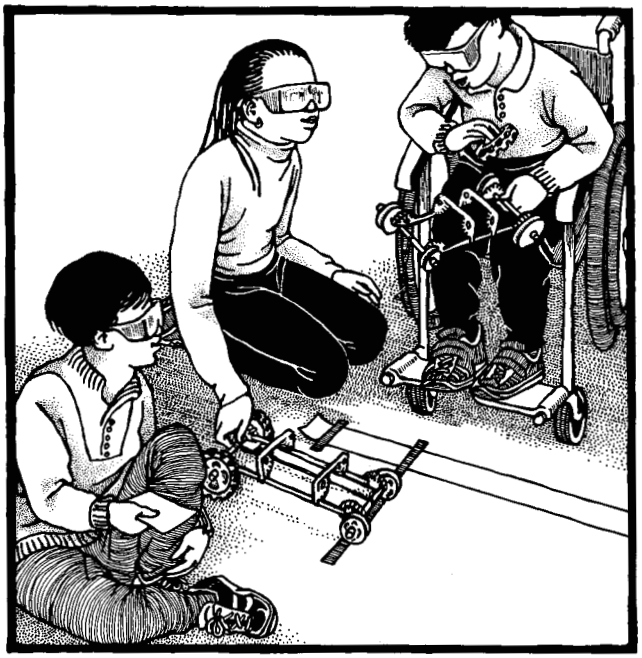
Motion and Design

Narrative Summary



This unit invites students to explore the physics of motion and to apply these concepts to technological design. Using plastic construction materials, weights, rubber bands, and propellers, students design and build vehicles. Students record their designs using technical two-view and three-view drawings. They test how fast the vehicles move and use their findings to redesign the vehicles to move more efficiently. Cost analysis is one of the students' design requirements. As students design their vehicles, they intuitively apply concepts such as friction and kinetic and potential energy. They also explore the effect of gravity on motion. The unit concludes by challenging students to solve a design challenge and to present their findings to the class.

Science Content

This unit emphasizes the application of scientific data and concepts to technological design. As students improve on the design of their vehicles—powered by rubber bands, propellers, and dropping weights—they make use of physical science concepts of motion and forces, energy transfer, and friction. Students develop abilities to identify and state a problem, design a solution, implement a solution, and evaluate the solution. Students learn that meeting design specifications—including cost—requires trade-offs in design and function. Science as a human endeavor is central to this unit.

Assessment

In a pre-unit assessment, students share what they know and want to know about how vehicles move and are designed. Given a set of requirements, students also design and build their first vehicle using K'NEX®. These activities are matched to a post-unit assessment following Lesson 16. The unit provides many opportunities for students to make, record, and revise designs. Teachers can use these designs and technical drawings to assess students' understanding of the design process. Embedded performance-based assessments, in which students meet design challenges and apply previously collected data, are scattered throughout the unit. In Lessons 14 through 16, students are asked to reflect on what they have learned and to apply their knowledge of technological design to a more complex problem. Additional assessments at the end of the unit include a student self-assessment, an activity in which students apply conceptual knowledge of motion to design and build a vehicle, an opportunity to evaluate the function and performance of an actual vehicle, and a review of student portfolios.

Goals for *Motion and Design*

This unit provides students an opportunity to explore the physics of motion and to apply those concepts to technological design. From their experiences, students are introduced to the following concepts, skills, and attitudes.

Concepts

- A force is any push or pull on an object. An unbalanced force is needed to make a resting object move, to bring a moving object to rest, or to change the direction of a moving object.
- A force can change the speed of an object. Greater forces can change the speed of an object faster than smaller forces.
- Friction is a force that occurs when two surfaces rub together. Friction opposes motion.
- If the same force is applied to a lighter vehicle and a heavier vehicle, the speed of the lighter vehicle will change more than the speed of the heavier vehicle.
- Energy can be stored in a rubber band and released to turn an axle or spin a propeller to make a vehicle move.
- A spinning propeller exerts a force that pushes air back and moves a vehicle forward.
- Friction must be considered when a vehicle is being designed.
- Air resistance is a force that can slow the speed of a moving vehicle.
- Design requirements specify how a vehicle or other product must perform.
- Cost is often an important consideration in designing a product.
- Engineers develop, modify, and improve designs to meet specific requirements.

Skills

- Designing, building, testing, and modifying vehicles to meet design requirements.
- Building vehicles from technical two- and three-view drawings.
- Recording vehicle designs through drawing.
- Observing how an object moves and describing its motion and changes in motion.
- Measuring the time it takes a vehicle to move a given distance.
- Collecting and recording data and analyzing it to determine representative values.
- Predicting the effect of an applied force on how a vehicle moves.
- Recording and comparing distances a vehicle travels under various conditions.
- Designing a vehicle that is propelled by stored energy.
- Solving design problems using previously collected data.
- Communicating results of an investigation through record sheets, written observations, drawings, and class discussions.

Attitudes

- Recognizing the role that technological design plays in daily problem solving.
- Appreciating how science can be used to solve practical problems.
- Recognizing the importance of repeating trials to gain valid test results.
- Valuing the application of test results to future investigations.

Motion and Design

Fundamental Concepts and Principles Addressed (K–4)

Science as Inquiry

Abilities necessary to do scientific inquiry

- Ask a question about objects, organisms, and events in the environment.
- Plan and conduct a simple investigation.
- Employ simple equipment and tools to gather data and extend the senses.
- Use data to construct a reasonable explanation.
- Communicate investigations and explanations.

Understandings about scientific inquiry

- Scientific investigations involve asking and answering a question and comparing the answer with what scientists already know about the world.
- Scientists use different kinds of investigations depending on the questions they are trying to answer.
- Simple instruments, like rulers, provide more information than scientists obtain using only their senses.
- Scientists develop explanations using observations and what they already know about the world.
- Scientists make the results of their investigations public.
- Scientists review and ask questions about the results of other scientists' work.

Physical Science

Properties of objects and materials

- Objects are made from one or more materials and can be described by the materials from which they are made.

Position and motion of objects

- The position of an object can be described by locating it relative to another object.
- An object's motion can be described by tracing and measuring its position over time.
- The position and motion of objects can be changed by pushing or pulling. The size of the change is related to the strength of the push or pull.

Science and Technology

Abilities of technological design

- Identify a simple problem.
- Propose a solution.
- Implementing proposed solutions.
- Evaluate a product or design.
- Communicate a problem, design, and solution.

Understandings about science and technology

- Science is a way of answering questions.
- Scientists and engineers work in teams with different individuals doing different things.
- Tools help scientists make better observations.
- Women and men of all ages, backgrounds, and groups engage in the varieties of scientific and technological work.

Science in Personal and Social Perspectives

Science and technology in local challenges

- People continue inventing new ways of doing things, solving problems, and getting work done.
- Science and technology have greatly influenced transportation.

History and Nature of Science

Science as a human endeavor

- Science and technology have been practiced by people for a long time.
- Men and women have made a variety of contributions throughout the history of science and technology.

- Many people choose science as a career. Many people derive great pleasure from doing science.
- There is still much more to be understood about science.

Unifying Concepts and Processes

Systems, order, and organization

Evidence, models, and explanation

Constancy, change, and measurement

Evolution and equilibrium

Form and function

Motion and Design

Fundamental Concepts and Principles Addressed (5–8)

Science as Inquiry

Abilities necessary to do scientific inquiry

- Identify questions that can be answered through scientific investigations.
- Use appropriate tools and techniques to gather, analyze, and interpret data.
- Develop descriptions, explanations, predictions, and models using evidence.
- Think critically and logically to make the relationships between evidence and explanations.
- Recognize and analyze alternative explanations and predictions.
- Communicate scientific procedures and explanations.
- Use mathematics in all aspects of scientific inquiry.

Understandings about scientific inquiry

- Scientists use different kinds of investigations, depending on the questions they are trying to answer.
- Mathematics is important in all aspects of scientific inquiry.
- Technology used to gather data enhances accuracy and allows scientists to quantify results.
- Scientific investigations sometimes result in new ideas for study or generate new methods for investigation.

Physical Science

Motions and forces

- The motion of an object can be described by its position, direction of motion, and speed. The motion can be represented on a graph.
- An object that is not being subjected to a force will continue to move at a constant speed in a straight line.
- 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.

Transfer of energy

- Energy is a property of many substances and is associated with heat, light, electricity, mechanical motion, and sound. Energy is transferred in many ways.

Science and Technology

Abilities of technological design

- Identify appropriate problems for technological design.
- Design a solution or product.
- Implement a proposed design.
- Evaluate completed technological designs or products.
- Communicate the process of technological design.

Understandings about science and technology

- Scientific inquiry and technological design have similarities and differences. Scientists propose explanations for questions; engineers propose solutions to problems and needs.
- Science and technology are reciprocal. Technology also provides tools for investigation, inquiry, and analysis.
- Perfectly designed solutions do not exist. All solutions have trade-offs, such as cost, efficiency, and appearance.
- Technological designs have constraints, such as properties of materials or friction. Other constraints limit choice in design.

Science in Personal and Social Perspectives

Science and technology in society

- Technology influences society through its products and processes.
- Science and technology have advanced through contributions of many different people.
- Scientists and engineers work in many different settings.
- Science cannot answer all questions and technology cannot solve all problems or meet all needs.

History and Nature of Science

Science as a human endeavor

- Women and men of various backgrounds engage in the activities of science. Some scientists work in teams and some work alone, but all communicate extensively with others.
- Science requires different abilities.

Nature of science

- Scientists formulate and test their explanations using observations, experiments, and mathematical models.
- It is part of scientific inquiry to evaluate the results of scientific investigations.

History of science

- Many individuals have contributed to the traditions of science.

Unifying Concepts and Processes

Systems, order, and organization
Evidence, models, and explanation
Constancy, change, and measurement
Evolution and equilibrium
Form and function