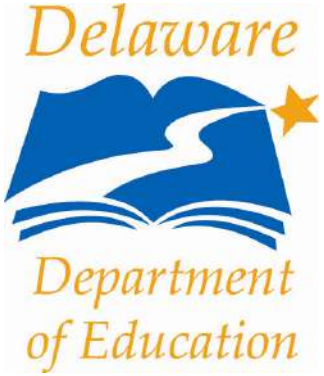
Delaware Science Coalition

Grade 6 Unit Template
Force & Motion



Preface: This unit has been created as a model for teachers in their designing or redesigning of course curricula. It is by no means intended to be inclusive; rather it is meant to be a springboard for a teacher's thoughts and creativity. The information we have included represents one possibility for developing a unit based on the Delaware content standards and the Backward Design framework and philosophy.

Unit Summary:
Force and Motion is a unit that studies forces and how they affect motion, eventually leading to an understanding of energy later in the middle school curriculum. Motion is first investigated both quantitatively and qualitatively. Secondly, the most common forces that affect motion are identified and analyzed in some detail including how these forces combine to produce an overall effect on the motion of an object.

Stage 1: Desired Results
Delaware Science Content Standards

This course focuses on the Delaware Science Content Standards and Grade Level Expectations in Standards 1 and 3 found on the following web site: http://www.doe.k12.de.us/programs/ci/content_areas/science.shtml

Standard One: The Nature and Application of Science and Technology

Understandings and Abilities of Scientific Inquiry:
Students should be able to:

1. Frame and refine questions that can be investigated scientifically, and generate testable hypotheses.
2. Design and conduct investigations with controlled variables to test hypotheses.
3. Accurately collect data through the selection and use of tools and techniques appropriate to the investigation. Construct tables, diagrams and graphs, showing relationships between two variables, to display and facilitate analysis of data. Compare and question results with and from other students.
4. Form explanations based on accurate and logical analysis of evidence. Revise the explanation using alternative descriptions, predictions, models and knowledge from other sources as well as results of further investigation.
5. Communicate scientific procedures, data, and explanations to enable the replication of results. Use computer technology to assist in communicating these results. Critical review is important in the analysis of these results.
6. Use mathematics, reading, writing, and technology when conducting scientific inquiries.

Science Technology and Society:
Students should know that:
1. Advances in technology can expand the body of scientific knowledge. Technological tools allow people to observe objects and phenomena that otherwise would not be possible. Technology enhances the quality, accuracy, speed and analysis of data gathered.

2. Science and technology in society are driven by the following factors: economical, political, cultural, social, and environmental. Increased scientific knowledge and technology create changes that can be beneficial or detrimental to individuals or society through impact on human health and the environment.

History and Context of Science:
Students should know that:
1. Over the course of human history, contributions to science have been made by different people from different cultures. Studying some of these contributions and how they came about provides insight into the expansion of scientific knowledge.

Standard 3: Energy and Its Effects
The Forms and Sources of Energy
Students should k now that:
1. Mechanical energy comes from the motion (kinetic energy) and position (potential energy) of objects. Gravitational potential energy and elastic potential energy are important forms of potential energy that contribute to the mechanical energy of objects.

Students should be able to:
- List, as basic forms of energy, light, heat, sound, electrical, and energy of motion.

Forces and the Transfer of Energy
Students should know that:
1. When the forces acting on an object are balanced, its motion will not change. Unbalanced forces will cause the object's motion to change. Changes in motion depend upon the size and direction of the total unbalanced force exerted on the object

Students will be able to:
- Conduct investigations on a moving object and make measurements of time and distance traveled and determine the average speed of moving objects.
- Graph and interpret distance versus time graphs for constant speed. Use the graphs to describe how the position of an object changes in a time interval.
- Describe how the speed of an object depends on the distance traveled and the travel time. Explain how the motion of an object can be described by its position, speed, and direction of motion.
- Give examples of objects at rest, and identify the forces that act on an object while it remains at rest (gravity, supportive forces, friction, other pushing or pulling forces). Explain that if the object is not moving, it must have at least two forces acting on it that are balanced.
- Give examples of moving objects and identify the forces that act on these objects. Select examples where only one force acts on the object and examples where two or more forces act on the object. Explain that unbalanced forces acting on an object will change its speed, direction of motion, or both.
- Conduct investigations to describe how the relative directions of forces simultaneously acting on an object (reinforce or cancel

each other) will determine how strongly the combination of these forces influences the motion of the object.
- Conduct investigations and describe how a force can be directed to increase the speed of an object, decrease the speed of the object or change the direction in which the object moves.
- Explain that an object that feels the effects of balanced forces may be at rest or may be moving in a straight line with a speed that does not change.

2. Gravity is a force that acts between masses over very large distances. Near the Earth's surface, gravity pulls objects and substances vertically downward

Students will be able to:
- Explain that the earth will pull on all objects with a force called gravity that is directed inward toward the center of the Earth.

Big Ideas

- Motion can be characterized by an object's speed and direction of travel. An object's average speed can be calculated from knowledge of distance and time.
- Balanced forces do not cause a change in the motion of an object; unbalanced forces do cause a change in the motion of an object.
- The impact of forces on the motion (or change in motion) of an object can be displayed and analyzed using graphical means.
- Gravity is a force that acts between masses over large distances and can influence the motion (or change in motion) of an object. Gravity acts vertically downward on the local scale and vertically inward on the global scale.
- Forces that influence the motion (or change in motion) of objects can be identified and combined to determine the overall effect of these forces.

Unit Enduring Understandings

Enduring Understanding: Energy takes many forms. These forms can be grouped into types of energy that are associated with the motion of mass (kinetic energy), and types of energy associated with the position of mass and with energy fields (potential energy).

Enduring Understanding: Changes take place because of the transfer of energy. Energy is transferred to matter through the action of forces. Different forces are responsible for the transfer of the different forms of energy.

Enduring Understanding: Energy readily transforms from one form to another, but these transformations are not always reversible. The details of these transformations depend upon the initial form of the energy and the properties of the materials involved. Energy may transfer into or out of a system and it may change forms, but the total energy cannot change.

Unit Essential Question(s)

- **How is speed measured and why is speed important?**

- **How can dot patterns and graphs be used to determine is something is moving at constant speed or not constant speed?**
- **What is gravity and what factors affect the strength of the pull of gravity?**
- **How are mass and weight different?**
- **How can you use the direction of motion to help determine the direction of a force such as air resistance and friction?**
- **Why is the direction of force important?**
- **How can you determine the total force?**
- **What affect do forces have on the motion of objects?**

Knowledge & Skills

Knowledge:

- The speed of an object is a description of how quickly an object is changing its location.
- Average speed can be determined by dividing the distance traveled by the time it takes to travel this distance.
- Information about an object's location and how quickly its location changes can be displayed in a variety of ways. One way is to use a graph, such as a bar graph or a scatter plot line graph.
- Bar graphs can be used to illustrate the how the speed of an object changes.
- Line graphs of distance versus time can be used to investigate how the speed of an object changes.
- Gravity is an attractive force that acts between objects even if the objects are not touching.
- The force of gravity will be too small to notice or measure unless at least one of the objects is extremely massive (such as a planet or star).
- Gravity acts vertically downward.
- Mass and weight are often confused but they are different quantities. Mass is the amount of matter from which things are made. Weight is the size of the gravitational force pulling the mass downwards.
- Gravity alone is the force that is responsible for keeping planets in orbit around the Sun in our solar system.
- Unbalanced forces change the motion of objects.
- When an object is at rest, the forces that act on the object are balanced.
- In almost all cases, there is more than one force acting on an object. The effects of some forces are apparent whereas effects of other forces are "hidden" by the effects of much larger forces.
- Identifying the specific forces that act on an object can help us predict how the forces will influence the motion of an object.
- Gravity, friction, air resistance, elastic forces, and tension forces are a few of the most common forces.
- Some forces, such as friction and air resistance, are dependent upon the direction of motion, whereas other forces such as gravity and supporting forces, do not depend upon the direction of motion.
- An object will respond to all forces that act on it so it is important to be able to identify the forces acting on an object.
- A force diagram is a sketch in which the forces acting on an object are represented using arrows.
- The total force is the combination of all forces acting on an object.
- The size of the total force and its direction will determine how it changes the motion of an object.

- When the forces acting on an object balance each other, the total force is zero and the motion of the object will not change. If the object is at rest and the forces acting on it are balanced, it will remain at rest.
- When the forces acting on an object are not balanced, the total force could increase the speed of an object, decrease the speed of an object, or change the direction in which the object moves.

Skills:

- Design and conduct an experiment to determine the speed of a moving object.
- Compare the speeds of two moving objects qualitatively (which is faster, which is slower) and quantitatively (how much faster).
- Measure time (in seconds) and distance (in centimeters).
- Collect data from multiple trials
- Calculate average speed
- Conduct investigations to compare constant speed and non-constant speed.
- Make distance versus time graphs using a dot car and using a motion detector.
- Analyze graphs to describe how the speed of an object changes.
- Use models to illustrate the direction gravity acts at different points on Earth.
- Identify the forces of gravity, supporting forces, air resistance, elastic forces and tension forces.
- Identify the force, whether it is a push or pull force, the direction of force and justify the choice using evidence.
- Create force diagrams using arrows to illustrate the direction and amount of force.

Stage 2: Assessment Evidence

Assessment: The summative assessment for Force and Motion will soon be on the Delaware Department of Education website: http://www.doe.k12.de.us/programs/ci/content_areas/science.shtml

Rubrics/checklists for Performance Tasks

The rubrics for the summative assessment for Force and Motion unit will soon be on the Delaware department of Education website: **http://www.doe.k12.de.us/programs/ci/content_areas/science.shtml**

Other Evidence

1. Student journals contain formative assessment of questions asked throughout the unit. These are often found in "Investigation Reflection" and "Applying what you have learned" sections.
2. Activity 1, Pages 9-12- Multiple data trails are collected and average speed is calculated. This is used to formatively assess student

understanding of the need to conduct multiple trials to find average speed.

3. Activity 2, pages 21-23, making distance versus time graphs. These graphs are used to formatively assess student understanding of graphing data as well as analyzing the graphs.
4. Activity 4- Identifying forces. These worksheets are used to formatively assess student understanding of the forces mentioned in this unit.
5. Activity 5- Making a Force diagram. This is used to formatively assess student understanding of forces.

Stage 3: Learning Plan
(Design Learning Activities To Align with Goals and Assessments)

Key learning events needed to achieve unit goals

The Delaware Department of Education's *Force and Motion* unit consists of five activities.

Activity 1: How Fast is it going? In this activity, students design and conduct an experiment to determine the speed of a moving object. They compare the speed of two moving objects qualitatively and quantitatively.

Activity 2: Graphical Displays of Motion: Using a felt tip marker, a Dot Car marks its position by leaving an ink mark on a paper at regular time intervals. By observing the spacing of these dots, it is possible to determine how the car's motion changes. Data is displayed and evaluated in bar graphs and line graphs.

Activity 3: A Look at Gravity In this activity, students start to identify the forces that affect motion. Gravity is the force responsible for holding everything on our planet and the solar system together and is arguably the most recognized force in our daily lives. This force is investigated in detail in this section.

Activity 4: Identifying Forces: In this activity, demonstrations and investigations will be conducted to identify forces acting on objects. Some forces are easy to identify and others are more difficult to recognize.

Activity 5: Drawing Forces In this activity, students will begin to diagram and examine forces in more detail. The students will describe the size of the force and also its direction. The direction that a force is exerted will affect the objects change in motion. The overall effect of all of the forces acting on the object is the emphasis of this activity.

Potential Misunderstandings:

Source: Stephans, Joseph. (1996). Targeting Students' Science Misconceptions.

1. Students find it difficult to recognize the tension in a string as force.
2. A chair or a table cannot exert a force since it has no motion.
3. Gravity is the same things as air pressure.
4. Force has a "living" quality, i.e., objects trying to fight their way upward against a will of gravity.
5. Constant motion requires a constant force- if you want to keep something moving along a horizontal track, you have to keep pushing, otherwise, you will run out of force and just stop. This represents a failure to distinguish the role of friction as a separate force.
6. If an object is not moving there is no force and is something is moving, there is a force acting on it.
7. Animate objects must exert a force to hold things up, but inanimate objects so not have to do so.

This unit is meant to be taught in a 5-6 week format when teaching science in a 40-55 minute class period each day. A suggested pacing guide is included below:

Monday	Tuesday	Wednesday	Thursday	Friday
Activity 1: How fast is it Going? Making Sense of Motion.	Activity 1: Data tables and calculations.	Activity 1: Determining the speed of the buggy, investigation reflections, applying what you have learned.	Activity 1; Speed limits- investigating further. Review of activity 1.	Activity 2- Making sense of motion, comparing constant speeds.
Activity 2- The dot-car, Part A.	Activity 2- The Dot-car, Part B.	Activity 2- Motion detector.	Activity 2- Motion detector.	Activity 2- Applying what you have learned.
Activity 2- Investigating further. Possible Go-Motion extensions.	Activity 3- The force of gravity. A plumb line.	Activity 3- Plumb line.	Activity 3- Mass and Weight.	Activity 3- Applying what you have learned. Investigating further.
Activity 4- making sense of forces. Identification of forces. Supportive forces.	Activity 4- Air resistance.	Activity 4- Elastic forces.	Activity 4- Friction.	Activity 4- friction.
Activity 4- Pulling forces of ropes.	Activity 4- Investigation reflection, summary of activity,	Activity 4- Investigating further.	Activity 5- Creating force diagrams, Part A.	Activity 5- making sense of forces, part B.
Activity 5- Making sense of forces, Part C.	Activity 5- Gravity and orbits, summary of activity,.	Activity 5- Investigating further, weightlessness.	Force and Motion Summative Assessment	Force and Motion Summative Assessment

Resources & Teaching Tips

Resource: Delaware Department of Education unit, Force and Motion. (2007)