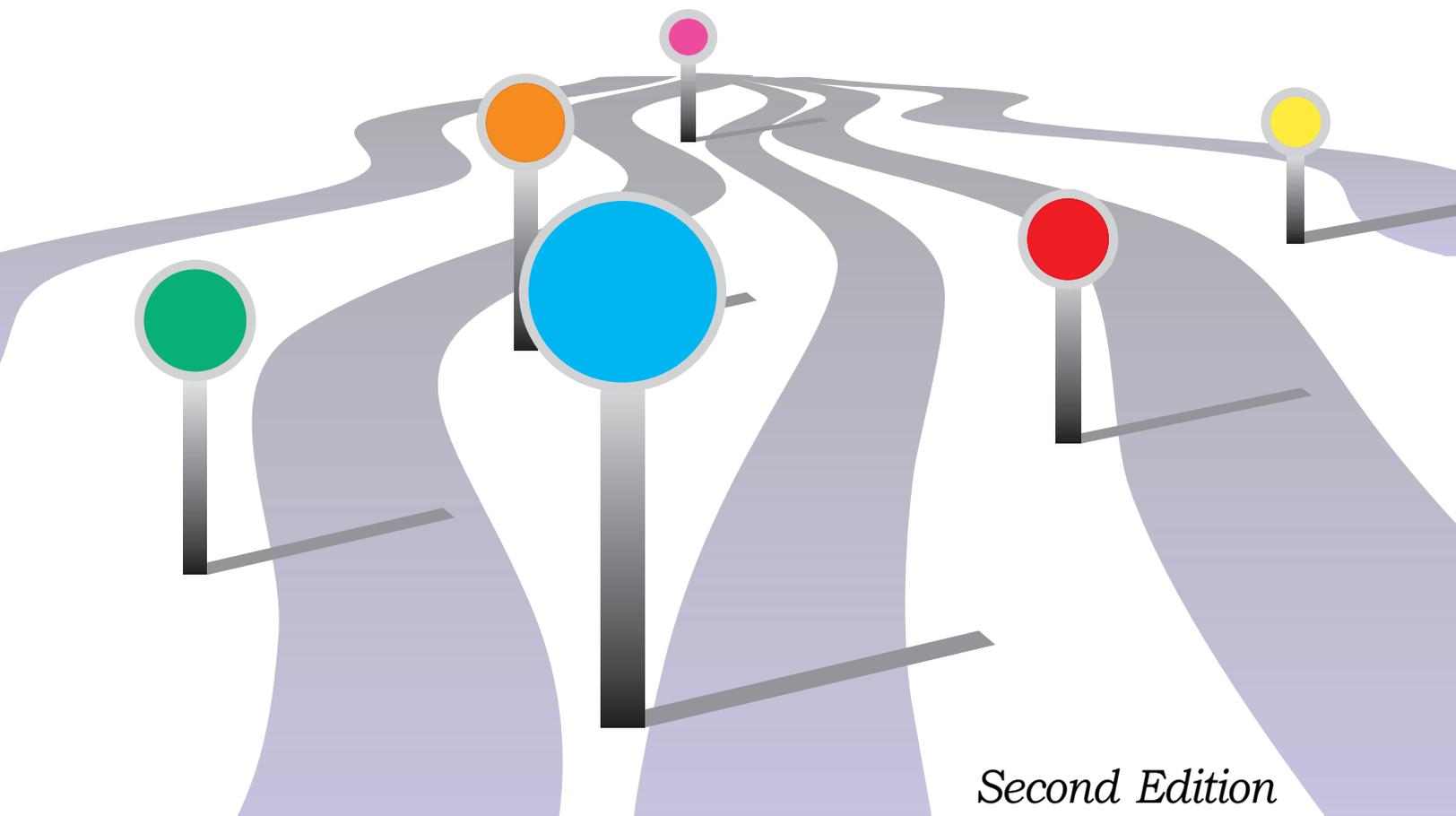


# NSTA PATHWAYS

To the Science Standards

*Middle School Edition*

Editor  
Steven J. Rakow



*Second Edition*

**Guidelines for Moving the Vision into Practice**



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## *NSTA Pathways to the Science Standards:* *Guidelines for Moving the Vision into Practice* *MIDDLE SCHOOL EDITION, Second Edition*

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## Program Standards

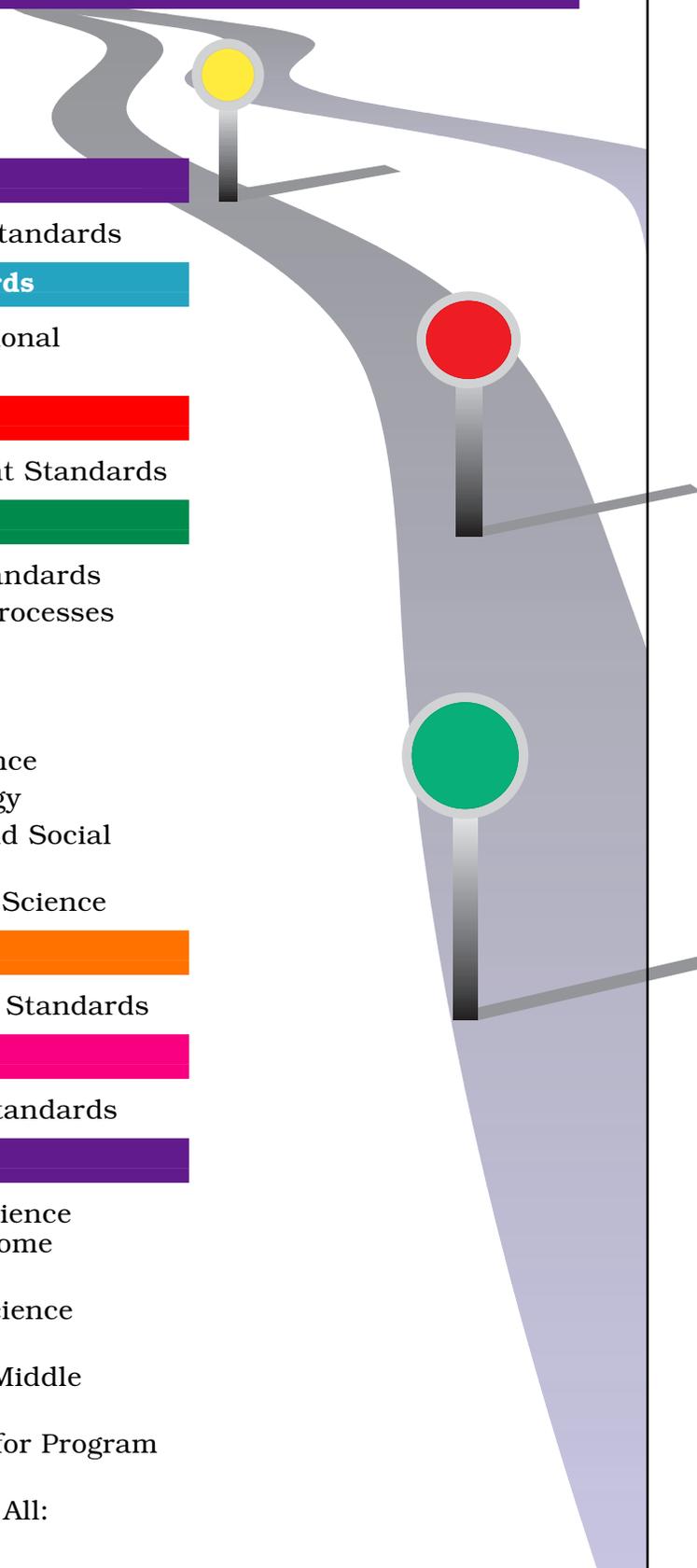
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## Physical Science

### CONTENT STANDARD B

### Building Conceptual Bridges

The chart shows a progression:

- from exploring and describing objects and their movements and orientations in grades K through 4
- to the properties of matter and the motion of objects in grades 5 through 8
- and finally, to the more sophisticated consideration of indirectly perceived structures (e.g. atomic) and relationships in grades 9 through 12.

Before middle grades, a student's experience with objects, motion, and energy centers on exploring one thing at a time. In middle grades, students are able to understand relationships and can graph one measurement in relation to another, such as distance vs force, force vs angle, and intensity or change over time. Graphs are analyzed in the search for possible trends. As they understand ratios and proportions better, students are able to project beyond the data.

Understanding energy, distinguishing between different kinds of energy, and learning about the nature of energy and energy transfer will show a steady progression through this grade level. This section will reflect an appreciation for the specific physical science concepts provided in lower grades, such as understanding the effect of gravity in

making things roll, fall, swing, and flow downhill. It shows the kinds of learning that will take place in grades 5 through 8 in physical science, such as testing variables that affect the motion of a pendulum.

Then it looks forward to how students will be prepared to address 9 through 12 grade level concepts and problems that involve determining rates of acceleration of falling or swinging bodies.



PHOTODISC

## Physical Science

### CONTENT STANDARD B

### A Classroom in Action



PHOTODISC

## Light On The Wall

The students in my class were engaged in an optical relay race using mirrors to reflect the light from flashlights onto target areas on the classroom wall. Each team of four students had been given a flashlight and a mirror with a distinctive shape. Numbered papers

and targets had been taped to the wall.

The room lights were turned off to enhance the effect of the light beams. As the targets were called out, the students took turns spotlighting them with the reflected beams. Student judges kept score. Shining light into people's eyes or onto one another was forbidden. Discussions about winning strategies emphasized the principle of the reflection of light in which the angle of incidence equals the angle of reflection. The activity was connected to a discussion on emergency signaling, the placement of safety mirrors, and other applications.

After the event, one student noted that although the mirror reflected a bright patch of light onto the shaded wall, he could still see the wall even though no direct light shone on it. If we cannot see an object unless light is traveling from that object to our eyes, how did light reach the wall if it was not reflected from our mirrors? This provided a good opportunity to talk about atmospheric scattering of light and about the not-so-obvious reflection of light in our surroundings.

Students were challenged to find and explain a variety of examples of reflected light. For those who needed greater direction, questions were posed, for example:

- Where does glare come from, and how do players in sports keep glare out of their eyes?
- How does clothing next to your face affect your appearance?
- What differences are there between home lighting and industrial lighting?
- How do artists draw shadows to make objects look three dimensional?
- What are the techniques used by photographers to create visual atmospheres?
- How does an interior designer use his expertise about light to create moods? How does a skylight work and what different designs are available?

Students apply the physics of reflection in a game format.

Safety rules must be agreed on before the event.

Concrete experiences should include multiple applications of principles.

Student questions can provide natural transitions within a teaching unit and often give rise to teaching opportunities.

The degree of choice must be adjusted to meet individual student readiness to choose.

## Physical Science

### CONTENT STANDARD B

### A Classroom in Action

- How do shadows change in intensity from morning to night?
- How do clouds reflect city lights at night?
- Which safety devices use reflected light?
- How do we know that particles in the air reflect light?

Individuals or pairs of students used various sources of information, such as printed matter, interviews, light probes, visits to commercial displays, and they use a dollhouse to try out ideas about lighting.

A computer simulation of illumination in an office environment helped students understand the effects of indirect lighting systems. The student groups reported the results of the various investigations to the whole class. The information fell into categories that related to sports, interior design, fashion, visual arts, theater, and safety.

Pat Stonefield, *7th grade science teacher*

New technology extends information resources and exploration platforms.

Content is derived from student effort. Evaluating their reports can assess student effort.

The group chosen was based on the topics resulting from the investigations rather than on topics that had been selected ahead of time.



MAX-KARL WINKLER

## Physical Science

### CONTENT STANDARD B

### Exploring the Standard

#### **Properties and changes of properties in matter**

*Substances have characteristic properties, such as density, boiling points, and solubility, all of which are independent of the size of the sample. A mixture of substances can often be broken down into the original components, or elements, showing one or more of its characteristic properties (NSES, page 154).*

Compared to upper elementary level students, middle level students have a better understanding of complex relationships, for example, they are able to understand that:

- density as a ratio of mass to volume.
- boiling point is affected by atmospheric pressure.
- solubility is dependent on pressure and temperature.

An understanding of these relationships is developed by concrete activities that involve hands-on manipulation of apparatus, making quantitative measurements, and interpreting data using graphs.

It is important to connect these characteristics to common experiences so that concepts can be reconstructed as needed, rather than being dependent on rote memory. Some relevant questions are

- What happens in a pressure cooker?

- Why does adding oil to boiling rice and pasta keep it from boiling over?
- What is in antifreeze and how does it keep your carburetor from freezing?

Substances react chemically with other substances to form compounds with different properties. In chemical reactions, the total mass of the reactants is conserved. Substances that react in similar ways are grouped together, as in the case of metals. Students should gain an understanding of rates of change and how different conditions and different substances alter the rates of change.

*There are more than 100 known elements. They are able to combine in many ways to produce compounds that make up the living and nonliving substances on Earth (NSES, page 154).*

It is easy for students to learn the chemical symbols of the common elements and those that make up common substances. Being able to decipher chemical names on product packages, such as hypochlorite (in bleach) or carbohydrate, calcium carbonate, and trisodium phosphate (in breakfast cereal) is empowering and provides a connection between chemistry and everyday life.

The concept of atoms as the units of matter helps students understand the conservation of matter in chemical reactions.

Carbon is the basic element for living organisms. At this level, students are interested in an introduction to organic chemistry.

A class period describing how chemists work in different specialties introduces the students to careers in chemistry, reinforcing the idea that chemistry is a valuable human endeavor.

#### **Motions and forces**

The motion of an object is described by its position, direction of movement, and its speed, and can be represented on a graph. Allow students to interpret graphs that show positive, negative, and irregular relationships. Vector diagrams can be used to differentiate between speed and velocity (velocity has a directional component, speed does not). A variety of instruments for measuring motion include time-lapse photography and strobe lights that “stop” motion.

An object that is not being subjected to a force will continue to move at a constant speed and in a straight line. Although difficult to demonstrate on Earth, with the constant presence of the planet’s gravity and the effects of friction, the principle of inertia helps to explain many well-known events like sports action, household accidents, and space walks.

## Physical Science

### CONTENT STANDARD B

### Exploring the Standard

KAREN REYNOLDS



Consider a skater who does not control a turn and continues in a straight line until stopped by a barrier, or an object on a slippery tray that stays behind as the tray moves forward and crashes to the floor.

Perhaps the most difficult part of accounting for the motion or lack of motion of an object is identifying the forces acting on that object compared to the effect of inertia. For example, when a ball is thrown, a forward force is exerted only until the ball leaves the hand after which inertia accounts for the continued forward motion, and gravity accounts for the downward path toward Earth. In *The Three Egg High Dive* (*Science Scope*, Reynolds Rap), all forces are balanced in the set up and nothing moves until an additional force removes the structures that support

the eggs, which plunge into the cups of water beneath.

If more than one force acts on an object moving along a straight line, the forces will either reinforce each other or cancel each other out, depending on their direction and magnitude. Unbalanced forces will cause changes in the speed or direction of an object's motion. The idea that an object that does not appear to be moving is being acted on by a set of balanced forces is not always easy to grasp because there is no obvious motion involved. Understanding phenomena, such as the sudden collapse of a structure due to unbalanced forces, is often an "Aha!" experience. When students identify forces acting from different directions, they appreciate how moving objects are controlled, and how they overcome friction.

The forces acting on natural and human made structures can be analyzed using computer simulations, physical models, and games like pool, soccer, bowling, and marbles that help to demon-

strate the principles of motion and the effects of collisions. The curved paths of satellites can be explained with the knowledge embedded in this standard.

This is a good place to discuss the connections to traffic safety.

### ***Transfer of energy***

Energy, in the form of heat, light, electricity, mechanical motion, sound, and nuclear energy, is a property associated with most substances. Energy is transferred in many ways.

Heat energy involves molecular motion.

Chemical energy depends on the arrangement of atoms and molecules. Mechanical energy is produced by moving bodies or by elasticity.

Potential gravitational energy results from the separation of mutually attracting masses.

## Physical Science

### CONTENT STANDARD B

### Exploring the Standard

Although students have already explored the properties of different kinds of energy, at the middle level students are able to quantify influences on energy transfer and identify multiple step transference within systems. A radio, for example, uses electricity to activate a magnet that produces vibrations that generate sound. Electricity is involved in many energy transfers and provides a fast method of distributing energy to distant locations.

Challenges that involve controlling the amount of energy, or the effects of energy transfer, allow students to describe more complex cause-and-effect relationships. This is an appropriate time to introduce the idea that energy cannot be created or destroyed, only changed from one form into another. Analyzing products or constructing devices from kits can provide engaging learning experiences. Students enjoy historical connections that trace technical applications of knowledge about energy. Addressing issues in local contexts, such as noise pollution, effects of artificial light, and the use of energy resources are also appropriate.

Heat moves in predictable ways, flowing from a warmer object to a cooler one, until both reach the same temperature. The use of instruments to make objective measurements of heat is important. It is interesting to measure heat

through sensors in the skin, but it can be misleading. Touching objects that have different heat conduction properties in the same ambient temperature can leave the impression that one object is cooler than the other, when, in fact, one object is carrying heat away from the fingers at a faster rate. Controlling the rate of heat movement, either through direct contact or at a distance, is a technical challenge. Examples in the manufacturing of clothing and machinery abound. Students enjoy contests that involve trying to keep an object cold or warm for a prolonged period. They also enjoy problems that involve analyzing the heat flow properties of different materials and finding out whether they are insulators or conductors.

Matter transmits, refracts, absorbs, scatters, and reflects light. In order for us to see an object, light emitted or scattered from that object must enter our eyes. Explorations with optics should include standard apparatus, such as mirrors, prisms, lenses, and various reflective surfaces. Practical applications of the optical properties of materials are found in cameras, jewelry, safety devises, and televisions. Light waves can be controlled and traced in many ways. Laser beams are used to read bar codes on grocery items and encoded information on compact discs. Special instruments and equipment can extend the sense of sight by

detecting and recording light. For example, a telescope focuses light from distant stars, a videocamera records motion that can be seen repeatedly or replayed at different speeds, and infrared and ultraviolet sensors indicate the existence of light outside the visible spectrum.

In most chemical and nuclear reactions, energy is transferred from one system to another. Heat, light, mechanical motion, or electricity might all be involved in such transfers. Most chemical reactions are not explosive, but rather are subtle and hardly noticeable. The transfer of energy associated with many reactions can be detected by monitoring temperature changes. When energy leaves one system, it is transferred into another system. Finding examples from physical, Earth, and life sciences, provide opportunities for exploring and building an understanding of the heat transfer concept. Food chains, food webs, and life cycles are examples of constant energy transfers, that depend on the sun, the ultimate source of energy for life on Earth. Convection cells in the mantle, oceans, and the atmosphere are driven by changes in relative buoyancy resulting from heat absorption and release.

An automobile converts chemical energy (liquid gasoline changes to vapor and is ignited) into heat that produces motion. Energy created by molecular motion in water

## Physical Science

### CONTENT STANDARD B

### Exploring the Standard

is released when water vapor condenses or liquid water freezes. Energy in the form of heat is absorbed when ice melts or liquid water evaporates. Finding out how a re-

frigerator works is a good way to see how heat flow is related to maintaining cool temperatures. The cooling effect of evaporation can be felt when wearing a wet tee shirt or

standing under a misting device. As one system gains energy, another system loses energy until a state of equilibrium is established.

## RESOURCES FOR THE ROAD

**Abell, Sandra K., Anderson, Maria, Ruth, Deb, and Sattler, Nancy.** (1996, September). What's the Matter? Studying the Concept of Matter in Middle School. *Science Scope*, 20 (1), 18-21.

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**Hartman, Dean.** (1992, September). Electric Mystery Boxes. *Science Scope*, 16 (7), 26-28.

**Janulaw, Al.** (1993, November/December). The Magnetic Pendulum. *Science Scope*, 17 (3), 50-52.

**Jones, Richard.** (1995, October). How Big, How Tall? The Scaling Principle Answers. *Science Scope*, 19 (2), 22-26.

**Ostlund, Karen L., and DiSpezio, Michael A.** (1996, February). Static Electricity Dynamically Explored. *Science Scope*, 19 (5), 12-16.

**Papacosta, Pan.** (1991, May). Electromagnet Dagnet. *Science Scope*, 14 (8), 18-21.

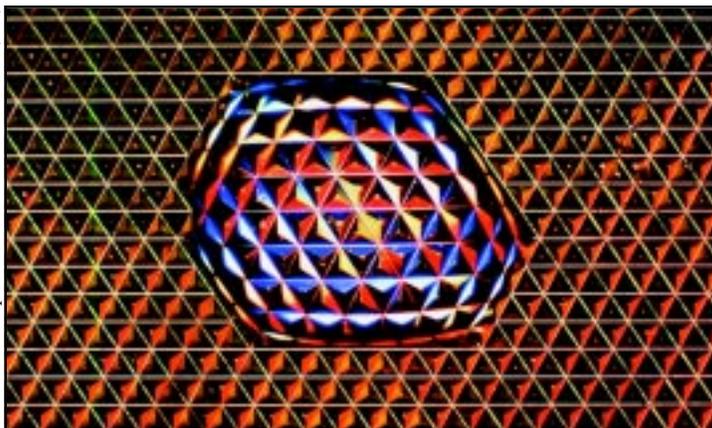
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**Reynolds, Karen.** (1983-1997). Reynolds Rap. *Science Scope*.

**Sterling, Donna.** (1996, October). Discovering Mendeleev's Model. *Science Scope*, 20 (2), 26-30.

The full text to most of these resources is available on NSTA's supplementary *Resources for the Road CD-ROM*.

NIKON #5—Drop of water on reflective material (10x)



Topic: states of matter  
Go to: <http://www.scilinks.org/>  
Code: PAM04

Topic: forces and motion  
Go to: <http://www.scilinks.org/>  
Code: PAM05

Topic: energy  
Go to: <http://www.scilinks.org/>  
Code: PAM06