MICHIGAN TEST FOR TEACHER CERTIFICATION (MTTC)

TEST OBJECTIVES
FIELD 019: PHYSICS

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%

I. FOUNDATIONS OF SCIENTIFIC INQUIRY

001 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.

002 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.

003 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.

004 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).

005 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.

II. MECHANICS

006 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.

007 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).

008 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.

009 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.

010 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.

III. ELECTRICITY AND MAGNETISM

011 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.

012 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.

013 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).

014 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).

IV. WAVES, ACOUSTICS, AND OPTICS

015 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.

016 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.

017 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.

018 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.

V. NATURE OF MATTER, THERMODYNAMICS, AND MODERN PHYSICS

019 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.

020 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.

021 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.

022 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.