Physics for the Logic Stage

Teacher Guide

Physics for the Logic Stage Teacher 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. 245 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 the elements of the periodic table along with specific information 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 text, the *DK Encyclopedia of Science*. 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 seventh 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 seventh 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. The following encyclopedias are scheduled to be used as reference books:

🕮 *The Kingfisher Science Encyclopedia (KSE):* This resource is appropriate for middle school students;

🕮 *Usborne Illustrated Dictionary of Science (UIDS):* This resource is approaching the high school level;

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, or list of facts) 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. 241-244.

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. (*If you have a print copy of this guide and would like a digital copy of the tests, please e-mail us at info@elementalscience.com with your request and we will send them to you*.)

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's a breakdown of how a normal two day week would work using week two:

- **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 "How does friction affect movement?" 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 "air resistance," "friction," "gravity," and "terminal velocity" 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. 121-122 in the *DK Encyclopedia 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:

Friction and Gravity

Friction is the force responsible for slowing down the movement of objects as they slide over each other. The rougher the surface or the heavier an object, the more friction is produced.

Without friction, we could not do a lot of things. For example, we could not walk because our shoes could not grip the ground without friction, and we could not grip because our fingers would not be able to hold the object. Friction is the force responsible for slowing a vehicle down when we hit the brakes.

Friction causes wear and tear on machines, but we can reduce friction an object experiences. We can use lubricants, like oil, reduce the friction. We can also use ball bearings, which reduce friction by causing objects to roll over each other instead of dragging.

Gravity is the force that pulls two objects together. The force of this gravitational pull is dependent upon the distance between the two objects and the mass of the two objects. The closer the objects are, the greater the force of gravity between them. Objects that have a great mass produce a larger gravitational force.

Gravity is the force responsible for creating the tides in the ocean. The gravity of the moon pulls on the ocean on the side of the Earth that is closest, causing it to bulge out. As the two bodies rotate around each other, the strength of the force changes, causing the tides.

What a typical five day schedule looks like

A typical five day schedule will take forty-five minutes to one hour per day. Here's 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 "How does friction affect movement?" 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 together and write an outline or list of facts***
  Begin by having the students read pp. 121-122 in the *DK Encyclopedia 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's a sample outline for the page on friction:

Friction

I. Force which slows down the movement of objects as they slide over each other.
   A. The rougher the surface, the more friction there is.
   B. Heavy objects would be easy to move without friction.

II. Without friction, we could not do a lot of things.
   A. We could not walk because our shoes could not grip the ground without friction.
   B. We could not grip because our fingers would not be able to hold the object.

III. Friction causes wear and tear on machines.
   A. You can reduce friction.
      i. Lubricants, like oil, reduce friction.
      ii. Ball bearings reduce friction because they cause objects to roll over each other instead of dragging.

IV. Friction is everywhere.
   A. There is friction between the brake pads and wheels on a bike.
   B. There is friction between gears.
   C. There is friction as an object moves through water.

V. Friction in the air.
   A. Air resistance is the friction force that objects feel as they move through the air.
   B. The faster an object is moving, the more air resistance it feels.
   C. Friction can heat things up, which is why a meteor burns up as it travels through our atmosphere.

- **Day 3:** ***Record the dates, define the vocabulary, and complete the sketch***
  Begin by having the students look up and define "air resistance," "friction," "gravity," and "terminal velocity" 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 "Relativity and Gravity" from *KSE* pp. 298-299, "Friction" from *KSE* pp. 308-309, or "Gravitation" from *UDIS* pp. 18-19. 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. Here is a sample report:

Gravity, Weight, and Realtivity

There is an attractive force that exists between all masses, which is known as gravity. The strength of the force between two objects depends upon the distance between them and their masses. Mass is a measure of the amount of matter in an object, which should not be confused with weight. Weight is the force experience by a given amount of mater within a gravitational field.

On Earth, the force of the gravity we feel would cause use to accelerate at 9.8 meters per second. The force of gravity on other planets is larger or smaller depending on the planet's size. However out in space, we are weightless because there is no gravitational force pulling on us.

Albert Einstein published a theory that showed nothing could *travel faster than the speed of light. This theory conflicted with the idea that there must be a gravitational pull to be able to travel at infinite speed, which was presented by Isaac Newton. Einstein fixed this with his General Theory of Relativity that describes gravity as a distortion of space and time.*

- **Day 5:** ***Complete one of the Want More activities***
  Have the students do the "Galileo's Tracks" activities or have them do the "Friction Demonstrion" on-line. 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. The units in *Physics for the Grammar Stage* will not match up with the units in *Physics for the Logic Stage*, so you will need to do each program as written.

- ***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 *Usborne Science Encyclopedia*. I have included a chart coordinating this resource in the Appendix of this guide on pg. 247-249.

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 info@elementalscience.com. I will be more than happy to answer them as soon as possible. You may also get additional help and other supplemental material at our Yahoo group.

💻 http://groups.yahoo.com/group/elemental_science/

I hope that you and your students enjoy *Physics for the Logic Stage*!

Book List

The following books were used when planning this study:

Encyclopedias for Reading Assignments

The following book is the main spine of this program. You will need to purchase both of these to complete the reading assignments scheduled in this program.

🕮 *The DK Encyclopedia of Science (DK EOS)* ISBN # 978-0756622204
🕮 *Bridges and Tunnels* by Donna Latham ISBN # 978-1-936749-51-5
🕮 *Robotics* by Kathy Ceceri ISBN # 978-1-93674-975-1

References for Reports

The following encyclopedias are scheduled for additional reference reading. They are optional, but I suggest that you purchase one or two to use throughout the year.

🕮 *The Kingfisher Science Encyclopedia (KSE)* ISBN # 978-0753466889*:* This resource is appropriate for middle school students;
🕮 *Usborne Illustrated Dictionary of Science (UIDS)* ISBN # 978-0794518479*:* This resource is approaching the high school level;

Experiment Equipment

If you would like to create a more lab-like experience for the students this year, I suggest using equipment that is more commonly found in the laboratory setting. Here's a list of material that you can substitute:

- ✓ **Jar** – Use a beaker or Erlenmeyer flask that is at between 750 and 1000 mL;
- ✓ **Cup** – Use a beaker or Erlenmeyer flask that is at between 200 and 500 mL;
- ✓ **Bottle** – Use an Erlenmeyer flask that is between 250 and 1000 mL;
- ✓ **Small cup** – Use a small beaker (50 mL) or test tube;
- ✓ **Eye dropper** – Use a pipette.

You can use the glass or plastic version of each of the above.

Safety Advisory

Some of the experiments in this book use boiling water or open flames. We recommend that your students use safety glasses and protective gear with each experiment to prevent accidents. Do not allow your students to perform any of the experiments marked "☢ **CAUTION**" on their own.

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:

- http://elementalblogging.com/units-of-measurement

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: Sound

Week	Materials
13	Glass bottle, Bell, Cork that fits the top of the glass bottle, Thread, Needle, Match
14	Shallow glass bowl or cup, Water, Music player
15	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
16	Partner, Blindfold

Unit 5: Light

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
27	Straws, Electrical tape, 6 ft. (2 m) of thin insulated wire, AAA battery, Sandpaper, Needle

Unit 7: Engineering

Week	Materials
28	Paper, Tape, Books, Can or glass
29	Craft sticks, Wood glue, Books, Binder clips
30	Salt dough (at least 3 to 4 cups), Cardboard square, Spoon, Craft sticks, Pipe cleaners, Aluminum foil, Toy car, Books or other heavy objects, Water
31	1.5-volt DC motor, 1 ft. insulated wire, Electrical tape, Cup or Jar, Foam tape, 2 AAA batteries, Rubber band, Cork, Cardboard, 3 Pens, Paper
32	Pencil, 1.5-volt DC motor, Small Solar Panel, Electrical tape, Scissors, CD, Glue, Tape, Clear dome from a drink cup
33	LED light bulb with two metal legs, 3-volt Watch battery, 2 Index cards, Aluminum foil, Scissors, Marker, Yarn, Glue, Toothpick, Tissue

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 ($1\ N = 1\ kg \cdot 1\ m/s^2$).
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's forced to change.
2. The greater the force on an object, the greater the change in its motion. The greater the mass of an object, the greater the force needed to change 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 • 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: Resultant Force

- Label the following—Forces pull in the same direction; add the forces together to get the resultant force; forces pull in equal, but opposite directions; the forces will cancel each other out for a zero resultant force; forces pull unequal, opposite directions; subtract the forces to get the resultant force.

Writing

- Reading Assignment: *DK Encyclopedia of Science* pp. 114-115 (Forces), pg. 116 (Combining Forces), & pg. 117 (Balanced Forces)
- Additional Research Readings
  - Force: *KSE* pp. 290-291, *UDIS* pp. 6-7

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, lived. 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 ☐ Define balance, force, force field, and newton on SG pg. 16 ☐ Enter the dates onto the date sheets on SG pp. 9-14	☐ Read pp. 114-117 from *DK EOS,* and then discuss what was read ☐ Color and label the "Resultant Force" sketch on SG pg. 19 ☐ Prepare an outline or narrative summary; write it on SG pp. 22-23

Supplies I Need for the Week

- ✓ 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

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 ☐ Enter the dates onto the date sheets on SG pp. 9-14	☐ Read pp. 114-117 from *DK EOS,* and then discuss what was read ☐ Write an outline on SG pg. 22	☐ Define balance, force, force field, and newton on SG pg. 16 ☐ Color and label the "Resultant Force" sketch on SG pg. 19	☐ Read one or all of the additional reading assignments ☐ Write a report on what you learned on SG pg. 23	☐ Complete one of the Want More Activities listed **OR** ☐ Study a scientist from the field of Physics

Supplies I Need for the Week

- ✓ 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

Things I Need to Prepare

Additional Information Week 1

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 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. 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 read *DK Encyclopedia of Science* pg. 123 (Measuring Forces). Then, have them 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

Forces, pp. 114-115

1. What does a force do? (*A force acts on an object or a force pushes or pulls an object.*) Name several examples. (*The wind blowing, gravity pulling, and the grasshopper leaping are all examples of force*.)
2. Where is a force field the strongest? (*A force field is strongest closest to the source of the force*.)
3. What is the difference between contact and non-contact forces? (*Contact forces are only produced when one object touches another. Non-contact forces can pull objects without touching them*.)

Combining Forces, pg. 116

1. What is a resultant force? (*The resultant force is the overall result of two or more forces*

acting on an object.)

2. How do you find the resultant when forces are pulling in the same direction? (*When forces are pulling in the same direction, you can find the resultant by adding the forces together.*)
3. How do you find the resultant when forces are pulling in the opposite direction? (*When forces are pulling in the opposite direction, you can find the resultant by subtracting one force from the other*.)

Balanced Forces pg. 117

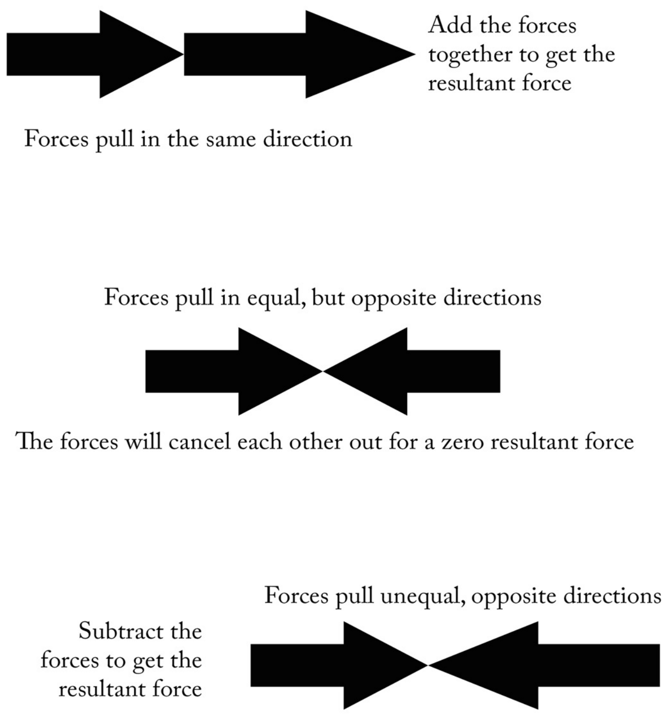
1. How is an object balanced? (*An object is balanced when the forces acting on it cancel each other out, which produces a zero resultant.*)
2. Why is balance important to architects? (*Architects design buildings and bridges so that the forces that act on the structure are balanced. This keeps the structure from falling down*.)

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. 250.
  Answers
  1. Resultant force = 0, 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 = 0, object is in balance

Sketch Week 1

Resultant Force



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 your 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 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.
4. Then, place the piece of sandpaper on your track. 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. Repeat with the felt.
5. Finally, place the foil over the track and coat it well with spray oil. Then, 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 Unit Overview Sheet 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: *DK Encyclopedia of Science* pg. 121 Friction, pg. 122 Gravity
- Additional Research Readings
  - 🕮 Relativity and Gravity: *KSE* pp. 298-299
  - 🕮 Friction: *KSE* pp. 308-309
  - 🕮 Gravitation: *UDIS* pp. 18-19

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 ☐ Define air resistance, friction, gravity, and terminal velocity on SG pg. 16 ☐ Enter the dates onto the date sheets on SG pp. 9-14	☐ Read pp. 121 & 122 from *DK EOS,* and then discuss what was read ☐ Color and label the "Types of Friction" sketch on SG pg. 25 ☐ Prepare an outline or narrative summary; write it on SG pp. 28-29

Supplies I Need for the Week

- ✓ Force Meter from last week
- ✓ Small wooden block (like a Jenga block), Eye-hook screw
- ✓ Sandpaper, Felt, Foil , Spray oil
- ✓ 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 ☐ Enter the dates onto the date sheets on SG pp. 9-14	☐ Read pp. 121 & 122 from *DK EOS,* and then discuss what was read ☐ Write an outline on SG pg. 28	☐ Define air resistance, friction, gravity, and terminal velocity on SG pg. 16 ☐ Color and label the "Types of Friction" sketch on SG pg. 25	☐ Read one or all of the additional reading assignments ☐ Write a report on what you learned on SG pg. 29	☐ Complete one of the Want More Activities listed **OR** ☐ Study a scientist from the field of Physics

Supplies I Need for the Week

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

Things I Need to Prepare

Additional Information Week 2

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.
- ☞ **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

Friction, pg. 121

1. How does the roughness of a surface affect the amount of friction? (*The rougher a surface, the stronger the force of friction.*)
2. Why is friction so important? (*Friction is important because without it we would continuously slide throughout life*.)
3. What does a streamlined design do? (*A streamlined design reduces friction so that the object can move more easily*.)

Gravity, pg. 122

1. What two things affect the force of gravity? (*The distance between the objects and the mass of the objects both affect the force of gravity*.)
2. What is the center of gravity? (*The center of gravity is the point at which the weight of an object appears to be located*.)
3. How does gravity cause the tides in the ocean? (*The gravity of the moon pulls on the ocean on the side of the Earth that is closest, causing it to bulge out. As the two bodies rotate around each other, the strength of the force changes, causing the tides.*)

Want More

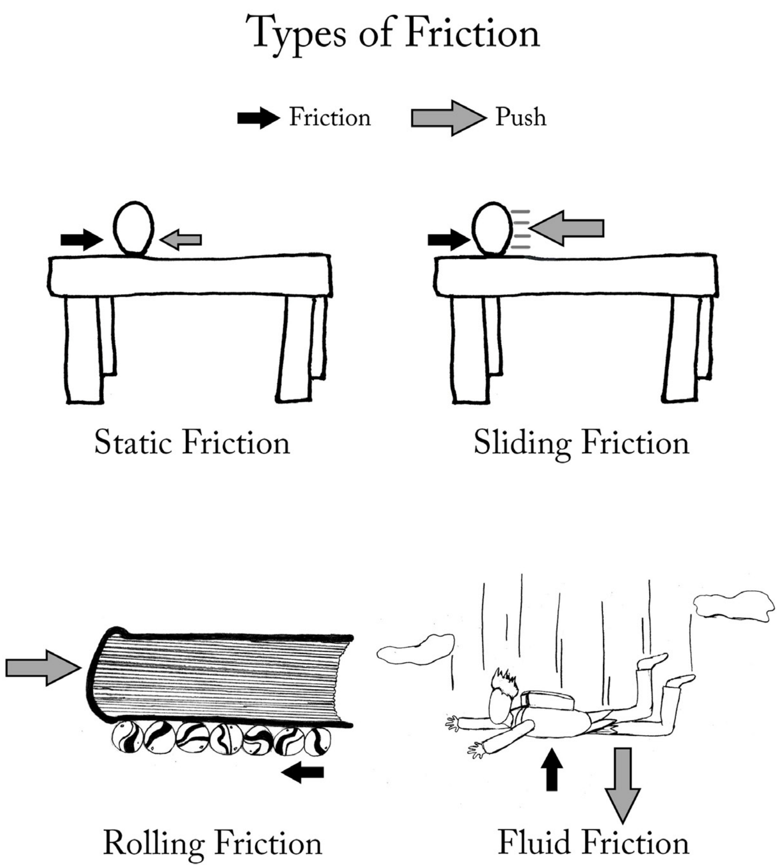
- **Galileo's Tracks** – Have the students study the effect of friction using a marble track, just like Galileo did. Have the students set up a track and send the marble down it several times. Each time, have them record the time it takes to get to the bottom. Then, have the student sprinkle some sand 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.*)

- **Friction Demonstration** – Do the friction simulation from the PhET website.
  - http://phet.colorado.edu/sims/html/gravity-force-lab/latest/gravity-force-lab_en.html
- **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 you will need to read one of the following definitions to your students and help them to figure out which of the four diagrams represents that 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.



Repeat this process for each definition until their sketch looks like the one pictured.

Student Assignment Sheet Week 3
Motion

Experiment: Investigating the Three Laws

Materials
- ✓ Jenga block with the eyehook from last week
- ✓ String
- ✓ 2 Toy cars
- ✓ Egg

Procedure
1. In this experiment, you will be investigating the three laws of motion. Begin by reading the introduction.
2. Test the three laws of motion.
   - **Motion Law # 1** – You will need a Jenga block with the eyehook and string. Tie the string to the block and place it on a smooth surface. Pull the block along with a decent amount of force and then stop suddenly. Observe what happens to the block.
   - **Motion Law # 2** – You will need the two toy cars and a partner for this test. Line up the two cars evenly on a flat surface. Gently push your car forward, while your partner pushes his car forward with a greater force at the same time. Observe what happens to the two cars.
   - **Motion Law # 3** – You will need an egg for this test. Head outside with the egg. Drop the egg onto the pavement from a height of four to five feet and observe what happens.
3. Draw conclusions and complete the experiment sheet.

Vocabulary & Memory Work

- ☐ Vocabulary: inertia, mass, weight, momentum
- ☐ Memory Work — This week, continue working on memorizing Newton's three laws of motion. Also work on memorizing the following equation from Newton's second law:
  - Force (F) = mass (m) • acceleration (a)

Sketch: 3 Laws of Motion

- Label each of the three sketches with the law of motion that they represent. (*See the experiment sheet for a list of the laws*.)

Writing

- Reading Assignment: *DK Encyclopedia of Science* pg. 120 Forces and Motion
- Additional Research Readings
  - Momentum: *KSE* pp. 296-297
  - Dynamics: *UDIS* pp. 12-13

Dates

- 1665 – The plague breaks out in London, which forces Isaac Newton to leave Trinity College in Cambridge. He goes home and spends the next two years working on his book, *Principia*, in which he shares his three laws of motion.

Schedules for Week 3

Two Days a Week

Day 1	Day 2
☐ Do the "Investigating the Three Laws" experiment, and then fill out the experiment sheet on SG pp. 32-33 ☐ Define inertia, mass, weight, and momentum on SG pg. 17 ☐ Enter the dates onto the date sheets on SG pp. 9-14	☐ Read pp. 120 from *DK EOS,* and then discuss what was read ☐ Color and label the "3 Laws of Motion" sketch on SG pg. 31 ☐ Prepare an outline or narrative summary; write it on SG pp. 34-35

Supplies I Need for the Week

- ✓ Jenga block with the eyehook from last week
- ✓ String
- ✓ 2 Toy cars
- ✓ Egg

Things I Need to Prepare

Five Days a Week

Day 1	Day 2	Day 3	Day 4	Day 5
☐ Do the "Investigating the Three Laws" experiment, and then fill out the experiment sheet on SG pp. 32-33 ☐ Enter the dates onto the date sheets on SG pp. 9-14	☐ Read pp. 120 from *DK EOS,* and then discuss what was read ☐ Write an outline on SG pg. 34	☐ Define inertia, mass, weight, and momentum on SG pg. 17 ☐ Color and label the "3 Laws of Motion" sketch on SG pg. 31	☐ Read one or all of the additional reading assignments ☐ Write a report on what you learned on SG pg. 35	☐ Complete one of the Want More Activities listed **OR** ☐ Study a scientist from the field of Physics

Supplies I Need for the Week

- ✓ Jenga block with the eyehook from last week
- ✓ String
- ✓ 2 Toy cars
- ✓ Egg

Things I Need to Prepare

Additional Information Week 3

Notes

- **Inertia vs. Momentum** – Inertia and momentum are often confused or used interchangeably. However, the two are quite different. The amount of inertia force an object experiences is only based on the object's mass, whereas the force of momentum an object feels is dependent upon its mass and its speed. In other words, inertia is how much something resists changes in motion, while momentum increases or decreases with motion.

Experiment Information

- **Note –** This experiment is meant to give your students the chance to see Newton's laws of motion in action. The experiment sheet looks a bit different because of this. So, there is no hypothesis and a separate procedure and observations section for each test.
- **Introduction –** (*from the Student Guide*) Isaac Newton built on Galileo's work on friction and motion through number of experiments. These tests led to his development of the three laws of motion. The laws state:
  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's forced to change.
  2. The greater the force on an object, the greater the change in its motion. The greater the mass of an object, the greater the force needed to change its motion.
  3. For every reaction, there is an equal but opposite reaction.

  In today's experiment, you are going to do three tests where you will see each of the laws in action.
- **Results –** For test one, the students should see that when they stopped suddenly, the block continued to move until the string went taut. Once the string was tight, the block to bounced back a bit and eventually stopped. For test two, the students should see that the car that was pushed with greater force moved faster and farther than the other car. For test three, the students should see that the egg cracked and splattered on the pavement.
- **Explanation –** In test one, the students are looking at inertia from the first law of motion. The block began to move because the student pulled the string attached to it. When the student stops suddenly, the block continues to move because the force of the sudden stop in the string has not acted on it yet. However, when then string goes taut, the force is strong enough to change the motion of the block and eventually stop it. In test two, the students should see that the force that acts on the second car is greater than the force that acts on the first one. This causes a greater change in the second car's motion, which means it goes faster and farther. In test three, the egg reaches its terminal velocity before it hits the pavement. It is moving with such a force that the action of the sudden stop causes an equally violent reaction. This reaction has the force to break apart the egg and splatter it on the pavement.

Discussion Questions

1. What did Aristotle believe about motion? (*Aristotle believed that for an object to move it had to be pushed by a force. He also believed that the object would only stop when the force was removed.*)
2. What did Galileo learn about motion? (*Galileo learned that a force was only need to start, stop, and accelerate an object. He found that if the object was already in motion, no force*

was needed to keep it in motion.)

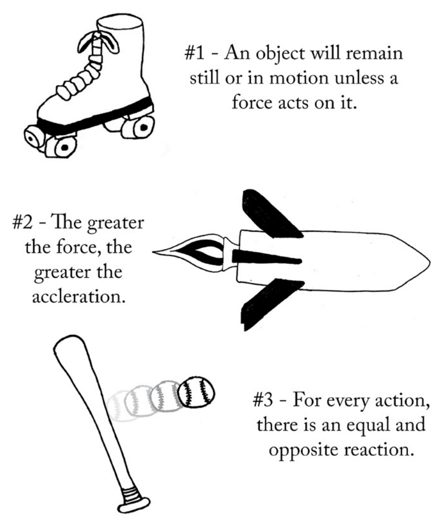
3. What did Isaac Newton discover about motion? (*Isaac Newton discovered three laws about motion. The first says that an object will stay still or keep on the same path at a constant speed unless a force pushes or pulls it. The second law says that the greater the force that acts on an object, the greater the change in movement. The third law says that for every action, there is an equal and opposite reaction.*)

Want More

- **Egg Drop Carrier** – Have the students test how to slow down the inertia and momentum of a falling egg so that the "reaction" from the third law of motion doesn't result in a cracked egg. You will need a raw egg, various shock absorbing materials (such as cotton balls, newspaper, packing peanuts or fabric), a 1 quart plastic container (the type that fruit is typically packed in), and masking tape. Have the student begin by examining the different shock absorbing materials you have and using it to fill the 1 quart container in such a way that the egg will be protected as it falls. Be sure to have the egg on hand so that you can measure it and make sure the egg fits in the remaining space. Have the students tape across the top of the container to hold in the egg and the materials. Now, have them hold their containers over their heads and drop it. Observe what happens. Did the egg crack? (*As the egg drops, its speed increases, which causes the force of momentum to increase. When it hits the ground, an equal shock force (Newton's 3rd Law of Motion) is sent back into the egg. If the egg was not protected, it would surely crack, like it did in the experiment from earlier this week. However, in this case, the materials surrounding the egg absorb most of the shock force, so that the force that the egg eventually felt was minimal.*)
- **Second Law Worksheet** – Have the students practice calculating acceleration, mass, and force using the second law of motion using the worksheet in the Appendix on pg. 251.
  Answers: 1. $a = 8\ m/s^2$ 2. $F = 160{,}000\ N$ 3. $m = 25\ kg$

Sketch Week 3

Three Laws of Motion



Unit 1 Forces and Motion
Unit Test Answers

Vocabulary Matching

1. B
2. E
3. K
4. A
5. F
6. M
7. H
8. C
9. I
10. L
11. N
12. D
13. J
14. O
15. G

True or False

1. True
2. False (*An object is balanced when the forces acting on it cancel each other out, which produces a zero resultant.*)
3. False (*A streamlined design reduces friction so that the object can move more easily.*)
4. True
5. True
6. False (*Isaac Newton discovered the three laws about motion*.)
7. False (*Average speed is the distance traveled divided by the time taken.*)
8. True

Short Answer

1. The resultant force is the overall result of two or more forces acting on an object.
2. The distance between the objects and the mass of the objects both affect the force of gravity.
3. The first says: an object will stay still or keep on the same path at a constant speed unless a force pushes or pulls it. The second law says: the greater the force that acts on an object, the greater the change in movement. The third law says: for every action there is an equal and opposite reaction.
4. Velocity is the measurement of speed in a particular direction.
5. Force (F) = mass (m) • acceleration (a)

Unit 1 Forces and Motion
Unit Test

Vocabulary Matching

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 ____

A. The measurement of force; 1 Newton (N) is the force is takes to move a one kilogram object at 1 meter per second squared ($1 N = 1 kg \cdot 1 m/s^2$).

B. A state of equilibrium when the forces acting on an object cancel each other out; also known as a zero resultant force.

C. The point at which the force acting on an object of air resistance is equal to the force of gravity acting on the object.

D. The force with which an object's mass is pulled toward the center of the Earth.

E. A push or pull that acts on an object.

F. The force that air exerts on an object as it falls.

G. The speed of an object in a particular direction.

H. The force that acts between two masses; it is an attractive force.

I. The tendency of an object to resist a change in its motion.

J. A change in an objects speed, direction, or both.

K. The area in which a force can be felt.

L. The amount of matter in an object.

M. A force that opposes the motion of objects that touch as they move past each other.

N. The tendency of an object to keep moving until a force stops it.

O. The ratio of the distance an object moves to the amount of time the object moves.

True or False

1. ____________________ Contact forces are only produced when one object touches another. Non-contact forces can pull objects without touching them.

2. ______________________ An object is balanced when the forces acting on it add to each other which produces a positive resultant force.

3. ______________________ A streamlined design increases friction so that the object can move more easily.

4. ______________________ The center of gravity is the point at which the weight of an object appears to be located.

5. ______________________ Aristotle believed that the object would only stop when the force was removed.

6. ______________________ Galileo discovered a great deal about motion, including the three laws of motion.

7. ______________________ Average speed is the speed at which an object is traveling at a given instant.

8. ______________________ Acceleration is a measure of how quickly velocity increases or decreases.

Short Answer

1. What is a resultant force?

2. What two things affect the force of gravity between two objects?

3. What are Newton's three laws of motion?

4. How are speed and velocity related?

5. Write the equation that relates force, mass, and acceleration that comes from Newton's second law of motion.

Appendix

Resultant Force Worksheet

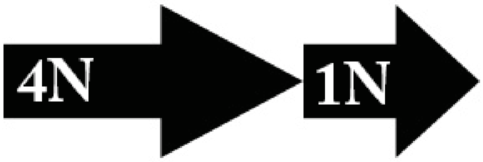
Introduction

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.

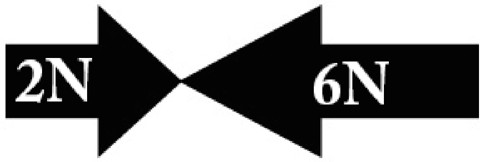
Sample Problems

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



Resultant Force = 5N

The object will continue in the same direction.

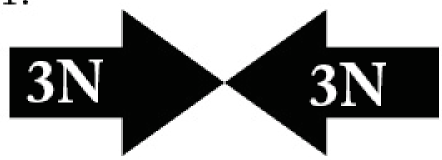


Resultant Force = -4N

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 ____________________

____

Second Law of Motion Worksheet

Introduction

Newton's second law of motion states that:

> *The greater the force on an object, the greater the change in its motion. The greater the mass of an object, the greater the force needed to change its motion.*

This law can also be written as an equation which looks like:

Force (F) = mass (m) • acceleration (a)

We can use this equation to calculate the acceleration of an object when we know its mass and the force that has acted on it.

Sample Problems

Let's say you are pushing a grocery cart full of oranges that has a mass of 35 kg with a net force of 10 N. What would the acceleration of the cart be?

F = 70 N (kg • m/s^2)   m = 35 kg   a = ?

Substitute and solve.

70 N = (35 kg) a

$$a = \frac{70\text{ N (or kg} \cdot \text{m/s}^2)}{35\text{ kg}}$$

$a = 2\ m/s^2$

Problems

Now it is your turn to try a few problems!

1. A girl kicks a 2.5 kg soccer ball with a net force of 20 N. What would the acceleration of the ball be?

2. A truck pulls a trailer with mass of 4000 kg up a hill at a rate of 40 m/s^2. What is the net force that acted on the trailer?

3. A 12.5N force accelerates a boy in a toy car at 0.5 m/s^2. What is the mass of the boy?

Physics for the Logic Stage

Student Guide

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: Resultant Force

- Label the following—Forces pull in the same direction; add the forces together to get the resultant force; forces pull in equal, but opposite directions; the forces will cancel each other out for a zero resultant force; forces pull unequal, opposite directions; subtract the forces to get the resultant force.

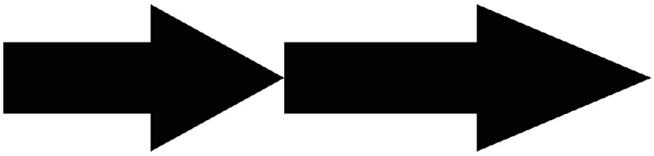
Writing

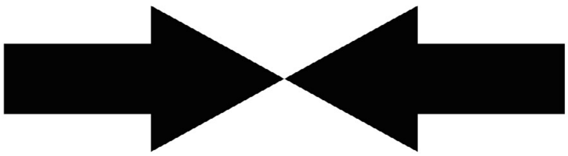
- Reading Assignment: *DK Encyclopedia of Science* pp. 114-115 (Forces), pg. 116 (Combining Forces), & pg. 117 (Balanced Forces)
- Additional Research Readings
  - 📖 Force: *KSE* pp. 290-291, *UDIS* pp. 6-7

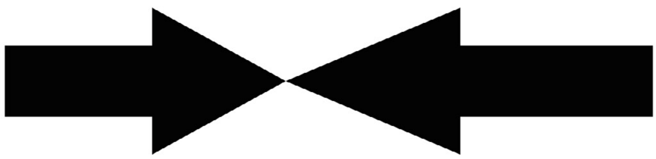
Dates

- 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, lived. 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

____

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Observations and Results

Object	Amount of Force in ____

Conclusion

Written Assignment Week 1

Discussion Questions

Forces pp. 114-115

1. What does a force do? Name several examples.
2. Where is a force field the strongest?
3. What is the difference between contact and non-contact forces?

Combining Forces pg. 116

1. What is a resultant force?
2. How do you find the resultant when forces are pulling in the same direction?
3. How do you find the resultant when forces are pulling in the opposite direction?

Balanced Forces pg. 117

1. How is an object balanced?
2. Why is balance important to architects?

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 your 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 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.
4. Then, place the piece of sandpaper on your track. 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. Repeat with the felt.
5. Finally, place the foil over the track and coat it well with spray oil. Then, 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

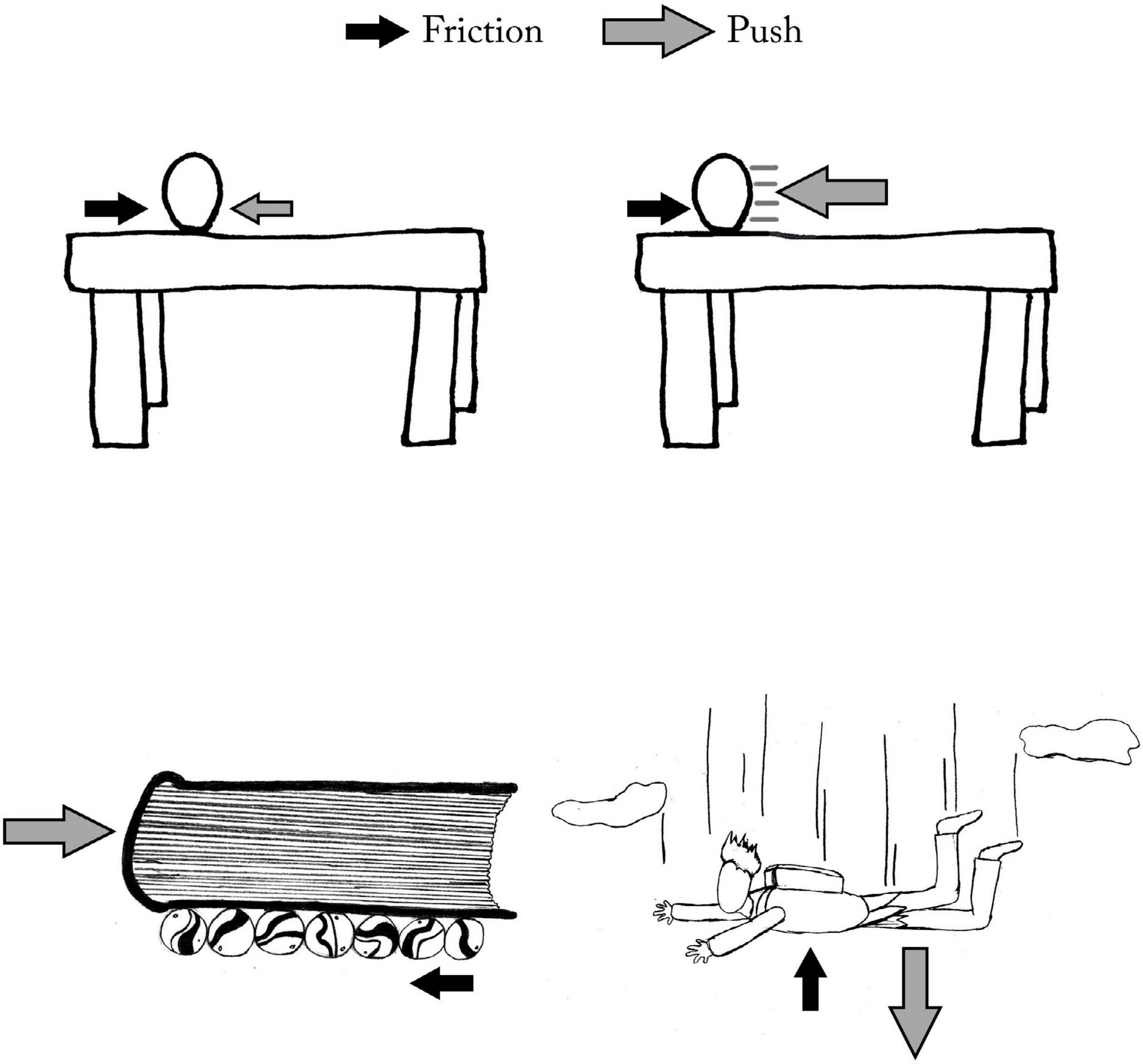
Writing

- Reading Assignment: *DK Encyclopedia of Science* pg. 121 Friction, pg. 122 Gravity
- Additional Research Readings
  - Relativity & Gravity: *KSE* pp. 298-299
  - Friction: *KSE* pp. 308-309
  - Gravitation: *UDIS* pp. 18-19

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



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

____

____

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Materials

______________________ ______________________

______________________ ______________________

______________________ ______________________

Procedure

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Observations & Results

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

Conclusion

Written Assignment Week 2

Discussion Questions

Friction, pg. 121

1. How does the roughness of a surface affect the amount of friction?
2. Why is friction so important?
3. What does a streamlined design do?

Gravity, pg. 122

1. What two things affect the force of gravity?
2. What is the center of gravity?
3. How does gravity cause the tides in the ocean?

Written Assignment Week 2

Student Assignment Sheet Week 3
Motion

Experiment: Investigating the Three Laws

Materials

- ✓ Jenga block with the eyehook from last week
- ✓ String
- ✓ 2 Toy cars
- ✓ Egg

Procedure

1. In this experiment, you will be investigating the three laws of motion. Begin by reading the introduction.
2. Test the three laws of motion.
   - **Motion Law # 1** – You will need a Jenga block with the eyehook and string. Tie the string to the block and place it on a smooth surface. Pull the block along with a decent amount of force and then stop suddenly. Observe what happens to the block.
   - **Motion Law # 2** – You will need the two toy cars and a partner for this test. Line up the two cars evenly on a flat surface. Gently push your car forward, while your partner pushes his car forward with a greater force at the same time. Observe what happens to the two cars.
   - **Motion Law # 3** – You will need an egg for this test. Head outside with the egg. Drop the egg onto the pavement from a height of four to five feet and observe what happens.
3. Draw conclusions and complete the experiment sheet.

Vocabulary & Memory Work

- ☐ Vocabulary: inertia, mass, weight, momentum
- ☐ Memory Work—This week, continue working on memorizing Newton's three laws of motion. Also work on memorizing the following equation from Newton's second law:
  - Force (F) = mass (m) • acceleration (a)

Sketch: 3 Laws of Motion

- Label each of the three sketches with the law of motion that they represent. (*See the experiment sheet for a list of the laws*.)

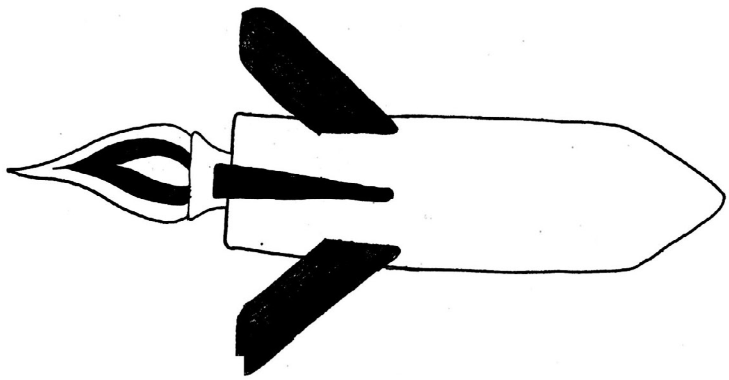
Writing

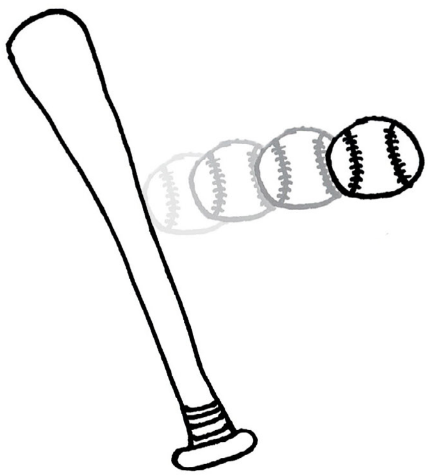
- Reading Assignment: *DK Encyclopedia of Science* pg. 120 Forces and Motion
- Additional Research Readings
  - Momentum: *KSE* pp. 296-297
  - Dynamics: *UDIS* pp. 12-13

Dates

- 1665 – The plague breaks out in London, which forces Isaac Newton to leave Trinity College in Cambridge. He goes home and spends the next two years working on his book, *Principia*, in which he shares his three laws of motion.

Sketch Week 3





Investigating the Three Laws

Introduction

Isaac Newton built on Galileo's work on friction and motion through number of experiments. These tests led to his development of the three laws of motion. The laws state:

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's forced to change.
2. The greater the force on an object, the greater the change in its motion. The greater the mass of an object, the greater the force needed to change its motion.
3. For every reaction, there is an equal but opposite reaction.

In today's experiment, you are going to do three tests where you will see each of the laws in action.

Motion Test #1

Procedure

____
____
____
____
____

Observation

____
____
____
____
____

Motion Test #2

Procedure

____
____
____

Observation

Motion Test #3

Procedure

Observation

Conclusion

Written Assignment Week 3

Discussion Questions

1. What did Aristotle believe about motion?
2. What did Galileo learn about motion?
3. What did Isaac Newton discover about motion?

Written Assignment Week 3