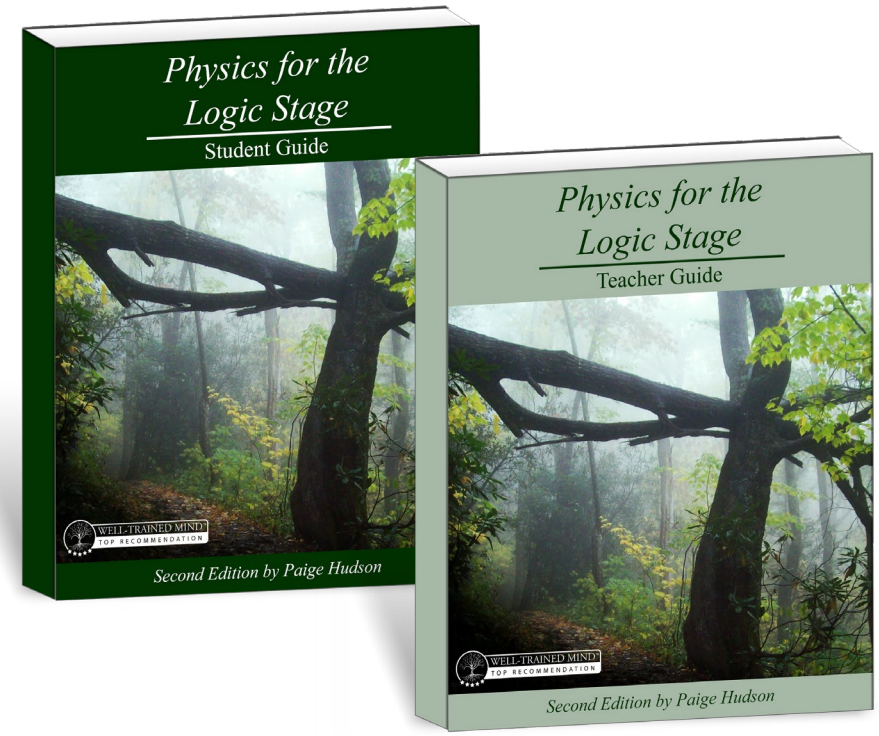


# Physics for the Logic Stage Sample Packet

The following sample packet includes the first two weeks of the *Physics for the Logic Stage* materials. You will see:

- ✓ The Teacher Guide (*beginning on pg. 3*)
- ✓ The Student Guide (*beginning on pg. 33*)

You can get more information and purchase this award-winning program here:

https://elementalscience.com/collections/physics-for-the-logic-stage

# Quick Start Guide

## In a Nutshell

Learn about motion, forces, thermodynamics, waves, electricity, magnetism, engineering, robotics, and nuclear physics through the following:

- ✓ Gathering information through reading the main spines.
- ✓ Doing hands-on science through experiments and projects.
- ✓ Keeping a record of what the students have learned.

See pp. 17-18 for a complete list of the topics explored in this program.

## What You Need

In addition to this guide, you will need the following:

1. A guide for the students. (You can purchase the *Physics for the Logic Stage Student Guide* to have it all laid out for you or just buy a composition book.)
2. The three spines:
   - 🕮 *Usborne Science Encyclopedia, 2015 Edition* (USE)
   - 🕮 *Usborne Illustrated Dictionary of Science, 2012 Edition* (UIDS)
   - 🕮 *Robotics* by Kathy Ceceri

   You can also purchase the *Kingfisher Science Encyclopedia, 2017 Edition* (KSE) for optional reading assignments. Head to the page below to get links to these books:

   💻 https://elementalscience.com/blogs/resources/pls
3. The experiment supplies (See a full list starting on pg. 19 or save yourself the time and purchase the *Physics for the Logic Stage Experiment Kit*.)

## How It Works

Each week you will . . .

- ✍ Guide the students as they do an experiment using the directions on the Student Assignment Sheet—this is in this guide as well as the student guide. The results and an explanation of the experiment are part of the additional information in this guide.
- ✍ Assign the reading, and when the students are finished, you will discuss what they read using the questions and answers in this guide.
- ✍ Assign appropriate written work—a list of facts, an outline, or a report.
- ✍ Assign vocabulary, memory work, and dates to add to a timeline.

You can add to their learning experience by also doing the additional activities suggested in this guide. For a more detailed explanation of the components of your week, we highly recommend reading the introduction starting on pg. 7 of this guide.

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# Physics for the Logic Stage
# Introduction

In *Success in Science: A Manual for Excellence in Science Education*, we state that the middle school student is "a bucket full of unorganized information that needs to be filed away and stored in a cabinet."[1] The goals of science instruction at the logic level are to begin to train students' brain to think analytically about the facts of science, to familiarize the students with the basics of the scientific method through inquiry-based techniques, and to continue to feed the students with information about the world around them. *Physics for the Logic Stage* integrates the above goals using the Classic Method of middle school science instruction as suggested in our book. This method is loosely based on the ideas for classical science education that are laid out in *The Well-Trained Mind: A Guide to Classical Education at Home* by Jessie Wise and Susan Wise Bauer.

This guide includes the four basic components of middle school science instruction as explained in *Success in Science*.

1. **Hands-on Inquiry –** Middle school students need to see real-life science, to build their problem-solving skills and to practice using the basics of the scientific method. This can be done through experiments or nature studies. In this guide, the weekly experiments fulfill this section of middle school science instruction.
2. **Information –** Middle school students need to continue to build their knowledge base, along with learning how to organize and store the information they are studying. The information component is an integral part of this process. In this guide, the reading assignments, vocabulary, and sketches contain all of the necessary pieces of this aspect of middle school science instruction.
3. **Writing –** The purpose of the writing component is to teach students how to process and organize information. You want them to be able to read a passage, pull out the main ideas and communicate them to you in their own words. The assigned outlines or reports in this guide give you the tools you need to teach this basic component to your student.
4. **The Science Project –** Once a year, all middle school students should complete a science project. Their projects should work through the scientific method from start to finish on a basic level, meaning that their questions should be relatively easy to answer. The science fair project, scheduled as a part of unit three fulfills the requirements of this component.

*Physics for the Logic Stage* also includes the two optional components of middle school science instruction, as explained in *Success in Science.*

1. **Around the Web –** Middle school students should gain some experience with researching on the Internet. So for this optional component, the students should, under your supervision, search the Internet for websites, YouTube videos, virtual tours, and activities that relate to what they are studying. In this guide, the "Want More" lessons recommend specific sites and activities for you to use.
2. **Quizzes or Tests –** During the middle school years it is not absolutely necessary that you

[1]Bradley R. Hudson & Paige Hudson, *Success in Science: A Manual for Excellence in Science Education* (Elemental Science, 2012) 52.

give quizzes or tests to the students. However, if you want to familiarize them with test-taking skills, we suggest that you give quizzes or tests that will set the students up for success. With that in mind, we have included optional tests for you to use with each unit.

My goal in writing this curriculum is to provide you with the tools to explore the field of physics while teaching the basics of the scientific method. During the years, the students will work on their observation skills, learn to think critically about the information they are studying and practice working independently. *Physics for the Logic Stage* is intended to be used with seventh through eighth grade students.

## What this Guide Contains in a Nutshell

This guide includes the weekly student assignment sheets, all the sketches pre-labeled for you and discussion questions to help you guide your discussion time. This guide also contains information for each experiment, including the expected results and an explanation of those results. There is a list of additional activities that you can choose to assign for each week. Finally, this guide includes possible schedules for you to use as you guide the students through *Physics for the Logic Stage*.

## What the Student Guide Contains

The Student Guide, which is sold separately, is designed to encourage independence in the students as they complete *Physics for the Logic Stage*. The Student Guide contains all the student assignment sheets, pre-drawn sketches ready for labeling, experiment pages, and blank report pages. The guide also includes blank date sheets as well as all the sheets they will need for the Science Fair Project. In short, the Student Guide contains all the pages the students will need and it is essential for successfully completing this program.

## Student Assignment Sheets

This Teacher Guide contains a copy of each of the student assignment sheets that are in the Student Guide. This way you can stay on top of what your students are studying. Each of the student assignment sheets contains the following:

- ✓ **Experiment**

  Each week will revolve around a weekly topic that it to be studied. Your student will be assigned an experiment that poses a question related to the topic. Each of these experiments will walk your students through the scientific method. (*See the Appendix pg. 243 for a brief explanation of the scientific method*.) In a nutshell, the scientific method trains the brain to examine and observe before making a statement of fact. It will teach your student to look at all the facts and results before drawing a conclusion. If this sounds intimidating, it's not. You are simply teaching your students to take the time to discover the answer to a given problem by using the knowledge they have and the things they observe during an experiment.

  Each week, the student assignment sheet will contain a list of the materials needed and the instructions to complete the experiment. The student guide contains an experiment sheet for your students to fill out. Each experiment sheet contains an introduction that is followed

by a list of materials, a hypothesis, a procedure, an observation, and a conclusion section. The introduction will give your students specific background information for the experiment. In the hypothesis section, they will predict the answer to the question posed in the lab. In the materials listed section, your students will fill out what they will use to complete the experiment. In the procedure section, they will recount step by step what was done during their experiment, so that someone else could read their report and replicate their experiment. In the observation section, your students will write what they saw. Finally, in the conclusion section they will write whether or not their hypothesis was correct and share any additional information they have learned from the experiment. If the students' hypotheses were not correct, discuss why and have them include that on their experiment sheet.

**Vocabulary & Memory Work**

Throughout the year, the students will be assigned vocabulary for each week. They will need to write out the definitions for each word on the Unit Vocabulary Sheet found in the Student Guide on the week that they are assigned. You may want to have your students also make flash cards to help them work on memorizing the words. This year, the students will memorize different laws and principles relating to each unit. There is a complete listing of the vocabulary words and memory work for each unit on the unit overview sheet in this guide along with a glossary and a list of the memory work in the Student Guide.

**Sketch**

Each week the students will be assigned a sketch to complete and label. The Student Guide contains an unlabeled sketch for them to use. They will color the sketch, label it and give it a title according to the directions on the Student Assignment Sheet. The information they need will be in their reading, but the sketch is not always identical to the pictures found in the encyclopedia. So, these sketch assignments should make the student think. This guide contains a completed sketch for you to use when checking their work.

**Writing**

Each week the students will be assigned pages to read from the spine texts, either the *Usborne Illustrated Dictionary of Science*, the *Usborne Science Encyclopedia*, or *Robotics*. Have them read the assigned pages and discuss what they have read with you. After you have finished reading and discussing the information, you have three options for your students' written assignments:

- ***Option 1: Have the students write an outline from the spine text***
  A typical eighth grader completing this program should be expected to write a two to three level outline for the pages assigned for the week. This outline should include the main point from each paragraph on the page as well as several supporting and sub supporting points;
- ***Option 2: Have the students write a narrative summary from the spine text***
  A typical eighth grader completing this program should be expected to write a three to six paragraph summary (or about a page) about what they have read in the spine text;
- ***Option 3: Have the students write both an outline and a written report***
  First, have the students read the assigned pages in the spine text. Then, have them write a two to three level outline for the assigned pages. Next, have the students do some additional research reading on the topic from one or more of the suggested reference

books listed below. Each topic will have pages assigned from these reference books for their research. In addition to the spines, the following encyclopedia is scheduled to be used as reference book:

- 🕮 *The Kingfisher Science Encyclopedia, 2017 Edition (KSE):* This resource is appropriate for middle school students.

Once the students complete the additional research reading, have them write a report of three to four paragraphs in length, detailing what they have learned from their research reading.

Your writing goal for middle school students is to have them write something (narrative summary, outline, list of facts, or experiment report) every day you do school, either in science or in another subject. So, the writing option you choose for this curriculum will depend on the writing the students are already doing in their other subjects.

When evaluating the students' reports, make sure that the information they have shared is accurate and that it has been presented in a grammatically correct form (i.e., look for spelling mistakes, run-on sentences, and paragraph form). In the Student Guide, there are two blank lined sheets for the students to use when writing their outlines and/or summaries. If you are having the students type their report, have them glue a copy of it into their Student Guide.

- 🕒 **Dates**

Each week the dates of important discoveries within the topic and the dates from the readings are given on the student assignment sheet. The students will enter these dates onto one of their date sheets. The date sheets are divided into the four time periods as laid out in *The Well-Trained Mind* by Susan Wise Bauer and Jessie Wise (Ancients, Medieval-Early Renaissance, Late Renaissance-Early Modern, and Modern). Completed date sheets are available for you to use in the appendix of this guide on pg. 239-242.

## Schedules

*Physics for the Logic Stage* is designed to take up to 5 hours per week. You and your students can choose whether to complete the work over five days or over two days. Each week I have included two scheduling options for you to use as you lead them through this program. They are meant to be guides, so feel free to change the order to better fit the needs of your students. I also recommend that you begin to let them be in charge of choosing how many days they would like to do science as this will help to begin to foster independence in their school work.

## Additional Information Section

The Additional Information Section includes tools that you will find helpful as you guide the students through this study. It is only found in the Teacher Guide, and it contains the following:

- ☞ **Experiment Information**

Each week, the Additional Information Section includes the expected experiment results and an explanation of those results for you to use with the students. When possible, you will also find suggestions on how to expand the experiment in the Take if Further section.

- 🗣 **Discussion Questions**

Each week the Additional Information Section includes possible discussion questions

from the main reading assignment, along with the answers. These are designed to aid you in leading the discussion time with the students. I recommend that you encourage them to answer in complete sentences, as this will help them organize their thoughts for writing their outline or report. If the students are already writing outlines or lists of facts, you do not need to have them write out the answers to the discussion questions before hand as there is plenty of writing required in this program already.

**Want More**

Each week, the Additional Information Section includes a list of activities under the Want More section. ***These activities are totally optional.*** The Want More activities are designed to explore the science on a deeper level by researching specific topics or through additional projects to do. The students do not have this information in their guide, so it is up to you whether or not to assign these.

☑ **Sketch**

Each week, the Additional Information Section includes copies of the sketches that have been labeled. These are included in this guide for you to use as you correct the students' work.

## Tests

The students will be completing a lot of work each week that will help you to assess what they are learning, so testing is not absolutely necessary. However, I have included end of unit tests that you can use if you feel the need to do so. The tests and the answers are included after the material for each unit in this guide. You can choose to give the tests orally or copy them for the students to fill out.

## What a Typical Two-day Schedule Looks Like

A typical two-day schedule will take one-and-a-half to two hours per day. Here is a breakdown of how a normal two-day week would work using week one:

- **Day 1:** ***Define the vocabulary, record the dates, do the experiment, and complete the experiment sheet***

  Begin day 1 by having the students do the "Can I measure force?" experiment. Have them read the introduction and perform the experiment using the directions provided. Next, have the students record their observations and results. After they discuss their results with you, have them write a conclusion for their experiment. Finish the day by having them look up and define "balance," "force," "force field," and "newton" using the glossary in the Student Guide and add the dates to their date sheets.

- **Day 2:** ***Read the assigned pages, discuss together, prepare an outline or narrative summary, and complete the sketch***

  Begin by having the students read pp. 6-7 in the *Usborne Illustrated Dictionary of Science*. Then, using the questions provided, discuss what they have read. Next, have them complete the sketch using the directions on the Student Assignment Sheet. Finally, have them write an outline or narrative summary. Here is a sample narrative summary:

**Forces**

A force can change velocity and shape of the object it affects. In other words, a force influences the motion and shape of an object. It is a vector quantity, which means it has both magnitude and direction, and the SI unit for force is Newtons. The main types of force are gravitational, magnetic, electric, and nuclear.

Magnetic force is the force between two moving charges. When discussing this type of force, we see a force field, or a region where the force has an effect. This force field has a range, which is the maximum distance that it can be felt. To show these magnetic force fields, we use lines with arrows to show the strength and direction of the forces.

Gravitational force is otherwise known as gravity. It is the force of attraction between two objects that have mass. This type of force is very small, unless one of the objects is very large, such as the size of a planet.

Electric force is the force between two electrically charged particles. If the charges are the same, the force pushes the objects away from each other. If the charges are different, the force pulls the objects towards each other.

Electric force is often combined with magnetic forces to create electromagnetic force, which is the force found between two molecules, otherwise known as intermolecular force. These intermolecular forces are involved in tension and compression. In tension, a force tries to pull the molecules apart, but the intermolecular forces resist the change. In compression, a force tries to push the molecules together, but the intermolecular forces resist that change.

While all these forces are at work, we also have frictional force, which opposes the motion of two surfaces that are touching each other. This is caused by the intermolecular attraction between the two surfaces. A static frictional force is one that exists between two surfaces that do not move when a force is applied to one of the objects. A dynamic, or sliding, frictional force is one that exists between two surfaces that slide over each other at a constant speed when a force is applied to one of the objects.

Finally, we have nuclear force, which is the force of attraction between the particles of an atomic nucleus. This force is so strong that it prevents the electric force of repulsion between the protons in the nucleus.

## What a Typical Five-day Schedule Looks Like

A typical five-day schedule will take forty-five minutes to one hour per day. Here is a breakdown of how a normal five-day week would work using week two:

- **Day 1:** ***Do the experiment and complete the experiment sheet***
  Begin day 1 by having the students do the "Can I measure force?" experiment. Have them read the introduction and perform the experiment using the directions provided. Next, have them record their observations and results, discuss their results with you, and then write a conclusion for their experiment.
- **Day 2:** ***Read the assigned pages, discuss them together and write an outline or list of facts***
  Begin by having the students read pp. 6-7 in the *Usborne Illustrated Dictionary of Science* and discuss what they have read using the provided questions. Then, have the students write a two- to three-level outline, and complete the sketch using the directions on the Student Assignment Sheet. Here is a sample outline for the page on forces:

**Forces**

I. A force can change the velocity and shape of the object it affects.
   A. It is a vector quantity.
      i. It has magnitude.
      ii. It has direction.
   B. The SI unit for force is Newtons.
II. The main types of force are gravitational, magnetic, electric, and nuclear.
   A. Magnetic force is the force between two moving charges.
      i. This force has a force field, or a region where the force has an effect, with a range, which is the maximum distance that it can be felt.
   B. Gravitational force is otherwise known as gravity.
      i. It is the force of attraction between two objects that have mass.
   C. Electric force is the force between two electrically charged particles.
      i. If the charges are the same, the force pushes the objects away from each other.
      ii. If the charges are different, the force pulls the objects towards each other.
   D. Electric force is often combined with magnetic forces to create electromagnetic force, which is the force found between two molecules, otherwise known as intermolecular force.
   E. Intermolecular forces are involved in tension and compression.
      i. In tension, a force tries to pull the molecules apart, but the intermolecular forces resist the change.
      ii. In compression, a force tries to push the molecules together, but the intermolecular forces resist that change.
   F. Nuclear force is the force of attraction between the particles of an atomic nucleus.
      i. This force is so strong that it prevents the electric force of repulsion between the protons in the nucleus.
III. Frictional force is the force that opposes the motion of two surfaces that are touching each other.
   A. It is caused by the intermolecular attraction between the two surfaces.
   B. A static frictional force is one that is between two surfaces that don't move when a force is applied to one of the objects.
   C. A dynamic, or sliding, frictional force is one that is between two surfaces that slide over each other at a constant speed when a force is applied to one of the objects.

- **Day 3:** ***Record the dates, define the vocabulary, and complete the sketch***
  Begin by having the students look up and define "balance," "force," "force field," and "newton" using the glossary in the Student Guide and add the dates to their date sheets. Then, have them complete the sketch using the directions on the Student Assignment Sheet.
- **Day 4:** ***Read from the additional reading assignments and prepare a written report***
  Begin by having the students read "Force" from *USE* pp. 118-121, or "Force" from

*KSE* pp. 290-291. Then, have the students use their outline along with what they have just read to write a three- to five-paragraph summary of what they have learned. This report can be as detailed as or more simplistic than the sample narrative.

- **Day 5:** ***Complete one of the Want More activities***
  Have the students do the "Tug of War" activity or have them do the "Resultant Force" worksheet. You could also have them read about a scientist from the field of physics.

## The Science Fair Project

I have scheduled time for the students to complete a science fair project during unit three. Janice VanCleave's *A+ Science Fair Projects* & Janice VanCleave's *A+ Projects in Physics: Winning Experiments for Science Fairs and Extra Credit* are excellent resources for choosing project topics within the field of physics. You can call your local school system to see if it allows homeschooled students to participate in the local school science fair or get information on national science fairs from them. Another option would be to have your students present their project in front of a group of friends and family.

## How to include your younger students

I recognize that many homeschool families have a range of different student ages. If you wish to have all your students studying the topic of physics you have two options for your elementary students when using this program with your middle school students:

- ***Option 1: Have your younger students use Physics for the Grammar Stage***
  I recommend this option if your younger students are in the second through fourth grade and/or your older students are ready for some independence. You will need to rearrange the units in *Physics for the Logic Stage* so that all the students will remain on similar topics. The older students will do Unit 2, Units 1, and then Unit 3 through Unit 8.

- ***Option 2: Have your younger students use Physics for the Logic Stage along with your older students***
  I recommend this option if your younger students are in the fourth through sixth grade and/or older students are not ready to work independently. However, you will need to adjust the work load for your younger students. Here are some suggestions on how to do that:
  - ✓ Have them watch and observe the experiments;
  - ✓ Add in some picture books from the library for each of the topics;
  - ✓ Read the reading assignments to them and have them narrate them back to you;
  - ✓ Let them color the sketches and then tell them how to label them.

  As for the reading assignments, you may find that the spines scheduled are too much for your younger students. If so, you can read to them out of the *DK Smithsonian Science: A Visual Encyclopedia (2018 Edition)*. I have included a chart coordinating this resource in the Appendix of this guide on pg. 245-247.

## Helpful Articles

Our goal is to provide you with the information you need to be successful in your quest to

educate your students in the sciences at home. This is the main reason we share tips and tools for homeschool science education on our blogs. As you prepare to guide your students through this program, you may find the following articles helpful:

- *Classical Science Curriculum for the Logic Stage Student* – This article explains the goals of logic stage science and demonstrates how the classical educator can utilize the tools they have at their disposal to reach these goals.
  - http://elementalblogging.com/classical-science-curriculum-logic/
- *Scientific Demonstrations vs. Experiments* – This article shares information about these two types of scientific tests and points out how to employ scientific demonstrations or experiments in your homeschool.
  - https://elementalscience.com/blogs/news/89905795-scientific-demonstrations-or-experiments
- *Writing in Homeschool Science: The Middle School Years and Beyond* – This podcast (and video) explains the goals of writing for logic stage science.
  - https://elementalscience.com/blogs/podcast/episode-13
- *A Simple Explanation of the Scientific Method* – This article details the steps of the scientific method, along with why it is so important to teach.
  - https://elementalscience.com/blogs/news/simple-explanation-of-the-scientific-method/
- *3 Tips to Encourage Independent Learning* – This podcast gives you tips to help your students make the move from dependent to independent learning.
  - https://elementalscience.com/blogs/podcast/87

## Additional Resources

The following page contains quick links to the activities suggested in this guide along with several helpful downloads:

- https://elementalscience.com/blogs/resources/pls

## Final Thoughts

If you find that this program contains too much work, please tailor it to the needs of your students. As the author and publisher of this curriculum I encourage you to contact me with any questions or problems that you might have concerning *Physics for the Logic Stage* at support@elementalscience.com. I will be more than happy to answer them as soon as I am able. I hope that you and your students enjoy *Physics for the Logic Stage*!

# Units of Measurement

## What are the two measuring systems?

- **The Standard or Standard American Engineering (SAE) System –** This system is used mainly in the United States and it uses units like inches, pounds and gallons. It was derived from an early English measuring system that has its roots in the Roman system of measurements.
- **The Metric System –** This system is used in most of the world and it uses units like meters, grams and liters. The system is base 10 and their names are formed with prefixes. It was derived from one of the early French measuring systems.

In the US, the standard system of units are more widely used on consumer products and in industrial manufacturing, while the metric system is more widely used in science, medicine and government. Since this program has been published in the US, I have used the standard system of measurement throughout for familiarity. However, because I believe that it is important for our students to be familiar with both systems, I have included metric measurements in parentheses.

## What about converting units?

Every student should know how to convert measurements inside of a given measuring system, such as knowing how to convert grams to kilograms or ounces to pounds. Normally, these conversion factors are taught as a part of your math program. However, I also recommend that you have your students memorize several basic conversion factors between the two systems. Here is a list of factors that the students should try to memorize:

- **Pounds to Kilograms:** 1 lb = 2.2 kg
- **Ounces to Grams:** 1 oz = 28.3 g
- **Gallons to Liters:** 1 gal = 3.785 L
- **Cups to Milliliters:** 1 c = 240 mL
- **Miles to Kilometers:** 1 mi = 1.61 km
- **Feet to Meters:** 1 ft = 0.305 m
- **Inches to Centimeters:** 1 in = 2.54 cm

With the global flow of information that occurs these days, it is very important for students to learn these most basic conversion factors. To learn more about the importance of units of measurement in science, read the following blog post:

https://elementalscience.com/blogs/science-activities/units-of-measurement

# Sequence of Study

## Basics of Physics – Forces, Motion , and Energy

**Unit 1: Forces and Motion** (4 Weeks)

- ✓ Forces
- ✓ Friction and Gravity
- ✓ Motion
- ✓ Speed and Acceleration

**Unit 2: Energy** (4 Weeks)

- ✓ Energy and Work
- ✓ Energy Sources
- ✓ Pressure
- ✓ Simple Machines

## Concepts in Physics – Heat, Light, and Sound

**Unit 3: Thermodynamics** (4 weeks)

- ✓ Heat
- ✓ Heat Transfer
- ✓ Heat Expansion
- ✓ Engines
- ✓ Science Fair Project

**Unit 4: Mechanical Waves** (4 Weeks)

- ✓ Waves
- ✓ Wave Interference
- ✓ Sound
- ✓ Hearing

**Unit 5: Electromagnetic Waves** (4 Weeks)

- ✓ Electromagnetic Waves
- ✓ Reflection and Refraction
- ✓ Visible Light
- ✓ Optics

## Applications in Physics – Electricity, Magnetism, and Engineering

**Unit 6: Electricity and Magnetism** (6 Weeks)

- ✓ Electricity
- ✓ Electrical Current
- ✓ Batteries
- ✓ Circuits
- ✓ Magnetism
- ✓ Electromagnetism

**Unit 7: Engineering and Robotics** (6 Weeks)

- ✓ Engineering
- ✓ Electronics
- ✓ Robotics
- ✓ Actuators and Effectors
- ✓ Sensors and Controllers
- ✓ AI and Computers

**Unit 8: Nuclear Physics** (3 weeks)

- ✓ Radioactivity
- ✓ Fission and Fusion
- ✓ Nuclear Power
- ✓ Scientist Study

## Year-end Review

**Review Test**

# Materials Listed by Week

## Basics of Physics – Forces, Motion , and Energy

### Unit 1: Motion

| Week | Materials |
|---|---|
| 1 | Thick, sturdy cardboard, 1 Brad fastener, Rubber band, Hole punch or nail, String – about 3 in (10 cm), 3 Jumbo paper clips, Pen, Objects of varying weight |
| 2 | Force meter from last week, Small wooden block (like a Jenga block), Eye-hook screw, Sandpaper, Felt, Foil, Spray oil, Tape measure |
| 3 | Jenga block with the eyehook from last week, String, 2 Toy cars, Egg |
| 4 | Cardboard or plastic track, Blocks or thick books, Toy car, Stopwatch |

### Unit 2: Energy

| Week | Materials |
|---|---|
| 5 | Goldfish cracker, Small marshmallow, Piece of lettuce, Piece of bacon fat, Aluminum pan, Matches, Safety glasses, Bucket of water |
| 6 | 2-Liter Soda bottle, 2 Cans – one large, one small, Screw, Water, Piece of clay, Cup measure, Tape measure |
| 7 | Foil, Black construction paper, Small cardboard box, Plastic wrap, Tape, Marshmallow, Small glass dish (one that will fit inside the box) |
| 8 | Materials will vary depending upon the simple machine the student chooses to build |

## Concepts in Physics – Heat, Light, and Sound

### Unit 3: Thermodynamics

| Week | Materials |
|---|---|
| 9-12 | *Science Fair Project supplies will vary depending on the project the students choose to do.* |

### Unit 4: Mechanical Waves

| Week | Materials |
|---|---|
| 13 | Shallow glass bowl or cup, Water, Music player |
| 14 | Large, rectangular dish, Water, 2 Pencils |
| 15 | Partner, Blindfold |
| 16 | Plastic jar, or small flower pot, A piece of latex material large enough to cover the lid of your jar (like the kind used for exercise bands), 1” plastic tubing, Rubber band, Air-dry clay, Salt |

## Unit 5: Electromagnetic Waves

| Week | Materials |
|---|---|
| 17 | 9 Ultraviolet light detecting beads, 3 Shallow dishes (not clear plastic or glass), Plastic Wrap, Two different levels of SPF sunscreen (i.e., SPF 15 and SPF 45), Rubber bands |
| 18 | 4 Pencils, 4 Clear glasses, Water, Oil, Alcohol, Corn syrup |
| 19 | Thin cardboard, Red, blue, and yellow paint, 6 Rubber bands, Hole punch |
| 20 | Jell-O™ (orange, lemon, or lime), Round bowl or jar – at least 4" (10 cm) in diameter, 1 Cup water, Dull knife, Plate, Flashlight |

# Applications in Physics - Electricity, Magnetism, and Engineering

## Unit 6: Electricity and Magnestism

| Week | Materials |
|---|---|
| 21 | Styrofoam pan, Aluminum pan, Wool, Plastic tongs |
| 22 | Light bulb, Copper wire, D battery, Electrical tape, Alligator clips, Organic material, such as a pickle, lemon slice, cheese, bread, or leaf |
| 23 | 2 AA disposable batteries (one fully charged, one completely dead), Ruler |
| 24 | Computer with Internet connection |
| 25 | 2 different types of magnets, such as a horseshoe magnet and a neodymium magnet, Paper clips (20 to 30), Paper, Cardboard, Thick books |
| 26 | D battery, Insulated copper wire – about 3 ft (1 m), 2 to 3 inch (5 to 8 cm) Nail, Electrical tape, Iron filings, Paper |

## Unit 7: Engineering

| Week | Materials |
|---|---|
| 27 | Pack of popsicle sticks, 10 Rubber bands, String, Roll of pennies (or 50 washers), Paper cup |
| 28 | Old electronic, Small screwdriver |
| 29 | 1.5-volt DC motor, 1 ft. insulated wire, Electrical tape, Cup, Foam tape, 2 AAA batteries, Rubber band, Cork, Marker, Cardboard, Paper |
| 30 | Pencil, 1.5-volt DC motor, Small Solar Panel, Electrical tape, Scissors, CD, Glue, Tape, Clear dome from a drink cup |
| 31 | 1 LED light bulb with two metal legs, 1 3-volt Watch battery, 2 Index cards, Scissors, Marker, Yarn, Gel glue, Toothpick, Tissue |
| 32 | Pen, (Optional - graph paper) |

## Unit 8: Nuclear Physics - No supplies needed.

# Physics
# Unit 1

## Forces and Motion

# Unit 1 Force and Motion
## Overview of Study

### Sequence of Study

**Week 1:** Force
**Week 2:** Friction and Gravity
**Week 3:** Motion
**Week 4:** Speed and Acceleration

### Materials by Week

| Week | Materials |
|---|---|
| 1 | Thick, sturdy cardboard, 1 Brad fastener, Rubber band, Hole punch or nail, String – about 3 in (10 cm), 3 Jumbo paper clips, Pen, Objects of varying weight |
| 2 | Force meter from last week, Small wooden block (like a Jenga block), Eye-hook screw, Sandpaper, Felt, Foil, Spray oil, Tape measure |
| 3 | Jenga block with the eyehook from last week, String, 2 Toy cars, Egg |
| 4 | Cardboard or plastic track, Blocks or thick books, Toy car, Stopwatch |

### Vocabulary for the Unit

1. **Balance** – A state of equilibrium when the forces acting on an object cancel each other out ; also known as a zero resultant force.
2. **Force** – A push or pull that acts on an object.
3. **Force field** – The area in which a force can be felt.
4. **Newton** – The measurement of force; one newton is the force is takes to move a one kilogram object at one meter per second squared ($1\ N = 1\ kg \bullet 1\ m/s^2$).
5. **Air resistance –** The force that air exerts on an object as it falls.
6. **Friction –** A force that opposes the motion of objects that touch as they move past each other.
7. **Gravity –** The force that acts between two masses; it is an attractive force.
8. **Terminal velocity –** The point at which the force acting on an object of air resistance is equal to the force of gravity acting on the object.
9. **Inertia –** The tendency of an object to resist a change in its motion.
10. **Mass –** The amount of matter in an object.
11. **Momentum –** The tendency of an object to keep moving until a force stops it.
12. **Weight –** The force with which an object's mass is pulled toward the center of the Earth.
13. **Acceleration –** A change in an object's speed, direction, or both.

**14. Speed –** The ratio of the distance an object moves to the amount of time the object moves.
**15. Velocity –** The speed of an object in a particular direction.

## Memory Work for the Unit

**Newton's Three Laws of Motion**

1. An object will not move unless a force, like a push or pull, moves it. Once it is moving, an object will not stop moving in a straight line unless it is forced to change.
2. A force acting on an object will change its motion. The greater the force on an object, the greater the change in its motion.
3. For every reaction, there is an equal but opposite reaction.

**Equations**

- Force Unit

  1 Newton (N) = 1 kilogram (kg) • 1 meter (m) / second ($s^2$)

- Motion Equation

  $F = m \bullet A$

  "F" stands for net force.
  "m" stands for mass.
  "A" stands for acceleration.

- Speed Equation

  $v = \frac{d}{t}$

  "*v*" stands for average speed.
  "d" stands for distance.
  "t" stands for time.

- Acceleration Equation

  $A = \frac{v_f - v_i}{t}$

  "A" stands for acceleration.
  "$v_f$" stands for final speed.
  "$v_i$" stands for initial speed.
  "t" stands for time.

## Notes

# Student Assignment Sheet Week 1
## Forces

**Experiment:** Can I measure force?

Materials

- ✓ Thick, sturdy cardboard
- ✓ 1 Brad fastener
- ✓ Rubber band
- ✓ Hole punch or nail
- ✓ String – about 3 in (10 cm)
- ✓ 3 Jumbo paper clips
- ✓ Pen
- ✓ Objects of varying weight

Procedure

1. Read the introduction to the experiment and then begin to assemble your force meter. Cut out a 3.5 in (9 cm) by 12 in (31 cm) rectangle from the cardboard. Then, punch a hole with the hole punch or nail near the top, large enough for the brad fastener to slide through. Slip one of the paper clips through the brad, through the hole, and fasten the brad on the opposite side. Slide the rubber band onto the opposite end of the paper clip. Next, take another paper clip and turn out a portion of the end to make a pointer. Tie the string to one end of the pointer paper clip and then slide the other end onto the rubber band. Take the third paper clip and fashion a hook out of it. Once you are done, attach the hook to the other end of the string. Hold your force meter at the top and mark where the pointer rests. This line will be your zero force mark. Now draw a scale down the remainder of your force meter. You can use finger widths, inches, or centimeters for your scale, just as long as you use the same measurement for each mark. (**Note—***You will need your force meter for next week's experiment as well*.)
2. Now that the force meter is assembled, you can use it to measure the different objects. Simply attach each object to the hook and observe what happens. Write down how much the rubber band stretched on the experiment sheet. Repeat this process for each of your objects.
3. Draw conclusions and complete the experiment sheet.

### Vocabulary & Memory Work

- ☐ Vocabulary: balance, force, force field, newton
- ☐ Memory Work—This week, work on memorizing the force equation:
  - 1 Newton (N) = 1 kilogram (kg) • 1 meter (m) / second ($s^2$)

**Sketch:** Force Diagram

- Label the following—Force W, Force component parallel to slope, Force component at right angles to slope

### Writing

- Reading Assignment: *Usborne Illustrated Dictionary of Science* pp. 6-7 (Force)
- Additional Research Readings
  - Force: *USE* pp. 118-121
  - Force: *KSE* pp. 290-291

### Dates

- c330 BC – Aristotle proposes that a force is needed to maintain motion.
- 1642-1727 – Isaac Newton, the English scientist who explained how force, mass, and acceleration are related, lives. The unit of force, the newton (N), is named after him.
- 1979 – Pakistani scientist, Abdus Salam, wins the Nobel Prize in Physics for his work with forces.

# Schedules for Week 1

## Two Days a Week

| Day 1 | Day 2 |
|---|---|
| ☐ Do the "Can I Measure Force?" experiment, and then fill out the experiment sheet on SG pp. 20-21<br>☐ Define balance, force, force field, and newton on SG pg. 16<br>☐ Enter the dates onto the date sheets on SG pp. 8-13 | ☐ Read pp. 6-7 from *UIDS,* and then discuss what was read<br>☐ Color and label the "Force Diagram" sketch on SG pg. 19<br>☐ Prepare an outline or narrative summary; write it on SG pp. 22-23 |
| Supplies I Need for the Week<br>✓ Thick, sturdy cardboard, 1 Brad fastener, Rubber band<br>✓ Hole punch or nail, String – about 3 in (10 cm)<br>✓ 3 Jumbo paper clips<br>✓ Pen, Objects of varying weight | |
| Things I Need to Prepare | |

## Five Days a Week

| Day 1 | Day 2 | Day 3 | Day 4 | Day 5 |
|---|---|---|---|---|
| ☐ Do the "Can I Measure Force?" experiment, and then fill out the experiment sheet on SG pp. 20-21<br>☐ Enter the dates onto the date sheets on SG pp. 8-13 | ☐ Read pp. 6-7 from *UIDS,* and then discuss what was read<br>☐ Write an outline on SG pg. 22 | ☐ Define balance, force, force field, and newton on SG pg. 16<br>☐ Color and label the "Force Diagram" sketch on SG pg. 19 | ☐ Read one or all of the additional reading assignments<br>☐ Write a report on what you learned on SG pg. 23 | ☐ Complete one of the Want More Activities listed<br>**OR**<br>☐ Study a scientist from the field of Physics |
| Supplies I Need for the Week<br>✓ Thick, sturdy cardboard, 1 Brad fastener, Rubber band<br>✓ Hole punch or nail, String – about 3 in (10 cm)<br>✓ 3 Jumbo paper clips<br>✓ Pen, Objects of varying weight | | | | |
| Things I Need to Prepare | | | | |

# Additional Information Week 1

## Experiment Information

- **Note** – Make sure your students keep their force meter for next week.
- **Introduction** – (*from the Student Guide*) Forces are all around us. They push and pull objects, causing them to move or change shape. In today's experiment, you are going to create your own force meter that can measure the amount of force an object exerts. In a force meter, an object applies a downward force, which stretches a rubber band or spring. We can measure the amount of displacement to determine how much force was applied.
- **Results** – The students' results will vary based on the objects that they choose to use. In general, they should see that a heavier object will cause the rubber band to stretch farther.
- **Explanation** – The weight of each objects acts as a force that pulls down on the rubber band, causing it to stretch. The more the object weighs, the greater the force, which causes the rubber band to stretch farther.
- **Troubleshooting Tips** – Be sure that the students use thick, sturdy cardboard when making their force meter or it can tear. To see a visual representation of a homemade force meter and how to calibrate it, check out the following video:
  https://www.youtube.com/watch?v=jwCwwKLa0GE
  If they want to make a sturdier version out of PVC pipe, have them follow the directions from this website:
  http://www.instructables.com/id/Be-a-scientist%3A-make-your-own-force-meter./
- **Take it Further** – Have the students calibrate the force meter to actual newtons (N). One newton exerts approximately a quarter of a pound of force (or about 100 grams). Hang something that weighs 0.25 lbs (100 g) on your force scale and mark where the guide line lands – this is the 1N mark. Now, repeat the process up with objects weighing up to 1 lb to find where 2N, 3N, and 4N would be. (**Note**—*Since the rubber band doesn't stretch linearly, the marks may not be evenly spaced*.)

## Discussion Questions

1. What does a force do? (*UIDS pg. 6 - A force influences the shape and/or motion of an object.*)
2. What is a vector quantity? (*UIDS pg. 6 - A vector quantity has both magnitude and direction*.)
3. What are the four main types of forces? (Describe each.) (*UIDS pp. 6-7 - The main types of forces are gravitational, magnetic, electric, and nuclear. Gravitational force is the attraction between two objects that have mass. Magnetic force is the force between two moving charges. Electric force is the force between two electrically charged particles. Nuclear force is the force of attraction between the particles of an atomic nucleus.*)
4. What are intermolecular forces? (*UIDS pg. 7 - Intermolecular forces are the electromagnetic forces between two molecules.*)
5. What is a frictional force? (*UIDS pg. 7 - Frictional force is a force that acts to oppose the motion of two touching objects or surfaces*.) (**Note**— *Students will be covering frictional forces in greater detail next week.*)

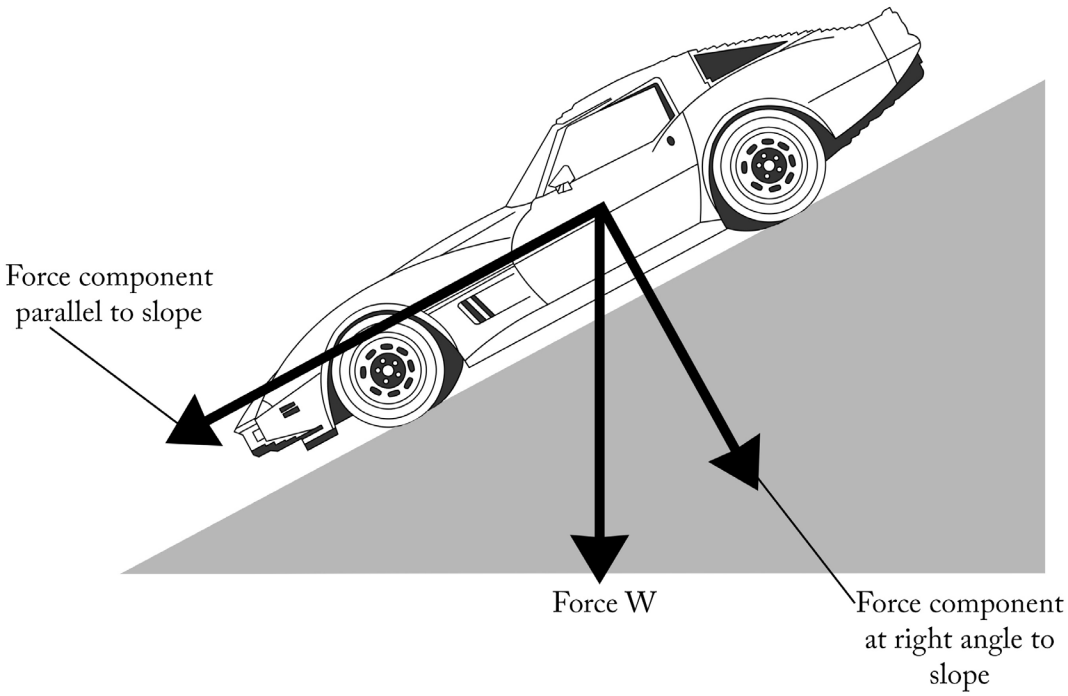
## Want More

- **Tug of War –** In a tug of war, each team is using force to pull the other team across the line. One team's pulling force cancels out the other team's pulling force, which keeps the players at a stand-still. That is, until one team's pulling force is greater than the other's! This week, explain to your students how force plays a role in tug of war and then let them try it out for themselves. If you can't get a team together, have the students do the tug of war simulation from the PhET website.
  - http://phet.colorado.edu/sims/html/forces-and-motion-basics/latest/forces-and-motion-basics_en.html
- **Resultant Force Worksheet –** Have the students complete the resultant force worksheet on Appendix pg. 248.

  Answers
  1. Resultant force = 0N, object is in balance
  2. Resultant force = -2N, object will begin moving in the opposite direction
  3. Resultant force = 8N, object will continue in the same direction
  4. Resultant force = 0N, object is in balance

## Sketch Week 1

Force Diagram



# Student Assignment Sheet Week 2
## Friction and Gravity

**Experiment:** How does friction affect movement?

Materials

- ✓ Force Meter from last week
- ✓ Small wooden block (aka. Jenga block)
- ✓ Eye-hook screw
- ✓ Sandpaper
- ✓ Felt
- ✓ Foil
- ✓ Spray oil
- ✓ Tape measure

Procedure

1. Read the introduction to the experiment and answer the question for the hypothesis section.
2. Screw the eye-hook screw into the top of the wooden block. Then, attach it to the hook on the force meter so that the block can be dragged horizontally. Next, use the tape measure to mark off a 1 foot (0.3 meter) track on a smooth surface, like a table our counter.
3. Now, place the block at the beginning of your track with the force meter in front over the track. Pull the block from the force meter evenly to the end in three seconds. Observe how much the rubber band on the force meter stretched and record that on your experiment sheet.
4. Then, place the piece of sandpaper on your track. Like before, put block at the beginning of the track and pull it evenly to the end in three seconds. Observe how much the rubber band on the force meter stretched and record that on your experiment sheet. Repeat with the felt.
5. Finally, place the foil over the track and coat it well with spray oil. Then, as before, put block at the beginning of your track and pull it evenly to the end in three seconds. Observe how much the rubber band on the force meter stretched and record that on your experiment sheet.
6. Draw conclusions and complete the experiment sheet.

### Vocabulary & Memory Work

- ☐ Vocabulary: air resistance, friction, gravity, terminal velocity
- ☐ Memory Work—This week, begin working on memorizing Newton's three laws of motion. (*See the Unit Overview Sheet for a complete listing*.)

**Sketch:** Types of Friction (*See the Sketch Notes on SG pg. 25*.)

- 🖼 Label the following – Static friction, sliding friction, rolling friction, fluid friction

### Writing

- Reading Assignment: *Usborne Illustrated Dictionary of Science* pp. 18-19 (Gravitation) and *Usborne Science Encyclopedia* pp. 124-125 (Friction)
- Additional Research Readings
  - 🕮 Relativity and Gravity: *KSE* pp. 298-299
  - 🕮 Friction: *KSE* pp. 308-309

### Dates

- 🕒 1630's – Galileo does a series of experiments with a marble and a series of differently-shaped tracks, which leads to the discovery of a retarding force called friction.
- 🕒 1955 – Christopher Cockerell invents the hovercraft, which uses a cushion of air that allows a vehicle to move without friction.

# Schedules for Week 2

## Two Days a Week

| Day 1 | Day 2 |
|---|---|
| ☐ Do the "How does friction affect movement?" experiment, and then fill out the experiment sheet on SG pp. 26-27<br>☐ Define air resistance, friction, gravity, and terminal velocity on SG pg. 16<br>☐ Enter the dates onto the date sheets on SG pp. 8-13 | ☐ Read pp. 18-19 from *UIDS* and pp. 124-125 from *USE,* and then discuss what was read<br>☐ Color and label the "Types of Friction" sketch on SG pg. 25<br>☐ Prepare an outline or narrative summary; write it on SG pp. 28-29 |
| Supplies I Need for the Week<br>✓ Force Meter from last week<br>✓ Small wooden block (like a Jenga block), Eye-hook screw<br>✓ Sandpaper, Felt, Foil , Spray oil<br>✓ Tape measure | |
| Things I Need to Prepare | |

## Five Days a Week

| Day 1 | Day 2 | Day 3 | Day 4 | Day 5 |
|---|---|---|---|---|
| ☐ Do the "How does friction affect movement?" experiment, and then fill out the experiment sheet on SG pp. 26-27<br>☐ Enter the dates onto the date sheets on SG pp. 8-13 | ☐ Read pp. 18-19 from *UIDS* and pp. 124-125 from *USE,* and then discuss what was read<br>☐ Write an outline on SG pg. 28 | ☐ Define air resistance, friction, gravity, and terminal velocity on SG pg. 16<br>☐ Color and label the "Types of Friction" sketch on SG pg. 25 | ☐ Read one or all of the additional reading assignments<br>☐ Write a report on what you learned on SG pg. 29 | ☐ Complete one of the Want More Activities listed<br>**OR**<br>☐ Study a scientist from the field of Physics |
| Supplies I Need for the Week<br>✓ Force Meter from last week<br>✓ Small wooden block (like a Jenga block), Eye-hook screw<br>✓ Sandpaper, Felt, Foil , Spray oil<br>✓ Tape measure | | | | |
| Things I Need to Prepare | | | | |

# Additional Information Week 2

## Notes

- **Mass vs. Weight** – Mass is the measurement of how much matter an object contains, whereas weight is the measurement of the pull of gravity on an object. The more mass an object contains, the more it weighs because there is more substance on which gravity can pull.

## Experiment Information

- **Note** – Make sure your students keep the Jenga block with the eye-screw in it for next week's experiment.
- I**ntroduction** – (*from the Student Guide*) When an object is in forward motion, several forces are acting on it. There is the driving force, which is propelling the object forward. There is weight (or gravity), which pulls the object downward. There is air resistance, which slows the object down. Finally, there is friction. In today's experiment, you are going to act as the driving force for a block as it moves across a track. Then, you are going to use a variety of materials to test how friction affects the motion of the block.
- **Results** – The students should see that more force was needed to pull the block when it was on the felt and sandpaper. They should see that less force was needed to pull the block when it was on the oil-covered foil.
- **Explanation** – Both the felt and the sandpaper increase the amount of friction that acts on the block as it slides over the track. The oil-coated foil reduces the amount of friction that acts on the block as it slides over the track. Friction is a force that opposes the motion of an object as it passes another. So, when friction increases, the object will slow down. Conversely, when friction is decreased, the object will speed up.
- **Troubleshooting** – The following video show how this experiment should be set up:
  https://m.youtube.com/watch?v=HP8H3HWBrZE
- **Take if Further** – Have the students explore other ways to reduce the friction the block experiences as it moves up the track. Round toothpicks or marbles would both be good ideas to test.

## Discussion Questions

1. What two things affect the force of gravity? (*UIDS pg. 18 - The distance between the objects and the mass of the objects both affect the force of gravity*.)
2. Is weight constant? Why or why not? (*UIDS pg. 18 - Weight is not constant because it is dependent upon the distant from and mass of the closest planet.)*
3. What is escape velocity? (*UIDS pg. 19 - Escape velocity is the minimum velocity an object must travel so that it can escape the gravitational pull of a planet.*)
4. What does it mean to be weightless? (*UIDS pg. 19 - When an object does not exert a force on its surroundings, it is said to be weightless*.)
5. How does the roughness of a surface affect the amount of friction? (*USE pg. 124 - The rougher a surface, the stronger the force of friction.*)
6. Is friction useful? (*USE pg. 124 - Yes, in some cases, such as braking or lighting a match, friction is useful. In other cases, such as in between machine parts, friction can be*

*damaging*.)

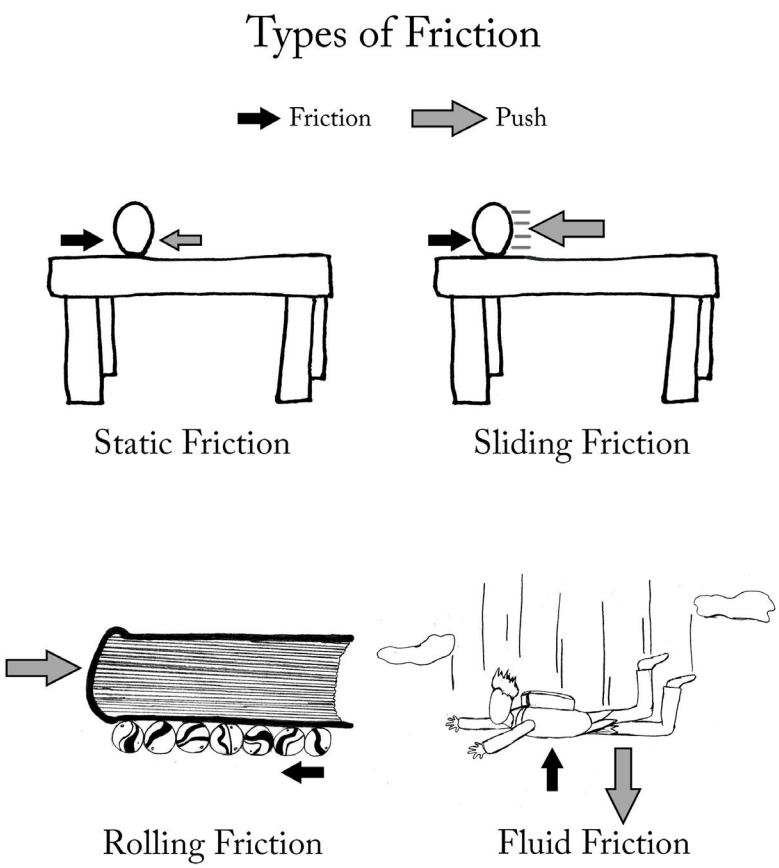
7. What does a lubricant do? (*USE pg. 125 - A lubricant reduces friction between surfaces.*)
8. What is drag? (*USE pg. 125 - Drag is the friction that occurs between the air and an object moving through it.*)
9. What does a streamlined design do? (*USE pg. 125 - A streamlined design reduces drag so that an object can move more easily*.)

## Want More

- **Galileo's Tracks** – Have the students study the effect of friction using a marble track, just like Galileo did. Have the students set up a track and send the marble down it several times. Each time, have them record the time it takes to get to the bottom. Then, have the student sprinkle some sand or salt all over the track. Have them send the marbles down several more times, recording the time it takes. (*The students should see that the marbles were much slower the second time, due to the amount of friction that was created by the sand or salt on the track*.)
- **Gravity** – Have the students test gravity using several objects from nature. Begin by taking a walk outside with the students. Have them look for several objects in nature that are round and about the same size. The objects should have different weights, such as a piece of fruit, a rock, and a nut. Once you get home, have the students hold each of the round objects in their hands and drop them at the same time. What happened? (*They should see that both of the objects hit the ground at the very same time. If you can do this safely from a porch or balcony that will give you a bit more height, your results will be even more amazing.*)

## Sketch Week 2

This week's sketch assignment is a bit different because the material is not covered in the main text. Instead the students will read the definitions of the types of friction on their sketch sheet to figure out which of the four diagrams represent that type of friction. You may need to help them with this process.



# Resultant Force Worksheet

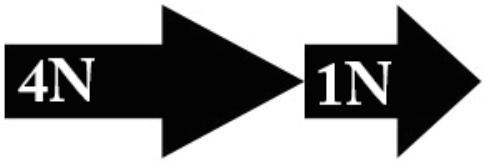
## Introduction

Objects have more than one force acting on them at any given time. If the forces are in the same direction, they add together. The effect of this addition on the object would be to accelerate, or move, it in that direction. If the forces are in opposing directions, they subtract or cancel each other out. The effect on the object depends upon the size of the opposing force. If the two forces are equal, they will balance each other out and the object will remain still. If one of the opposing forces is greater, the end result will be for the object to accelerate, or move, in that direction.

We can determine how an object will move by calculating the resultant force. The resultant force, which is also known as the net force, is the overall force acting on an object after all the forces are combined. To calculate the resultant force we use vector quantities to represent the forces. These vectors have both direction and size.

## Sample Problems

Here are two sample problems for calculating the resultant force using vectors:




Resultant Force = 5N

The object will continue in the same direction.


Resultant Force = -4N

The object will begin moving in the opposite direction.

## Problems

1.


Resultant Force = _____

The object will _____

_____

2.


Resultant Force = _____

The object will _____

_____

3.


Resultant Force = _____

The object will _____

_____

4.


Resultant Force = _____

The object will _____

_____

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# Physics for the Logic Stage
# Letter to the Student

## Dear Student,

Welcome to your journey through physics, which is the study of forces, motion, and more. This year you will examine the basics of physics, the concepts, and how these principles can be applied. You will look at sound, light, electricity, robots, and more along your voyage. This guide is written to you, so enjoy your journey!

## What does this guide contain?

First, this guide includes the Date Sheets and Unit Materials for each of the units. The Unit Materials include the Vocabulary Sheet for the unit, weekly Student Assignment Sheets, blank sketches, Experiment Sheets, and space for each of your writing assignments. After the Unit Materials, you will find the Appendix of this guide. In it you will find a list of all the memory work for the year, a glossary, and a place to record any additional activities you have done that pertain to biology.

## Student Assignment Sheets

The Student Assignment Sheets contain your weekly assignments for each week. Each of the student assignment sheets contains the following:

- ✓ **Experiment –** Each week will revolve around a weekly topic. You will be assigned an experiment to complete that poses a question about what you are studying. Each Student Assignment Sheet contains the list of materials you will need and the instructions to complete the experiment. This guide also includes experiment sheets for you to fill out each week. In each of these experiments, you will use the scientific method.

  **A Word about the Scientific Method –** The scientific method is a method for asking and answering scientific questions. This is done through observation and experimentation. The following steps are key to the scientific method:

  1. **Ask a Question –** The scientific method begins with asking a question about something you observe. Your questions must be about something you can measure. Good questions begin with how, what, when, who, which, why, or where.
  2. **Do Some Research –** You need to read about the topic from your question so that you can have background knowledge of the topic. This will keep you from repeating mistakes of the past.
  3. **Formulate a Hypothesis –** A hypothesis is an educated guess about the answer to your question. Your hypothesis must be easy to measure and answer the original question you asked.
  4. **Test with Experimentation –** Your experiment tests whether your hypothesis is true or false. It is important for your test to be fair. This means that you may need to run multiple tests. If you do, be sure to only change one factor at a time so that you can determine which factor is causing the difference.

5. **Record and Analyze Observations or Results –** Once your experiment is complete, you will collect and measure all your data to see if your hypothesis is true or false. Scientists often find that their hypothesis was false. If this is the case, they will formulate a new hypothesis and begin the process again until they are able to answer their question.
6. **Draw a Conclusion –** Once you have analyzed your results, you can make a statement about them. This statement communicates your results to others.

Each of your experiment sheets will begin with a question and an introduction. The introduction will give you some background knowledge for the experiment. The experiment sheet also contains sections for the materials, a hypothesis, a procedure, an observation, and a conclusion. In the materials section, you need to fill out what you used to complete the experiment. In the hypothesis section, you need to predict the answer to the question posed in the lab. In the procedure section, you need to write a step-by-step account of what you did during your experiment. In other words, you need to provide enough detail so that someone else could read your report and replicate your experiment. In the observation section, you need to write what you saw and observed as well as any results you measured. Finally in the conclusion section, you need to write whether or not your hypothesis was correct and any additional information you have learned from the experiment. If your hypothesis was not correct, discuss why with your teacher and then include why your experiment did not work on your experiment sheet.

**Safety Advisory—**Do not perform any of the experiments marked " ☢ **CAUTION** " on your own. Be sure you have adult supervision.

**Vocabulary and Memory Work –** Throughout the year, you will be assigned vocabulary and memory work for each unit. Each week, you will need to look up the word in the glossary on pp. 273-278 and fill out the definitions on the Unit Vocabulary Sheet found at the beginning of each unit. You may also want to make flash cards to help you work on memorizing these words. Each week, you will also have a memory work selection. Simply repeat this selection until you have it memorized, and then say the selection to your teacher. There is a complete listing of the memory work selections in the Appendix on pp. 261-264.

**Sketch –** Each week, you will be assigned a sketch to complete. Color the sketch and label it with the information given on the Student Assignment Sheet. Be sure to give your sketch a title.

**Writing –** Each week, you will be writing an outline and/or a narrative summary. The student assignment page will give you a reading assignment for the topic from your spine text, either *Usborne Illustration Dictionary of Science,* the *Usborne Science Encyclopedia,* or *Robotics*. After you have finished the assignment, discuss what you have read with your teacher. Your teacher will let you know whether to write an outline or a narrative summary from your reading. Your teacher may also assign additional research reading out of the following book:

*The Kingfisher Science Encyclopedia (KSE)*

Once you finish the additional reading, prepare a narrative summary about what you have learned from your reading. Your outlines should be three-level main topic style outlines and your narrative summaries should be three to four paragraphs in length, unless otherwise assigned by your teacher.

- **Dates –** Each week, dates of important discoveries within the topic and dates from the readings are given on the student assignment sheet. You will enter these dates onto one of four date sheets. The date sheets are divided into the four time periods laid out in *The Well-Trained Mind* by Susan Wise Bauer and Jessie Wise (Ancients, Medieval-Early Renaissance, Late Renaissance-Early Modern, and Modern). These sheets are found in the ongoing projects section of this guide. You can choose to just write the dates and information on the sheet or you can draw a timeline in the space provided and enter your dates on that.

## How to schedule this study

*Physics for the Logic Stage* is designed to take up to three hours per week. You, along with your teacher, can choose whether to complete the work over five days or over two days. Below are two options for scheduling to give you an idea of how you can schedule your week:

- ✓ A typical two-days-a-week schedule
  - **Day 1 –** Define the vocabulary, do the experiment, complete the experiment page, and record the dates.
  - **Day 2 –** Read assigned pages and discuss together, prepare the science report or outline, and complete the sketch.
- ✓ A typical five-days-a-week schedule
  - **Day 1 –** Do the experiment and complete the experiment page.
  - **Day 2 –** Record the dates and define the vocabulary.
  - **Day 3 –** Read assigned pages and discuss together and complete the sketch.
  - **Day 4 –** Prepare the science report or outline.
  - **Day 5 –** Complete one of the Want More activities from the Teacher Guide.

## Final Thoughts

As the author and publisher of this curriculum, I encourage you to contact me with any questions or problems that you might have concerning *Physics for the Logic Stage* at support@elementalscience.com. I will be more than happy to answer them as soon as I am able. I hope that you will enjoy *Physics for the Logic Stage*!

Sincerely,
Paige Hudson, BS Biochemistry, Author

# Ancients 5000 BC–400 AD

# Medieval-Early Renaissance 400AD-1600AD

# Late Renaissance-Early Modern 1600 AD-1850 AD

# Late Renaissance-Early Modern 1600 AD-1850 AD

# Modern 1850 AD-Present

# Modern 1850 AD-Present

# Physics
# Unit 1

## Forces and Motion

# Unit 1 Forces and Motion
## Vocabulary Sheet

Define the following terms as they are assigned on your Student Assignment Sheet.

1. Balance – _____

2. Force – _____

3. Force field – _____

4. Newton – _____

5. Air resistance – _____

6. Friction – _____

7. Gravity – _____

8. Terminal velocity – _____

9. Inertia – _____

_____

_____

10. Mass – _____

_____

_____

11. Momentum – _____

_____

_____

12. Weight – _____

_____

_____

13. Acceleration – _____

_____

_____

14. Speed – _____

_____

_____

15. Velocity – _____

_____

_____

# Student Assignment Sheet Week 1
## Forces

**Experiment:** Can I Measure Force?

Materials

- ✓ Thick, sturdy cardboard
- ✓ 1 Brad fastener
- ✓ Rubber band
- ✓ Hole punch or nail
- ✓ String – about 3 in (10 cm)
- ✓ 3 Jumbo paper clips
- ✓ Pen
- ✓ Objects of varying weight

Procedure

1. Read the introduction to the experiment and then begin to assemble your force meter. Cut out a 3.5 in (9 cm) by 12 in (31 cm) rectangle from the cardboard. Then, punch a hole with the hole punch or nail near the top, large enough for the brad fastener to slide through. Slip one of the paper clips through the brad, through the hole, and fasten the brad on the opposite side. Slide the rubber band onto the opposite end of the paper clip. Next, take another paper clip and turn out a portion of the end to make a pointer. Tie the string to one end of the pointer paper clip and then slide the other end onto the rubber band. Take the third paper clip and fashion a hook out of it. Once you are done, attach the hook to the other end of the string. Hold your force meter at the top and mark where the pointer rests. This line will be your zero force mark. Now draw a scale down the remainder of your force meter. You can use finger widths, inches, or centimeters for your scale, just as long as you use the same measurement for each mark. (**Note—***You will need your force meter for next week's experiment as well*.)
2. Now that the force meter is assembled, you can use it to measure the different objects. Simply attach each object to the hook and observe what happens. Write down how much the rubber band stretched on the experiment sheet. Repeat this process for each of your objects.
3. Draw conclusions and complete the experiment sheet.

### Vocabulary & Memory Work

- ☐ Vocabulary: balance, force, force field, newton
- ☐ Memory Work—This week, work on memorizing the force equation:
  - 1 Newton (N) = 1 kilogram (kg) • 1 meter (m) / second ($s^2$)

**Sketch:** Force Diagram

- Label the following—Force W, Force component parallel to slope, Force component at right angles to slope

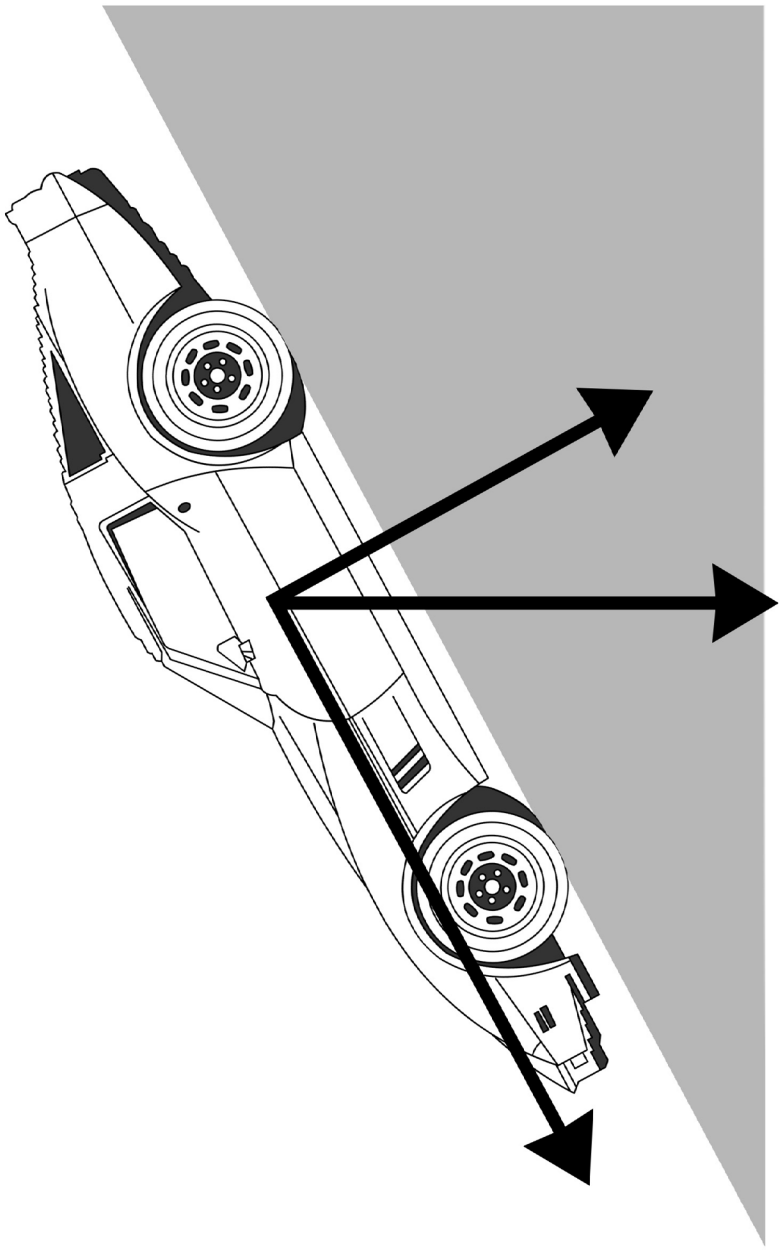
### Writing

- Reading Assignment: *Usborne Illustrated Dictionary of Science* pp. 6-7 (Force)
- Additional Research Readings
  - Force: *USE* pp. 118-121
  - Force: *KSE* pp. 290-291

### Dates

- c330 BC – Aristotle proposes that a force is needed to maintain motion.
- 1642-1727 – Isaac Newton, the English scientist who explained how force, mass, and acceleration are related, lives. The unit of force, the newton (N), is named after him.
- 1979 – Pakistani scientist, Abdus Salam, wins the Nobel Prize in Physics for his work with forces.

# Sketch Week 1



# Can I Measure Force?

## Introduction

Forces are all around us. They push and pull objects, causing them to move or change shape. In today's experiment, you are going to create your own force meter that can measure the amount of force an object exerts. In a force meter, an object applies a downward force, which stretches a rubber band or spring. We can measure the amount of displacement to determine how much force was applied.

## Materials

_____ _____

_____ _____

_____ _____

_____ _____

_____ _____

## Procedure

_____

_____

_____

_____

_____

_____

_____

_____

_____

## Observations and Results

| Object | Amount of Force in ____ |
|---|---|
| | |

| | |
|---|---|
| | |
| | |
| | |
| | |

## Conclusion

# Written Assignment Week 1

## Discussion Questions

1. What does a force do?
2. What is a vector quantity?
3. What are the four main types of forces? (Describe each.)
4. What are intermolecular forces?
5. What is a frictional force?

# Written Assignment Week 1

# Student Assignment Sheet Week 2
## Friction and Gravity

**Experiment:** How does friction affect movement?

Materials

- ✓ Force Meter from last week
- ✓ Small wooden block (aka. Jenga block)
- ✓ Eye-hook screw
- ✓ Sandpaper
- ✓ Felt
- ✓ Foil
- ✓ Spray oil
- ✓ Tape measure

Procedure

1. Read the introduction to the experiment and answer the question for the hypothesis section.
2. Screw the eye-hook screw into the top of the wooden block. Then, attach it to the hook on the force meter so that the block can be dragged horizontally. Next, use the tape measure to mark off a 1 foot (0.3 meter) track on a smooth surface, like a table our counter.
3. Now, place the block at the beginning of your track with the force meter in front over the track. Pull the block from the force meter evenly to the end in three seconds. Observe how much the rubber band on the force meter stretched and record that on your experiment sheet.
4. Then, place the piece of sandpaper on your track. Like before, put block at the beginning of the track and pull it evenly to the end in three seconds. Observe how much the rubber band on the force meter stretched and record that on your experiment sheet. Repeat with the felt.
5. Finally, place the foil over the track and coat it well with spray oil. Then, as before, put block at the beginning of your track and pull it evenly to the end in three seconds. Observe how much the rubber band on the force meter stretched and record that on your experiment sheet.
6. Draw conclusions and complete the experiment sheet.

### Vocabulary & Memory Work

- ☐ Vocabulary: air resistance, friction, gravity, terminal velocity
- ☐ Memory Work—This week, begin working on memorizing Newton's three laws of motion. (*See Appendix pg. 261 for a complete listing*.)

**Sketch:** Types of Friction (*See the Sketch Notes*.)

- 🖼 Label the following – Static friction, sliding friction, rolling friction, fluid friction

### Writing

- ✍ Reading Assignment: *Usborne Illustrated Dictionary of Science* pp. 18-19 (Gravitation) and *Usborne Science Encyclopedia* pp. 124-125 (Friction)
- ✍ Additional Research Readings
  - 🕮 Relativity and Gravity: *KSE* pp. 298-299
  - 🕮 Friction: *KSE* pp. 308-309

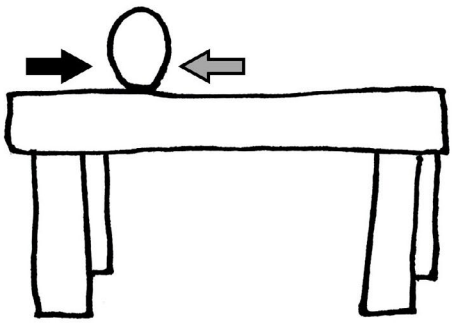
### Dates

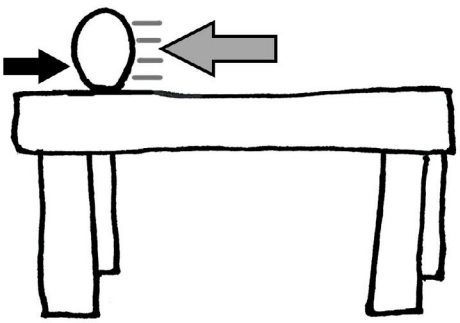
- 🕒 1630's – Galileo does a series of experiments with a marble and a series of differently-shaped tracks, which leads to the discovery of a retarding force called friction.
- 🕒 1955 – Christopher Cockerell invents the hovercraft, which uses a cushion of air that allows a vehicle to move without friction.

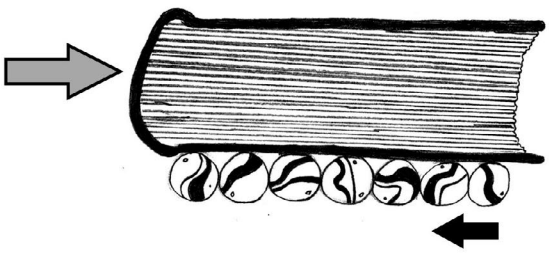
# Sketch Week 2

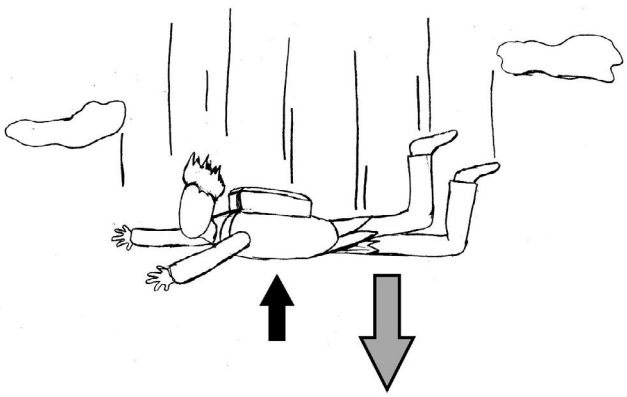
This week's sketch assignment is a bit different because the material is not covered in the main text. Instead you will need to read the definitions below and figure out which of the four diagrams represents the particular type of friction.

- **Fluid friction** - The force that opposes the motion of an object through a fluid. (*In physics, water or air are both examples of fluids*.)
- **Static friction** – The friction force that acts on objects that are not in motion, keeping them in balance.
- **Rolling friction** – The force caused by the changing shape of the points of contact as an object rolls across a surface. This type of friction is 10 to 100 times less than static or sliding friction.
- **Sliding friction** – The force that opposes the direction of motion of an object as it slides over a surface.







# How does friction affect movement?

## Introduction

When an object is in forward motion, several forces are acting on it. There is the driving force, which is propelling the object forward. There is weight (or gravity), which pulls the object downward. There is air resistance, which slows the object down. Finally, there is friction. In today's experiment, you are going to act as the driving force for a block as it moves across a track. Then, you are going to use a variety of materials to test how friction affects the motion of the block.

## Hypothesis

## Materials

## Procedure

## Observations and Results

| | On Smooth Surface | On Sandpaper | On Felt | On Foil With Oil |
|---|---|---|---|---|
| **Amount of Force in ___** | | | | |

_____

_____

_____

_____

## Conclusion

_____

_____

_____

_____

_____

_____

_____

# Written Assignment Week 2

## Discussion Questions

1. What two things affect the force of gravity?
2. Is weight constant? Why or why not?
3. What is escape velocity?
4. What does it mean to be weightless?
5. How does the roughness of a surface affect the amount of friction?
6. Is friction useful?
7. What does a lubricant do?
8. What is drag?
9. What does a streamlined design do?

# Written Assignment Week 2

# elemental science

## Are you ready to start?

Learn about motion, forces, thermodynamics, waves, electricity, magnetism, engineering, robotics, and nuclear physics by purchasing *Physics for the Logic Stage* here:

https://elementalscience.com/collections/physics-for-the-logic-stage


Or check out the rest of our award-winning Classical Science sereies here:

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