



*Michigan*  
TEST FOR TEACHER CERTIFICATION  
**STUDY GUIDE**

## 19 Physics



## TABLE OF CONTENTS

### **PART 1:** General Information About the MTTC Program and Test Preparation

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<b>OVERVIEW OF THE TESTING PROGRAM .....</b>	<b>1-1</b>
Contact Information	
Test Development Process	
Characteristics of the Tests	
Test Administration	
Score Reporting	
<b>HOW TO PREPARE FOR THE TESTS .....</b>	<b>1-4</b>
Plan Your Course of Study	
<b>THE DAY OF THE TEST: HELPFUL HINTS.....</b>	<b>1-5</b>
Preparing for the Test Administration	
Test-Taking Tips	
Test Directions	

### **PART 2:** Test Objectives and Sample Test Questions

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<b>INTRODUCTION .....</b>	<b>2-1</b>
<b>TEST OBJECTIVES .....</b>	<b>2-3</b>
<b>SAMPLE MULTIPLE-CHOICE TEST QUESTIONS.....</b>	<b>2-9</b>
<b>ANSWER KEY FOR THE SAMPLE MULTIPLE-CHOICE TEST QUESTIONS.....</b>	<b>2-21</b>

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## **PART 1: General Information About the MTTC Program and Test Preparation**

The first section of the study guide is available in a separate PDF file. Click the link below to view or print this section.

[General Information About the MTTC Program and Test Preparation](#)

## PART 2: Test Objectives and Sample Test Questions

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### INTRODUCTION

This section includes a list of the test objectives, immediately followed by sample test questions and an answer key for the field covered by this study guide.

#### Test Objectives

As noted, the test objectives are broad, conceptual statements that reflect the knowledge, skills, and understanding an entry-level teacher needs in order to teach effectively in a Michigan classroom. Each field's list of test objectives represents the **only** source of information about what a specific test will cover and, therefore, should be studied carefully.

The test objectives are organized into groups known as "subareas." These subareas define the major content areas of the test. You will find a list of subareas at the beginning of the test objective list. The percentages shown in the list of subareas indicate the approximate weighting of the subareas on the test.

#### Sample Multiple-Choice Test Questions

The sample multiple-choice test questions included in this section are designed to give the test-taker an introduction to the nature of the test questions included on the MTTC test for each field. The sample test questions represent the various types of test 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 predict your performance on the test as a whole. Use the answer key that follows the sample test questions to check your answers.

To help you identify which test objective is being assessed, the objective statement to which the question corresponds is listed in the answer key. When you are finished with the sample test questions, you may wish to go back and review the entire list of test objectives and descriptive statements once again.

#### Physics (19) Field-Specific Information

For the Physics (19) test, you will be provided with one of the following models of scientific calculators at the test administration. You may not use your own calculator or calculator manual for this test. The models distributed are subject to change; directions for use will not be provided at the test site.

- Texas Instruments TI-30X
- Texas Instruments TI-30X Solar
- Texas Instruments TI-30Xa
- Texas Instruments TI-30Xs
- Texas Instruments TI-30XII

## TEST OBJECTIVES

All examinees taking the Physics test (Field 19) will be provided with a Texas Instruments scientific calculator with functions that include the following: addition, subtraction, multiplication, division, square root, percent, sine, cosine, tangent, exponents, and logarithms. **You may NOT bring your own calculator to the test.**

Subarea	Approximate Percentage of Questions on Test
Foundations of Scientific Inquiry	12%
Mechanics	24%
Electricity and Magnetism	24%
Waves, Acoustics, and Optics	20%
Nature of Matter, Thermodynamics, and Modern Physics	20%

### FOUNDATIONS OF SCIENTIFIC INQUIRY

**Understand the principles and procedures of scientific inquiry.**

Includes formulating research questions and investigations in physics; developing valid experimental designs for collecting and analyzing data and testing hypotheses; recognizing the need for controlled experiments; understanding procedures for collecting and interpreting data to maintain objectivity; recognizing independent and dependent variables, and analyzing the role of each in experimental design; identifying an appropriate method (e.g., graph, table, equation) for presenting data for a given purpose; applying mathematics to investigations in physics and the analysis of data; interpreting results presented in different formats; evaluating the validity of conclusions; and assessing the reliability of sources of information.

**Apply knowledge of methods and equipment used in scientific investigations.**

Includes selecting and using appropriate measurement devices and methods for collecting data; evaluating the accuracy and precision of measurement in a given situation; identifying uncertainties in measurement; identifying procedures and sources of information related to the safe use, storage, and disposal of materials and equipment related to physics investigations; identifying hazards associated with laboratory practices and materials (e.g., projectiles, lasers, electricity, radioactive materials, liquid nitrogen); and applying procedures for preventing accidents and dealing with emergencies.

**Understand the development of scientific thought and inquiry.**

Includes demonstrating knowledge of the reliance of scientific investigations on empirical data, verifiable evidence, and logical reasoning; recognizing the effect of researcher bias on scientific investigations and the interpretation of data; demonstrating an awareness of the contributions made to physics by individuals of diverse backgrounds and from different time periods; and recognizing the dynamic nature of scientific knowledge, including ways in which scientific knowledge changes.

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## PHYSICS

### **Understand the relationships of physics to technological and societal issues, both contemporary and historical.**

Includes recognizing the relationships between science and technology; analyzing political and social factors that influence developments in physics, including current issues and controversies related to physics research and technology (e.g., energy sources and use, applications and effects of various types of radiation); and evaluating the credibility of scientific claims made in various forums (e.g., the Internet, professional journals, advertising).

### **Understand interrelationships among the physical, life, and earth/space sciences.**

Includes recognizing major unifying themes and concepts that are common to the various scientific disciplines (e.g., patterns, cause and effect, conservation of energy, entropy); describing the integration and interdependence of the sciences; and understanding the interdisciplinary connections among the sciences and their applications in real-world contexts.

## MECHANICS

### **Analyze motion in one and two dimensions.**

Includes analyzing information related to displacement, speed, velocity, and acceleration presented in one or more representations (e.g., graphs, tables, equations); solving problems involving constant acceleration (e.g., free fall); applying principles of trigonometry and properties of vectors to analyze motion in two dimensions (e.g., uniform circular motion, projectile motion); and applying calculus to analyze motion in one dimension.

### **Understand Newton's laws of motion and the law of universal gravitation.**

Includes applying Newton's laws of motion, both descriptively and mathematically, in a variety of situations; solving a variety of problems involving different types of forces (e.g., normal, tension, friction) in one and two dimensions; analyzing the vector nature of force; determining methods for measuring force and differentiating between mass and weight; and applying the law of universal gravitation and Kepler's laws in a variety of situations (e.g., satellite and planetary motion).

### **Understand conservation of energy and conservation of momentum.**

Includes applying the concepts of work, energy, and power in a variety of situations (e.g., inclined planes, pulleys); analyzing the kinetic and potential energy of various systems (e.g., a simple pendulum, a spring that obeys Hooke's law, a satellite in orbit); and applying the principles of conservation of energy and conservation of linear momentum to situations, including elastic and inelastic collisions.

### **Understand torque, static equilibrium, and rotational dynamics.**

Includes analyzing the forces and torques acting in a given situation; applying the concepts of force, torque, and energy to analyze the operation of simple devices (e.g., wrench, beam on a pivot); applying the conservation of angular momentum; and analyzing the motion of a rigid body in terms of moment of inertia, rotational kinetic energy, and angular momentum.

**Understand the characteristics of oscillatory motion.**

Includes analyzing models of simple harmonic motion (e.g., mass on a spring, simple pendulum); recognizing the relationship between the simple harmonic oscillator and uniform circular motion; applying the law of conservation of energy to oscillating systems; and recognizing the effects of damping.

**ELECTRICITY AND MAGNETISM****Understand electric charge, electric fields, and electric potential.**

Includes describing the nature of charge; describing static charges in conductors and insulators; applying Coulomb's law to determine forces and fields due to various charge distributions (e.g., electric dipole); and applying the concepts of electrostatic potential energy, potential, and capacitance.

**Understand simple circuits.**

Includes describing the properties of conductors, insulators, semiconductors, and superconductors; applying Ohm's and Kirchhoff's laws to the analysis of series and parallel circuits; properly using voltmeters and ammeters; determining power dissipated by circuit elements; and analyzing energy transfer and conservation in electrical circuits.

**Understand magnetic fields.**

Includes describing the properties of permanent magnets; applying laws (e.g., Biot-Savart, Ampere's) to determine the orientation and strength of a magnetic field; determining the effect of a magnetic field on moving charges; and explaining the role of magnetic force and torque in the operation of technological devices (e.g., solenoids, galvanometers, motors, loudspeakers).

**Understand electromagnetic induction.**

Includes finding the rate of change of magnetic flux through a surface; analyzing factors that affect the magnitude of an induced emf; determining the direction of an induced current or emf; recognizing that magnetic energy is stored in an inductor; describing alternators and the basic properties of alternating current; and using the principle of electromagnetic induction to explain the operation of technological devices (e.g., generators, transformers, dynamic microphones).

**WAVES, ACOUSTICS, AND OPTICS****Understand the characteristics of waves and wave motion.**

Includes describing the transfer of momentum and energy by wave motion; comparing longitudinal and transverse waves; analyzing and relating the characteristics of waves (e.g., amplitude, wavelength, frequency, speed); explaining reflection, refraction, diffraction, and the Doppler effect; and applying the principle of superposition to investigate the properties of constructive and destructive interference.

**Understand the principles of sound and acoustics.**

Includes explaining the production and propagation of sound waves; applying the principles of standing waves to explain resonance and to analyze the production of musical sounds in vibrating strings and air columns; analyzing the relationship between sound and human perception of sound; and describing and applying the Doppler effect.

**Understand electromagnetic waves and the electromagnetic spectrum.**

Includes identifying the connection between Maxwell's equations and the generation and propagation of electromagnetic waves; demonstrating knowledge of radiometry and photometry; describing the electromagnetic spectrum in terms of wavelength, frequency, and energy; describing how the wave theory of light is applied to a variety of phenomena (i.e., interference, diffraction, and polarization); and analyzing applications of double-slit interference, diffraction gratings, and interferometers.

**Understand ray optics.**

Includes applying the laws of reflection, total internal reflection, and refraction; using ray diagrams with lenses and mirrors; applying the thin lens and spherical mirror equations; explaining the operation of optical instruments (e.g., microscope, telescope, fiber optic cable); and describing the effect of limit resolution.

**NATURE OF MATTER, THERMODYNAMICS, AND MODERN PHYSICS****Understand the particulate nature of matter.**

Includes recognizing basic characteristics of the states of matter; describing how the Maxwell-Boltzmann theory applies to an ideal gas; analyzing phase changes; and describing the properties of materials at low temperatures.

**Understand the laws of thermodynamics.**

Includes differentiating between temperature, internal energy, and heat; calculating heat loss or gain using specific heat; identifying processes of thermal energy transfer (i.e., convection, conduction, radiation); applying the principles of enthalpy, internal energy, and thermodynamic work; applying the law of conservation of energy; and analyzing the relationship between entropy and the availability of energy to perform work.

**Understand the basic ideas of quantum mechanics and relativity.**

Includes explaining blackbody radiation and the photoelectric effect; describing evidence of the dual nature of light and matter; demonstrating a basic understanding of wave functions and the Schrödinger equation; recognizing models of atomic structure and their relationship to spectroscopy; describing the operation of lasers; and demonstrating a basic understanding of the theory of special relativity.

**Understand the basic ideas of nuclear physics.**

Includes recognizing models of the nucleus; describing properties of nuclei (e.g., magnetic moments) and their applications (e.g., nuclear magnetic resonance); relating nuclear structure and forces to radioactivity; solving problems involving half-life; differentiating between fission and fusion reactions and their applications; calculating energy transformations in nuclear reactions; and demonstrating a basic understanding of the properties of quarks and the standard model of elementary particle physics.

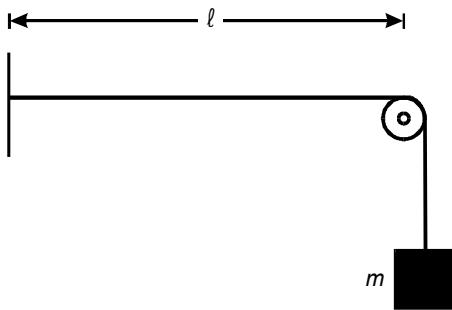
## CONSTANTS

Description	Value
Acceleration of gravity on Earth ( $g$ )	9.8 m/s <sup>2</sup>
Speed of light in a vacuum ( $c$ )	$3.00 \times 10^8$ m/s
Planck's constant ( $h$ )	$6.63 \times 10^{-34}$ J·s = $4.14 \times 10^{-15}$ eV·s
Electron rest mass	$9.11 \times 10^{-31}$ kg
Proton rest mass	$1.67 \times 10^{-27}$ kg
Charge of electron	$-1.60 \times 10^{-19}$ C
Coulomb's constant ( $k_e$ )	$9.0 \times 10^9$ N·m <sup>2</sup> /C <sup>2</sup>
Boltzmann's constant ( $k$ )	$1.38 \times 10^{-23}$ J/K
Gas constant ( $R$ )	8.31 J/mol·K
Gravitational constant ( $G$ )	$6.67 \times 10^{-11}$ N·m <sup>2</sup> /kg <sup>2</sup>
Permeability of free space ( $\mu_0$ )	$4\pi \times 10^{-7}$ T·m/A
Avogadro's number	$6.02 \times 10^{23}$ particles/mole

## SAMPLE MULTIPLE-CHOICE TEST QUESTIONS

All examinees taking the Physics test (Field 19) will be provided with a Texas Instruments scientific calculator with functions that include the following: addition, subtraction, multiplication, division, square root, percent, sine, cosine, tangent, exponents, and logarithms. **You may NOT bring your own calculator to the test.**

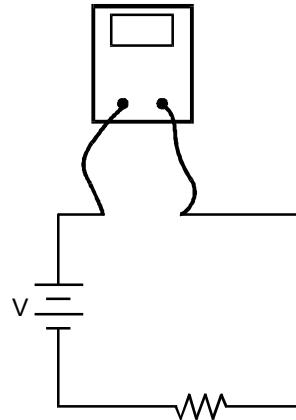
1. Use the diagram below to answer the question that follows.



The diagram shows a string from which different masses may be suspended. The pitch of the note produced when the string is plucked is measured using an electronic tuning device. Which of the following is the dependent variable in this experiment?

- A. frequency
- B. mass
- C. wavelength
- D. amplitude

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

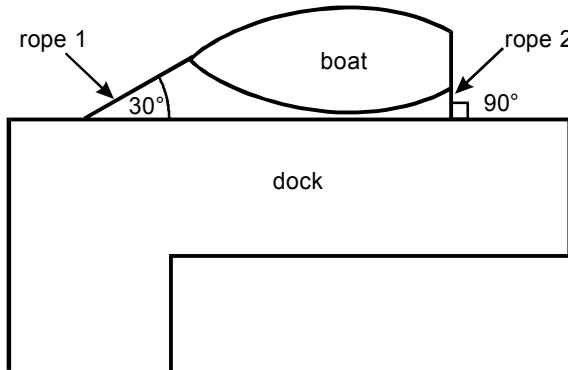


The meter in the circuit above is positioned to measure:

- A. charge stored in the resistor.
- B. current through the resistor.
- C. impedance of the resistor.
- D. potential difference across the resistor.

3. In the 1930s Lise Meitner proposed a mathematical theory that explained how barium was produced when a uranium nucleus was struck by a neutron. Which of the following best describes the significance of this work?
  - A. It described the process that would later be used to develop atomic energy.
  - B. It provided the basis for Einstein to develop the theory of relativity.
  - C. It described the processes of mass-energy transformations that occur in stars.
  - D. It verified earlier theories proposed by Fermi and Oppenheimer.
4. A wheel of radius 0.5 m rotates with an angular speed of 4 rad/s. What is the linear speed of a point on the outer rim of the wheel?
  - A. 2 m/s
  - B. 4 m/s
  - C. 8 m/s
  - D. 16 m/s

Use the diagram below to answer the two questions that follow.

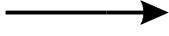
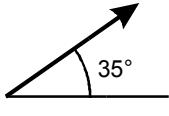
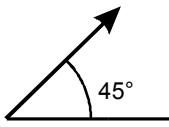
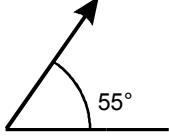


The diagram shows a small boat at a dock in a river with a current flowing. The boat is tied to the dock by rope 1 at the front end and by rope 2 at the back end. The tension in rope 1 is 200 N at an angle of  $30^\circ$  with the dock. The tension in rope 2 is 73 N perpendicular to the dock.

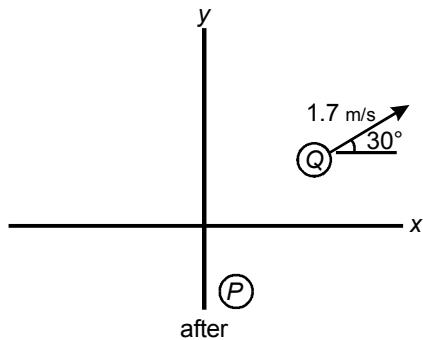
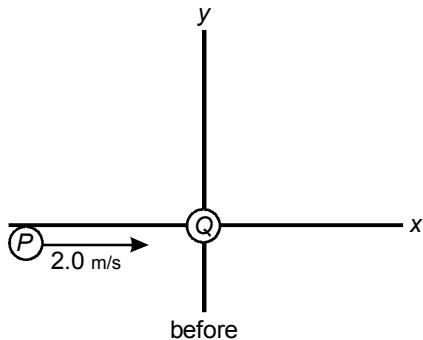
5. What is the magnitude of the force from the current on the boat?

- A. 127 N
- B. 173 N
- C. 245 N
- D. 283 N

6. Which of the following could represent the direction of the force from the current on the boat?

- A. 
- B. 
- C. 
- D. 

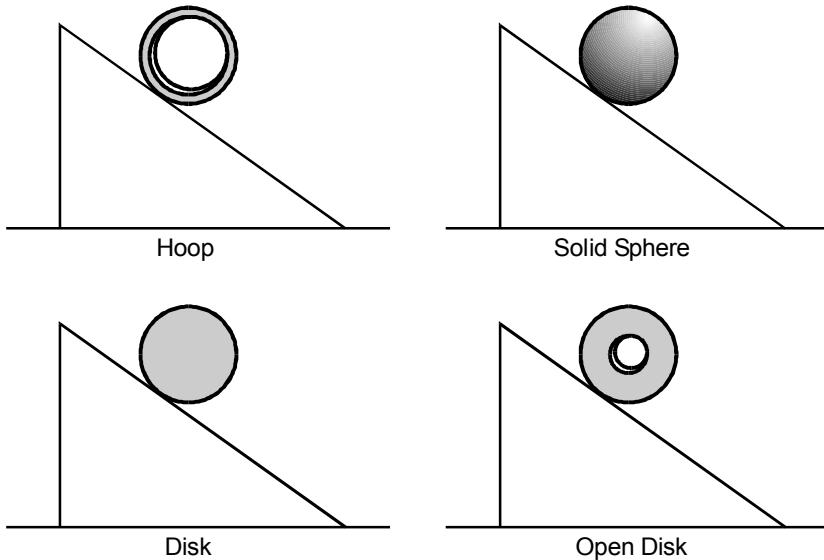
7. Use the diagram below to answer the question that follows.



Two identical disks on a frictionless surface collide. Initially, disk  $Q$  is at rest and disk  $P$  has a horizontal velocity of 2.0 m/s. After the collision, disk  $Q$  has a velocity of 1.7 m/s in the direction shown. What is the  $y$ -component of the velocity of disk  $P$  after the collision?

- A.  $-0.85$  m/s
- B.  $-1.0$  m/s
- C.  $-1.5$  m/s
- D.  $-1.7$  m/s

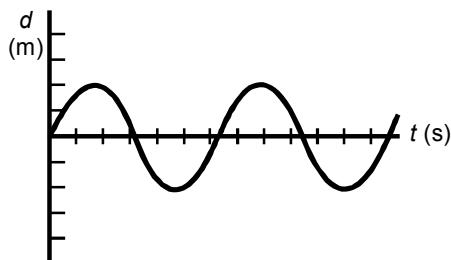
8. Use the diagram below to answer the question that follows.



A hoop, a solid sphere, a disk, and an open disk all have the same mass and radius and roll without slipping down an incline. Which one will have the least acceleration?

- A. the hoop
- B. the solid sphere
- C. the disk
- D. the open disk

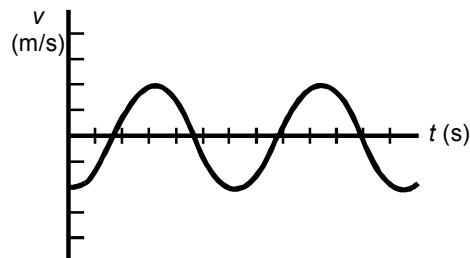
9. Use the graph below to answer the question that follows.



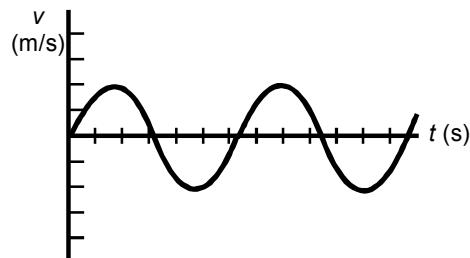
The graph shows the displacement,  $d$ , of a mass as a function of time.

Which of the following graphs shows the velocity,  $v$ , of the mass as a function of time?

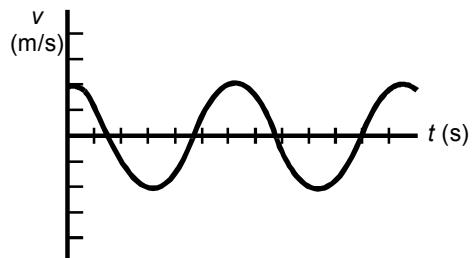
A.



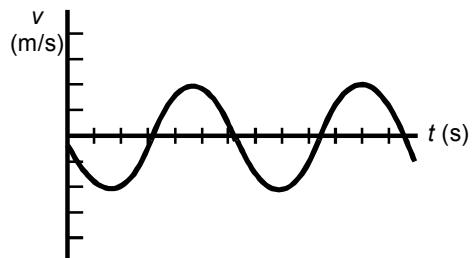
B.



C.

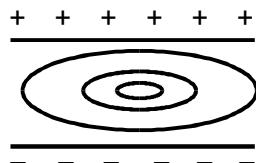


D.

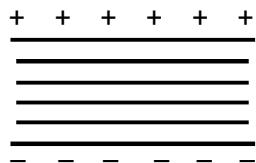


10. Which of the following diagrams correctly represents the lines of equipotential for the electric field between the two charged parallel plates of a capacitor?

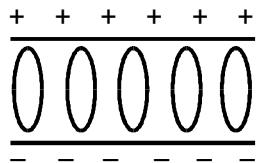
A.



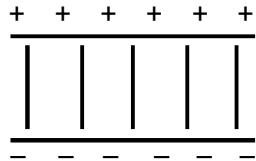
B.



C.



D.



11. A flashlight consists of two 1.5 V batteries and a lamp wired in series. The illuminated lamp has a resistance of  $20 \Omega$ . How much charge passes through the lamp each minute?

A. 0.15 C

B. 6.7 C

C. 9.0 C

D. 400 C

12. The magnetic field inside a solenoid of length  $L$  with 100 turns of wire carrying a current  $I$  has magnitude  $B$ . If the number of turns of wire is doubled while  $L$  and  $I$  remain constant, the magnitude of the field will be:

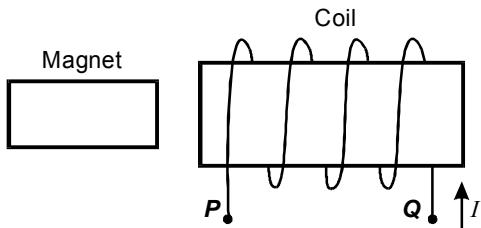
A.  $\frac{1}{2}B$ .

B.  $\sqrt{2}B$ .

C.  $2B$ .

D.  $4B$ .

13. Use the diagram below to answer the question that follows.

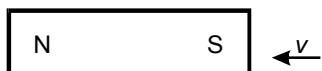


The diagram above shows a bar magnet to the left of a coil of wire. What is the orientation and the direction of motion of the magnet with respect to the coil to induce a current that flows from point *Q* to point *P* at the time shown?

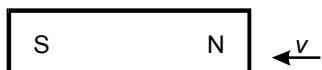
A.



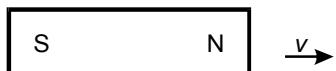
B.



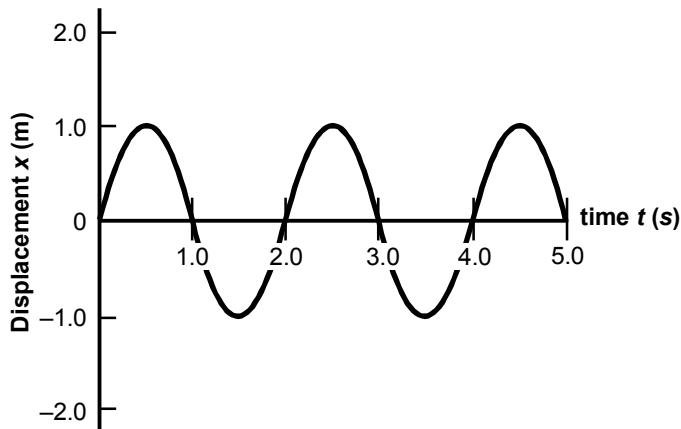
C.



D.



14. Use the graph below to answer the question that follows.



Waves of velocity 4.0 m/s travel along a rope. The graph shows the displacement of a single point on the rope as a function of time. Which of the following is the wavelength of the waves on the rope?

- A. 1.0 m
- B. 2.0 m
- C. 4.0 m
- D. 8.0 m

15. A stationary source is producing sound with a frequency  $f = 500$  Hz. The velocity of sound in air is 343 m/s. An observer approaches the source at 20 m/s. What pitch is heard by the observer?

- A. 235 Hz
- B. 472 Hz
- C. 531 Hz
- D. 728 Hz

16. Use the mirror equation below to answer the question that follows.

$$\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f}$$

An object is located 5.0 cm in front of a concave mirror whose focal length is 20.0 cm. Where is the image located?

- A. 4.0 cm in front of the mirror
- B. 5.7 cm behind the mirror
- C. 6.7 cm behind the mirror
- D. 8.0 cm in front of the mirror

17. Which of the following is a feature of the Maxwell-Boltzmann theory of an ideal gas?

- A. The speeds of the gas molecules are distributed about an average determined by temperature.
- B. The overlapping wavelengths of the gas molecules result in a predictable relationship between pressure and volume.
- C. The energy levels of the gas molecules are only allowed to be in discrete, quantized states.
- D. The gas molecules are modeled as an ensemble of weakly interacting quantum mechanical harmonic oscillators.

18. A resistor submerged in 200 g of water at 20°C is connected to a 10 V DC power source. A current of 0.5 A is applied to the resistor. Assuming the system is thermally insulated, which of the following expressions represents the temperature increase of the water after 5 minutes (specific heat of water = 4.18 J/g°C)?

A. 
$$\frac{(10)(0.25)(5)}{(4.18)(200)}$$

B. 
$$\frac{(10)(1)(0.25)(60)}{(4.18)(200)}$$

C. 
$$\frac{(10)(1)(5)(60)}{(4.18)(200)}$$

D. 
$$\frac{(10)(0.5)(5)(60)}{(4.18)(200)}$$

19. Photons of energy 4.98 eV are incident on a metal with a work function of 4.73 eV. What is the maximum kinetic energy of an electron emitted from the metal?

A. 0.25 eV

B. 1.05 eV

C. 4.85 eV

D. 9.71 eV

20. Which of the following best describes the principle of magnetic resonance imaging (MRI) used in medical research?

A. mapping the magnetic field generated by electron transitions in molecules

B. measuring the energy absorbed as nuclear magnetic moments flip between spin states

C. using a magnetic field to focus the paths of emissions from a radioisotope

D. producing high-energy electromagnetic waves using superconducting magnets

**ANSWER KEY FOR THE SAMPLE MULTIPLE-CHOICE TEST QUESTIONS**

<b>Item Number</b>	<b>Correct Response</b>	<b>Objective</b>
1.	A	Understand the principles and procedures of scientific inquiry.
2.	B	Apply knowledge of methods and equipment used in scientific investigations.
3.	A	Understand the development of scientific thought and inquiry.
4.	A	Analyze motion in one and two dimensions.
5.	C	Understand Newton's laws of motion and the law of universal gravitation.
6.	C	Understand Newton's laws of motion and the law of universal gravitation.
7.	A	Understand conservation of energy and conservation of momentum.
8.	A	Understand torque, static equilibrium, and rotational dynamics.
9.	C	Understand the characteristics of oscillatory motion.
10.	B	Understand electric charge, electric fields, and electric potential.
11.	C	Understand simple circuits.
12.	C	Understand magnetic fields.
13.	C	Understand electromagnetic induction.
14.	D	Understand the characteristics of waves and wave motion.
15.	C	Understand the principles of sound and acoustics.
16.	C	Understand ray optics.
17.	A	Understand the particulate nature of matter.
18.	D	Understand the laws of thermodynamics.
19.	A	Understand the basic ideas of quantum mechanics and relativity.
20.	B	Understand the basic ideas of nuclear physics.