

**North Carolina Science Essential Standards  
Unit Planning Pack with Resources**

**Subject Area/Grade:** Physical Science, grade 3

**Title:** Force, Speed and Gravity

**1 Unit Theme:** *(to be completed by the unit organizer)*

**2 Conceptual Lens:** *(to be completed by the unit organizer)*

**3 Identify the Big Ideas:** *(Align to Essential Standards)*  
Force and Motion                      Gravity

**4 Enduring Understanding**      *Generalizations)*

- Mass and force affect motion
- There are fundamental forces of nature that influence the universe.
- Gravity is a fundamental force.
- The earth's gravity pulls on any object on or near the Earth, without touching it.

**5 Essential Questions**      *(Guiding Questions)*

How do objects move? What affects motion?  
How do forces affect objects?  
What is speed? Why do we say that "speed is relative"?  
Why do objects fall? What is gravity? How is gravity related to mass?  
What would happen if there were no force of gravity?

**NC Science Essential Standards**

**3.P.1 Understand motion and factors that affect motion.**

- 3.P.1.1 Infer changes in speed or direction resulting from forces acting on an object.
- 3.P.1.2 Compare the relative speeds (faster or slower) of objects that travel the same distance in different amounts of time.
- 3.P.1.3 Explain the effect of earth's gravity on the motion of any object on or near the earth.

## Essential Terminology

weight    force    motion    speed    gravity    direction    time    friction    distance    attract    mass

## GRAPHIC ORGANIZERS:

NC Science Essential Standards; Physical Science Domain; Forces and Motion Strand  
Atlas of Science Literacy page 43 in Volume 1, page 27 in Volume 2

Qwiki graphic organizers:

Gravity of Earth [http://www.theinfoexp.com/q/#/Gravity\\_of\\_Earth](http://www.theinfoexp.com/q/#/Gravity_of_Earth)

How Do forces affect objects? [http://www.eduplace.com/science/hmsc/content/organizer/3/org\\_3f\\_15\\_1.pdf](http://www.eduplace.com/science/hmsc/content/organizer/3/org_3f_15_1.pdf)

How Can Motion be Described? [http://www.eduplace.com/science/hmsc/content/organizer/3/org\\_3f\\_15\\_2.pdf](http://www.eduplace.com/science/hmsc/content/organizer/3/org_3f_15_2.pdf)

What are gravity and friction? [http://www.eduplace.com/science/hmsc/content/organizer/4/org\\_4f\\_16\\_2.pdf](http://www.eduplace.com/science/hmsc/content/organizer/4/org_4f_16_2.pdf)

## Science For All Americans

*(minimum ADULT content knowledge)*

### MOTION

Motion is as much a part of the physical world as matter and energy are. Everything moves—atoms and molecules; the stars, planets, and moons; the earth and its surface and everything on its surface; all living things, and every part of living things. Nothing in the universe is at rest.

Since everything is moving, there is no fixed reference point against which the motion of things can be described. All motion is relative to whatever point or object we choose. Thus, a parked bus has no motion with reference to the earth's surface; but since the earth spins on its axis, the bus is moving about 1,000 miles per hour around the center of the earth. If the bus is moving down the highway, then a person walking up the aisle of the bus has one speed with reference to the bus, another with respect to the highway, and yet another with respect to the earth's center. There is no point in space that can serve as a reference for what is actually moving.

Changes in motion—speeding up, slowing down, changing direction—are due to the effects of forces. Any object maintains a constant speed and direction of motion unless an unbalanced outside force acts on it. When an unbalanced force does act on an object, the object's motion changes. Depending on the direction of the force relative to the direction of motion, the object may change its speed (a falling apple) or its direction of motion (the moon in its curved orbit), or both (a fly ball).

### FORCES OF NATURE

The two kinds of forces we are commonly aware of are gravitational and electromagnetic.

Everything in the universe exerts gravitational forces on everything else, although the effects are readily noticeable only when at least one very large mass is involved (such as a star or planet). Gravity is the force behind the fall of rain, the power of rivers, the pulse of tides; it pulls the matter of planets and stars toward their centers to form spheres, holds planets in orbit, and gathers cosmic dust together to form stars. Gravitational forces are thought of as involving a gravitational field that affects space around any mass. The strength of the field around an object is proportional to its mass and diminishes with distance from its center. For example, the earth's pull on an individual will depend on whether the person is, say, on the beach or far out in space.

**NGSS Framework** (recommended Adult content knowledge)

### **PS2.B: TYPES OF INTERACTIONS**

*What underlying forces explain the variety of interactions observed?*

All forces between objects arise from a few types of interactions: gravity, electromagnetism, and strong and weak nuclear interactions. Collisions between objects involve forces between them that can change their motion. Any two objects in contact also exert forces on each other that are electromagnetic in origin. These forces result from deformations of the objects' substructures and the electric charges of the particles that form those substructures (e.g., a table supporting a book, friction forces). Gravitational, electric, and magnetic forces between a pair of objects do not require that they be in contact. These forces are explained by force fields that contain energy and can transfer energy through space. These fields can be mapped by their effect on a test object (mass, charge, or magnet, respectively). Objects with mass are sources of gravitational fields and are affected by the gravitational fields of all other objects with mass. Gravitational forces are always attractive. For two human-scale objects, these forces are too small to observe without sensitive instrumentation. Gravitational interactions are nonnegligible, however, when very massive objects are involved. Thus the gravitational force due to Earth, acting on an object near Earth's surface, pulls that object toward the planet's center. Newton's law of universal gravitation provides the mathematical model to describe and predict the effects of gravitational forces between distant objects. These long-range gravitational interactions govern the evolution and maintenance of large-scale structures in the universe (e.g., the solar system, galaxies) and the patterns of motion within them.

Electric forces and magnetic forces are different aspects of a single electromagnetic interaction. Such forces can be attractive or repulsive, depending on the relative sign of the electric charges involved, the direction of current flow, and the orientation of magnets. The forces' magnitudes depend on the magnitudes of the charges, currents, and magnetic strengths as well as on the distances between the interacting objects. All objects with electrical charge or magnetization are sources of electric or magnetic fields and can be affected by the electric or magnetic fields of other such objects. Attraction and repulsion of electric charges at the atomic scale explain the structure, properties, and transformations of matter and the contact forces between material objects (link to PS1.A and PS1.B). Coulomb's law provides the mathematical model to describe and predict the effects

of electrostatic forces (relating to stationary electric charges or fields) between distant objects. The strong and weak nuclear interactions are important inside atomic nuclei. These short-range interactions determine nuclear sizes, stability, and rates of radioactive decay (see PS1.C).

*Grade Band Endpoints for PS2.B*

**By the end of grade 2.** When objects touch or collide, they push on one another and can change motion or shape.

**By the end of grade 5.** Objects in contact exert forces on each other (friction, elastic pushes and pulls). Electric, magnetic, and gravitational forces between a pair of objects do not require that the objects be in contact—for example, magnets push or pull at a distance. The sizes of the forces in each situation depend on the properties of the objects and their distances apart and, for forces between two magnets, on their orientation relative to each other. The gravitational force of Earth acting on an object near Earth's surface pulls that object toward the planet's center.

### **PS3 Energy**

*(excerpt)*

Motion energy is also called kinetic energy; defined in a given reference frame, it is proportional to the mass of the moving object and grows with the square of its speed. Matter at any temperature above absolute zero contains thermal energy.

Thermal energy is the random motion of particles (whether vibrations in solid matter or molecules or free motion in a gas), this energy is distributed among all the particles in a system through collisions and interactions at a distance. In contrast, a sound wave is a moving pattern of particle vibrations that transmits energy through a medium.

Electric and magnetic fields also contain energy; any change in the relative positions of charged objects (or in the positions or orientations of magnets) changes the fields between them and thus the amount of energy stored in those fields. When a particle in a molecule of solid matter vibrates, energy is continually being transformed back and forth between the energy of motion and the energy stored in the electric and magnetic fields within the matter. Matter in a stable form minimizes the stored energy in the electric and magnetic fields within it; this defines the equilibrium positions and spacing of the atomic nuclei in a molecule or an extended solid and the form of their combined electron charge distributions (e.g., chemical bonds, metals).

Energy stored in fields within a system can also be described as potential energy. For any system where the stored energy depends only on the spatial configuration of the system and not on its history, potential energy is a useful concept (e.g., a massive object above Earth's surface, a compressed or stretched spring). It is defined as a difference in energy compared to some arbitrary reference configuration of a system. For example, lifting an object increases the stored energy in the gravitational field between that object and Earth (gravitational potential energy) compared to that for the object at Earth's surface; when the object falls, the stored energy decreases and the object's kinetic energy increases. When a pendulum swings, some stored energy is transformed into kinetic energy and back again into stored energy during each swing. (In both examples energy is transferred out of the system due to collisions with air and for the pendulum also by friction in its support.) Any change in potential energy is accompanied by changes in other forms of energy within the system, or by energy transfers into

or out of the system.

*Grade Band Endpoints for PS3.A*

**By the end of grade 2.** [Intentionally left blank.]

**By the end of grade 5.** The faster a given object is moving, the more energy it possesses. Energy can be moved from place to place by moving objects or through sound, light, or electric currents. (Boundary: At this grade level, no attempt is made to give a precise or complete definition of energy.)

**Benchmarks for Science Literacy** (recommended grade band benchmarks)

Kindergarten through Grade 2

From the outset, students should view, describe, and discuss all kinds of moving things—themselves, insects, birds, trees, doors, rain, fans, swings, volleyballs, wagons, stars, etc.—keeping notes, drawing pictures to suggest their motion, and raising questions: Do they move in a straight line? Is their motion fast or slow? How can you tell? How many ways does a growing plant move? The questions count more than the answers, at this stage. And students should gain varied experiences in getting things to move or not to move and in changing the direction or speed of things that are already in motion.

Presumably students will start "making music" from the first day in school, and this provides an opportunity to introduce vibrations as a phenomenon rather than a theory. With the drums, bells, stringed and other instruments they use, including their own voices, they can feel the vibrations on the instruments as they hear the sounds. These experiences are important for their own sake and at this point do not need elaboration.

By the end of the 2nd grade, students should know that

- Things move in many different ways, such as straight, zigzag, round and round, back and forth, and fast and slow. 4F/P1
- The way to change how something is moving is to give it a push or a pull. 4F/P2
- Things that make sound vibrate. 4F/P3

Grades 3 through 5

Students should continue describing motion. And they can be more experimental and more quantitative as their measurement skills sharpen. Determining the speed of fast things and slow things can present a challenge that students will readily respond to. They also can work out for themselves some of the general relationships between force and change of motion and internalize the notion of force as a push or pull of one thing on another—whether rubber bands, magnets, or explosions.

Students should also increase their inventory of examples of periodic motion and perhaps devise ways of measuring different rates of vibration. And students should use prisms to see that white light produces a whole "rainbow" of colors. (The idea that white light is "made up of" different colors is difficult and should be postponed to later grades.) There is nothing to be gained at this stage, however, from linking light to wave motion.

By the end of the 5th grade, students should know that

- Changes in speed or direction of motion are caused by forces. 4F/E1a

- The greater the force is, the greater the change in motion will be. The more massive an object is, the less effect a given force will have. 4F/E1bc
- How fast things move differs greatly. Some things are so slow that their journey takes a long time; others move too fast for people to even see them. 4F/E2
- Light travels and tends to maintain its direction of motion until it interacts with an object or material. Light can be absorbed, redirected, bounced back, or allowed to pass through. 4F/E3\*\* (ASL)

### **Unpacked Content** *(for students)*

3.P.1.1 Students know that when a force acts on an object it will result in a change of speed and / or direction.

3.P.1.2 Students know that speed can vary. Students know that varying the speed of a moving object will affect the time it takes for the object to travel a particular distance.

3.P.1.3 Students know that the earth 'pulls' on all objects on or near the earth without touching those objects.

### **Identify Misconceptions**

\*Construct formative assessment probes – see 'how to' on pages 85, 102, and 183 in Science Formative Assessment by Page Keeley.

Use formative probes: Uncovering Student ideas in Science, Volumes 1-4, by Page Keeley

I) Volume 1 Talking about Gravity p. 97      II) Volume 4 Standing on One Foot p. 61

Formative Assessment Probes (articles, how-to, free-online) by Page Keeley, et al

[http://pal.tnet.net/docs/outreach/educators/education\\_pedagogy\\_research/assessment\\_probes\\_uncovering\\_student\\_ideas.pdf](http://pal.tnet.net/docs/outreach/educators/education_pedagogy_research/assessment_probes_uncovering_student_ideas.pdf)

[http://www.ode.state.or.us/teachlearn/subjects/science/resources/msef2010-formative\\_assessment\\_probes.pdf](http://www.ode.state.or.us/teachlearn/subjects/science/resources/msef2010-formative_assessment_probes.pdf)

### **North Carolina Connections:** (local and state resources)

#### [Catawba Science Center](#)

CSC also provides a variety of educational and fun programming for school groups, children, families, adults, and other community groups. 243 3rd Avenue NE (street address), P.O. Box 2431, Hickory, NC 28603, (828) 322-8169

#### [Imagination Station Science Museum](#)

Interactive programs are designed to promote student investigation into various science concepts. 224 East Nash Street, Wilson, NC 27894 Phone (252) 291-5113.

#### [North Carolina Museum of Life and Science](#)

Experience how inquiry-based teaching energizes your students and encourages science discovery. 433 West Murray Avenue (street address), P.O. Box 15190, Durham, NC 27704, (919) 220-5429

#### [SciWorks, the Science Center and Environmental Park of Forsyth County](#)

Enjoy interactive, hands-on special exhibits and programs in spacious exhibit halls. 400 West Hanes Mill Rd., Winston-Salem,

(336) 767-6730

**[North Carolina NASA Educator Resource Center](#)**

J. Murrey Atkins Library UNC Charlotte 9201 University City Blvd., Charlotte, NC 28223 704-687-2559

**Annotated TEACHER Resources**

**Force and Movement Interactivity**

[http://www.bbc.co.uk/schools/scienceclips/ages/6\\_7/forces\\_movement.shtml](http://www.bbc.co.uk/schools/scienceclips/ages/6_7/forces_movement.shtml)

In this lesson, students use an online interactive activity to learn about how varying force and mass can impact motion.

**Catapult Creations**

<http://www.uen.org/Lessonplan/preview.cgi?LPid=21632>

Students build their own catapult and explore how it works.

**Free Fall Air Resistance Model**

<http://www.compadre.org/Repository/document/ServeFile.cfm?ID=10002&DocID=1641>

The Free Fall Air Resistance model allows the user to examine the motion of an object in free fall, and motion under the effect of air resistance. This is simply one-dimensional motion (vertical motion) under the influence of gravity. The blue ball moves under the influence of gravity alone. The red ball moves under the influence of gravity and air resistance

**Teachers' Domain: Virtual Pendulum**

<http://www.teachersdomain.org/resource/phy03.sci.phys.mfw.zpendulumint/>

This interactive Shockwave simulation, produced by PBS Zoom, lets users explore pendulum motion in a unique game-like format. Swing it back and forth from different heights and change the length of the string. But now it gets more complicated: the user can jump to another planet to see how changing gravity affects the motion of the pendulum.

**Parkworld Plot**

<http://www.engineeringinteract.org/resources/parkworldplot.htm>

An interactivity in which students analyze different areas and mechanisms of an amusement park to determine its safety.

**Pushes and Pulls, Big and Small**

<http://www.mhschool.com/science/2000/student/2/sims/sim4.html>

An interactivity in which students experiment with forces created by different masses.

**Raceway to Science**

<http://www.cape.k12.mo.us/blanchard/hicks/news%20pages/Force%20pdf%20files/Raceway%20to%20Science.pdf>

Students work with toy cars and identify what causes them to move shorter and longer distances.

### **Gravity Games for kids**

<http://www.wartgames.com/themes/science/gravity.html>

An assortment of online games that help students to learn about gravity.

### **Gravity Launch**

<http://sciencenetlinks.com/lessons/gravity-launch/>

Students explore how the earth's and moon's gravity affects the path of a rocket launched into space.

### **Position and Motion of Objects Flash Interactives**

<http://www.learningscience.org/psc1bpositionmotionobjects.htm>

Flash learning tools focused on fundamental concepts and principles of force and motion.

### **Smart Exchange**

<http://exchange.smarttech.com/search.html>

<http://exchange.smarttech.com/search.html?q=%20force%20and%20motion>

A directory of Smart Board lessons that teachers can download and use.

### **Sid the Science Kid**

<http://www.pbs.org/teachers/sid/activities/forceandmotion/>

Video clips and lesson extensions about force and motion concepts.

### **Teachers Domain**

<http://www.teachersdomain.org/>

Free digital media for educational use.

### **Zoom Forces and Energy**

<http://pbskids.org/zoom/activities/sci/>

A collection of activities from which teachers can select individual activities for student exploration.

### **8 Workshops in Force and Motion**

<http://www.learner.org/workshops/force/>

Explore science concepts in force and motion and come away with a deeper understanding that will help you engage your students in their own explorations. With science and education experts as your guides, learn more about gravity, friction, air resistance, magnetism, and tension through activities, discussions, and demonstrations. Extensive footage shot in real classrooms.

### **Understanding Motion and Force**

<http://www.teachersdomain.org/resource/tdpd.sci.epssc2/>

Professional development designed to improve educators' understanding and teaching of physical science.

### **Teaching Elementary Physical Science**

<http://www.teachersdomain.org/resource/tdpd.sci.eps/>



Teaching Elementary Physical Science is designed to increase educators' understanding and teaching of physical science.

**VIDEO**

**Bill Nye**

<http://www.free-tv-video-online.me/player/gorillavid.php?id=1iegrzd07w6n>

Motion

<http://www.free-tv-video-online.me/player/gorillavid.php?id=ltd183yvp8do>

Gravity

**Thank Goodness for Gravity**

<http://www.teachersdomain.org/resource/ket09.sci.ess.gravity/>

The boy featured in this video has concerns about spinning through space on Earth until he is introduced to a Foucault pendulum.

**WRITING PROMPTS**

1. We see cars and trucks around us everywhere. There are so many cars and trucks that sometimes we forget how important they are and how they make our lives more comfortable. Write an expository paper explaining how cars and trucks make life more comfortable. Give reasons why you think as you do.
2. You work for a newspaper. Write one positive headline and one negative headline about how machines are affecting our lives. Write a paragraph explaining each headline.
3. There are many kinds of rides in the amusement park, and they move in many different ways. Describe your favorite amusement park ride, and explain how it moves.