Certification Examinations for Oklahoma Educators™

Oklahoma Subject Area Tests™

STUDY GUIDE

014 Physics

Oklahoma Commission for Teacher Preparation

OK-SG-FLD014-03

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The first two sections of the study guide are available in a separate PDF file. Click the link below to view or print these sections.

Study Guide Introduction and General Information About the Certification Examinations for Oklahoma Educators

FIELD-SPECIFIC INFORMATION

• Test Competencies
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INTRODUCTION

This section includes a list of the test competencies, as well as a set of practice selected-response (multiple-choice) questions and one or more practice constructed-response assignments (if applicable), for the test field included in this study guide.

Test Competencies

The test competencies are broad, conceptual statements that reflect the subject-matter skills, knowledge, and understanding an entry-level educator needs to teach effectively in Oklahoma public schools. The list of test competencies for each test field represents the **only** source of information about what a specific test will cover and therefore should be reviewed carefully.

The descriptive statements that follow the competencies are included to provide examples of possible content covered by each competency. These descriptive statements are neither exhaustive nor exclusionary.

Practice Test Questions

The practice selected-response questions and any practice constructed-response assignments included in this section are designed to give you an introduction to the nature of the questions included in this OSAT test field. The practice test questions represent the various types of questions you may expect to see on an actual test; however, they are **not** designed to provide diagnostic information to help you identify specific areas of individual strengths and weaknesses or to predict your performance on the test as a whole.

To help you prepare for your OSAT, each practice selected-response question in this section is preceded by the competency it measures and followed by a brief explanation of the correct response. On the actual test, the competencies, correct responses, and explanations will **not** be given.

If the test field included in this guide has a constructed-response assignment, a sample response is provided immediately following the practice constructed-response assignment. The sample response in this guide is for illustrative purposes only. Your written response should be your original work, written in your own words, and not copied or paraphrased from some other work.

A description of the process that is used for scoring the constructed-response assignment is provided in addition to the OSAT performance characteristics and score scale.

When you are finished with the practice test questions, you may wish to go back and review the entire list of test competencies and descriptive statements for your test field.

SUBAREAS:

I. Foundations of Scientific Inquiry
II. Mechanics and Thermodynamics
III. Electricity and Magnetism
IV. Waves, Sound, and Light
V. Quantum Theory and the Atom

SUBAREA I—FOUNDATIONS OF SCIENTIFIC INQUIRY

Competency 0001

Understand the relationships and common themes that connect mathematics, science, and technology.

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

Apply the laws of physics to various sciences and other disciplines outside of physics.

Analyze the use of physics, mathematics, and other sciences in the design of a solution to a given scientific or technological problem.

Analyze the role of technology in the advancement of scientific knowledge.

Use a variety of software (e.g., spreadsheets, graphing utilities, statistical packages, simulations) and information technologies to model and solve problems in mathematics, science, and technology.

Competency 0002

Understand the historical and contemporary contexts of the study of physics and the applications of physics to everyday life.

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

Analyze the significance of key events, theories, and individuals in the history of physics.

Assess the societal implications of developments in physics (e.g., nuclear technology, solid state technology).

Competency 0003

Understand the process of scientific inquiry and the role of observation and experimentation in explaining natural phenomena.

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

Analyze processes by which new scientific knowledge and hypotheses are generated.

Analyze ethical issues related to the process of scientific research (e.g., accurately reporting experimental results).

Evaluate the appropriateness of a specified experimental design to test a given hypothesis.

Assess the role of communication among scientists in promoting scientific progress.

Competency 0004

Understand principles of measurement and the process of gathering, organizing, reporting, and interpreting scientific data.

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

Evaluate the appropriateness of units of measurement, measuring devices, or methods of measurements for a given situation.

Assess the appropriateness of a given method or procedure for collecting data for a specified purpose.

Assess the use of statistical methods for analyzing data.

Analyze relationships among factors (e.g., inverse, linear, quadratic) as indicated by experimental data.

Competency 0005

Understand equipment, materials, and chemicals used in science investigations; and apply procedures for their proper and safe use.

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

Analyze the principles upon which given laboratory instruments are based (e.g., ammeters, oscilloscopes).

Analyze hazards associated with given laboratory materials (e.g., lasers, electrical equipment, chemicals).

Apply proper procedures for safety in the laboratory (e.g., use of goggles).

Apply proper procedures for dealing with accidents and injuries in the laboratory.

SUBAREA II—MECHANICS AND THERMODYNAMICS

A. Mechanics

Competency 0006

Understand concepts related to motion in one and two dimensions, and solve problems that require the use of algebra, calculus, and graphing.

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

Apply the terminology, units, and equations used to describe and analyze one- and two-dimensional motion.

Analyze the motion of freely falling objects near the surface of the earth.

Solve problems involving distance, displacement, speed, velocity, and acceleration.

Interpret information presented in one or more graphic representations related to distance, displacement, speed, velocity, and constant acceleration.

Competency 0007

Understand characteristics of forces and methods used to measure force, and solve problems involving forces.

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

Identify the forces acting in a given situation.

Analyze and solve problems involving gravitational and frictional forces.

Find the resultant force in a given situation.

Solve statics problems involving torques.

Competency 0008

Understand and apply the laws of motion (including relativity).

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

Describe the characteristics of each of Newton's laws of motion, and analyze their applications.

Apply Newton's laws of motion to solve problems.

Understand the implications of special relativity for the laws of motion.

Competency 0009

Understand uniform circular motion and simple harmonic motion, and solve problems involving these types of motion.

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

Apply vector analysis to describe uniform circular motion.

Determine the magnitude and direction of the forces acting on a particle in uniform circular motion.

Understand the relationships among displacement, velocity, and acceleration in simple harmonic motion (e.g., simple pendulum).

Apply the principles of simple harmonic motion to solve problems involving oscillatory phenomena (e.g., mass on a spring).

Competency 0010

Understand the concepts of energy, work, and power, and the principles of conservation of energy and momentum.

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

Analyze mechanical systems in terms of work, power, and energy.

Use the concept of conservation of energy to solve problems.

Determine power, mechanical advantage, and efficiency as they relate to work and energy in simple machines.

Use the concept of conservation of momentum to solve problems.

Competency 0011

Understand the dynamics of rotational motion and the properties of fluids.

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

Apply the law of conservation of angular momentum.

Apply the concepts of center of mass, moment of inertia, and rotational kinetic energy to analyze the rotational motion of an object.

Apply the concepts of force, pressure, and density.

Use Archimedes' and Bernoulli's principles to analyze properties of fluids.

B. Heat Energy

Competency 0012

Understand the concept of heat energy and the laws of thermodynamics.

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

Solve calorimetry problems involving heat capacity, specific heat, heat of fusion, and heat of vaporization.

Analyze methods of heat transfer (i.e., conduction, convection, and radiation) in practical situations.

Apply the first law of thermodynamics in a variety of situations.

Use the principle of entropy to analyze the operation of heat engines (e.g., Carnot cycle).

Competency 0013

Understand the kinetic-molecular theory and its relationship to thermodynamics.

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

Analyze the behavior of an ideal gas in terms of the kinetic-molecular theory (e.g., internal energy of a gas).

Analyze the properties of materials in terms of molecular arrangement and forces.

Analyze phase changes in terms of kinetic-molecular theory and molecular structure.

Understand the molecular interpretation of entropy.

SUBAREA III—ELECTRICITY AND MAGNETISM

Competency 0014

Understand electric charge, electric fields, electric potential, and capacitance.

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

Analyze the behavior of an electroscope in given situations.

Apply Coulomb's law to determine the forces between charges.

Apply principles of electrostatics to determine electric field intensity and electric potential for a given charge distribution.

Understand the relationship among capacitance, charge, and potential difference.

Competency 0015

Understand the components and properties of direct current circuits.

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

Analyze a DC circuit in terms of conservation of energy and conservation of charge (i.e., Kirchhoff's laws and Ohm's law).

Analyze energy relationships and transformations in electric circuits.

Interpret schematic diagrams of electric circuits.

Apply principles of DC circuits to reduce a complex circuit to a simpler equivalent circuit.

Competency 0016

Understand magnetic fields and electromagnetic induction.

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

Determine the orientation and magnitude of a magnetic field in a given situation (e.g., wire of infinite length, solenoid).

Determine the magnitude and direction of the force on a charge or charges moving in a magnetic field.

Analyze factors that affect the magnitude of an induced electromotive force (EMF).

Analyze the use of electromagnetism in technology (e.g., motors, generators, meters, transformers).

Competency 0017

Understand alternating currents and the operation of conductors, semiconductors, and superconductors.

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

Analyze the current, voltage, and phase relationships in an RLC circuit.

Describe the flow of electrons in conductors and semiconductors.

Analyze the function of a solid-state device (e.g., diode, transistor) in a given electrical circuit.

Recognize the properties of superconductors (e.g., critical temperature, Meissner effect).

SUBAREA IV—WAVES, SOUND, AND LIGHT

Competency 0018

Understand waves and wave motion, and analyze problems involving wave motion.

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

Compare the transfer of energy and momentum in longitudinal and transverse waves.

Analyze the characteristics (e.g., frequency, period, amplitude, speed, wavelength) of waves.

Analyze factors determining the energy and power of a wave.

Apply the superposition principle to determine characteristics of a resultant wave.

Competency 0019

Understand the principles of wave reflection, refraction, diffraction, interference, polarization, dispersion, and the Doppler effect.

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

Analyze practical applications of wave reflection, refraction, diffraction, interference, polarization, dispersion, and the Doppler effect (e.g., radar, sonar, polarizers).

Apply Snell's law to determine index of refraction, angle of refraction, or critical angle as a wave passes from one medium to another.

Analyze problems involving diffraction and interference in single and multiple slits.

Competency 0020

Understand the characteristics of sound waves and the means by which sound waves are produced and transmitted.

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

Analyze the energy, power, and intensity of sound waves (including the decibel scale).

Analyze factors that affect the speed of sound in different media.

Solve problems involving resonance, harmonics, and overtones in vibrating strings and air columns.

Competency 0021

Understand the production and characteristics of electromagnetic waves.

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

Analyze the properties (e.g., energy, frequency, wavelength) and components (e.g., visible light, ultraviolet radiation) of the electromagnetic spectrum.

Analyze the energy, frequency, and amplitude of electromagnetic waves in terms of the vibrations of the sources that produce them (e.g., molecules, electrons, nuclear particles).

Analyze practical applications of electromagnetic waves (e.g., infrared detectors, solar heating, X-ray machines, microwave ovens).

Competency 0022

Understand and apply the principles of lenses and mirrors.

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

Compare types and characteristics of lenses and mirrors.

Use a ray diagram to locate the focal point or point of image formation of a lens or mirror.

Apply the thin lens equation to solve problems involving lenses and mirrors.

Analyze applications of lenses and mirrors (e.g., telescopes, compound microscopes, eyeglasses).

SUBAREA V—QUANTUM THEORY AND THE ATOM

Competency 0023

Understand the photoelectric effect, quantum theory, and the dual nature of light and matter.

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

Apply the laws of photoelectric emission to explain photoelectric phenomena.

Analyze bright-line spectra in terms of electron transitions.

Understand the principles of stimulated emission of radiation as applied to lasers and masers.

Analyze evidence supporting the dual nature of light and matter.

Competency 0024

Understand physical models of atomic structure and the nature of elementary particles.

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

Analyze historic and contemporary models of atomic structure (e.g., Rutherford, Bohr, Schrödinger).

Interpret notation used to represent elements, molecules, ions, and isotopes.

Understand the relationship between the design of particle accelerators and elementary particle characteristics.

Competency 0025

Understand the principles of radioactivity and types and characteristics of radiation, and analyze the process of radioactive decay and detection.

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

Apply principles of the conservation of mass number and charge to balance equations for nuclear reactions.

Analyze radioactive decay in terms of the half-life concept.

Analyze the nuclear disintegration series for a given isotope.

Understand the basic operation of types of radiation detectors.

Competency 0026

Understand types and characteristics of nuclear reactions, methods of initiating and controlling them, and applications of nuclear reactions to the generation of electricity.

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

Analyze characteristics of fission and fusion reactions.

Understand the operation of components of a nuclear reactor (e.g., moderator, fuel rods, control rods).

Apply the principle of conservation of mass-energy to calculate nuclear mass defect and binding energy.

Analyze the reasons for using the isotopes commonly used to fuel nuclear reactors and the problems associated with the waste products generated by nuclear reactions.

CONSTANTS

Description	Value
Acceleration of gravity on Earth (g)	9.8 m/s^2
Speed of light in a vacuum (c)	3.00×10^{8} m/s
Planck's constant (h)	6.63×10^{-34} J•s = 4.14×10^{-15} eV•s
Electron rest mass	9.11×10^{-31} kg
Proton rest mass	1.67×10^{-27} kg
Charge of electron	-1.60×10^{-19} C
Coulomb's constant (k_e)	9.0×10^{9} N•m^2/C^2
Boltzmann's constant (k)	1.38×10^{-23} J/K
Gas constant (R)	8.31 J/mol•K
Gravitational constant (G)	6.67×10^{-11} N•m^2/kg^2
Permeability of free space (μ_0)	$4\pi \times 10^{-7}$ T•m/A
Avogadro's number	6.02×10^{23}

FORMULAS

Not all formulas necessary are listed, nor are all formulas listed used on this test.

Description	Formula
Constant acceleration	$v = v_i + at$
	$x = x_i + v_i t + \frac{1}{2}at^2$
	$v^2_f - v^2_i = 2a(x_f - x_i)$
	$\overline{v} = \frac{v_i + v_f}{2}$
Circular motion	$a_c = \frac{v^2}{r}$
	$\theta = \theta_i + \omega_i t + \frac{1}{2}\alpha t^2$
	$\omega = \omega_i + \alpha t$
	$v = r\omega$
	$a = r\alpha$
	$\tau = I\alpha$

FORMULAS (continued)

Description	Formula
Spring	$F = -kx$
	$PE = \frac{1}{2}kx^2$
	$T = 2\pi\sqrt{\frac{m}{k}}$
	$\Omega = \sqrt{\frac{k}{m}}$
Pendulum	$T = 2\pi\sqrt{\frac{L}{g}}$
Relativity	$\gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}$
	$v' = \frac{u + v}{1 + \frac{uv}{c^2}}$
Speed of sound in an ideal gas	$v = \sqrt{\frac{\gamma RT}{M}}$
Speed of waves in a string	$v = \sqrt{\frac{T}{\mu}}$
Standing wave condition for a string fixed at both ends	$2L = n\lambda$, n is an integer
Standing wave condition for a string fixed at one end	$4L = n\lambda$, n is odd
Optics	$n_1 \sin \theta_1 = n_2 \sin \theta_2$
	$n = \frac{c}{v}$
	$\frac{1}{f} = \frac{1}{p} + \frac{1}{q}$
Thermodynamics	$T_k = T_c + 273$
	$\Delta U = nc_v \Delta T$
	$Q = mc \Delta T$
	$PV = nRT$
	$\frac{1}{2}m\overline{v^2} = \frac{3}{2}kT$

FORMULAS (continued)

Description	Formula
Fluids	$P = \rho gh$
Magnetism	$\boldsymbol{F} = qv \times B$
	$\boldsymbol{F} = qvB \sin \theta$
	$\boldsymbol{F} = I\ell \times B$
	$\boldsymbol{F} = I\ell B \sin \theta$
	$\mathcal{E}_{\text{ave}} = -\frac{\Delta \phi}{\Delta t}$
	$\phi = B_{\perp}A$
Alternating circuit	$\mathcal{E} = -L\frac{dI}{dt}$
	$\omega_0 = \frac{1}{\sqrt{LC}}$
	$X_L = \omega L$
	$X_C = \frac{1}{\omega C}$
	$Z = \sqrt{(X_C - X_L)^2 + R^2}$
Photoelectric effect	$eV_s = hf - \phi$
Wave-particle relations	$\Delta p \Delta x \geq \frac{h}{4\pi}$
	$E = hf$
	$\lambda = \frac{h}{p}$

NOTES FOR PHYSICS TEST

In questions on electricity and magnetism, the term *current* refers to "conventional current," which is the flow of charge from positive to negative, and the use of right-hand rules is assumed.

While attention has been paid to significant figures, no answer should be considered incorrect solely because of the number of significant figures unless specifically stated in the question.

Practice Selected-Response Questions

Competency 0004

Understand principles of measurement and the process of gathering, organizing, reporting, and interpreting scientific data.

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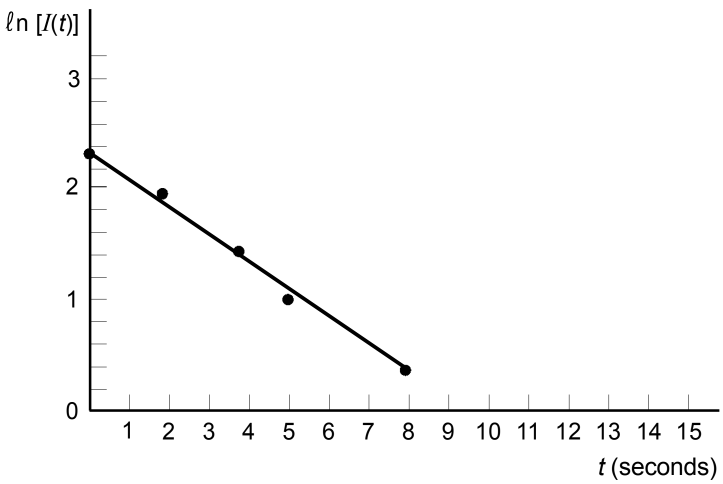
1. **Use the graph below to answer the question that follows.**



The current in a circuit is measured as a function of time, and the data are plotted in the graph above as $\ell n[I(t)]$ on the vertical axis and t on the horizontal axis. If the current is given by an equation of the form $I(t) = Ce^{bt}$, what are the approximate values for C and b, respectively?

A. $C = 0.25$, $b = -2.3$

B. $C = 0.25$, $b = -10$

C. $C = -10$, $b = -0.25$

D. $C = 10$, $b = -0.25$

Correct Response: D. Taking the natural logarithm of both sides of the equation for the current and using the laws of logarithms results in $\ell n[I(t)] = \ell n Ce^{bt} = \ell n C + \ell n e^{bt} = \ell n C + bt$. Therefore, $\ell n[I(t)] = bt + \ell n C$ is a linear equation in t, where b is the slope of the line and $\ell n C$ is the y-intercept. From the graph, the slope of the line is $\frac{0.33 - 2.33}{8 - 0} = {}^{-}0.25$. From the graph, the y-intercept is approximately $2.33 = \ell n C$. This equation can be solved by taking the inverse natural logarithm of both sides, which results in $C = 10.27$.

Competency 0007

Understand characteristics of forces and methods used to measure force, and solve problems involving forces.

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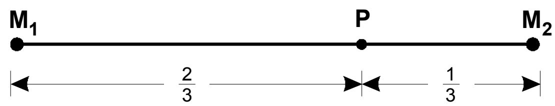
2. **Use the diagram below to answer the question that follows.**



The diagram above shows two point masses, M_1 and M_2, separated by a distance of 1 unit. If the net gravitational force on a third point mass at P is zero, what is the value of M_2?

A. $M_2 = \frac{1}{9}M_1$

B. $M_2 = \frac{1}{4}M_1$

C. $M_2 = \frac{1}{3}M_1$

D. $M_2 = \frac{1}{2}M_1$

Correct Response: B. The gravitational force at any point along the line joining the two masses has a horizontal component only. If a point mass m is located at P the force from M_1 points to the left, and the force from M_2 points to the right. For the net gravitational force to be zero at point P, the magnitude of the force from each mass must be equal. The magnitude of the gravitational field of a point mass M on mass m is $\frac{GMm}{r^2}$. Therefore, at point P

$$\frac{GM_1m}{\left(\frac{2}{3}\right)^2} = \frac{GM_2m}{\left(\frac{1}{3}\right)^2}.$$

Solving this equation for M_2 results in $M_2 = \frac{1}{4}M_1$.

Competency 0010

Understand the concepts of energy, work, and power, and the principles of conservation of energy and momentum.

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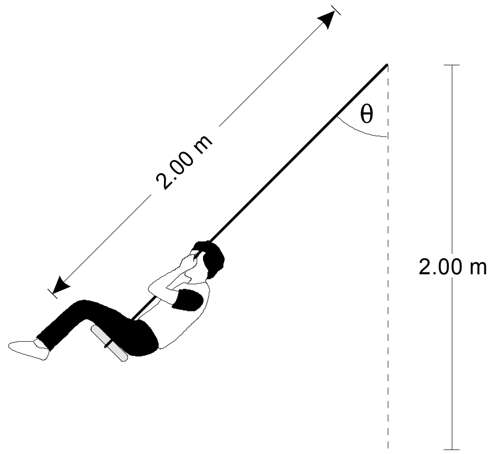
3. **Use the diagram below to answer the question that follows.**



The length of each of the swing ropes on the playground swing shown above is 2.00 meters. What is the maximum speed attainable on the swing if the maximum value of θ is 45.0°?

A. 1.40 m/s

B. 2.00 m/s

C. 3.39 m/s

D. 8.85 m/s

Correct Response: C. Define the potential energy at the lowest point of the path of the swing to be zero. At this point the swing attains its maximum speed and its total mechanical energy is kinetic energy only. When the swing is at its maximum height, h_{max} ($\theta = 45°$), the total energy is potential energy only. By the principle of the conservation of mechanical energy, $mgh_{max} = \frac{1}{2} mv^2_{max}$, or $v_{max} = \sqrt{2gh_{max}}$. Using triangle trigonometry, $h_{max} = 2 \text{ m} - 2\cos 45° \text{ m} = .586 \text{ m}$. Using $g = 9.8 \text{ m/s}^2$, and substituting these values into the expression above, results in $v_{max} = 3.39$ m/s.

Competency 0012

Understand the concept of heat energy and the laws of thermodynamics.

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4. **Use the table below to answer the question that follows.**

Properties of Aluminum	
Melting Point	660°C
Heat of Fusion	4.0×10^5 J/kg
Specific Heat	890 J/kg•°C

The amount of energy needed to produce 1 mole (27 g) of aluminum metal from bauxite ore is 297 kJ. Approximately how much energy could be saved per mole by recycling discarded aluminum (at an initial temperature of 20°C) by melting instead of producing it from bauxite ore?

A. 260 kJ

B. 270 kJ

C. 280 kJ

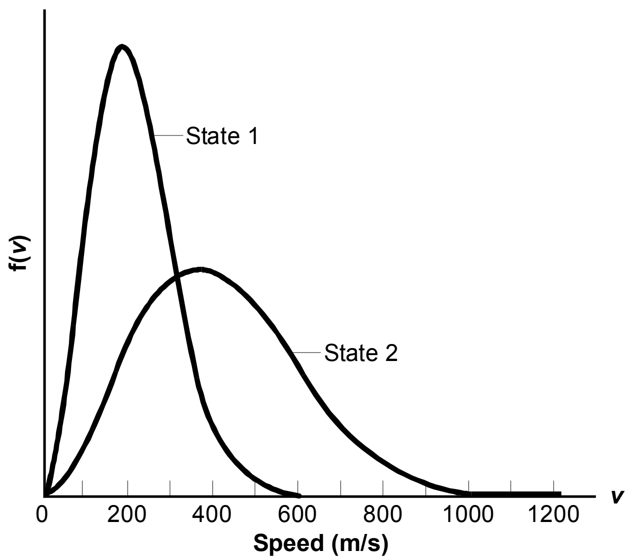
D. 290 kJ

Correct Response: B. To melt the aluminum, a quantity of thermal energy equal to $\Delta Q = mc\Delta T$ must be added to bring the aluminum from 20°C to 660°C, and an additional quantity $Q = m$L must be added to change the aluminum from the solid to the liquid phase. Therefore, the total energy is $\Delta Q = mc\Delta T + m$L. Substituting the appropriate values given in the table results in ΔQ = (0.027 kg)(890 J/kg•°C) (660°C – 20°C) + (0.027 kg)(4.0 × 10^5 J/kg) = 26,000 J of energy to melt one mole of aluminum (when reported to two significant figures). The amount of energy saved is 297 kJ – 26 kJ ≈ 270 kJ.

Competency 0013

Understand the kinetic-molecular theory and its relationship to thermodynamics.

5. **Use the graph below to answer the question that follows.**



An ideal gas at a constant volume is taken from State 1 to State 2. The graph above shows the speed distribution curves f(*v*) for the gas in each of the states. Which of the following statements best describes how the gas was taken from State 1 to State 2?

A. Thermal energy was added to the gas causing an increase in the temperature of the gas.

B. Work was done on the gas causing an increase in the temperature of the gas.

C. Thermal energy was removed from the gas causing a decrease in the temperature of the gas.

D. Work was done by the gas causing a decrease in the temperature of the gas.

Correct Response: A. From the first law of thermodynamics, $\Delta Q = dE - W = C\Delta T - pdV$. Since V is constant, $dV = 0$, so no work was done by or on the gas. From the speed distribution curves, the average speed (v_a) of the molecules is greater in State 2 than in State 1. Since $T \propto \frac{1}{2}mv_a^2$, the temperature of the gas is greater in State 2. Thus, both ΔT and ΔQ are positive.

Competency 0015

Understand the components and properties of direct current circuits.

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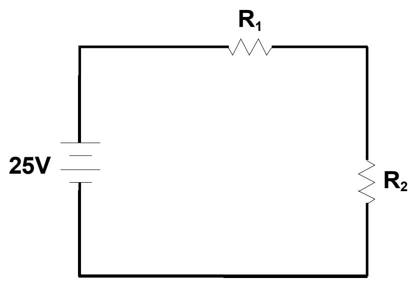
6. **Use the circuit diagram below to answer the question that follows.**



In the DC circuit above, R_1 = 5 Ω and R_2 = 10 Ω. Which of the following changes to the circuit would result in a current flow of 2 amperes through R_2?

A. Connect a 5 Ω resistor in series with R_1 and R_2.

B. Connect a 5 Ω resistor in parallel with R_1.

C. Connect a 5 Ω resistor in parallel with R_2.

D. Connect a 10 Ω resistor in parallel with R_1.

Correct Response: B. The equivalent resistance R_e of two resistors R_a and R_b in parallel is given by $\frac{1}{R_e} = \frac{1}{R_a} + \frac{1}{R_b}$. If a 5 Ω resistor is connected in parallel with R_1, $\frac{1}{R_e} = \frac{2}{5\ \mathrm{W}}$ or $R_e = 2.5\ \Omega$. Since R_e and R_2 are in series, the total resistance of the circuit is $R_e + R_2 = 12.5\ \Omega$. Using Ohm's law and solving for I results in $I = \frac{V}{R} = 2$ amperes of current flowing through R_2.

Competency 0016

Understand magnetic fields and electromagnetic induction.

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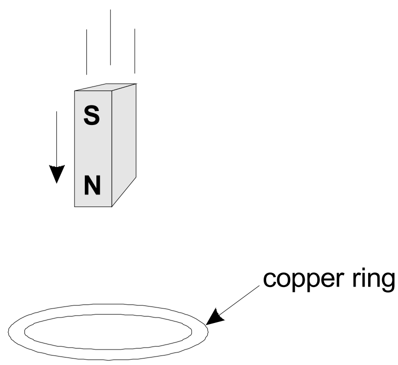
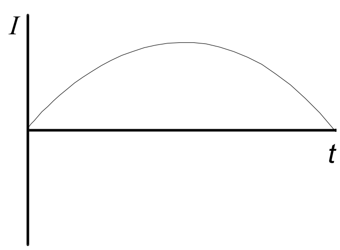
7. **Use the diagram below to answer the question that follows.**

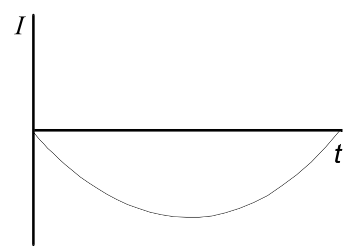


A magnet is passed through a copper ring at a constant speed as shown above. If current in the counterclockwise direction is considered positive, which of the following graphs could represent the current (I) in the ring as a function of time (t)?

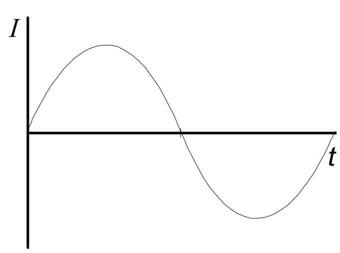
A.



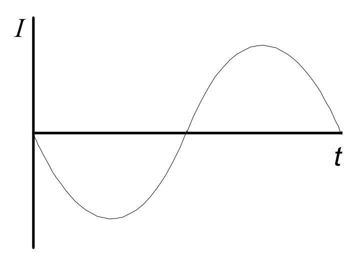
B.



C.



D.



Correct Response: C. According to Lenz's law, the current induced in the ring will be in a direction to oppose the change in magnetic flux through the coil. As the north pole of the magnet approaches the ring, the current will be induced in a direction to create a magnetic field in the ring such that the north pole of the field due to the current repels the north pole of the bar magnet. It follows from the right-hand rule that the current will flow in the counter-clockwise, or positive, direction. After the magnet has passed halfway through the loop, the current in the loop will reverse direction to produce a magnetic field with a north pole pointing down to attract the receding south pole of the bar magnet. The current will therefore be negative as the bar recedes from the copper loop.

Competency 0019

Understand the principles of wave reflection, refraction, diffraction, interference, polarization, dispersion, and the Doppler effect.

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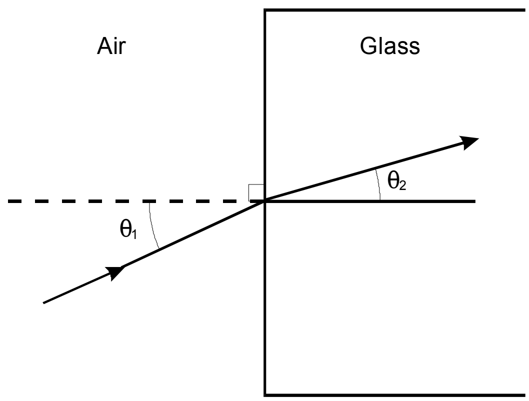
8. **Use the diagram below to answer the question that follows.**



The diagram above shows a ray of light passing from air (speed of light in air = v_1) to glass (speed of light in glass = v_2) with an angle of incidence of θ_1. Which of the following represents $\sin\theta_2$?

A. $\frac{v_1}{v_2}(\sin\theta_1)$

B. $\frac{v_1}{v_2}(\cos\theta_1)$

C. $\frac{v_2}{v_1}(\sin\theta_1)$

D. $\frac{v_2}{v_1}(\cos\theta_1)$

Correct Response: C. From Snell's law, $n_1 \sin\theta_1 = n_2 \sin\theta_2$, where θ_1 is the angle of incidence, θ_2 is the angle of refraction, n_1 is the index of refraction for air, and n_2 is the index of refraction for glass. Therefore, $\sin\theta_2 = \frac{n_1}{n_2}\sin\theta_1$. The index of refraction is related to v, the speed of light in the given material, by $n = \frac{c}{v}$, where c is the speed of light in a vacuum. Substituting this result for n_1 and n_2 results in $\sin\theta_2 = \frac{v_2}{v_1}\sin\theta_1$.

Competency 0021

Understand the production and characteristics of electromagnetic waves.

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9. Which statement best explains how a microwave oven operates?

   A. Electromagnetic radiation excites electron transitions in hydrogen atoms. This energy is transmitted to the rest of the food by re-radiation.

   B. Electromagnetic radiation excites the nuclei of hydrogen atoms by nuclear magnetic resonance. This energy is transmitted to the rest of the food by conduction.

   C. Electromagnetic radiation increases the translational energy of water molecules. This energy is transmitted to the rest of the food by convection.

   D. Electromagnetic radiation excites rotational levels of water molecules. This energy is transmitted to the rest of the food by conduction.

Correct Response: D. According to classical electrodynamics, electromagnetic radiation consists of oscillating electric and magnetic fields that propagate through a vacuum at the speed of light. These fields exert forces and/or torques on charged particles. Microwaves are part of the electromagnetic spectrum with a frequency close to the resonant frequency of rotation of the water molecules, which causes them to rotate vigorously. This rotational thermal energy is then transmitted to the rest of the food by collisions between molecules, which is conduction.

Competency 0023

Understand the photoelectric effect, quantum theory, and the dual nature of light and matter.

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10. Which of the following best explains why macroscopic objects have properties that are more particle-like than wave-like?

    A. The wavelength of a macroscopic object is too small for the object to be diffracted.

    B. The laws of quantum mechanics are valid only for quantities of the order of Planck's constant.

    C. The uncertainty principle implies a small value for the position and momentum of macroscopic objects.

    D. The wave function for a macroscopic object has both a real and an imaginary part.

Correct Response: A. Wave-like properties of objects are observed when an object undergoes diffraction. Diffraction requires scattering from an obstacle or aperture of approximately the same size as the wavelength of the incident object. Since $p\lambda = h$, and $h = 6.63 \times 10^{-34}$ J • s, using $p = mv =$ (1 kg)(1 m/s) for a typical macroscopic object results in a wavelength of the order of 10^{-33} m. This wavelength is significantly smaller than the size of the nucleus of an atom (10^{-15} m).

11. **Use the information below to complete the exercise that follows.**

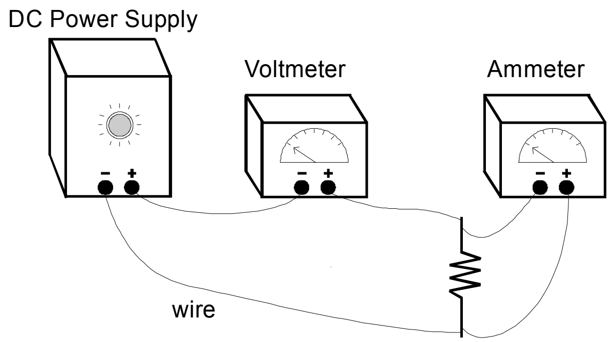
A lab team of four students in a physics class is designing an experiment to determine the relationship between voltage and current in a simple circuit. The group's design is given below.

Experiment to Determine Relationship between Voltage and Current in a Simple Circuit

Materials: Variable (0–15 volt) DC power supply, ammeter, voltmeter, two resistors, connecting wires

Procedure:

1. Wire the circuit as shown, with the 100-ohm resistor.



2. Adjust the power supply so that the voltmeter reads 2 volts.
3. Read the ammeter and record the current and the voltage in the data table.
4. Replace the 100-ohm resistor with the 150-ohm resistor.
5. Repeat steps 2 and 3.

Data analysis: Put data in a table and look for a pattern.

- Identify two significant weaknesses in the proposed experimental design and explain why they are weaknesses, from a scientific perspective.

- Describe two modifications that should be made to the procedures and discuss how they address these weaknesses and enhance the scientific validity of the investigation.

- Describe an effective way to analyze and report the data and discuss why this way is effective.

◆ ◆ ◆ ◆ ◆ ◆ ◆ ◆

FOR YOUR REFERENCE ONLY—*The constructed-response item is written to assess understanding in Subarea I, Foundations of Scientific Inquiry, which consists of the competencies listed below.*

Understand the relationships and common themes that connect mathematics, science, and technology.

Understand the historical and contemporary contexts of the study of physics and the applications of physics to everyday life.

Understand the process of scientific inquiry and the role of observation and experimentation in explaining natural phenomena.

Understand principles of measurement and the process of gathering, organizing, reporting, and interpreting scientific data.

Understand equipment, materials, and chemicals used in science investigations; and apply procedures for their proper and safe use.

A Very Good Response to the Practice Constructed-Response Assignment

The first significant weakness is that the voltmeter and ammeter are not used correctly. Not only are the polarities reversed, the voltmeter is wired in series with the circuit and the ammeter is wired in parallel. This is opposite to how the meters should be used. If the two meters are used in this way, the data will not be valid. It is also very likely that the ammeter will be damaged, since ammeters are very sensitive to current.

The second significant weakness in the design is the failure to measure the correct variables in the experiment. The purpose of the experiment is to determine the relationship between voltage and current in a simple circuit. However, as designed, the experiment fixes the value of the voltage at 2 volts, varies the resistance, and measures the resulting current. Hence, the experiment is measuring how current varies with resistance instead of how the current varies with voltage. In addition, only two data points are being collected. This is too few data points from which to draw any kind of reliable conclusion.

The first modification I would make would be to change the way the two instruments are wired by replacing the ammeter with the voltmeter, and vice versa. In other words, I would wire the ammeter in series to measure the current in the wire. I would next wire the voltmeter in parallel with the resistor to measure the voltage across the resistor. In addition, I would make certain that the polarities of the two instruments are correct. This modification will enhance the scientific validity of the experiment by helping ensure that the data collected is valid.

For the second modification I would make the following changes to the numbered procedures as follows.

2. Adjust the power supply so that the voltmeter reads 0 volts.
3. Read the ammeter and record the current and the voltage in the data table.
4. Increase the voltage by 2 volts.
5. Repeat steps 3 and 4 up to 14 volts.
6. Replace the 100-ohm resistor with the 150-ohm resistor.
7. Repeat steps 2 through 5.

This second modification will enhance the validity of the investigation, because as the voltage is varied, the corresponding current can be measured. In this modification, the voltage is the independent variable, and the current is the dependent variable. It will then be possible to examine the relationship between the voltage and current, which is the goal of the experiment. Repeating the experiment with a different

(continued)

resistor allows students to investigate whether the voltage/current relationship is the same for different values of circuit resistance. In addition, the students will be collecting 8 data points for each resistor, which should more clearly indicate any kind of a relationship in the data.

The data should be reported in two different tables; one table for the 100 Ω resistor, and one table for the 150 Ω resistor. Each table should have columns for voltage and current. These tables should be included in the lab report.

Each table of data should be graphed on an I versus V graph. Students should be able to conclude that the relationship between voltage and current in a simple circuit is linear, i.e., if you double the voltage, you double the current. Further analysis should be done by finding the equation of each line.

CONSTRUCTED-RESPONSE ASSIGNMENT SCORING

All responses to OSAT constructed-response assignments (written and oral) are scored using scoring scales that describe varying levels of performance. These scales were approved by committees of Oklahoma educators who reviewed both the performance characteristics and the scoring scales.

Each response is scored by multiple scorers according to standardized procedures during scoring sessions held immediately after each administration of the CEOE. Scorers with relevant professional backgrounds are oriented to these procedures before the scoring session and are carefully monitored during the scoring sessions.

A constructed-response assignment response is designated unscorable if it is blank, not on the assigned topic, illegible or unintelligible, not in the appropriate language, or of insufficient length to score. If you do not provide a scorable response for each constructed-response assignment on your test, you cannot pass the test regardless of your scores on the other section(s) of the test.

Sample Performance Characteristics for Constructed-Response Assignments

PURPOSE	The extent to which the response achieves the purpose of the assignment
SUBJECT MATTER KNOWLEDGE	Accuracy and appropriateness in the application of subject matter knowledge
SUPPORT	Quality and relevance of supporting details
RATIONALE	Soundness of argument and degree of understanding of the subject matter

Sample Scoring Scale for Constructed-Response Assignments

SCORE POINT	SCORE POINT DESCRIPTION
4	**The "4" response reflects a thorough knowledge and understanding of the subject matter.** • The purpose of the assignment is fully achieved. • There is a substantial, accurate, and appropriate application of subject matter knowledge. • The supporting evidence is sound; there are high-quality, relevant examples. • The response reflects an ably reasoned, comprehensive understanding of the topic.
3	**The "3" response reflects a general knowledge and understanding of the subject matter.** • The purpose of the assignment is largely achieved. • There is a generally accurate and appropriate application of subject matter knowledge. • The supporting evidence generally supports the discussion; there are some relevant examples. • The response reflects a general understanding of the topic.
2	**The "2" response reflects a partial knowledge and understanding of the subject matter.** • The purpose of the assignment is partially achieved. • There is a limited, possibly inaccurate or inappropriate application of subject matter knowledge. • The supporting evidence is limited; there are few relevant examples. • The response reflects a limited, poorly reasoned understanding of the topic.
1	**The "1" response reflects little or no knowledge and understanding of the subject matter.** • The purpose of the assignment is not achieved. • There is little or no appropriate or accurate application of subject matter knowledge. • The supporting evidence, if present, is weak; there are few or no relevant examples. • The response reflects little or no reasoning about or understanding of the topic.
U	**The response is unscorable because it is illegible, not written to the assigned topic, written in a language other than English, or of insufficient length to score.**
B	**There is no response to the assignment.**

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