

# Tennessee Science Curriculum Framework

## Conceptual Physics

### Course Description

Conceptual Physics is a laboratory course that examines the interactions between matter and energy. Students explore physics concepts through an inquiry approach integrated with appropriate algebra-based mathematics.

Conceptual Physics students investigate:

- Inquiry
- Technology and Engineering
- Mathematics
- Mechanics
- Thermodynamics
- Waves and Optics
- Electricity and Magnetism
- Nuclear Science

### Embedded Inquiry

#### Conceptual Strand

*Understandings about scientific inquiry and the ability to conduct inquiry are essential for living in the 21<sup>st</sup> century.*

#### Guiding Question

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

#### Course Level Expectations

**CLE 3237.Inq.1** Recognize that science is a progressive endeavor that reevaluates and extends what is already accepted.

**CLE 3237.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 3237.Inq.3** Use appropriate tools and technology to collect precise and accurate data.

**CLE 3237.Inq.4** Apply qualitative and quantitative measures to analyze data and draw conclusions that are free of bias.

**CLE 3237.Inq.5** Compare experimental evidence and conclusions with those drawn by others about the same testable question.

**CLE 3237.Inq.6** Communicate and defend scientific findings.

### **Checks for Understanding (Formative/Summative Assessment)**

- ✓ **3237.Inq.1** Develop a testable question for a scientific investigation.
- ✓ **3237.Inq.2** Develop an experimental design for testing a hypothesis.
- ✓ **3237.Inq.3** Select appropriate independent, dependent, or controlled variables for an experiment.
- ✓ **3237.Inq.4** Perform an experiment to test a prediction.
- ✓ **3237.Inq.5** Gather, organize, and transform data from an experiment into a table, graph, or diagram.
- ✓ **3237.Inq.6** Analyze data from a table, graph, or diagram.
- ✓ **3237.Inq.7** Analyze and interpret the results of an experiment.
- ✓ **3237.Inq.8** Apply knowledge and data-interpretation skills to support a conclusion.
- ✓ **3237.Inq.9** Determine whether data supports or contradicts a simple hypothesis or conclusion.
- ✓ **3237.Inq.10** Analyze experimental results and identify possible sources of experimental error.
- ✓ **3237.Inq.11** State a conclusion in terms of the relationship between two or more variables.
- ✓ **3237.Inq.12** Compare the results of an experiment with what is already known about the topic under investigation.
- ✓ **3237.Inq.13** Suggest alternative explanations for the same set of observations.
- ✓ **3237.Inq.14** Formulate and revise scientific explanations and models using logic and evidence.

## **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 Expectations**

- CLE 3237.T/E.1** Explore the impact of technology on social, political, and economic systems.
- CLE 3237.T/E.2** Differentiate among elements of the engineering design cycle: design constraints, model building, testing, evaluating, modifying, and retesting.
- CLE 3237.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 3237.T/E.4** Describe the dynamic interplay among science, technology, and engineering within living, earth-space, and physical systems.

### **Checks for Understanding (Formative/Summative Assessment)**

- ✓ **3237.T/E.1** Select appropriate tools to conduct a scientific inquiry.
- ✓ **3237.T/E.2** Apply the engineering design process to construct a prototype that meets developmentally appropriate specifications.

- ✓**3237.T/E.3** Explore how the unintended consequences of new technologies can impact human and non-human communities.
- ✓**3237.T/E.4** Present research on current engineering technologies that contribute to improvements in our daily lives.
- ✓**3237.T/E.5** Design a series of multi-view drawings that can be used by other students to construct an adaptive design and test its effectiveness.

## **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 conceptual physics?*

### **Course Level Expectations**

- CLE 3237.Math.1** Understand the mathematical principles that underlie the science of physics.
- CLE 3237.Math.2** Utilize appropriate mathematical equations and processes to solve basic physics problems.

### **Checks for Understanding (Formative/Summative Assessment)**

- ✓**3237.Math.1** Use a variety of notations appropriately (e.g., exponential, functional, square root).
- ✓**3237.Math.2** Select and apply an appropriate method for computing with real numbers, and evaluate the reasonableness of results.
- ✓**3237.Math.3** Apply and interpret rates of change from graphical and numerical data.
- ✓**3237.Math.4** Analyze graphs to describe the behavior of functions.
- ✓**3237.Math.5** Interpret results of algebraic procedures.
- ✓**3237.Math.6** Model real-world phenomena using functions and graphs.
- ✓**3237.Math.7** Articulate and apply algebraic properties in symbolic manipulation.
- ✓**3237.Math.8** Apply and communicate measurement concepts and relationships in algebraic and geometric problem-solving situations.
- ✓**3237.Math.9** Make decisions about units, scales, and measurement tools that are appropriate for problem situations involving measurement.
- ✓**3237.Math.10** Collect, represent, and describe linear and nonlinear data sets developed from the real world.
- ✓**3237.Math.11** Make predictions from a linear data set using a line of best fit.
- ✓**3237.Math.12** Interpret a data set using appropriate measures of central tendency.
- ✓**3237.Math.13** Choose, construct, and analyze appropriate graphical representations for a data set.
- ✓**3237.Math.14** Use real numbers to represent real-world applications (e.g., slope, rate of change, probability, and proportionality).
- ✓**3237.Math.15** Apply right triangle relationships including the Pythagorean Theorem and the distance formula.

- ✓ **3237.Math.16** Use concepts of length, area, and volume to estimate and solve real-world problems.
- ✓ **3237.Math.17** Demonstrate an understanding of rates and other derived and indirect measurements (e.g., velocity, miles per hour, revolutions per minute, and cost per unit).

## **Standard 1 – Mechanics**

### **Conceptual Strand 1**

*The laws and properties of mechanics provide the foundations of Conceptual Physics.*

### **Guiding Question 1**

*How do the laws and properties of mechanics govern the basic understanding of physics concepts?*

### **Course Level Expectations**

- CLE 3237.1.1** Investigate fundamental physical quantities of mass and time.
- CLE 3237.1.2** Analyze and apply Newton’s three laws of motion.
- CLE 3237.1.3** Differentiate among work, energy, and power.
- CLE 3237.1.4** Investigate kinematics and dynamics.
- CLE 3237.1.5** Investigate and apply Archimedes’s Principle.
- CLE 3237.1.6** Explore Pascal’s Principle.
- CLE 3237.1.7** Analyze applications of Bernoulli’s Principle.

### **Checks for Understanding (Formative/Summative Assessment)**

- ✓ **3237.1.1** Investigate, measure, and calculate position, displacement, velocity and acceleration.
- ✓ **3237.1.2** Analyze vector diagrams.
- ✓ **3237.1.3** Explore characteristics of rectilinear motion and create distance-time graphs and velocity-time graphs.
- ✓ **3237.1.4** Investigate the characteristics of centripetal motion and centripetal acceleration.
- ✓ **3237.1.5** Evaluate the dynamics of systems in motion and collisions including friction, gravity, impulse and momentum, change in momentum and conservation of momentum.
- ✓ **3237.1.6** Investigate projectile motion.
- ✓ **3237.1.7** Distinguish between mass and weight using SI units.
- ✓ **3237.1.8** Measure and calculate mechanical advantage of mechanical devices.
- ✓ **3237.1.9** Relate time to the independent variable of most experiments.
- ✓ **3237.1.10** Relate inertia, force, or action-reaction forces to Newton’s three laws of motion and distinguish among the three laws in various scenarios.
- ✓ **3237.1.11** Compare, contrast, and apply the characteristic properties of scalar and vector quantities.
- ✓ **3237.1.12** Investigate the definitions of force, work, power, kinetic energy and potential energy.
- ✓ **3237.1.13** Analyze the characteristics of energy, and conservation of energy including friction, and gravitational potential energy.

- ✓ **3237.1.14** Investigate the buoyant force exerted on floating and submerged objects.
- ✓ **3237.1.15** Investigate the apparent weight of an object submerged in a fluid.
- ✓ **3237.1.16** Explain why objects float or sink in terms of force or density.
- ✓ **3237.1.17** Examine the motion of fluids.
- ✓ **3237.1.18** Recognize the effects of Bernoulli's principle on fluid motion (e.g., lift, ball trajectories, and wind around/over object).

## **Standard 2 – Thermodynamics**

### **Conceptual Strand 2**

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

### **Guiding Question 2**

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

### **Course Level Expectations**

- CLE 3237.2.1** Explore the relationships among temperature, heat, and internal energy.
- CLE 3237.2.2** Compare Fahrenheit, Celsius, and Kelvin temperature scales.
- CLE 3237.2.3** Investigate exchanges in internal energy.

### **Checks for Understanding (Formative/Summative Assessment)**

- ✓**3237.2.1** Investigate the relationship between temperature and kinetic energy.
- ✓**3237.2.2** Distinguish among internal energy, temperature, and heat.
- ✓**3237.2.3** Investigate heat changes using calorimetry.
- ✓**3237.2.4** Investigate energy changes associated with heats of fusion and vaporization.
- ✓**3237.2.5** Explore thermal expansion and contraction.
- ✓**3237.2.6** Apply the Second Law of Thermodynamics to the Carnot engine.
- ✓**3237.2.7** Apply the Laws of Thermodynamics to atmospheric and climatic changes.
- ✓**3237.2.8** Recognize that absolute zero is the absence of molecular kinetic energy.
- ✓**3237.2.9** Relate the First Law of Thermodynamics as an application of the Law of Conservation of Energy to heat transfer through conduction, convection, and radiation.

## **Standard 3 – Waves and Optics**

### **Conceptual Strand 3**

*Investigating wave behavior reveals information about sound and light.*

### **Guiding Question 3**

*How does the wave model explain the phenomena of sound and light?*

### **Course Level Expectations**

- CLE 3237.3.1** Explore conditions associated with simple harmonic motion.
- CLE 3237.3.2** Investigate Hooke's law.
- CLE 3237.3.3** Understand wave mechanics.

- CLE 3237.3.4 Examine the Doppler Effect.
- CLE 3237.3.5 Explore the characteristics and properties of sound.
- CLE 3237.3.6 Describe the characteristics of the electromagnetic spectrum.
- CLE 3237.3.7 Investigate the interaction of light waves.
- CLE 3237.3.8 Explore the optical principles of mirrors and lenses.
- CLE 3237.3.9 Investigate the phenomenon of color.

#### **Checks for Understanding (Formative/Summative Assessment)**

- ✓ 3237.3.1 Investigate simple harmonic motion.
- ✓ 3237.3.2 Explore Hooke's Law.
- ✓ 3237.3.3 Investigate and analyze wavelength, frequency and amplitude of longitudinal and transverse waves.
- ✓ 3237.3.4 Compare mechanical and electromagnetic waves.
- ✓ 3237.3.5 Investigate reflection, refraction, diffraction, and interference of sound waves.
- ✓ 3237.3.6 Demonstrate the Doppler Effect.
- ✓ 3237.3.7 Determine the speed of sound experimentally and describe how various materials and temperatures affect wave transmission.
- ✓ 3237.3.8 Measure spring constants.
- ✓ 3237.3.9 Compare wave characteristics to natural auditory phenomena.
- ✓ 3237.3.10 Explore properties of the electromagnetic spectrum.
- ✓ 3237.3.11 Examine properties of light waves.
- ✓ 3237.3.12 Investigate reflection, refraction, diffraction, and interference of light waves.
- ✓ 3237.3.13 Investigate the polarization of plane and curved mirrors.
- ✓ 3237.3.14 Use ray tracings to solve optics of mirrors and lenses problems.
- ✓ 3237.3.15 Solve problems related to Snell's laws.
- ✓ 3237.3.16 Investigate optical phenomena (e.g., mirage, optical illusions, and dichromatic lens effect).
- ✓ 3237.3.17 Distinguish between coherent and incoherent light.
- ✓ 3237.3.18 Examine the properties of lasers.
- ✓ 3237.3.19 Explore the additive and subtractive properties associated with color formation.

## **Standard 4 – Electricity and Magnetism**

### **Conceptual Strand 4**

*Various tools and equipment can be used to investigate the interplay between magnetic fields and the generation of electricity.*

### **Guiding Question 4**

*What force and energy concepts are needed to explain magnetism and electricity?*

### **Course Level Expectations**

- CLE 3237.4.1 Distinguish among electric forces, electric charges, and electric fields.
- CLE 3237.4.2 Explore static and current electricity.
- CLE 3237.4.3 Investigate Ohm's law.
- CLE 3237.4.4 Compare and contrast series and parallel circuits.
- CLE 3237.4.5 Analyze components of electrical schematic diagrams.

**CLE 3237.4.6** Investigate magnetic poles, magnetic fields, and electromagnetic induction.

**Checks for Understanding (Formative/Summative Assessment)**

- ✓ **3237.4.1** Measure voltage, current, and resistance.
- ✓ **3237.4.2** Draw electric field lines, given a scenario of charged particles.
- ✓ **3237.4.3** Draw and explain series and parallel circuits.
- ✓ **3237.4.4** Identify components of series and parallel circuits and solve problems related to voltage, current, and resistance.
- ✓ **3237.4.5** Build series and parallel circuits and describe how they function.
- ✓ **3237.4.6** Demonstrate and explain electromagnetic induction.
- ✓ **3237.4.7** Sketch the magnetic field lines around a bar magnet.
- ✓ **3237.4.8** Create a simple electromagnet.

## **Standard 5 – Nuclear Science**

### **Conceptual Strand 5**

*A deep understanding of particle physics is accomplished by investigating the principles of nuclear science.*

### **Guiding Question 5**

*What particle physics concepts explain nuclear science?*

### **Course Level Expectations**

- CLE 3237.5.1** Investigate the properties and structure of the atom.
- CLE 3237.5.2** Explore the dynamics of the nucleus: radioactivity, nuclear decay, radiocarbon/uranium dating, and half-life.
- CLE 3237.5.3** Compare and contrast nuclear fission and nuclear fusion.
- CLE 3237.5.4** Investigate quantum theory.

### **Checks for Understanding (Formative/Summative Assessment)**

- ✓ **3237.5.1** Identify the parts of an atom.
- ✓ **3237.5.2** Describe the properties and location of subatomic particles.
- ✓ **3237.5.3** Explain how particles behave like waves.
- ✓ **3237.5.4** Describe three forms of radioactivity in terms of changes in atomic number or mass number.
- ✓ **3237.5.5** Investigate the concept of half-life.
- ✓ **3237.5.6** Write balanced equations for the three forms of radioactive decay.
- ✓ **3237.5.7** Explain carbon-14 or uranium dating methods.
- ✓ **3237.5.8** Distinguish between nuclear fission and nuclear fusion in terms of transmutation.
- ✓ **3237.5.9** Investigate the history of nuclear science.