# Physics Curriculum

# (3231)

The purpose of this document is to give Knox County Tennessee, High School Physics teachers an aid in pacing their physics course as well as showcase recommended activities/labs. This summer 2011 revision is the third revision of this "living" document after the significant state curriculum revision in 2009.

Knox County Science is a strong supporter of Project Based Learning activities and Inquiry. These foci have been and will be an important part of our curriculum. It is expected that teachers will integrate the inquiry into each physics course topic discussed here. Laboratory experiments with low equipment requirements are included at the end of each unit. Teachers that have access to precision laboratory equipment will be able to expand the number and complexity of student labs.

The format of this document is to include the "Tennessee Course Level Expectations," "Checks for Understanding" and "State Performance Indicators." "Suggested Knox County Additional Learning Activities" are included immediately after each Tennessee unit specifications and "Recommended resources" are located at the end of the document. Recommended Resources include suggested writing prompts, helpful web sites, and other valuable information.

This guide is a work in progress and will evolve as improved activities, methods and resources become available. Teacher input is sincerely appreciated for any improvements offered to this guide. It is our hope that Knox County will exceed all expectations in our Physics Curriculum.

updated summer 2011

# Physics: Embedded Inquiry

## Pacing guide

*This material is embedded within the context of other standards and thus does not need a specific time period set aside.*

## Guiding Question

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

| Course Level Expectations | Checks for Understanding |
|---|---|
| **CLE 3231.Inq.1** Recognize that science is a progressive endeavor that reevaluates and extends what is already accepted.<br>**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.<br>**CLE 3231.Inq.3** Use appropriate tools and technology to collect precise and accurate data.<br>**CLE 3231.Inq.4** Apply qualitative and quantitative measures to analyze data and draw conclusions that are free of bias.<br>**CLE 3231.Inq.5** Compare experimental evidence and conclusions with those drawn by others about the same testable question.<br>**CLE 3231.Inq.6** Communicate and defend scientific findings. | ✓**3231.Inq.1** Trace the historical development of a scientific principle or theory.<br>✓**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.<br>✓**3231.Inq.3** Select appropriate independent, dependent, or controlled variables for an experiment.<br>✓**3231.Inq.4** Analyze the components of a properly designed scientific investigation.<br>✓**3231.Inq.5** Perform an experiment to test a prediction.<br>✓**3231.Inq.6** Select appropriate tools and technology to collect precise and accurate quantitative and qualitative data.<br>✓**3231.Inq.7** Determine if data supports or contradicts a hypothesis or conclusion.<br>✓**3231.Inq.8** Recognize, analyze, and evaluate alternative explanations for the same set of observations.<br>✓**3231.Inq.9** Evaluate the accuracy and precision of data.<br>✓**3231.Inq.10** State a conclusion in terms of the relationship between two or more variables.<br>✓**3231.Inq.11** Defend a conclusion based on scientific evidence.<br>✓**3231.Inq.12** Analyze experimental results and identify possible sources of bias or experimental error.<br>✓**3231.Inq.13** Compare the results of an experiment with what is already known about the topic under investigation. |

| Course Level Expectations<br>(Embedded Inquiry Continued) | Checks for Understanding<br>(Embedded Inquiry Continued) |
|---|---|
| | ✓**3231.Inq.14** Suggest alternative explanations for the same set of observations.<br>✓**3231.Inq.15** Formulate and revise scientific explanations and models using logic and evidence.<br>✓**3231.Inq.16** Compare conclusions that offer different, but acceptable explanations for the same set of experimental data. |

**State Performance Indicators**

**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.

## Physics: Embedded Technology and Engineering

### Pacing guide

*This material is embedded within the context of other standards and thus does not need a specific time period set aside.*

### Guiding Question

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

| Course Level Expectations | Checks for Understanding |
|---|---|
| **CLE 3231.T/E.1** Explore the impact of technology on social, political, and economic systems.<br>**CLE 3231.T/E.2** Differentiate among elements of the engineering design cycle: design constraints, model building, testing, evaluating, modifying, and retesting.<br>**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.<br>**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.<br>✓**3231.T/E.2** Apply the engineering design process to construct a prototype that meets developmentally appropriate specifications.<br>✓**3231.T/E.3** Evaluate a protocol to determine the degree to which an engineering design process was successfully applied.<br>✓**3231.T/E.4** Explore how the unintended consequences of new technologies can impact human and non-human communities.<br>✓**3231.T/E.5** Evaluate the overall benefit to cost ratio of a new technology.<br>✓**3231.T/E.6** Present research on current engineering technologies that contribute to improvements in our daily lives.<br>✓**3231.T/E.7** Design a series of multi-view drawings that can be used by others to construct an adaptive design and test its effectiveness. |

**State Performance Indicators**

**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.

## Physics: Embedded Mathematics

### Pacing guide

*Most of this material is embedded within the context of other standards; however instructional time must be used to review aspects of mathematics: 11% of the course (9 instructional days).*

### Guiding Question

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

| Course Level Expectations | Checks for Understanding |
|---|---|
| **CLE.3231.Math.1** Graph relationships and functions between manipulated (independent) variables and responding (dependent) variables.<br>**CLE.3231.Math.2** Solve for variables in an algebraic formula.<br>**CLE.3231.Math.3** Apply statistical techniques to manipulate data.<br>**CLE.3231.Math.4** Investigate trigonometric connections to physics.<br>**CLE.3231.Math.5** Utilize calculus to understand physics principles. | ✓**3231.Math.1** Plot points on the Cartesian coordinate graphing system.<br>✓**3231.Math.2** Graph basic relations and functions.<br>✓**3231.Math.3** Determine the slope of a linear function.<br>✓**3231.Math.4** Determine the frequency, range, mode, median, and mean from a list of data.<br>✓**3231.Math.5** Utilize a graphing calculator to enter data and find basic statistics: frequency, range, means, mode, median, and standard deviation.<br>✓**3231.Math.6** Solve for all variables based on a formula.<br>✓**3231.Math.7** Solve for the *t* – value, *p* (probability), and % of confidence between two lists of data (manipulated variables and responding variables).<br>✓**3231.Math.8** Reject or accept a null hypothesis based on statistical analysis.<br>✓**3231.Math.9** Find the regression line (equation) between data for manipulated and responding variables.<br>✓**3231.Math.10** Utilize trigonometric functions (sine, cosine, and tangent) to solve simple vector problems.<br>✓**3231.Math.11** Apply the laws of sine and cosine to solve vector problems.<br>✓**3231.Math.12** Solve mechanics problems using the quadratic formula.<br>✓**3231.Math.13** Find the derivative (velocity function) of a distance (displacement) function. |

| Course Level Expectations<br>(Embedded Mathematics Continued) | Checks for Understanding<br>(Embedded Mathematics Continued) |
|---|---|
| | ✓**3231.Math.14** Find the derivative (acceleration function) of a velocity function.<br>✓**3231.Math.15** Link various calculus procedures to solve physics problems. |

**State Performance Indicators**

**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: i.e. $y = x^2$.
**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 (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.

## Suggested Knox County Additional Learning Activities

***Measurement and Calculation***

- **Lab:** "Measure this," student teams measure areas as defined by instructor. The measurements of student teams are graphed for a singular item. Uncertainty, accuracy, random error and systemic error are discussed.
- Analyze uncertainty in numerical values by proper use of significant digits
- Solve problems involving numerical conversions of units and metric prefixes, including proper use of scientific notation.
- Create and/or utilize a proper scientific graph and analyze the relation between variables by finding/using a line or curve of best fit and its corresponding equation.

***Graphic Analysis***

- Analyze position-time graphs to create velocity-time and acceleration-time graphs. Reverse the process and create position-time graphs from velocity-time and acceleration-time graphs.

***Vectors***

- **Lab:** "Treasure Hunt," student teams compete in developing vector diagrams for a specific target location of their choice.
- **Lab:** " Vector Travel" – students get a set of latitude/longitude coordinates and must download the appropriate map from the teacher's website then draw the given vectors on the map to determine the final destination..
- Practice the use of trigonometry to split vectors into horizontal and vertical components.

## Physics: Standard 1 - Mechanics

### Pacing guide

*55% of the course (47 instructional days)*

### Guiding Question

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

| Course Level Expectations | Checks for Understanding |
|---|---|
| **CLE 3231.1.1** Investigate fundamental physical quantities of length, mass, and time.<br>**CLE 3231.1.2** Analyze and apply Newton's three laws of motion.<br>**CLE 3231.1.3** Understand work, energy, and power.<br>**CLE 3231.1.4** Investigate kinematics and dynamics.<br>**CLE 3231.1.5** Investigate and apply Archimedes's Principle.<br>**CLE 3231.1.6** Explore Pascal's Principle.<br>**CLE 3231.1.7** Develop an understanding of Bernoulli's Principle and its applications. | ✓**3231.1.1** Explore displacement, velocity, and acceleration<br>Average Velocity: $v_{av} = (d_f-d_i)/(t_f-t_i)$;<br>Final Velocity: $v_f = v_i+a\Delta t$;<br>Final Velocity of Falling object: $v_f = v_i+g\Delta t$;<br>Average Acceleration: $a_{av} = (v_f-v_i)/(t_f-t_i)$;<br>Displacement of Falling object (horizontal): $d = v_i \Delta t+(1/2) a\Delta t^2$;<br>Displacement of Falling object (vertical): $\Delta d = v_i \Delta t +(1/2)g \Delta t^2$.<br>✓**3231.1.2** Analyze vector diagrams and solve composition and resolution problems for force and momentum.<br>✓**3231.1.3** Explore characteristics of rectilinear motion and create displacement-time graphs (velocity), velocity-time graphs (acceleration and distance).<br>✓**3231.1.4** Investigate the characteristics of centripetal motion and centripetal acceleration<br>Centripetal Force: $F_c = (mv^2)/r$;<br>Angular Velocity: $\omega=\Delta\theta/\Delta t$;<br>Angular Acceleration: $\alpha = \Delta\omega/\Delta t$.<br>✓**3231.1.5** Evaluate the dynamics of systems in motion including friction, gravity, impulse and momentum, change in momentum, and conservation of momentum.<br>Coefficient of Friction: $\mu = F_f/F_N$;<br>Law of Universal Gravitation: $F_G = (G m_1m_2)/d^2$;<br>Impulse: $F\Delta t = m\Delta t$.<br>✓**3231.1.7** Apply mathematics to solve motion problems. |

| **Course Level Expectations** (Mechanics Continued) | **Checks for Understanding** (Mechanics Continued) |
|---|---|
| | ✓**3231.1.8** Experiment with elastic and inelastic collisions.<br>✓**3231.1.9** Experiment with pendulums Pendulum period:<br>$T = 2\pi \sqrt{l/g}$<br>✓**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].<br>✓**3231.1.11** Apply elementary calculus to solve motion problems:<br>Velocity = derivative of position<br>Acceleration = derivative of velocity.<br>✓**3231.1.12** Experiment with elastic and inelastic collisions<br>Elastic : $m_1v_1 + m_2v_2 = m_1v_3+m_2v_4$;<br>Inelastic: $m_1v_1+m_2v_2 = (m_1+m_2)v_3$<br>✓**3231.1.13** Distinguish between mass and weight using base units in the SI system.<br>✓**3231.1.14** Associate time with the independent variable in most experiments.<br>✓**3231.1.15** Relate inertia, force, or action-reaction forces to Newton's three laws of motion.<br>✓**3231.1.16** Compare, contrast, and apply characteristic properties of scalar and vector quantities.<br>✓**3231.1.17** Investigate the definitions of force, work, power, kinetic energy, and potential energy.<br>Force: $F = ma$;<br>Work: $W = Fd$;<br>Power: $P = (F\Delta d)/ \Delta t$;<br>Kinetic Energy: $E_K = 0.5mv^2$;<br>Potential Energy: $E_P = mg\Delta h$.<br>✓**3231.1.18** Analyze the characteristics of energy, conservation of energy including friction, and gravitational potential energy [Gravitational Potential Energy: $E_p=mg\Delta h$].<br>✓**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<br>Work: $W= F\Delta d$;<br>Power: $P = (F\Delta d)/\Delta t$;<br>Efficiency = $(W_{OUT}/W_{IN})x100\%$. |

| **Course Level Expectations** (Mechanics Continued) | **Checks for Understanding** (Mechanics Continued) |
|---|---|
| | ✓**3231.1.20** Describe rotational equilibrium and relate this factor to torque<br>Rotational Inertia: $T = I\alpha$;<br>Torque: $T = Fr$<br>✓**3231.1.21** Determine the magnitude of the buoyant force exerted on a floating object or a submerged object ($F_B = m_f g = \rho_f V_f g$).<br>✓**3231.1.22** Investigate the apparent weight of an object submerged in a fluid ($F_{net} = F_B - F_g$).<br>✓**3231.1.23** Explain, in terms of force and/or density, why some objects float and some objects sink.<br>✓**3231.1.24** Calculate the pressure exerted by a fluid according to Pascal's Principle ($P_{inc} = F_1/A_1 = F_2/A_2$).<br>✓**3231.1.25** Calculate how pressure varies with water depth ($P = P_0 + \rho gh$).<br>✓**3231.1.26** Examine the motion of a fluid using the continuity equation ($A_1v_1 = A_2v_2$).<br>✓**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). |

## State Performance Indicators

**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 ($\mu_s$ and $\mu_k$); select the appropriate coefficient of friction and calculate the force necessary to move the object.
**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 $T = 2\pi \sqrt{l/g}$
**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.

## Suggested Knox County Additional Learning Activities

***Kinematics***

- **Lab:** "velocity vs time," student teams construct position vs time graphs from a bowling ball rolling down an incline. From the position vs time graph relation, students will develop a velocity vs time graph and discuss how this relates to acceleration.
- State the displacement and velocity relations for cases of constant acceleration and use these to solve problems given appropriate initial conditions and values.
- **Lab*:*** "Human Cannonball," student groups use horizontal and vertical relations to calculate the path and landing position of angular and horizontal projectiles around a problem based learning expectation. Student teams then launch the projectile to prove their concept.

## Suggested Knox County Additional Learning Activities (Mechanics Continued)

***Forces***

- Complete the "FCI" standardized test pre and post instruction.
- **Lab:** "g," student teams experimentally calculate the value of "g" utilizing a picket fence and photo gates or motion detectors.
- State Newton's 1st and 2nd Laws of Motion and apply these laws to physical situations in order to determine what forces act on an object and to explain the object's resulting behavior.
- Recognize the difference between weight and mass and convert from one to the other.
- Understand and utilize the relation between friction force, normal force, and coefficient of friction for both cases: static and kinetic.
- Apply force components to objects on an incline and solve related problems.

***Conservation Laws***

- **Lab:** "Rollercoaster," build a simple table top rollercoaster using pipe insulation and a small ball that exits the rollercoaster as a horizontal projectile. Calculate the horizontal displacement with nothing more than a meter stick and knowledge of energy conservation.
- Calculate mechanical kinetic energy and gravitational potential energy (in Joules) and use conservation of energy to solve related problems.
- Relate and equate work and energy and solve related problems.
- Define and calculate power (in Watts or horsepower) and solve related problems.
- State and apply the law of conservation of momentum with proper consideration to internal and external forces.
- **Lab**:"Power," students run up a flight of stairs and determine their horsepower. W-FD, P=W/t
- **Lab:**"Egg Drop," students design the interior of a shoebox to hold a raw egg so that it can remain intact when dropped from the top of the stadium bleachers. Students calculate momentum of the collision.
- **Lab**: "Egg Passenger," students develop paper bumpers for their team dynamics cart. Students utilize a "GoMotion" sensor and LoggerPro to identify terminal velocity, calculate momentum and calculate impulse.

***Circular Motion and Universal Gravitation***

- **Lab**: "Circular Motion," teams use stop watches, string, 6" of ½" pipe, a racquetball, and weights. Put the string through the pipe and attach the racquetball on one end with weights on the other end. Swing the racquet ball in a circle. State and apply the relation between the weight on the system, speed, radius, and period for uniform circular motion.
- Define and calculate period and frequency and solve related problems.
- State and apply the relation between speed, radius, and centripetal acceleration for circular motion and solve related problems.
- Combine equations of circular motion and gravitation to solve problems involving orbital motion. State relations among rotational kinematic quantities: angular displacement, angular velocity, and angular acceleration and solve related problems.
- Define and calculate torque and solve related problems, including statics problems in which net torque equals zero is a condition for equilibrium.
- Define and describe moment of inertia and its relation to mass and radius and solve related problems.
- Solve problems that relate net torque to moment of inertia and angular acceleration.
- **Activity:** "Tangential Velocity," students line up in a straight line and hold on to a long piece of PVC pipe. A person on one end can only rotate while the others have to keep up.

# Physics: Standard 2 - Thermodynamics

## Pacing guide

*6% of the course (5 instructional days)*

## Guiding Question

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

| Course Level Expectations | Checks for Understanding |
|---|---|
| **CLE 3231.2.1** Develop an understanding of temperature, heat, and internal energy.<br>**CLE 3231.2.2** Compare Celsius, Kelvin and the Absolute temperature scales.<br>**CLE 3231.2.3** Investigate exchanges in internal energy. | ✓**3231.2.1** Investigate temperature in relationship to kinetic energy.<br>✓**3231.2.2** Identify the characteristics of internal energy and temperature/heat (joules/calories).<br>✓**3231.2.3** Experiment with change in heat content (quantity of thermal energy) and relate to kinetic energy and specific heat.<br>✓**3231.2.4** Investigate phase changes of heat of fusion, heat of vaporization, and heat of sublimation<br>Change in Heat: $\Delta Q = mHf$ and $\Delta Q = mHv$.<br>✓**3231.2.5** Explore thermal expansion and contraction<br>Linear Expansion: $\Delta l = li\ \alpha\Delta T$ ;<br>Volumetric Expansion: $\Delta V = Vi\beta\Delta T$.<br>✓**3231.2.6** Apply the second law of thermodynamics to the Carnot engine.<br>✓**3231.2.7** Apply the Laws of Thermodynamics to the atmospheric levels of the earth (i.e., greenhouse effect and climate change).<br>✓**3231.2.8** Recognize that absolute zero is the absence of molecular kinetic energy.<br>✓**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.<br>Heat Lost = Heat Gained, $QL = QG$.<br>✓**3231.2.10** Investigate calorimetry, kinetic energy, and specific heat<br>Change in Heat: $\Delta Q = mC\Delta T$ |

**State Performance Indicators**

**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.

**Suggested Knox County Additional Learning Activities**

- Define thermal or internal energy as the combination of kinetic energy and potential energy associated with phase of matter.
- Solve calorimetry problems relating heat energy to change in temperature and/or phase change using specific heat, heat of fusion, heat of vaporization, etc.
- Define and apply temperature scales in terms of average kinetic energy and recognize absolute zero as absence of molecular kinetic energy.
- Solve problems involving $1^{st}$ Law of Thermodynamics.
- Solve problems involving $2^{nd}$ Law of Thermodynamics and heat engines and the efficiency of the Carnot cycle.

## Physics: Standard 3 - Waves

### Pacing guide

*10% of the course (9 instructional days)*

### Guiding Question

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

| Course Level Expectations | Checks for Understanding |
|---|---|
| **CLE 3231.3.1** Explore conditions associated with how waves carry energy and simple harmonic motion.<br>**CLE 3231.3.2** Investigate Hooke's law.<br>**CLE 3231.3.3** Understand wave mechanics.<br>**CLE 3231.3.4** Examine the Doppler Effect.<br>**CLE 3231.3.5** Explore the characteristics and properties of sound. | ✓**3231.3.1** Investigate simple harmonic motion.<br>✓**3231.3.2** Investigate and analyze wavelength, frequency, period, and amplitude of longitudinal and transverse waves.<br>✓**3231.3.3** Describe a wave interaction as reflection, refraction, diffraction, or interference.<br>✓**3231.3.4** Explore Hooke's Law.<br>✓**3231.3.5** Investigate reflection, refraction, diffraction, and interference of sound waves.<br>✓**3231.3.6** Compare mechanical and electromagnetic waves.<br>✓**3231.3.7** Explain the Doppler Effect.<br>Source moving toward stationary listener: $f_{LF} = f_s \frac{v}{v - v_s}$<br>Source moving away from stationary listener: $f_{LB} = f_s \frac{v}{v + v_s}$<br>Listener moving toward stationary source: $f_{LC} = f_s \frac{v + v_{LC}}{v}$<br>Listener moving away from stationary source: $f_{LO} = f_s \frac{v - v_{LO}}{v}$<br>✓**3231.3.8** Determine the speed of sound experimentally and describe the effects various materials and temperatures on sound.<br>✓**3231.3.9** Measure spring constants.<br>✓**3231.3.10** Solve problems related to wave length, frequency, period, and speed<br>Wave velocity: $v = f\lambda$ and<br>Period: $T=1/f$. |

| Course Level Expectations (Waves Continued) | Checks for Understanding (Waves Continued) |
|---|---|
| | ✓**3231.3.11** Determine the speed of sound experimentally using various materials and temperatures<br>Sound velocity: $v_s = f\lambda$;<br>Sound velocity (using air temperature): $v_s = 331.5 m/s + (0.56 m/s\ ^oC)(T)$.<br>✓**3231.3.12** Describe simple harmonic motion.<br>✓**3231.3.13** Compare the wave characteristics of natural auditory phenomena. |

## State Performance Indicators

**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 waves.

## Suggested Knox County Additional Learning Activities

***Waves***

- Define, apply, and give examples of the following concepts: wave, pulse vs. continuous wave, source, medium, longitudinal wave, transverse wave, surface wave, crest, trough, compression, and rarefaction.
- State conditions necessary for Simple Harmonic Motion and describe its properties.
- Solve problems of Simple Harmonic Motion in which period is related to mass and spring constant or length of pendulum and gravitational field strength.
- Define, apply and give examples of the following wave parameters: speed, wavelength, frequency, period, and amplitude and state the influence of source and medium on each wave parameter.
- Interactive Lecture Demonstration: students participate in optics experiments displayed by instructor through writing their predictions on paper. State the relation between speed, wavelength, and frequency for a wave, and use this relation to solve related problems.
- Explain causes and results of the Doppler Effect and solve related problems.
- State the wave type and medium of EMR and sound and identify the speed of each. State and recognize the different types of electromagnetic radiation (EMR): radio, microwave, infrared, light, ultraviolet, x-ray, gamma.
- Create and/or analyze graphs of waves.
- Solve problems involving interference and superposition of waves such as: standing waves and harmonics, Young's experiment, diffraction gratings, etc.

# Physics: Standard 4 - Optics

## Pacing guide

*10% of the course (9 instructional days)*

## Guiding Question

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

| Course Level Expectations | Checks for Understanding |
|---|---|
| **CLE 3231.4.1** Describe the characteristics of the electromagnetic spectrum.<br>**CLE 3231.4.2** Investigate the interaction of light waves.<br>**CLE 3231.4.3** Explore the optics of lenses.<br>**CLE 3231.4.4** Analyze the optics of mirrors.<br>**CLE 3231.4.5** Investigate the phenomenon of color. | ✓**3231.4.1** Explore properties of electromagnetic radiation.<br>✓**3231.4.2** Examine properties of light waves.<br>✓**3231.4.3** Investigate the polarization of light.<br>✓**3231.4.4** Investigate the optical properties of plane and curved mirrors<br>Focal length: $1/f = 1/d_o + 1/d_i$;<br>Images in mirrors and lens, $h_i/h_o = d_i/d_o$.<br>✓**3231.4.5** Investigate the optical properties of plane and curved mirrors.<br>✓**3231.4.6** Draw, explain, and solve problems for the optics of mirrors and lenses.<br>✓**3231.4.7** Investigate optical phenomena (i.e., mirage, optical illusions, and dichromatic lens effect).<br>✓**3231.4.8** Solve problems related to Snell's law<br>Index of refraction: $n = (\sin \theta_r / \sin \theta_i)$;<br>Snell's law: $n_i \sin \theta_i = n_r \sin \theta_r$.<br>✓**3231.4.9** Differentiate among transmission, reflection, refraction, diffraction, and interference of light waves.<br>✓**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]. |

## State Performance Indicators

**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.

updated summer 2011

## Suggested Knox County Additional Learning Activities

***Reflection, Refraction, and Optics***

- **Lab**: student teams are given a random spring, a ring stand and a weight set. Students apply Hooke's Law to develop the value for K.
- State and apply the law of reflection and construct or analyze a diagram showing angles of incidence and reflection relative to a normal.
- State and apply the law of refraction and construct or analyze a diagram showing angles of incidence and reflection relative to a normal.
- Define and apply index of refraction and Snell's Law and solve related problems.
- Describe what is meant by dispersion and give an example of it.
- Construct ray diagrams for showing location, orientation, and size of object and image for plane, convex, and concave mirrors, and convex and concave lenses.
- Solve problems involving location, size, magnification, and orientation of images formed by lenses and mirrors and determine whether images are virtual or real.
- State factors that affect focal length for mirrors and lenses and solve problems relating a mirrors focal length to its radius of curvature.
- **Activity**: "Law of Reflection," students position plane mirrors perpendicular to the ground and put the mirrors in a position where they can see their entire body. Student groups must describe why their view is limited in terms of incident light rays and reflected light rays.
- **Activity**: "Refraction," students place a pencil in a beaker of water. Student teams describe how the pencil looks after it is placed in the water. Students are asked for explanations.
- **Lab**: "Meter stick Optics," student teams are given a meter stick optics kit and given a convex lens and asked to determine the focal length. An inquiry version of this lab would ask for the student teams to create a telescope from two convex lenses. Students then create ray diagrams to explain the experiment.

## Physics: Standard 5 – Electricity and Magnetism

### Pacing guide

*6% of the course (5 instructional days)*

### Guiding Question

*How does an electric charge produce electric and magnetic fields?*

| Course Level Expectations | Checks for Understanding |
|---|---|
| **CLE 3231.5.1** Examine the properties of electric forces, electric charges, and electric fields.<br>**CLE 3231.5.2** Explore the flow of charge and electric currents.<br>**CLE 3231.5.3** Investigate Ohm's law.<br>**CLE 3231.5.4** Compare and contrast series and parallel circuits.<br>**CLE 3231.5.5** Analyze schematic diagrams.<br>**CLE 3231.5.6** Understand magnetic poles, magnetic fields, and investigate electromagnetic induction.<br>**CLE 3231.5.7** Understand that moving charges give rise to magnetism. | ✓**3231.5.1** Create a simple electromagnet.<br>✓**3231.5.2** Draw an electric field, given a scenario of charged particles.<br>✓**3231.5.3** Solve problems of resistance using Ohm's law [$\mathcal{E}$ = IR (or V=IR)].<br>✓**3231.5.4** Draw and explain series and parallel circuits.<br>✓**3231.5.5** Solve problems related to voltage, current, and resistance<br>Voltage, V = IR;<br>Series circuits, $R_T = R_1+R_2+\ldots$,<br>$I_T = I_1 = I_2 = \ldots$, $V_T = V_1 + V_2+\ldots$;<br>Parallel circuits, $1/R_T = 1/R_1+1/R_2+\ldots$,<br>$I_T = I_1+I_2+\ldots$, $V_T = V_1=V_2 = \ldots$.<br>✓**3231.5.6** Build series and parallel circuits to demonstrate how they function.<br>✓**3231.5.7** Demonstrate a generated current by electromagnetic induction. |

### State Performance Indicators

**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.
**SPI.3231.5.8** Identify common components of electrical circuitry from a schematic drawing such as batteries, resistors, lamps, ammeters, voltmeters, and variable resistors.

### Suggested Knox County Additional Learning Activities

***Electric Fields***

- Solve problems relating electric field strength and direction to a point charge or collection of point charges and sketch electric field lines.
- Solve problems relating an electric field to its effects on a point charge located in the field.

updated summer 2011

- Solve problems relating electric potential to a point charge or collection of point charges.

***Magnetism***

- Identify and illustrate the concepts of magnetic fields and poles explain and apply the properties thereof.
- Explain and apply the concepts of ferromagnetism and the theory of domains.
- Solve problems in which a point charge moves in a magnetic field, relating field strength, velocity, and charge via the right hand rule.
- Solve problems relating force on a segment of wire within a magnetic field to the strength of the field, the length of the wire, and the current in the wire.
- Determine the magnetic field produced by a direct current in an infinite linear wire, or a circular loop of wire, and solve related problems.
- Describe and explain the general process of electromagnetic induction.
- **Lab:** "Magnetic Fields." students place a piece of paper over a powerful magnet. They sprinkle iron filings over the paper and observe the pattern that develops. Students describe the pattern and why the pattern exists.

***Electricity***

- **Lab:** "Circuits," students use a voltmeter to measure the voltage across various batteries and voltage drops for various series/parallel circuit combinations. Reconstruct schematic diagrams for the circuits tested. Analyze the schematic diagrams and determine current and resistance for each branch circuit.
- Solve problems involving capacitors relating charge to voltage and capacitance, and/or relating capacitance to field strength, area, dielectric constant, and separation for a parallel plate capacitor.
- Calculate the equivalent capacitance for a set of capacitors in series or parallel and solve related problems.

## Physics: Standard 6 – Nuclear Physics

### Pacing guide

*2% of the course (2 instructional days)*

### Guiding Question

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

| Course Level Expectations | Checks for Understanding |
|---|---|
| **CLE 3231.6.1** Investigate the properties and structure of the atom.<br>**CLE 3231.6.2** Investigate properties of the quantum theory.<br>**CLE 3231.6.3** Explore the dynamics of the nucleus: radioactivity, radiocarbon/uranium dating, and half-life.<br>**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.<br>✓**3231.6.2** Solve half-life problems<br>Decay constant: $k=0.693/T_{(1/2)}$;<br>Nuclear decay: $A_f = A_o e^{kt}$.<br>✓**3231.6.3** Explain dating methods using carbon-14 or uranium.<br>✓**3231.6.4** Investigate the concept of half-life.<br>✓**3231.6.5** Explain how particles behave like waves.<br>✓**3231.6.6** Distinguish between coherent and incoherent light.<br>✓**3231.6.7** Recognize how the quantum theory explains the photoelectric effect.<br>✓**3231.6.8** Investigate the history and current events associated with nuclear and radioactive science.<br>✓**3231.6.9** Identify the parts of an atom.<br>✓**3231.6.10** Describe the properties and location of subatomic particles.<br>✓**3231.6.11** Describe three forms of radioactivity.<br>✓**3231.6.12** Distinguish between nuclear fission and nuclear fusion.<br>✓**3231.6.13** Investigate and describe quantum mechanics and the properties of quantum theory.<br>✓**3231.6.14** Explain the changes in atomic number or mass number for each form of radioactivity.<br>✓**3231.6.15** Discuss transmutation and transuranium.<br>✓**3231.6.16** Explain how particles behave like waves. |

## State Performance Indicators

**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.

## Suggested Knox County Additional Learning Activities

***Atomic and Nuclear Physics***

- Identify and describe and locate the subatomic particles that make up the atom.
- Compare and contrast the Bohr model and quantum models of the atom including description of wave-particle duality.
- Balance equations involving nuclear reactions and radioactive decay and list and describe the three types of radiation.
- Explain the concept of half-life and solve related problems.
- Use quantum theory to explain and/or solve problems involving: the photoelectric effect, nuclear fission, nuclear fusion, pair production, etc.
- State and explain the unique properties of laser light and explain the production process as it relates to quantum properties of atoms.

# Resources

## Writing Prompts

1) Imagine you are Christopher Columbus and you are recruiting a crew to make the trans-Atlantic voyage to reach India that the excessive amount of supplies will sink the ship. Write a persuasive essay explaining, through your knowledge of physics, that the ship can withstand the extra weight of supplies without sinking. (MECHANICS: Archimedes Principle)
2) Come up with a new scam-diet plan involving a way to "lose weight" by traveling to other planets, or living at higher elevations. (MECHANICS: Universal Law of Gravitation)
3) Design and explain a new way to get into Earth orbit using springs, an elevator or whatever else you wish. This is supposed can be theoretical, not necessarily realistic. (MECHANICS)
4) Some astronauts, while in Earth orbit, constantly feel nauseous due to orientation issues. Write about your proposal for a design of headgear that would always allow the astronaut to see one side of the capsule as the floor. (OPTICS)
5) The U.S. Government wants to send people to Mars. Write a proposal that would allow the astronauts to experience gravitational effects while in-transit to the "red planet". (MECHANICS: Centripetal Force)
6) Obtain a copy of the video called, "The Dark Secret of Hendrik Shon." This video discusses the work of a research scientist who misleads his colleagues with data that was later shown to be false. Students should write a position paper regarding the ethics of misstating/overstating results.

# General Helpful Web Sites

The Physics Classroom Tutorial: an excellent site that gives good basic physics information. Most important is the emphasis on understanding graphs of all types. The Physics Classroom tutorial pages were written by Tom Henderson, science teacher at Glenbrook South High School in Glenview, Illinois.

http://www.glenbrook.k12.il.us/GBSSCI/PHYS/CLASS/1DKin/1DKinTOC.html

The Open Directory Project: the largest, most comprehensive human-edited directory of the Web. It is constructed and maintained by a vast, global community of volunteer editors. Physics lesson plans of all types are indexed here.

http://www.dmoz.org/Science/Physics/Education/Lesson_Plans/

SMILE Program Physics Index: the SMILE website is hosted by the Illinois Institute of Technology. It indexes almost 200, single concept lesson plans.

http://www.iit.edu/~smile/physinde.html

PBS and NOVA: NOVA is the highest rated science series on public television and offers many of these valuable programs for on-line viewing. These award winning broadcasts cover multiple topics. A few physics favorites are: “The Elegant Universe,” “Hunting the Hidden Dimension,” and “Dark Matter.”

http://www.pbs.org/wgbh/nova/programs/

NASA: has significant resources for educators. Their activities and lessons are for all age groups.

http://teacherlink.ed.usu.edu/tlnasa/units/index.html

AAPT: the American Association of Physics Teachers has public areas on their web site that are helpful. Full access to the web site and magazine articles requires membership.

http://www.aapt.org/

## Homework Help

Some good websites to help students with their homework.

http://www.hippocampus.org/Physics

http://www.physicsclassroom.com/

http://www.launc.tased.edu.au/online/sciences/Physics/tutes1.html

## Animations

Many excellent free resources are available in addition to the resources available from your textbook publisher.

PhET: Interactive Simulations, University of Colorado, Boulder is one excellent source for fun simulations that promote student practice and interest in physics concepts. Simulations range from very basic to the intricate. Simulations are updated frequently.

http://phet.colorado.edu/index.php

Flash Animations for Physics: David M. Harrison, Dept. of Physics, Univ. of Toronto has developed an excellent page of animations designed to illustrate physics concepts.

http://www.upscale.utoronto.ca/GeneralInterest/Harrison/Flash/#chaos

updated summer 2011