CERTIFICATION EXAMINATIONS FOR OKLAHOMA EDUCATORS™ (CEOE™)

OKLAHOMA SUBJECT AREA TESTS™ (OSAT™)

FIELD 113: PHYSICAL SCIENCE

TEST FRAMEWORK

September 2019

	Subarea	Range of Competencies
I.	Science Practices and the Engineering Process	0001–0004
II.	Forces, Electromagnetics, and Waves	0005–0008
III.	Matter and Energy	0009–0014
IV.	Earth and Space Systems	0015–0017
V.	Pedagogical Content Knowledge	0018

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SUBAREA I—SCIENCE PRACTICES AND THE ENGINEERING PROCESS

Competency 0001

Apply knowledge of scientific practices and techniques to physical science investigations.

The following topics are examples of content that may be covered under this competency.

- Apply knowledge of how to plan and conduct scientific lessons and investigations, including relating the instruction topics to students' prior knowledge and natural phenomena.
- Apply knowledge of how to ask questions that arise from observation, how to identify relationships, and how to make a scientific claim that can be supported or rejected based on evidence.
- Apply knowledge of methods and procedures for designing and carrying out scientific studies and for collecting data (e.g., identifying control and experimental groups, defining dependent and independent variables).
- Analyze the appropriateness of a specified experimental design in testing a scientific claim.
- Apply knowledge of basic safety concerns and proper procedures for preventing and responding to accidents and injuries in the laboratory or in the field.

Competency 0002

Apply knowledge of the processes of gathering, organizing, and interpreting scientific data.

The following topics are examples of content that may be covered under this competency.

- Evaluate the appropriateness of a given method or procedure for collecting data for a specified purpose.
- Apply knowledge of mathematical and computational thinking (e.g., trends, correlations) to methods of data representation (e.g., graph, table, diagram), including their organization, relative ability to present given experimental data, and interpretation.
- Apply knowledge of scientific measurements and mathematical concepts necessary in physical science investigations (e.g., scientific notation, unit conversion, significant digits, statistical methods).
- Evaluate the claims, evidence, and reasoning supporting or refuting scientific conclusions.

Competency 0003

Apply knowledge of engineering design to physical science.

The following topics are examples of content that may be covered under this competency.

- Apply knowledge of relationships between scientific concepts, technology, and engineering design.
- Analyze an engineering problem, including the design criteria (e.g., size, weight, durability), benefits, and possible drawbacks of a design or solution.
- Evaluate a specific engineering design solution or compare design solutions based on constraints (e.g., material, temporal, social, ethical).
- Apply knowledge of prototype testing, the extent to which different criteria are met for a given design, and the modifications needed to optimize a design solution.

Competency 0004

Apply crosscutting concepts to physical science concepts, processes, and phenomena.

The following topics are examples of content that may be covered under this competency.

- Analyze common patterns within or across physical science concepts (e.g., the organization and classification of phenomena, the reactivity of substances).
- Differentiate between causal and correlational relationships and identify the scientific principles behind causal relationships (e.g., thermodynamic principles responsible for air circulation in a room, oxidation reactions responsible for the rusting of steel).
- Apply knowledge of scale, proportion, and quantity in relation to physical science concepts (e.g., size, time, energy).
- Apply knowledge of system modeling (e.g., physical, mathematical, computer-based) to show correlations, solve problems, and predict outcomes.
- Apply knowledge of the general principles of matter and energy, including their conservation, transfer, and relation to the inputs and outputs of a defined system.
- Apply knowledge of the relationships between structure and function in physical or chemical systems, including the relationship between the composition and properties of a material.
- Apply knowledge of stable and unstable systems, including feedback mechanisms and factors that affect the stability of a system.

SUBAREA II—FORCES, ELECTROMAGNETICS, AND WAVES

Competency 0005

Apply knowledge of forces and motion.

The following topics are examples of content that may be covered under this competency.

- Use graphs and equations to analyze and model situations related to distance, displacement, speed, velocity, and constant acceleration in one dimension.
- Apply knowledge of Newton's laws of motion and solve related problems, including in relation to natural phenomena (e.g., ball rolling down a ramp, planetary motion, space walk).
- Analyze one- and two-dimensional motion using vectors, including freely falling objects near the surface of the earth.
- Apply knowledge of forces acting in a given system (e.g., gravitational, spring, friction), distinguish between contact and field forces, and distinguish between mass and weight.
- Apply knowledge of the vector nature of force and analyze components of gravitational and frictional forces (e.g., acceleration due to gravity, universal gravitation, coefficient of friction, static friction).

Competency 0006

Apply knowledge of work, power, energy, and momentum in mechanical systems.

The following topics are examples of content that may be covered under this competency.

- Analyze mechanical systems in terms of work, power, and energy.
- Apply knowledge of the conservation of energy and solve related problems involving kinetic and potential energy.
- Apply knowledge of the key concepts of momentum (e.g., conservation of momentum, the impulse-momentum theorem) in various situations and solve related problems.
- Apply knowledge of simple machines to determine their relative power, mechanical advantage, and efficiency in relation to work and energy.

Competency 0007

Apply knowledge of electricity, magnetism, and electromagnetism.

The following topics are examples of content that may be covered under this competency.

- Apply Coulomb's law to determine the forces between charges and to examine how those forces vary with distance.
- Analyze electric field lines and the motion of a charged particle in an electric field.
- Apply knowledge of the flow of electric charge in conductors, semiconductors, and superconductors in relation to a variety of factors (e.g., elementary charge, number of electrons, current, time).
- Apply knowledge of energy and power in circuits (e.g., electricity generation, current flow, dissipation rate, energy consumption).
- Analyze models of direct current circuits using Ohm's law and Kirchhoff's rules and solve related problems.
- Apply knowledge of the properties of permanent magnets, magnetic field lines, the direction and magnitude of a magnetic field for basic current elements (e.g., wire of infinite length, solenoid), and induced electromotive force (emf).
- Analyze the structure and function of technology and technological components that require the use of electromagnetism (e.g., motors, generators, transformers, induction technology, wireless systems).

Competency 0008

Apply knowledge of waves.

The following topics are examples of content that may be covered under this competency.

- Apply knowledge of the types (e.g., longitudinal, transverse), characteristics (e.g., frequency, period, amplitude, speed, wavelength), and structure of waves in various media.
- Analyze changes in wave behavior, including reflection, refraction, diffraction, and the Doppler effect.
- Apply knowledge of sound production and perception in relation to wave interference and standing waves.
- Analyze the components of the electromagnetic spectrum (e.g., visible light, ultraviolet radiation, gamma rays), including their effects when interacting with matter (e.g., conversion to heat, ionization of atoms, emission of electrons).
- Apply knowledge of analog and digital methods of storing and transmitting information through electromagnetic waves (e.g., optical fibers, radio signals), including the advantages and disadvantages of these processes.
- Apply knowledge of the characteristics and functioning of lenses, mirrors, and prisms, including the use of ray diagrams for determining a resultant image (e.g., virtual, real, magnified, inverted).

SUBAREA III—MATTER AND ENERGY

Competency 0009

Apply knowledge of atomic structure and the periodic table.

The following topics are examples of content that may be covered under this competency.

- Analyze the major features of, supporting evidence for, and changes made to historical models of atomic structure (e.g., Democritus, plum pudding model, Bohr, quantum model).
- Apply knowledge of the properties of various subatomic particles (e.g., masses, charges, locations, arrangements), including the effect of subatomic particles on atomic properties.
- Analyze trends within periods and groups in the periodic table (e.g., valence electrons, ionization energies, atomic radii), and predict relative and chemical properties of given elements based on their positions in the periodic table.
- Apply knowledge of the processes of fission, fusion, and radioactive decay (e.g., alpha, beta, gamma) and the associated changes in an atom's composition.

Competency 0010

Analyze chemical structure, intermolecular forces, and bonding.

The following topics are examples of content that may be covered under this competency.

- Apply knowledge of representations of molecular structure (e.g., Lewis dot, molecular geometry) and of the IUPAC nomenclature of common compounds.
- Analyze the characteristics of various types of intermolecular forces (e.g., dipole-dipole, hydrogen bonds), including distinguishing between different types of forces.
- Relate the intermolecular forces present within a given substance to the properties and structure of that substance at the macro scale.
- Analyze intramolecular bond types (e.g., covalent, ionic, metallic), their properties (e.g., reactivity, strength, energetic potential), and the likelihood of their formation.

Competency 0011

Apply knowledge of stoichiometry and chemical reactions.

The following topics are examples of content that may be covered under this competency.

- Apply knowledge of the mole concept, Avogadro's number, the conservation of matter, and balancing chemical equations.
- Apply knowledge of stoichiometry (e.g., limiting reagents, percent yield), empirical and formula mass, and percent composition, including solving related problems and identifying common substances.
- Distinguish between physical and chemical changes and understand evidence of chemical changes (e.g., color change, gas evolution).
- Analyze types of chemical reactions (e.g., synthesis, decomposition, displacement, combustion), including comparing reaction types.
- Apply knowledge of the initial state of reactants (e.g., valence electrons, trends in the periodic table, chemical properties) to predict the resulting products.
- Analyze factors (e.g., concentration, catalyst presence, temperature) that will affect the rate of a reaction.

Competency 0012

Apply knowledge of the phases of matter.

The following topics are examples of content that may be covered under this competency.

- Apply knowledge of chemical and physical properties to identify a substance.
- Evaluate a substance based on its chemical and physical properties to separate it into its components.
- Apply knowledge of the properties of the phases of matter (i.e., solid, liquid, gas, and plasma) and the arrangement and movement of particles in various phases of matter through use of the kinetic molecular theory.
- Analyze phase changes through diagrams and the kinetic molecular theory.
- Apply knowledge of the gas laws and solve related problems.

Competency 0013

Apply knowledge of aqueous solutions.

The following topics are examples of content that may be covered under this competency.

- Analyze factors (e.g., temperature, pressure, molecular structure) that affect solubility and solve related problems (e.g., molarity, molality, percent concentration).
- Apply knowledge of colligative properties of solutions, including in relation to the functioning of solutions in natural phenomena (e.g., consumer, industrial).
- Solve problems related to the hydronium and hydroxide ion concentration and the pH and pOH for various acid, base, and electrolyte solutions.
- Apply the principles of acid-base chemistry to acid-base titration and common observable phenomena (e.g., chemical weathering, metal corrosion, acid rain).

Competency 0014

Apply knowledge of the principles of energy and thermodynamics.

The following topics are examples of content that may be covered under this competency.

- Apply knowledge of the concepts of heat and temperature, the difference between them, and modes of heat transfer (e.g., conduction, convection, radiation), including natural phenomena (e.g., air movement, ocean circulation).
- Apply knowledge of energy conversion (e.g., chemical to mechanical) using the laws of thermodynamics in relation to energy at the macroscopic level and the microscopic level and of energy conversion in natural phenomena.
- Apply knowledge of calorimetry and endothermic and exothermic reactions.

SUBAREA IV—EARTH AND SPACE SYSTEMS

Competency 0015

Apply knowledge of space systems.

The following topics are examples of content that may be covered under this competency.

- Apply knowledge of theories for the origin of the universe and the types of evidence used to infer the size, scale, and relative structure of the universe (e.g., stellar neighborhoods, galactic clusters), including evidence for the continued evolving structure of the universe (e.g., background radiation, red shift).
- Analyze the characteristics of main sequence stars and the life cycle of stars, including through the use of the Hertzsprung-Russell (H-R) diagram and through an understanding of the formation, early development, and evolution of stars.
- Apply knowledge of the origin, evolution, and scale of the solar system (e.g., planets, Oort cloud, Kuiper belt, asteroid belt) and Kepler's laws to relate the real and apparent motions of the planets and other celestial bodies.
- Apply knowledge of the celestial sphere model of the earth, moon, and sun system (e.g., path of the ecliptic, orbital characteristics) and the relationships between the earth, moon, and sun (e.g., tilt of the earth's axis, rotation of the earth and moon, distance between the earth and sun).
- Apply knowledge of the effects of the earth's relative position and motion with respect to the sun (e.g., length of day, change of seasons, length of year) and the effects of the relative positions and motions of the earth, moon, and sun (e.g., phases of the moon, tides, eclipses).

Competency 0016

Apply knowledge of Earth systems.

The following topics are examples of content that may be covered under this competency.

- Apply knowledge of the origin, evolution, and key events in the history of Earth's atmosphere, lithosphere, hydrosphere, and biosphere.
- Demonstrate knowledge of the layered structure and composition of the earth, the sources of the earth's internal energy, the major processes affecting the earth's interior that drive and shape the movement of tectonic plates (e.g., thermal convection, ridge push, slab pull).
- Analyze evidence for seafloor spreading and plate tectonics (e.g., continent/ocean basin shape) and apply the theory of plate tectonics to explain topographic features (e.g., island chains, faults, volcanoes, mountain ranges).
- Analyze the characteristics and properties of sedimentary, igneous, and metamorphic rock and the processes by which different kinds of rocks are formed.
- Apply knowledge of the processes of weathering (e.g., mechanical, chemical, biological), the processes of erosion by various agents (e.g., wind, water, glaciers), and factors that affect the rate and patterns of these processes.
- Apply knowledge of factors (e.g., topography, temperature) that affect regional and global wind patterns (e.g., insolation, Coriolis effect) and the formation of weather patterns (e.g., thunderhead, snow).
- Apply knowledge of the chemical and physical properties of water (e.g., high specific heat, surface tension) and relate these properties to the behavior of water in Earth systems.

Competency 0017

Apply knowledge of natural hazards and human impacts.

The following topics are examples of content that may be covered under this competency.

- Analyze biogeochemical cycles of major elements and compounds (e.g., nitrogen, carbon, phosphorus, sulfur), including the factors that affect the movement of those chemical species.
- Analyze the mechanisms behind, evidence for, and impacts of global climate change, including understanding the greenhouse effect and its positive and negative attributes.
- Apply knowledge of the causes, characteristics, and impacts of natural hazards (e.g., tornadoes, droughts, earthquakes), including their impacts on human communities and populations and possible engineering solutions and strategies (e.g., flood barriers, tsunami early warning systems) to mitigate their impact on communities.
- Apply knowledge of the various forms of renewable (e.g., solar, wind, geothermal, hydropower) and nonrenewable (e.g., coal, oil, natural gas, nuclear) energy and natural resources (e.g., silicon, gold, marble), including understanding their characteristics, availability, uses, advantages/disadvantages, and sustainability potential.
- Analyze human activities that affect a given Earth system (e.g., chlorofluorocarbons, nutrient-laden runoff, intensive agriculture) and their direct and indirect impacts on Earth systems.
- Apply knowledge of strategies and methods for minimizing (e.g., sustainable agriculture, erosion control measures), monitoring (e.g., climate change models, satellite monitoring of deforestation), and mitigating the effects of human activities on the environment (e.g., renewal of coastal marshes, strip mine reclamation, cover cropping, control of invasive species).

SUBAREA V—PEDAGOGICAL CONTENT KNOWLEDGE

Competency 0018

Analyze a lesson plan for a given learning standard in the Oklahoma Academic Standards for Science or in the Next Generation Science Standards, including examples of student work and/or assessments, and describe subsequent activities that address student needs.

The following topics are examples of content that may be covered under this competency.

- Apply knowledge of standards-based learning goals for physical science content and processes.
- Analyze assessment results of student learning and/or samples of student work for a particular lesson in physical science, citing specific evidence from the exhibits that identifies a significant scientific strength as well as a significant area of need shown by the student or students.
- Describe an appropriate instructional strategy or intervention that would help the student or students improve in the identified area of need.
- Describe how your analysis of assessment data and/or student work can be used to inform future instruction with respect to this content area and the development and reinforcement of sound scientific practice.