Motion Program of Study (grades 3-5) Standards and Benchmarks

This document is part of an
Inquiry-based Science Curriculum from
The *Guided Inquiry supporting Multiple Literacies* Project
at the *University of Michigan*

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This project was supported by the following funders:

National Science Foundation
Opinions expressed are those of the authors
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Reach Institute
Opinions expressed are those of the authors
and not necessarily those of the Foundation

MOTION: STANDARDS AND BENCHMARKS

Nothing in the universe is at rest. Motion is as essential to understanding the physical world as matter and energy are. The benchmarks for understanding the motion of objects and repeating patterns of motion do not demand the use of equations. For purposes of science literacy, a qualitative understanding is sufficient. Equations may clarify relationships for the most mathematically apt students, but for many students they are difficult and may obscure the ideas rather than clarify them. For example, almost all students can grasp that the effect of a force on an object's motion will be greater if the force is greater and will be less if the object has more mass — but learning a = F/m (which to many teachers seems like the same thing) is apparently much harder.

Newton's laws of motion are simple to state, and sometimes teachers mistake the ability of students to recite the three laws correctly as evidence that they understand them. The fact that it took such a long time, historically, to codify the laws of motion suggests that they are not self-evident truths, no matter how obvious they may seem to us once we understand them well. Much research in recent years has documented that students typically have trouble relating formal ideas of motion and force to their personal view of how the world works.

These are three of the obstacles:

1. A basic problem is the ancient perception that sustained motion requires sustained force. The contrary notion that it takes force to change an object's motion, that something in motion will move in a straight line forever without slowing down unless a force acts on it, runs counter to what we can see happening with our eyes.
2. Limitations in describing motion may keep students from learning about the effect of forces. Students of all ages tend to think in terms of motion or no motion. So the first task may be to help students divide the category of motion into steady motion, speeding up, and slowing down. For example, falling objects should be described as falling faster and faster rather than just falling down. As indicated earlier, the basic idea expressed in Newton's second law of motion is not difficult to grasp, but vocabulary may get in the way if students have to struggle over the meaning of force and acceleration. Both terms have many meanings in common language that confound their specialized use in science.

Elementary Grades Instruction

During their early years, children's natural curiosity leads them to explore the world by observing and manipulating common objects and materials in their environment. Children compare, describe, and sort as they begin to form explanations of the world. Developing a subject-matter knowledge base to explain and predict the world requires many experiences over a long period. Young children bring these experiences, understanding, and ideas to school. When students describe and manipulate objects by pushing, pulling, throwing, dropping, and rolling, they also begin to focus on the position of objects: describing location as up, down, in front, or behind, and discovering the various kinds of motion and forces are required to control it. From the outset, students should view, describe, and discuss all kinds of **moving things**—themselves, insects, birds, trees, doors, rain, fans, swings, volleyballs, wagons, stars, etc.—keeping notes, drawing pictures to suggest their motion, and raising questions: Do they move in a straight line? Is their motion fast or slow? How can you tell? Students should gain varied experiences in getting things to move or not to move and in changing the direction or speed of things that are already in motion.

By using simple objects, such as rolling balls and mechanical toys, students can move from qualitative to quantitative descriptions of moving objects and begin to describe the **forces** acting on the objects. Determining the speed of fast things and slow things can present a challenge that students will readily respond to. They also can work out for themselves some of the general relationships between force and change of motion and internalize the notion of force as a push or pull of one thing on another.

Students' everyday experience is that **friction** causes all moving objects to slow down and stop. Through experiences in which friction is reduced, students can begin to see that a moving object with no friction would continue to move indefinitely, but most students believe that the force is still acting if the object is moving or that it is "used up" if the motion stops. Students also think that friction, not is the principle reason objects remain at rest or require a force to move. Students associate force with motion and have difficulty understanding balanced forces in equilibrium, especially if the force is associated with static, inanimate objects, such as a book resting on the desk.

The understanding of **energy** involves the idea that energy is an important property of substances and that most change involves energy transfer. Students might have some of the same views of energy as they do of force--that it is associated with animate objects and is linked to motion. In addition, students view energy as a fuel or something that is stored, ready to use, and gets used up. The intent at this level is for students to improve their understanding of energy by experiencing many kinds of energy transfer.

STANDARD: Understands motion and the principles that explain it

	Types of Motion	**Describing Motion**	**Forces changes Motion**	**Force/Mass & Δ Motion**	**Newton's Laws**
K-2	Knows that things move in many different ways (*e.g., straight line, zigzag, vibration, circular motion*).	Knows that the position of an object can be described by locating it relative to another object or the background.	**Knows that the position and motion of an object can be changed by pushing or pulling.**		
3-5		**Knows that an object's motion can be described by tracing and measuring its position over time.**	**Knows that when a force is applied to an object, the object either speeds up, slows down, or goes in a different direction**	**Knows the relationship between the strength of a force and its effect on an object (*e.g., the greater the force, the greater the change in motion; the more massive the object, the smaller the effect of a given force*).**	
6-8		**Knows that an object's motion can be described and represented graphically according to its position**, direction of motion, **and speed**.	Understands effects of balanced and unbalanced forces on an object's motion (*e.g., if more than one force acts on an object along a straight line, then the forces will reinforce or cancel one another, depending on their direction and magnitude; unbalanced forces such as friction will cause changes in the speed or direction on an object's motion*).		Knows that a moving object that is not subjected to an additional force will continue to move at a constant speed and in a straight line.

http://www.mcrel.org/standards-benchmarks/standardslib/science.html

Grade K-2 Benchmarks	**Sources**
Knows that the position of an object can be described by locating it relative to another object or the background.	NRC: *National Science Education Standards*, p. 127 (*Explicitly stated*) CDE: *Science Framework for California Public Schools*, p. 53 (*Explicitly stated*) NAEP: *1996 Science Framework*, p. 63 (*Explicitly stated*) New Standards: Elementary School, p. 132 (*Implied*) NAEP: *Science Assessment and Exercise Specifications*, p. 96 (*Explicitly stated*)
Knows that things move in many different ways (*e.g., straight line, zigzag, vibration, circular motion*).	Project 2061: *Benchmarks for Science Literacy*, p. 89 (*Explicitly stated*) CDE: *Science Framework for California Public Schools*, p. 54 (*Explicitly stated*) NAEP: *1996 Science Framework*, p. 64 (*Implied*) NAEP: *Science Assessment and Exercise Specifications*, p. 97 (*Implied*)
Knows that the position and motion of an object can be changed by pushing or pulling.	NRC: *National Science Education Standards*, p. 127 (*Explicitly stated*) Project 2061: *Benchmarks for Science Literacy*, p. 89 (*Explicitly stated*) CDE: *Science Framework for California Public Schools*, p. 55 (*Explicitly stated*) NAEP: *1996 Science Framework*, pp. 63, 64 (*Implied*) MI Curriculum Framework, p. 25 (*Explicitly stated*)

Grade 3-5 Benchmarks	**Sources**
Knows that an object's motion can be described by tracing and measuring its position over time.	NRC: *National Science Education Standards*, p. 127 (*Explicitly stated*) CDE: *Science Framework for California Public Schools*, p. 54 (*Explicitly stated*) NAEP: *1996 Science Framework*, p. 63 (*Implied*) New Standards: Elementary School, p. 132 (*Explicitly stated*) NAEP: *Science Assessment and Exercise Specifications*, p. 96 (*Explicitly stated*)
Knows that when a force is applied to an object, the object either speeds up, slows down, or goes in a different direction	Project 2061: *Benchmarks for Science Literacy*, p. 89 (*Implied*) CDE: *Science Framework for California Public Schools*, p. 55 (*Explicitly stated*) NAEP: *1996 Science Framework*, pp. 62, 64 (*Implied*) International Baccalaureate: Middle Years Science, p. 33 (*Implied*) NAEP: *Science Assessment and Exercise Specifications*, p. 96 (*Explicitly stated*) MI Curriculum Framework, p. 25 (*Explicitly stated*)
Knows that the relationship between the strength of a force and its effect on an object. (*e.g., the greater the force, the greater the change in motion; the more massive the object, the smaller the effect of a given force*).	NRC: *National Science Education Standards*, p. 127 (*Implied*) Project 2061: *Benchmarks for Science Literacy*, p. 89 (*Explicitly stated*) CDE: *Science Framework for California Public Schools*, p. 56 (*Implied*) MI Curriculum Framework, p. 27 (*Implied*)

Grade 6-8 Benchmarks	**Sources**
Knows that an object's motion can be described and represented graphically according to its position, direction of motion, and speed.	NRC: *National Science Education Standards*, p. 154 (*Explicitly stated*) International Baccalaureate: Physics, pp. 25-26 (*Explicitly stated*) NAEP: *Science Assessment and Exercise Specifications*, p. 103 (*Implied*) Pearsall: NSTA: *The Content Core*, p. 104 (*Implied*) MI Curriculum Framework, p. 25 (*Explicitly stated*)
Understands effects of balanced and unbalanced forces on an object's motion (*e.g., if more than one force acts on an object along a straight line, then the forces will reinforce or cancel one another, depending on their direction and magnitude; unbalanced forces such as friction will cause changes in the speed or direction on an object's motion*).	NRC: *National Science Education Standards*, p. 154 (*Explicitly stated*) Project 2061: *Benchmarks for Science Literacy*, p. 90 (*Implied*) CDE: *Science Framework for California Public Schools*, pp. 56, 57 (*Explicitly stated*) NAEP: *1996 Science Framework*, p. 64 (*Explicitly stated*) International Baccalaureate: Middle Years Science, pp.33, 136 (*Implied*) International Baccalaureate: Physics, pp. 26-27, 45, 61 (*Implied*) New Standards: Middle School, p. 92 (*Explicitly stated*) NAEP: *Science Assessment and Exercise Specifications*, pp. 103-104 (*Explicitly stated*) Pearsall: NSTA: *The Content Core*, pp. 104-105 (*Implied*) MI Curriculum Framework, p. 25 (*Explicitly stated*)
Knows that an object that is not being subjected to a force will continue to move at a constant speed and in a straight line.	NRC: *National Science Education Standards*, p. 154 (*Explicitly stated*) Project 2061: *Benchmarks for Science Literacy*, p. 90 (*Explicitly stated*) CDE: *Science Framework for California Public Schools*, p. 57 (*Explicitly stated*) NAEP: *1996 Science Framework*, p. 64 (*Explicitly stated*) International Baccalaureate: Middle Years Science, pp. 32, 33 (*Implied*) New Standards: Middle School, p. 92 (*Implied*) Pearsall: NSTA: *The Content Core*, pp. 104-105 (*Explicitly stated*)