Fifth Grade Companion Document

5-Unit 1: Measuring Changes in Motion

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Introduction to the K-7 Companion Document
An Instructional Framework

Overview

The Michigan K-7 Grade Level Content Expectations for Science establish what every student is expected to know and be able to do by the end of Grade Seven as mandated by the legislation in the State of Michigan. The Science Content Expectations Documents have raised the bar for our students, teachers and educational systems.

In an effort to support these standards and help our elementary and middle school teachers develop rigorous and relevant curricula to assist students in mastery, the Michigan Science Leadership Academy, in collaboration with the Michigan Mathematics and Science Center Network and the Michigan Science Teachers Association, worked in partnership with Michigan Department of Education to develop these companion documents. Our goal is for each student to master the science content expectations as outlined in each grade level of the K-7 Grade Level Content Expectations.

This instructional framework is an effort to clarify possible units within the K-7 Science Grade Level Content Expectations. The Instructional Framework provides descriptions of instructional activities that are appropriate for inquiry science in the classroom and meet the instructional goals. Included are brief descriptions of multiple activities that provide the learner with opportunities for exploration and observation, planning and conducting investigations, presenting findings and expanding thinking beyond the classroom.

These companion documents are an effort to clarify and support the K-7 Science Content Expectations. Each grade level has been organized into four teachable units- organized around the big ideas and conceptual themes in earth, life and physical science. . The document is similar in format to the Science Assessment and Item Specifications for the 2009 National Assessment for Education Progress (NAEP). The companion documents are intended to provide boundaries to the content expectations. These boundaries are presented as “notes to teachers”, not comprehensive descriptions of the full range of science content; they do not stand alone, but rather, work in conjunction with the content expectations. The boundaries use seven categories of parameters:

a. **Clarifications** refer to the restatement of the “key idea” or specific intent or elaboration of the content statements. They are not intended to denote a sense of content priority. The clarifications guide assessment.
b. **Vocabulary** refers to the vocabulary for use and application of the science topics and principles that appear in the content statements and expectations. The terms in this section along with those presented

within the standard, content statement and content expectation comprise the assessable vocabulary.

c. **Instruments, Measurements and Representations** refer to the instruments students are expected to use and the level of precision expected to measure, classify and interpret phenomena or measurement. This section contains assessable information.
d. **Inquiry Instructional Examples** presented to assist the student in becoming engaged in the study of science through their natural curiosity in the subject matter that is of high interest. Students explore and begin to form ideas and try to make sense of the world around them. Students are guided in the process of scientific inquiry through purposeful observations, investigations and demonstrating understanding through a variety of experiences. Students observe, classify, predict, measure and identify and control variables while doing “hands-on” activities.
e. **Assessment Examples** are presented to help clarify how the teacher can conduct formative assessments in the classroom to assess student progress and understanding
f. **Enrichment and Intervention** is instructional examples the stretch the thinking beyond the instructional examples and provides ideas for reinforcement of challenging concepts.
g. **Examples, Observations, Phenomena** are included as exemplars of different modes of instruction appropriate to the unit in which they are listed. These examples include reflection, a link to real world application, and elaboration beyond the classroom. These examples are intended for instructional guidance only and are not assessable.
h. **Curricular Connections and Integrations** are offered to assist the teacher and curriculum administrator in aligning the science curriculum with other areas of the school curriculum. Ideas are presented that will assist the classroom instructor in making appropriate connections of science with other aspects of the total curriculum.

This Instructional Framework is NOT a step-by-step instructional manual but a guide developed to help teachers and curriculum developers design their own lesson plans, select useful portions of text, and create assessments that are aligned with the grade level science curriculum for the State of Michigan. It is not intended to be a curriculum, but ideas and suggestions for generating and implementing high quality K-7 instruction and inquiry activities to assist the classroom teacher in implementing these science content expectations in the classroom.

5th Grade Unit 1:
Measuring Changes in Motion

Content Statements and Expectations

5-Unit 1: Measuring Changes in Motion

Big Ideas (Key Concepts)

- Every force is part of an interaction between two objects.
- Forces are pushes and pulls that can be contact or non-contact forces.
- Motion is described relative to something else (point of reference).
- A change in motion is due to unbalanced forces.
- No change in motion and an object at rest are due to balanced forces.

Clarification of Content Expectations

Standard: Force and Motion

Content Statement – P.FM.M.2
Force Interactions- Some forces between objects act when the objects are in direct contact (touching), such as friction and air resistance, or when they are not in direct contact (not touching), such as magnetic force, electrical force, and gravitational force.

Content Expectations

P.FM.05.21 Distinguish between contact forces and non-contact forces.

Instructional Clarifications

1. Distinguish means to recognize or know the differences between contact forces and non-contact forces.
2. A force is a push or a pull that causes an object to accelerate (change in speed and/or direction) in the direction of force.
3. Contact forces are pushes and pulls that result from direct touching of objects (for example: a foot kicking a soccer ball, a bat striking a baseball, hand pushing on an object, shoes/feet against a floor).
4. Friction is the rubbing of two surfaces. It is the force of two surfaces in contact with each other.
5. Non-contact forces are pushes and pulls that result without direct touching of objects acting at a distance (for example: gravity, magnet attraction and repulsion, and electrical fields).

Assessment Clarifications

1. Contact forces are pushes and pulls that result from direct touching of objects.
2. Non-contact forces are pushes and pulls that result without direct touching of objects. (Gravity, magnets, and electrical fields are examples of non-contact forces.)

3. A force is a push or a pull that causes an object to change its speed and/or direction in the direction of the force.

P.FM.05.22 Demonstrate contact and non-contact forces to change the motion of an object.

Instructional Clarifications

1. Demonstrate is to show through manipulation of materials, drawings, and written and verbal explanations changes in the motion of an object either by contact or non-contact forces.
2. A force is a push or a pull that causes an object to accelerate (change in speed and/or direction) in the direction of the force.
3. Contact forces are pushes and pulls that result from direct touching of objects (for example: a foot kicking a soccer ball, a bat striking a baseball, hand pushing on an object, shoes/feet against a floor)
4. Non-contact forces are pushes and pulls that result without direct touching of objects (for example: a magnet attracting or repelling another magnet or magnetic material through a distance, gravitational pull on objects on earth and/or in space)
5. Change in motion is a change in direction, speed or both.

Assessment Clarifications:

1. Show how contact forces change the motion of an object.
2. Show how non-contact forces change the motion of an object.

Content Statement – P.FM.M.3

Force- Forces have a magnitude and direction. Forces can be added. The net force on an object is the sum of all of the forces acting on the object. The speed and/or direction of motion of an object changes when a non-zero net force is applied to it. A balanced force on an object does not change the motion of the object (the object either remains at rest or continues to move at a constant speed in a straight line).

Content Expectations

P.FM.05.31 Describe what happens when two forces act on an object in the same or opposing directions.

Instructional Clarification:

1. Describe means to tell or depict in written or spoken words how two forces act on an object in the same or opposing directions
2. A force is a push or a pull that causes an object to accelerate (change in speed and/or direction) in the direction of its application.
3. Two forces acting on an object in the same direction cause the object to accelerate (speed up, slow down and/or change direction) in the direction of the forces.

4. Two forces acting on an object in opposing directions can be of equal strength and are therefore, balanced (zero net force). The result will be that if the object is at rest, it will stay at rest (not move). If the object is moving, it will continue to move a constant speed in a straight line.
5. Two forces acting on an object in opposing directions can be of unequal strength and therefore, are unbalanced (non-zero net force). The result will be motion (starting or speeding up) in the direction of the stronger force.

Assessment Clarification:

1. A force is a push or a pull that causes an object to change speed and/or direction in the direction of the force.
2. Two forces acting on an object in the same direction cause the object to accelerate (speed up, slow down and/or change direction) in the direction of the forces.
3. Two forces acting on an object in opposing directions can be of equal strength and are therefore, balanced (zero net force). The result will be that if the object is at rest, it will stay at rest (not move). If the object is moving, it will continue to move a constant speed in a straight line.
4. Two forces acting on an object in opposing directions can be of unequal strength and therefore, are unbalanced (non-zero net force). The result will be motion in the direction of the stronger force.

P.FM.05.32 Describe how constant motion is the result of balanced (zero net) forces.

Instructional Clarification

1. Describe means to tell or depict in written or spoken words how constant motion is the result of balanced forces
2. A force is a push or a pull that causes an object to change speed and/or direction in the direction of the force.
3. Forces acting on an object in opposing directions of equal strength are balanced (zero net force).
4. When all forces are balanced an object that is moving will keep moving in a straight line at a constant speed.
5. If an object is at rest, not moving, it will stay at rest if all of the forces are balanced.

Assessment Clarification

1. A force is a push or a pull that causes an object to accelerate (change in speed and/or direction) in the direction of its application.
2. Forces acting on an object in opposing directions of equal strength are balanced (zero net force).
3. When all forces are balanced an object that is moving will keep moving in a straight line at a constant speed.
4. If an object is at rest, not moving, it will stay at rest if all of the forces acting on it are balanced.

P.FM.05.33 Describe how changes in the motion of objects are caused by a non-zero net (unbalanced) force.

Instructional Clarification:

1. Describe means to tell or depict in written or spoken words how changes in motion of objects are caused by a non-zero force.
2. An object experiencing a change in its motion (speeding up, slowing down, or changing direction) is said to be accelerating. A common misconception is that acceleration is limited to an increase in speed.
3. A force is a push or a pull that causes an object to accelerate (change in speed and/or direction) in the direction of the force.
4. Forces acting on an object in opposing directions of unequal strength are unbalanced (non-zero net force).
5. An object at rest will begin to move if a non-zero net force is applied to it. It will move in the direction of the non-zero net force.
6. An object that is in motion will speed up, slow down and/or change direction if a non-zero net force is applied to it. It will speed up, slow down, or change direction in the direction of the non-zero net force.

Assessment Clarification

1. A force is a push or a pull that causes an object to change speed and/or direction in the direction of the force.
2. Forces acting on an object in opposing directions of unequal strength are unbalanced (non-zero net force).
3. An object at rest will begin to move if a non-zero net force is applied to it. It will move in the direction of the force.
4. An object that is in motion will speed up, slow down, and/or change direction if a non-zero net (unbalanced) force.

P.FM.05.34 Relate the size of change in motion to the strength of unbalanced forces and the mass of the object.

Instructional Clarification

1. Relate means to establish an association or a connection between size of the change of motion to the strength of unbalanced forces and the mass of the object.
2. Magnitude (size) refers to a force's strength.
3. Forces acting on an object in opposing directions of unequal strength are unbalanced (non-zero net force).
4. A change in motion is change in speed and/or direction.
5. Mass is measured in grams or kilograms using a balance. Mass is related to an object's resistance to changes in motion. The greater the mass of an object the greater force is required to change the motion of the object.
6. The strength of an unbalanced force is the measurement of how strong (greater) or weak (lesser) the push or pull is that causes the change in motion. A weaker or lesser force causes a small change; a strong or greater force causes a larger change in the motion of objects.

Assessment Clarification

1. Forces acting on an object in opposing directions of unequal strength are unbalanced (non-zero net force).
2. A change in motion is change in speed and/or direction.
3. Mass is measured in grams or kilograms using a balance. Mass is related to an objects resistance to changes in motion. The greater the mass of an object the greater the force is required to change the motion of the object.
4. The strength of an unbalanced force is the measurement of how strong (greater) or weak (lesser) the push or pull is that causes the change in motion. A weaker or lesser force causes a small change; a strong or greater force causes a larger change in the motion of objects.

Content Statement – P.FM.M.4

Speed- Motion can be described by a change in position relative to a point of reference. The motion of an object can be described by its speed and the direction it is moving. The position and speed of an object can be measured and graphed as a function of time.

Content Expectations

P.FM.05.41 Explain the motion of an object relative to a point of reference.

Instructional Clarification

1. Explain is to clearly describe by means of illustrations (drawings), demonstrations, written reports or verbally the motion of an object relative to a point of reference.
2. Motion is relative or in relation to something else (point of reference).
3. A point of reference offers all observers a common frame through which to judge motion and its changes. A point of reference is the point from which movement is determined.

Assessment Clarification

1. Describe the motion of an object in relation to a point of reference.

P.FM.05.42 Describe the motion of an object in terms of distance, time and direction, as the object moves, and in relationship to other objects.

Instructional Clarification

1. Describe means to tell or depict in written or spoken words the motion of an object in terms of distance, time, and direction.
2. Speed is the ratio of distance covered per unit of time, S=D/T.
3. The direction of the motion is in relation to a point of reference. Direction can be described as up, down, right, left, north, south, east, west, forward and backward.
4. An object's motion can be described in terms of speed and motion.

5. The term distance describes amount of space between two things or points. Distance is measured in millimeters, centimeters, meters, and kilometers.

Assessment Clarification

1. Speed is the ratio of distance covered per unit of time, S=D/T.
2. The direction of the motion is in relation to a point of reference. Direction can be described as up, down, right, left, north, south, east, and west.
3. An object's motion can be described in terms of speed and motion.
4. The term distance describes amount of space between two things or points. Distance is measured in millimeters, centimeters, meters, and kilometers.

P.FM.05.43 Demonstrate how motion can be measured and represented on a graph.

Instructional Clarification

1. Demonstrate means to show through manipulation of materials, drawings, and written or verbal explanation with a graph how motion can be measured and represented.
2. An object's motion can be measured by its position and speed.
3. An object's position can be measured and graphed as a function of time.
4. An object's speed can be measured and graphed as a function of time.
5. Represent motion on a position versus time graph.
6. Represent motion on a speed versus time graph.

Assessment Clarification

1. An object's motion can be measured by its position and speed.
2. An object's position can be measured and graphed as a function of time.
3. An object's speed can be measured and graphed as a function of time.
4. Represent motion on a position versus time graph.
5. Represent motion on a speed versus time graph.

Inquiry Process, Inquiry Analysis and Communication, Reflection and Social Implications

Inquiry Processes
S.IP.05.11 Generate scientific questions about motion based on observations, investigations and research.
S.IP.05.12 Design and conduct scientific investigations on motion and changes in motion.
S.IP.05.13 Use tools and equipment (stop watches, meter sticks and tapes, models, balances) appropriate to scientific investigation of motion.
S.IP.05.14 Use metric measurement devices in the investigation of motion.
S.IP.05.15 Construct charts and graphs from data and observations dealing with motion and changes in motion.
S.IP.05.16 Identify patterns in data regarding motion.
Inquiry Analysis and Communication
S.IA.05.11 Analyze information from data tables and graphs to answer scientific questions on motion.
S.IA.05.12 Evaluate data, claims, and personal knowledge through collaborative science discourse about motion.
S.IA.05.13 Communicate and defend findings of observations and investigations about motion using evidence.
S.IA.05.14 Draw conclusions from sets of data from multiple trials of a scientific investigation on motion and changes in motion.
S.IA.05.15 Use multiple sources of information on motion and changes in motion to evaluate strengths and weaknesses of claims, arguments, or data.
Reflection and Social Implications
S.RS.05.11 Evaluate the strengths and weaknesses of claims, arguments, and data regarding motion and changes in motion.
S.RS.05.12 Describe limitations in personal and scientific knowledge regarding motion and changes in motion.
S.RS.05.13 Identify the need for evidence in making scientific decisions about motion.
S.RS.05.15 Demonstrate scientific concepts about motion through various illustrations, performances, models, exhibits, and activities
S.RS.05.16 Design solutions to problems concerning the motion of objects using technology.
S.RS.05.17 Describe the effect humans and other organisms have on the balance in the natural world when force is applied to an object.
S.RS.05.19 Describe how the science and technology of motion have advanced because of the contribution of many people throughout history and across cultures.

Vocabulary

Critically important-State Assessable	Instructionally Useful
balanced force change of direction change of motion change of speed force strength friction graph magnetic attraction magnetic repulsion mass relative position constant speed direction of motion gravitational force speed unbalanced force zero net force non-zero net force	acceleration applied force kinetic energy mechanical motion Newton's laws of motion pulley deceleration inertia velocity magnitude

Instruments, Measurements, Representations

Measurement	Instruments	Representations
mass	balance	kilograms, grams
distance	meter stick, measuring tape	kilometer, meter, centimeter
time	stop watch, timer, clock with second hand	hours, minutes seconds,
speed	meter stick, measuring tape, stop watch, timer, clock with second hand	kilometers /hour, meters/second, centimeters/second

Instructional Framework

The following Instructional Framework is an effort to clarify possible units within the K-7 Science Grade Level Content Expectations. The Instructional Framework provides descriptions of instructional activities that are appropriate for inquiry science in the classroom and meet the instructional goals. Included are brief descriptions of multiple activities that provide the learner with opportunities for exploration and observation, planning and conducting investigations, presenting findings, and expanding thinking beyond the classroom. The Instructional Framework is NOT a step-by-step instructional manual, but a guide intended to help teachers and curriculum developers design their own lesson plans, select useful and appropriate resources and create assessments that are aligned with the grade level science curriculum for the State of Michigan.

Instructional Examples

Force Interactions: P.FM.05.21, P.FM.05.22
Forces: P.FM.05.31, P.FM.05.32, P.FM.05.33, P.FM.05.34
Speed: P.FM.05.41, P.FM.05.42, P.FM.05.43

Objectives

- Describe motion as the result of contact and non-contact forces.
- Observe the affects of zero and non-zero net forces acting on an object.
- Given a point of reference describe motion in terms of speed, distance, time, and direction.
- Construct and analyze graphs of motion.

Engage and Explore

- Introduce observations of motion using a variety of balls and other rolling objects (marbles, tennis balls, golf balls, toy cars, dowels, cylinders, etc.) and ramps. Give students sufficient time to explore motion of a variety of objects, raise questions, conduct trial and error investigations, and describe their observations in their own terms and current understandings. (P.FM.05.41, P.FM.05.42, S.IP.05.11)
- Encourage students to ask *what would happen if…* questions to explore the relationship between the size of the force and the change in motion and the mass of the object and the change in motion. Have students conduct investigations to determine the size of forces needed to change the motion of objects. (P.FM.05.34, S.IP.05.11, S.IA.05.12, S.IA.05.13, S.IA.05.14, S.IA.05.15, S.IA.05.16)
- Make a class chart that classifies the descriptions of motion into motion words, speed words, and direction words. Ask students if any of the descriptions of motion are measurable. (P.FM.05.41, P.FM.05.42, S.IP.05.15)

- Further develop student experiences with describing motion by measuring distance and time of different types of motion that they can generate by themselves, (hop, skip, walk, run, hop on one foot, walk backwards, crawl, etc.) and compare the distances traveled over time. (P.FM.05.41, P.FM.05.42, S.IP.05.11, S.IP.05.12, S.IA.05.13, P.FM.05.43)
- Distribute metric measuring tapes and stop watches and give students the opportunity to explore the measurement of distance and time as related to the motion of different objects and themselves. (P.FM.05.41, P.FM.05.42, S.IP.05.11, S.IP.05.12, S.IA.05.13, P.FM.05.43)
- Ask students to describe what started the objects in motion. Review the term force from their experiences in the third grade or introduce the term force if students are not yet familiar with the term. (P.FM.05.21)
- Students explore forces and their affect on motion by setting up low friction cars with and without fans attached to them. They observe a car at rest with out any fans attached. They observe the motion of a car with two fans attached in opposing directions, one fan attached, and three fans attached (two oriented in the same direction, and one in the opposite direction. They are asked to predict how the cars will move after the fan or fans are turned on. They record their results. (P.FM.05.31, P.FM.05.32, P.FM.05.33, P.FM.05.34)
- Students explore the motion of an object relative to a reference point by moving their bodies in front of a sensor to recreate distance-time graphs. (P.FM.05.41, P.FM.05.42, P.FM.05.43)

Explain and Define

- Explain the terms balanced and unbalanced forces. Ask students to define the terms in their own words and give examples of when the forces were balanced and unbalanced in the balloon rocket demonstration. (P.FM.05.31, P.FM.05.32, P.FM.05.33, S.IA.05.12)
- Students experience balanced and unbalanced forces through the game of tug-of-war. As a class, discuss the forces acting on objects at rest and explain that objects at rest have balanced forces acting on them. Relate balanced forces to tug-of-war when the pull is equal from each team and unbalanced when one team pulls harder than another. The students understand that the balanced and unbalanced forces are the forces exerted on the rope by each team. (P.FM.05.31, P.FM.05.32, P.FM.05.33)
- Introduce the spring scale, as a tool to measure the net force, in Newtons, that cause various changes in the motion of objects. Spring scales can be attached to a variety of material as it is pulled across a variety of surfaces and up and down ramps. Students collect data and compare the forces and variables that affect the forces of motion. (P.FM.05.31, P.FM.05.32, P.FM.05.33, S.IP.05.13)
- Introduce the balance as a tool to measure the mass of different objects they are using for investigations into forces and motion. (P.FM.05.34, S.IP.05.13)
- Students move a bowling ball using only a rubber mallet. Tapping the ball with the mallet can only move the ball, and the mallet cannot be kept in constant contact with the ball. This forces to the students to observe the

direction of the taps that are necessary to start the ball moving, keep the ball moving in a given direction, and to stop the ball and bring it to rest. The students identify the use of the mallet as a contact force and compare it the use of magnetism, gravity or electrical forces to move objects. (P.FM.05.21, P.FM.05.22)

- Students discuss the effect of the force of the fan or fans on the cars. When did the cars go faster? Were the forces ever balanced? When were the forces unbalanced? (P.FM.05.31, P.FM.05.32, P.FM.05.33, P.FM.05.34)
- Students explain what they had to do to recreate the different parts of the graphs. For example, what did they have to do make the line slope up or down for a certain amount of time. What happened to the graph when they moved away from the sensor? What did they have to do make the line flat? What happened when they were moving the fastest or slowest? (P.FM.05.41, P.FM.05.42, P.FM.05.43)

Elaborate and Apply

- Challenge student to use the balloon rocket to design a demonstration that shows motion with two forces act on an object in the same direction and then in opposite directions. Give students sufficient materials and time to investigate the use of 2 or more balloons. (P.FM.05.31, P.FM.05.32, P.FM.05.33, S.RS.05.11, S.RS.05.12, S.RS.05.13, S.RS.05.15)
- Elaborate on balanced and unbalanced forces by introducing non-contact forces. The forces students are most likely to have explored are pushes and pulls that come in contact with the moving object. Once students understand that net forces change the motion of objects, introduce the force of gravity, magnets, and electricity. Have students move objects using the different polarity of the object and magnets. (P.FM.05.21, P.FM.05.22)
- Have students design an investigation that demonstrates the least amount of force needed to move an object, using their knowledge of friction, gravity, magnitude of force, and mass of an object. (P.FM.05.21, P.FM.05.22, S.IP.05.11, S.IP.05.12, S.IP.05.13, S.IP.05.14, S.IP.05.15, S.IP.05.16, S.IA.05.13)
- Demonstrations of gravity should include the following kinds of investigations, dropping objects and observing the path of falling objects, observing the path of baseballs, volleyballs, footballs, basketballs, ping pong balls, marbles after being launched. (P.FM.05.21, P.FM.05.22)
- Demonstrations of magnetic forces include moving magnetic marbles/ball bearings of various sizes and weights. (P.FM.05.21, P.FM.05.22)
- Design a paper airplane that will stay aloft for x number of minutes. Have students measure the distance and time for multiple trials of their airplane and calculate and graph the speed. Encourage students to analyze their plane design and make modifications to increase the distance and/or speed of the plane. Discuss the force of friction as air resistance (contact force) and how friction is considered in designs of vehicles of flight.

(P.FM.05.21, P.FM.05.22, P.FM.05.43, S.IA.05.11, S.IA.05.12, S.IA.05.13, S.IA.05.14, S.RS.05.15)

- Demonstrate static electricity changing the direction of a stream of water as it comes out of a faucet or is poured from a container into another container. The use of static electricity can also be use to move or stop the motion of a hanging object suspended from a string. An inflated balloon rubbed on a fabric can be used to pick up tiny bits of paper to show static electricity. (P.FM.05.21, P.FM.05.22)
- The students draw diagrams, pictures or concept maps to indicate how they are thinking about force and its relationship to motion. (P.FM.05.31, P.FM.05.32, P.FM.05.33, P.FM.05.34)
- Students discuss speeding up and slowing down as represented on the graphs that they created moving in front of the sensor. (P.FM.05.41, P.FM.05.42, P.FM.05.43)

Evaluate Student Understanding

Formative Assessment Examples

- Demonstrations and explorations using magnets to change motion which would include moving a magnetic object that is at rest, repelling or attracting another magnet from distance. (P.FM.05.21, P.FM.05.22)
- Provide students with examples of graphs created in the activity from P.FM.05.41, P.FM.05.42, and P.FM.05.43. The students determine if the cars could match any of the distance-time graphs. (P.FM.05.31, P.FM.05.32, P.FM.05.33, P.FM.05.34)
- Students illustrate via graphs or number lines what it means to move regarding distance, time and direction. (P.FM.05.41, P.FM.05.42, P.FM.05.43)
- Students write in science journals, quick writes, and poetry to reflect knowledge of forces and motion.
- Use classroom discussion following an inquiry activity to assess understanding of motion and forces.
- Design inquiry experiments using contact and non-contact forces to assess understanding of the forces from a distance and forces that make contact with the object.

Summative Assessment Examples

- End of unit test
- Poster, brochure, or Power Point presentation on energy transfer
- Written report on uses/benefits of alternative power

Enrichment

- Students explore speed, distance, and direction building and programming robots using Lego Mindstorm kits. For example, Lego robots can be programmed to speed up and/or slow down, go forward, reverse and go backward etc. Students can use stopwatches to time a robot traveling over a course taking marking the times at regular intervals of distance. Afterwards, the students create distance-time graphs using the data.
- Students build and use weather instruments such as wind vanes and anemometers to make observations of the motion of the air.
- Students build air popper devices using various cylinders such as gift-wrap paper tubes, coffee cans, Pringles cans, balloons, wax paper or other kinds of material. The students attach the balloon to one of the open ends of the tube, and poke a hole the center of the other end of the cylinder in the case of Pringles and coffee cans. In the case of gift-wrap paper or paper towel cylinders the other end is covered with wax paper or newspaper. A hole is poked in the center of the paper at this end. The air popper devices are then used to propel an object across a length of table or other surface. A feather works very, and can be used to conduct "feather races". Pointing the end of the device with the hole at the feather and plucking or tapping the end with the balloon moves the feather or other object. Students can make observations of speed, direction, mass, and contact forces.
- Students research the Maglev train to learn more about how non-contact forces are used to reduce the use of natural resources.

Intervention

- Students further explore forces and their affect on motion by observing the motion of cars as they move across a table. The students will attach fishing line or some other string to one end of a car and attach a baggy to the other end. The baggy is for adding weights, which will exert a force on the car when hung over the end of the table. The students should attach enough line so that the car can travel one meter when they release the car. In the first set of trials, the baggy will contain 10 grams and the car will have 0 grams on top of it. The students observe the motion of the car after it is released. They can time the car stopping it when it reaches the end of a meter. They should repeat this several times to see if the results are consistent. Next, the students add 10 grams to the top of the car, and observe the motion of car when they release it. The baggy still contains the original 10 grams. Finally, the students place 20 grams on the top of the car while keeping the baggy at 10 grams, and record the results.

- After completing the above trials the students will conduct three new trials. In the first trial, the car will not have any additional grams added as in the first trial above, but the weight in the baggy will now be increased to 20 grams. The students repeat the procedure above. For the second trial 10 grams is added and for the third trial 20 grams is added.
- The third set of trials will be conducted with 30 grams in the baggy. Once again, the car will have 0 grams, then 10 grams, and finally 20 grams for each of the subsequent trials. There will be a total of nine trials in all. Students record their observations and discuss the results. Do they observe a pattern or patterns? What are the forces acting on the car? Is or are the forces contact or non-contact forces?
- Center an index card over the top of a glass, and place a coin in the center of the index card. Flick the card from the side with one or two fingers. Observe the motion of the card and the coin. Place the coin on a table or other level surface. Observe it for a while. Note that the card flew off in the direction of the force of applied to it by the finger. The coin stayed in place and dropped due the force of gravity.

Examples, Observations, and Phenomena (Real World Context)

Examples of contact forces causing motion include wind-propelling sailboat across water, a horse pulling a wagon or a car pulling a trailer, a person pushing a cart of books, etc.

Examples of a contact force and a non-contact force causing motion or changes in motion would be throwing a rock or ball. You and your hand provide the contact force that gets it going. Gravity acting on the rock or ball causes it to start falling and speeding up in the direction of the ground. When it hits the ground it stops which is another change in motion.

A person riding in a car with groceries or other objects not restrained by a seat belt provides another real life scenario. When the driver steps on the brake friction between the road and the tires changes the motion of the car as it comes to a stop. The seat belt applies a force to the driver and other passengers and changes the motion of the people in the car from moving to not moving. The groceries or other objects not restrained keep doing what they are doing which is moving, and change position in the car that is probably to wind up on the floor.

Two students push with equal force on a chair or cart on opposite sides and the result is that the chair or cart does not move. Because the forces are the same and in opposite directions, they cancel each other out. The net force acting on the chair or cart is zero. The net force is what is left over when you figure in all the effects of different forces acting on something. Next add another student to one of the sides so that there are now two students pushing against one. The chair or cart will move in the direction of the greater force. The additional student causes the forces to be unbalanced for a non-zero net force.

Automobiles start moving and stop moving faster than trucks. Automobiles have smaller masses than trucks. In general, it is easier to change the speed and/or direction of an automobile than a truck. This is also true of motorcycles and automobiles. The motorcycle may have a smaller engine (smaller force), but it also has a smaller mass.

Literacy Integration

Reading

R.IT.05.01 analyze the structure, elements, features, style, and purpose of informational genre, including research reports, "how-to" articles, and essays.

R.CM.05.01 connect personal knowledge, experiences, and understanding of the world to themes and perspectives in text through oral and written responses.

R.CM.05.02 retell through concise summarizations grade-level narrative and informational text.

R.CM.06.04 apply significant knowledge from grade-level science, social studies, and mathematics texts.

Read the book - *THE MAGIC SCHOOL BUS PLAYS BALL: A Book About Forces* by Joanna Cole.

Writing

W.PR.05.01 Students will set a purpose, consider audience, and replicate authors' styles and patterns when writing a narrative or informational piece.

W.PR.05.04 Students will revise drafts based on constructive and specific oral and written responses to writing by identifying sections of the piece to improve organization and flow of ideas (e.g., position/evidence organizational pattern, craft such as titles, leads, endings, and powerful verbs).

W.PS.05.01 Students will exhibit personal style and voice to enhance the written message in both narrative (e.g., personification, humor, element of surprise) and informational writing (e.g., emotional appeal, strong opinion, credible support).

Speaking

S.CN.06.01 Students will adjust their use of language to communicate effectively with a variety of audiences and for different purposes by asking and responding to questions and remarks to engage the audience when presenting.

S.CN.06.02 Students will speak effectively using rhyme, rhythm, cadence, and word play for effect in narrative and informative presentations.

- Small groups of students create and perform skits that show physical properties of the three states of matter.

Mathematics Integration

N.ME.05.08 Understand the relative magnitude of ones, tenths, and hundredths and the relationship of each place value to the place to its right.

N.MR.05.15 Multiply a whole number by powers of 10: 0.01, 0.1, 1, 10, 100, 1000, and identify patterns.

N.FL.05.16 Divide numbers by 10's, 100's, 1000's using mental strategies.

M.UN.05.03 Compare the relative sizes of one cubic inch to one cubic foot, and one cubic centimeter to one cubic meter.

M.UN.05.04 Convert measurements of length and weight within a given system using easily manipulated numbers.

D.RE.05.01 Read and interpret line graphs, e.g., distance-time graphs.