Grad 8 Science, Quarter 3, Unit 3.1

Force and Motion

Overview

Number of instructional days 25 (1 day = 50 minutes)

Content to be learned

- Measure time and distance for a moving object.
- Solve the mathematical expression $s = d/t$ using student-collected data.
- Solve for any unknown in the expression $s = d/t$ given values for the other two variables.
- Describe and graphically represent that the acceleration of an object is proportional to the force on the object.
- Describe and graphically represent that the acceleration of an object is inversely proportional to mass of an object.

Science processes to be integrated

- Use appropriate scientific tools and units.
- Solve for any unknown given values for the other two variables in an equation.
- Graph, interpret, analyze, and report data.
- Perform experiments, make observations, and make predictions.
- Examine patterns of change.

Essential questions

- What are the relationships among speed, distance, and time?
- How can the value of any one of the variables in the formula $s = d/t$ be determined if the other two variables are known?
- How can the relationship between acceleration and the force acting on the object be represented?
- What trend would be shown in a graph that shows the relationship between mass and acceleration?
- What trend would be shown in a graph that shows the relationship between acceleration and the force applied to an object?

Written Curriculum

Grade-Span Expectations

PS 3 - The motion of an object is affected by forces.

PS3 (5-8) INQ+ POC –8

Use data to determine or predict the overall (net effect of multiple forces (e.g., friction, gravitational, magnetic) on the position, speed, and direction of motion of objects.

PS3 (7-8) – 8
Students demonstrate an understanding of motion by…

8a measuring distance and time for a moving object and using those values a well as the relationship s=d/t to calculate speed and graphically represent the data.

8b solving for any unknown in the expression s=d/t given values for the other two variables.

8e describing or graphically representing that the acceleration of an object is proportional to the force on the object and inversely proportional to the object's mass.

Clarifying the Standards

Prior Learning

Prior to grade 8, students have learned that force is a push and pull action. They have learned how electric currents and magnets have a force on each other. Students learned about the relationship between force and gravity. Students have learned how to conduct experiments to show evidence of how the amount of force can change the direction and speed of an object. They have learned how to interpret graphs that show the speed of different objects as well as how to differentiate between force, motion, speed, and acceleration.

In grades K–2, students have observed and sorted objects that are or are not attracted to magnets. They can show how pushing and pulling an object affects its motion and predicting the direction the object will move. They have shown objects will fall to earth unless something is holding them up.

In grades 3–4, students have used prior knowledge to investigate and predict if an object is attracted to a magnet. They have described what happens when magnets of opposite poles are placed near each other. They have explored the relative strength of magnets. Students continued to predict the direction and have described the motion of various objects and their relative change of position. Students have investigated and conducted experiments to demonstrate that applied forces (including gravity) changes the speed and direction of an object.

In grades 5–6, students have shown that electric currents and magnets can exert a force on each other. They learned that a force is a push or a pull and have explained that a change in the speed of an object is caused by forces. Students continued using data and graphs to compare relative speed of objects.

In grade 7, students have made and tested predictions of how unbalanced forces can change speed and/or direction. They have measured distance and time for a moving object and have calculated speed. They know the difference among speed, velocity, and acceleration.

Current Learning

Students have learned about speed in previous grades and have used the formula $s = d/t$ to calculate speed. They will have measured time and distance so this is reinforcement level instruction. In grade 8 students are introduced to graphically representing this relationship. In addition, given any two of the variables in the formula, they solve for the third. This graphing concept is new and the instruction is developmental. This concept could be reinforced with the math curriculum.

Students also examine the direct relationship between force and acceleration, and the indirect relationship between mass and acceleration. Students for the first time describe and graphically represent that the acceleration of an object is proportional to the force on the object and inversely proportional to mass. Instruction at this point is developmental.

Students use appropriate scientific tools and units to measure speed, distance, and acceleration. To meet the requirements of the standard, inquiry and patterns of change must be embedded in the instruction. If students are graphing speed, they must not only be able to graph the data, but also identify patterns. When students are investigating the relationships among force, mass, and acceleration, they should be involved in inquiry. They should be able to predict what happens to the acceleration of an object if there is a change in the force applied on the mass of the object.

Students are actively engaged in measuring time and distance and using those values to calculate speed. For example, students can alter the slope of a ramp and allow a vehicle to roll down. Students can then measure the time differences with a stopwatch or motion sensor. They can measure distance differences using meter sticks with appropriate units from the metric system. They can then calculate the speed and graph the results either by hand or with a graphing program. They look for patterns within the graphs and interpret these patterns to make predictions. Students may also design and build a model roller coaster to explore the effects of changing the slope on speed.

Future Learning

Students in high school will deepen their knowledge of motion by using the relationships among force, mass, velocity, momentum, and acceleration to predict and explain the motion of objects by predicting and/or graphing the path of objects in different reference planes. They will use a variety of means to explain how distance and velocity change over time for a free-falling object.

Additional Research Findings

The benchmarks for understanding the motion of objects and repeating patterns of motion do not require 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 and applying the formula $a = F/m$ (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. 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.

A basic problem is the perception that sustained motion requires sustained force. The 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.

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 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. Students should have lots of experiences to shape their ideas about motion and forces long before encountering laws. Especially helpful are experimentation and discussion of what happens as surfaces become more or less free of friction.

“Students have no trouble believing that an object at rest stays that way unless acted on by a force; they see it every day. The difficult notion is that an object in motion will continue to move unabated unless acted on by a force. Telling students to disregard their eyes will not do the trick—the things around them *do* appear to slow down of their own accord unless constantly pushed or pulled. The more experiences the students can have in seeing the effect of reducing friction, the easier it may be to get them to imagine the friction-equals-zero case.” (*Benchmarks for Science Literacy,* p. 87)

Students tend to think of force as a property of an object ("an object has force," or "force is within an object") rather than as a relation between objects.

Students believe constant speed needs some cause to sustain it. In addition, students believe that the amount of motion is proportional to the amount of force; that if an object is not moving, there is no force acting on it; and that if an object is moving there is a force acting on it in the direction of the motion.

“Research has shown less success in changing middle-school students' ideas about force and motion. Nevertheless, some research indicates that middle-school students can start understanding the effect of constant forces to speed up, slow down, or change the direction of motion of an object. This research also suggests it is possible to change middle-school students' belief that a force always acts in the direction of motion.” (*Atlas of Science Literacy*, p. 62)

Notes About Resources and Materials

Prentice Hall *Motion, Forces, and Energy*, (8a 16–25; 8e 34–38, 52–54)

Designing a roller coaster

- www.learner.org

Interactive lesson plans

- www.science-class.net

Lab activities

- www.thesciencedesk.com

Acceleration lab

- www.sciencespot.net

Physics lesson plans, scientific method, metric system, motion, etc

- www.middleschoolscience.com/class3.htm

Grade 8 Science, Quarter 3, Unit 3.2

Energy

Overview

Number of instructional days 20 (1 day = 50 minutes)

Content to be learned

- Show that within a system energy transforms from one form to another.
- Show the transfer of potential energy to kinetic energy using a real world example.
- Construct a model to explain that energy can be transformed from one form to another.
- Explain that while energy can be stored, transferred, or transformed, the total amount of energy is conserved.
- Describe the effect of changing voltage in an electrical circuit.
- Differentiate between electromagnetic and mechanical waves.

Processes to be used

- Use real-world examples.
- Explain the transfer of energy.
- Construct a model.
- Describe cause and effect relationships.
- Examine patterns of change.
- Examine energy transfers within systems.
- Describe how energy is transformed within a system.

Essential questions

- What are some examples of the transfers of potential energy to kinetic energy in real world examples?
- What kinds of models can be used to explain the transformation of energy from one form to another?
- How does changing the voltage in an electrical circuit affect that system?
- What does it mean when it is said that energy is conserved?
- What is the difference between electromagnetic and mechanical waves?

Written Curriculum

Grade-Span Expectations

PS 2 - Energy is necessary for change to occur in matter. Energy can be stored, transferred, and transformed, but cannot be destroyed.

PS2 (5-8)-SAE+ POC- 6

Given a real-world example, show that within a system, energy transforms from one form to another (i.e., chemical, heat, electrical, gravitational, light, sound, mechanical).

PS2 (7-8)- 6 Students demonstrate an understanding of energy by…

6a using a real world example to explain the transfer of potential energy to kinetic energy.

6b constructing a model to explain the transformation of energy from one form to another. (e.g. an electrical circuit changing electrical energy to light energy in a light bulb).

6c explaining that while energy may be stored, transferred, or transformed, the total amount of energy is conserved.

6d describing the effect of changing voltage in an electrical circuit.

PS3 (5-8) SAE+INQ – Local Assessment Only

Experiment, observe, or predict how energy might be transferred by means of waves.

PS3 (7-8) – LA Students demonstrate an understanding of the visible spectrum of light by…

LAc differentiating between electromagnetic and mechanical waves.

Clarifying the Standards

Prior Learning

In grades 7 and below, students have had experiences with investigating and collecting data to classify pitches and/or volumes from different objects. They are able to distinguish sound that is transferred through solids, liquids, and gases. Students are able to show evidence of the different variations of heat production. Students are able to identify conductors and insulators through the use of various materials. They are able to construct an electrical circuit. Students are able to explain potential energy as well as how the different ways energy is stored. Students understand the properties of the different forms of energy and how it is stored. Students were introduced to the concept of potential energy.

In grades K–2, students have also experimented and described how objects make sound. They described the various effects of light (including the sun). They know the sun is the source of heat energy and have described how it warms the land and water. They have described the change in temperature of an object by adding or subtracting heat.

In grades 3–4, students continued to experiment with sound and have added data to explain the causes of pitch and volume changes. They continued to investigate light and now have predicted and described how light rays are reflected, refracted and absorbed. They know that heat moves from warm objects to cooler objects and eventually becomes the same temperature.

In grades 5–6, students have identified real world examples of heat energy transfer.

In grade 7, students designed a diagram, model, or analogy to explain motion of molecules in warmer and cooler states. They have explained the differences and diagramed how energy travels through different materials through conduction, convection and radiation.

Current Learning

In grade 8, students are introduced to the concept of kinetic energy. This content is developmental, however students have already learned about potential, so this part is reinforcement. They explain how energy can be transferred from potential energy to kinetic energy. Students construct a model illustrating the transformation of energy from one form to another. Simple examples include an elastic band stretched and unstretched, a spring compressed and uncompressed or a Slinky. More advanced examples include having students identify points of greatest or least potential and kinetic energy, such as a roller coaster diagram. Videos or interactive web sites that demonstrate these are of high interest to middle school students.

In addition, students describe the effects of changing voltage in an electrical circuit. They may build a simple electrical circuit and change the number of batteries and observe the effects on the brightness of a bulb. They can also describe how the energy is transferred and transformed from one form to another and from one place to another and explain this in terms of the Law of Conservation of Energy.

Furthermore, in the local assessment, students will learn how energy can be transferred by waves and differentiate between electromagnetic waves and mechanical waves. Differentiating between electromagnetic and mechanical waves is a local assessment and is new material and therefore instruction is developmental.

Students will explain the transfer and transformation of energy when they construct various models and apply real world examples to demonstrate their understanding. Students will be describing the cause and effect relationships of the transfer and transformation of energy when they build a simple circuit and change the voltage. They are looking for patterns in various forms of energy transfer and transformation by comparing their models and diagrams to real world examples such as the simple circuit or the roller coaster.

Students will be using a variety of investigations and demonstrations to show and explain the transfer and transformation of energy. Some examples are “poppers,” or a pendulum to demonstrate the transfer of potential to kinetic energy, building a simple electrical circuit to demonstrate the transformation of chemical energy to mechanical energy to light and heat energy. A model roller coaster can be fashioned from foam pipe insulation and marbles.

Future Learning

In high school, students will further their knowledge of energy by describing and diagramming changes in energy transformation that occur in different systems. Students will also explain the Law of Conservation of Energy as it relates to the efficiency of a system and how the efficiency is reduced due to heat loss.

Additional Research Findings

“At this level, students should be introduced to energy primarily through energy transformations. Students should trace where energy comes from (and goes next) in examples that involve several different forms of energy along the way: heat, light, motion of objects, chemical, and elastically distorted materials. To change something's speed, to bend or stretch things, to heat or cool them, to push things together or tear them apart all require transfers (and some transformations) of energy."

"At this early stage, there may be some confusion in students' minds between energy and *energy sources*. Focusing on energy transformations may get around this somewhat. Food, gasoline, and batteries obviously get used up. But the energy they contain does not disappear; it is changed into other forms of energy."

"The most primitive idea is that the energy needed for an event must come from somewhere. That should trigger children's interest in asking, for any situation, where the energy comes from and (later) asking where it goes. Where it comes from is usually much more evident than where it goes, because some usually diffuses away as radiation and random molecular motion." (*Benchmarks for Science Literacy*, p. 24)

The energy-cannot-be-created-or-destroyed way of stating conservation fully may be more intuitive than the abstraction of a constant energy total within an isolated system. The quantitative (equal amounts) idea should probably wait until high school. (*Benchmarks for Science Literacy* p. 84)

Students rarely think energy is measurable and quantifiable. Students' alternative conceptualizations of energy influence their interpretations of textbook representations (and definitions) of energy.

While students may have difficulty conceptualizing what energy is they should be able to recognize different forms especially those with perceivable effects. Middle- and high-school students tend to think that energy transformations involve only one form of energy at a time. The transformation of motion to heat seems to be difficult for students to accept, especially in cases with no temperature increase. Finally, it may not be clear to students that some forms of energy, such as light, sound, and chemical energy, can be used to make things happen.

The idea of energy conservation seems counterintuitive to middle- and high-school students who hold on to the everyday use of the term energy. Teach heat dissipation ideas at the same time as energy conservation. It would be beneficial in teaching conservation of energy to use an appropriate model (such as a flashlight). In addition, middle- and high-school students tend to use their conceptualizations of energy to interpret energy conservation ideas. Some students interpret the idea that "energy is not created or destroyed" to mean that energy is stored up in the system and can even be released again in its original form or they may believe that no energy remains at the end of a process, but may say that "energy is not lost" because an effect was caused during the process (for example, a weight was lifted). (*Atlas of Science Literacy, vol. 2,* p. 24)

Students of all ages have difficulty reasoning that all parts of a circuit are interrelated and influence each other. Many students believe that in circuit energy is being "used up" as opposed to dissipated. (*Atlas of Science Literacy, vol. 2,* p. 26)

Notes About Resources and Materials

Prentice Hall textbook, *Motion, Forces, and Energy*

- 6a Potential and Kinetic Energy pp. 140–145
- 6b Energy Conversion and Conservation pp. 148–153

- 6c Energy Conversions and Fossil Fuels pp. 154–157
- Lab p. 146, Soaring Straws (gravitational potential energy depends on elastic potential energy)

Potential and kinetic energy

- http://msteacher.org/return_list_science.aspx?id=1536

Teacher resource

- http://www.ftexploring.com/energy/energy-1.htm

Demonstration of potential and kinetic energy (physics, scroll to end, roller coaster)

- www.middleschoolscience.com

Student resource

- http://ed.fnal.gov/ntep/f98/projects/nrel_energy_2/energy.html

Interactive lessons

- http://classroom.jc-schools.net/sci-units/energy.htm
- http://science-class.net (click on physics, energy)