**Subject Matter Knowledge Matrix**

**Middle School: Mathematics/Science, 5-8**

Students in Massachusetts must meet rigorous academic standards, which are outlined in the [Massachusetts Curriculum Frameworks](https://www.doe.mass.edu/frameworks/). To do so, they must have access to educators with strong content knowledge and pedagogical skills, the building blocks of effective instructional practice.

In support of this, the [Subject Matter Knowledge Guidelines](https://www.doe.mass.edu/edprep/domains/instruction/smk-guidelines.docx) set forth the content knowledge expectations for educator licensure in Massachusetts. Through these expectations, the Massachusetts Department of Elementary and Secondary Education (DESE) seeks to ensure that educators entering the workforce have sufficient content knowledge in their licensure area to support students in mastering the Massachusetts Curriculum Frameworks.

While the Curriculum Frameworks serve as an anchor, the intent is not that educators should simply know the content included in the Frameworks. Rather, educators must move beyond basic or functional knowledge to a level of fluency or expertise with the academic standards such that they can teach and support students in mastering the content.

The figure below shows a steady progression, not in the amount of information one knows, but in the depth and ability to use that information for a specific purpose. The boxes below the continuum outline some assessments used to determine varying levels of content knowledge. The depth at which the knowledge and application of content knowledge must be demonstrated is dependent on the stage of development for an individual educator (i.e. Basic, Functional, Fluent, or Expert) and/or license type (Provisional, Initial, or Professional).



This worksheet should be completed for Middle School: Mathematics/Science, 5-8 programs, for which Subject Matter Knowledge expectations come from multiple [Curriculum Frameworks](https://www.doe.mass.edu/frameworks/). Within this document you will find sections covering the following SMK expectations:

[Mathematics](#_Mathematics_Content_Progression)

* Mathematics Content Progression
* Mathematical Rigor
* Standards for Mathematics Practices

[Science and Technology/Engineering](#_Science_and_Technology/Engineering)

* Science and Technology/Engineering Content Progression
* Science and Technology/Engineering Practices

# Mathematics Content Progression

The Mathematics Content Progression outlines the core mathematical knowledge that students should learn from PK through grade 12. To create a strong vertical progression of learning, educators should have the content knowledge to support PK-12 students in mastering prerequisite and advanced content standards. Teachers need to be able to access knowledge from prior grades, and teachers who are aware of later content can make better choices about what to emphasize, what language to use, and what larger contexts to provide for their students. This expectation allows teachers to meet students where they are and prepare them for where they are going.

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| **Instructions*:***The content knowledge below must either be covered directly through program coursework or screened during the admissions process. For each grade level, list the numbers/abbreviations/titles of the **sponsoring organization’s required courses where the content knowledge is explicitly targeted and coherently addressed**. Then, **briefly describe where in the syllabus the content is covered** (i.e., unit name, week number, objective number). Course identifiers should match those of submitted syllabi and content knowledge for each grade level should not be spread across too many courses.     The full [Mathematics Curriculum Framework](https://www.doe.mass.edu/frameworks/current.html), including the Guiding Principles which are also available in Appendix A of this document, should be consulted when designing programs to ensure appropriate content coverage and rigor for each licensure field’s grade span. Sponsoring Organizations should prioritize content fluency in the grade span for the license while ensuring functional content knowledge in the two grade levels below and above the grade span. |

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| **Mathematics Content Progression**  | **Course(s) or Screening**  |
| *Example Row*  | *EDU 101 – Weeks 5-7*  |
| **Grade 3**: Instructional time should focus on four critical areas: (1) developing understanding of multiplication and division and strategies for multiplication and division within 100; (2) developing understanding of fractions, especially unit fractions (fractions with numerator 1); (3) developing understanding of the structure of rectangular arrays and of area; and (4) describing and analyzing two-dimensional shapes.  |   |
| **Grade 4:** Instructional time should focus on three critical areas: (1) developing understanding and fluency with multi-digit multiplication, and developing understanding of dividing to find quotients involving multi-digit dividends; (2) developing an understanding of fraction equivalence, addition and subtraction of fractions with like denominators, and multiplication of fractions by whole numbers; (3) and understanding that geometric figures can be analyzed and classified based on their properties, such as having parallel sides, perpendicular sides, particular angle measures, and symmetry.  |   |
| **Grade 5:** Instructional time should focus on four critical areas: (1) developing fluency with addition and subtraction of fractions, and developing understanding of the multiplication of fractions and of division of fractions in limited cases (unit fractions divided by whole numbers and whole numbers divided by unit fractions); (2) extending division to 2-digit divisors, integrating decimal fractions into the place value system and developing understanding of operations with decimals to hundredths, and developing fluency with whole number and decimal operations; and (3) developing understanding of measurement systems and determining volumes to solve problems; and (4) solving problems using the coordinate plane.  |   |
| **Grade 6:** Instructional time should focus on five critical areas: (1) connecting ratio and rate to whole number multiplication and division, and using concepts of ratio and rate to solve problems; (2) completing understanding of division of fractions and extending the notion of number to the system of rational numbers, which includes negative numbers; (3) writing, interpreting, and using expressions and equations; (4) developing understanding of statistical thinking; and (5) reasoning about geometric shapes and their measurements.  |   |
| **Grade 7:** Instructional time should focus on four critical areas: (1) developing understanding of and applying proportional relationships; (2) developing understanding of operations with rational numbers and working with expressions and linear equations; (3) solving problems involving scale drawings and informal geometric constructions, and working with two- and three-dimensional shapes to solve problems involving area, surface area, and volume; and (4) drawing inferences about populations based on samples.  |   |
| **Grade 8**: Instructional time should focus on three critical areas: (1) formulating and reasoning about expressions and equations, including modeling an association in bivariate data with a linear equation and solving linear equations and systems of linear equations; (2) grasping the concept of a function and using functions to describe quantitative relationships; and (3) analyzing two- and three-dimensional space and figures using distance, angle, similarity, and congruence, and understanding and applying the Pythagorean Theorem.  |   |
| **Model Algebra I**: Instructional time should focus on four critical areas: (1) deepen and extend understanding of linear and exponential relationships; (2) contrast linear and exponential relationships with each other and engage in methods for analyzing, solving, and using quadratic functions; (3) extend the laws of exponents to square and cube roots; and (4) apply linear models to data that exhibit a linear trend. |   |
| **Model Geometry:** Instructional time should focus on more complex geometric situations and deepen their explanations of geometric relationships by presenting and hearing formal mathematical arguments. Important differences exist between this course and the historical approach taken in geometry classes. For example, transformations are emphasized in this course. Close attention should be paid to the introductory content for the Geometry conceptual category. |  |
| **Model Mathematics I**: Instructional time should focus on six critical areas, each of which is described in more detail below: (1) extend understanding of numerical manipulation to algebraic manipulation; (2) synthesize understanding of function; (3) deepen and extend understanding of linear relationships; (4) apply linear models to data that exhibit a linear trend; (5) establish criteria for congruence based on rigid motions; and (6) apply the Pythagorean Theorem to the coordinate plane. |  |
| **Model Mathematics II**: Instructional time should focus on five critical areas: (1) extend the laws of exponents to rational exponents; (2) compare key characteristics of quadratic functions with those of linear and exponential functions; (3) create and solve equations and inequalities involving linear, exponential, and quadratic expressions; (4) extend work with probability; and (5) establish criteria for similarity of triangles based on dilations and proportional reasoning. |  |

# Mathematical Rigor

Students reach fluency by building understanding of mathematical concepts – this lays a strong foundation that prepares them for more advanced math work – and by building automaticity in the recall of basic computation facts, such as addition, subtraction, multiplication, and division. As students apply their mathematical knowledge and skills to solve real-world problems, they also gain an understanding of the importance of mathematics throughout their lives. To achieve mathematical understanding, students should be actively engaged in meaningful mathematics. The content and practice standards focus on developing students in the following areas:

* Conceptual understanding – make sense of the math, reason about and understand math concepts and ideas
* Procedural fluency – know mathematical facts, compute and do the math
* Capacity – solve a wide range of problems in various contexts by reasoning, thinking, and applying the mathematics they have learned.

Educators should have the content knowledge to support PK-12 students in achieving this mathematical understanding.

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| **Instructions:** Initial licensure program candidates must reach a level of fluent content knowledge to be endorsed. They must be able to apply content in a range of contexts and vertically connect content to build students’ knowledge. As such, sponsoring organizations must have at least one course at the fluent level for Mathematical Rigor.   Please list the numbers/abbreviations/titles of the **required course(s) where the elements of Mathematical Rigor are explicitly targeted and coherently addressed**. Course identifiers should match the numbers/abbreviations/titles of submitted syllabi.    Then, **briefly describe how course(s) teach candidates to understand content and practice standards using the elements of Mathematical Rigor**.   |

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|    **Mathematical Rigor**  | **Fluent**  *Initial*  *Licensure*    |
| *Example Row*  | *EDU 101 – Weeks 5-7*  |
| * Conceptual understanding – make sense of the math, reason about and understand math concepts and ideas
* Procedural fluency – know mathematical facts, compute and do the math
* Capacity – solve a wide range of problems in various contexts by reasoning, thinking, and applying the mathematics they have learned.
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| *Description:*   |

# Standards for Mathematical Practice

The Standards for Mathematical Practice describe skills that mathematics educators at all levels should seek to develop in their PK-12 students. They complement the content standards so that students increasingly engage with the subject matter as they grow in mathematical maturity and expertise throughout the elementary, middle, and high school years.

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| **Instructions*:***Initial licensure program candidates must reach a level of fluent content knowledge in order to be endorsed. They must be able to apply content in a range of contexts and vertically connect content to build students’ knowledge. As such, sponsoring organizations must have at least one course covering the practices at the fluent level.   Please list the numbers/abbreviations/titles of the **required courses where practices are explicitly targeted and coherently addressed**. Then, **briefly describe where in the syllabus each practice is covered** (i.e., unit name, week number, objective number). Course identifiers should match those of submitted syllabi and practices should not be spread across too many courses.  |

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|   **Standards for Mathematical Practice**   | **Fluent** *Initial* *Licensure*   |
| *Example Row*  | *EDU 101 – Weeks 5-7*  |
| **1. Make sense of problems and persevere in solving them.** Mathematically proficient students start by explaining to themselves the meaning of a problem and looking for entry points to its solution. They analyze givens, constraints, relationships, and goals. They make conjectures about the form and meaning of the solution and plan a solution pathway rather than simply jumping into a solution attempt. They consider analogous problems and try special cases and simpler forms of the original problem to gain insight into its solution. They monitor and evaluate their progress and change course if necessary. Older students might, depending on the context of the problem, transform algebraic expressions or change the viewing window on their graphing calculator to get the information they need. Mathematically proficient students can explain correspondences between equations, verbal descriptions, tables, and graphs or draw diagrams of important features and relationships, graph data, and search for regularity or trends. Younger students might rely on using concrete objects or pictures to help conceptualize and solve a problem. Mathematically proficient students check their answers to problems using a different method, and they continually ask themselves, “Does this make sense?” They can understand others’ approaches to solving complex problems and identify correspondences among different approaches.   |   |
| **2. Reason abstractly and quantitatively.** Mathematically proficient students make sense of the quantities and their relationships in problem situations. Students bring two complementary abilities to bear on problems involving quantitative relationships: the ability to decontextualize—to abstract a given situation and represent it symbolically and manipulate the representing symbols as if they have a life of their own, without necessarily attending to their referents—and the ability to contextualize, to pause as needed during the manipulation process to probe into the referents for the symbols involved. Quantitative reasoning entails habits of creating a coherent representation of the problem at hand; considering the units involved; attending to the meanings of quantities, not just how to compute them; and knowing and flexibly using different properties of operations and objects.   |   |
| **3. Construct viable arguments and critique the reasoning of others.** Mathematically proficient students understand and use stated assumptions, definitions, and previously established results in constructing arguments. They make conjectures and build a logical progression of statements to explore the truth of their conjectures. They can analyze situations by breaking them into cases and can recognize and use counterexamples. They justify their conclusions, communicate them to others, and respond to the arguments of others. They reason inductively about data, making plausible arguments that take into account the context from which the data arose. Mathematically proficient students are also able to compare the effectiveness of two plausible arguments, distinguish correct logic or reasoning from that which is flawed, and—if there is a flaw in an argument—explain what it is. Elementary students can construct arguments using concrete referents such as objects, drawings, diagrams, and actions. Such arguments can make sense and be correct, even though they are not generalized or made formal until later grades. Later, students learn to determine domains to which an argument applies. Students at all grades can listen or read the arguments of others, decide whether they make sense, and ask useful questions to clarify or improve the arguments.   |   |
| **4. Model with mathematics.** Mathematically proficient students can apply the mathematics they know to solve problems arising in everyday life, society, and the workplace. In early grades, this might be as simple as writing an addition equation to describe a situation. In middle grades, a student might apply proportional reasoning to plan a school event or analyze a problem in the community. By high school, a student might use geometry to solve a design problem or use a function to describe how one quantity of interest depends on another. Mathematically proficient students who can apply what they know are comfortable making assumptions and approximations to simplify a complicated situation, realizing that these may need revision later. They can identify important quantities in a practical situation and map their relationships using such tools as diagrams, two-way tables, graphs, flowcharts and formulas. They can analyze those relationships mathematically to draw conclusions. They routinely interpret their mathematical results in the context of the situation and reflect on whether the results make sense, possibly improving the model if it has not served its purpose.   |   |
| **5. Use appropriate tools strategically.** Mathematically proficient students consider the available tools when solving a mathematical problem. These tools might include pencil and paper, concrete models, a ruler, a protractor, a calculator, a spreadsheet, a computer algebra system, a statistical package, or dynamic geometry software. Proficient students are sufficiently familiar with tools appropriate for their grade or course to make sound decisions about when each of these tools might be helpful, recognizing both the insight to be gained and their limitations. For example, mathematically proficient high school students analyze graphs of functions and solutions generated using a graphing calculator. They detect possible errors by strategically using estimation and other mathematical knowledge. When making mathematical models, they know that technology can enable them to visualize the results of varying assumptions, explore consequences, and compare predictions with data. Mathematically proficient students at various grade levels can identify relevant external mathematical resources, such as digital content located on a website, and use them to pose or solve problems. They can use technological tools to explore and deepen their understanding of concepts.   |   |
| **6. Attend to precision.** Mathematically proficient students try to communicate precisely to others. They try to use clear definitions in discussion with others and in communicating their own reasoning verbally and/or in writing. In problem solving they state the meaning of the symbols they choose, including using the equal sign consistently and appropriately. They are careful about specifying units of measure and labeling axes to clarify the correspondence with quantities in a problem. They calculate accurately and efficiently, expressing numerical answers with a degree of precision appropriate for the problem context. In the elementary grades, students give carefully formulated explanations to each other. By the time they reach high school, they have learned to examine claims and make explicit use of definitions.   |   |
| **7. Look for and make use of structure.** Mathematically proficient students look closely to discern a pattern or structure. Young students, for example, might notice that three and seven more is the same amount as seven and three more, or they may sort a collection of shapes according to how many sides the shapes have. Later, students will see 7 x 8 equals the well-remembered 7 x 5 + 7 x 3, in preparation for learning about the distributive property. In the expression x 2 + 9x + 14, older students can see the 14 as 2 x 7 and the 9 as 2 + 7. They recognize the significance of an existing line in a geometric figure and can use the strategy of drawing an auxiliary line for solving problems. They also can step back for an overview and shift perspective. They can see complicated things, such as some algebraic expressions, as single objects or as being composed of several objects. For example, they can see 5 – 3(x – y) 2 as 5 minus a positive number times a square, and use that to realize that its value cannot be more than 5 for any real numbers x and y.   |   |
| **8. Look for and express regularity in repeated reasoning.** Mathematically proficient students notice if calculations are repeated and look both for general methods and for shortcuts. Upper elementary students might notice when dividing 25 by 11 that they are repeating the same calculations over and over again, and conclude they have a repeating decimal. By paying attention to the calculation of slope as they repeatedly check whether points are on the line through (1, 2) with slope 3, middle school students might abstract the equation (y – 2)∕(x – 1) = 3. Noticing the regularity in the way terms cancel when expanding (x – 1)(x + 1), (x – 1)(x 2 + x + 1), and (x – 1)(x 3 + x 2 + x + 1) might lead them to the general formula for the sum of a geometric series. As they work to solve a problem, mathematically proficient students maintain oversight of the process, while attending to the details. They continually evaluate the reasonableness of their intermediate results.   |   |

# Science and Technology/Engineering Content Progression

The Science and Technology/Engineering Framework includes the following domains of science: Earth and Space, Life, Physical and Technology/Engineering. All domains of science should be addressed in PK through grade 8.At the high school level, courses may specialize in one or more domains. To view this progression, see [Appendix III of the Science and Technology/Engineering Curriculum Framework](https://www.doe.mass.edu/frameworks/scitech/2016-04.pdf#page=134).

To create a strong vertical progression of learning, educators should have the content knowledge to support PK-12 students in mastering prerequisite and advanced standards. Teachers need to be able to access knowledge from prior grades, and teachers who are aware of later content can make better choices about what to emphasize, what language to use, and what larger contexts to provide for their students. This expectation allows teachers to meet students where they are and prepare them for where they are going.

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| **Science and Technology/Engineering Content Progression**  | **Course(s) or Screening**  |
| *Example Row*  | *EDU 101 – Weeks 5-7*  |
| **Grade 3:** Students develop and sharpen their skills at obtaining, recording and charting, and analyzing data in order to study their environment. They use these practices to study the interactions between humans and earth systems, humans and the environment, and humans and the designed world. They learn that these entities not only interact but influence behaviors, reactions, and traits of organisms. Students reason and provide evidence to support arguments for the influence of humans on nature and nature on human experience. * Earth and Space Science: students analyze weather patterns and consider humans’ influence and opportunity to impact weather-related events.
* Life Science: they study the interactions between and influence of the environment and human traits and characteristics.
* Physical Science: Students consider the interactions and consequent reactions between objects and forces, including forces that are balanced or not.
* Technology/Engineering: They use the engineering design process to identify a problem and design solutions that enhance humans’ interactions with their surroundings and to meet their needs.
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| **Grade 4:** Students observe and interpret patterns related to the transfer of matter and energy on Earth, in physical interactions, and in organisms. Each domain relates to the use of matter and energy over time and for specific purposes. * Earth and Space Science: students interpret patterns of change over time as related to the deposition and erosion in landscape formation. They study today’s landscapes to provide evidence for past processes.
* Life Science: students learn that animals’ internal and external structures support life, growth, behavior, and reproduction.
* Physical Science: Students learn about energy—its motion, transfer, and conversion—in different physical contexts.
* Technology/Engineering: They work through the engineering design process, focusing on developing solutions by building, testing, and redesigning prototypes to fit a specific purpose.
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| **Grade 5:** Students model, provide evidence to support arguments, and obtain and display data about relationships and interactions among observable components of different systems. By studying systems, grade 5 students learn that objects and organisms do not exist in isolation and that animals, plants and their environments are connected to, interact with, and are influenced by each other. An ability to describe, analyze, and model connections and relationships of observable components of different systems is key to understanding the natural and designed world.  * Earth and Space Science: They study the relationships between Earth and other nearby objects in the solar system and the impact of those relationships on patterns of events as seen from Earth. They learn about the relationship among elements of Earth’s systems through the cycling of water and human practices and processes with Earth’s resources.
* Life Science: They also learn about the connections and relationships among plants and animals, and the ecosystems within which they live, to show how matter and energy are cycled through these (building on the theme of grade 4).
* Physical Science: Students build on Grade 2 understanding about matter to deepen their understand of properties, phase change, and the particulate nature of matter. They develop initial understandings of gravity.
* Technology/Engineering: Students consider what “technology” means, explore the history of human invention and innovation, and come to understand design solutions as complex systems.
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| **Grade 6:** The integration of Earth and space, life, and physical sciences with technology/engineering gives students relevant and engaging opportunities with natural phenomena and design problems that highlight the relationship of structure and function in the world around them. Students relate structure and function through analyzing the macro- and microscopic world. Students use models and provide evidence to make claims and explanations about structure-function relationships in different STE domains.* Earth and Space Science: Students explore Earth features and processes.
* Life Science: They understand the role of cells and anatomy in supporting living organisms.
* Physical Science: They explore the properties of materials and waves.
* Technology/Engineering: Students begin to use criteria and constraints to inform their designs, and deepen their understanding of how specific materials and tools will best serve specific needs.
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| **Grade 7:** Students focus on systems and cycles using their understanding of structures and functions, connections and relationships in systems, and flow of matter and energy developed in earlier grades. A focus on systems requires students to apply concepts and skills across disciplines, since most natural and designed systems and cycles are complex and interactive. Through grade 7, students begin a process of moving from a more concrete to an abstract perspective, since many of the systems and cycles studied are not directly observable or experienced. This also creates a foundation for exploring cause and effect relationships in more depth in grade 8. * Earth and Space Science: Students gain experience with plate tectonics and interactions of humans and Earth processes.
* Life Science: They explore organism systems to support and propagate life, and ecosystem dynamics.
* Physical Science: Students build on grade 3 and 4 understandings to develop more complex understandings of motion and energy systems.
* Technology/Engineering: They explore key technological systems used by society.
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| **Grade 8** **– Cause and Effect:** Students use more robust abstract thinking skills to explain causes of complex phenomena and systems. Many causes are not immediately or physically visible to students. An understanding of cause and effect of key natural phenomena and designed processes allows students to explain patterns and make predictions about future events. Being able to analyze phenomena for evidence of causes and processes that often cannot be seen, and being able to conceptualize and describe those, is a significant outcome for grade 8 students.  * Earth and Space: Students explore the causes of seasons and tides and causes of plate tectonics and weather or climate.
* Life Science: They study the role of genetics in reproduction, heredity, and artificial selection.
* Physical Science: Students learn how atoms and molecules interact to explain the substances that make up the world and how materials change.
* Technology/Engineering: The focus at this grade is on manufacturing processes and systems.
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| **High School – Earth and Space Science:** The high school Earth and space science standards build from middle school and allow high school students to explain additional and more complex phenomena related to Earth processes and systems, interactions among Earth’s systems, and interactions of Earth’s systems and human actions. The standards expect students to apply a variety of science and engineering practices to three core ideas of earth and space science:  * Earth’s place in the universe
* Earth’s systems
* Earth and human activity
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| **High School – Biology:** The high school biology standards build from middle school and allow high school students to explain additional and more complex phenomena related to genetics, the functioning of organisms, and interrelationships between organisms, populations, and the environment. The standards expect students to apply a variety of science and engineering practices to four core ideas of biology: * From molecules to organisms: structures and processes
* Ecosystems: interactions, energy, and dynamics
* Heredity: inheritance and variation of traits
* Biological evolution: unity and diversity
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| **High School – Chemistry:** The high school chemistry standards build from middle school physical sciences standards and allow high school students consider how structure and composition at sub-atomic scales explain structure-property relationships in chemistry and influence energy transformations and dissipation of energy during chemical and physical changes. The standards expect students to apply a variety of science and engineering practices to three core ideas of chemistry: * Matter and its interactions
* Motion and stability: forces and interactions
* Energy
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| **High School – Introductory Physics:** The high school introductory physics standards build from middle school and allow high school students to explain additional and more complex phenomena central to the physical world. The standards expect students to apply a variety of science and engineering practices to three core ideas of physics: * Motion and stability: forces and interactions
* Waves and their applications in technologies for information transfer
* Energy
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# Science and Technology/Engineering Practices

The Science and Engineering Practices describe the skills that science educators at all levels should seek to develop in their PK-12 students. This represents a shift from the traditional “scientific method”. Scientific inquiry and engineering design are dynamic and complex processes. Each requires engaging in a range of science and engineering practices to analyze and understand the natural and designed world. They are not defined by a linear, step-by-step approach. They are embedded within the content standards so that as students increasingly engage with the subject matter they grow in scientific maturity and expertise throughout the elementary, middle, and high school years. The progression of the practices by grade band is viewable Appendix I of the [Science and Technology/Engineering Curriculum Framework](https://www.doe.mass.edu/frameworks/current.html).

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| **Instructions*:***Initial licensure program candidates must reach a level of fluent content knowledge to be endorsed. They must be able to apply content in a range of contexts and vertically connect content to build students’ knowledge. As such, sponsoring organizations must have at least one course covering the practices at the fluent level.   Please list the numbers/abbreviations/titles of the **required courses where all eight practices are explicitly targeted and coherently addressed**. Then, **briefly describe where in the syllabus the practices are covered** (i.e., unit name, week number, objective number). Course identifiers should match those of submitted syllabi.    Please note that all eight Science and Technology/Engineering practices overlap and **should be covered together** rather than being split across multiple courses.  |

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|  **Science and Technology/Engineering Practices**   | **Fluent** *Initial* *Licensure*   |
| *Example Row*  | *EDU 101 – Weeks 5-7*  |
| The National Research Council’s *Framework for K-12 Science Education* identifies eight essential science and engineering practices that outline the skills necessary to engage in scientific inquiry and engineering design. These practices are core to the [Science and Technology/Engineering Curriculum Framework](https://www.doe.mass.edu/frameworks/current.html).    It is necessary to teach all of these practices embedded with content, so students develop an understanding and facility with the practices in appropriate contexts.  * Students in grades K-12 should engage in all eight practices over each grade band.
* Practices grow in complexity and sophistication across the grades.
* The eight practices are not separate; they intentionally overlap and interconnect.

  1. Asking questions (for science) and defining problems (for engineering) * Asking questions and defining problems in PK-5 builds on prior experiences and progresses to simple descriptive questions that can be tested and to specifying qualitative relationships.
* Asking questions and defining problems in 6-12 progresses to specifying relationships between variables, clarifying arguments and models, and evaluating empirically testable questions and design problems using models and simulations.

  2. Developing and using models. * Modeling in PK-5 builds on prior experiences and progresses to using, developing, and revising simple models (e.g., diagram, drawing, physical replica, diorama, dramatization, or storyboard) that represent concrete events or design solutions.
* Modeling in 6-12 builds on PK-5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems, and to show relationships among variables between systems and their components in the natural and designed worlds.

  3. Planning and carrying out investigations. * Planning and carrying out investigations to answer questions or test solutions to problems in PK-5 builds on prior experiences and progresses to simple investigations that control variables, which provide data & evidence to support explanations or design solutions.
* Planning and carrying out investigations in 6-12 builds on pre-K-5 experiences and progresses to include investigations that use multiple variables and provide evidence for and test conceptual, mathematical, physical, and empirical models.

  4. Analyzing and interpreting data. * Analyzing data in PK-5 builds on prior experiences and collecting, recording, and sharing observations, and progresses to introducing quantitative approaches to collecting data and conducting multiple trials. When possible and feasible, digital tools should be used.
* Analyzing data in 6-12 builds on PK-5 experiences and includes quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis. It progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data.

  5. Using mathematics and computational thinking. * Mathematical and computational thinking in PK-5 builds on prior experience and recognizing that mathematics can be used to describe the natural and designed worlds and progresses to extending quantitative measurements to a variety of physical properties and using computation and mathematics to analyze data and compare alternative design solutions.
* Mathematical and computational thinking in 6-12 builds on pre-K-5 experiences and includes identifying patterns in large data sets and using mathematical concepts to support explanations and arguments. It progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.

  6. Constructing explanations (for science) and designing solutions (for engineering). * Constructing explanations and designing solutions in PK-5 builds on prior experiences and includes use of evidence and ideas in constructing evidence-based accounts of natural phenomena and designing solutions. It progresses to the use of evidence in constructing explanations that specify variables that describe and predict phenomena and in designing multiple solutions to design problems.
* Constructing explanations and designing solutions in 6-12 builds on pre-K-5 experiences and includes constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories. It progresses to constructing and critiquing explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.

  7. Engaging in argument from evidence. * Engaging in argument from evidence in PK-5 builds on prior experiences and includes comparing ideas and representations about the natural and designed worlds. It progresses to critiquing the scientific explanations or solutions proposed by peers by citing relevant evidence about the natural and designed worlds.
* Engaging in argument from evidence in 6-12 builds on PK-5 experiences and includes constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed worlds. It progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed worlds. Arguments may also come from current scientific or historical episodes in science.

  8. Obtaining, evaluating, and communicating information. * Obtaining, evaluating, and communicating information in PK-5 builds on prior experiences and includes observations and texts to communicate new information. It progresses to evaluating the merit and accuracy of ideas and methods.
* Obtaining, evaluating, and communicating information in 6-12 builds on PK-5 experiences and progresses to evaluating the validity and reliability of claims, methods, and designs.
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