SUPERCHARGED SCIENCE

Unit 1: Mechanics

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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 have been some allowances made for really big things (like the cosmos) and for really small things (like the atom). Other than that, Newton's Laws 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. They are truly a foundation for understanding the world around you.

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How to Use This Lesson Plan

The e-Science program is appropriate for students in 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 with using tools and hot glue guns as they build the robots, laser shows, hovercraft, catapults, roller coasters, chemistry experiments, and much more.

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 those two objects. Friction is not necessarily due to the roughness of the objects but rather to chemical bonds “sticking and slipping” over one another.

The four **fundamental forces** in order of their relative strength are strong nuclear force, electromagnetism, weak nuclear force, and gravity.

Gravity is a force that attracts things to one another and accelerates all things equally. This means that 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

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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 have been some allowances made for really big things (like the cosmos) and for really small things (like the atom). Other than that, Newton's Laws 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 but not up? And when did people first start noticing that we stick to the surface of the planet instead of floating 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 experiments 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 pulls 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

What causes things to slow down? 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. It is also dependent on how much pressure is put on the materials, whether the materials are wet, dry, 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 have been some allowances made for really big things (like the cosmos) and for really small things (like the atom). Other than that, Newton's Laws are pretty much dead on.

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Force

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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 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 and gravitational fields.

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 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…it 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—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 as if you were 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 many scientists spend 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!