Principles of Technology I, Principles of Technology II, Biology for Technology Curriculum Standards

The Background:

State of Tennessee Rules, Regulations and Minimum Standards for the Governance of Tennessee Public Schools (0520-1-3-.05, State Curriculum, Requirement D) states *The State Board of Education shall adopt curriculum standards for each subject area, grades K-12. These standards shall specify learning expectations and include performance indicators. The approved standards shall be the basis for planning instructional programs in each local school system. Adopted textbooks shall be aligned with state curriculum standards.*

Revised curriculum standards for science must be implemented by school districts during the 2009-2010 school year. Most of the Standards for Science 9-12 were approved at the January 2008 Board meeting. This submission of standards for second reading for the courses Principles of Technology I and II and Biology for Technology constitutes the final courses that the Department of Education will submit for approval in the area of science. The standards will be used to guide the science textbook adoption in these areas during school year 2008-2009.

The Master Plan Connection:

This item supports the State Board's Master Plan by providing a high quality science curriculum that has been developed in accordance with the national standards in science, is aligned with the National Assessment for Educational Progress 2009 Science Framework, and ACT College Readiness Benchmarks.

The Recommendation:

The Department of Education recommends adoption of the updated standards for Principles of Technology I and II and Biology for Technology on final reading. The SBE staff concurs with this recommendation.

Tennessee Science Curriculum Framework

Principles of Technology I
3220

Course Description

Principles of Technology I is a laboratory science course that deals with the relationship between matter and energy and how they interact. This course will have a strong emphasis in the application of physics in technology. Completion of Principles of Technology I satisfies a lab science credit.

Principles of Technology I students will study:

- Mechanical
- Fluids
- Electrical
- Thermal

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

CLE 3220.Inq.1 Recognize that science and technology are progressive endeavors that reevaluate and extend what is already accepted.

CLE 3220.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 3220.Inq.3 Use appropriate tools and technology to collect precise and accurate data.

CLE 3220.Inq.4 Apply qualitative and quantitative measures to analyze data and draw conclusions that are free of bias.

CLE 3220.Inq.5 Compare experimental evidence and conclusions with those drawn by others about the same testable question.

CLE 3220.Inq.6 Communicate and defend scientific findings.

Checks for Understanding (Formative/Summative Assessment)

- ✓**3220.Inq.1** Conduct scientific investigations that include testable questions, verifiable hypotheses, and appropriate variables to explore new phenomena or verify the experimental results of others.
- ✓**3220.Inq.2** Select appropriate independent, dependent, or controlled variables for an experiment.
- ✓**3220.Inq.3** Analyze the components of a properly designed scientific investigation.
- ✓**3220.Inq.4** Perform an experiment to test a prediction.
- ✓**3220.Inq.5** Select appropriate tools and technology to collect precise and accurate quantitative and qualitative data.
- ✓**3220.Inq.6** Determine if data supports or contradicts a hypothesis or conclusion.
- ✓**3220.Inq.7** Recognize, analyze, and evaluate alternative explanations for the same set of observations.
- ✓**3220.Inq.8** Evaluate the accuracy and precision of data.
- ✓**3220.Inq.9** State a conclusion in terms of the relationship between two or more variables.
- ✓**3220.Inq.10** Defend a conclusion based on scientific evidence.
- ✓**3220.Inq.11** Analyze experimental results and identify possible sources of bias or experimental error.
- ✓**3220.Inq.12** Compare the results of an experiment with what is already known about the topic under investigation.
- ✓**3220.Inq.13** Suggest alternative explanations for the same set of observations.
- ✓**3220.Inq.14** Formulate and revise models using logic and evidence.
- ✓**3220.Inq.15** Compare conclusions that offer different, but acceptable explanations for the same set of experimental data.

Embedded Mathematics

Conceptual Strand

Investigating physics principles is accomplished by applying mathematical rules.

Guiding Question

What skills and understandings of mathematics are needed to investigate physics?

Course Level Expectations

CLE.3220 Math.1 Graph relationships and functions between manipulated (independent) variables and responding (dependent) variables.
CLE.3220 Math.2 Solve for variables in an algebraic formula.
CLE.3220 Math.3 Apply statistical techniques to manipulate data.
CLE.3220 Math.4 Investigate trigonometric connections to technology.

Checks for Understanding (Formative/Summative Assessment)

- ✓**3220.Math.1** Plot points on the Cartesian coordinate graphing system.
- ✓**3220.Math.2** Graph basic relations and functions using a graphing calculator or a computer program.

✓**3220.Math.3** Determine the slope of a linear function.
✓**3220.Math.4** Determine the frequency, range, mode, median, and mean from a list of data.
✓**3220.Math.5** Utilize a graphing calculator or a computer program to enter data and find basic statistics: frequency, range, means, mode, median, and standard deviation.
✓**3220.Math.6** Solve for all variables based on a formula.
✓**3220.Math.7** Utilize trigonometric functions (sine, cosine, and tangent) to solve simple vector problems.
✓**3220.Math.8** Apply the laws of sine and cosine to solve vector problems.
✓**3220.Math.9** Solve mechanics problems using the quadratic formula.
✓**3220.Math.10** Solve mechanics problems using radians, degrees and revolutions.

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 3220.T/E.1 Explore the impact of technology on social, political, and economic systems.
CLE 3220.T/E.2 Differentiate among elements of the engineering design cycle: design constraints, model building, testing, evaluating, modifying, and retesting.
CLE 3220.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 3220.T/E.4 Describe the dynamic interplay among science, technology, and engineering within living, earth-space, and physical systems.
CLE 3220.T/E.5 Comply with all local, state, and federal safety regulations.

Checks for Understanding (Formative/Summative Assessment)

✓**3220.T/E.1** Distinguish among tools and procedures best suited to conduct a specified scientific inquiry.
✓**3220.T/E.2** Apply the engineering design process to construct a prototype that meets developmentally appropriate specifications.
✓**3220.T/E.3** Evaluate a protocol to determine the degree to which an engineering design process was successfully applied.
✓**3220.T/E.4** Explore how the unintended consequences of new technologies can impact human and non-human communities.
✓**3220.T/E.5** Evaluate the overall benefit to cost ratio of a new technology.
✓**3220.T/E.6** Present research on current bioengineering technologies that advance health and contribute to improvements in our daily lives.

✓**3220.T/E.7** Design a series of multi-view drawings that can be used by other students to construct an adaptive design and test its effectiveness.
✓**3220.T/E.8** Apply industry standard measurements and identifiers.

Standard I – Mechanical

Conceptual Strand I

Laws, properties and applications of mechanics are the foundations of principles of technology.

Guiding Question I

How do the laws, properties, and application of mechanics govern the understanding of technology?

Course Level Expectations

CLE 3220.1.1	Investigate fundamental mechanical quantities of force.
CLE 3220.1.2	Investigate fundamental mechanical quantities of work and power.
CLE 3220.1.3	Investigate fundamental mechanical quantities of rate.
CLE 3220.1.4	Investigate fundamental mechanical quantities of resistance.
CLE 3220.1.5	Investigate fundamental mechanical quantities of energy.
CLE 3220.1.6	Investigate fundamental mechanical quantities of force transformers.

Checks for Understanding (Formative/Summative Assessment)

3220.1.1.a	Distinguish between units of force in the SI and the English systems.
b	Distinguish between scalar and vector quantities of force.
c	Investigate the forces involved in determining torque.
d	Measure torque forces using appropriate tools.
e	Analyze force as it applies to Newton's three laws of motion.
f	Explain the relationship of input work and output work in linear and rotational force transformers.
g	Use equations of work in equals work out to find an unknown force or displacement when using a pulley system or a lever as the force transformer.
h	Explain the difference between ideal mechanical advantage (IMA) and actual mechanical advantage (AMA).
i	Use force transformer equations to find IMA and AMA.
j	Identify different kinds of force transformers for linear mechanical systems and rotational systems.
k	Calculate efficiency of force transformers using IMA and AMA equations.
l	Find the mechanical advantage of rotational force transformers using appropriate units.
3220.1.2.a	Distinguish between units of work and power in the SI and the English systems.
b	Explain the relationship between work done on an object, force applied, and the distance at which the object moves.

c	Measure work done in linear and rotational systems to include radians and degrees.
d	Analyze the efficiency of mechanical systems as related to input work and output work.
3220.1.3.a	Distinguish between units of rate in the SI and the English systems.
b	Calculate and measure speed and velocity in linear and rotational systems.
c	Calculate and measure acceleration in linear and rotational systems.
d	Describe how a voltage transformer is used to step up or step down voltage.
3220.1.4.a	Explain the relationship between frictional force (f), the coefficient of friction (μ), and the force pressing two surfaces together (N).
b	Distinguish between static and kinetic friction.
c	Distinguish between surface friction and fluid drag.
3220.1.5.a	Distinguish between gravitational potential energy and elastic potential energy.
b	Distinguish between potential and kinetic energy.
c	Using Hooke's law, calculate the potential energy of a spring.
d	Distinguish between linear kinetic energy and rotational kinetic energy.
e	Calculate gravitational potential energy, kinetic energy (linear and rotational),and elastic potential energy.
f	Use the law of conservation of energy to describe how one form of energy changes to another form with no loss of energy.
g	Determine the moment of inertia of a spinning object based on the object's mass, shape, and axis of rotation.

Standard II – Fluids

Conceptual Strand II

The physical laws and properties of fluids are an integrated part of how technology works.

Guiding Question II

How do the laws and properties of fluids govern the basic understanding of technology?

Course Level Expectations

CLE 3220.2.1	Investigate fundamental fluid quantities of force.
CLE 3220.2.2	Investigate fundamental fluid quantities of work and power.
CLE 3220.2.3	Investigate fundamental fluid quantities of rate.
CLE 3220.2.4	Investigate fundamental fluid quantities of resistance.
CLE 3220.2.5	Investigate fundamental fluid quantities of energy.
CLE 3220.2.6	Investigate fundamental fluid quantities of force transformers.

Checks for Understanding (Formative/Summative Assessment)

3220.2.1.a	Distinguish the difference between hydraulic and pneumatic fluid systems.
b	Distinguish between density and specific gravity, using the formula D=m/v.

c	Explore buoyant force using Archimedes principle.
d	Use Pascal's law pressure=force/area.
e	Measure fluid pressure differences using appropriate meters (manometer, pressure gauge ….).
f	Differentiate between gauge pressure and absolute pressure.
3220.2.2.a	Define work in a fluid system, using metric or English units.
b	Describe open and closed systems.
c	Calculate work done in open and closed systems.
d	Define power in a fluid system, using metric or English units.
e	Calculate efficiency by dividing power out by power in.
3220.2.3.a	Calculate fluid flow rate by using either volume or mass of a fluid divided by time.
b	Identify various situations in daily living where volume and mass flow are calculated.
3220.2.4.a	Describe resistance as an opposition to fluid motion.
b	Explain the difference between laminar and turbulent flow.
c	Explain the difference between mechanical and fluid drag.
e	Describe how to reduce the resistance of fluid flow.
f	Describe how length, diameter, and viscosity affect fluid flow.
3220.2.5.a	Relate energy in fluid systems to energy in mechanical systems.
b	Explain and demonstrate Bernoulli's principle.
3220.2.6.a	Explain how hydraulic jack works as fluid force transformer.
b	Explain how force is amplified through mechanical advantage in a fluid system.
c	Identify various fluid transformers.

Standard III – Electrical

Conceptual Strand III

Laws, properties, and applications of electricity are part of the foundations of today's technology.

Guiding Question III

How do the laws, properties, and applications of electricity govern the use and development of technology.

Course Level Expectations

CLE 3220.3.1	Investigate fundamental electrical quantities of force.
CLE 3220.3.2	Investigate fundamental electrical quantities of work and power.
CLE 3220.3.3	Investigate fundamental electrical quantities of rate.
CLE 3220.3.4	Investigate fundamental electrical quantities of resistance.
CLE 3220.3.5	Investigate fundamental electrical quantities of energy.
CLE 3220.3.6	Investigate fundamental electrical quantities of force transformers.

Checks for Understanding (Formative/Summative Assessment)

3220.3.1.a	Explain the two types of electricity (direct and alternating current).
b	Identify the components of the circuit.

c	Investigate circuit schematics.
d	Sketch an electrical schematic for series and parallel circuits.
e	Construct a series and a parallel circuit and measure voltages.
f	Use a multimeter (digital and analog) to measure voltage.
g	Explain how electrical forces create voltage.
3220.3.2.a	Calculate work in electrical systems, given voltage and charge, using appropriate units.
b	Measure current in the circuit using a multimeter.
c	Set up a multimeter to measure current.
d	Construct a circuit, with proper meter placement, to measure current and voltage.
e	Define joule as a unit of measurement.
f	Calculate efficiency, using input electrical work and output mechanical work.
g	Define the mechanical and electrical work involved in the operation of a solenoid.
h	Define power in an electrical system as electrical work divided by time.
i	Measure power in an electrical system using proper units.
3220.3.3.a	Describe charge flow rate (I) as a quantity of charge moved (Q) per unit of time (t) or I=Q/t.
b	Distinguish between frequency and period.
c	Calculate frequency and period using measurements read from the oscilloscope.
3220.3.4.a	Describe resistance in electrical systems.
b	Explain the differences among conductors, insulators, and semi-conductors, based on the material's resistivities.
c	Compare the accuracy of resistance by color code to actual readings made with a digital multimeter.
d	Use Ohm's law to calculate the resistance in a circuit.
e	Show how resistance in a wire depends on (1) length of the wire, (2) cross-sectional area of the wire, and (3) material of which the wire is made.
f	Measure resistance in electrical systems and calculate in appropriate units.
g	Calculate resistance in both series and parallel circuits, using appropriate formulas.
3220.3.5.a	Describe the nature and storage of electrical potential energy in a capacitor and a conductor.
b	Describe how a capacitor and a inductor work.
c	Measure the energy needed to charge a capacitor and the energy released upon discharge, using a multimeter.
d	Discuss the relationship between work and electrical energy.
3220.3.6.a	Demonstrate how a voltage transformer is used to step up or step down voltage.
b	Explain the relationship between voltage in, voltage out, and number of wire windings in a voltage transformer.
c	Find the mechanical advantage of a voltage transformer.
d	Calculate the operating efficiency of a voltage transformer.

Standard IV – Thermal

Conceptual Strand IV

Understanding the laws of thermal energy is essential to understanding modern technology.

Guiding Question IV

How are the laws of thermal energy essential to understanding modern technology?

Course Level Expectations

CLE 3220.4.1		Investigate fundamental thermal quantities of force.
CLE 3220.4.2		Investigate fundamental thermal quantities of power.
CLE 3220.4.3		Investigate fundamental thermal quantities of rate.
CLE 3220.4.4		Investigate fundamental thermal quantities of resistance.
CLE 3220.4.5		Investigate fundamental thermal quantities of energy.
CLE 3220.4.1	a	Identify the direction of movement of heat energy in a thermal system when temperature information is known.
	b	Name and describe the force-like quantity in a thermal system.
	c	Differentiate between the Fahrenheit and Celsius scales.
	d	Measure temperature with devices (thermometers, thermocouples) and convert between the Fahrenheit and Celsius scales.
CLE 3220.4.2	a	Define power in a thermal system as energy divided by time.
CLE 3220.4.3	a	Calculate heat-flow rate Q_H as heat energy (H) moved per unit time (t), using appropriate units.
	b	Define specific heat capacity.
	c	Explain the difference between sensible heat and latent heat as it relates to change of state.
	d	Measure specific heat of different metals.
CLE 3220.4.4	a	Describe resistance in a thermal system
	b	Define thermal conductivity (k) as a measure of certain materials' ability to conduct heat.
	c	Explain the relationship between resistance, temperature difference, and heat flow.
CLE 3220.4.5	a	Describe the relationship between thermal energy and work.
	b	Describe and calculate the mechanical equivalent of heat.
	c	Discuss the three ways that heat energy is transferred.
	d	Describe the role heat energy in the law of conservation.

Tennessee Science Curriculum Framework

Principles of Technology II

Course Description

Principles of Technology II is a laboratory science course that deals with the relationship between matter and energy and how they interact. This course will have a strong emphasis in the application of physics in technology. Completion of Principles of Technology I and II is equivalent to a credit in physics.

Principles of Technology II students will study:

- Momentum
- Waves and Vibrations
- Energy Convertors
- Transducers
- Radiation
- Light and Optical Systems
- Time Constants

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

CLE 3256.Inq.1 Recognize that science and technology are progressive endeavors that reevaluate and extend what is already accepted.

CLE 3256.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 3256.Inq.3 Use appropriate tools and technology to collect precise and accurate data.

CLE 3256.Inq.4 Apply qualitative and quantitative measures to analyze data and draw conclusions that are free of bias.

CLE 3256.Inq.5 Compare experimental evidence and conclusions with those drawn by others about the same testable question.

CLE 3256.Inq.6 Communicate and defend scientific findings.

Checks for Understanding (Formative/Summative Assessment)

- ✓**3256.Inq.1** Conduct scientific investigations that include testable questions, verifiable hypotheses, and appropriate variables to explore new phenomena or verify the experimental results of others.
- ✓**3256.Inq.2** Select appropriate independent, dependent, or controlled variables for an experiment.
- ✓**3256.Inq.3** Analyze the components of a properly designed scientific investigation.
- ✓**3256.Inq.4** Perform an experiment to test a prediction.
- ✓**3256.Inq.5** Select appropriate tools and technology to collect precise and accurate quantitative and qualitative data.
- ✓**3256.Inq.6** Determine if data supports or contradicts a hypothesis or conclusion.
- ✓**3256.Inq.7** Recognize, analyze, and evaluate alternative explanations for the same set of observations.
- ✓**3256.Inq.8** Evaluate the accuracy and precision of data.
- ✓**3256.Inq.9** State a conclusion in terms of the relationship between two or more variables.
- ✓**3256.Inq.10** Defend a conclusion based on scientific evidence.
- ✓**3256.Inq.11** Analyze experimental results and identify possible sources of bias or experimental error.
- ✓**3256.Inq.12** Compare the results of an experiment with what is already known about the topic under investigation.
- ✓**3256.Inq.13** Suggest alternative explanations for the same set of observations.
- ✓**3256.Inq.14** Formulate and revise models using logic and evidence.
- ✓**3256.Inq.15** Compare conclusions that offer different, but acceptable explanations for the same set of experimental data.

Embedded Mathematics

Conceptual Strand

Investigating physics principles is accomplished by applying mathematical rules.

Guiding Question

What skills and understandings of mathematics are needed to investigate physics?

Course Level Expectations

CLE.3256 Math.1 Graph relationships and functions between manipulated (independent) variables and responding (dependent) variables.
CLE.3256 Math.2 Solve for variables in an algebraic formula.
CLE.3256 Math.3 Apply statistical techniques to manipulate data.
CLE.3256 Math.4 Investigate trigonometric connections to physics.

Checks for Understanding (Formative/Summative Assessment)

- ✓**3256.Math.1** Plot points on the Cartesian coordinate graphing system.
- ✓**3256.Math.2** Graph basic relations and functions.
- ✓**3256.Math.3** Determine the slope of a linear function.

✓**3256.Math.4** Determine the frequency, range, mode, median, and mean from a list of data.
✓**3256.Math.5** Utilize a graphing calculator or a computer program to enter data and find basic statistics: frequency, range, means, mode, median, and standard deviation.
✓**3256.Math.6** Solve for all variables based on a formula.
✓**3256.Math.7** Utilize trigonometric functions (sine, cosine, and tangent) to solve simple vector problems.
✓**3256.Math.8** Apply the laws of sine and cosine to solve vector problems.
✓**3256.Math.9** Solve mechanics problems using the quadratic formula.
✓**3256.Math.10** Solve mechanics problems using radians, degrees and revolutions.

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 3256.T/E.1 Explore the impact of technology on social, political, and economic systems.
CLE 3256.T/E.2 Differentiate among elements of the engineering design cycle: design constraints, model building, testing, evaluating, modifying, and retesting.
CLE 3256.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 3256.T/E.4 Describe the dynamic interplay among science, technology, and engineering within living, earth-space, and physical systems.
CLE 3256.T/E.5 Comply with all local, state, and federal safety regulations.

Checks for Understanding (Formative/Summative Assessment)

✓**3256.T/E.1** Distinguish among tools and procedures best suited to conduct a specified scientific inquiry.
✓**3256.T/E.2** Apply the engineering design process to construct a prototype that meets developmentally appropriate specifications.
✓**3256.T/E.3** Evaluate a protocol to determine the degree to which an engineering design process was successfully applied.
✓**3256.T/E.4** Explore how the unintended consequences of new technologies can impact human and non-human communities.
✓**3256.T/E.5** Evaluate the overall benefit to cost ratio of a new technology.
✓**3256.T/E.6** Present research on current bioengineering technologies that advance health and contribute to improvements in our daily lives.

✓**3256.T/E.7** Design a series of multi-view drawings that can be used by other students to construct an adaptive design and test its effectiveness.
✓**3256.T/E.8** Apply industry standard measurements and identifiers.

Standard 1 – Momentum

Conceptual Strand 1

Laws of momentum are the foundations of the motions of objects.

Guiding Question 1

How do the laws and properties of momentum govern the basic understanding of motion?

Course Level Expectations

CLE 3256.1.1 Describe linear momentum and its relationship to mass and velocity.
CLE 3256.1.2 Describe angular momentum and its relationship to moment of inertia and angular velocity.
CLE 3256.1.3 Describe impulse.
CLE 3256.1.4 State the law of conservation of momentum as it affects linear or angular motion.
CLE 3256.1.5 Describe the relationship of impulse to change in momentum.

Checks for Understanding (Formative/Summative Assessment)

✓**3256.1.1a** Define linear momentum.
b Identify appropriate English and SI units for linear momentum.
. c Calculate the linear momentum of an object.
d Apply momentum equations to the movement of objects and fluids.
✓**3256.1.2a** Define angular momentum.
b Identify appropriate English and SI units for angular momentum.
c Calculate angular momentum of an object.
d Apply momentum equations to the rotation of objects.
✓**3256.1.3a** Define linear impulse.
b Define angular impulse.
✓**3256.1.4a** Describe the conservation of linear momentum in isolated systems.
b Identify workplace applications where technicians measure or control linear and angular momentum.
✓**3256.1.5a** Explain how the linear impulse ($F\Delta t$) is related to a change in the linear momentum $\Delta(mv)$.
b Solve a problem that involves conservation of linear momentum.
c Explain how angular impulse relates to a change in angular momentum.
d Solve a problems that involves conservation of angular momentum.

Standard 2 – Waves and Vibrations

Conceptual Strand 2

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

Guiding Question 2

How do the laws of wave motion relate to understanding the use of waves as a form of energy?

Course Level Expectations

CLE 3256.2.1 Describe wave motion in general.
CLE 3256.2.2 Describe how waves transmit (move) energy.
CLE 3256.2.3 List the characteristics that are used to describe a wave.
CLE 3256.2.4 Distinguish between longitudinal and transverse waves.
CLE 3256.2.5 Measure wave characteristics.

Checks for Understanding (Formative/Summative Assessment)

- ✓**3256.2.1a** Describe a harmonic wave (sine wave).
  - b Identify examples of wave interference.
  - c Define natural frequency of an object.
  - d Define resonance.
- ✓**3256.2.2a** Define wave speed for a traveling harmonic wave.
  - b State what is meant by the phase difference between two harmonic waves.
  - c Describe what is meant by interference of waves.
  - d Describe what is meant by superposition of waves..
  - e Distinguish between constructive and destructive interference.
  - f Research for examples of wave resonance.
  - g Identify workplace applications where technicians measure and control waves and vibrations.
- ✓**3256.2.3a** Define and experiment with wavelength of a harmonic wave.
  - b Define and experiment with frequency of a harmonic wave.
  - c Define and experiment with period of a harmonic wave.
  - d Define and experiment with amplitude of a harmonic wave.
  - e Define the phase of a harmonic wave.
  - f Solve problems that involve wave characteristics.
  - e Describe what is meant by a standing wave.
- ✓**3256.2.4a** Distinguish between the characteristics of a wave.
  - b Define the frequency of a harmonic wave.
  - c Classify waves as longitudinal or transverse.
- ✓**3256.2.5a** Measure the characteristics of a wave.
  - b Calculate natural frequency and period of oscillation of several vibrating systems.
  - c Use a transducer to measure the vibrations of a vibrating structure.
  - d Use a dual trace oscilloscope to compare the output from two vibration transducers.

Standard 3 – Energy Converters

Conceptual Strand 3

Understanding how energy is converted from one form to another is essential to design and operation of machines in technology.

Guiding Question 3

How do energy converting devices function?

Course Level Expectations

CLE 3256.3.1 Describe the purpose of an energy convertor.
CLE 3256.3.2 Identify mechanical energy convertors.
CLE 3256.3.3 Identify and investigate fluid energy convertors.
CLE 3256.3.4 Identify and investigate electrical energy convertors.
CLE 3256.3.5 Identify and investigate thermal energy convertors.
CLE 3256.3.6 Describe energy convertors and calculate their efficiency.

Checks for Understanding (Formative/Summative Assessment)

✓**3256.3.1a** Experiment with a mechanical energy convertor.
b Experiment with a fluid energy convertor.
c Experiment with an electrical energy convertor.
d Experiment with a thermal energy convertor.

✓**3256.3.2a** Convert mechanical energy to fluid energy with a pump and explain the process.
b Explain how a fan changes mechanical energy to fluid energy.
c Explain and demonstrate how an alternator converts mechanical energy to electrical energy.
d Investigate how a friction (inertia) welder changes mechanical energy to thermal energy.
e Identify workplace applications where technicians use and control mechanical energy convertors.

✓**3256.3.3a** Describe how a windmill converts fluid energy to mechanical energy.
b Explain how a turbine changes fluid energy to mechanical energy.
c Describe a process that converts fluid energy to electrical energy.
d Research and explain how an air conditioner uses fluids to remove thermal energy.
e Identify workplace applications where technicians use and control fluid energy convertors.

✓**3256.3.4a** Explain how an electric motor converts electrical energy to mechanical energy.
b Describe and investigate how a solenoid changes electrical energy to mechanical energy.
c Investigate how a high-resistance conducting wire converts electrical energy to thermal energy.
d Identify workplace applications where technicians use and control electrical energy convertors.

✓**3256.3.5a** Explain and demonstrate how a bimetallic strip changes thermal energy to mechanical energy.
b Convert thermal energy to fluid energy with a combustion engine and describe the process.
c Explain how a thermopile changes thermal energy to electrical energy.
d Identify workplace applications where technicians use and control thermal energy convertors.
✓**3256.3.6a** Determine the efficiency of a convertor that has mechanical input energy.
b Calculate the efficiency of a converter that has fluid input energy.
c Calculate the efficiency of a converter that has electrical input energy.
d Calculate the efficiency of a converter that has thermal input energy.

Standard 4 – Transducers

Conceptual Strand 4

Transducers sense the conditions of energy systems, helping monitor and maintain the safe operation of these systems.

Guiding Question 4

How is the safe operation of energy systems affected by transducers.

Course Level Expectations

CLE 3256.4.1 Define a transducer as a device that senses mechanical, fluid, electrical or thermal information.
CLE 3256.4.2 Describe the action of a transducer in general terms.
CLE 3256.4.3 Distinguish between an energy convertor and a transducer.
CLE 3256.4.4 Identify transducers that change mechanical signals into electrical signals and demonstrate the process.
CLE 3256.4.5 Identify transducers that change fluid signals into mechanical or electrical signals and investigate the process.
CLE 3256.4.6 Identify transducers that change electrical signals into mechanical or thermal information and investigate the process.
CLE 3256.4.7 Identify transducers that change thermal signals into mechanical, fluid, or electrical information and investigate the process.

Checks for Understanding (Formative/Summative Assessment)

✓**3256.4.1a** Explain what a mechanical transducer does.
b Explain what a fluid transducer does.
c Explain what an electrical transducer does.
d Explain what a thermal transducer does.
✓**3256.4.2a** Identify workplace applications where technicians use transducers.
✓**3256.4.3a** Solve problems that involve mechanical transducers.
b Solve problems that involve fluid transducers.
c Solve problems that involve electrical transducers.
d Solve problems that involve thermal transducers.

✓3256.4.4a Describe how a strain gage translates a mechanical input signal into an electrical output signal.
b Explain and demonstrate the piezoelectric effect.
c Explain how an accelerometer translates a mechanical input signal into an electrical output signal.
✓3256.4.5a Demonstrate how a bourdon gage changes a pressure input signal into a mechanical output signal.
b Compare pressure measurements made with a compound pressure gage to measurements made with a manometer.
c Investigate how a barometer changes a pressure input signal into a mechanical output signal.
d Describe how a flowmeter changes a fluid rate into an electrical signal.
e Explain how an anemometer changes a wind speed into an electrical signal.
✓3256.4.6a Describe how a moving coil transducer changes an electrical input into a mechanical output signal.
b Demonstrate how a meter reading depends on the interaction between a stationary magnetic field and the magnetic field created when current flows through the moving coil.
c Investigate why an ammeter has a low-resistance shunt connected in parallel with the transducer circuit and measure the resistance.
d Investigate why a voltmeter has a high-resistance resistor connected in series with the transducer circuit and measure the resistance.
e Calibrate the scale of a voltmeter.
f Describe how an electrostrictive transducer changes an electrical signal into a mechanical signal.
g Demonstrate what a photoconductive transducer does.
h Discuss the two types of transducers used in sonar systems.
✓3256.4.7a Demonstrate how a bimetallic strip changes a thermal input signal to a mechanical output signal.
b Describe how a thermograph changes a thermal input signal into recorded output information.
c Demonstrate how a thermocouple translates a thermal input signal to an electrical output signal.
d Explain how a thermistor changes a thermal input signal to an electrical output signal.

Standard 5 – Radiation

Conceptual Strand 5

Understanding electricity and magnetism is explained by the physics of electrons and magnets.

Guiding Question 5

How do the properties of electricity and magnetism relate to the physics of electrons and magnets?

Course Level Expectations

CLE 3256.5.1 Describe what is meant by electromagnetic radiation.

CLE 3256.5.2 Describe what is meant by nuclear radiation.

CLE 3256.5.3 Identify workplace applications where technicians measure or control radiation.

Checks for Understanding (Formative/Summative Assessment)

✓**3256.5.1a** Identify electromagnetic (EM) spectrum divisions, comparing their ranges of wavelength and frequency values.

b Identify four characteristics of EM radiation (wavelength, speed, frequency, and energy).

c Describe the speed of EM radiation in terms of wave frequency (f) and wavelength (λ).

d Investigate the characteristics of a photon, explaining how its energy depends on its wavelength or frequency.

e Solve problems for speed (v) and energy (E) of EM radiation by using the formulas: $v = \lambda t$; and $E=hf$, or $E=hc/\lambda$.

f Describe the wavelength limits, frequency limits and color content of the visible EM spectrum.

✓**3256.5.2a** Define nuclear decay.

b Identify three main components of nuclear radiation.

c Describe alpha particles, beta particles and gamma rays by giving their approximate mass and electrical charge and identify their symbols.

d Compare the relative hazards of alphas, betas and gammas by identifying materials that stop them.

e Define element, isotope, nuclide, atomic number, and mass number.

f Explain the meaning of symbols used to identify different nuclides.

g Differentiate between fission and fusion.

h Use Einstein's equation, $E = mc^2$, to change atomic mass to energy.

i Demonstrate how radiation energy follows the inverse square law.

j Detect nuclear radiation using appropriate instruments.

✓**3256.5.3a** Identify workplace applications where technicians measure and control EM radiation.

b Identify workplace applications where technicians work with nuclear radiation.

c Describe safety procedures that technicians must follow when working with nuclear radiation.

Standard 6 – Light and Optical Systems

Conceptual Strand 6

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

Guiding Question 6

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

Course Level Expectations

CLE 3256.6.1 Describe how light can be represented by light rays.
CLE 3256.6.2 Describe how light can be represented by waves.
CLE 3256.6.3 Identify the special characteristics of laser light.
CLE 3256.6.4 Identify several optical systems that process light.
CLE 3256.6.5 Identify workplace applications where technicians measure and control light.

Checks for Understanding (Formative/Summative Assessment)

- ✓**3256.6.1a** Explain and demonstrate the reflection of light.
  - **b** Use light ray diagrams in a drawing to show how light is reflected from plane (flat) mirrors.
  - **c** Use light ray diagrams in a drawing to show how light is reflected from spherical mirrors.
  - **d** Explain what is meant by the curvature and focal length of a mirror.
  - **e** Use light ray diagrams to show how light rays are reflected by a mirror.
  - **f** Discuss refraction of light and demonstrate the bending of the path of a light ray..
  - **g** Given a drawing of refracted light, calculate the index of refraction using Snell's law.
  - **h** Use light ray diagrams in a drawing to show how lenses bend and focus light.
  - **i** Determine the focal length of a lens.
  - **j** Use light ray diagrams to show how light is refracted through a lens.
  - **k** Distinguish between convex and concave lenses.
  - **l** Sketch examples of convex and concave lenses..
  - **m** Identify workplace applications where technicians use ray optics
- ✓**3256.6.2 a** Distinguish between constructive and destructive interference.
  - **b** Describe what is meant by interference fringes.
- ✓**3256.6.3 a** Explain what is meant by collimated light.
  - **b** Explain how light spreads as it travels.
  - **c** Identify the three main components of a laser and investigate their functions.
  - **d** Identify three main types of lasers.
  - **e** Investigate characteristics of laser light.
  - **f** Describe what is meant by coherent light.
  - **g** Calculate radiant power and power density.
  - **h** Explain how lasers can produce extremely high power densities on targets.
- ✓**3256.6.4 a** Explain diffraction.
  - **b** Use a light ray diagram to demonstrate how light diffracts.
  - **c** Explain diffraction grating.
  - **d** Investigate a grating spectrometer.
  - **e** Describe how the human eye forms an image of light.

f Investigate abnormalities (nearsightedness, farsightedness, astigmatism) and identify the appropriate corrective lenses.
g Describe how a camera forms an image on film.

✓**3256.6.5 a** Identify workplace applications where technicians use ray optics.
b Identify workplace applications where technicians use interference of light.
c Identify workplace applications where technicians use diffraction of light.
d Identify workplace applications where technicians use lasers.

Standard 7 – Time Constants

Conceptual Strand 7

Time constant describes how quickly nonlinear processes change.

Guiding Question 7

How would time constants be used describe nonlinear motion?

Course Level Expectations

CLE 3256.7.1 Distinguish between uniform change and nonuniform change..
CLE 3256.7.2 Identify systems where time constants are needed to describe system behaviour.
CLE 3256.7.3 Define three time constants (labeled $T_{1/2}$, T_{90} and τ).
CLE 3256.7.4 Identify workplace applications where technicians measure and control time constants.

Checks for Understanding (Formative/Summative Assessment)

✓**3256.7.1a** Draw a curve that shows a linear increase or decrease of a variable with time.
b Draw a curve that shows an exponential increase or decrease of a variable with time.

✓**3256.7.2** Explain why it is important to know the time constant of a thermocouple.

✓**3256.7.3a** Given the equation that describes how fast a vibration is slowing down (damped oscillation), identify the time constant and predict when the vibration is about 99% damped out.
b Given the equation that describes how fast a tank is emptied, identify the time constant and predict when the tank will be about 99% empty.
c Given the equation that describes the charging of a capacitor, identify the 1/e time constant and predict when the capacitor will be charged.
d Given the equation that describes the charging of a capacitor, identify the 1/e time constant and predict when the capacitor will be discharged.
e Draw a curve that represents the cooling rate of an isolated container of hot liquid located in a room at some cooler temperature (T).

✓**3256.7.4** Identify workplace applications in electrical and thermal systems where technicians measure or control time constants.

Tennessee Science Curriculum Framework

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Inquiry

Embedded Conceptual Strand - Inquiry

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

Guiding Question - Inquiry

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

Embedded Inquiry

Conceptual Strand

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Guiding Question

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

Course Level Expectations

CLE 3258.Inq.1 Recognize that science is a progressive endeavor that reevaluates and extends what is already accepted.

CLE 3258.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 3258.Inq.3 Use appropriate tools and technology to collect precise and accurate data.

CLE 3258.Inq.4 Apply qualitative and quantitative measures to analyze data and draw conclusions that are free of bias.

CLE 3258.Inq.5 Compare experimental evidence and conclusions with those drawn by others about the same testable question.

CLE 3258.Inq.6 Communicate and defend scientific findings.

Checks for Understanding (Formative/Summative Assessment)

✓**3258.Inq.1** Trace the historical development of a scientific principle or theory, such as cell theory, evolution, or DNA structure.

✓**3258.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.

✓**3258.Inq.3** Select appropriate tools and technology to collect precise and accurate quantitative and qualitative data.

✓**3258.Inq.4** Determine if data supports or contradicts a hypothesis or conclusion.

✓**3258.Inq.5** Compare or combine experimental evidence from two or more investigations

✓**3258.Inq.6** Recognize, analyze, and evaluate alternative explanations for the same set of observations.

✓**3258.Inq.7** Analyze experimental results and identify possible sources of experimental error.

✓**3258.Inq.8** Formulate and revise scientific explanations and models using logic and evidence.

✓**3258.Inq.9** Relate inquiry methods to problems encountered in a variety of careers.

State Performance Indicators

SPI 3258 Inq.1 Select a description or scenario that reevaluates and/or extends a scientific finding.

SPI 3258 Inq.2 Analyze the components of a properly designed scientific investigation.

SPI 3258 Inq.3 Determine appropriate tools to gather precise and accurate data.

SPI 3258 Inq.4 Evaluate the accuracy and precision of data.

SPI 3258 Inq.5 Defend a conclusion based on scientific evidence.

SPI 3258 Inq.6 Determine why a conclusion is free of bias.

SPI 3258 Inq.7 Compare conclusions that offer different, but acceptable explanations for the same set of experimental data.

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 3258.T/E.1 Explore the impact of technology on social, political, and economic systems.

CLE 3258.T/E.2 Differentiate among elements of the engineering design cycle: design constraints, model building, testing, evaluating, modifying, and retesting.

CLE 3258.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 3258.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)

✓**3258. T/E.1** Select appropriate tools to conduct a scientific inquiry.

✓**3258. T/E.2** Apply the engineering design process to construct a prototype that meets developmentally appropriate specifications.

✓**3258. T/E.3** Explore how the unintended consequences of new technologies can impact human and non-human communities.

✓**3258. T/E.4** Present research on current bioengineering technologies that advance health and contribute to improvements in our daily lives.

✓**3258. 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.

State Performance Indicators

SPI 3258.T/E.1 Distinguish among tools and procedures best suited to conduct a specified scientific inquiry.

SPI 3258.T/E.2 Evaluate a protocol to determine the degree to which an engineering design process was successfully applied.

SPI 3258.T/E.3 Evaluate the overall benefit to cost ratio of a new technology.

SPI 3258.T/E.4 Assess the principles that determine if a new technology will improve the quality of life for an intended audience.

Standard 1 – Cells

Conceptual Strand 1

All living things are made of cells that perform functions necessary for life.

Guiding Question 1

How are cells organized to carry on the processes of life?

Course Level Expectations

CLE 3258.1.1 Compare the structure and function of cellular organelles in both prokaryotic and eukaryotic cells.
CLE 3258.1.2 Distinguish among the structure and function of the four major organic macromolecules found in living things.
CLE 3258.1.3 Describe how enzymes regulate chemical reactions in the body.
CLE 3258.1.4 Describe the processes of cell growth and reproduction.
CLE 3258.1.5 Compare different models used to explain the movement of materials into and out of cells.

Check for Understanding (Formative/Summative Assessment)

✓**3258.1.1** Investigate cells using a compound microscope.
✓**3258.1.2** Construct a model of a prokaryotic or eukaryotic cell.
✓**3258.1.3** Design and conduct an experiment to investigate the effect of various solute concentrations on water movement in cells.
✓**3258.1.4** Design a graphic organizer that compares the structure and function of proteins, carbohydrates, lipids, and nucleic acids.
✓**3258.1.5** Conduct tests to detect the presence of proteins, carbohydrates, and lipids.
✓**3258.1.6** Analyze experimental data to distinguish between active and passive transport.
✓**3258.1.7** Model the movement of chromosomes during mitosis in plant and animal cells.
✓**3258.1.8** Use food labels to investigate the dietary value of various food items in relation to lipids, carbohydrates, and proteins.

State Performance Indicators

SPI 3258.1.1 Identify the cellular organelles associated with major cell processes.
SPI 3258.1.2 Distinguish between prokaryotic and eukaryotic cells.
SPI 3258.1.3 Distinguish among proteins, carbohydrates, lipids, and nucleic acids.
SPI 3258.1.4 Identify a positive test for carbohydrates, lipids, and proteins.
SPI 3258.1.5 Identify how enzymes control chemical reactions in the body.
SPI 3258.1.6 Determine the relationship between cell growth and cell reproduction.
SPI 3258.1.7 Predict the movement of water and other molecules across selectively permeable membranes.
SPI 3258.1.8 Compare and contrast active and passive transport.

Standard 2 – Interdependence

Conceptual Strand 2

All life is interdependent and interacts with the environment.

Guiding Question 2

How do living things interact with one another and with the non-living elements of their environment?

Course Level Expectations

CLE 3258.2.1 Investigate how the dynamic equilibrium of an ecological community is associated with interactions among its organisms.
CLE 3258.2.2 Analyze and interpret population data, graphs, or diagrams.
CLE 3258.2.3 Predict how climate change, human activity, geologic events, and the introduction of non-native species impact an ecosystem.
CLE 3258.2.4 Describe the events associated with biological succession.

Check for Understanding (Formative/Summative Assessment)

✓**3258.2.1** Analyze human population graphs to predict the impact on global resources, and economic and social factors.
✓**3258.2.2** Construct and maintain a model of an ecosystem. Include a food web to show relatedness, interdependency, and relation to extinction.

✓**3258.2.3** Monitor and evaluate changes in a yeast population.
✓**3258.2.4** Use an outdoor habitat to identify the abiotic and biotic factors, plant and animal populations, producers, consumers, and decomposers.
✓**3258.2.5** Conduct research on how human influences have changed an ecosystem; communicate findings through written or oral presentations.
✓**3258.2.6** Describe a sequence of events that illustrates biological succession.
✓**3258.2.7** Select a local environmental issue and role-play officials, workers, citizens, and special interest groups.
✓**3258.2.8** Interview an environmental agent to determine local issues of interdependence.

State Performance Indicators

SPI 3258.2.1 Predict how population changes of organisms at different trophic levels affect an ecosystem.
SPI 3258.2.2 Interpret the relationship between environmental factors and fluctuations in population size.
SPI 3258.2.3 Determine how the carrying capacity of an ecosystem is affected by interactions among organisms.
SPI 3258.2.4 Predict how various types of human activities affect the environment.
SPI 3258.2.5 Make inferences about how a specific environmental change affects biodiversity.
SPI 3258.2.6 Predict how an environmental change may lead to the extinction of a species.
SPI 3258.2.7 Analyze factors responsible for biological succession.

Standard 3 – Matter and Energy

Conceptual Strand 3

Matter cycles and energy flows through the biosphere.

Guiding Question 3

What are the scientific explanations for how matter cycles and energy flows through the biosphere?

Course Level Expectations

CLE 3258.3.1 Analyze energy flow through an ecosystem..
CLE 3258.3.2 Investigate the relationship between the processes of photosynthesis and aerobic cellular respiration.
CLE 3258.3.3 Investigate various types of respiration.
CLE 3258.3.4 Describe the events which occur during the major biogeochemical cycles.

Check for Understanding (Formative/Summative Assessment)

✓**3258.3.1** Track energy flow through an ecosystem.
✓**3258.3.2** Conduct an experiment to investigate photosynthesis and cellular respiration.
✓**3258.3.3** Construct concept maps to explain the processes of photosynthesis and cellular respiration.
✓**3258.3.4** Investigate the importance of industrial applications of fermentation.
✓**3258.3.5** Construct models of the carbon, oxygen, nitrogen, phosphorous, and water cycles.
✓**3258.3.6** Keep a food diary for one week and analyze energy consumption and use.
✓**3258.3.7** Develop a week-long cafeteria menu based on recommended dietary intake.

State Performance Indicators

SPI 3258.3.1 Interpret a diagram that illustrates energy transformations in an ecosystem.
SPI 3258.3.2 Compare and contrast photosynthesis and cellular respiration in terms of energy transformation.
SPI 3258.3.3 Distinguish between aerobic and anaerobic respiration.
SPI 3258.3.4 Predict how changes in a biogeochemical cycle can affect an ecosystem.

Standard 4 – Heredity

Conceptual Strand 4

Organisms reproduce and transmit hereditary information.

Guiding Question 4

What are the principal mechanisms by which living things reproduce and transmit hereditary information from parents to offspring?

Course Level Expectations

CLE 3258.4.1 Investigate how genetic information is encoded in nucleic acids.

CLE 3258.4.2 Describe the relationships among genes, chromosomes, proteins, and hereditary traits.

CLE 3258.4.3 Compare different patterns of inheritance (i.e., simple dominance, sex linkage, co-dominance, incomplete dominance, multiple alleles, and polygenic traits).

CLE 3258.4.4 Recognize how meiosis and sexual reproduction contribute to genetic variation in a population.

CLE 3258.4.5. Describe the role of mutations in human genetic disorders.

CLE 3258.4.6 Assess the scientific and ethical ramifications of emerging genetic technologies (e.g., recombinant DNA, cloning, transgenic organisms, stem cells, and DNA fingerprinting.)

Check for Understanding (Formative/Summative Assessment)

✓**3258.4.1** Use models of DNA, RNA, and amino acids to explain replication and protein synthesis.

✓**3258.4.2** Complete and interpret genetics problems that illustrate simple dominance, sex linkage, co-dominance, incomplete dominance, multiple alleles, and polygenic traits.

✓**3258.4.3** Apply data to complete and interpret a genetic pedigree.

✓**3258.4.4** Describe how the process of meiosis affects the number of chromosomes in a gamete.

✓**3258.4.5** Associate gene mutation with changes in the DNA molecule.

✓**3258.4.6** Design an informational brochure to describe a human genetic disorder.

✓**3258.4.7** Conduct research to explore the scientific and ethical issues surrounding emerging DNA technologies.

✓**3258.4.8** Research careers that relate to genetics and inheritance, such as lab technician, forensic pathologist, livestock breeder, genetic counselor, medical doctor, and role-play discussion of a genetic issue by that professional.

State Performance Indicators

SPI 3258.4.1 Identify the structure and function of DNA.

SPI 3258.4.2 Associate the process of DNA replication with its biological significance.

SPI 3258.4.3 Recognize the interactions between DNA and RNA during protein synthesis.

SPI 3258.4.4. Determine the probability of a particular trait in an offspring, given the genotype of the parents and the mode of inheritance.

SPI 3258.4.5 Apply pedigree data to interpret various modes of genetic inheritance.

SPI 3258.4.6 Describe how meiosis is involved in the production of egg and sperm cells.

SPI 3258.4.7 Describe how meiosis and sexual reproduction contribute to the amount of genetic variation in a population

SPI 3258.4.8 Determine the relationship between mutations and human genetic disorders.

SPI 3258.4.9 Evaluate the scientific and ethical issues associated with genetic technologies.

Standard 5 – Biodiversity and Change

Conceptual Strand 5

A rich variety and complexity of organisms have developed in response to changes in the environment.

Guiding Question 5

How does natural selection explain how organisms have changed over time?

Course Level Expectations

CLE 3258.5.1 Associate structural, functional, and behavioral adaptations with the ability of organisms to survive under various environmental conditions.
CLE 3258.5.2 Analyze the relationship between form and function in living things.
CLE 3258.5.3 Explain how genetic variation and changing environmental conditions can result in adaptation of populations and the emergence of new species.
CLE 3258.5.4 Summarize the supporting evidence for the theory of evolution.
CLE 3258.5.5 Explain how evolution contributes to the amount of biodiversity.
CLE 3258.5.6 Explore the evolutionary basis of modern classification systems.

Check for Understanding (Formative/Summative Assessment)

✓**3258.5.1** Create graphic organizers to demonstrate the relationship between form and function in representative organisms.
✓**3258.5.2** Predict the types of plants and animals indigenous to a biome by determining the characteristics of that biome.
✓**3258.5.3** Demonstrate how natural selection in response to a changing environment may exhibit new characteristics and may form a new species.
✓**3258.5.4** Investigate causes and consequences of antibiotic resistance.
✓**3258.5.5** Associate fossil data with biological and geological changes in the environment.
✓**3258.5.6** Analyze a variety of models, samples, or diagrams to demonstrate the genetic relatedness of organisms.
✓**3258.5.7** Use a dichotomous key to identify an unknown organism.
✓**3258.5.8** Investigate an organism that has or may become extinct and examine the impact of humans on the species.
✓**3258.5.9** Design a scale model of a time line showing emergence and extinction of various life forms on earth.

State Performance Indicators

SPI 3258.5.1 Compare and contrast the structural, functional, and behavioral adaptations of animals or plants found in different environments.
SPI 3258.5.2 Recognize the relationship between form and function in living things.
SPI 3258.5.3 Recognize the relationships among environmental change, natural selection, and the emergence of a new species.
SPI 3258.5.4 Determine how the amount of biodiversity and the ability of a population to adapt to a changing environment are related.
SPI 3258.5.5 Apply evidence from the fossil record, comparative anatomy, DNA, and protein sequences to support modern classification systems.

SPI 3258.5.6 Infer relatedness among different organisms using modern classification systems.

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Standard 1 – Cells

Conceptual Strand 1

All living things are made of cells that perform functions necessary for life.

Guiding Question 1

How are cells organized to carry on the processes of life?

Course Level Expectations

CLE 3258.1.1 Compare the structure and function of cellular organelles in both prokaryotic and eukaryotic cells.
CLE 3258.1.2 Distinguish among the structure and function of the four major organic macromolecules found in living things.
CLE 3258.1.3 Describe how enzymes regulate chemical reactions in the body.
CLE 3258.1.4 Describe the processes of cell growth and reproduction**.**
CLE 3258.1.5 Compare different models used to explain the movement of materials into and out of cells.

Check for Understanding (Formative/Summative Assessment)

✓**3258.1.1** Investigate cells using a compound microscope.
✓**3258.1.2** Construct a model of a prokaryotic or eukaryotic cell.
✓**3258.1.3** Design and conduct an experiment to investigate the effect of various solute concentrations on water movement in cells.
✓**3258.1.4** Design a graphic organizer that compares the structure and function of proteins, carbohydrates, lipids, and nucleic acids.
✓**3258.1.5** Conduct tests to detect the presence of proteins, carbohydrates, and lipids.
✓**3258.1.6** Analyze experimental data to distinguish between active and passive transport.
✓**3258.1.7** Model the movement of chromosomes during mitosis in plant and animal cells.
✓**3258.1.8** Use food labels to investigate the dietary value of various food items in relation to lipids, carbohydrates, and proteins.

State Performance Indicators

SPI 3258.1.1 Identify the cellular organelles associated with major cell processes**.**
SPI 3258.1.2 Distinguish between prokaryotic and eukaryotic cells.
SPI 3258.1.3 Distinguish among proteins, carbohydrates, lipids, and nucleic acids.
SPI 3258.1.4 Identify a positive test for carbohydrates, lipids, and proteins.
SPI 3258.1.5 Identify how enzymes control chemical reactions in the body.
SPI 3258.1.6 Determine the relationship between cell growth and cell reproduction.
SPI 3258.1.7 Predict the movement of water and other molecules across selectively permeable membranes.
SPI 3258.1.8 Compare and contrast active and passive transport.

Standard 2 – Interdependence

Conceptual Strand 2

All life is interdependent and interacts with the environment.

Guiding Question 2

How do living things interact with one another and with the non-living elements of their environment?

Course Level Expectations

CLE 3258.2.1 Investigate how the dynamic equilibrium of an ecological community is associated with interactions among its organisms.
CLE 3258.2.2 Analyze and interpret population data, graphs, or diagrams.
CLE 3258.2.3 Predict how climate change, human activity, geologic events, and the introduction of non-native species impact an ecosystem.
CLE 3258.2.4 Describe the events associated with biological succession.

Check for Understanding (Formative/Summative Assessment)

✓**3258.2.1** Analyze human population graphs to predict the impact on global resources, and economic and social factors.
✓**3258.2.2** Construct and maintain a model of an ecosystem. Include a food web to show relatedness, interdependency, and relation to extinction.

✓**3258.2.3** Monitor and evaluate changes in a yeast population.
✓**3258.2.4** Use an outdoor habitat to identify the abiotic and biotic factors, plant and animal populations, producers, consumers, and decomposers.
✓**3258.2.5** Conduct research on how human influences have changed an ecosystem; communicate findings through written or oral presentations.
✓**3258.2.6** Describe a sequence of events that illustrates biological succession.
✓**3258.2.7** Select a local environmental issue and role-play officials, workers, citizens, and special interest groups.
✓**3258.2.8** Interview an environmental agent to determine local issues of interdependence.

State Performance Indicators

SPI 3258.2.1 Predict how population changes of organisms at different trophic levels affect an ecosystem.
SPI 3258.2.2 Interpret the relationship between environmental factors and fluctuations in population size.
SPI 3258.2.3 Determine how the carrying capacity of an ecosystem is affected by interactions among organisms.
SPI 3258.2.4 Predict how various types of human activities affect the environment.
SPI 3258.2.5 Make inferences about how a specific environmental change affects biodiversity.

SPI 3258.2.6 Predict how an environmental change may lead to the extinction of a species.
SPI 3258.2.7 Analyze factors responsible for biological succession.

Standard 3 – Matter and Energy

Conceptual Strand 3

Matter cycles and energy flows through the biosphere.

Guiding Question 3

What are the scientific explanations for how matter cycles and energy flows through the biosphere?

Course Level Expectations

CLE 3258.3.1 Analyze energy flow through an ecosystem..
CLE 3258.3.2 Investigate the relationship between the processes of photosynthesis and aerobic cellular respiration.
CLE 3258.3.3 Investigate various types of respiration.
CLE 3258.3.4 Describe the events which occur during the major biogeochemical cycles.

Check for Understanding (Formative/Summative Assessment)

✓**3258.3.1** Track energy flow through an ecosystem.
✓**3258.3.2** Conduct an experiment to investigate photosynthesis and cellular respiration.
✓**3258.3.3** Construct concept maps to explain the processes of photosynthesis and cellular respiration.
✓**3258.3.4** Investigate the importance of industrial applications of fermentation.
✓**3258.3.5** Construct models of the carbon, oxygen, nitrogen, phosphorous, and water cycles.
✓**3258.3.6** Keep a food diary for one week and analyze energy consumption and use.
✓**3258.3.7** Develop a week-long cafeteria menu based on recommended dietary intake.

State Performance Indicators

SPI 3258.3.1 Interpret a diagram that illustrates energy transformations in an ecosystem.
SPI 3258.3.2 Compare and contrast photosynthesis and cellular respiration in terms of energy transformation.
SPI 3258.3.3 Distinguish between aerobic and anaerobic respiration.
SPI 3258.3.4 Predict how changes in a biogeochemical cycle can affect an ecosystem.

Standard 4 – Heredity

Conceptual Strand 4

Organisms reproduce and transmit hereditary information.

Guiding Question 4

What are the principal mechanisms by which living things reproduce and transmit hereditary information from parents to offspring?

Course Level Expectations

CLE 3258.4.1 Investigate how genetic information is encoded in nucleic acids.

CLE 3258.4.2 Describe the relationships among genes, chromosomes, proteins, and hereditary traits.

CLE 3258.4.3 Compare different patterns of inheritance (i.e., simple dominance, sex linkage, co-dominance, incomplete dominance, multiple alleles, and polygenic traits).

CLE 3258.4.4 Recognize how meiosis and sexual reproduction contribute to genetic variation in a population.

CLE 3258.4.5. Describe the role of mutations in human genetic disorders.

CLE 3258.4.6 Assess the scientific and ethical ramifications of emerging genetic technologies (e.g., recombinant DNA, cloning, transgenic organisms, stem cells, and DNA fingerprinting.)

Check for Understanding (Formative/Summative Assessment)

✓**3258.4.1** Use models of DNA, RNA, and amino acids to explain replication and protein synthesis.

✓**3258.4.2** Complete and interpret genetics problems that illustrate simple dominance, sex linkage, co-dominance, incomplete dominance, multiple alleles, and polygenic traits.

✓**3258.4.3** Apply data to complete and interpret a genetic pedigree.

✓**3258.4.4** Describe how the process of meiosis affects the number of chromosomes in a gamete.

✓**3258.4.5** Associate gene mutation with changes in the DNA molecule.

✓**3258.4.6** Design an informational brochure to describe a human genetic disorder.

✓**3258.4.7** Conduct research to explore the scientific and ethical issues surrounding emerging DNA technologies.

✓**3258.4.8** Research careers that relate to genetics and inheritance, such as lab technician, forensic pathologist, livestock breeder, genetic counselor, medical doctor, and role-play discussion of a genetic issue by that professional.

State Performance Indicators

SPI 3258.4.1 Identify the structure and function of DNA.

SPI 3258.4.2 Associate the process of DNA replication with its biological significance.

SPI 3258.4.3 Recognize the interactions between DNA and RNA during protein synthesis.

SPI 3258.4.4. Determine the probability of a particular trait in an offspring, given the genotype of the parents and the mode of inheritance.

SPI 3258.4.5 Apply pedigree data to interpret various modes of genetic inheritance.

SPI 3258.4.6 Describe how meiosis is involved in the production of egg and sperm cells.

SPI 3258.4.7 Describe how meiosis and sexual reproduction contribute to the amount of genetic variation in a population

SPI 3258.4.8 Determine the relationship between mutations and human genetic disorders.
SPI 3258.4.9 Evaluate the scientific and ethical issues associated with genetic technologies.

Standard 5 – Biodiversity and Change

Conceptual Strand 5

A rich variety and complexity of organisms have developed in response to changes in the environment.

Guiding Question 5

How does natural selection explain how organisms have changed over time?

Course Level Expectations

CLE 3258.5.1 Associate structural, functional, and behavioral adaptations with the ability of organisms to survive under various environmental conditions.
CLE 3258.5.2 Analyze the relationship between form and function in living things.
CLE 3258.5.3 Explain how genetic variation and changing environmental conditions can result in adaptation of populations and the emergence of new species.
CLE 3258.5.4 Summarize the supporting evidence for the theory of evolution.
CLE 3258.5.5 Explain how evolution contributes to the amount of biodiversity.
CLE 3258.5.6 Explore the evolutionary basis of modern classification systems.

Check for Understanding (Formative/Summative Assessment)

✓**3258.5.1** Create graphic organizers to demonstrate the relationship between form and function in representative organisms.
✓**3258.5.2** Predict the types of plants and animals indigenous to a biome by determining the characteristics of that biome.
✓**3258.5.3** Demonstrate how natural selection in response to a changing environment may exhibit new characteristics and may form a new species.
✓**3258.5.4** Investigate causes and consequences of antibiotic resistance.
✓**3258.5.5** Associate fossil data with biological and geological changes in the environment.
✓**3258.5.6** Analyze a variety of models, samples, or diagrams to demonstrate the genetic relatedness of organisms.
✓**3258.5.7** Use a dichotomous key to identify an unknown organism.
✓**3258.5.8** Investigate an organism that has or may become extinct and examine the impact of humans on the species.
✓**3258.5.9** Design a scale model of a time line showing emergence and extinction of various life forms on earth.

State Performance Indicators

SPI 3258.5.1 Compare and contrast the structural, functional, and behavioral adaptations of animals or plants found in different environments.
SPI 3258.5.2 Recognize the relationship between form and function in living things.

SPI 3258.5.3 Recognize the relationships among environmental change, natural selection, and the emergence of a new species.

SPI 3258.5.4 Determine how the amount of biodiversity and the ability of a population to adapt to a changing environment are related.

SPI 3258.5.5 Apply evidence from the fossil record, comparative anatomy, DNA, and protein sequences to support modern classification systems.

SPI 3258.5.6 Infer relatedness among different organisms using modern classification systems.

Tennessee Science Curriculum Framework

Principles of Technology I
3220

Course Description

Principles of Technology I is a laboratory science course that deals with the relationship between matter and energy and how they interact. This course will have a strong emphasis in the application of physics in technology. Completion of Principles of Technology I satisfies a lab science credit.

Principles of Technology I students will study:

- Force
- Work and Power
- Rate
- Resistance
- Energy
- Force Transformers

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

CLE 3220.Inq.1 Recognize that science and technology are progressive endeavors that reevaluate and extend what is already accepted.

CLE 3220.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 3220.Inq.3 Use appropriate tools and technology to collect precise and accurate data.

CLE 3220.Inq.4 Apply qualitative and quantitative measures to analyze data and draw conclusions that are free of bias.

CLE 3220.Inq.5 Compare experimental evidence and conclusions with those drawn by others about the same testable question.

CLE 3220.Inq.6 Communicate and defend scientific findings.

Checks for Understanding (Formative/Summative Assessment)

- ✓**3220.Inq.1** Conduct scientific investigations that include testable questions, verifiable hypotheses, and appropriate variables to explore new phenomena or verify the experimental results of others.
- ✓**3220.Inq.2** Select appropriate independent, dependent, or controlled variables for an experiment.
- ✓**3220.Inq.3** Analyze the components of a properly designed scientific investigation.
- ✓**3220.Inq.4** Perform an experiment to test a prediction.
- ✓**3220.Inq.5** Select appropriate tools and technology to collect precise and accurate quantitative and qualitative data.
- ✓**3220.Inq.6** Determine if data supports or contradicts a hypothesis or conclusion.
- ✓**3220.Inq.7** Recognize, analyze, and evaluate alternative explanations for the same set of observations.
- ✓**3220.Inq.8** Evaluate the accuracy and precision of data.
- ✓**3220.Inq.9** State a conclusion in terms of the relationship between two or more variables.
- ✓**3220.Inq.10** Defend a conclusion based on scientific evidence.
- ✓**3220.Inq.11** Analyze experimental results and identify possible sources of bias or experimental error.
- ✓**3220.Inq.12** Compare the results of an experiment with what is already known about the topic under investigation.
- ✓**3220.Inq.13** Suggest alternative explanations for the same set of observations.
- ✓**3220.Inq.14** Formulate and revise models using logic and evidence.
- ✓**3220.Inq.15** Compare conclusions that offer different, but acceptable explanations for the same set of experimental data.

Embedded Mathematics

Conceptual Strand

Investigating physics principles is accomplished by applying mathematical rules.

Guiding Question

What skills and understandings of mathematics are needed to investigate physics?

Course Level Expectations

CLE.3220 Math.1 Graph relationships and functions between manipulated (independent) variables and responding (dependent) variables.
CLE.3220 Math.2 Solve for variables in an algebraic formula.
CLE.3220 Math.3 Apply statistical techniques to manipulate data.
CLE.3220 Math.4 Investigate trigonometric connections to technology.

Checks for Understanding (Formative/Summative Assessment)

- ✓**3220.Math.1** Plot points on the Cartesian coordinate graphing system.
- ✓**3220.Math.2** Graph basic relations and functions using a graphing calculator or a computer program.

✓**3220.Math.3** Determine the slope of a linear function.
✓**3220.Math.4** Determine the frequency, range, mode, median, and mean from a list of data.
✓**3220.Math.5** Utilize a graphing calculator or a computer program to enter data and find basic statistics: frequency, range, means, mode, median, and standard deviation.
✓**3220.Math.6** Solve for all variables based on a formula.
✓**3220.Math.7** Utilize trigonometric functions (sine, cosine, and tangent) to solve simple vector problems.
✓**3220.Math.8** Apply the laws of sine and cosine to solve vector problems.
✓**3220.Math.9** Solve mechanics problems using the quadratic formula.
✓**3220.Math.10** Solve mechanics problems using radians, degrees and revolutions.

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 3220.T/E.1 Explore the impact of technology on social, political, and economic systems.
CLE 3220.T/E.2 Differentiate among elements of the engineering design cycle: design constraints, model building, testing, evaluating, modifying, and retesting.
CLE 3220.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 3220.T/E.4 Describe the dynamic interplay among science, technology, and engineering within living, earth-space, and physical systems.
CLE 3220.T/E.5 Comply with all local, state, and federal safety regulations.

Checks for Understanding (Formative/Summative Assessment)

✓**3220.T/E.1** Distinguish among tools and procedures best suited to conduct a specified scientific inquiry.
✓**3220.T/E.2** Apply the engineering design process to construct a prototype that meets developmentally appropriate specifications.
✓**3220.T/E.3** Evaluate a protocol to determine the degree to which an engineering design process was successfully applied.
✓**3220.T/E.4** Explore how the unintended consequences of new technologies can impact human and non-human communities.
✓**3220.T/E.5** Evaluate the overall benefit to cost ratio of a new technology.
✓**3220.T/E.6** Present research on current bioengineering technologies that advance health and contribute to improvements in our daily lives.

✓**3220.T/E.7** Design a series of multi-view drawings that can be used by other students to construct an adaptive design and test its effectiveness.
✓**3220.T/E.8** Apply industry standard measurements and identifiers.

Standard I – Mechanical

Conceptual Strand I

Laws, properties and applications of mechanics are the foundations of principles of technology.

Guiding Question I

How do the laws, properties, and application of mechanics govern the understanding of technology?

Course Level Expectations

CLE 3220.1.1	Investigate fundamental mechanical quantities of force.
CLE 3220.1.2	Investigate fundamental mechanical quantities of work and power.
CLE 3220.1.3	Investigate fundamental mechanical quantities of rate.
CLE 3220.1.4	Investigate fundamental mechanical quantities of resistance.
CLE 3220.1.5	Investigate fundamental mechanical quantities of energy.
CLE 3220.1.6	Investigate fundamental mechanical quantities of force transformers.

Checks for Understanding (Formative/Summative Assessment)

3220.1.1.a	Distinguish between units of force in the SI and the English systems.
b	Distinguish between scalar and vector quantities of force.
c	Investigate the forces involved in determining torque.
d	Measure torque forces using appropriate tools.
e	Analyze force as it applies to Newton's three laws of motion.
f	Explain the relationship of input work and output work in linear and rotational force transformers.
g	Use equations of work in equals work out to find an unknown force or displacement when using a pulley system or a lever as the force transformer.
h	Explain the difference between ideal mechanical advantage (IMA) and actual mechanical advantage (AMA).
i	Use force transformer equations to find IMA and AMA.
j	Identify different kinds of force transformers for linear mechanical systems and rotational systems.
k	Calculate efficiency of force transformers using IMA and AMA equations.
l	Find the mechanical advantage of rotational force transformers using appropriate units.
3220.1.2.a	Distinguish between units of work and power in the SI and the English systems.
b	Explain the relationship between work done on an object, force applied, and the distance at which the object moves.
c	Measure work done in linear and rotational systems to include radians and degrees.

d	Analyze the efficiency of mechanical systems as related to input work and output work.
3220.1.3.a	Distinguish between units of rate in the SI and the English systems.
b	Calculate and measure speed and velocity in linear and rotational systems.
c	Calculate and measure acceleration in linear and rotational systems.
d	Describe how a voltage transformer is used to step up or step down voltage.
3220.1.4.a	Explain the relationship between frictional force (f), the coefficient of friction (μ), and the force pressing two surfaces together (N).
b	Distinguish between static and kinetic friction.
c	Distinguish between surface friction and fluid drag.
3220.1.5.a	Distinguish between gravitational potential energy and elastic potential energy.
b	Distinguish between potential and kinetic energy.
c	Using Hooke's law, calculate the potential energy of a spring.
d	Distinguish between linear kinetic energy and rotational kinetic energy.
e	Calculate gravitational potential energy, kinetic energy (linear and rotational),and elastic potential energy.
f	Use the law of conservation of energy to describe how one form of energy changes to another form with no loss of energy.
g	Determine the moment of inertia of a spinning object based on the object's mass, shape, and axis of rotation.

Standard II – Fluids

Conceptual Strand II

The physical laws and properties of fluids are an integrated part of how technology works.

Guiding Question II

How do the laws and properties of fluids govern the basic understanding of technology?

Course Level Expectations

CLE 3220.2.1	Investigate fundamental fluid quantities of force.
CLE 3220.2.2	Investigate fundamental fluid quantities of work and power.
CLE 3220.2.3	Investigate fundamental fluid quantities of rate.
CLE 3220.2.4	Investigate fundamental fluid quantities of resistance.
CLE 3220.2.5	Investigate fundamental fluid quantities of energy.
CLE 3220.2.6	Investigate fundamental fluid quantities of force transformers.

Checks for Understanding (Formative/Summative Assessment)

3220.2.1.a	Distinguish the difference between hydraulic and pneumatic fluid systems.
b	Distinguish between density and specific gravity, using the formula D=m/v.
c	Explore buoyant force using Archimedes principle.
d	Use Pascal's law pressure=force/area.
e	Measure fluid pressure differences using appropriate meters (manometer, pressure gauge ….).
f	Differentiate between gauge pressure and absolute pressure.

3220.2.2.a	Define work in a fluid system, using metric or English units.
b	Describe open and closed systems.
c	Calculate work done in open and closed systems.
d	Define power in a fluid system, using metric or English units.
e	Calculate efficiency by dividing power out by power in.
3220.2.3.a	Calculate fluid flow rate by using either volume or mass of a fluid divided by time.
b	Identify various situations in daily living where volume and mass flow are calculated.
3220.2.4.a	Describe resistance as an opposition to fluid motion.
b	Explain the difference between laminar and turbulent flow.
c	Explain the difference between mechanical and fluid drag.
e	Describe how to reduce the resistance of fluid flow.
f	Describe how length, diameter, and viscosity affect fluid flow.
3220.2.5.a	Relate energy in fluid systems to energy in mechanical systems.
b	Explain and demonstrate Bernoulli's principle.
3220.2.6.a	Explain how hydraulic jack works as fluid force transformer.
b	Explain how force is amplified through mechanical advantage in a fluid system.
c	Identify various fluid transformers.

Standard III – Electrical

Conceptual Strand III

Laws, properties, and applications of electricity are part of the foundations of today's technology.

Guiding Question III

How do the laws, properties, and applications of electricity govern the use and development of technology.

Course Level Expectations

CLE 3220.3.1	Investigate fundamental electrical quantities of force.
CLE 3220.3.2	Investigate fundamental electrical quantities of work and power.
CLE 3220.3.3	Investigate fundamental electrical quantities of rate.
CLE 3220.3.4	Investigate fundamental electrical quantities of resistance.
CLE 3220.3.5	Investigate fundamental electrical quantities of energy.
CLE 3220.3.6	Investigate fundamental electrical quantities of force transformers.

Checks for Understanding (Formative/Summative Assessment)

3220.3.1.a	Explain the two types of electricity (direct and alternating current).
b	Identify the components of the circuit.
c	Investigate circuit schematics.
d	Sketch an electrical schematic for series and parallel circuits.
e	Construct a series and a parallel circuit and measure voltages.
f	Use a multimeter (digital and analog) to measure voltage.

	g	Explain how electrical forces create voltage.
3220.3.2.	a	Calculate work in electrical systems, given voltage and charge, using appropriate units.
	b	Measure current in the circuit using a multimeter.
	c	Set up a multimeter to measure current.
	d	Construct a circuit, with proper meter placement, to measure current and voltage.
	e	Define joule as a unit of measurement.
	f	Calculate efficiency, using input electrical work and output mechanical work.
	g	Define the mechanical and electrical work involved in the operation of a solenoid.
	h	Define power in an electrical system as electrical work divided by time.
	i	Measure power in an electrical system using proper units.
3220.3.3.	a	Describe charge flow rate (I) as a quantity of charge moved (Q) per unit of time (t) or I=Q/t.
	b	Distinguish between frequency and period.
	c	Calculate frequency and period using measurements read from the oscilloscope.
3220.3.4.	a	Describe resistance in electrical systems.
	b	Explain the differences among conductors, insulators, and semi-conductors, based on the material's resistivities.
	c	Compare the accuracy of resistance by color code to actual readings made with a digital multimeter.
	d	Use Ohm's law to calculate the resistance in a circuit.
	e	Show how resistance in a wire depends on (1) length of the wire, (2) cross-sectional area of the wire, and (3) material of which the wire is made.
	f	Measure resistance in electrical systems and calculate in appropriate units.
	g	Calculate resistance in both series and parallel circuits, using appropriate formulas.
3220.3.5.	a	Describe the nature and storage of electrical potential energy in a capacitor and a conductor.
	b	Describe how a capacitor and a inductor work.
	c	Measure the energy needed to charge a capacitor and the energy released upon discharge, using a multimeter.
	d	Discuss the relationship between work and electrical energy.
3220.3.6.	a	Demonstrate how a voltage transformer is used to step up or step down voltage.
	b	Explain the relationship between voltage in, voltage out, and number of wire windings in a voltage transformer.
	c	Find the mechanical advantage of a voltage transformer.
	d	Calculate the operating efficiency of a voltage transformer.

Standard IV – Thermal

Conceptual Strand IV

Understanding the laws of thermal energy is essential to understanding modern technology.

Guiding Question IV

How are the laws of thermal energy essential to understanding modern technology?

Course Level Expectations

CLE 3220.4.1	Investigate fundamental thermal quantities of force.
CLE 3220.4.2	Investigate fundamental thermal quantities of power.
CLE 3220.4.3	Investigate fundamental thermal quantities of rate.
CLE 3220.4.4	Investigate fundamental thermal quantities of resistance.
CLE 3220.4.5	Investigate fundamental thermal quantities of energy.
CLE 3220.4.1a	Identify the direction of movement of heat energy in a thermal system when temperature information is known.
b	Name and describe the force-like quantity in a thermal system.
c	Differentiate between the Fahrenheit and Celsius scales.
d	Measure temperature with devices (thermometers, thermocouples) and convert between the Fahrenheit and Celsius scales.
CLE 3220.4.2a	Define power in a thermal system as energy divided by time.
CLE 3220.4.3a	Calculate heat-flow rate Q_H as heat energy (H) moved per unit time (t), using appropriate units.
b	Define specific heat capacity.
c	Explain the difference between sensible heat and latent heat as it relates to change of state.
d	Measure specific heat of different metals.
CLE 3220.4.4a	Describe resistance in a thermal system
b	Define thermal conductivity (k) as a measure of certain materials' ability to conduct heat.
c	Explain the relationship between resistance, temperature difference, and heat flow.
CLE 3220.4.5a	Describe the relationship between thermal energy and work.
b	Describe and calculate the mechanical equivalent of heat.
c	Discuss the three ways that heat energy is transferred.
d	Describe the role heat energy in the law of conservation.

Tennessee Science Curriculum Framework

Principles of Technology II

Course Description

Principles of Technology II is a laboratory science course that deals with the relationship between matter and energy and how they interact. This course will have a strong emphasis in the application of physics in technology. Completion of Principles of Technology I and II is equivalent to a credit in physics.

Principles of Technology II students will study:

- Momentum
- Waves and Vibrations
- Energy Convertors
- Transducers
- Radiation
- Light and Optical Systems
- Time Constants

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

CLE 3256.Inq.1 Recognize that science and technology are progressive endeavors that reevaluate and extend what is already accepted.

CLE 3256.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 3256.Inq.3 Use appropriate tools and technology to collect precise and accurate data.

CLE 3256.Inq.4 Apply qualitative and quantitative measures to analyze data and draw conclusions that are free of bias.

CLE 3256.Inq.5 Compare experimental evidence and conclusions with those drawn by others about the same testable question.

CLE 3256.Inq.6 Communicate and defend scientific findings.

Checks for Understanding (Formative/Summative Assessment)

- ✓**3256.Inq.1** Conduct scientific investigations that include testable questions, verifiable hypotheses, and appropriate variables to explore new phenomena or verify the experimental results of others.
- ✓**3256.Inq.2** Select appropriate independent, dependent, or controlled variables for an experiment.
- ✓**3256.Inq.3** Analyze the components of a properly designed scientific investigation.
- ✓**3256.Inq.4** Perform an experiment to test a prediction.
- ✓**3256.Inq.5** Select appropriate tools and technology to collect precise and accurate quantitative and qualitative data.
- ✓**3256.Inq.6** Determine if data supports or contradicts a hypothesis or conclusion.
- ✓**3256.Inq.7** Recognize, analyze, and evaluate alternative explanations for the same set of observations.
- ✓**3256.Inq.8** Evaluate the accuracy and precision of data.
- ✓**3256.Inq.9** State a conclusion in terms of the relationship between two or more variables.
- ✓**3256.Inq.10** Defend a conclusion based on scientific evidence.
- ✓**3256.Inq.11** Analyze experimental results and identify possible sources of bias or experimental error.
- ✓**3256.Inq.12** Compare the results of an experiment with what is already known about the topic under investigation.
- ✓**3256.Inq.13** Suggest alternative explanations for the same set of observations.
- ✓**3256.Inq.14** Formulate and revise models using logic and evidence.
- ✓**3256.Inq.15** Compare conclusions that offer different, but acceptable explanations for the same set of experimental data.

Embedded Mathematics

Conceptual Strand

Investigating physics principles is accomplished by applying mathematical rules.

Guiding Question

What skills and understandings of mathematics are needed to investigate physics?

Course Level Expectations

CLE.3256 Math.1 Graph relationships and functions between manipulated (independent) variables and responding (dependent) variables.
CLE.3256 Math.2 Solve for variables in an algebraic formula.
CLE.3256 Math.3 Apply statistical techniques to manipulate data.
CLE.3256 Math.4 Investigate trigonometric connections to physics.

Checks for Understanding (Formative/Summative Assessment)

- ✓**3256.Math.1** Plot points on the Cartesian coordinate graphing system.
- ✓**3256.Math.2** Graph basic relations and functions.
- ✓**3256.Math.3** Determine the slope of a linear function.

✓**3256.Math.4** Determine the frequency, range, mode, median, and mean from a list of data.
✓**3256.Math.5** Utilize a graphing calculator or a computer program to enter data and find basic statistics: frequency, range, means, mode, median, and standard deviation.
✓**3256.Math.6** Solve for all variables based on a formula.
✓**3256.Math.7** Utilize trigonometric functions (sine, cosine, and tangent) to solve simple vector problems.
✓**3256.Math.8** Apply the laws of sine and cosine to solve vector problems.
✓**3256.Math.9** Solve mechanics problems using the quadratic formula.
✓**3256.Math.10** Solve mechanics problems using radians, degrees and revolutions.

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 3256.T/E.1 Explore the impact of technology on social, political, and economic systems.
CLE 3256.T/E.2 Differentiate among elements of the engineering design cycle: design constraints, model building, testing, evaluating, modifying, and retesting.
CLE 3256.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 3256.T/E.4 Describe the dynamic interplay among science, technology, and engineering within living, earth-space, and physical systems.
CLE 3256.T/E.5 Comply with all local, state, and federal safety regulations.

Checks for Understanding (Formative/Summative Assessment)

✓**3256.T/E.1** Distinguish among tools and procedures best suited to conduct a specified scientific inquiry.
✓**3256.T/E.2** Apply the engineering design process to construct a prototype that meets developmentally appropriate specifications.
✓**3256.T/E.3** Evaluate a protocol to determine the degree to which an engineering design process was successfully applied.
✓**3256.T/E.4** Explore how the unintended consequences of new technologies can impact human and non-human communities.
✓**3256.T/E.5** Evaluate the overall benefit to cost ratio of a new technology.
✓**3256.T/E.6** Present research on current bioengineering technologies that advance health and contribute to improvements in our daily lives.

✓**3256.T/E.7** Design a series of multi-view drawings that can be used by other students to construct an adaptive design and test its effectiveness.
✓**3256.T/E.8** Apply industry standard measurements and identifiers.

Standard 1 – Momentum

Conceptual Strand 1

Laws of momentum are the foundations of the motions of objects.

Guiding Question 1

How do the laws and properties of momentum govern the basic understanding of motion?

Course Level Expectations

CLE 3256.1.1 Describe linear momentum and its relationship to mass and velocity.
CLE 3256.1.2 Describe angular momentum and its relationship to moment of inertia and angular velocity.
CLE 3256.1.3 Describe impulse.
CLE 3256.1.4 State the law of conservation of momentum as it affects linear or angular motion.
CLE 3256.1.5 Describe the relationship of impulse to change in momentum.

Checks for Understanding (Formative/Summative Assessment)

✓**3256.1.1a** Define linear momentum.
b Identify appropriate English and SI units for linear momentum.
. c Calculate the linear momentum of an object.
d Apply momentum equations to the movement of objects and fluids.
✓**3256.1.2a** Define angular momentum.
b Identify appropriate English and SI units for angular momentum.
c Calculate angular momentum of an object.
d Apply momentum equations to the rotation of objects.
✓**3256.1.3a** Define linear impulse.
b Define angular impulse.
✓**3256.1.4a** Describe the conservation of linear momentum in isolated systems.
b Identify workplace applications where technicians measure or control linear and angular momentum.
✓**3256.1.5a** Explain how the linear impulse ($F\Delta t$) is related to a change in the linear momentum $\Delta(mv)$.
b Solve a problem that involves conservation of linear momentum.
c Explain how angular impulse relates to a change in angular momentum.
d Solve a problems that involves conservation of angular momentum.

Standard 2 – Waves and Vibrations

Conceptual Strand 2

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

Guiding Question 2

How do the laws of wave motion relate to understanding the use of waves as a form of energy?

Course Level Expectations

CLE 3256.2.1 Describe wave motion in general.
CLE 3256.2.2 Describe how waves transmit (move) energy.
CLE 3256.2.3 List the characteristics that are used to describe a wave.
CLE 3256.2.4 Distinguish between longitudinal and transverse waves.
CLE 3256.2.5 Measure wave characteristics.

Checks for Understanding (Formative/Summative Assessment)

- ✓**3256.2.1a** Describe a harmonic wave (sine wave).
  - b Identify examples of wave interference.
  - c Define natural frequency of an object.
  - d Define resonance.
- ✓**3256.2.2a** Define wave speed for a traveling harmonic wave.
  - b State what is meant by the phase difference between two harmonic waves.
  - c Describe what is meant by interference of waves.
  - d Describe what is meant by superposition of waves..
  - e Distinguish between constructive and destructive interference.
  - f Research for examples of wave resonance.
  - g Identify workplace applications where technicians measure and control waves and vibrations.
- ✓**3256.2.3a** Define and experiment with wavelength of a harmonic wave.
  - b Define and experiment with frequency of a harmonic wave.
  - c Define and experiment with period of a harmonic wave.
  - d Define and experiment with amplitude of a harmonic wave.
  - e Define the phase of a harmonic wave.
  - f Solve problems that involve wave characteristics.
  - e Describe what is meant by a standing wave.
- ✓**3256.2.4a** Distinguish between the characteristics of a wave.
  - b Define the frequency of a harmonic wave.
  - c Classify waves as longitudinal or transverse.
- ✓**3256.2.5a** Measure the characteristics of a wave.
  - b Calculate natural frequency and period of oscillation of several vibrating systems.
  - c Use a transducer to measure the vibrations of a vibrating structure.
  - d Use a dual trace oscilloscope to compare the output from two vibration transducers.

Standard 3 – Energy Converters

Conceptual Strand 3

Understanding how energy is converted from one form to another is essential to design and operation of machines in technology.

Guiding Question 3

How do energy converting devices function?

Course Level Expectations

CLE 3256.3.1 Describe the purpose of an energy convertor.
CLE 3256.3.2 Identify mechanical energy convertors.
CLE 3256.3.3 Identify and investigate fluid energy convertors.
CLE 3256.3.4 Identify and investigate electrical energy convertors.
CLE 3256.3.5 Identify and investigate thermal energy convertors.
CLE 3256.3.6 Describe energy convertors and calculate their efficiency.

Checks for Understanding (Formative/Summative Assessment)

✓**3256.3.1a** Experiment with a mechanical energy convertor.
b Experiment with a fluid energy convertor.
c Experiment with an electrical energy convertor.
d Experiment with a thermal energy convertor.

✓**3256.3.2a** Convert mechanical energy to fluid energy with a pump and explain the process.
b Explain how a fan changes mechanical energy to fluid energy.
c Explain and demonstrate how an alternator converts mechanical energy to electrical energy.
d Investigate how a friction (inertia) welder changes mechanical energy to thermal energy.
e Identify workplace applications where technicians use and control mechanical energy convertors.

✓**3256.3.3a** Describe how a windmill converts fluid energy to mechanical energy.
b Explain how a turbine changes fluid energy to mechanical energy.
c Describe a process that converts fluid energy to electrical energy.
d Research and explain how an air conditioner uses fluids to remove thermal energy.
e Identify workplace applications where technicians use and control fluid energy convertors.

✓**3256.3.4a** Explain how an electric motor converts electrical energy to mechanical energy.
b Describe and investigate how a solenoid changes electrical energy to mechanical energy.
c Investigate how a high-resistance conducting wire converts electrical energy to thermal energy.

d Identify workplace applications where technicians use and control electrical energy convertors.

✓**3256.3.5a** Explain and demonstrate how a bimetallic strip changes thermal energy to mechanical energy.

b Convert thermal energy to fluid energy with a combustion engine and describe the process.

c Explain how a thermopile changes thermal energy to electrical energy.

d Identify workplace applications where technicians use and control thermal energy convertors.

✓**3256.3.6a** Determine the efficiency of a convertor that has mechanical input energy.

b Calculate the efficiency of a converter that has fluid input energy.

c Calculate the efficiency of a converter that has electrical input energy.

d Calculate the efficiency of a converter that has thermal input energy.

Standard 4 – Transducers

Conceptual Strand 4

Transducers sense the conditions of energy systems, helping monitor and maintain the safe operation of these systems.

Guiding Question 4

How is the safe operation of energy systems affected by transducers.

Course Level Expectations

CLE 3256.4.1 Define a transducer as a device that senses mechanical, fluid, electrical or thermal information.

CLE 3256.4.2 Describe the action of a transducer in general terms.

CLE 3256.4.3 Distinguish between an energy convertor and a transducer.

CLE 3256.4.4 Identify transducers that change mechanical signals into electrical signals and demonstrate the process.

CLE 3256.4.5 Identify transducers that change fluid signals into mechanical or electrical signals and investigate the process.

CLE 3256.4.6 Identify transducers that change electrical signals into mechanical or thermal information and investigate the process.

CLE 3256.4.7 Identify transducers that change thermal signals into mechanical, fluid, or electrical information and investigate the process.

Checks for Understanding (Formative/Summative Assessment)

✓**3256.4.1a** Explain what a mechanical transducer does.

b Explain what a fluid transducer does.

c Explain what an electrical transducer does.

d Explain what a thermal transducer does.

✓**3256.4.2a** Identify workplace applications where technicians use transducers.

✓**3256.4.3a** Solve problems that involve mechanical transducers.

b Solve problems that involve fluid transducers.

c Solve problems that involve electrical transducers.
d Solve problems that involve thermal transducers.

✓**3256.4.4a** Describe how a strain gage translates a mechanical input signal into an electrical output signal.
b Explain and demonstrate the piezoelectric effect.
c Explain how an accelerometer translates a mechanical input signal into an electrical output signal.

✓**3256.4.5a** Demonstrate how a bourdon gage changes a pressure input signal into a mechanical output signal.
b Compare pressure measurements made with a compound pressure gage to measurements made with a manometer.
c Investigate how a barometer changes a pressure input signal into a mechanical output signal.
d Describe how a flowmeter changes a fluid rate into an electrical signal.
e Explain how an anemometer changes a wind speed into an electrical signal.

✓**3256.4.6a** Describe how a moving coil transducer changes an electrical input into a mechanical output signal.
b Demonstrate how a meter reading depends on the interaction between a stationary magnetic field and the magnetic field created when current flows through the moving coil.
c Investigate why an ammeter has a low-resistance shunt connected in parallel with the transducer circuit and measure the resistance.
d Investigate why a voltmeter has a high-resistance resistor connected in series with the transducer circuit and measure the resistance.
e Calibrate the scale of a voltmeter.
f Describe how an electrostrictive transducer changes an electrical signal into a mechanical signal.
g Demonstrate what a photoconductive transducer does.
h Discuss the two types of transducers used in sonar systems.

✓**3256.4.7a** Demonstrate how a bimetallic strip changes a thermal input signal to a mechanical output signal.
b Describe how a thermograph changes a thermal input signal into recorded output information.
c Demonstrate how a thermocouple translates a thermal input signal to an electrical output signal.
d Explain how a thermistor changes a thermal input signal to an electrical output signal.

Standard 5 – Radiation

Conceptual Strand 5

Understanding electricity and magnetism is explained by the physics of electrons and magnets.

Guiding Question 5

How do the properties of electricity and magnetism relate to the physics of electrons and magnets?

Course Level Expectations

CLE 3256.5.1 Describe what is meant by electromagnetic radiation.
CLE 3256.5.2 Describe what is meant by nuclear radiation.
CLE 3256.5.3 Identify workplace applications where technicians measure or control radiation.

Checks for Understanding (Formative/Summative Assessment)

✓**3256.5.1a** Identify electromagnetic (EM) spectrum divisions, comparing their ranges of wavelength and frequency values.
b Identify four characteristics of EM radiation (wavelength, speed, frequency, and energy).
c Describe the speed of EM radiation in terms of wave frequency (f) and wavelength (λ).
d Investigate the characteristics of a photon, explaining how its energy depends on its wavelength or frequency.
e Solve problems for speed (v) and energy (E) of EM radiation by using the formulas: $v = \lambda t$; and $E=hf$, or $E=hc/\lambda$.
f Describe the wavelength limits, frequency limits and color content of the visible EM spectrum.
✓**3256.5.2a** Define nuclear decay.
b Identify three main components of nuclear radiation.
c Describe alpha particles, beta particles and gamma rays by giving their approximate mass and electrical charge and identify their symbols.
d Compare the relative hazards of alphas, betas and gammas by identifying materials that stop them.
e Define element, isotope, nuclide, atomic number, and mass number.
f Explain the meaning of symbols used to identify different nuclides.
g Differentiate between fission and fusion.
h Use Einstein's equation, $E = mc^2$, to change atomic mass to energy.
i Demonstrate how radiation energy follows the inverse square law.
j Detect nuclear radiation using appropriate instruments.
✓**3256.5.3a** Identify workplace applications where technicians measure and control EM radiation.
b Identify workplace applications where technicians work with nuclear radiation.
c Describe safety procedures that technicians must follow when working with nuclear radiation.

Standard 6 – Light and Optical Systems

Conceptual Strand 6

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

Guiding Question 6

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

Course Level Expectations

CLE 3256.6.1 Describe how light can be represented by light rays.
CLE 3256.6.2 Describe how light can be represented by waves.
CLE 3256.6.3 Identify the special characteristics of laser light.
CLE 3256.6.4 Identify several optical systems that process light.
CLE 3256.6.5 Identify workplace applications where technicians measure and control light.

Checks for Understanding (Formative/Summative Assessment)

✓**3256.6.1a** Explain and demonstrate the reflection of light.
b Use light ray diagrams in a drawing to show how light is reflected from plane (flat) mirrors.
c Use light ray diagrams in a drawing to show how light is reflected from spherical mirrors.
d Explain what is meant by the curvature and focal length of a mirror.
e Use light ray diagrams to show how light rays are reflected by a mirror.
f Discuss refraction of light and demonstrate the bending of the path of a light ray..
g Given a drawing of refracted light, calculate the index of refraction using Snell's law.
h Use light ray diagrams in a drawing to show how lenses bend and focus light.
i Determine the focal length of a lens.
j Use light ray diagrams to show how light is refracted through a lens.
k Distinguish between convex and concave lenses.
l Sketch examples of convex and concave lenses..
m Identify workplace applications where technicians use ray optics

✓**3256.6.2 a** Distinguish between constructive and destructive interference.
b Describe what is meant by interference fringes.

✓**3256.6.3 a** Explain what is meant by collimated light.
b Explain how light spreads as it travels.
c Identify the three main components of a laser and investigate their functions.
d Identify three main types of lasers.
e Investigate characteristics of laser light.
f Describe what is meant by coherent light.
g Calculate radiant power and power density.

h Explain how lasers can produce extremely high power densities on targets.

✓**3256.6.4 a** Explain diffraction.

b Use a light ray diagram to demonstrate how light diffracts.

c Explain diffraction grating.

d Investigate a grating spectrometer.

e Describe how the human eye forms an image of light.

f Investigate abnormalities (nearsightedness, farsightedness, astigmatism) and identify the appropriate corrective lenses.

g Describe how a camera forms an image on film.

✓**3256.6.5 a** Identify workplace applications where technicians use ray optics.

b Identify workplace applications where technicians use interference of light.

c Identify workplace applications where technicians use diffraction of light.

d Identify workplace applications where technicians use lasers.

Standard 7 – Time Constants

Conceptual Strand 7

Time constant describes how quickly nonlinear processes change.

Guiding Question 7

How would time constants be used describe nonlinear motion?

Course Level Expectations

CLE 3256.7.1 Distinguish between uniform change and nonuniform change..

CLE 3256.7.2 Identify systems where time constants are needed to describe system behaviour.

CLE 3256.7.3 Define three time constants (labeled $T_{1/2}$, T_{90} and τ).

CLE 3256.7.4 Identify workplace applications where technicians measure and control time constants.

Checks for Understanding (Formative/Summative Assessment)

✓**3256.7.1a** Draw a curve that shows a linear increase or decrease of a variable with time.

b Draw a curve that shows an exponential increase or decrease of a variable with time.

✓**3256.7.2** Explain why it is important to know the time constant of a thermocouple.

✓**3256.7.3a** Given the equation that describes how fast a vibration is slowing down (damped oscillation), identify the time constant and predict when the vibration is about 99% damped out.

b Given the equation that describes how fast a tank is emptied, identify the time constant and predict when the tank will be about 99% empty.

c Given the equation that describes the charging of a capacitor, identify the 1/e time constant and predict when the capacitor will be charged.

d Given the equation that describes the charging of a capacitor, identify the 1/e time constant and predict when the capacitor will be discharged.

e Draw a curve that represents the cooling rate of an isolated container of hot liquid located in a room at some cooler temperature (T).

✓**3256.7.4** Identify workplace applications in electrical and thermal systems where technicians measure or control time constants.