SUPERCHARGED SCIENCE

Unit 1: Mechanics

www.ScienceLearningSpace.com

Appropriate for Grades:
Lesson 1 (K-12), Lesson 2 (K-12)
Duration: 6-15 hours, depending on how many activities you do!

In 1666 Newton did his early work on his Three Laws of Motion. To this day, those laws still hold true. There has been some allowances for really big things (like the cosmos) and for really small things (like the atom). Other than that, Newton's Law's are pretty much dead on.

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Table of Contents

How to Use This Lesson Plan 3

Materials for Experiments 8

Key Vocabulary 11

Unit Description 12

Objectives 13
- Lesson 1: Force 13
- Lesson 2: Gravity 14
- Lesson 3: Friction 15

Textbook Reading 16

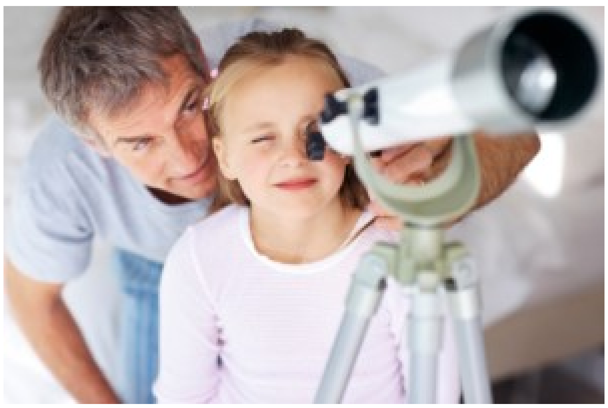
Activities, Experiments, Projects 21
- Lesson 1: Forces 21
- Lesson 2: Gravity 23
- Lesson 3: Friction 25

Exercises for Unit 1: Mechanics 28
- Lesson 1: Forces Exercises 28
- Lesson 2: Gravity Exercises 29
- Lesson 3: Friction Exercises 30
- Answers to Exercises 31

How to Use This Lesson Plan

The e-Science program is appropriate for students grades K-12. You'll find lots of experiments for students in this entire grade range. Younger students can still work through most of the program with a bit of your help (for using tools and hot glue guns) as they build the robots, laser shows, hovercraft, catapults, roller coasters, chemistry experiments, and much more.

One program. All ages.



We find that learning is not segmented depending on age/grade, but rather dependent on a child's experience and interest, as well as the parent's goals. Thus our program supports this type of learning.

Most families of younger students want their kids to get excited about science, so they use the program differently than older students by focusing on experiments and activities and barely touching textbooks and academic material.

For older students, the K-8 content is included as a free bonus when you sign up for Grades 9-12. Many high school students use it extensively as a foundation.

Remember, your own goals for your child's science learning combined with your schooling philosophy will determine what is right for you.

Your child can have an outstanding science education, with little effort from you. We've taken most of the headache and hassle out of figuring out what to teach and how to present it to your child with our videos, audio teleclasses, projects, experiments, activities, textbook downloads, quizzes, and more. Your kids will soon be teaching YOU science!

When a teacher plans out a lesson, there are nine master steps to follow to make sure all the bases are covered. We've done this work for you work the e-Science program, but in case you're curious, here are the nine steps:

- **Unit Description: *This answers the "What is it?" and "Why should I care?"*** *about each unit.* This is where you'll find the overview of what the unit is all about. Each unit is broken down into Lessons, each of which last 1 – 3 weeks, depending on how much science you choose to do.

- **Outcomes/Goals: *What do you want the students to learn?*** The main scientific principle is embedded in here, and this stays at the forefront of the teacher's mind when they build the lesson plan for the topic. We've outlined these for you in the lesson plan. Each unit covers one key science principle.

- **Objectives/Highlights: *Detail the key concept and topic into chunks.*** Key concepts are often too big to teach in one swallow, so break it down into smaller bite-sized pieces presented in a logical order for students to understand. We've done this part for you in the lesson plan.

- **Introduction: *How will you present the topic to the students?*** This is where you figure out how to get your students hungry for your message. How will you get students interested in what you want them to learn? The introduction should spark their interest and give them something to think about and look forward to. This is already prepared for you, so you don't have to gather any demonstration materials together – it's all on the introduction video for each unit.

- **Development: *This stirs up interest and gets students motivated to learn.*** In a traditional classroom, this is the discussion about the topic itself, any useful background information, and questions that pop up from the students. We have live discussions (MP3) delivering an introduction to the group of students, complete with questions. It's a great way to start your new unit, and you don't have to prepare any notes!

- **Practice: *Bringing the key concept to life.*** The bulk of a science lesson is spent doing experiments and activities that cause the students to get curious about their world. This is the heart of the e-Science program, as there is a staggeringly long list of experiments, projects, and activities. Pace yourself and do the ones that best fit your goal, time and budget. Each experiment has an instructional step-by-step video that students can watch on their own as they build their project.

- **Further Study: *Answering questions and gaining momentum.*** After your students have completed a few experiments, questions are naturally going to pop up. The reading material with each unit is designed to help answer any questions that come up when you did your experiments and activities. If they still have questions, that's why we offer unlimited support – simply type in your question and you'll get a quick and quality response.

- **Evaluation: *How well did you teach and how well did they learn the material?*** Print out the exercises and have your students complete the exercises for the lesson so you know their comprehension level and where to spend more time.

- **Closure: *Before moving on, celebrate your success!*** This is where students can submit feedback, share photos, discuss what they've learned and figured out, and what still doesn't make sense. The comment sections hold many proud moments and images from our students!

(Note: the e-Science program does not cover creation or evolution so all families may participate. The focus of the program is on how to launch the rocket, build the robot, use a microscope, take measurements and data, etc.)

How NOT to Teach Science

Most traditional science lesson plans will have you read textbook material first, and then if you've got time, do an experiment or two… most of which are sadly boring and don't spark curiosity at all. And kids forget 95% of what you try to teach them when you do it this way.

There's no single "right way" to teach kids, because each student has their own personal learning style. All kids have their own unique learning mode (visual, auditory, kinesthetic, or digital), and the e-Science Learning Program covers all four. While kids have all four, there's usually a strong preference for one in order for them to get their *A-HA!* moment. Here are the four different modes:

- Auditory learners need to hear it to understand what's going on

- Visual learners need to see the experiment to understand the scientific idea

- Kinesthetic kids need to actually DO the experiment themselves for the ideas to really make sense
- Digital kids must read the actual text and words for it to make sense, whether on paper or on a computer screen (digital does not refer to computers, but rather words/digits on a page)

The trouble comes in when we try to teach kids according to OUR learning style. For example, I'm a visual learner, but my son is auditory. So he will *tell* me about his experiment but I haven't got a clue as to what he's talking about. However, as soon as he *shows* me what he's been building, I totally get it.

But no matter which style you learn best in, if you start out with a stale, flat entrance to learning science, your kids are going to get bored no matter how you deliver it.

The Best Way to Learn Science

We recommend teaching science from the inside-out, meaning that you start with an experiment or two that really *hooks* your kids… the kind that makes them (and you) say; *"WOW!"* or "*Cool!"*

Let them roll around and play with the experiment for awhile, and when they come running back to you with questions like *"Why did that happen?"* or *"What's going on here?"*, then they've signaled you that they are ready for the more academic reading and lesson videos.

The e-Science program has a lot of overlap in the content, so you won't have to stress over missing any content if you don't "do it all". For example, if you've got a more auditory learner, you'll probably spend most of your time with the teleclasses and videos. Digital students prefer the text downloads and reading about the experiment from the website. Kinesthetic and visual students will prefer watch the videos and build the projects.

We all have all four modes, but you'll find a stronger preference for one of these. You'll find more information about this in the Parent Resource section.

"Help!!! I can't answer my kid's questions!"

At Supercharged Science, we don't believe it's your job as a parent to have all the answers. The next time your child runs to you with questions, you can honestly say, "Gosh – I'm not sure. Let's take a look together…" Your job as a parent is to be the biggest cheerleader for your student, meaning that you show them total confidence in their abilities to figure things out. You don't need to have all the answers. In fact, you're not supposed to. (Big *sigh* of relief here!)

Ever notice how science experiments don't usually work? You want your project to happen a certain way (for example, your paper airplane to fly), but after working at it you find your results are not as you expected (after folding the airplane, it consistently nose-dives).

Most people stop here and give up, but this is where the greatest opportunity for learning starts. Stop to take a closer look and really start to ask quality questions, like:

- *"Does it matter what type of paper we use?"*
- *"Is it heavy on one side?"*
- *"What if we add a paper clip to the nose?"*
- *"How do real airplanes keep from nose-diving?"*

Help your kids out by teaching them how to ask questions based on what they observe happening – that's how real scientists do their thing! But sometimes you really do get stuck and need help, so that's why **this e-Science program includes Unlimited Support for as long as you need it.** My team and I are committed to your long-term success and not here to offer you a one-time solution.

What this means is that you're off the hot-seat with having to come up with all the answers. We love it when kids contact us with their questions, because it shows that they are taking charge of their own education. What this *really* means is that your child is now finding their answers to their questions, freeing up your mind for more important things.

There is an easy way for kids to get their questions answered. Simply post the question on the e-Science program (in the comment box of every experiment). Just type in your question in the comment box and *presto!* you'll see an answer in less than a day.

Materials for Experiments

How many of these items do you have?

You'll find dozens of experiments with every lesson, so you can pick and choose the experiments you want to do. This program has *hundreds* of experiments, projects, and activities to choose from depending on your child's interest, your family budget, and what's available to you in your area. **You don't need to do them *all* to get a great science education!**

Focus on *quality*, not quantity when planning your activity list.

Here's how to use this shopping list:

1. Look over the list and circle the items you already have on hand.
2. Browse the experiments and note which ones use the materials you already have. Those are the experiments you can start with.
3. After working through the experiments, your child might want to expand and do more activities. Make a note of the materials and put them on your next shopping trip OR order them online using the links provided below.

We've tried to keep it simple for you by making the majority of the items things most people have within reach (both physically and budget-wise). We'll be re-using these materials in later units as well.

Force Experiments
Balloon (7-9” Latex works great)
Ping Pong Ball
Tissue paper or newspaper
Handful of packing peanuts or paper confetti
Bubble juice (make your own with 12 cups cold water and 1 cup liquid dish soap)
Ball (any size)
Compass (or make your own from a needle, cup of water, magnet, and a cork)
Paper clips (10-15)
Magnet
String or yarn (about 2 feet long)
O-shaped cereal (any brand is fine)
Milk (or water)
Spoon and bowl

Rope (about 3′ long)
Paper (copy paper is fine, but if you can find at least one sheet of heavy paper like cardstock, that would be even better)
Two pencils or sticks
Index cards
Blocks
Straws
Clay
Disposable cups

OPTIONAL: (These are not required, but still nice to have…)
Neon bulb (RS# 272-712)
Fluorescent bulb
Wool sweater
Plastic bag (like from the grocery store)

Gravity Experiments
Ball (any size)
Stopwatch or timer
Pencil
Paper
Ruler
2 quarters
Ping Pong Ball and Golf Ball (or two different kinds of balls that are the same size but different weight)

Hovercraft Project
(You may order the Hovercraft Parts from us at a discount.)
1 wood skewer
1 wood popsicle stick
1 straw
16 oz. Styrofoam cup (the kind used for sodas)
1 foam hamburger container (5.5″ square and 3″ high when closed)
1 foam meat tray (approx. 10″x12″x1″)
2 3VDC motors (RS #273-223)
2 three-blade propellers (check your local hobby store)
9V battery clip with wires (RS #270-325)
9V battery (get a good kind, like Duracell or Energizer)
1 SPST switch (RS #275-0407)

Additional Items for Grades 9-12:

Calculator
Paper, pencil or pen
Shoes (you won't be damaging these – any shoes with treads will work fine)
Yarn or string (about 2' long)
Rubber band
Ruler
Heavy book
2 magnets (preferably the flimsy business-card style)
Rope (3' or longer)
Dowels or round (not hexagonal) pencils
Handful of marbles
2 cookie sheets
A board or table (about 2 feet by 12 inches, but anything about that size will do)
Index card or scrap of cardboard
2 small mirrors (mosaic mirrors from the craft store work well)
2 rare earth magnets (RS# 64-1895 or similar)
Nylon filament (thin nylon thread works, too)
4 donut magnets (RS #64-1888)
Laser pointer (any kind will work – even the cheap key-chain type)
Water glass (or cleaned out pickle jar)
Wooden spring-type clothespin
Hot glue gun

Key Vocabulary

Force is a push or a pull, like pulling a wagon or pushing a car.

A **force field** is an invisible area around an object within which that object can cause other objects to move. A force field can be attractive (pull an object towards it) or repulsive (push an object away).

The four **force fields** are gravity, magnetic, electric, and electromagnetic.

Friction is the force between two objects in contact with one another, due to the electro-magnetic forces between two objects. Friction is not necessarily due to the roughness of the objects but rather to chemical bonds "sticking and slipping" over one another.

Four **fundamental forces i**n order of relative strength they are strong nuclear force, electromagnetism, weak nuclear force, and gravity.

Gravity is a force that attracts things to one another. Gravity accelerates all things equally. Which means all things speed up the same amount as they fall.

All bodies (objects) have a **gravitational field**. The larger a body is, the greater the strength of the gravitational field.

The **inverse square law** states that the closer something gets to the object causing the force, the stronger the force gets on that object.

Kinetic friction is the friction between two objects where at least one of them is moving.

The **net force** is the sum of all the forces on an object.

Mass is a measure of how much matter (how many atoms) make up an object.

Weight is a measure of how much gravity is pulling on an object.

Static friction is the friction between two objects that are not moving.

Unit Description

In 1666 Newton did his early work on his Three Laws of Motion. To this day, those laws still hold true. There has been some allowances for really big things (like the cosmos) and for really small things (like the atom). Other than that, Newton's Law's are pretty much dead on.

Newton's Laws are all they used to get the first man to the moon. They are an amazingly powerful and wonderful area of physics. I like them because evidence of them is everywhere. If something moves or can be moved, it follows Newton's Laws.

You can't sit in a car, walk down the road, drink a glass of milk, or kick a ball without using Newton's Laws. I also like them because they are relatively easy to understand and yet open up worlds of answers and questions.

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Objectives

Lesson 1: Force

In 1666 Newton did his early work on his Three Laws of Motion. To this day, those laws still hold true. There has been some allowances for really big things (like the cosmos) and for really small things (like the atom). Other than that, Newton's Law's are pretty much dead on.

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If I asked you to define the word ***force***, what would you say?

You probably have a feeling for what force means, but you may have trouble putting it into words. It's kind of like asking someone to define the word "and" or "the". Well, this lesson is all about giving you a better feeling for what the word force means. We'll be talking a lot about forces in many lessons to come. So, pay attention! The simplest way to define force is to say that it means a push or a pull like pulling a wagon or pushing a car. That's a correct definition, but there's a lot more to what a force is than just that.

Here are the highlights for this lesson:

1. A force is a push or a pull.
2. There are four fundamental forces. In order of strength they are strong nuclear force, electromagnetism, weak nuclear force, and gravity.
3. A force field is an invisible area around an object within which that object can cause other objects to move.
4. A force field can be attractive (pull an object towards it) or repulsive (push an object away).

5. The closer something gets to the object causing the force, the stronger the force gets on that object. This is the inverse-square law.
6. The four basic force fields are gravity, magnetic, electric, and electromagnetic.
7. An object will be pushed or pulled in the direction in which the overall net force is acting on it.
8. The net force is the sum of all the forces on an object.

Lesson 2: Gravity

Whenever I teach a class about gravity, I'll drop something (usually something large). After the heads whip around, I ask the hard question: *"Why did it fall?"*

You already know the answer – **gravity**.

But *why?* Why does gravity pull things down, not up? And when did people first start noticing that we stick to the surface of the planet and not float up into the sky?

No one can tell you *why* gravity is… that's just the way the universe is wired. Gravitation is a natural thing that happens when you have mass. Galileo was actually one of the first people to do science experiment on gravity.

Here are the highlights for this lesson:

1. Gravity is a force that attracts things to one another.
2. All bodies (objects) have a gravitational field.
3. The larger a body is, the greater the strength of the gravitational field.
4. Bodies must be very, very large before they exert any noticeable gravitational field.
5. Gravity accelerates all things equally. Which means all things speed up the same amount as they fall.
6. Gravity does not care what size things are or whether things are moving. All things are

accelerated towards the Earth at the same rate of speed.

7. Gravity does pull on things differently. Gravity is pulling greater on objects that weigh more.
8. Weight is a measure of how much gravity is pulling on an object.
9. Mass is a measure of how much matter (how many atoms) make up an object.

Lesson 3: Friction

If you answered friction, you're right. But what is *friction* really? Would your hands feel warmer if they were larger? Or rougher? Or darker? What sorts of things affect the amount of friction between two surfaces?

If you read a textbook from twenty years ago, you'll find some things have changed about how we think about friction. Engineers used to only look at surface roughness… but then they took a look on the molecular level and saw a few things that made us update our way of thinking about treads.

1. Friction is the force between two objects in contact with one another.
2. Friction is dependent on the materials that are in contact with one another. How much pressure is put on the materials. Whether the materials are wet or dry. Whether they are hot or cold…in other words, it's quite complicated!
3. Static friction is the friction between two objects that are not moving.
4. Kinetic friction is the friction between two objects where at least one of them is moving.
5. Friction happens due to the electro-magnetic forces between two objects.
6. Friction is not necessarily due to the roughness of the objects but rather to chemical bonds "sticking and slipping" over one another.

Textbook Reading

In 1666 Newton did his early work on his Three Laws of Motion. To this day, those laws still hold true. There has been some allowances for really big things (like the cosmos) and for really small things (like the atom). Other than that, Newton's Law's are pretty much dead on.

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Force

If I asked you to define the word force, what would you say? You probably have a feeling for what force means, but you may have trouble putting it into words. It's kind of like asking someone to define the word "and" or "the".

Well, this lesson is all about giving you a better feeling for what the word force means. We'll be talking a lot about forces in many lessons to come. So, pay attention! The simplest way to define force is to say that it means a push or a pull like pulling a wagon or pushing a car. That's a correct definition, but there's a lot more to what a force is than just that. Let's take a look.

The Foursome of Forces

There are four types of forces. They are, in order of strength, strong nuclear force, electromagnetism, weak nuclear force, and gravity. That's it. Those are all the forces that do all the pushing and pulling in the entire universe. The strong and weak nuclear forces are responsible for holding atoms together. They are quite important, but unless you're dealing with physics at a quantum (atomic) level they are not something you need to know too much about. So we won't spend any time on them here.

As you look at the list of the fearsome foursome of forces, you may notice a couple of strange things. The first thing you may have asked yourself is, "Gravity is the weakest force!!??" Believe it or not, of all the forces, gravity is the weakling. It is actually much weaker than the other three. In fact, the other three have a tendency to pick on gravity, which isn't very nice.

Some other questions you might be thinking are "Where is friction in the list?" and "What about pulling a wagon, what kind of force is that?" Excellent questions my perceptive pupil! Here comes a bit of a shocker. Friction, which is what allows you to pull a wagon, push a car, and sit in your chair without sliding off, is actually an electromagnetic force.

You can sit in your chair because there are electromagnetic interactions between the atoms in your, uh...rear section, and the atoms in the chair. In fact, you aren't touching that chair. Or I should say, your matter is not touching the matter of the chair. The electromagnetic fields around your atoms and the chair's atoms are touching but particles of matter are not. This fact comes in Force 1 very handy when you're in the back of the car with your brother or sister and they yell, "Will you STOP touching me!" Now you can say with great smugness, "I'm not touching you, only my electromagnetic forces are!" Isn't physics fun?

As for pulling a wagon, you can think of yourself as a living, breathing electromagnetic force maker. When you pull a wagon, you are using electromagnetic force to work your muscles and do what needs to be done to get that wagon going.

Force Fields

You may wonder what force fields have to do with a serious examination of physics like the one in this lesson. You probably consider force fields to be something you might hear about in a science fiction scene such as

... Meanwhile, in section 27B of the Horse Crab Galaxy, First Mate Fred frets, "Captain Clyde! the force field is too strong. Our ship will never make it through." "Never worry First Mate Fred!" exclaims Captain Clyde calmly. "I've increased power to the neutron-frapters so we will be just fine." "Captain Clyde, that's genius. You're my hero!" First Mate Fred fawns.

Truthfully, however, force fields aren't just something for science fiction writers. They are actually a very real and very mysterious part of the world in which you live. So, what is a force field? Well, I can't tell you. To be honest, nobody can.

There's quite a bit that is still unknown about how they work. A force field is a strange area that surrounds an object. That field can push or pull other objects that wander into its area. Force fields can be extremely tiny or larger than our solar system.

A way to picture a force field is to imagine an invisible bubble that surrounds a gizmo. If some other object enters that bubble, that object will be pushed or pulled by an invisible force that is caused by the gizmo. That's pretty bizarre to think about isn't it? However, it happens all the time.

As you sit there right now, you are engulfed in at least two huge force fields, the Earth's magnetic field and the Earth's gravitational field.

Gravity

This next lesson may give you a sinking sensation but don't worry about it. It's only because we're talking about gravity. You can't go anywhere without gravity.

Even though we deal with gravity on a constant basis, there are several misconceptions about it. Let's get to an experiment right away and I'll show you what I mean.

When you drop a golf ball and a ping pong ball from the same height, what happens?

What you should see is that both objects hit the ground at the same time! Gravity accelerates both items equally and they hit the ground at the same time. Any two objects will do this, a brick and a Buick, a flower and a fish, a kumquat and a cow!

But what if you drop a feather and a ball at the same time? There is one thing that will change the results and that is *air resistance*. The bigger, lighter and fluffier something is, the more air resistance can affect it and so it will fall more slowly. Air resistance is a type of friction which we will be talking about later. In fact, if you removed air resistance, a feather and a flounder would hit the ground at the same time!!!

Where can you remove air resistance? The moon!!! One of the Apollo missions actually did this (well, they didn't use a flounder they used a hammer). An astronaut dropped a feather and a hammer at the same time and indeed, both fell at the same rate of speed and hit the surface of the moon at the same time.

Ask someone this question: Which will hit the ground first, if dropped from the same height, a bowling ball or a tennis ball? Most will say the bowling ball. In fact, if you asked yourself that question 5 minutes ago, would you have gotten it right? It's conventional wisdom to think that the heavier object falls faster.

Unfortunately, conventional wisdom isn't always right. Gravity accelerates all things equally. In other words, gravity makes all things speed up or slow down at the same rate.

This is a great example of why the scientific method (more on this later) is such a cool thing.

Many, many years ago, there was a man of great knowledge and wisdom named Aristotle. Whatever he said, most people believed to be true. The trouble was he didn't test everything that he said. One of his statements was that objects with greater weight fall faster than objects with less weight.

Everyone believed that this was true. Hundreds of years later Galileo came along and said "Ya know...that doesn't seem to work that way. I'm going to test it" The story goes that Galileo grabbed a melon and an orange and went to the top of the Leaning Tower of Pisa. He said, "Look out below!" and dropped them!

By doing that, he showed that objects fall at the same rate of speed no matter what their size. It is true that it was Galileo who "proved" that gravity accelerates all things equally no matter what their weight, but there is no real evidence that he actually used the Leaning Tower of Pisa to do it.

Friction

Now let's talk about the other ever present force on this Earth, and that's friction. Friction is the force between one object rubbing against another object. Friction is what makes things slow down. Without friction things would just keep moving unless they hit something else. Without friction, you would not be able to walk. Your feet would have nothing to push against and they would just slide backward all the time like you're doing the moon walk.

Friction is a very complicated interaction between pressure and the type of materials that are touching one another. However, when you take a closer look at it, it's really quite complex. What kind of surfaces are rubbing together? How much of the surfaces are touching? And what's the deal with this stick and slip thing anyway? Friction is a concept that's many scientists are spending a lot of time on.

Static friction is the friction between two objects that are not moving. Kinetic friction is the friction between two objects where at least one of them is moving. Friction happens due to the electro-magnetic forces between two objects. Friction is not necessarily due to the roughness of the objects but rather to chemical bonds "sticking and slipping" over one another.

Understanding friction is very important in making engines and machines run more efficiently and safely. There are many mysteries and discoveries to be uncovered with this concept. Go out and make some!

Activities, Experiments, Projects

Lesson 1: Forces

Note: This section is an abbreviated overview of the experiments online.

Experiment: Detecting the Magnetic Field

Remember, there are four different kinds of forces: strong nuclear force, electromagnetism, weak nuclear force, and gravity. There are also four basic force fields that you come into contact with all the time. They are the gravitational field, the electric field, the magnetic field, and the electromagnetic field. Notice that those four force fields really only use two of the four different kinds of force: electromagnetism and gravity. Let's take a quick look at what causes these four fields and what kind of objects they can affect, starting with the magnetic field.

You're probably fairly familiar with magnetic fields. If you've ever stuck a magnet to a refrigerator, you've taken advantage of magnetic fields. Sticking a magnet to a refrigerator is one of those every day experiences that should just be absolutely flabbergasting. There you are holding an "I'd Rather be Relative" magnet and it sticks to the fridge! But wait a minute, if you put it on the wall… it falls off! How does it "know" what to stick to? Not only does it stick to the fridge, it also pushes some things away, attracts other things and couldn't care less about still other things. What's that all about?! We rarely think about what magnets do but, wow, the things they do are weird!

Magnetic fields come from objects that have a surplus of electrons all moving in the same direction. This can be an electric wire with current running through it or one of several special types of metals. Iron, nickel and cobalt are the most common metals that can be magnetic. Magnetic fields can only affect objects that can be magnetic themselves. That's why a magnet can attract an iron nail, but it can't attract an aluminum can. The iron nail can be magnetic, but the aluminum cannot. Magnets can also be attractive or repulsive. Two magnets with the same kind of poles facing one another will push themselves apart. Two magnets with opposite poles facing one another will pull themselves together.

Using a compass and the Earth, you can do a simple experiment to detect the magnetic field of our planet. (If you don't have a compass, just slide a magnet along the length of a needle several times (make sure you only swipe in one direction!) then stick it through a cork or bit of foam. Float the needle-foam thing in a cup of water.)

1. Look at the compass

2. Walk anywhere and keep your eye on the compass.

3. Turn around in circles and keep your eye on the compass (don't get too dizzy).

Again a very simple little activity, but I hope you can see the point. No matter where you went or what you did, that needle always pointed the same direction! The Earth's magnetic force field, another strange and mysterious force, always pushes that needle in the same direction. It's invisible and you can't feel it…but the needle can!

Experiment: Force Cereal

Did you know that your cereal may be magnetic? Find a bowl of some sort of "O" shaped cereal, milk, a bowl, and a spoon. Ready?

1. Fill the bowl with milk.

2. Put about 20 pieces of cereal (not the whole box!) into the bowl.

3. Stir up the bowl a little and watch what happens.

If you watched carefully, you saw that as the cereal "O's" got close to one another, they attracted each other. The closer they got, the stronger was their attraction to each other and the faster they moved towards each other. If you wait and watch long enough, you get a nice tight batch of cereal all clustered together in one or two big blobs. This activity is a great illustration of what is meant by the inverse square law because the attraction between "O's" was stronger the closer they got to each other.

I discovered this activity one morning as I was eating cereal. The same thing happens with bubbles when you're doing the dishes. Science is everywhere! Feel free to eat the cereal.

Activities, Experiments, Projects

Lesson 2: Gravity

Note: This section is an abbreviated overview of the experiments online.

Experiment: Forever Falling

If I pitch a ball toward the sunset at the exact same instant that I drop another one from my other hand, which one reaches the ground first?

For this experiment, you need:

2 rulers or paint sticks
2 coins
A sharp eye and ear
A partner is good for this one too

1. Place one of the rulers flat so that it is diagonal across the edge of a table with half the ruler on the table and half sticking off.

2. Place one coin on the table, just in front of the ruler and just behind the edge of the table. Place the other coin on the ruler on the side where it's off the table.

3. Put your finger right in the middle of the ruler on the table so that you are holding it in such a way that it can spin a bit under your finger. Now with the other ruler you are going to smack the end of the first ruler so that the first ruler pushes the coin off the desk and the coin that's resting on the ruler falls to the ground.

4. Now, before you smack the ruler, make a prediction. Will the coin that falls straight down or the coin that is flying forward hit the ground first?

5. Try it. Do the test and look and listen carefully to what happens. It's almost better to use your ears here than your eyes. Do it a couple of times.

Are you surprised by what you see and/or hear? Most people are. It's not what you would expect.

The coins hit the ground at the SAME time. Is that odd or what? Gravity doesn't care if something is moving or not. Everything falls at the same rate of speed.

Experiment: Detecting the Gravitational Field

Here's what we're going for – there is an invisible force acting on you and the ball. As you will see in later lessons, things don't change the way they are moving unless a force acts on them. When you jump, the force that we call gravity pulled you back to Earth. When you throw a ball, something invisible acted on the ball forcing it to slow down, turn around, and come back down. Without that force field, you and your ball would be heading out to space right now!

Here's what you need: You, the Earth (or any planet that's convenient), and a ball.

Here's what you do:

1. Jump!
2. Carefully observe whether or not you come back down.
3. Take the ball and throw it up.
4. Again, watch carefully. Does it come down?

Gravity is probably the force field you are most familiar with. If you've ever dropped something on your foot you are painfully aware of this field! Even though we have known about this field for a looooong time, it still remains the most mysterious field of the four.

What we do know is that all bodies, from small atoms and molecules to gigantic stars, have a gravitational field. The more massive the body, the larger its gravitational field. As we said earlier, gravity is a very weak force, so a body really has to be quite massive (like moon or planet size) before it has much of a gravitational field. We also know that gravity fields are not choosy. They will attract anything to them.

All types of bodies, from poodles to Pluto, will attract and be attracted to any other type of body. One of the strangest things about gravity is that it is only an attractive force.

Gravity, as far as we can tell, only pulls things towards it. It does not push things away. All the other forces are both attractive (pull things towards them) and repulsive (push things away). (Gravity will be covered more deeply in a later lesson.)

Activities, Experiments, Projects

Lesson 3: Friction

Note: This section is an abbreviated overview of the experiments online.

Experiment: Tracking Your Treads

Now let’s talk about the other ever present force on this Earth, and that’s friction. Friction is the force between one object rubbing against another object. Friction is what makes things slow down.

Without friction things would just keep moving unless they hit something else. Without friction, you would not be able to walk. Your feet would have nothing to push against and they would just slide backward all the time like you’re doing the moon walk.

Friction is a very complicated interaction between pressure and the type of materials that are touching one another. Let’s do a couple of experiments to get the hang of what friction is.

Here's what you need:

About 5 different shoes (they do not need to be stinky)
A board, or a tray, or a large book at least 15 inches long and no more then 2 feet long.
A ruler
Paper
Pencil
A partner

1. Put the board (or whatever you’re using) on the table.

2. Put the shoe on the board with the back of the shoe touching the back of the board.

3. Have a partner hold the ruler upright (so that the12 inches end is up and the 1 inch end is on the table) at the back of the board.

4. Slowly lift the back of the board leaving the front of the board on the table. (You’re making a ramp with the board). Eventually the shoe will begin to slide.

5. Stop moving the board when the shoe slides and measure the height that the back of the board was lifted to.

6. Look at the 5 shoes you chose and test them. Before you do, make a hypothesis for which shoe will have the most friction. Make a

hypothesis. On a scale from 1 to 5 (or however many shoes you're using) rate the shoes you picked. 1 is low friction and 5 would be high friction. Write the hypothesis next to a description of the shoes on a piece of paper. The greater the friction the higher the ramp has to be lifted. Test all of the shoes.

7. Analyze the shoes. Do the shoes with the most friction show any similarities? Are the bottoms made out of the same type of material? What about the shoes with very little friction?

Any surprises with which shoe had the most or least friction? Compare the shoe with the most friction and the shoe with the least friction. Do you notice anything? Usually, the shoe that has the most friction has more shoe surface touching the board then most of the other shoes.

Also, often the shoe with the least friction, has the least amount of shoe touching the board. Since friction is all about two things rubbing together, the more surface that's rubbing, the more friction you get. A tire on you car should have treads but a race car tire will be absolutely flat with no treads at all. Why?

The race car doesn't have to worry about rain or wetness so it wants every single bit of the tire to be touching the surface of the track. That way, there is as much friction as possible between the tire and the track. The tire on your car has treads to cut through mud and water to get to the nice firm road underneath. The treads actually give you less friction on a flat dry road!

Some of you might have used a skateboard shoe for your experiment. Notice, that the skateboard shoe has quite a flat bottom compared to most other shoes. This is because a skateboarder wants as much of his or her shoe to touch the board at all times.

Experiment: Stick and Slip

Friction is everywhere! Imagine what the world would be like without friction! Everything you do, from catching baseballs to eating hamburgers, to putting on shoes, friction is a part of it. If you take a quick look at friction, it is quite a simple concept of two things rubbing together.

However, when you take a closer look at it, it's really quite complex. What kind of surfaces are rubbing together? How much of the surfaces are touching? And what's the deal with this stick and slip thing anyway? Friction is a concept that's many scientists are spending a lot of time on. Understanding friction is very important in making engines and machines run more efficiently and safely.

You need:

2 Business card magnets (those thin flat magnets that are the size of business cards)
Fingers

1. Take two business card magnets and stick them together black side to black side. They should be together so that the pictures (or whatever's on the magnets) are on the outside like two pieces of bread on a sandwich.

2. Now grab the sides of the magnets and drag one to the right and the other to the left so that they still are magnetically stuck together as they slide over one another.

Did you notice what happened as they slid across one another? They stuck and slipped didn't they? This is a bit like friction. As two surfaces slide across one another, they chemically bond and then break apart. Bond and break, bond and break as they slide. The magnets magnetically "bonded" together and then broke apart as you slide them across on another. (The chemical bonds don't work quite like the magnetic "bonds" but it gives a decent model of what's happening.) There are many mysteries and discoveries to be uncovered with this concept. Go out and make some!

Exercises for Unit 1: Mechanics

Lesson 1: Forces Exercises

1. Name at least one force that is acting on you right now.

2. Name at least two invisible force fields that are surrounding you right now.

3. What kind of an object can be affected by a gravitational force field?

4. What kind of an object can be affected by an electrical force field?

5. What kind of an object can be affected by a magnetic force field?

6. What happens to the force on an object as it gets closer and closer to a magnet?

7. How does the force of the Sun's gravitational pull on Neptune (the farthest planet from the Sun if you don't count Pluto) compare to the force of the Sun's gravitational pull on Mercury (the closest planet to the Sun).

Exercises for Unit 1: Mechanics

Lesson 2: Gravity Exercises

1. Of the following objects, which ones are attracted to one another by gravity? a) Apple and Banana b) Beagle and Chihuahua c) Earth and You d) All of the above

2. Gravity accelerates all things differently...True or False??

3. Gravity pulls on all things differently...True or False??

4. If I drop a golf ball and a golf cart at the same time from the same height, which hits the ground first?

5. There is a monkey hanging on the branch of a tree. A wildlife biologist wants to shoot a tranquilizer dart at the monkey to mark and study him. The biologist very carefully aims directly at the shoulder of the monkey and fires. However, the gun makes a loud enough noise that the monkey gets scared, lets go of the branch and falls directly downward. Does the dart hit where the biologist was aiming or does it go higher or lower then he aimed? (This, by the way, is an old thought problem.)

6. Why don’t a feather and a brick hit the ground at the same time?

Exercises for Unit 1: Mechanics

Lesson 3: Friction Exercises

1. What is friction?

2. Walking would be easier without friction....True or False.

3. Why does a feather fall slower than a brick?

4. Put a coin on a piece of paper. Then quickly pull the paper out from under the coin. What does static friction and kinetic friction have to do with this?

5. What was the experiment with the magnets showing?

Answers to Forces Exercises

1. Gravity is pulling on you. If you're sitting your chair is pushing up on you as well.

2. Gravity and magnetic fields. To be honest, you are probably also sitting in an electromagnetic field as well. Can you get a radio or a cell phone to work where you are? If so, you're in an electromagnetic field.

3. Any object can be pulled by a gravitational force field.

4. Any object. An electrically charged object or a neutral object can be pushed or pulled by an electric field.

5. Another magnet or something with a metal in it that can be magnetic.

6. The force the magnet exerts on the object becomes greater and greater as the object gets closer. The inverse-square rule is a way of describing how force increases as objects get closer together.

7. Since Neptune is farther away, the inverse-square rule says that the Sun's gravitation pull on it is much smaller.

Answers to Gravity Exercises

1. D. All bodies are attracted to other bodies by gravity. But a body has to be really stinkin' big before it's noticeable.

2. FALSE!!! Gravity accelerates all things at the same rate. All things fall at the same rate of speed no matter what (ignoring air resistance, that is).

3. True. That's why some things weigh more then other things. Gravity pulls more on the big stinky guy sitting next to me on the bus, then it does on me.

4. They hit the ground at the same time. Gravity accelerates all things equally.

5. The monkey and the dart fall downward at the same rate of speed. So the dart would hit exactly where the biologist aimed! In fact, if the monkey didn't let go, the dart would have hit lower than the biologist aimed.

6. They do...if you're on the moon! On Earth, the friction between the air and the feather causes the feather to slow down and the brick to win the race.

Answers to Friction Exercises

1. Friction is the force between one object rubbing against another object. Air resistance, by the way, is the friction of one object rubbing against millions and billions of air molecules.

2. FALSE!!! Walking would be impossible without friction. Your feet couldn't push back against the floor to move you forward.

3. Air friction slows the feather down. The feather rubs against many, many, many air molecules as it falls through the air. The feather is light and large enough that the air molecules actually slow it down.

4. If you pull the paper slowly, the static friction between the penny and the paper isn't broken. So the penny rides along with the paper. If you pull it quickly, you can overcome that static friction and the paper will slide along under the penny without moving it. As long as the paper is moving fast enough the kinetic friction between the paper and the penny isn't enough to move the penny.

5. That objects "stick and slip" as they rub against one another. (Don't forget, that the magnet thing is a good model but it doesn't work quite like that in the real world.)