy and temperature/heat (joules/calories). ✓**3231.2.3** Experiment with change in heat content (quantity of thermal energy) and relate to kinetic energy and specific heat. ✓**3231.2.4** Investigate phase changes of heat of fusion, heat of vaporization, and heat of sublimation Change in Heat: $\Delta Q = mH_f$ and $\Delta Q = mH_v$. ✓**3231.2.5** Explore thermal expansion and contraction Linear Expansion: $\Delta l = l_i \alpha \Delta T$; Volumetric Expansion: $\Delta V = V_i \beta \Delta T$. ✓**3231.2.6** Apply the second law of thermodynamics to the Carnot engine.	**SPI.3231.2.1** Relate temperature changes with the changes of kinetic energy and the flow of heat energy. **SPI.3231.2.2** Solve an applied problem of heat exchange with respect to specific heat. **SPI.3231.2.3** Given a schematic of a refrigeration process, identify the four parts of the process. **SPI.3231.2.4** Describe all forms of heat exchange. **SPI.3231.2.5** Demonstrate a conceptual understanding of the First and Second Laws of Thermodynamics and their implications in natural phenomena.

	✓**3231.2.7** Apply the Laws of Thermodynamics to the atmospheric levels of the earth (i.e., greenhouse effect and climate change). ✓**3231.2.8** Recognize that absolute zero is the absence of molecular kinetic energy. ✓**3231.2.9** Relate the First Law of Thermodynamics as an application of the Law of Conservation of Energy and heat transfer through conduction, convection, and radiation. Heat Lost = Heat Gained, $Q_L = Q_G$. ✓**3231.2.10** Investigate calorimetry, kinetic energy, and specific heat Change in Heat: $\Delta Q = mC\Delta T$	

Physics: Standard 3 - Waves

Conceptual Strand:

Understanding sound is accomplished by investigating wave behavior.

Guiding Question

How do the properties of mechanical waves and light explain how waves behave?

Course Level Expectation	Checks for Understanding	State Performance Indicators
CLE 3231.3.1 Explore conditions associated with how waves carry energy and simple harmonic motion. **CLE 3231.3.2** Investigate Hooke's law. **CLE 3231.3.3** Understand wave mechanics. **CLE 3231.3.4** Examine the Doppler Effect. **CLE 3231.3.5** Explore the characteristics and properties of sound.	✓**3231.3.1** Investigate simple harmonic motion. ✓**3231.3.2** Investigate and analyze wavelength, frequency, period, and amplitude of longitudinal and transverse waves. ✓**3231.3.3** Describe a wave interaction as reflection, refraction, diffraction, or interference. ✓**3231.3.4** Explore Hooke's Law. ✓**3231.3.5** Investigate reflection, refraction, diffraction, and interference of sound waves. ✓**3231.3.6** Compare mechanical and electromagnetic waves. ✓**3231.3.7** Explain the Doppler Effect.	**SPI.3231.3.1** Identify the components of standing waves; including nodes, antinodes, fundamental, numeric harmonics, and overtones. **SPI.3231.3.2** Distinguish between longitudinal and transverse waves and identify components of all mechanical waves including wavelength, frequency, period, crest, trough, and amplitude. **SPI.3231.3.3** Select the type of mechanical waves that apply to natural wave phenomena such as sound, water or earthquake. **SPI.3231.3.4** Differentiate among the wave interactions of reflection, refraction, diffraction, or interference (constructive and destructive interferences). **SPI.3231.3.5** Solve sound problems related to speed of sound in air at various temperatures. **SPI.3231.3.6** Demonstrate a proficiency in solving problems related to wavelength, frequency, period, and speed of mechanical

	Source moving toward stationary listener: $f_{LF} = f_s \frac{v}{v - v_s}$ Source moving away from stationary listener: $f_{LB} = f_s \frac{v}{v + v_s}$ Listener moving toward stationary source: $f_{LC} = f_s \frac{v + v_{LC}}{v}$ Listener moving away from stationary source: $f_{LO} = f_s \frac{v - v_{LO}}{v}$ ✓**3231.3.8** Determine the speed of sound experimentally and describe the effects various materials and temperatures on sound. ✓**3231.3.9** Measure spring constants. ✓**3231.3.10** Solve problems related to wave length, frequency, period, and speed Wave velocity: $v = f\lambda$ and Period: $T=1/f$. ✓**3231.3.11** Determine the speed of sound experimentally using various materials and temperatures Sound velocity: $v_s = f\lambda$; Sound velocity (using air temperature): $v_s = 331.5\text{m/s} + (0.56\ \text{m/s}\ ^{o}\text{C})\ (T)$. ✓**3231.3.12** Describe simple harmonic motion. ✓**3231.3.13** Compare the wave characteristics of natural auditory phenomena.	waves.

Physics: Standard 4 - Optics

Conceptual Strand:

Understanding optics is accomplished by investigating the behavior and laws of light.

Guiding Question:

How do the properties and behavior of light relate to the basic principles of optics?

Course Level Expectation	Checks for Understanding	State Performance Indicators
CLE 3231.4.1 Describe the characteristics of the electromagnetic spectrum. **CLE 3231.4.2** Investigate the interaction of light waves. **CLE 3231.4.3** Explore the optics of lenses. **CLE 3231.4.4** Analyze the optics of mirrors. **CLE 3231.4.5** Investigate the phenomenon of color.	✓**3231.4.1** Explore properties of electromagnetic radiation. ✓**3231.4.2** Examine properties of light waves. ✓**3231.4.3** Investigate the polarization of light. ✓**3231.4.4** Investigate the optical properties of plane and curved mirrors Focal length: $1/f = 1/d_o + 1/d_i$; Images in mirrors and lens, $h_i/h_o = d_i/d_o$. ✓**3231.4.5** Investigate the optical properties of plane and curved mirrors. ✓**3231.4.6** Draw, explain, and solve problems for the optics of mirrors and lenses. ✓**3231.4.7** Investigate optical phenomena (i.e., mirage, optical illusions, and dichromatic lens effect). ✓**3231.4.8** Solve problems related to Snell's law Index of refraction: $n = (\sin \theta_r / \sin \theta_i)$;	**SPI.3231.4.1** Distinguish among the various categories of the electromagnetic spectrum. **SPI.3231.4.2** Explain polarization of light. **SPI.3231.4.3** Solve problems related to Snell's law. **SPI.3231.4.4** Given a drawing of a laboratory optics bench with a singular lens; choose the measurements that will enable the calculation of focal length. **SPI.3231.4.5** Identify the properties of light related to reflection, refraction, diffraction, and interference of light waves. **SPI.3231.4.6** Using light ray diagrams, identify the path of light using a convex lens, a concave lens, a plane mirror, a concave mirror and a convex mirror.

	Snell's law: $n_i \sin \theta_i = n_r \sin \theta_r$. ✓**3231.4.9** Differentiate among transmission, reflection, refraction, diffraction, and interference of light waves. ✓**3231.4.10** Explore the formation of color (both additive and subtractive properties) [Additive Color Theory: W= B+G+R: Y= G+R: =B+G: M = R+B; Subtractive Color Theory: B=W–Y: C= W–R: M=W–G].	

Physics: Standard 5 - Electricity and Magnetism

Conceptual Strand

Electric change is the fundamental quantity that underlies electricity and magnetism.

Guiding Question

How does an electric charge produce electric and magnetic fields?

Course Level Expectation	Checks for Understanding	State Performance Indicators
CLE 3231.5.1 Examine the properties of electric forces, electric charges, and electric fields. **CLE 3231.5.2** Explore the flow of charge and electric currents. **CLE 3231.5.3** Investigate Ohm's law. **CLE 3231.5.4** Compare and contrast series and parallel circuits. **CLE 3231.5.5** Analyze schematic diagrams. **CLE 3231.5.6** Understand magnetic poles, magnetic fields, and investigate electromagnetic induction. **CLE 3231.5.7** Understand that moving charges give rise to magnetism.	✓**3231.5.1** Create a simple electromagnet. ✓**3231.5.2** Draw an electric field, given a scenario of charged particles. ✓**3231.5.3** Solve problems of resistance using Ohm's law [$\mathcal{E} = IR$ (or $V=IR$)]. ✓**3231.5.4** Draw and explain series and parallel circuits. ✓**3231.5.5** Solve problems related to voltage, current, and resistance Voltage, $V = IR$; Series circuits, $R_T = R_1+R_2+\ldots$, $I_T = I_1 = I_2 = \ldots$, $V_T = V_1+ V_2+\ldots$; Parallel circuits, $1/R_T = 1/R_1+1/R_2+ \ldots$, $I_T = I_1+I_2+ \ldots$, $V_T = V_1=V_2 = \ldots$. ✓**3231.5.6** Build series and parallel circuits to demonstrate how they function. ✓**3231.5.7** Demonstrate a generated current by electromagnetic induction.	**SPI.3231.5.1** Given a scenario of charged particles; predict and sketch the resulting electric fields. **SPI.3231.5.2** Given a diagram of charged particles, sketch arrows that represent repulsion and attraction. **SPI.3231.5.3** Explain the relationship between magnetism and current. **SPI.3231.5.4** Identify the equilibrium point between two spheres of differing charges. **SPI.3231.5.5** Find the equivalent resistance for a combination series and parallel circuit. **SPI.3231.5.6** Solve electricity problems related to voltage, current, and resistance using Ohm's law. **SPI.3231.5.7** Given voltage and current or current and resistance; calculate power and work.

	✓**3231.5.8** Design a lab to demonstrate the flow of charged particles and an electric current. ✓**3231.5.9** Analyze a given group of charges for repulsion and attraction. ✓**3231.5.10** Distinguish between charged particles related to repulsion and attraction. ✓**3231.5.11** Describe the electric field that fills the space around a charged particle or group of charges Coulomb's law, $F= k (Q_1Q_2)/d^2$. ✓**3231.5.12** Identify components of series and parallel circuits and solve problems related to voltage, current, and resistance. ✓**3231.5.13** Describe how current is generated by electromagnetic induction.	**SPI.3231.5.8** Identify common components of electrical circuitry from a schematic drawing such as batteries, resistors, lamps, ammeters, voltmeters, and variable resistors.

Physics: Standard 6 - Nuclear Physics

Conceptual Strand:

Nuclear physics can be better understood with a deeper understanding of particle physics.

Guiding Question:

How is the investigation of nuclear particles related to a better understanding of nuclear physics?

Course Level Expectation	Checks for Understanding	State Performance Indicators
CLE 3231.6.1 Investigate the properties and structure of the atom. **CLE 3231.6.2** Investigate properties of the quantum theory. **CLE 3231.6.3** Explore the dynamics of the nucleus: radioactivity, radiocarbon/uranium dating, and half-life. **CLE 3231.6.4** Compare and contrast nuclear fission and nuclear fusion.	✓**3231.6.1** Write and balance equations for the three forms of radioactive decay. ✓**3231.6.2** Solve half-life problems Decay constant: $k=0.693/T_{(1/2)}$; Nuclear decay: $A_f=A_oe^{kt}$. ✓**3231.6.3** Explain dating methods using carbon-14 or uranium. ✓**3231.6.4** Investigate the concept of half-life. ✓**3231.6.5** Explain how particles behave like waves. ✓**3231.6.6** Distinguish between coherent and incoherent light. ✓**3231.6.7** Recognize how the quantum theory explains the photoelectric effect. ✓**3231.6.8** Investigate the history and current events associated with nuclear and radioactive science.	**SPI.3231.6.1** Solve half-life problems. **SPI.3231.6.2** Identify parts of an atom (protons, electrons, neutrons, nucleus, and electron cloud). **SPI.3231.6.3** Describe and identify the three basic forms of radioactivity (alpha particles, beta particles, and gamma rays) **SPI.3231.6.4** Identify nuclear reactions given descriptions of the reactions. **SPI.3231.6.5** Identify the major historical achievements of modern nuclear physicists related to the discovery of atomic particles, quantum theory, and the standard model.

	✓**3231.6.9** Identify the parts of an atom. ✓**3231.6.10** Describe the properties and location of subatomic particles. ✓**3231.6.11** Describe three forms of radioactivity. ✓**3231.6.12** Distinguish between nuclear fission and nuclear fusion. ✓**3231.6.13** Investigate and describe quantum mechanics and the properties of quantum theory. ✓**3231.6.14** Explain the changes in atomic number or mass number for each form of radioactivity. ✓**3231.6.15** Discuss transmutation and transuranium. ✓**3231.6.16** Explain how particles behave like waves.	