C. UNIT NAME: EXPERIMENTING WITH FORCES AND MOTION NGSS 8-15

Content Area: **Science**
Course(s):
Time Period: **Trimester 3**
Length: **12 lessons**
Status: **Published**

Unit Overview

In this unit, students are presented with many "daily life" experiences as portals to the study of the basic physics of forces and motion. Students investigate different forces, how those forces change the motion of objects, and the different forms energy can take. Students begin to construct a knowledge base by engaging in inquiries that allow them to explore relationships and concepts in motion and energy physics. Reading selections reinforce these concepts by focusing on such diverse applications as battery-powered devices, cars, sports, engineering, and amusement park rides- in other words, experiences that most young middle school students love.

This unit is mostly laboratory and project based. However, there are many important reading selections from both the STC and Pearson publications. The Pearson Interactive Science series listed in the bibliography is used mainly as a reinforcement for the lab activities and as an additional source of readings, vocabulary, and diagrams. In addition, many other sources of reading materials, videos, and other media are used to enhance the lesson, such as *National Geographic, Smithsonian Magazine, Science Scope* (NSTA), *BrainPop, YouTube, Science Illustrated,* and other relevant books and current events.

This unit will be learned in the third trimester.

Essential Questions

- What is a force?
- How is a net force calculated?
- What is a balanced force?
- What is an unbalanced force?
- How do mass and weight differ?
- What is friction?
- How does friction force affect an object?
- How is frictional force calculated?
- How do magnetic forces cause objects to move?
- How are magnets and the Earth's magnetic field related?
- What is inertia and how does it affect an object?
- How is inertia calculated?
- What is speed?
- What is velocity?
- What is acceleration?
- How are speed, velocity, and acceleration related and calculated?
- How are speed, velocity, and acceleration represented on a graph?
- What is the difference between kinetic and potential energy and how are they calculated?

- How is kinetic and potential energy manifested in a spring?

Content

- A force is a push or a pull on an object
- Different forces exist and act on bodies in different ways
- The net force on an object is the sum of all forces on the object
- If the net force on an object is not zero, then the object has an unbalanced force acting on it
- Forces occur in equal and opposite pairs (Newton's Third Law)
- Unbalanced forces change the motion of an object
- An object accelerates (changes it speed) when an unbalanced force acts on it
- Weight and mass are different characteristics of an object and are measured in different units
- Mass is related to the amount of matter in an object
- Weight is a measure of the force of gravity on an object
- Friction is the force that resists motion between two surfaces
- Frictional forces depend on the types of surfaces in contact
- The force needed to move an object across a horizontal surface at a constant speed is equal in magnitude, but opposite in direction, to the force of friction
- Magnets can exert forces of attraction or repulsion on each other
- Only certain materials are considered magnetic
- Magnetic forces can cause objects to move
- A compass can be constructed by suspending a magnet so that it is free to rotate
- The Earth has a magnetic field
- Inertia is a property of matter that renders it resistant to a change in motion
- An object at rest will stay at rest if an unbalanced force is not applied to the object
- A moving object will remain in motion if an unbalanced force is not applied to the object
- An object changes its speed if an unbalanced force acts on an object
- Average speed is calculated by dividing total distance by the total time it takes to travel that distance
- Velocity considers both speed and direction
- An object accelerates if it changes its speed or direction
- Kinetic energy is the energy of motion of an object
- Potential energy is the stored energy of an object
- Energy is transferred from one object to another when "work" is done
- Friction turns some kinetic energy into heat energy

Skills

- Compare and discuss ideas about forces, energy, and motion
- Design and perform experiments with forces, energy, and motion
- Use scientific instruments to gather and analyze data
- Use math skills to analyze data
- Write evidence-based conclusions for experiments with forces, energy, and motion
- Communicate results through writings, tables, graphs, and presentations

- Reflect on experiences with forces, energy, and motion through discussions
- Use results of previous experiments with forces, energy, and motion to predict outcomes in new situations
- Use previously learned concepts and skills to understand basic physics concepts
- Read to obtain more information about the nature of forces, energy, and motion; how we use forces, energy, and motion; and the history of development of ideas about basic physics

Assessments

The majority of this unit is an inquiry-based hands-on approach to learning. It consists of laboratory activities which vary in their intensity, approach, skill, and evaluative measurements. For example, some of the lab activities are "walk-through" labs, where the student is guided through a procedure and a process, and is asked to make connections among the main concepts presented in the activity and associated readings. Other lab activities consist of a problem that is presented to the student, which he or she must solve by designing an experiment (which is then peer and teacher evaluated before proceeding with the lab activity) and collecting data. Regardless of the lab activity, students are evaluated based on the quality and presentation of the collected data in graphic organizers; the efficacy and accuracy of the experimental design; the connections made between the experimental design, the data collected, and the conclusion of the laboratory report- i.e. "tying it all together to see the big picture"; and lab etiquette and adherence to safety rules.

Other evidence for learning includes several short 5-10 question quizzes, and end-of-unit lab practical (hands-on) test, end-of-unit paper test based on the labs, and several creative projects, which may include posters, skits, songs and poems, presentations, and science fair projects (Science Fair projects span several units and may not be completed within any one single unit presented within Folsom School's Science Curriculum).

Standards

NGSS Standard Correlation

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 car and stationary objects, and between a meteor and a space vehicle.] [*Assessment Boundary: Assessment is limited to vertical or horizontal interactions in one dimension.*]

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.] [*Assessment Boundary: Assessment is limited to forces and changes in motion in one-dimension in an inertial reference frame and to change in one variable at a time. Assessment does not include the use of trigonometry.*]

MS-PS2-3: Ask questions about data to determine the factors that affect the strength of electric and magnetic forces. [Clarification Statement: Examples of devices that use electric and magnetic forces could include electromagnets, electric motors, or generators. Examples of data could include the effect of the number of turns of wire on the strength of an electromagnet, or the effect of increasing the number or strength of magnets on the speed of an electric motor.] [*Assessment Boundary: Assessment about questions that require quantitative answers is limited to proportional reasoning and algebraic thinking.*]

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.] [*Assessment Boundary: Assessment does not include Newton's Law of Gravitation or Kepler's Laws.*]

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.] [*Assessment Boundary: Assessment is limited to electric and magnetic fields, and limited to qualitative evidence for the existence of fields.*]

MS-PS3-1: Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object. [Clarification Statement: Emphasis is on descriptive relationships between kinetic energy and mass separately from kinetic energy and speed. Examples could include riding a bicycle at different speeds, rolling different sizes of rocks downhill, and getting hit by a wiffle ball versus a tennis ball.]

MS-PS3-2: Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system. [Clarification Statement: Emphasis is on relative amounts of potential energy, not on calculations of potential energy. Examples of objects within systems interacting at varying distances could include: the Earth and either a roller coaster cart at varying positions on a hill or objects at varying heights on shelves, changing the direction/orientation of a magnet, and a balloon with static electrical charge being brought closer to a classmate's hair. Examples of models could include representations, diagrams, pictures, and written descriptions of systems.] [*Assessment Boundary: Assessment is limited to two objects and electric, magnetic, and gravitational interactions.*]

MS-PS3-3: Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.* [Clarification Statement: Examples of devices could include an insulated box, a solar cooker, and a Styrofoam cup.] [*Assessment Boundary: Assessment does not include calculating the total amount of thermal energy transferred.*]

MS-PS3-4: Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample. [Clarification Statement: Examples of experiments could include comparing final water temperatures after different masses of ice melted in the same volume of water with the same initial temperature, the temperature change of samples of different materials with the same mass as they cool or heat

in the environment, or the same material with different masses when a specific amount of energy is added.] [*Assessment Boundary: Assessment does not include calculating the total amount of thermal energy transferred.*]

MS-PS3-5: Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object. [Clarification Statement: Examples of empirical evidence used in arguments could include an inventory or other representation of the energy before and after the transfer in the form of temperature changes or motion of object.] [*Assessment Boundary: Assessment does not include calculations of energy.*]

Resources

Smithsonian Institution, 2012. *Science and Technology Concepts- Secondary: Experimenting with Forces and Motion.* (Toler- Developer of module).

Pearson 2011. Interactive Science: *Forces and Energy.* Upper Saddle River, NJ