Massachusetts Tests for Educator Licensure (MTEL™)

FIELD 51: MIDDLE SCHOOL MATHEMATICS/SCIENCE TEST OBJECTIVES

Subarea	Multiple-Choice	Range of Objectives	Approximate Test Weighting
I.	Number Sense and Operations	01–04	8%
II.	Patterns, Relations, and Algebra	05–10	12%
III.	Geometry and Measurement	11–15	9%
IV.	Data Analysis, Statistics, and Probability	16–17	6%
V.	Trigonometry, Calculus, and Discrete Mathematics	18–20	5%
VI.	History, Philosophy, and Methodology of Science	21–24	8%
VII.	Chemistry	25–28	8%
VIII.	Physics	29–32	8%
IX.	Biology	33–36	8%
X.	Earth and Space Science	37–40	8%
			80%
	Open-Response		
XI.	Integration of Knowledge and Understanding of Mathematics	41	**10%**
XII.	Integration of Knowledge and Understanding of Science	42	**10%**

Effective after September 1, 2003

Massachusetts Tests for Educator Licensure (MTEL™)
Test Objectives
Field 51: Middle School Mathematics/Science

SUBAREAS:

NUMBER SENSE AND OPERATIONS
PATTERNS, RELATIONS, AND ALGEBRA
GEOMETRY AND MEASUREMENT
DATA ANALYSIS, STATISTICS, AND PROBABILITY
TRIGONOMETRY, CALCULUS, AND DISCRETE MATHEMATICS
HISTORY, PHILOSOPHY, AND METHODOLOGY OF SCIENCE
CHEMISTRY
PHYSICS
BIOLOGY
EARTH AND SPACE SCIENCE
INTEGRATION OF KNOWLEDGE AND UNDERSTANDING OF MATHEMATICS
INTEGRATION OF KNOWLEDGE AND UNDERSTANDING OF SCIENCE

NUMBER SENSE AND OPERATIONS [8%]

0001 Understand the structure of numeration systems and multiple representations of numbers.

For example: place value; number bases (e.g., base 2, base 10); order relations; relationships between operations (e.g., multiplication as repeated additions); number factors and divisibility; prime and composite numbers; prime factorization; multiple representations of numbers (e.g., physical models, diagrams, numerals); and properties of early numeration systems (e.g., Mayan, Mesopotamian, Egyptian).

0002 Understand principles and operations related to integers, fractions, decimals, percents, ratios, and proportions.

For example: order of operations; identity and inverse elements; associative, commutative, and distributive properties; absolute value; operations with signed numbers; multiple representations (e.g., area models for multiplication) of number operations; analyzing standard algorithms for addition, subtraction, multiplication, and division of integers and rational numbers; number operations and their inverses; and the origins and development of standard computational algorithms.

0003 Understand and solve problems involving integers, fractions, decimals, percents, ratios, and proportions.

For example: solving a variety of problems involving integers, fractions, decimals, percents (including percent increase and decrease), ratios, proportions, and average rate of change; and using estimation to judge the reasonableness of solutions to problems.

0004 Understand the properties of real numbers and the real number system.

For example: rational and irrational numbers; properties (e.g., closure, distributive, associative) of the real number system and its subsets; operations and their inverses; the real number line; roots and powers; the laws of exponents; scientific notation; using number properties to prove theorems (e.g., the product of two even numbers is even); and problems involving real numbers and their operations.

PATTERNS, RELATIONS, AND ALGEBRA [12%]

0005 Understand and use patterns to model and solve problems.

For example: making conjectures about patterns presented in numeric, geometric, or tabular form; representing patterns and relations using symbolic notation; identifying patterns of change created by functions (e.g., linear, quadratic, exponential); and using finite and infinite series and sequences (e.g., Fibonacci, arithmetic, geometric) to model and solve problems.

0006 Understand how to manipulate and simplify algebraic expressions and translate problems into algebraic notation.

For example: the nature of a variable; evaluating algebraic expressions for a given value of a variable; the relationship between standard computational algorithms and algebraic processes; expressing direct and inverse relationships algebraically; expressing one variable in terms of another; manipulating and simplifying algebraic expressions; solving equations; and using algebraic expressions to model situations.

0007 Understand properties of functions and relations.

For example: the difference between functions and relations; the generation and interpretation of graphs that model real-world situations; multiple ways of representing functions (e.g., tabular, graphic, verbal, symbolic); properties of functions and relations (e.g., domain, range, continuity); piecewise-defined functions; addition, subtraction, and composition of functions; and graphs of functions and their transformations [e.g., the relationships among $f(x)$, $f(x + k)$, and $f(x) + k$].

0008 Understand properties and applications of linear relations and functions.

For example: the relationship between linear models and rate of change; direct variation; graphs of linear equations; slope and intercepts of lines; finding an equation for a line; methods of solving systems of linear equations and inequalities (e.g., graphing, substitution); and modeling and solving problems using linear functions and systems.

0009 Understand properties and applications of quadratic relations and functions.

For example: methods of solving quadratic equations and inequalities (e.g., factoring, completing the square, quadratic formula, graphing); real and complex roots of quadratic equations; graphs of quadratic functions; quadratic maximum and minimum problems; and modeling and solving problems using quadratic relations, functions, and systems.

0010 Understand properties and applications of exponential, polynomial, rational, and absolute value functions and relations.

For example: problems involving exponential growth (e.g., population growth, compound interest) and decay (e.g., half-life); inverse variation; modeling problems using rational functions; properties and graphs of polynomial, rational, and absolute value functions; and the use of graphing calculators and computers to find numerical solutions to problems involving exponential, polynomial, rational, and absolute value functions.

GEOMETRY AND MEASUREMENT [9%]

0011 Understand principles, concepts, and procedures related to measurement.

For example: using appropriate units of measurement; unit conversions within and among measurement systems; problems involving length, area, volume, mass, capacity, density, time, temperature, angles, and rates of change; problems involving similar plane figures and indirect measurement; the effect of changing linear dimensions on measures of length, area, or volume; and the effects of measurement error and rounding on computed quantities (e.g., area, density, speed).

0012 Understand the principles of Euclidean geometry and use them to prove theorems.

For example: the nature of axiomatic systems; undefined terms and postulates of Euclidean geometry; relationships among points, lines, angles, and planes; methods for proving triangles congruent; properties of similar triangles; justifying geometric constructions; proving theorems within the axiomatic structure of Euclidean geometry; and the origins and development of geometry in different cultures (e.g., Greek, Hindu, Chinese).

0013 Apply Euclidean geometry to analyze the properties of two-dimensional figures and to solve problems.

For example: using deduction to justify properties of and relationships among triangles, quadrilaterals, and other polygons (e.g., length of sides, angle measures); identifying plane figures given characteristics of sides, angles, and diagonals; the Pythagorean theorem; special right triangle relationships; arcs, angles, and segments associated with circles; deriving and applying formulas for the area of composite shapes; and modeling and solving problems involving two-dimensional figures.

0014 Solve problems involving three-dimensional shapes.

For example: area and volume of and relationships among three-dimensional figures (e.g., prisms, pyramids, cylinders, cones); perspective drawings; cross sections (including conic sections) and nets; deriving properties of three-dimensional figures from two-dimensional shapes; and modeling and solving problems involving three-dimensional geometry.

0015 Understand the principles and properties of coordinate and transformational geometry.

For example: representing geometric figures (e.g., triangles, circles) in the coordinate plane; using concepts of distance, midpoint, slope, and parallel and perpendicular lines to classify and analyze figures (e.g., parallelograms); characteristics of dilations, translations, rotations, reflections, and glide-reflections; types of symmetry; properties of tessellations; transformations in the coordinate plane; and using coordinate and transformational geometry to prove theorems and solve problems.

DATA ANALYSIS, STATISTICS, AND PROBABILITY [6%]

0016 Understand descriptive statistics and the methods used in collecting, organizing, reporting, and analyzing data.

For example: constructing and interpreting tables, charts, and graphs (e.g., line plots, stem-and-leaf plots, box plots, scatter plots); measures of central tendency (e.g., mean, median, mode) and dispersion (e.g., range, standard deviation); frequency distributions; percentile scores; the effects of data transformations on measures of central tendency and variability; evaluating real-world situations to determine appropriate sampling techniques and methods for gathering and organizing data; making appropriate inferences, interpolations, and extrapolations from a set of data; interpreting correlation; and problems involving linear regression models.

0017 Understand the fundamental principles of probability.

For example: representing possible outcomes for a probabilistic situation; counting strategies (e.g., permutations and combinations); computing theoretical probabilities for simple and compound events; using simulations to explore real-world situations; connections between geometry and probability (e.g., probability as a ratio of two areas); and using probability models to understand real-world phenomena.

TRIGONOMETRY, CALCULUS, AND DISCRETE MATHEMATICS [5%]

0018 Understand the properties of trigonometric functions and identities.

For example: degree and radian measure; right triangle trigonometry; the law of sines and the law of cosines; graphs and properties of trigonometric functions and their inverses; amplitude, period, and phase shift; trigonometric identities; and using trigonometric functions to model real-world periodic phenomena.

0019 Understand the conceptual basis of calculus.

For example: the concept of limit; the relationship between slope and rates of change; how the derivative relates to maxima, minima, points of inflection, and concavity of curves; the relationship between integration and the area under a curve; modeling and solving basic problems using differentiation and integration; and the development of calculus.

0020 Understand the principles of discrete/finite mathematics.

For example: properties of sets; recursive patterns and relations; problems involving iteration; properties of algorithms; finite differences; linear programming; properties of matrices; and characteristics and applications of graphs and trees.

HISTORY, PHILOSOPHY, AND METHODOLOGY OF SCIENCE [8%]

0021 Understand the nature of scientific thought and inquiry and the historical development of major scientific ideas.

For example: the reliance of scientific investigation on empirical data; the use of verifiable evidence, reasoning, and logical arguments; the importance of avoiding bias; the evaluation of scientific claims and arguments; science and technology in the ancient world (e.g., China, Greece); the foundations for modern science in the seventeenth and eighteenth centuries; the development of modern science in the nineteenth and twentieth centuries; key figures, discoveries, and theories (e.g., the Copernican revolution, Darwin's theory of evolution); and social, religious, and economic conditions that supported or inhibited the development of science and technology.

0022 Understand principles and procedures of research and experimental design.

For example: the formulation of testable hypotheses; the use of carefully planned research to solve problems; procedures and considerations, including validity and reliability, in setting up and conducting scientific investigations; the use of sampling techniques; and hypothesis testing using control and experimental groups.

0023 Understand procedures for gathering, organizing, interpreting, evaluating, and communicating scientific information.

For example: the systematic observation of phenomena; strategies, tools, and technologies for gathering, measuring, recording, and processing data; advantages and disadvantages of various measurement methods and devices; solving problems involving measurement; the use of various formats (e.g., graphs, flowcharts, tables, step-by-step directions, maps, reports) for organizing, communicating, and interpreting information; the use of data for making predictions and drawing conclusions; and developing models and statistical methods for interpreting and reporting data.

0024 Understand the safe and proper use of tools, equipment, and materials (including chemicals and living organisms) related to classroom and other science investigations.

For example: practices and requirements related to the safe use and storage of tools and equipment; the use and proper disposal of materials; procedures for preventing accidents in the science laboratory; procedures for dealing with accidents and injuries in the science laboratory; and proper practices and requirements related to the use and care of living organisms.

CHEMISTRY [8%]

0025 Understand the structure and nature of matter.

For example: the atomic and molecular structure of matter; the structure of the atom; the use of models of atomic structure to explain chemical behavior; the relationship between atomic structure and the organization of the periodic table; the difference between mixtures and pure substances; and chemical symbols, formulas, and equations.

0026 Understand the nature of physical changes in matter.

For example: states of matter and their characteristics; properties of common materials; physical properties and changes; changes of state and related changes in energy; the concept of mass; the principle of conservation of matter; and types and properties of mixtures and solutions.

0027 Understand the nature of chemical changes in matter.

For example: the description of chemical changes in terms of properties and composition of reactants and products; the use of the principle of conservation of matter to analyze chemical reactions; types of chemical bonds, their characteristics, and their effects on the characteristics of matter; and factors that affect rates of reaction.

0028 Understand the kinetic molecular model of matter.

For example: use of the kinetic molecular theory to explain the states of matter; interrelationships among pressure, temperature, and volume in gaseous systems; and the relationship between temperature and kinetic energy.

PHYSICS [8%]

0029 Understand the concepts of force, motion, work, and power.

For example: Newton's laws of motion; the relationship between mass and inertia; the difference between mass and weight; the vector nature of force, displacement, velocity, and acceleration; characteristics of force, work, and power; the motion of an object in terms of speed, velocity, acceleration, inertia, and momentum; distance-versus-time graphs; and the types and characteristics of simple machines.

0030 Understand the concept of energy and the forms that energy can take.

For example: the concept of conservation of energy; forms of energy (e.g., mechanical, light, thermal, electrical, nuclear); the classification of energy as kinetic or potential; the relationship between kinetic and potential energy; processes of energy transfer and conversion; elastic and inelastic collisions; and the concepts of entropy and thermodynamics.

0031 Understand characteristics of waves and the behavior of sound and light waves.

For example: transverse and longitudinal waves; characteristics (e.g., amplitude, wavelength, frequency) of waves and oscillations; the relationship of wave characteristics to wave speed and wave energy; the relationship between wave characteristics and properties of sound (e.g., loudness, pitch) and light (e.g., color, intensity); wave interactions; the properties and behavior of sound and light waves in various media; phenomena related to light and the behavior of light in various situations (e.g., refraction, diffraction, dispersion); and characteristics and properties of the electromagnetic spectrum.

0032 Understand principles of electricity, magnetism, and electromagnetism.

For example: the properties and formation of static electricity; characteristics of electron flow and electric current; characteristics and components (e.g., batteries, resistors) of simple electric circuits; the interpretation of electric circuit diagrams; characteristics of magnets and magnetic fields; and the principles of electromagnetism.

BIOLOGY [8%]

0033 Understand the characteristics and life processes of living organisms.

For example: differences between living organisms and nonliving things; basic cell structures and their functions; comparisons between animal cells and plant cells; growth of multicellular organisms by cell growth and reproduction; processes of photosynthesis and cellular respiration; homeostatic and metabolic processes; levels of biological organization (i.e., molecules, cells, tissues, organs, and systems); and structures and functions of major systems in plants and animals and interactions between the systems.

0034 Understand principles related to the inheritance of characteristics.

For example: how characteristics are passed on from generation to generation, including mutations and the influence of environmental factors on the inheritance of characteristics; and the structures and functions of DNA, genes, and chromosomes.

0035 Understand principles and theories related to biological evolution.

For example: theories and processes associated with the origin and evolution of life and scientific evidence for these theories and processes; methods used to investigate evolution; the roles of genetic and phenotypic variation, environmental factors, and natural selection in speciation; and the connection between evolutionary relationships and taxonomy.

0036 Understand characteristics of populations, communities, ecosystems, and biomes.

For example: biotic and abiotic factors that affect populations, communities, ecosystems, and biomes; strategies used by organisms to obtain basic requirements for life (e.g., food, shelter, oxygen, water); interrelationships among organisms, including humans, in ecosystems; energy transfers in food webs and food chains; the process of ecological succession; responses of ecosystems to change; and factors regulating population sizes within ecosystems.

Field 51: Middle School Mathematics/Science
Test Objectives

EARTH AND SPACE SCIENCE [8%]

0037 Understand geologic history and processes related to the changing earth.

For example: theories of the origin and history of the earth; methods of determining the relative and absolute ages of inorganic and organic materials; the structure and composition of the earth and its layers; types and characteristics of minerals, rocks, and soils; the processes of mineral formation; processes that are involved in the formation and destruction of igneous, sedimentary, and metamorphic rock; the theory of plate tectonics and supporting evidence; processes of structural change of the earth's crust; the effects of various agents (e.g., glaciers, water, wind) on the earth's surface; important topographical features of the earth and their characteristics; types and characteristics of maps and map projections commonly used in science; and the effects of catastrophic phenomena (e.g., earthquakes, collisions with asteroids) on the earth and its inhabitants.

0038 Understand characteristics and properties of the hydrosphere.

For example: properties of water; characteristics of oceans, surface water, and ground water; and use of the water cycle to explain the movement and renewal of ground water and of water in oceans, glaciers, rivers, lakes, and watersheds.

0039 Understand the earth's atmosphere, weather, and climate.

For example: the structure and characteristics of the atmosphere; factors that contribute to the uneven heating of the earth's surface; the effects on weather of the uneven heating of the earth's surface; mechanisms of energy transfer in the atmosphere; air pressure and the movement of air in the atmosphere; cloud formation and precipitation; equipment and techniques used to monitor the weather; the interpretation of meteorological information; and techniques used to predict the weather and climatic change.

0040 Understand components of the solar system and universe and their interactions.

For example: the planets and their characteristics; interactions and movements of the earth, moon, and sun (e.g., seasons, moon phases, tides, eclipses); characteristics of stars and other objects in the solar system and universe; and theories of the origin and evolution of the universe.

Field 51: Middle School Mathematics/Science
Test Objectives

INTEGRATION OF KNOWLEDGE AND UNDERSTANDING OF MATHEMATICS [10%]

In addition to answering multiple-choice items, candidates will prepare written responses to questions addressing content from the preceding mathematics objectives (1–20), which are summarized in the objective and descriptive statement below.

0041 Prepare an organized, developed analysis on a topic related to one or more of the following: number sense and operations; patterns, relations, and algebra; geometry and measurement; data analysis, statistics, and probability; and trigonometry, calculus, and discrete mathematics.

For example: presenting a detailed solution to a problem involving one or more of the following: place value, number base, and the structure and operations of number systems; application of ratios and proportions in a variety of situations; properties, attributes, and representations of linear functions; modeling problems using exponential functions; the derivative as a rate of change and the integral as area under the curve; applications of plane and three-dimensional geometry; and design, analysis, presentation, and interpretation of a statistical survey.

INTEGRATION OF KNOWLEDGE AND UNDERSTANDING OF SCIENCE [10%]

In addition to answering multiple-choice items, candidates will prepare written responses to questions addressing content from the preceding science objectives (21–40), which are summarized in the objective and descriptive statement below.

0042 Prepare an organized, developed analysis on a topic related to one or more of the following: history, philosophy, and methodology of science; chemistry; physics; biology; and earth and space science.

For example: the structure and nature of matter; chemical and physical changes in matter; the concepts of energy, force, and motion; characteristics and behavior of waves, sound, and light; characteristics and life processes of living organisms; principles and theories related to the inheritance of characteristics and biological evolution; the structure and composition of the earth and processes of structural change in the earth's crust; characteristics and properties of the hydrosphere and atmosphere; components of the solar system and universe and their interactions; and the nature of scientific thought and inquiry.