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Georgia Assessments for the Certification of Educators®

GACE® Study Companion

Physics Assessment

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About the Assessment

Assessment Name	Physics
Grade Level	6–12
Test Code	Test I: 030 Test II: 031 Combined Test I and Test II: 530
Testing Time	Test I: 2 hours Test II: 2 hours Combined Test I and Test II: 4 hours
Test Duration	Test I: 2.5 hours Test II: 2.5 hours Combined Test I and Test II: 5 hours
Test Format	Computer delivered
Number of Selected-response Questions	Test I: 60 Test II: 60 Combined Test I and Test II: 120
Question Format	The test consists of a variety of short-answer questions such as selected-response questions, where you select one answer choice or multiple answer choices (depending on what the question asks for), questions where you enter your answer in a text box, and other types of questions. You can review the possible question types in the ***Guide to Taking a GACE Computer-delivered Test***.
Number of Constructed-response Questions	Test I: 0 Test II: 0 Combined Test I and Test II: 0

The GACE Physics assessment is designed to measure the professional knowledge of prospective teachers of secondary school Physics in the state of Georgia.

This assessment includes two tests. You may take either test individually or the full assessment in a single session. The testing time is the amount of time you will have to answer the questions on the test. Test duration includes time for tutorials and directional screens that may be included in the test.

The questions in this assessment assess both basic knowledge across content areas and the ability to apply principles.

The total number of questions that are scored is typically smaller than the total number of questions on the test. Most tests that contain selected-response questions also include embedded pretest questions, which are not used in calculating your score. By including pretest questions in the assessment, ETS is able to analyze actual test-taker performance on proposed new questions and determine whether they should be included in future versions of the test.

Content Specifications

Each test in this assessment is organized into content **subareas**. Each subarea is further defined by a set of **objectives** and their **knowledge statements**.

- The objectives broadly define what an entry-level educator in this field in Georgia public schools should know and be able to do.
- The knowledge statements describe in greater detail the knowledge and skills eligible for testing.
- Some tests also include content material at the evidence level. This content serves as descriptors of what each knowledge statement encompasses.

See a breakdown of the subareas and objectives for the tests in this assessment on the following pages.

Test I Subareas

Subarea	Approx. Percentage of Test
I. Mechanics	60%
II. Thermodynamics, Atomic and Modern Physics	40%

Test I Objectives

Subarea I: Mechanics

Objective 1: Understands kinematics, vector and scalar quantities, and reference frames, including applications

The beginning Physics teacher:

A. Understands vector and scalar quantities in describing motion and forces
   - Scalars such as mass, speed, time, and energy
   - Vectors such as displacement, velocity, acceleration, force, and momentum
   - Vector components
   - Vector addition (resultant vector)

B. Understands motion in terms of displacement, velocity, and acceleration
   - Linear motion, including graphical interpretation
   - Simple harmonic motion, including pendulums and springs
   - Circular motion
   - Projectile motion
   - Rotational kinematics, such as angular displacement, angular velocity, and angular acceleration

C. Understands frames of reference and their applications
   - Coordinate systems
   - Relative velocity

Objective 2: Understands Newton's laws of motion, force, and universal gravitation, including applications

The beginning Physics teacher:

A. Understands Newton's three laws of motion
   - Newton's first law of motion (mass, inertia, inertial reference frame)
   - Newton's second law of motion (net force, equilibrium)
   - Newton's third law of motion (action-reaction forces)
   - Applications such as inclined planes, simple pendulums, and Atwood's machine

B. Understands friction, including forces and coefficients
   - Normal force
   - Frictional force
   - Air resistance
   - Coefficients of static and kinetic friction

C. Understands circular motion
   - Centripetal acceleration
   - Centripetal force

D. Understands simple harmonic motion
   - Restoring force and Hooke's law
   - Properties of simple harmonic motion, such as frequency, period, amplitude, and damping
   - Pendulums
   - Spring oscillation

E. Understands Newton's law of universal gravitation
   - Gravitational force and Newton's law of universal gravitation
   - Satellites and orbital motion
   - Acceleration due to gravity

F. Understands the difference between weight and mass
   - Weight
   - Mass
   - Misconceptions about weight and mass
   - Relationship between density and mass

G. Understands Kepler's three laws of planetary motion
    - Kepler's first law (law of ellipses)
    - Kepler's second law (law of equal areas)
    - Kepler's third law (relationship between orbital period and mean orbital radius)
H. Understands basic fluid mechanics
    - Properties of fluids, such as buoyancy, density, and pressure
    - Pascal's principle
    - Archimedes' principle
    - Bernoulli's principle

Objective 3: Understands energy, linear momentum, angular momentum, and conservation laws, including applications

The beginning Physics teacher:

A. Understands energy, work, and power and how they are related to one another
    - Mechanical energy (kinetic energy, potential energies, conservation of energy)
    - Energy transformations
    - Energy, work, and power
    - Simple machines, including the lever, pulley, and inclined plane
    - Mechanical advantage
B. Understands linear momentum and impulse and how they are related to one another
    - Linear momentum
    - Impulse
    - Impulse and change in momentum
C. Understands conservation laws
    - Conservation of energy
    - Conservation of linear momentum
    - Conservation of angular momentum
D. Understands the difference between elastic and inelastic collisions
    - Elastic collisions
    - Inelastic collisions
    - Conservation of kinetic energy
    - Conservation of linear momentum
    - Collisions in one and two dimensions

E. Understands rotational motion
   - Center of mass
   - Angular momentum
   - Rotational inertia (moment of inertia)

Subarea II: Thermodynamics, Atomic and Modern Physics

Objective 1: Understands the laws of thermodynamics, heat, energy, and kinetic molecular theory, including applications

The beginning Physics teacher:

A. Understands temperature, temperature scales, heat, and heat capacity
   - Temperature (average kinetic energy)
   - Temperature scales
   - Heat as thermal energy
   - Difference between temperature and heat
   - Heat capacity and specific heat
   - Calorimetry
   - Thermal expansion

B. Understands the mechanisms of heat transfer
   - Conduction
   - Convection
   - Radiation

C. Understands different forms of energy and the transformations between them
   - Forms of energy, such as kinetic, potential, mechanical, electrical, electromagnetic, thermal, chemical, and nuclear
   - Energy transformations
   - Conservation of energy

D. Understands energy involved in phase transitions between the various states of matter
   - Phase transitions
   - Phase diagrams
   - Heating and cooling diagrams
   - Heats of vaporization, fusion, and sublimation

E. Understands kinetic molecular theory and the ideal gas laws
    - Kinetic molecular theory (assumptions of the theory, temperature, pressure, average molecular speeds)
    - Ideal gases and the ideal gas law
F. Understands the laws of thermodynamics
    - First law (internal energy, conservation of energy, work, heat)
    - Second law (entropy)
    - Third law (absolute zero)
    - Zeroth law (thermal equilibrium)
    - P-V diagrams
    - Thermodynamic processes, including isothermal, adiabatic, spontaneous, reversible, and irreversible
    - Carnot cycle, heat engines, and efficiency

Objective 2: Understands atomic models and spectra, radioactivity, and topics in modern physics, including applications

The beginning Physics teacher:

A. Understands the organization, structure, and states of matter
    - Atoms, molecules, ions
    - Solids, liquids, gases, plasmas
    - Chemical and physical properties and changes
B. Understands the nature of atomic and subatomic structure, including various models of the atom
    - Atomic and subatomic structure (electrons, protons, neutrons, and isotopes)
    - Models of the atom, such as the Bohr model
    - Experimental basis of atomic models (Rutherford's gold-foil experiment, Millikan's oil-drop experiment, Thomson's experiment)
C. Understands the relationship of atomic spectra to electron energy levels
    - Bohr model of the atom
    - Discrete electron energy levels
    - Electron energy transitions in atoms
    - Absorption and emission spectra

D. Understands the characteristics, processes, and effects of radioactivity
   - Radioactivity and radioactive decay processes
   - Alpha particles, beta particles, and gamma radiation
   - Half-life
   - Radioisotopes
   - Nuclear forces (strong and weak) and binding energy
   - Fission and fusion
   - Nuclear reactions

E. Understands topics in modern physics
   - Wave-particle duality
   - Photoelectric effect
   - Blackbody radiation
   - Special relativity
   - Mass-energy equivalence
   - Heisenberg uncertainty principle
   - de Broglie's hypothesis

Test II Subareas

Subarea	Approx. Percentage of Test
I. Electricity and Magnetism	40%
II. Optics and Waves	32%
III. Scientific Inquiry, Processes, Technology, and Society	28%

Test II Objectives

Subarea I: Electricity and Magnetism

Objective 1: Understands electrostatics, Coulomb's force law, and electric field and potential, including applications

The beginning Physics teacher:

A. Understands Coulomb's law
   - Electric charge
   - Electrostatic force and Coulomb's law
   - Charging by conduction versus charging by induction

B. Understands electric field and electric potential
   - Electric field
   - Electric potential
   - Voltage and potential difference
   - Electrical potential energy
   - Electric flux

C. Understands basic applications of Gauss's law
   - Electric field inside a conductor (Faraday cage)
   - Electric field of an infinite plane

D. Understands the conductive and resistive properties of materials
   - Conductors
   - Insulators
   - Semiconductors
   - Superconductors

Objective 2: Understands current, resistance, electrical circuits, and sources of potential, including applications

The beginning Physics teacher:

A. Understands electric current, resistance, potential difference, energy, power, and the relationships between them
    - Electric current
    - Potential difference and voltage
    - Resistance and resistivity
    - Ohm's law
    - Energy and power
    - Direct current (DC) and alternating current (AC)
B. Understands capacitance and inductance
    - Capacitance and capacitors
    - Inductance and inductors
C. Understands how to analyze simple series, parallel, and combination circuits
    - Series, parallel, and combination circuits
    - Ohm's law and equivalent resistance
    - Kirchhoff's laws
    - Proper use of ammeters and voltmeters
    - Equivalent capacitance
D. Understands simple electrical devices and sources of electric potential
    - Batteries
    - Photocells
    - Generators

Objective 3: Understands magnetic fields and forces, and changing electric and magnetic fields, including applications

The beginning Physics teacher:

A. Understands magnetic fields
    - Magnetic field and magnetic flux
    - Magnets and magnetic poles, such as bar magnets, permanent magnets, electromagnets
    - Magnetic field generated by a steady current (Biot-Savart law)

B. Understands magnetic forces

- Force between current-carrying wires
- Lorentz force law (force on point charge)
- Direction of fields and forces (right-hand rule)

C. Understands how a changing electric field produces a magnetic field and how a changing magnetic field produces an electric field

- Ampere's law
- Lenz's law (direction of induced current)
- Faraday's law of induction
- Motional emf

Subarea II: Optics and Waves

Objective 1: Understands types of waves, wave properties and phenomena, and the Doppler effect, including applications

The beginning Physics teacher:

A. Understands types of waves and their characteristics

- Transverse and longitudinal waves
- Amplitude, wavelength, frequency, period, speed, energy
- Superposition and phase
- Intensity and inverse square law
- Standing waves

B. Understands basic wave phenomena

- Reflection, refraction, Snell's law, dispersion, total internal reflection
- Diffraction, interference, superposition, Young's double-slit interference experiment
- Polarization
- Scattering, absorption, transmission
- Resonance and natural frequencies, harmonics, beats

C. Understands the fundamentals of the Doppler effect

- Doppler effect and apparent frequency
- Moving source
- Moving observer
- Redshift (blueshift) of light

Objective 2: Understands light, the electromagnetic spectrum, geometric optics, and sound, including applications

The beginning Physics teacher:

A. Understands electromagnetic waves and the electromagnetic spectrum
   - Characteristics of electromagnetic waves
   - Visible light and color
   - Electromagnetic spectrum (radio waves, microwaves, infrared, visible, ultraviolet, X rays, and gamma rays)

B. Understands geometric optics
   - Ray tracing
   - Focal point, image distance, image size and magnification, real versus virtual image, image orientation
   - Simple lenses (converging, diverging)
   - Mirrors (plane, convex, concave, spherical, parabolic)
   - Thin lens and mirror equations
   - Simple instruments such as the magnifying glass, telescope, and microscope
   - Prisms

C. Understands the characteristics of sound
   - Compressional waves
   - Speed of sound (sonic boom, sound barrier)
   - Pitch (frequency), loudness (intensity)
   - Beats
   - Air columns (open and closed pipes), standing waves, and harmonics

Subarea III: Scientific Inquiry, Processes, Technology, and Society

Objective 1: Understands scientific inquiry and technology, and the relationship to society and the environment

The beginning Physics teacher:

A. Understands the processes involved in scientific inquiry
   - Identifying and formulating problems
   - Forming and testing hypotheses
   - Development of theories, models, postulates, assumptions, and laws
   - Process skills including observing, comparing, inferring, categorizing, generalizing, and concluding

B. Understands experimental design
   - Testing hypotheses
   - Significance of controls, independent and dependent variables
   - Use and identification of variables
   - Data collection planning

C. Understands the nature of scientific knowledge
   - Subject to change
   - Consistent with experimental evidence
   - Reproducibility
   - Peer review
   - Unifying concepts and processes, including systems, models, constancy and change, equilibrium, and form and function

D. Understands the major historical developments in physics and the contributions of major historical figures
   - How current principles, laws, models, and theories in physics developed over time
   - Major developments in physics, such as the atomic model and Newtonian mechanics
   - Major historical figures in the development of physics

E. Understands the impact of physics and technology on society and the environment
   - Space exploration, communications
   - Climate change, greenhouse gases, ozone layer depletion, acid rain, water pollution, noise pollution
   - Production, storage, and disposal issues associated with consumer products
   - Recycling

F. Understands applications of physics in daily life
   - Communications, such as wireless devices, fiber optics, and satellites
   - Research tools, such as space telescopes, lasers, and particle colliders
   - Medicine, such as medical imaging and lasers
   - Transportation, including superconductors and magnetic levitation
   - Other applications

G. Understands the advantages and disadvantages associated with various types of energy use
   - Renewable and nonrenewable energy resources
   - Conservation, recycling, and sustainability

- Pros and cons of power generation based on various sources, such as fossil and nuclear fuel, hydropower, wind power, solar power, and geothermal power
- Storage and distribution of renewable energy, including alternative fuels, fuel cells, and rechargeable batteries

Objective 2: Understands how to conduct laboratory processes, including the collection and analysis of data

The beginning Physics teacher:

A. Understands how to collect, evaluate, manipulate, interpret, and report data
   - Measurement uncertainty and significant figures in collected data and calculations
   - Organization and presentation of data
   - Interpreting and drawing valid conclusions from data presented in tables, graphs, and charts
   - Noting trends in data and relationships between variables.
   - Making predictions and drawing conclusions based on data

B. Understands units of measurement, notation systems, conversions, and mathematics used in physics
   - Standard units of measurement
   - Unit conversion and dimensional analysis
   - Scientific notation
   - Measurement equipment

C. Understands basic error analysis
   - Determining mean
   - Accuracy and precision
   - Identifying sources and effects of error and/or uncertainty
   - Percent error

D. Understands the appropriate preparation, use, storage, and disposal of materials in the laboratory
   - Appropriate use
   - Safe disposal
   - Appropriate storage
   - Preparation for classroom use
   - Safe procedures and safety precautions

E. Understands the appropriate use, maintenance, and calibration of laboratory equipment
   - Appropriate use

- Appropriate storage
- Maintenance
- Calibration
- Preparation for classroom use
- Safety procedures and precautions when using equipment

F. Understands safety procedures and precautions for the high school physics laboratory

- Location and use of standard safety equipment, such as eyewash stations and showers
- Laboratory safety rules for students
- Appropriate apparel and conduct in the laboratory, such as wearing goggles
- Emergency procedures

Practice Questions

The practice questions in this study companion are designed to familiarize you with the types of questions you may see on the assessment. While they illustrate some of the formats and types of questions you will see on the test, your performance on these sample questions should not be viewed as a predictor of your performance on the actual test. Fundamentally, the most important component in ensuring your success is familiarity with the content that is covered on the assessment.

To respond to a practice question, choose one of the answer options listed. Be sure to read the directions carefully to ensure that you know what is required for each question. You may find it helpful to time yourself to simulate actual testing conditions. A correct answer and a rationale for each sample test question are in the section following the practice questions.

Keep in mind that the test you take at an actual administration will have different questions, although the proportion of questions in each subarea will be approximately the same. You should not expect the percentage of questions you answer correctly in these practice questions to be exactly the same as when you take the test at an actual administration, since numerous factors affect a person's performance in any given testing situation.

Directions: Each of the questions or incomplete statements below is followed by four suggested answers or completions. Select the one that is best in each case.

1. A book lies on a table that rests on a floor. According to Newton's third law, the reaction to the force of the book pushing down on the table is the force of the

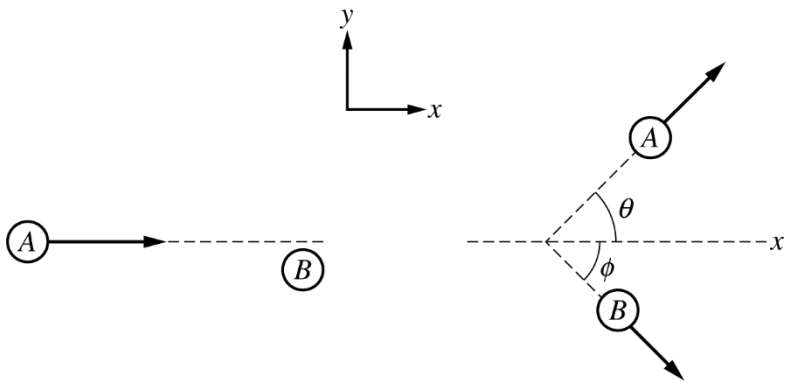
   A. floor pushing up on the table.
   B. floor pushing up on the book.
   C. table pushing down on the floor.
   D. table pushing up on the book.

Answer and Rationale

2. A ball at rest is dropped from the top of a 12-meter-tall building. If air resistance can be neglected, at what distance above the ground does the kinetic energy of the ball equal its potential energy? (Assume that the potential energy is zero at ground level.)

   A. 12 m
   B. 8 m
   C. 6 m
   D. 2 m

Answer and Rationale



Before Collision After Collision

3. The preceding figure shows hockey puck *A* sliding on the ice in the $+x$-direction. The puck collides in a glancing blow with a second identical puck, *B*, that is initially at rest. After the collision, puck *A* moves in the $+y$-direction with speed υ. What is the y-component of *B*'s velocity after the collision?

A. $-\frac{1}{2}\upsilon$

B. $-\frac{1}{\sqrt{2}}\upsilon$

C. $-\upsilon$

D. $-\sqrt{2}\upsilon$

Answer and Rationale

4. Two satellites move in circular orbits around Earth. The radius of the orbit of the outer satellite is three times the radius of the orbit of the inner satellite, as measured from Earth's center. If the orbital speed of the inner satellite is υ, then the orbital speed of the outer satellite is

   A. $\upsilon/3$
   B. $\upsilon/\sqrt{3}$
   C. $\sqrt{3}\cdot\upsilon$
   D. 3υ

Answer and Rationale

5. A mass is suspended from a vertical spring and displaced downward a distance *Y* from its equilibrium position. After being released, it oscillates with period *T*. At a time 5*T*/4, the acceleration of the mass is

   A. a maximum and directed upward.
   B. a maximum and directed downward.
   C. constant.
   D. zero.

Answer and Rationale

6. In a test of an automobile air bag, a mannequin with a mass of 70 kg hits a stationary air bag. The velocity of the mannequin at the instant of impact is 25 m/s. After 0.25 s the mannequin has come to a complete stop and the air bag has deflated. The average force on the mannequin during the 0.25 s interval is most nearly

   A. 70 N
   B. 700 N
   C. 7,000 N
   D. 70,000 N

Answer and Rationale

7. A thin ring of mass 50 g and radius 5.0 cm is spinning at a frequency of 6.0 rev/s. Mass is added uniformly to the ring until it has a final mass of 75 g. What is the final spinning frequency of the ring?

   A. 0 rev/s
   B. 4 rev/s
   C. 6 rev/s
   D. 8 rev/s

Answer and Rationale

8. An ideal gas expands isothermally from an initial volume of V and an initial pressure of P to a final volume of $3V$. The final pressure of the gas is

   A. $\frac{1}{3}P$
   B. P
   C. $3P$
   D. $9P$

Answer and Rationale

9. A washer consists of a 3.00 cm diameter circle of sheet metal with a 1.00 cm diameter circular hole in the middle. If the metal washer is heated until the diameter of the washer is 3.03 cm, then the diameter of the hole will be

   A. 0.97 cm
   B. 0.99 cm
   C. 1.00 cm
   D. 1.01 cm

Answer and Rationale

10. An excited electron in an atom makes a transition back to its ground state. This transition occurs with the emission of which of the following?

    A. A proton
    B. $\bar{A}$ neutron
    C. A photon
    D. An alpha particle

Answer and Rationale

11. A nucleus can emit a negative beta particle according to the reaction represented below, where $n =$ neutron, p = proton, e^- = electron, and $\nu =$ antineutrino.

$$n \rightarrow p + e^- + \bar{\nu}$$

    Which of the following best states the information in the reaction?

    A. A neutron is composed of an electron and a proton
    B. The mass of a neutron is equal to the mass of a proton plus the mass of an electron
    C. Since a neutrino has no rest mass or charge, a neutron may decay into a proton and an electron
    D. The mass of a neutron is greater than the mass of a proton plus the mass of an electron

Answer and Rationale

12. In a particle accelerator, it becomes increasingly difficult to increase a particle's speed because of

    A. relativistic mass increase.
    B. time dilation.
    C. length contraction.
    D. inelastic collisions.

Answer and Rationale

13. If three 4-ohm resistors were connected in various ways in a circuit, which THREE of the following could be an approximate equivalent resistance of the circuit?

    A. 0.75 ohm
    B. 2.67 ohms
    C. 6 ohms
    D. 12 ohms

Answer and Rationale

14. Faraday's law of electromagnetic induction describes how an electric field can be produced at a point in space by

    A. an electric charge.
    B. a constant magnetic field.
    C. a changing magnetic field.
    D. a steady current.

Answer and Rationale

15. If electrons have a velocity of 4.0×10^6 m/s at right angles to a magnetic field of 0.20 N/A·m, what is the magnitude of the force on a single electron?

    A. 1.3×10^{-13} N
    B. 1.6×10^{-14} N
    C. 6.4×10^{-19} N
    D. 3.2×10^{-26} N

Answer and Rationale

16. Which of the following items will be attracted to the north pole of a permanent magnet by a magnetic force?

    A. The north pole of another permanent magnet
    B. A piece of iron that is not a permanent magnet
    C. A positively charged glass rod
    D. A negatively charged rubber rod

Answer and Rationale

17. If equal and opposite charges are placed on the two plates of a parallel plate capacitor and the plates are then moved apart, which of the following remain(s) constant?

    A. Voltage only
    B. Capacitance only
    C. Charge only
    D. Voltage and capacitance

Answer and Rationale

18. A beam of light travels obliquely from one medium to another medium of higher index of refraction *n*. Which THREE of the following are true about the beam of light?

    A. Its speed increases.
    B. Its wavelength decreases.
    C. Its frequency remains the same.
    D. It bends toward the normal.

Answer and Rationale

19. Which of the following is an example of the Doppler effect?

    A. Sudden increase in pitch when a moving sound source is moving away from a listener
    B. Sudden increase in pitch when a moving listener is moving away from a sound source
    C. Sudden drop in pitch as a moving sound source passes and moves away from a listener
    D. Continuous drop in pitch as a moving sound source approaches a listener

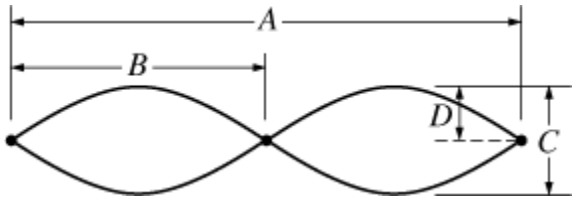
Answer and Rationale

20. Polarized sunglasses are used to cut glare from sunlight reflected at a glancing angle off cars, water, and other surfaces. Such sunglasses are a practical application of which of the following physical principles?

A. Brewster's law
B. Lenz's law
C. Coulomb's law
D. Snell's law

Answer and Rationale

21. The figure below shows a transverse standing wave produced on a string by a vibrating source.



Which of the following correctly indicates the wavelength and amplitude of the wave?

	Wavelength	Amplitude
A.	*A*	*C*
B.	*A*	*D*
C.	*B*	*C*
D.	*B*	*D*

Answer and Rationale

22. Which THREE of the following are appropriate to use in a school laboratory for the measurement of the density of a small rock sample?

    A. Water
    B. A graduated cylinder
    C. A platform balance
    D. A thermometer

Answer and Rationale

23. The electric company uses high voltage to transmit electricity over long distances because

    A. less energy is lost during transmission.
    B. high voltage is safer.
    C. higher frequencies are possible.
    D. larger currents occur at high voltage.

Answer and Rationale

24. The true length of a block of wood is 1.010 cm. Three measurements of this block produced the following values: 1.4 cm, 1.2 cm, and 0.9 cm. Which of the following statements is true concerning these measurements?

    A. They are precise and accurate.
    B. They are precise but not accurate.
    C. They are accurate but not precise.
    D. They are neither precise nor accurate.

Answer and Rationale

Answer Key and Rationales

Question Number	Correct Answer	Rationale
1	D	Option (D) is correct. The reaction force to the force of the book pushing down on the table is the force of the table pushing up on the book. These two forces are equal in magnitude and opposite in direction. ***Back to Question***
2	C	Option (C) is correct. When a ball is dropped from rest from a height h above the ground, its initial energy is entirely potential energy (PE) and is equal to mgh, where m is the mass of the ball and g is the acceleration due to gravity. In the absence of air resistance, as the ball falls, its potential energy is transformed into kinetic energy (KE) only. By energy conservation, at any instant during the fall, the total energy is equal to the initial energy mgh; that is, PE + KE = mgh. When PE = KE, then 2PE = mgh or PE = $mg(h/2)$. This means that PE = KE at a height of $h/2$ = 6 m above the ground. ***Back to Question***
3	C	Option (C) is correct. Linear momentum is conserved during a collision. Linear momentum is also a vector quantity. Prior to the collision, the y-component of the momentum is equal to zero because puck A is moving in the x-direction. This means that after the collision, the y-component of the momentum must be equal to zero. Thus, $m_A v_{Ay} + m_B v_{By} = 0$. But, $m_A = m_B$ and $v_{Ay} = v$, which gives $v_{By} = -v$. ***Back to Question***

		Rationale
4	B	Option (B) is correct. For circular orbital motion in a gravitational field, $\frac{\upsilon^2}{R} = \frac{GM}{R^2}$, which gives $\upsilon^2 = \frac{GM}{R}$. Thus, letting υ_i, R_i denote the velocity and the radius of the orbit of the inner satellite and υ_o, R_o the velocity and the radius of the orbit of the outer satellite, one has $(\frac{\upsilon_o}{\upsilon_i})^2 = \frac{R_i}{R_o}$, or $\upsilon_o = \upsilon\sqrt{\frac{R_i}{R_o}} = \frac{\upsilon}{\sqrt{3}}$ since $\upsilon_i = \upsilon$. ***Back to Question***
5	D	Option (D) is correct. At 5*T*/4, the mass is situated midway between its highest and lowest positions. At this position, the sum of the two forces acting on the mass is zero; thus, its acceleration is zero. ***Back to Question***
6	C	Option (C) is correct. The average force $\overline{F}$ is equal in magnitude to the change in the momentum of the mannequin divided by the elapsed time, or $\overline{F} = \frac{m\Delta V}{\Delta t} = \frac{(70\text{ kg})(25\text{ m/s})}{0.25\text{ s}} = 7{,}000\text{ N}$. ***Back to Question***

Question Number	Correct Answer	Rationale
7	B	Option (B) is correct. The additional mass is added uniformly to the ring, which means that no external torques act on the system and angular momentum is conserved. Now, the angular momentum is equal to the product of the ring's mass, the ring's angular velocity, and the square of the ring's radius. Because the radius is also constant, conservation of angular momentum gives (50 g) × (6.0 rev/s) = (75 g) × (final angular frequency), or final angular frequency = 4 rev/s. ***Back to Question***
8	A	Option (A) is correct. During an isothermal process, the temperature remains constant. For an ideal gas, where $PV = nRT$, this means that $P_iV_i = P_fV_f$, where i and f denote the initial and final states, respectively. Now, $P_i = P$, $V_i = V$, and $V_f = 3V$. Thus, $PV = 3VP_f$, or $P_f = P/3$. ***Back to Question***
9	D	Option (D) is correct. At a given radius, the linear expansion is the same in all radial directions and is equal to the product of the radius, the thermal expansion coefficient, and the temperature change. Thus, the expansion of the inner diameter will be equal to one-third the expansion of the outer diameter, or 0.01 cm, for a total internal diameter of 1.01 cm. ***Back to Question***

Question Number	Correct Answer	Rationale
10	C	Option (C) is correct. When an electron makes a transition from a higher energy level to a lower energy level, a photon is emitted. ***Back to Question***
11	D	Option (D) is correct. The antineutrino carries energy and has a very small, but nonzero, rest mass. Thus, the mass of a neutron must be greater than the mass of a proton plus the mass of an electron. ***Back to Question***
12	A	Option (A) is correct. In a particle accelerator, the particles are accelerated to relativistic speeds. According to the theory of special relativity, a particle's relativistic mass (inertia) increases as the particle's speed increases. Thus, greater and greater forces are needed to accelerate the particle as its speed increases. ***Back to Question***

Question Number	Correct Answer	Rationale
13	B, C, D	Options (B), (C), and (D) are correct. There are four possible combinations of three 4-ohm resistors. The combinations, along with their corresponding equivalent resistances, are as follows: for three in series, equivalent resistance is 12 ohms; for three in parallel, equivalent resistance is 1.33 ohms; for two in series connected in parallel to a third, equivalent resistance is 2.67 ohms; and for two in parallel connected in series to a third, equivalent resistance is 6 ohms. The value 0.75 ohm is not possible for the equivalent resistance. ***Back to Question***
14	C	Option (C) is correct. For circuits, Faraday's law of electromagnetic induction states that the induced electromotive force in a circuit is equal to the rate of change of the magnetic flux through it. In general, Faraday's law relates an electric field in vacuum to the rate of change of a magnetic field. ***Back to Question***
15	A	Option (A) is correct. According to the Lorentz force law, $F = qvB = (1.6 \times 10^{-19}\ \text{C})(4.0 \times 10^{8}\ \text{m/s})\ (0.20\ \text{N/A}\cdot\text{m}) = 1.3 \times 10^{-13}\ \text{N}$. ***Back to Question***

Question Number	Correct Answer	Rationale
16	B	Option (B) is correct. Iron is easily magnetized. When iron is brought close to a permanent magnet, the iron will become magnetized in such a way as to be attracted to the permanent magnet. ***Back to Question***
17	C	Option (C) is correct. The capacitance C of a parallel plate capacitor decreases as the distance between the plates increases. The charge Q on the plates is isolated and will not change. By the definition of capacitance, namely $C = Q/V$, the voltage V will increase, since C decreases and Q remains constant. ***Back to Question***
18	B, C, D	Options (B), (C), and (D) are correct. According to Snell's law $n_1 \sin\theta_1 = n_2 \sin\theta_2$. When $n_2 > n_1$, then $\theta_2 < \theta_1$. This means that the beam bends toward the normal. The frequency f of the light will remain unchanged. Since the speeds of the light in the two mediums are $\upsilon_1 = \frac{c}{n_1}$ and $\upsilon_2 = \frac{c}{n_2}$, $\upsilon_2 < \upsilon_1$ because $n_2 > n_1$. This means the speed υ is decreasing, not increasing. The wavelength is found from $\lambda = \frac{\upsilon}{f}$. Since the frequency f remains the same and the speed υ decreases, the wavelength λ decreases because $\lambda_2 < \lambda_1$. ***Back to Question***

Question Number	Correct Answer	Rationale
19	C	Option (C) is correct. Options A, B, and D are NOT true of the Doppler effect. Option C is true. The pitch drops as a moving sound source passes and then moves away from a listener.

Question Number	Correct Answer	Rationale
		Back to Question
20	A	Option (A) is correct. According to Brewster's law, reflected light will always be polarized in a horizontal direction, parallel to the reflecting surface. Polarized sunglasses are constructed to block this reflected light and to transmit light polarized only in the vertical direction. ***Back to Question***
21	B	Option (B) is correct. The wavelength is equal to twice the distance between nodes, or length *A* in the figure. The amplitude is equal to the maximum displacement of the wave from zero displacement, or length *D* in the figure. ***Back to Question***

Question Number	Correct Answer	Rationale
22	A, B, C	Options (A), (B), and (C) are correct. Density is equal to mass per unit volume. The platform balance can be used to determine the mass and the graduated cylinder and water are used to measure the volume of the water displaced by putting the rock sample in the graduated cylinder. ***Back to Question***
23	A	Option (A) is correct. When electricity is transmitted over long distances at high voltages, lower currents are needed to deliver the same amount of power at the higher voltage. Thus, the energy loss arising from resistive (Joule) heating is significantly reduced, resulting in more efficient transmission. ***Back to Question***
24	D	Option (D) is correct. The measurements differ from the true length by 0.39 cm, 0.19 cm, and –0.11 cm. Thus, the measurements are quite different in value from the true value, which means that they are not accurate. The measurements are also quite different in value from one another (not repeatable), which means that they are not precise. ***Back to Question***

Preparation Resources

The resources listed below may help you prepare for the GACE assessment in this field. These preparation resources have been identified by content experts in the field to provide up-to-date information that relates to the field in general. You may wish to use current issues or editions of these materials to obtain information on specific topics for study and review.

Guide to Taking a GACE Computer-delivered Assessment

This guide explains how to navigate through a GACE assessment and how to answer different types of test questions. This free download is available in the Test Preparation Resources section of the GACE website at ***www.gace.ets.org/prepare***.

Reducing Test Anxiety

This guide provides practical help for people who suffer from test anxiety. Designed specifically for GACE test takers, but useful to anyone who has to take tests, this guide reviews the major causes of test anxiety and offers practical advice for how to counter each one. Download this guide for free from the Test Preparation Resources section of the GACE website at ***www.gace.ets.org/prepare***.

Study Tips: Preparing for a GACE Assessment

This document contains useful information on preparing for selected-response and constructed-response tests. The instruction, tips, and suggestions can help you become a better-prepared test taker. See the Test Preparation Resources section of the GACE website at ***www.gace.ets.org/prepare*** for this free download.

Journals

American Scientist, Sigma XI, the Scientific Research Society

Nature, The Nature Publishing Group

The Physics Teacher, American Association of Physics Teachers

The Science Teacher, National Science Teachers Association

Other Resources

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Online Resources

American Association for the Advancement of Science — ***www.aaas.org***

American Association of Physics Teachers — ***www.aapt.org***

American Physical Society — ***www.aps.org***

National Science Teachers Association — ***www.nsta.org***

Georgia Department of Education — ***www.doe.k12.ga.us***