7th Grade - Science - Forces and Motion

Unit: Science , Grade(s) 7

Force, Motion, and Energy

Duration: 4 Weeks

Unit

Scope and Sequence

Topic: Forces and Motion

Duration: 3.5 Weeks

In this unit, students will learn about gravity's role in the acceleration of falling objects, in orbiting, and in projectile motion. Students will also study Newton's laws of motion. Finally, students will learn how to calculate momentum and will study the law of conservation of momentum.

PA Standards

- 3.2.6.B1: Explain how changes in motion require a force.
- 3.2.6.B7: Understand how theories are developed.
    - Identify questions that can be answered through scientific investigations and evaluate the appropriateness of questions.
    - Design and conduct a scientific investigation and understand that current scientific knowledge guides scientific investigations.
    - Describe relationships using inference and prediction.
    - Use appropriate tools and technologies to gather, analyze, and interpret data and understand that it enhances accuracy and allows scientists to analyze and quantify results of investigations.
    - Develop descriptions, explanations, and models using evidence and understand that these emphasize evidence, have logically consistent arguments, and are based on scientific principles, models, and theories.
    - Analyze alternative explanations and understanding that science advances through legitimate skepticism.
    - Use mathematics in all aspects of scientific inquiry.
    - Understand that scientific investigations may result in new ideas for study, new methods, or procedures for an investigation or new technologies to improve data collection.
- 3.2.8.B1: Explain how inertia is a measure of an object's mass. Explain how momentum is related to the forces acting on an object.
- 3.2.8.B6: PATTERNS Explain how physics principles underlie everyday phenomena and important technologies.
- 3.2.8.B7: Compare and contrast scientific theories.
    - Know that both direct and indirect observations are used by scientists to study the natural world and universe.
    - Identify questions and concepts that guide scientific investigations.
    - Formulate and revise explanations and models using logic and evidence.
    - Recognize and analyze alternative explanations and models.
    - Explain the importance of accuracy and precision in making valid measurements.

Next Generation Science Standards

- **MS-PS2-1.** Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects.* [Clarification Statement: Examples of practical problems could include the impact of collisions between two cars, between a c ar and stationary objects, and between a meteor and a space vehicle.]
- **MS-PS2-2.** Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object. [Clarification Statement: Emphasis is on balanced (Newton's First Law) and unbalanced forces in a system, qualitative comparisons of forces, mass and changes in motion (Newton's Second Law), frame of reference, and specification of units.]
- **MS-PS2-4.** Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects. [Clarification Statement: Examples of evidence for arguments could include data generated from simulations or digital tools; and charts displaying mass, strength of interaction, distance from the Sun, and orbital periods of objects within the solar system.]

- **MS-PS2-4.** Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects. [Clarification Statement: Examples of evidence for arguments could include data generated from simulations or digital tools; and charts displaying mass, strength of interaction, distance from the Sun, and orbital periods of objects within the solar system.]
- **MS-PS2-5.** Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact. [Clarification Statement: Examples of this phenomenon could include the interactions of magnets, electrically-charged strips of tape, and electrically-charged pith balls. Examples of investigations could include first-hand experiences or simulations.]

Next Generation Science Standards (Engineering)

- **MS-ETS1-1.** Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
- **MS-ETS1-2**. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
- **MS-ETS1-3.** Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.
- **MS-ETS1-4.** Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

Eligible Content

- S8.A.1.1.1 Distinguish between a scientific theory and an opinion, explaining how a theory is supported with evidence, or how new data/information may change existing theories and practices.
- S8.A.1.1.2 Explain how certain questions can be answered through scientific inquiry and/or technological design.
- S8.A.1.1.3 Use evidence, such as observations or experimental results, to support inferences about a relationship.
- S8.A.1.1.4 Develop descriptions, explanations, predictions, and models using evidence.
- S8.A.1.2.3 Describe fundamental scientific or technological concepts that could solve practical problems (e.g., Newton's laws of motion, Mendelian genetics).
- S8.A.2.1.1 Use evidence, observations, or a variety of scales (e.g., mass, distance, volume, temperature) to describe relationships.
- S8.A.2.1.2 Use space/time relationships, define concepts operationally, raise testable questions, or formulate hypotheses.
- S8.A.2.1.3 Design a controlled experiment by specifying how the independent variables will be manipulated, how the dependent variable will be measured, and which variables will be held constant.
- S8.A.2.1.4 Interpret data/observations; develop relationships among variables based on data/observations to design models as solutions.
- S8.A.2.1.5 Use evidence from investigations to clearly communicate and support conclusions.
- S8.A.2.2.1 Describe the appropriate use of instruments and scales to accurately and safely measure time, mass, distance, volume, or temperature under a variety of conditions.
- S8.A.2.2.2 Apply appropriate measurement systems (e.g., time, mass, distance, volume, temperature) to record and interpret observations under varying conditions.
- S8.A.3.2.2 Describe how engineers use models to develop new and improved technologies to solve problems.
- S.6.C.3.1.2 Explain why gravitational force depends on how much mass the objects have and the distance between them.
- S.7.C.3.1.2 Describe forces acting on an object (e.g., friction, gravity, balanced verses unbalanced).
- S8.C.3.1.1 Describe forces acting on objects (e.g., friction, gravity, balanced versus unbalanced).

Starting Points

Science and Engineering Practices:

Asking Questions and Defining Problems

Asking questions and defining problems in grades 6–8 builds from grades
K–5 experiences and progresses to specifying relationships between variables, and clarifying arguments and models.

* Ask questions that can be investigated within the scope of the classroom, outdoor environment, and museums and other public facilities with available resources and, when appropriate, frame a hypothesis based on observations and scientific principles. (MS-PS2-3)

Planning and Carrying Out Investigations

Planning and carrying out investigations to answer questions or test solutions to problems in 6–8 builds on K–5 experiences and progresses to include investigations that use multiple variables and provide evidence to support explanations or design solutions.

* Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed

to do the gathering, how measurements will be recorded, and how many data are needed to support a claim. (MS-PS2-2)
* Conduct an investigation and evaluate the experimental design to produce data to serve as the basis for evidence that can meet the goals of the investigation. (MS-PS2-5)

Constructing Explanations and Designing Solutions

Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.
* Apply scientific ideas or principles to design an object, tool, process or system. (MS-PS2-1)

Engaging in Argument from Evidence

Engaging in argument from evidence in 6–8 builds from K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world.
* Construct and present oral and written arguments supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem. (MS-PS2-4)

Physical Science:

The performance expectations in the topic **Forces and Interactions** focus on helping students understand ideas related to why some objects will keep moving, why objects fall to the ground and why some materials are attracted to each other while others are not. Students answer the question, "How can one describe physical interactions between objects and within systems of objects?" At the middle school level, the PS2 Disciplinary Core Idea from the NRC Framework is broken down into two sub-ideas: Forces and Motion and Types of interactions. By the end of middle school, students will be able to apply Newton's Third Law of Motion to relate forces to explain the motion of objects. Students also apply ideas about gravitational, electrical, and magnetic forces to explain a variety of phenomena including beginning ideas about why some materials attract each other while other repel. In particular, students will develop understanding that gravitational interactions are always attractive but that electrical and magnetic forces can be both attractive and negative. Students also develop ideas that objects can exert forces on each other even though the objects are not in contact, through fields. Students are also able to apply an engineering practice and concept to solve a problem caused when objects collide. The crosscutting concepts of cause and effect; system and system models; stability and change; and the influence of science, engineering, and technology on society and the natural world serve as organizing concepts for these disciplinary core ideas. In these performance expectations, students are expected to demonstrate proficiency in asking questions, planning and carrying out investigations, and designing solutions, and engaging in argument; and to use these practices to demonstrate understanding of the core ideas.

The performance expectations in the topic **Energy** help students formulate an answer to the question, "How can energy be transferred from one object or system to another?" At the middle school level, the PS3 Disciplinary Core Idea from the NRC Framework is broken down into four sub-core ideas: Definitions of Energy, Conservation of Energy and Energy Transfer, the Relationship between Energy and Forces, and Energy in Chemical Process and Everyday Life. Students develop their understanding of important qualitative ideas about energy including that the interactions of objects can be explained and predicted using the concept of transfer of energy from one object or system of objects to another, and that that the total change of energy in any system is always equal to the total energy transferred into or out of the system. Students understand that objects that are moving have kinetic energy and that objects may also contain stored (potential) energy, depending on their relative positions in a field. Students will also come to know the difference between energy and temperature, and begin to develop an understanding of the relationship between force and energy. Students are also able to apply an understanding of design to the process of energy transfer. The crosscutting concepts of scale, proportion, and quantity; systems and system models; and energy are called out as organizing concepts for these disciplinary core ideas. These performance expectations expect students to demonstrate proficiency in developing and using models, planning investigations, analyzing and interpreting data, and designing solutions, and engaging in argument from evidence; and to use these practices to demonstrate understanding of the core ideas in PS3.

Performance Objectives

SWBAT:

- describe Newton's Laws IOT explain how changes in motion require a force.
- explain how inertia is a measure of an object's mass IOT provide evidence that it is the natural tendency of objects to resist changes in their state of motion.
- describe how momentum is related to the forces acting on an object IOT determine the velocity of the object.
- describe a closed system IOT explain the law of the conservation of momentum.
- apply Newton's Third Law IOT design a solution to a problem involving the motion of two colliding objects.
- plan an investigation IOT provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.**
- construct and present arguments using evidence IOT support the claim that gravitational interactions are attractive and depend on the masses of interacting objects.**

- conduct an investigation and evaluate the experimental design IOT provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact.**

** These objectives applied more than once throughout the Quarters and/or Units. Teachers may address them and build on students' prior knowledge within multiple content areas.

Key Terms and Definitions

terminal velocity – the constant velocity of a falling object when the force of air resistance is equal in magnitude and opposite in direction to the force of gravity
free fall – the motion of a body when only the force of gravity is acting on the body
projectile motion – the curved path that an object follows when thrown, launched, or otherwise projected near the surface of the Earth
inertia – the tendency of an object to resist being moved or, if the object is moving, to resist a change in speed or direction until an outside force acts on the object
momentum – a quantity defined as the product of the mass and velocity of an object

Essential Questions

How do force and mass affect the change in an object's motion?
How do we prove that gravitational forces are attractive and depend on the mass of the interacting objects?
What forces exist between objects, even when the objects are not in contact?

Instructional Resources

Video on laws of motion
http://www.sciencechannel.com/games-and-interactives/newtons-laws-of-motion-interactive/

Ck-12 videos and activities on gravity and laws of motion
http://www.ck12.org/search/?q=terminal%20velocity&source=ck12&grade=6&grade=7&grade=8

Videos on laws of motion
https://www.khanacademy.org/science/physics/forces-newtons-laws

Video on 3 laws of motion
https://www.youtube.com/watch?v=mn34mnnDnKU

Explanation of 3rd law of motion
https://www.youtube.com/watch?v=VfpKzwrhmqQ

Ck-12 content on laws of motion
http://www.ck12.org/search/?q=newton's%20laws&referrer=teacher_landing&autoComplete=false

Ck-12 content on momentum
http://www.ck12.org/search/?q=momentum&source=ck12&grade=7

Newton's laws activities (scroll down)
http://swift.sonoma.edu/education/

Amusement park physics - interactive site
http://www.learner.org/interactives/parkphysics/

Physics demos and activities
http://www.edgalaxy.com/journal/2012/8/3/50-physics-lesson-plans-for-middle-school-students.html

Gravity overview
http://spaceplace.nasa.gov/what-is-gravity/en/

Laws of motion worksheet and activities
http://sciencespot.net/Media/newtonslab.pdf

Laws of motion powerpoint
http://sciencespot.net/Media/NewtonsChallenge.pptx

Standards Covered

Next Generation Science Standards

Engineering Design Middle School

SCI.6-8.MS-ETS1: Engineering Design

- SCI.6-8.MS-ETS1-1: **Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.**
- SCI.6-8.MS-ETS1-2: **Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.**
- SCI.6-8.MS-ETS1-3: **Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.**
- SCI.6-8.MS-ETS1-4: **Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.**

Middle School Physical Sciences

SCI.6-8.MS-PS2: Motion and Stability: Forces and Interactions

- SCI.6-8.MS-PS2-4: **Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects. Examples of evidence for arguments could include data generated from simulations or digital tools; and charts displaying mass, strength of interaction, distance from the Sun, and orbital periods of objects within the solar system. Assessment does not include Newton's Law of Gravitation or Kepler's Laws.**
- SCI.6-8.MS-PS2-5: **Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact. Examples of this phenomenon could include the interactions of magnets, electrically-charged strips of tape, and electrically-charged pith balls. Examples of investigations could include first-hand experiences or simulations. Assessment is limited to electric and magnetic fields, and limited to qualitative evidence for the existence of fields.**

PA Assess Science

S.6.C: Physical Sciences

S.6.C.3: Principles of Motion and Force

- S.6.C.3.1: **Explain why an object's motion is the result of all forces acting on it.**
  - S.6.C.3.1.2: **Explain why gravitational force depends on how much mass the objects have and the distance between them.**

S.7.C: Physical Sciences

S.7.C.3: Principles of Motion and Force

- S.7.C.3.1: **Explain the principles of force and motion.**
  - S.7.C.3.1.2: **Describe forces acting on an object (e.g., friction, gravity, balanced verses unbalanced).**

S8.A: The Nature of Science

S8.A.1: Reasoning and Analysis

- S8.A.1.1: **Explain, interpret, and apply scientific, environmental, or technological knowledge presented in a variety of formats (e.g., visuals, scenarios, graphs).**
  - S8.A.1.1.1: **Distinguish between a scientific theory and an opinion, explaining how a theory is supported with evidence, or how new data/information may change existing theories and practices.**
  - S8.A.1.1.2: **Explain how certain questions can be answered through scientific inquiry and/or technological design.**
  - S8.A.1.1.3: **Use evidence, such as observations or experimental results, to support inferences about a relationship.**
  - S8.A.1.1.4: **Develop descriptions, explanations, predictions, and models using evidence.**
- S8.A.1.2: **Identify and explain the impacts of applying scientific, environmental, or technological knowledge to address solutions to practical problems.**
  - S8.A.1.2.3: **Describe fundamental scientific or technological concepts that could solve practical problems (e.g., Newton's laws of motion, Mendelian**

genetics).

S8.A.2: Processes, Procedures, and Tools of Scientific Investigations

- S8.A.2.1: **Apply knowledge of scientific investigation or technological design in different contexts to make inferences to solve problems.**
  - S8.A.2.1.1: **Use evidence, observations, or a variety of scales (e.g., mass, distance, volume, temperature) to describe relationships.**
  - S8.A.2.1.2: **Use space/time relationships, define concepts operationally, raise testable questions, or formulate hypotheses.**
  - S8.A.2.1.3: **Design a controlled experiment by specifying how the independent variables will be manipulated, how the dependent variable will be measured, and which variables will be held constant.**
  - S8.A.2.1.4: **Interpret data/observations; develop relationships among variables based on data/observations to design models as solutions.**
  - S8.A.2.1.5: **Use evidence from investigations to clearly communicate and support conclusions.**
- S8.A.2.2: **Apply appropriate instruments for a specific purpose and describe the information the instrument can provide.**
  - S8.A.2.2.1: **Describe the appropriate use of instruments and scales to accurately and safely measure time, mass, distance, volume, or temperature under a variety of conditions.**
  - S8.A.2.2.2: **Apply appropriate measurement systems (e.g., time, mass, distance, volume, temperature) to record and interpret observations under varying conditions.**

S8.A.3: Systems, Models, and Patterns

- S8.A.3.2: **Apply knowledge of models to make predictions, draw inferences, or explain technological concepts.**
  - S8.A.3.2.2: **Describe how engineers use models to develop new and improved technologies to solve problems.**

S8.C: Physical Sciences

S8.C.3: Principles of Motion and Force

- S8.C.3.1: **Describe the effect of multiple forces on the movement, speed, or direction of an object.**
  - S8.C.3.1.1: **Describe forces acting on objects (e.g., friction, gravity, balanced versus unbalanced).**

PA Science Academic Stds

1: Compare and contrast scientific theories.

1: Understand how theories are developed.

2: Identify questions that can be answered through scientific investigations and evaluate the appropriateness of questions.

2: Know that both direct and indirect observations are used by scientists to study the natural world and universe.

3: Design and conduct a scientific investigation and understand that current scientific knowledge guides scientific investigations.

4: Describe relationships using inference and prediction.

5: Recognize and analyze alternative explanations and models.

5: Use appropriate tools and technologies to gather, analyze, and interpret data and understand that it enhances accuracy and allows scientists to analyze and quantify results of investigations.

6: Develop descriptions, explanations, and models using evidence and understand that these emphasize evidence, have logically consistent arguments, and are based on scientific principles, models, and theories.

6: Explain the importance of accuracy and precision in making valid measurements.

7: Analyze alternative explanations and understanding that science advances through legitimate skepticism.

8: Use mathematics in all aspects of scientific inquiry.

PA Science and Technology and Engineering

3: Identify questions and concepts that guide scientific investigations.

3.2.6: Physical Sciences: Chemistry and Physics

3.2.B: Physics

- 3.2.B.1: **Force & Motion of Particles and Rigid Bodies Students acquire the knowledge and skills needed to:**
  - 3.2.6.B1: **Explain how changes in motion require a force.**
- 3.2.B.7: **Science as Inquiry Students acquire the knowledge and skills needed to:**

3.2.8: Physical Sciences: Chemistry and Physics

3.2.B: Physics

- 3.2.B.1: **Force & Motion of Particles and Rigid Bodies Students acquire the knowledge and skills needed to:**
  - 3.2.8.B1.a: **Explain how inertia is a measure of an object's mass.**

- 3.2.8.B1.b: **Explain how momentum is related to the forces acting on an object.**

- 3.2.B.6: **Unifying Themes Students acquire the knowledge and skills needed to:**
  - 3.2.8.B6: **Patterns: Explain how physics principles underlie everyday phenomena and important technologies.**

- 3.2.B.7: **Science as Inquiry Students acquire the knowledge and skills needed to:**

4: Formulate and revise explanations and models using logic and evidence.

9: Understand that scientific investigations may result in new ideas for study, new methods, or procedures for an investigation or new technologies to improve data collection.

Additional Properties

Author: Curriculum, Specialist3

Cost/Fee: No

Restricted Use: No

Rights:

Keywords:

Created by: DON, PAULA (9/17/2015 4:14 PM)

Last modified by: Curriculum, Specialist3 (8/17/2016 11:31 AM)