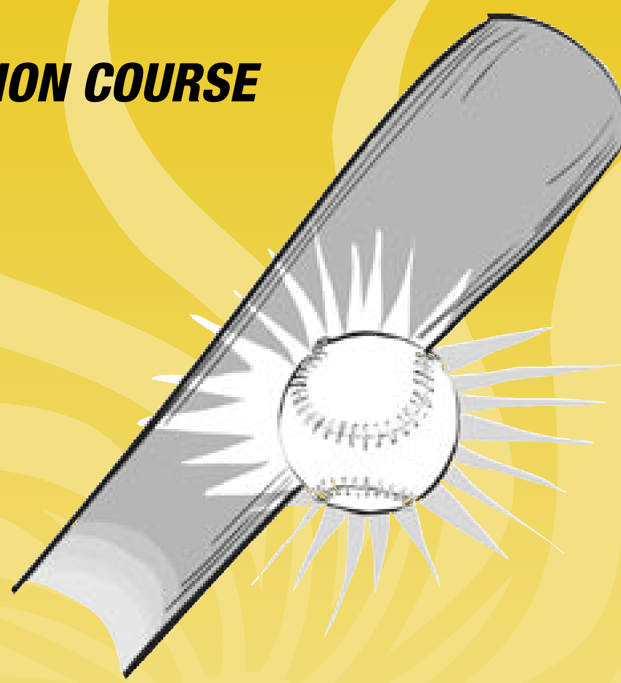
OVERVIEW
FORCE AND MOTION COURSE



WELCOME TO FORCE AND MOTION

The world is filled with motion. Some motion happens without human intervention: Earth revolves around the Sun, snowflakes fall to the ground, waves surge across the sea, salmon swim up rivers to fulfill their destinies. Other motions are under our control: clock hands faithfully monitor time, jet planes streak across the sky, baseballs fly over center field fences, bicycles race in the Tour de France. Both natural and designed motions are part of our perception of the world—there is nothing special about them.

What we take for granted is often worthy of contemplation, in part because it is so commonplace. Familiarity can breed a sense of innate understanding where none really exists. We rarely question what makes things move, often resorting to the popular nonexplanation, "That's the way the world works."

Forces make things move or, more accurately, make things *change* their motion. The two natural forces that affect most of the motion we are aware of are the force of gravity and the electromagnetic force. If a peanut slips between your fingers in the backyard, the force of gravity will pull it to the ground. If the same peanut happens to fall onto the picnic table, the force of gravity will still pull the peanut, but it will not fall to the ground. Why? Because the table is pushing up against the peanut with a force exactly equal to the force exerted by gravity pulling the peanut down. The force opposing the force of gravity is the electromagnetic force, expressed in countless molecular interactions in the matter in Earth and the table.

These ideas seem to conflict. Over here force results in change of motion. But over there force produces no change of motion. Welcome to force and motion. This is where you and your students will start to uncover explanations for why things work in the ways we expect them to work.

FOSS AND NATIONAL STANDARDS

The **Force and Motion Course** for grades 6–8 supports the following National Science Education Standards.

SCIENCE AS INQUIRY

Develop students' abilities to do and understand scientific inquiry.

- Design and conduct scientific investigations.
- Use appropriate tools and techniques to gather, analyze, and interpret data.
- Develop descriptions, explanations, predictions, and models using evidence.
- Think critically and logically to make the connections between evidence and explanations.
- Communicate scientific procedures and explanations.
- Use mathematics in scientific inquiry.
- Understand that different kinds of questions suggest different kinds of scientific investigations; current knowledge guides scientific investigations; mathematics and technology are important scientific tools.
- Understand that scientific explanations emphasize evidence.

CONTENT: PHYSICAL SCIENCE

Develop students' understanding of motions and forces.

- The motion of an object can be described by its position, direction of motion, and speed. Motion can be measured and represented on a graph.
- An object that is not being subjected to a (net) force will continue to move at a constant speed.
- If more than one force acts on an object along a straight line, then the forces will reinforce or cancel one another, depending on their direction and magnitude. Unbalanced forces will change the speed or direction of an object's motion.

HISTORY AND NATURE OF SCIENCE

Develop students' understanding of the nature of scientific inquiry and appreciation of the history of science.

- Scientists formulate and test their explanations of nature, using observation, experiments, and theoretical and mathematical models. Although all scientific ideas are tentative and subject to change and improvement in principle, for most major ideas in science, there is much experimental and observational confirmation. Those ideas are not likely to change greatly in the future.

FOSS MIDDLE SCHOOL PROGRAM COMPONENTS

FOSS for Middle School is a general science curriculum for students and their teachers in grades 6–8. The curriculum is organized into topical courses in three strands: **Earth and Space Science, Life Science,** and **Physical Science and Technology.** Each course is an in-depth unit requiring 9–12 weeks to teach.

This course, designed for students in grades 6–8, includes the following five interconnected components:

- A detailed ***Force and Motion Teacher Guide*** in a three-ring binder, including overview, materials preparation, goals and objectives, at-a-glance investigation chart, science background, lesson plans, transparency masters, teacher answer sheets, assessments with masters and scoring guides, multimedia user guide, and references (books, multimedia, websites). Chapters of the teacher guide are separated by tabs for easy use. **Force and Motion** has eight investigations, each with multiple parts.
- A **kit of laboratory equipment** packaged for multiple classes of 32 students each. The kit also contains class resource materials such as videos. Each course is designed for one teacher working with five sections of students per day. The kit includes transparencies for the investigations.
- The ***FOSS Force and Motion Lab Notebook*** consisting of student sheets and organizers for students to use during the investigations. One copy of the lab notebook is included in the kit. The lab notebook can be a consumable item if one is purchased for each student. The book is produced in black and white and the pages are perforated, so individual sheets can be used as duplication masters, adding flexibility to your use of the notebook.
- A ***FOSS Force and Motion Resources*** book containing data and readings that are used throughout the course. Thirty-two copies of the full-color resources book come with the kit. They are intended to be used as classroom resources, shared by all students.
  Additional copies of the resources book can be purchased if it is important for each student in every class to have a copy.
- The ***FOSS Force and Motion*** **multimedia** program is intended to be a whole-class demonstration tool and an individual or small-group interactive instructional tool. The multimedia is woven into the instruction and is linked to many investigations. The multimedia is provided on CD-ROM (five disks included in the kit) and is available on the Web (www.fossweb.com/forceweb).

	SYNOPSIS	SCIENCE CONCEPTS	THINKING PROCESSES
1	**Here to There (5 sessions)** Students are introduced to motion as a change of position, and distance as the magnitude of a change in position. They work with air trolleys to define terms, gather and graph data, and analyze outcomes. They analyze graphic representations of races between several different competitors in both print and multimedia formats.	• Position is the location of an object at any given time. • Motion is the act of changing position. • Distance is the amount of change of position. • A reference point is an arbitrary point on an object, used to establish its position. • Calculate distance (*d*) using the distance equation.	• Observe and describe an object's motion in terms of change of position. • Explain how to use a reference point to determine the distance moved by an object. • Measure distance in standard metric units. • Use tools to gather data and mathematics to organize data.
2	**Speed (5–6 sessions)** Students learn that speed is the rate at which an object changes position. They gather data from cars rolling down ramps and representations of moving vehicles to investigate and solve speed problems. They are introduced to making and analyzing distance-versus-time graphs.	• Speed is the rate of change of position of an object: $v = d / \Delta t$. • The slope of the line on a speed graph represents speed; steeper slopes represent higher speeds. • The equation for calculating distance when speed and time are known is $d = v \times \Delta t$. • Average speed is the total distance traveled by an object divided by the total time needed to go that distance.	• Conduct experiments to acquire distance and time data and to determine speed. • Use tools to gather data and mathematics to organize data. • Use mathematics to solve problems involving unknown quantities. • Explain speed in terms of distance and time.
3	**Comparing Speeds (8–9 sessions)** Students learn how to analyze and represent speed to solve problems. They gather data for students walking and running, and use representations of boat races and the Iditarod race to investigate and solve speed problems. They practice making and analyzing speed graphs.	• The slope of a line on a distance-versus-time graph represents speed; steeper slopes represent higher speeds. • A distance-versus-time graph can be used to determine an object's speed.	• Conduct experiments to acquire time and distance data and to determine speed. • Use tools to gather and organize data and solve problems involving unknown quantities. • Use speed graphs to determine head starts. • Explain speed in terms of distance and time.
4	**Representing Motion (7 sessions)** Students learn to represent motion in graphs. They distinguish between position graphs and distance graphs and analyze both to describe motion. They extract data from word problems, create data tables, and construct motion graphs. They also collect and organize data for their own motion, using meter tapes and stopwatches.	• The difference between an object's initial and final positions is displacement. • Constant speed and average speed yield straight lines on distance-versus-time graphs. • Complex motion events can be analyzed into coherent segments called legs.	• Use tools to gather and organize data. • Transform narrative accounts of motion events into graphic representations. • Generate motion scenarios from graphic representations of motion events. • Explain the difference between displacement and distance. • Explain what a horizontal line on a speed graph represents.

MEDIA	FOSS READINGS
FOSS Multimedia: *Moving Along*	
	• *Time: The Infinite Line (optional)* • *First in Flight* • *How Fast Do Things Go?*
FOSS Multimedia: *Photo Finish* FOSS Multimedia: *Graphing* Video: *Sled Dogs: An Alaskan Epic*	• *Iditarod: The Last Great Race on Earth*
FOSS Multimedia: *Motion Graphs*	• *Motion Review* • *Boston Treasure Hunt* • *Riding on Springer Hill*

SYNOPSIS	SCIENCE CONCEPTS	THINKING PROCESSES
5		
Acceleration (9 sessions) Students learn to identify and measure changing velocity and calculate position and velocity from time and acceleration data. They experience constant velocity and acceleration with their own movement. They collect and analyze velocity and position data using mechanical and electronic Dotcars.	• Acceleration is change of velocity ($\Delta\overline{v}$) per unit time, measured in units of change of position (Δx) per unit of time per unit of time. • Objects rolling down slopes accelerate; acceleration is greater on steeper slopes. • The mass of a rolling car has little effect on its acceleration.	• Use tools (mechanical and electronic Dotcars) to collect time and distance data and mathematics to organize and analyze the data. • Use equations to calculate acceleration, displacement, and velocity of rolling objects. • Identify and interpret graphs of accelerating motion and constant velocity.
6		
Force (7–8 sessions) Students are introduced to forces and their relationship to motion. Students use pushers and spring scales to explore the idea that forces add; the sum is net force. Friction is introduced as a force opposing motion. Students explore friction with real-world and simulated force-bench activities.	• A force is a push or pull. • Net force is the sum of all the forces acting on a mass. • A net force applied to a mass produces acceleration. • Friction is a force that acts to resist movement.	• Use tools (pushers, spring scales, and multimedia simulations) to apply force and investigate friction and motion. • Analyze illustrations of forces in motion. • Use multimedia simulations to investigate force and motion. • Describe change of motion as a result of net force.
NOTE: This is a recommended ending point for grade six students.		
7		
Gravity (7 sessions) Students learn that gravity is a universal force pulling objects to Earth with predictable acceleration. They use spring scales to establish the relationship between force and mass. They explore real and hypothetical falling objects and replicate one of Galileo's experiments.	• Gravity is a force pulling masses toward each other; the strength of the force depends on the objects' masses. • The force of gravity accelerates objects in free fall and objects rolling downhill. • The acceleration produced by the force of gravity is about 10 m/s^2 toward Earth.	• Determine the relationship between mass and the force of gravity, using spring scales. • Gather time and displacement data electronically to investigate the acceleration of gravity. • Explain gravity as a universal force. • Discuss Galileo's discovery of acceleration due to gravity.
8		
Momentum (8 sessions) Students learn to analyze collision interactions in terms of inertia, momentum, and impulse. Inertia is introduced in demonstrations, and students use the Dotcar to collect data for analysis. *Understanding Car Crashes,* a video, is viewed and discussed. The finale is a version of the egg drop called Bean Brains, in which students apply their knowledge of momentum.	• Inertia is the property of matter that tends to keep masses in uniform motion; it resists change of motion. • Inertia is proportional to mass; large masses have a lot of inertia. • Momentum is inertia in motion; it is the product of an object's velocity and mass. • A net force applied to an object can change its momentum. • An impulse is a force applied for a period of time.	• Conduct simple investigations to demonstrate inertia of both stationary and moving masses. • Use a force scale to determine the force needed to stop cars traveling at different speeds. • Use electronic Dotcar data to calculate velocity and momentum. • Explain how inertia and momentum affect passenger safety in car crashes. • Explain and apply the interplay of force and time (impulse) and momentum in crashes.

MEDIA	FOSS READINGS
FOSS Multimedia: ***Dotmaker*** FOSS Multimedia: ***Dotcar*** software	• *Faster and Faster* • *The Other Great Race: Armadillo and Hare* • *The Making of a Dotcar*
FOSS Multimedia: *Force Bench*	• *Aristotle, Galileo, & Newton* • *The Force Bench Free Experimentation*
Video: *Galileo: On the Shoulders of Giants*	• *Gravity: It's the Law* • *How to Get and Hold on to a Moon*
Video: *Understanding Car Crashes*	• *How Much Oomph?*

FOSS TEACHER GUIDE

The *Force and Motion Teacher Guide* is just that—a guide. It is designed to be an information and planning tool to help you understand and enjoy your introduction to mechanics, much like an interpretive brochure might guide your visit to historic Williamsburg. A good guide will suggest the best path to follow, and will enrich your visit with history, facts, and lore as you proceed. Like any good guide it will also point out places to rest, where to stop for refreshments. You should feel comfortable and confident that you know what you are doing as you go along.

Like a good guide it may be pressed into service less as you become more and more familiar with the territory. On your third visit to Williamsburg you might head straight for the main street, passing by some of the introductory exhibits, and you might visit your favorite spots in a slightly different order than you did before. You might even leave the trail here and there to drink in some of the historical ambiance in a way quite different from that intended by the preparer of the guide brochure.

The first time you visit the **FOSS Force and Motion Course,** we hope you will follow our suggested sequence to get the lay of the land. The guide is filled with information to help you have an excellent first use of the course. It may seem overwhelming at first, but in a short time you will discover how to use it effectively. Here's what we suggest.

Look at the **Table of Contents** to see how the teacher guide is assembled. You'll notice that the guide is subdivided into chapters. Turn each tab to see how much information there is in each section.

Next read the **Overview** chapter completely. This describes the scope of the course content and discusses issues of instruction, assessment, management, and safety.

Now turn all the pages in the guide, pausing to read the **Goal and Objectives** of each investigation carefully. In this way you will be able to get a very good sense of the curriculum.

Finally digest Investigation 1, *Here to There,* thoroughly. Read the science background carefully and study the **at-a-glance chart** to see how the investigation is subdivided. The chart also provides a dissected overview of the several days of classroom actions, including the use of media (website, video, and readings) and the assessments. Project the actions you read about into your classroom. Visualize students grappling with the problems and working with materials in small groups. If you have the kit at hand, bring out the materials as you read, and do the investigations. Then read Investigation 2 carefully, then 3, 4, 5, and so forth. Keep the *Force and Motion Teacher Guide* close at hand (even in hand) during your first excursion into this topic to ensure a safe and productive adventure.