SCIENCE

Massachusetts

GRADE	SCORES		TOTAL SCORE
A-	Content and Rigor	6/7	9/10
	Clarity and Specificity	3/3	

REPORT CARD

Content & Rigor	**5.7**
Scientific Inquiry & Methodology	5
Physical Science	5
Physics	4
Chemistry	7
Earth & Space Science	6
Life Science	7
Clarity & Specificity	**2.8**

Average numerical evaluations

Document(s) Reviewed

- *Massachusetts Science and Technology/ Engineering Curriculum Framework.* October 2006. Accessed from: http://www.doe.mass.edu/frameworks/scitech/1006.pdf

Overview

Conveniently and clearly presented in a single document, the Massachusetts science standards are easy to read and easy to use. The language is straightforward, and the science is mostly sound and presented logically. The standards do suffer from a few faults, however: The treatment of major subjects, like high school physics, is sometimes brief. But overall, these standards provide a solid foundation for planning a K-12 science program.

Organization of the Standards

The Massachusetts K-8 science standards are divided into four familiar strands: earth and space science, life science (biology), physical sciences (physics and chemistry), and technology/engineering. Each strand is then divided into sub-strands, which vary from grade band to grade band. Finally, standards are listed for three grade bands rather than by grade: preK-2, 3-5, and 6-8. The state then provides "ideas for developing investigations and learning experiences," which are meant to help guide classroom instruction, for each grade band.

At the high school level, the standards are similarly organized, though here they are presented by content area, rather than by grade band, for the following: earth and space science, biology, chemistry, introductory physics, and technology/engineering.

Content and Rigor

Across disciplines, the quality and depth of the Massachusetts science standards is strong. The materials, particularly for high school students, are clear and comprehensive. The few stumbles are in the nature of minor omissions rather than major gaps or errors.

Scientific Inquiry and Methodology

The scientific inquiry and methodology standards are straightforward and well integrated with disciplinary content throughout the standards, thus making these process standards an organic element of instruction and learning rather than an afterthought or add-on. Mathematical problem-solving is stressed in concert with investigation and experimentation. Further, the need for students to communicate effectively about their work in science, both orally and in writing, is emphasized.

Massachusetts does, however, make a few missteps in handling science as inquiry. For instance, the history of science is shortchanged, and the place of science within society—beyond consideration of engineering design—is largely ignored.

Physical Science

Although generally solid, the physical science standards for pre-Kindergarten through eighth grade suffer from omission or short-changing of several important topics. These include gravitation, kinematics, crystalline solids, and heat, as well as electricity and magnetism, optics, and modern physics. There are also some illogical sequences, as in grades three through five, when magnetic energy is presented first, followed by electromagnets, and finally magnets in general. Also in that grade band, a list of "basic forms of energy" fails to include mechanical energy.

High School Physics

The high school physics standards are systematic, logical, and pedagogically sound. Study of physics begins with kinematics and then dynamics (though Newton's laws are compressed into a single sentence). This treatment is followed by energy and momentum conservation, with clear mention of the work-energy theorem at the outset. Heat, waves, electromagnetism, and electromagnetic radiation then follow. A supplementary discussion explores mathematical tools that the student is expected to master and use.

The main criticism one can level at the physics materials is their brevity. Not counting auxiliary information, the entire coverage fills fewer than three-and-a-half pages. Modern physics—the physics of the twentieth and twenty-first centuries, comprising quantum mechanics and relativity, among other things—is not covered at all. An excellent course could be planned and implemented on the basis of the physics materials—but so could a fairly sketchy and incomplete one, while still meeting their minimal requirements. One is at a loss to infer with accuracy what depth of understanding students will gain from a course based on this information.

High School Chemistry

The high school chemistry standards are handled with a refreshing level of depth and specificity. They are clearly written, address expected content rigorously, and will prepare Massachusetts's students to excel in college chemistry. Those students not heading to college will have a better appreciation and understanding of how chemistry impacts their lives. In the "solutions, rates of reaction, and equilibrium" sub-strand, for example, the content includes: the solution process; concentration using molarity in dilution and stoichiometry problems; the factors that affect the rate of dissolving; the properties of solutions vs. pure solvents (colligative properties); the factors affecting chemical-reaction rates; and the prediction of equilibrium shifts due to stress factors (Le Châtelier's principle).

Just a few important subjects are missing: carbon chemistry, molecular polarity and bond angles, and metallic bonding. Equilibrium is mentioned in the sub-strand header listed above but is not further defined. This missing content is partially offset by the expanded coverage in other areas of chemistry (both basic and more advanced). These standards address topics that include buffers, percent composition, empirical/molecular formulas, percent yield, VSEPR theory, the ideal gas law, stoichiometry, solution dilution, and colligative properties.

A safety note: An "inquiry skills" standard (SIS2) encourages neophyte chemistry students to design their own experiments. Doing so could be very dangerous! This activity should not be assigned without knowledgeable adult supervision.

Earth and Space Science

Overall, earth and space science is covered comprehensively. Particular areas of strength are earthquake processes and relative and absolute dating. Only minor weaknesses mar Massachusetts's strong standards in this realm of science. The evidence trail leading to the theory of plate tectonics is slighted, and some significant high school subject matter is missing, including stellar evolution and volcanic processes.

Life Science

The life science section begins with an easy to follow, lucid, and to-the-point introduction, spelling out how biological concepts will be presented and developed from pre-Kindergarten through twelfth grade. And, though the standards provide less detail than some other states in the early grades, the critical material is covered—and is well developed. Examples of exercises further explain and back up the standards. The coverage of evolution in grades six through eight is both appropriate and good; the term is used without apology or evasiveness. Evidence from fossils and comparative anatomy is adduced.

High school material is clear and concise, yet also comprehensive. An excellent physiology section goes into substantial detail. Treatment of evolution at the high school level is also thorough; as is the case in almost all states, however, human evolution is absent.

Overall, the Massachusetts science standards present much of the essential content that students need to master. The few drawbacks and omissions bring the overall average score for content and rigor to six out of seven. (See Appendix A: Methods, Criteria, and Grading Metric.)

Clarity and Specificity

In general, Massachusetts's standards are organized in a clear, unambiguous manner. In earth and space science, for example, students are asked to "recognize, interpret, and be able to create models of the earth's common physical features in various mapping representations, including contour maps" (grades 6-8).

And in high school chemistry we find this series of clear, deep, and specific items:

> **Solutions, Rates of Reaction, and Equilibrium**
>
> ***Central Concepts*: Solids, liquids, and gases dissolve to form solutions. Rates of reaction and chemical equilibrium are dynamic processes that are significant in many systems (e.g., biological, ecological, geological).**
>
> **7.1 Describe the process by which solutes dissolve in solvents.**
>
> **7.2 Calculate concentration in terms of molarity. Use molarity to perform solution dilution and solution stoichiometry.**
>
> **7.3 Identify and explain the factors that affect the rate of dissolving (e.g., temperature, concentration, surface area, pressure, mixing).**
>
> **7.4 Compare and contrast qualitatively the properties of solutions and pure solvents (colligative properties such as boiling point and freezing point).**
>
> **7.5 Identify the factors that affect the rate of a chemical reaction (temperature, mixing, concentration, particle size, surface area, catalyst).**
>
> **7.6 Predict the shift in equilibrium when a system is subjected to a stress (Le Châtelier's principle) and identify the factors that can cause a shift in equilibrium (concentration, pressure, volume, temperature). (high school chemistry)**

In places, however, more detail would help. Again in chemistry, students are told that heat is connected to particle motion and to temperature, but temperature is not defined, nor does it appear in the standards glossary. As another example, one standard asks students to "explain how electromagnets can be made, and give examples of how they can be used" with a corresponding exercise having students "make and use an electromagnet" (grades 3-5). There is no further explanation of how or why doing so might be worthwhile.

Still, these slips are minor, and as such, the Massachusetts standards earn a three out of three for clarity and specificity. (See Appendix A: Methods, Criteria, and Grading Metric.)