TEACHER'S GUIDE FOR
GRANDPA JOHN'S SCIENCE LAB Video Series

INTRODUCTION

This guide is designed for parents and teachers who are using the Grandpa John's Science Lab VHS/DVDs. These materials are a series of physics demonstrations which are done at the elementary school level. John Clayton is a public high school physics teacher.

The objectives of this series are:

1) To impress students with the fact that science and faith in God are friends and not enemies.

2) To show children that scientifically competent people believe in God, and bring God into their thinking as they strive to understand the world in which we live.

3) To instill and nurture in children a curiosity and love for science as a tool to investigate the world in which they live.

4) To build an understanding of the physical world in which we live - to show how it can be used to benefit man.

5) To provide children with a view that sees God as a being of incredible intelligence and wisdom, who has designed all aspects of the creation with purpose and order and function.

In this series we have three subject areas of physics that we are considering - Magnetism and electricity, sound and light, and mechanics.

This guide will have four sections for each video presentation.
These sections are:

Content: An explanation for the teacher of the science content of the presentation. We assume that you do not know any science, and we try to fill in for you what we are saying and help you understand it. You may or may not need this, and you can accomplish the same thing by talking to a science teacher, engineer, or someone with a strong science background. Our explanation here will be simplified and hopefully will be all you need. You can always contact us via e mail, phone, or letter if it is not clear.

Activities: A listing of other things your student can do to expand on what we have covered, or experiments that you can have them do to continue to develop the concept we are presenting. This may be experiments, field trips, research studies, web site exercises, or library projects.

Biblical connections: suggestions about how what we have studied relates to stories in the Bible. This may be an explanation, a possibility, or a way to convict the student about God's wisdom, purposes, and power.

What next: This contains suggestions about how you can integrate what you have just studied with other topics. These connections will include not only science units and investigations, but also what might be done in other disciplines such as history, math, or English. There will also be references to other video materials and books that can be used from both our program and other programs, and where we intend to go next in our series of demonstrations.

CONTENTS

Does God Exist? Resources Available for the Students:
God Made ItAll Perfect video series of 20 lessons on VHS/DVDs
Children's Book Series - 16 books on design in the creation written for children
For the Teachers:
Does God Exist? video series of 24 lessons on DVDs
The Source book on science and faith
Children's Course - 13 lesson series with complete guide
Dandy Designs - Four books on design in the creation
Canyonlands and the Biblical Record video on geology on DVDs

MAGNETISM AND ELECTRICITY

SESSION 1 MAGNETISM

CONTENTS: Science understands that magnetism is caused by the properties of electrons. This is something that God in His wisdom planned and designed, and while we don't understand all that causes electrons to have a magnetic property, we are quite sure that is what the cause of magnetism is. We believe that electrons spin on an axis, just like the earth does. This spin property results in a north and a south pole for each electron. What the magnetic properties are for various materials depends upon how the magnetic fields of electrons match up. If you have two electrons sitting next to each other, and one spins one way making its north magnetic field be at the electron's top, and the other spins the opposite way making that electron's north pole to be at the bottom you will have virtually no detectable magnetic field. A good way to visualize this is to put two magnets next to each other with the north poles facing different directions. They will be drawn together and there will be very little detectable external magnetism from the magnets. They neutralize each other.

For most common materials the electrons are arranged around the nucleus of the atom the way we have just described, and they have no magnetic properties - especially organic materials, things related to living tissue. In some materials, however, the electrons are suspended around the nucleus in such a way that many of the electrons have their electrons pointing the same direction. That is what we were trying to show in the video with the balls. Such materials show a lot of magnetism. They are easily magnetized and stay magnetized for long periods of time. These are called ferromagnetic materials, and they are used for magnets which have all kinds of uses around the home and the business. Iron is the best known ferromagnetic material.

If some of the electrons have their north poles pointing the same way, and especially if those electrons are fairly easy to move around, the material will show some magnetism, but won't stay magnetic for a long period of time. These materials are called diamagnetic, and materials like zinc are designed that way. Materials that have very few if any electrons pointing the same way are said to be paramagnetic. They show little if any magnetic properties because the electrons are held in positions that send each electron's magnetic field every which way.

Our studies of earth materials tell us that the interior of the earth has a great deal of iron, nickel, cobalt, and other materials that are ferromagnetic. The density of the earth as a planet also tells us that the interior must be much more dense than the surface rocks which contain lots of silicon and are less dense than the planet as a whole. The spin of the earth is also believed to be responsible for generating the magnetic field as we see it, and we see that other planets and the sun also have magnetic fields. The shielding of our planet by its magnetic field is critical to the survival of life on Earth, because space is full of dangerous radiation. This is a problem that NASA is wrestling with as we prepare to travel in space. Most radiation has a charge, and that means it is responsive to magnetic fields. That allows us to be protected by our magnetic field. At the poles where the field is not able to move the dangerous particles away from the earth, they come in and ionize the upper layers of our atmosphere causing it to glow in very much the same way that a flu orescent light glows. The auroras are a constant reminder that our planet is specially designed to allow us to be able to exist.

Our simplified explanation of magnetism needs to also bring to our student's attention the fact that living things have magnetic properties too. Small sections of brain cells in most living things have magnetic orientations, and these allow birds and animals like whales to be able to migrate from one place to another with incredible precision. The fact that our bodies have different amounts of ferromagnetic materials in different types of tissues allows MRIs that can see what a plain X-ray could not. The list of properties and uses of magnetism is virtually endless, all a wonderful testimony to the wisdom and planning of God.

ACTIVITIES: Get a number of magnets. These can come from a supply house, a school, or your refrigerator. If you know someone who works at the phone company or has a TV or appliance repair business, they will have magnets you can get. A supply of iron filings available from an art or crafts store or from a scientific supply house would also be useful.

1) You can duplicate what we did in the video by taking a piece of paper and some iron filings, available from scientific supply houses and most novelty shops for very little money. Put the paper over a magnet, and shake iron filings on the top of the paper. Look at what happens. The filings outline the magnetic field. Now put two magnets side by side with both north poles pointing the same way. Look at the pattern of the filings now. Put the magnets so north is next to south and sprinkle the filings over the paper again. Notice the patterns and the changes that take place. These experiments demonstrate what we talked about in the video. Let the magnets touch with north touching south. Look at the pattern now.

2) Take a large sewing needle or an iron nail. Make sure the needle or nail sticks to your magnet (it may be aluminum which won't react). Sprinkle the filings over the needle or nail before you have any contact with the magnet. Notice that the filings are totally random. Now let it touch the magnet with one end pointing away from the magnet. Notice there is a pattern to the filings now. Disconnect the needle and notice the magnetism disappears. If you heat the needle it will lose it magnetism quicker because the increased molecular action due to the heat will disorient the electrons. If you were to heat the magnet to a very high temperature, its magnetism would disappear for the same reason.

3) Find some pictures of the Sun taken up close. These are available in any encyclopedia or on the web. National Geographic also has many books and issues of their mgazine that have these pictures. Show the magnetic storms that take place on the Sun. Sunspots generally are magnetic disturbances and occur in pairs. The Sun is so hot that electrons are separated from the nuclei of atoms, and when this happens there are huge magnetic fields produced by the nuclei. The forces that take place in the center of the Sun generate magnetic fields even though the temperature is very high, so this is a different cause.

4) Find pictures of the earth showing the earth's magnetic fields. This magnetic field of the earth protects us from the radiation and active particles of outer space. As particles from the Sun and outer space come to the earth, they are repelled by the earth's magnetic field. Gravity is pulling the particles in and the magnetic field repels them. These particles get caught in this tug of war and end up in belts surrounding the earth called the Van Allen Radiation Belts. We know the core of the earth must be ferromagnetic, and we know it is very hot. In the past the earth's magnetic field has collapsed and been re-established with an opposite polarity. This is called a magnetic reversal. Evidence shows us that the earth's magnetic field has reversed over 20 times, and this is used to date things and to understand major changes that have happened in the earth's history.

BIBLICAL CONNECTIONS: One ongoing concept that we encourage you to bring to your young people studying this material is that everything we learn in science shows us God's wisdom, planning, and design for us. The importance of magnetism is massive. All of chemistry and the bonding of materials is dependent on magnetism. Chemical reactions are controlled by whether the electrons are paired magnetically or not in reacting materials. Magnetism protects us as humans from the hostile environment of interstellar space. God has used magnetism as a shield for life on earth, and when man travels in space he has to be concerned about what happens when you get outside that shield. This is a problem that has not been solved by NASA yet, and is a major concern in a journey to Mars, or living on the Moon, for example.

Another biblical connection is the relationship to evolution and the history of the earth. Neo-Darwinism and naturalism assume that nothing has ever happened process-wise in the history of the earth that is not going on right now. The snappy way of saying this is that "the present is the key to the past." This assumption means that erosion, glaciers, volcanoes, local floods, earthquakes, etc., are the only processes that have shaped the earth. This assumption is called "uniformitarianism." The Bible is at odds with this assumption because it tells us that occasionally there have been events in the earth's past that are not what is happening today. The flood of Noah in Genesis 6-7 is an example, as are the plagues in Egypt. What would happen if the earth lost its magnetic field, as we see it has during magnetic reversals? The Van Allen Belts would collapse on the earth, radiation levels would go sky high until the field re-established itself, and the affect it would have upon the earth would be anything but uniformitarianism. The largest Van Allen Belt is a belt of hydrogen ions, and hydrogen added to an oxygen rich atmosphere produces water. This could be a massive source of water and would have a major impact upon climate. Whether this contributed to the "waters of heaven" of the flood or not is speculation, but the point is that uniformitarianism is not well supported, and the Bible record is.

WHAT NEXT: This discussion of magnetism has massive uses in other content areas. In your health unit you can talk about MRIs and how magnetism is used to study the inside of the human body. A field trip to an MRI lab might be of great interest to children, and any museum of science/industry will have a discussion of magnetism. Magnets do not have any healing affect as far as we know right now, but it is a very important diagnostic tool. The use of compasses and their effects on history is a good way to discuss ancient history. You might even make a compass. Take a needle that you can magnetize, put it on a cork and float it in a cup of water. The needle will point north. Ancient mariners used the stars for navigation, but when it was cloudy they were helpless. The invention ofthe compass made sailing possible even in places that were cloudy. Information storage has been a major use of magnetism by man. Computers used magnetism to store data for decades, and video tapes and audio cassettes (including eight tracks) stored sound and visual images magnetically on tape that had ferromagnetic coatings in it. There are all kinds of studies that students can do on this in English, history, and business classes.

SESSION 2 MAGNETISM GENERATES ELECTRICITY

CONTENT: It isn't hard to understand what is happening here. Imagine an electron with a north and a south pole lying in a wire. All of a sudden a strong magnetic field sweeps across the wire. What will happen to the electron? Obviously it will move. How much it will move will depend on how strong the magnet is and how easy it is for the electron to move through the wire it is in. Copper, silver and gold allow electrons to move very easily, so we make wire out of these materials. Gold and silver are used in computers because they don't oxidize (rust) and corrode. You have seen copperware pots and tools, and they turn black and green as other materials combine with the copper. Gold and silver don't do that, and this has great historical significance and is what the real value ofgold is. When you wind wire into a loop putting more electrons in the path of the magnetic field, you will get more motion of the electrons. This winding is called a coil, and it is used in many ways in electricity and electronics.

Transformers are a common sense idea. If you have a few coils of wire, you have just a few electrons (relatively speaking) and when a magnetic field comes along not too much can happen. When you have a huge coil, you have massive numbers of electrons and so a lot more can happen. Transformers can step up electricity or step it down depending on what you need. Things like toys that plug into the wall, door bells, small motors, etc. all need to be safe and not start fires, so we use step-down transformers to reduce the energies involved. Fluorescent lights, high wattage heaters, and many industrial applications need huge energies and thus want transformers that can step up the energies. In your automobile the spark plugs need thousands of volts to generate a spark that will ignite the gas. A transformer called an ignition coil does this, but it is just a step-up transformer. 'Your local mechanic can probably give you one to show your students.

ACTIVITIES: Have the students make their own coil. Just take some wire and wind it up. Connect the ends of the coil to an light-emitting diode (LED). The simplest thing to do is to get a Christmas tree light that is an LED and hold the ends of the coil to the two wires on the bulb. When a magnet is shoved through the coil the LED will glow. You can also find a coil in any TV junk box or electronics kit. A commercial coil will give better results because it is wound more times. There may be more than two connectors on the coil, so you will have to experiment with it to see what works. Be sure to get a coil that has a hollow interior you can shove the magnet through.

Another good activity is to get a generator. Novelty stores have these devices where you turn a crank and connect the outputs to a bulb or LED. Any car mechanic can show you one from an old car. Some children enjoy taking them apart to get the magnet out and to see how they worked. An adult needs to cut the casing off to avoid the kids getting cut as they try to do it. In generators the magnet and the coil go back and forth, so the electricity generated goes back and forth. This is called AC or alternating current electricity. The electricity that comes from a battery or solar cell is called DC or direct current electricity because it only flows one way. In the US our generators revolve at a rate that causes our electricity to go back and forth 60 times a second, and we call it 60 cycle. In Europe the generators turn just a little more slowly, so their electricity is 50 cycle.

Your local power company will have videos and books explaining how they generate electricity. Nuclear power stations and power companies that sell electricity to local agencies also have much literature that is free, and may have video presentations. A visit to the local power facility is a good trip for the family to take, and if there are windmills in your area, the operators will usually be glad to take the kids on a tour of their equipment and explain how the windmill works.

BIBLICAL CONNECTIONS: God's design of both the chemistry of materials that allow electrons to move and of magnetism itself is an area that should constantly be kept in front of children. We live as well as we do because of the way God has designed every aspect of nature, and electricity could not be generated if it were not for the design of materials like copper and of magnets.

WHAT NEXT: Electricity is generated by rotating a coil of wire in a magnetic field. The mechanical energy to rotate the coil can come from any number of sources. In the old days, water pushed wheels that were geared to rotate the coil and this is still used extensively today - called hydroelectric power. The importance of this to the industrial age in America and in Europe is pretty obvious and makes a good history unit. There are also ecological concerns in this, because when coal or nuclear energy are used to push the coil around, there are biproduct problems.

SESSION 3 ELECTRICITY GENERATES MAGNETISM

CONTENT: To understand what is happening here, take a big handful of paperclips and hold them in your hands. Put your hands together side by side and make a small long slit between your hands. Shake the paperclips around and notice what has to happen for the clips to fall through your hands. Only when they line up with the space between your hands can they fall through. If they are perpendicular to that space they cannot get through. This is what happens to electrons. When they flow through a wire they line up. All of their north and south poles point the same way. That means that their magnetic fields add up, and around the wire there will be a magnetic field. The more electrons there are (the higher the current flow) the more magnetism there will be. If you have a ferromagnetic material close by, the magnetic fields will add up and a powerful magnet will be generated. This is called an electromagnet and it is used in numerous ways - doorbells, solenoids in washing machines, electric switches, and industrial material moving equipment.

The jumping ring demonstration shows us another property God has built into the way materials behave in magnetism. This is called Lenz's law, and it simply says what you saw - that when a current is caused in a conducting material like the copper ring, the magnetic field of the ring opposes the original magnetic field. This causes the ring to jump up in the air as you saw. The ring got hot because a lot of current is flowing through it. The magnetron heaters that generate heat in copper plates without actually being in contact with electricity work this way. It is also what allows us to have an electric motor. In the motor, a coil is allowed to rotate within a magnetic field. When electricity flows through the the coil it makes the coil a magnet. Since it is free to turn, it will interact with the magnetic field of the stationary magnet around it, and this movement is the business end of an electric motor. The stationary magnet may also be an electromagnet, so it isn't necessary to have a permanent magnet to have a motor.

ACTIVITIES: Children have a good time making their own electromagnets. Just take a nail and wind a wire around it, making 20 or 30 loops around the nail (the more loops the stronger the magnet will be). Attach the ends of the wire to a power source - a battery or a train transformer. Don't connect it to any wall plug, and keep your hand on the transformer if you use it to make sure it doesn't get too hot. A lantern battery, nine-volt battery or a D-cell battery is best. There are kits you can get for this, but a homemade electromagnet will be more fun. The electromagnet will pick up paper clips, tacks or iron filings, and when you disconnect the power it will drop what it is holding. In a junk yard, they move heavy steel in just this way.

Solenoids can be found in doorbells, washing machines, or other appliances, and printing equipment. Your serviceman can give you one to show the kids and may be able to help you hook it up to a power source to make it work.

There are kits that can be purchased at Radio Shack or any hobby store that allow kids to build their own motor. These kits will also have an explanation guide with them which will be helpful. If you have a small motor that has died for some reason, taking it apart to see its working parts can be a fun activity as well. Again, adult help in cutting through the housing may be essential.

BIBLICAL CONNECTIONS: See the previous section.

WHAT NEXT: Without this property of electricity we would not have washing machines, driers, dishwashers, or any number of other labor saving devices, and what would we do without electric motors? The whole history of the industrial age is based on what we have been studying. It is important to understand that God's design of electrons, magnetism, and materials is what has allowed us to have things like motors which we use in everything from cars to washing machines to refrigerators. When God told man in the Garden of Eden to subdue the earth and have dominion over all things, He knew He had all the resources man would need to do that and to survive. Using it wisely and without damaging the "Garden" God told man to take care of (Genesis 2:15) is a challenge we are still working on. A separate study of how we can take care of what God has given us locally and nationally is an option in this study (environmental science).

SESSION 4 STATIC ELECTRICITY

CONTENT: God has created matter so that there are negative charges and positive charges. Neutral charges are when the amount of positive and negative are equal. Static electricity is when large numbers of positive and/or negative charges exist in a given location. When you shuffle your feet across a wool rug, you rub electrons off of the rug and onto your body. Those electrons want to get out of you, so if you touch your little brother's ear they will jump to him because he is neutral (and don't tell me you never did that.) Most of us know about static cling and other aspects of static electricity that we confront in our daily activities.

The pith ball demonstration shows how fast the electrons move and how quickly they can change. The balls jump back and forth as their charges change, sometimes attracting each other and sometimes repelling each other. An electric field is simply an area of force caused by the charges. When the electroscope gets charged by contact, we are just rubbing charges off of one object on to another. When we charge by induction we are allowing electrons to move from one place to another which they will do to get away from negatively charged objects. Isolating the electrons, by removing their escape route as we did in the demonstration, allows charges to build up in a different way than just rubbing them off.

In nature there are many places where this happens. Raindrops can carry electric charge, and when they fall out of a cloud they will make the cloud charged. If the cloud gets charged enough, a spark may jump to neutralize the cloud. This is what lightning is. Lightning is important to us in a positive way. It takes nitrogen gas in the atmosphere and turns it into nitrates that plants can use to make us food. This is called nitrogen fixation and it is a major design feature of the creation. Lightning can also be dangerous as we all know, but a little common sense can avoid the hazards of lightning.

There is a discussion of corona, sometimes called St. Elmo's Fire, in the video. When you get a very large charge in a small volume it can ionize the air around the charge. What that means is the electrons are being added or taken away from the air molecules. This gives the purple glow described in the video. St. Elmo was a monk who was in the top of a church tower and first observed the purple glow. Nitrogen makes up 78% of the atmosphere, and the nitrogen is what gives the glow we are talking about. Lightning rods actually produce this glow and because charged air molecules are around the lightning rod, they make the chances of a lightning strike less. They are not designed to take the lightning and carry it to ground as is usually assumed.

A few word explanations may be needed here. Voltage is the energy electrons have. In the demonstrations there are some very large voltages. These are not dangerous because there are very few electrons involved. The number of electrons that flow per second is called the amperage. A good comparison to help understand this would to be to compare a raindrop with Niagara Falls. The raindrop has a lot of energy because it falls from clouds - thousands of feet up. It has little current because there are just a few drops. When a raindrop hits you it doesn't blow a hole in you because even though there is a lot of energy it won't do a lot of damage because of the small number of drops. Niagara Falls has very little energy because the water only falls 167 feet. It is dangerous because there is so much current - so many drops flowing over the falls.

ACTIVITIES: There are many experiments your children can do with static electricity, Take a telescope and look at the tips of a neighbor's TV antenna during an electric storm and see if you can see the purple glow of corona. Let them do the rug and brother's ear routine if they have never done it, and explain what is happening. In the local novelty shop there will be spark balls where when you touch the glass of the ball the spark inside jumps to your finger. These are frequently on display to attract customers. Your local school or museum will have a Van de Graaf generator - a large domed device that is used to demonstrate static electricity. One of the favorite demonstrations is to put a child's hand on the dome of the generator and watch their hair stand straight up due to the electric charge. There is a device called the Cottrell Dust Precipitator which uses static electricity to remove dust particles from the air. It is used in smokeless ash trays and in industrial applications to fight pollution. Research on this subject is of interest to many young people.

BIBLICAL CONNECTIONS: An interesting biblical connection to this subject is Jeremiah 10:13 and 51:16. In ancient times people assumed that lightning was a supernatural manifestation of the gods. When you did something the gods didn't like, they zapped you for it. Most of us have seen statues or drawings of Zeus, Jupiter, or Thor showing them with lightning bolts in their hands. Ancient people knew that lightning can occur even when there was no apparent rain locally, and they had no explanation of lightning. Jeremiah indicates that rain and lightning are associated as natural complementary phenomena, and we now know that statement is true. It is one of many places where the knowledge expressed in the Bible predates scientific understandings of the things we observe.

The other biblical point that needs to be made is that lightning is not an evil thing or a flaw in God's design. It benefits plants and is destructive only when people do foolish things. We can use static electricity for many good things and the power of things in nature is clearly seen in what lightning can do.

WHAT NEXT: Mankind discovered current electricity that we use for our comfort and work, by studying static electricity. Electricity was first noticed when electric charge was seen to make frog legs jump in a laboratory. We now use electricity to start hearts that have stopped and to regulate hearts by a device called a pacemaker. Our bodies and our minds are electrical devices, far exceeding the computers and electrical devices that mankind has developed. Our next demonstrations will talk about electricity and how we use the control of electrons to make our lives more comfortable. All of this is based on the properties that God has built into electrons and the other building blocks of matter.

SESSION 5 CURRENT ELECTRICITY

CONTENT: The difference between static electricity and current electricity is that we have found ways to control and use electrons for good uses. God did this in the creation of life, because everything about your body is controlled by current electricity. Your brain sends electrical signals to tell your limbs what to do, and muscles are stimulated to work by this electricity. When a person gets electrocuted, the damage is that the control system is messed up so that the heart and other organs are no longer controlled properly.

There are three things involved in current electricity, some of which we have already made reference to. Voltage is the energy that causes electrons to flow. It can be caused chemically or by magnetism. Our household electricity is generated by wires cutting magnetic fields, but batteries and solar cells produce this energy chemically. Current is the actual flow of electrons. It is measured in amperes which is how many electrons are flowing past a point per second. If you didn't read the section in static electricity, be sure to do so. The thing that controls electrons is resistance. Some materials allow electrons to flow very easily - things like copper, silver and gold. Some materials make it very hard for electrons to flow through them - like wood, mica, and most plastics. Some materials allow electrons to flow, but make it hard. These materials are called semiconductors and include things like carbon and germanium. Resistance is the ratio of voltage to current. If a material allows very few electrons flow when it has a moderate voltage applied to it, it has a low resistance. A short circuit is when there is almost no resistance and electrons flow so fast they burn things up and produce a spark.

If something has a fairly high resistance and electrons are forced through it, there will be heat generated. That is how an electric stove burner or electric heater works. A incandescent bulb like the ones in our demonstration works by getting a wire so hot it gives off light. Fluorescent bulbs, by the way, do not work this way but on a chemical process with very high voltages and small currents. We hope the demonstrations were clear about how this is used and controlled, but feel free to e-mail us if you have a question.

I hope the explanation of series and parallel was pretty well understood. In series, voltage (energy) is divided between the objects using the electricity, so if we have six identical bulbs using 120 volts each bulb will get 20 volts. The bulbs will be dimmer than they were when they got 120 each. The current in a series circuit is constant because current is how many electrons flow through, and there is no way for electrons to escape, they all have to go through each bulb. In parallel the voltage across each bulb is the same. It is like jumping off a table, no matter which side of the table you jump off of, the distance to the floor is the same. What does change in parallel is current, because the electrons will divide, and if the six bulbs are identical, each bulb will get one sixth of the total current flow. If the bulbs have different resistances, more electrons will go through the lower resistances, so the big bulb we used is brighter because the high electron flow made it hotter.

ACTIVITIES: There are kits available from places like Radio Shack or any hobby shop that have experiments kids can do and things they can build. If you use D or C cells or solar cells there is no hazard involved, because the energies are so low. You can do simple experiments at home with the bulb out of a flashlight and a battery. Put two bulbs together in different ways and see how bright they get. Put a material between the battery and the bulb to see what different materials do to the brightness of the bulb. The way you do this is to run a wire from one pole of the battery to the light bulb, another wire from a different part of the light bulb to one end of the material you are testing, a third wire from the end of that material back to the other pole of the battery. In most small light bulbs one contact will be at the very bottom of the bulb, and another on the metal side of the base. Try this to make sure the bulb glows before putting the material to be tested into the circuit. Just run a wire from the battery to the bulb and another wire from the other point on the bulb back to the other pole of the battery. Polarity doesn't matter in these experiments.

A plastic spoon, for example, will keep the bulb from burning while a silver spoon will not affect its brightness. Aluminum foil, copper wire, wet salt and dry salt, nails, vinegar on paper toweling, an orange are other materials you can test. Put human skin as the medium - nothing will conduct. Try human hair - same result. Our bodies have high electrical resistance. Putting saliva on a paper towel will conduct due to the salt in our saliva.

BIBLICAL CONNECTIONS: Every material has its own resistance to the flow of electrons. What must be true of our bodies for them to be able to work by electrical signals coming from the brain? They must have electrical conductors that can send these signals. We call these "wires" nerves, and they are a vital part of our bodies. They have to be sheathed in a non-conducting material. If that sheathing breaks down we have a disease known as multiple sclerosis. The wonderful design of the human body can be brought out in showing how this electrical system works. It speaks of David's comment in Psalms 139:14 that "I am fearfully and wonderfully made." Children need to see science as a friend to their faith and realize that the more we know of the creation, the closer we come to the Creator.

WHAT NEXT: Electrons not only are used directly, but they also give us light. The way light is produced, the way it travels, and how we can control light is where we will go next in our studies and demonstrations.

SESSION 6 ELECTRICAL RESISTANCE

CONTENT: The pickle demonstration is designed to get the idea across that all objects allow electrons to flow, but some are better conductors than others. Pickles don't conduct very well, so they get hot when the electrons flow through them. The human body will do the same thing, which is why electricity can be dangerous. This is more of an object lesson, so the content is fairly obvious.

The hot dog demonstration is there just to reinforce what was said in the last session about series and parallel and to make practical application of what we hope the student has learned.

ACTIVITIES: There are kits where you can do this kind of demonstration with small light bulbs, and they are available from Radio Shack or most hobby shops.

BIBLICAL CONNECTIONS: The pickle demonstration tried to make the concept of how important it is to stay plugged into the power source of the universe. You might wish to talk about how we can be the "light of the world," and how in practice we do what the pickle demonstration suggests.

WAVE MOTION, LIGHT, AND SOUND

SESSION 1 WAVE MOTION

CONTENT: This section of study and learning involves sound, color, and light. All of these phenomena are waves, so our first demonstration involves some properties of wave motion. There are two kinds of waves - transverse and longitudinal. Longitudinal waves are waves in which a material is disturbed by something. You have to have a material and something to push and/or pull that material. Sound is the classic example of a longitudinal wave. When you make a sound you squeeze air, and the compression you generate travels through the air. If you were in a vacuum (like outer space) sound would not happen - so all those science fiction movies that have loud sounds during space wars are fictitious.

Sound can travel through things other than air, and when it does it travels at a different speed. If you have ever been swimming in a lake when a motorboat goes by, you know it is louder under water than in the air. The sound wave travels faster in water. Outlaws used to put their ears on the train track to listen to when the train was coming, because sound travels even faster in a solid than in a liquid or a gas. The stethoscope works on this principle. Sound is not the only longitudinal wave. Earthquakes and shock waves of all kinds are longitudinal waves.

The other kind of wave is a transverse wave. All kinds of radiation including light and electricity travel by transverse waves. Light is a highly complex subject. It is really a particle that behaves as a wave. Imagine a balloon being inflated and then deflated over and over again. Imagine you were watching this balloon being inflated and deflated as it moves through space. If you looked at the edge of the balloon, what would you see? The answer is a sine wave or snaking type of wave. This is actually a two-dimensional particle having no thickness. It is very complex and difficult to imagine, but it is the way God created light, and that construction allows wonderful things. It can go through a vacuum, it can make electric eyes or photocells work because it can knock electrons out of things, it can be polarized making sunglasses, and it can go through some types of solids like glass. Other types of transverse rays like X-rays and radio waves can go through almost anything. All of these phenomena are the same kind of wave, and what we hope to do in this presentation is to get the children to begin to understand how this works and what it makes possible.

ACTIVITIES: You can duplicate what we did in the video by getting a slinky and doing the same demonstrations. One of the neat ways to see what waves do is to go to a small pond with some rocks and make your own waves. This can also be done in a dishpan, bath tub, or mud puddle - but a pond works really well. When you toss a rock in the pond the waves diffuse - they move out on concentric rings. Sound waves and light waves do the same thing. Notice what happens when the waves get into shallow water. The bottom of the wave gets slowed up as it drags on the bottom and the wave turns - a process called refraction. A beam of light bends when it enters glass or water. You can take a laser pointer that you get free on certain key chains or for $2.00 at a novelty store and demonstrate that with a glass of water. Put a drop or two of milk in the water so you can see the wave.

Put an object like a log or a cement block into the pond. Let the water get quiet and toss a rock in front of it. The waves will hit the block and reflect. An echo is a sound wave that does this. Light bounces off a mirror. There are rules for the angles involved, and these are used to make devices like projectors and speaker systems. You can also demonstrate reflection and the angles involved with a pool table.

Throw two rocks into the pond so they hit near each other at the same time. The waves from each rock will cross and when they do they will either kill each other off, or build each other up. This is called interference. Waves either constructively interfere or destructively interfere. We will see this in some later demonstrations. When sound waves destructively interfere we get silence. We normally hear this as beats when tuning an instrument - alternating periods of loudness and quietness. In the case of light waves, destructive interference produces darkness.

This is a wonderful time to include a minicourse on how our bodies work. The ear uses all of these things we have been talking about. The cilia that pick up sound waves naturally vibrate at a particular frequency. When we hear music, different cilia are vibrating and the signal is sent to the brain so we can hear it. A diagram of the ear shows how all of this works, with the cochlea, the ear drum, and the inner ear all using what we have discussed. The fluid in the inner ear is used because liquids carry sound better than gases. Our throat and vocal chords are wonderfully designed to produce a wide range of sounds allowing us to talk. The eye has a lens which refracts light to bring it to the fovea where we see detail. Our bodies are wonderfully designed to use wave motion.

BIBLICAL CONNECTIONS: Psalm 139:14 is a good passage to use to discuss how God has designed us to use the different waves that He has built into the creation. In the Genesis 1 account, it is interesting that light appears in verse 3, but that "signs, seasons, days and years" don't appear until verses 14-19. The nature of light is that it is generated by matter and energy and changes in matter and energy. When the heaven (from the Hebrew shamayim) was created, waves would have been a part of that. The kinds of waves that would produce visible light is in verse 3. Later the light holders become visible to provide for man "signs seasons, days, and years." Light is something special that God designed, and waves are a necessary part of the creation process.

WHAT NEXT: What we want to do now is to explore sound and light and learn more about how they work and how we use them. Each of these topics has massive numbers of activities that can be done, and we hope that you will find ways to make them exciting and interesting to your students.

SESSION 2 RESONANCE

CONTENT: A simple example of resonance is to swing a child on a swing. If you push with the right rhythm you can get the child to swing higher and higher. The pendulum-like nature of a swing has a certain frequency, and if you synchronize your push with that frequency, you can get the swing to go up higher with each push. If you were out of sync with the swing, and pushed up when the swing was coming down it would destroy the swing's motion and create chaos. This is what resonance is all about. With waves, you want to push at just the right time so that you increase the amplitude of the wave's motion. The demonstration on the video is pretty obvious. The number of applications of this principle may not be quite as obvious.

There is a negative to resonance or constructive interference. In solids there is always a frequency at which the material naturally vibrates. A tuning fork naturally vibrates at the frequency written on it. Other frequencies don't make the tuning fork vibrate. A bridge vibrates at a certain natural frequency. What happens if people or natural forces work on the bridge at the same frequency it naturally vibrates at? The bridge will pick up that vibration and may actually shake itself down. The Tacoma Narrows Bridge in the state of Washington actually had that happen to it, and videos ofthat bridge moving up and down and eventually collapsing are available on the web or on TV. When bands or military units march across a bridge, they are supposed to break step for that reason. Constructive interference, or resonance, is not always a good thing.

Lasers are resonance devices. They do not use one wave because light waves are so short in wavelength, but if you had 1000 waves bouncing back and forth in synch, they would reinforce each other just as the sound waves do, and their energy would add up. This is what light waves in lasers do, and they gain energy with each bounce as they stimulate other electrons to shift in the atom adding light at the same frequency and in step with the original light wave.

ACTIVITIES: You can do the swing demonstration I just described as a study of resonance, and in fact everything I described in the video can be done as an activity. Idle the car and listen, and perhaps set things on the dash or hood and see how they respond differently. Plucking a guitar or violin string will also do this, and when you finger the instrument the length changes and that changes the resonant frequency of the string. Take a good piece of crystal and rub a moistened finger around the edge, or tap it with a pencil. The glass or goblet will "sing" at a certain pitch. Add water to the glass and that pitch will change because the natural frequency has changed. Most of what we do with sound involves resonance. When speakers in a entertainment center don't sound right, it is usually because something in the system is resonating and making one frequency sound louder than the others, messing the system up.

A neat demonstration of this with sound is to get a tuning fork used for song leading, and a long tube that holds water. When you hit the tuning fork and hold it over the tube you don't hear much. If you carefully add water to the tube, you will eventually hit a point where the waves reinforce each other in constructive interference, and the sound will be very loud. When you play a clarinet or a trombone you do the same thing. One sound or frequency is louder than all the others.

BIBLICAL CONNECTIONS: I hope that all of this might have moved you to think about things like the walls of Jericho and Joshua. You may view the fall of the walls as an act of God directly, but it also could be done by marching around the city and generating sound both in marching and with the ram horns that were at the frequency of the walls. You also need to expand on how our ears work. The cilia mentioned in the last section work on the principle of resonance - as do our vocal cords. Each cilia is like a guitar string - it vibrates at a certain natural frequency depending on its length. When that cilia resonates with a certain frequency we hear a pitch and the brain can tell us what that pitch is. This was mentioned in the demonstration, but needs to be emphasized to let children see the wonderful construction of the human ear. Our vocal cords also vibrate at a natural frequency giving our voices the pitch that they have. Men's vocal cords are generally lower because of the larger size - just as a bass fiddle is different than a cello which is different than a violin.

SESSION 3 HOW WE USE WAVES

CONTENT: Sound is a longitudinal wave in which matter is compressed and stretched out to make longitudinal waves pass through the air or some other material. Our ears and our vocal chords as humans are very specialized. As waves pass through our ears, we can hear frequencies as different pitches. For humans we hear as low as 20 waves per second passing through our ears. Any frequency less than 20 we don't hear. Snakes, elephants and whales do hear in this range which is called infrasonic. The highest frequency we hear is 20,000 waves per second. Frequencies above 20,000 are called ultrasonic. This is age dependent. The older you get, the lower the frequency range you hear. A baby will hear well over 20,000 waves per second (or hertz), and a hinge will generate a wave of about 35,000. That means when you open the door to the baby's room, you wake them up. Dogs, bats, pigs, and most birds hear in the ultrasonic range. You can also hear parts of a wave, so half of a 20,000 hertz wave you might hear faintly - and we call those harmonics, overtones, or undertones depending on what fraction of the wave we are talking about.

The amplitude of the wave determines how loud the sound is and is measured in decibels. Sounds can be so loud as to physically injure, and 120 decibels is called the threshold of pain. It is simply a measure of the energy of the sound. The tone quality of a sound is determined by the shape of the wave. By playing different frequencies together we can change the shape of the wave and that makes it sound different. Voices sound different because there are different shapes of waves coming out of our mouths.

If you look carefully at the waves on the oscilloscope as I do the demonstrations, you will notice that when I first hit the tuning fork, the amplitude (how big the wave is) is large, and gradually becomes smaller. You will also notice that higher pitches put more waves on the screen than lower ones. As different sounds go into the microphone, the wave pattern is different. The wonderful world of sound is a carefully designed and controlled world that has great flexibility. That allows us to have many different kinds of music.

ACTIVITIES: If you can borrow an oscilloscope from a school, TV repairman, or medical facility you can do the demonstrations done in the video and let the students see their own voices. Most science and/or industry museums (not aquariums, planetariums, or natural history museums) will have a set-up to allow that to be done. These same museums will usually have a sound focusing demonstration in which people can talk to each other 100 feet apart and the sound waves are reflected so you can hear each other. If you are ever in Chicago, the Museum of Science and Industry there has a wonderful exhibit of these things. You can also borrow a dog whistle and a dog from someone and show the students what ultrasonic means and how it works.

Another wonderful field trip is to take the students to visit an audiologist. Let them have their hearing tested and have the technician explain what she or he is using and how it works. Most audiologists can test the frequencies the student hears as well as the loudness.

An old demonstration is to make the tin can phone. Take two tin cans and connect a wire to each of them - preferably a fairly heavy metal wire. Put the students in different rooms with each having a tin can to talk into and listen to. This works well and can be a good demonstration that sound travels better in solids than in gases.

BIBLICAL CONNECTIONS: One thing that comes out of these discussions biblically is an understanding of what is a miracle and what is not. When an animal talks to a human - like the serpent or Balaam's ass (donkey), there has to be a special provision for the speech to occur. The ass does not have the vocal apparatus to speak to a human, so a miracle of God has to be involved in the process. The serpent has to be a permanent miraculous sign to mankind for the same reason. In Job 38:7 where there is a reference to the morning stars singing together, the reference has to be poetic and interpretive in nature, as sounds don't travel through space. It is interesting that stars do send out transverse waves in the 20 to 20,000 hertz range.

WHAT NEXT: Light is different than sound. It travels much faster for one thing. Sound travels 1087 feet per second in air (331 meters/sec.) while light travels 186,000 miles per sec. (300,000,000 meters/sec.) What that means is that light arrives at our eyes almost instantaneously while sound takes time. A neat experiment is to be a mile or so from a sound source and measure how long it takes for the sound to get to you after you see it. Drive the car a mile down the road and have your student say now into a cell phone and honk the horn to let them see how long it takes to get to you. Divide the distance in feet (5280 feet in a mile) by the time and you should get something close to the 1087. Higher temperatures make the sound go faster. You also can measure how far away lightning is by watching a strike and then counting the seconds. Multiply the seconds by 1000 (1100 if it is hot) and you will have a good approximation of how far away the lightning hit. It is also interesting that as fast as light goes it takes eight minutes for light to get to the Earth from the Sun. The closest star to the earth takes 4.3 years for its light to get to us.

SESSION 4 THE SPECTRUM OF LIGHT

CONTENT: Light is much different than sound. It not only travels faster, as we have pointed out, but light is a strange particle that behaves as a wave. Because it is a particle, it can go through a vacuum (light gets here from the Sun for that reason.) It also can knock electrons out of some crystals which is how solar cells and electric eyes work.

Even though light is a particle it behaves as a wave. If you want to visualize how a particle can behave as a wave, go back to program 2, Session 1 where we talked about the balloon analogy. Light does everything waves do and virtually everything particles do. They are two-dimensional particles that have some strange properties. If I throw ordinary particles at you and you catch them, you gain mass as the mass of the particles adds up. Shining a light on someone does not make them heavier (and is thus no excuse for being overweight).

Light has different frequencies just as sound does. We perceive these different frequencies as color. Blue has the highest frequency of visible light and red the lowest. Just as we have sound frequencies that are beyond what our ears can perceive, so too there are light frequencies beyond what our eyes can see. On the high end of the frequency scale we have ultraviolet which is more energetic and has a higher frequency than visible light, Still higher frequencies are X-rays followed by gamma rays. These bigger frequencies can be so high and so energetic that they can be dangerous to our cells as they pass through us. On the low frequency end of the color spectrum we have infrared, followed by radio waves. Some radio waves are as long as a football field and have relatively low frequencies to go with the low energies they have. The liquid crystals we demonstrate in the video are a chemical that absorbs infrared and changes its color as it absorbs that energy. We can use this for measuring the temperatures of things and finding places in our body where there is poor circulation (cold spots) due to circulation problems.

Prisms and diffraction gratings separate light into its various colors - a spectrum. The light is generated by electrons changing their distance from the nucleus of the atom. When the electron jumps down to a lower orbit it gives off energy and that is what light is. Each electron will produce its own color or energy, so we get more lines as we have more electrons jumping. Neon has ten electrons that shift and hydrogen has one. That means the neon spectrum will have ten times as many lines as hydrogen. In reality electrons can shift more than one way, so this is an over-simplification, but it is the basic idea of what is going on.

We use spectra to tell what something is made of. When a bullet is fired from a gun, it leaves some of the gun barrel on the bullet. Spectral analysis can prove what gun a bullet came from, or whether a victim was touched by an accused person or was in a certain place. Forensic science makes massive use of spectra as do all science labs. The stellar spectra shown give some idea of how spectra are used in our studies of space. Not only can we tell what stars are made of, but by looking at the atmosphere of a star we can tell how hot it is. If there is water vapor in the atmosphere of a star we know its temperature is over the boiling point of water (and some stars are not that hot). If there is iron in the atmosphere it has to be hot enough to vaporize iron. By knowing the temperatures at which materials boil we can get a good estimate of how hot stars are.

ACTIVITIES: Light is fun to work with. You can buy diffraction grating material very inexpensively from any science supply house and look at various lights with it. Neon will be in any red sign, and Christmas lights and LEDs are great things to examine. A prism can be made by taking almost any glass object and shining sunlight through it and looking at the "rainbow" produced. Prisms are available in most novelty shops or science supply houses. Take the laser mentioned earlier and notice what it does with a diffraction grating or prism. A good research project for a bright student is to look up the "Doppler Effect" and explain how it is used to tell the speed of something - police use this to catch speeders. A visit to almost any lab will show some uses of spectrometers. Our Dandy Designs books and our web site at dandydesigns.org all have numerous examples of how light and color and spectra are used.

Another neat topic is to experiment with how we see color. The color of an opaque object is what that object reflects. A blue shirt is blue because it reflects blue and absorbs every other color. If you shine a red light on a blue shirt it will appear to be black. Most fabrics are not 100% the color you see, and some colors you see reflect more than one thing. Yellow actually reflects red and green for example. he pure colors or primary colors of light are red, green, and blue. her colors like yellow, magenta, violet, cyan, orange, brown, etc., are mixes of colors. Students can try this with various colors of light made with Christmas lights, and shine them on various colors of fabric or paper. This has many uses in theater and entertainment.

BIBLICAL CONNECTIONS: The strange properties of light can open the door for many discussions about God and His nature. If God is light (1 John 1:5) and light has all these wonderful properties, then these are also properties of God. The Bible is full of various references and uses of light. It is also useful to look at how we are to be the light of the world. The design of light and the fact that it is early in the creation is significant. It is also significant that the creation of light in Genesis 1:3 was long before the establishment of "signs, season, days, and years (Gen 1:14-19). The cosmos is created in verse 1 and light is a part of that creation, but the light holders and the things man needed light to measure by come much later. Our little booklet God's Revelation in His Rocks and His Word goes into that in some depth and is available on our web site (doesgodexist.org).

WHAT NEXT: We have one more thing we want to do with light and that is to explore its unusual and wonderful nature more deeply by looking at polarized light. This property of light helps us understand even more how light is different than the rest of the physical things that exist in the creation.

SESSION 4 POLARIZATION

CONTENT: Light is two dimensional. That means that light has no thickness. It has length and it has width, but no thickness. If you haven't read our little booklet A Help in Understanding What God Is which is on our web site, it would help you to do so. Light is what the man in "Flatland" is all about. Because it has only two dimensions, light can be controlled by the use of special crystals in which the molecules of the crystals are in layers. The only way the light can get through the crystals is if the plane of the light is parallel to the crystal's molecules. If you want an analogy to understand this, take a knife and put the blade parallel to the pages of a magazine or book. You can pass the knife through the pages fairly easily, but if you tried to pass the knife perpendicularly to the book or magazine, it would stop you. Polaroids do the same thing to light. The reflection of light is pretty easy to understand if you have ever skipped flat rocks on a lake. Visualizing light as having a plane may be hard for you, but that is the wonderful thing about the creation in which we live. Our physical world is not all there is, and light is a vivid proof of that which we can experimentally see.

In 3-D movies what happens is that two projectors are used with a polaroid in front on one projector with its plane vertical and the other horizontal. The polar glasses you wear have one Polaroid vertical and one horizontal, so each projected image is seen with one eye. The two image slightly off from each other give the illusion of 3-D. If you take the glasses off you will see the double image.

ACTIVITIES: There are several ways you can do this. Polaroid sunglasses can provide two polaroid lenses, and you can usually find them in the sunglasses bin at Goodwill. If you have a pair of glasses from a 3-D movie, they can be used. Sheets of polaroid can be purchased from science supply houses. Have your student do the experiments we do in the video and let them look at crystals of salt, sugar, or any other clear crystals you have around the house. Kids find a variety of ways of experimenting with this wonderful property of light and will find many cases in nature where animals and plants use polarized light for a variety of biological purposes. The two examples in the video are designed to start them thinking about that, but under the ocean many living things use polarized light since the surface of the ocean will reflect light in the same way it does a flat rock thrown at its surface. There are also some examples in astronomy where reflecting objects can be identified by the polarized properties of the light we get from those objects. Ask the kids, "if you saw a light in the sky, how could you tell if it was a star or a space ship?" The point is that a star would not have polarized light since it is giving off its own light, but a spaceship would be reflecting light and some of its light would be polarized and would dim if you looked at it through a rotating polaroid lens.

BIBLICAL CONNECTIONS: The fact that animals have polaroid properties in their eyes is a wonderful example of God's incredible design in the world around us. We have several articles in our Dandy Designs series on this subject.

WHAT NEXT: Light and waves are a huge subject area. Research is continuing on whether gravity is a wave. How you control waves is a wonderful subject for kids to study. Our next subject is a completely different subject area—the subject of mechanics and materials.

MECHANICS

SESSION 1 LINEAR MOTION

CONTENT: The first law of Newton is a common sense idea, but is most practically seen in the satellite reference presented. The second law gets into some new units of measurement and some fundamental understandings of the world in which we live. Hopefully, this presentation will get the students started on thinking about the constant design features ofthe world in which they live. The definitions are pretty straight forward. Force is a push or a pull and is measured in pounds in the English system and newtons in the metric system. Mass is how many molecules of material there are and is measured in slugs in the English system and kilograms (or grams - which is 1000th of a kilogram) in the metric system. Acceleration is how fast we change the velocity. Velocity is speed and is measured in miles per hour or feet per second in the English system, and Kilometers per hour or meters per second in the metric system. If you change the speed of something from 20 miles per hour to 50 miles per hour in 10 seconds the acceleration would be 50 minus 20 divided by 10 per 30 miles per hour changed every 10 seconds or 3 miles per hour every second. If the acceleration was 30 miles per hour every second, after ten seconds the object would be traveling 300 miles per hour - a much bigger acceleration. If that doesn't help you comprehend it, just think about the acceleration of a minivan compared to a hot sports car. The sports car has a lot more acceleration.

One interesting area that applies to this is objects falling. Gravity is a force and it pulls on things. The acceleration of the earth's gravity is 32 feet per second of change every second. If an object is dropped out of a hot air balloon, after one second it would be going 32 feet per second. After two seconds it would be going 64 feet per second. After three seconds it would be 96 feet per second. If kids watch a ball, they can see this first hand. The only factor that modifies this is wind resistance. That is why sky divers flatten out their bodies as they fall - to slow down the velocity.

The best example of the third law (action/reaction) is the kick of a gun. When a bullet goes one direction, the gun kicks back in the opposite direction. The bullet's mass is small, so the kick is small. When a cannon fires a big shell the reaction is much larger. Jumping out of a boat is another example, where the boat is pushed the opposite direction from the direction we jump.

The last subject on this lesson is momentum. We all have a common sense idea of what momentum is, and the football example is familiar to most of us. In the case of the gun kicking, the momentum of the bullet one direction will be equal to the gun momentum in the opposite direction. Since the bullet mass is small, its velocity will be large. Since the gun's mass is large, its velocity will be much smaller. Momentum and the action/reaction law are closely related. The best way to teach this material is to let the kids do the activities that allow them to see it first-hand.

ACTIVITIES:

First Law: Get the student on an air hockey table, and ask them why things move for so long with such a small push. The first law works here, and since friction is low we can see a little of what motion is without friction. This is also a great demonstration of the third law. A pool table is a second choice, but air tables are wonderful ways to see what we are talking about. Another way to get kids thinking is to ask them how long the rocket would have to be going on a space ship to travel from Earth orbit to Mars or some other galaxy? The answer is a few seconds - just long enough to leave Earth's orbit. Since the first law applies, the spaceship would never slow down the whole trip. Most of your fuel would have to be spent slowing it down when you get to your destination.

Second Law: Again, an air hockey table with pucks is perfect for experiments on this subject. Put a rock on a puck and see how fast it goes for the same push given with no rock on it. Repeat the experiments done on the video. A simple wagon can be done the same way, with no one in it, one person in it, two people in it, etc. The force needed to make it move goes up with the greater mass (the more people in the wagon).

Third Law and Momentum: Put a student on roller skates or ice skates and have them throw a ping pang ball to you, then a basket ball, then a medicine ball (a heavy ball or object). Remember to get them to express why they move differently in terms of the momentum involved, and the fact that the ball goes one way makes them go the other. Many examples can be given - what happens when you run into a car or a freight car on a railroad compared to running into a bicycle are typical examples. If you have the air hockey table, collide one puck with three stacked up on one another and notice the speed changes. On a pool table collide a pool ball with a ping pong ball or a tennis ball. How do they differ than when a pool ball hits another pool ball. You can also do this with a bowling ball. The number of examples are virtually infinite.

BIBLICAL CONNECTIONS: The major points to get young people to see in this material is the wisdom and design that is built into the construction of the cosmos. There are lots of "what would happen" questions that you could use. What would happen if the sun were not as large as it is? A smaller sun would have less gravity and the earth would fly out of its orbit. What would happen if the earth were bigger (more massive) than it is? It would have to go much faster around the Sun and we would weigh much more. In addition our atmosphere would be thinner and poisonous gases that escape the earth now would be retained, killing us. The speeds, masses, and distances of things in the creation have to be just what they are for us to exist, and as elementary children begin to grasp these concepts they can see what a wonderful engineer God has to be. Romans 1:19-22 makes a clear reference to this, and passages like Psalm 19 also apply.

WHAT NEXT: What we have done so far has been linear motion where things go in a straight line. What happens if things go round and round - which is much more common in our world than straight line motion.

SESSION 2 CIRCULAR MOTION

CONTENT: The only thing that is different in appearance between circular motion and what we did in linear motion is the way things move. Instead of measuring distance in feet or miles we measure it in revolutions. Speed is measured in revolutions per second or revolutions per minute (RPM). Force is applied tangentially to the wheel, and mass is still the same. What is different about circular motion is what happens to momentum. When something spins, the affect of that spin builds up because the wheel is going over and over the same point. This adds a stability that things that move in a straight line don't have, and we call that inertia. The spinning bike wheel has stability that is the result of its motion, its mass, and its geometry. A solid object won't behave exactly the way a spoked object like our wheel does, so a top might be different than an open wheel. The earth then, will do all the things our bike wheel does, but it will do it on a grander scale because of its size and geometry. Everything in the creation spins, from electrons to black holes. The last set of demonstrations with the inverting top and plastic wedge shows how important the construction of the object that is spinning is. When the center of gravity gets off center, new forces are added that can cause changes in spin like those we show.

The second set of demonstrations with the cork on a string, the weight pulling down and the spinning of the cork around the center is slightly different but only due to the new geometry. That demonstration is something you can do with your students, and I hope you will. You can use a toilet paper cylinder or take the center out of a ball point pen and use the outside for the holder. Fishing sinkers can be used for the weights and washers or paper clips used for what you spin around. How fast the object spins around depends on how massive the object is, how far it is from what it is spinning around, and how much force the object it is spinning around pulls on it. If you put a lot of sinkers on the bottom, you will have to spin the object really fast to keep it going. The smaller the radius of spin, the faster you have to spin it. Be careful - things tend to fly off when they are spinning.

In our solar system, a big planet like Jupiter has to go much faster to stay in orbit around the Sun than a smaller planet like Earth. Something far out in space like Pluto has to move very slowly or it would be thrown into outer space. The speed of man-made orbiting satellites has to be computed and very carefully controlled to allow them to stay in orbit. This is done by engineers who spend many years of study and use sophisticated equipment, Our orbit around the Sun had to also be carefully controlled and computed by God or we would not be here.

ACTIVITIES: Toy gyroscopes are available in any toy or novelty store, and they can be very entertaining. If your student skates, take them skating and let them do a spin holding their arms out, and then pulling them in as they go into the spin. You can also do "crack the whip" where you have five or six people holding hands and you make a turn. The last person in the chain goes the fastest and is most likely to be thrown from the group. Another great demonstration is to put them on a stool that can spin freely with little friction, and spin them with their legs out and then have them pull in their legs while they are spinning and see how their spin rate increases. In most public places there is a cylinder you can put a coin in and watch it spiral into the center. When the coin goes in, it goes slowly around and around, but as it gets closer to the center (the radius gets less) what happens to its spin rate? This is another wonderful demonstration of what we are talking about. Amusement parks use this for all of the "thrill rides" from roller coasters to bullet whips. All planetariums and most science museums will have demonstrations of these things and are great teaching tools. You might also have your student do a research study of the Coriolis force, which is an application of circular motion to weather and how things move across the surface of the earth. Your student could even do a demonstration of this on a merry-go-round at the playground. Research studies into pulsars in astronomy and what happens to the spin rate of a star when it becomes smaller by blowing off its outside layers is also interesting.

There are so many ways to experiment with circular motion that the activities are almost endless.

BIBLICAL CONNECTIONS: What would happen if God had made the earth flat? What would happen if the earth spun much faster than it does? How about if the earth spun more slowly than it does? The rate of spin of things is critical to our survival, and God's design of the cosmos using circular motion as a main tool to allow things to be constant and stable is a great demonstration of God's genius. I would encourage you to keep putting the beauty, wisdom, and complexity of circular motion before your students as you study. It is a wonderful demonstration of the fact that the creation cannot be a product of chance. There are too many factors that have to be carefully planned for chance to be an adequate mechanism.

WHAT NEXT: It is my hope that these brief explorations of the wonderful world of physics will encourage your students to want to learn more. This subject is huge, and we have barely scratched the surface of all there is to know about it. Our next investigation will be a brief look at the nature of materials.

SESSION 3 ELASTICITY

CONTENT: One of the amazing things that science has done for us in the past 25 years, is to give us a massive number of new miracle materials. We now have clothes that won't wrinkle and plastics we can put in our teeth that are nearly as hard as the original material. We can make replacements for our knees and hips that serve as workable replacements for the original knees and hips that are a part of our bodies. These new materials are possible because we have finally understood something ofthe way in which God has made atoms and molecules and how these structures interact with each other. The experiment that we do in the video is one you can and should do with your students. This is also a wonderful way to introduce your students to the making and using of graphs. Make a graph of how much a rubber band stretches plotted on the Y axis as seen to the right, plotted against the force that stretches it plotted along the X axis. You can use a rubber band fastened to a sock by a paper clip and add marbles or sand or rocks or nails or washers - all the same weight. The rubber band will stretch linearly . Eventually you will reach a point where the stretching stops and as you add more weight the rubber band stretches little if at all. The point where this happens is called the elastic limit, and the rubber band will not return to its original length simply can't hang on to each other as they did before. You will still be able to add weights, but nothing happens. Eventually the rubber band will break (watch your feet so you don't get a sock full of weights landing on you.

This graph (which is called a modulus graph) can be constructed for any material. Something like steel or wood would not stretch much, so the graph would be very flat. Something like the glass we demonstrate is brittle, and once you reach the elastic limit, it breaks almost instantly. Cotton has a large modulus section and thus can be wrinkled fairly easily. Polyester has a short modulus section and thus doesn't wrinkle. When you iron cotton, you realign the molecules and get rid of the wrinkles. The skin in our knuckles and knees has a graph like a rubber band, but the skin in the soles of our feet is more like wood. Muscles and tendons are more like a rubber band and bones and teeth are more like wood and steel. It is incredible to realize that making a human body that will work means paying careful attention to the modulus graph and properties for every material in the body. If teeth were like muscles they would bend when you tried to chew something. Remember the vertical axis is how much it stretches and the horizontal axis is how much force is put on it.

The reason some balls bounce and others don't is because the ones that don't have been stretched beyond their elastic limit. The material doesn't try to return to its original length, so it just dies. There is actually a number called a restitution constant that measures this. Balls that bounce stretch out of shape, and when they return to their original shape they transfer energy in the opposite direction and bounce up nearly as much as when they hit. The loss of height is when energy is converted into heat inside the ball due to the process.

ACTIVITIES: I encourage you to do the lab described in the content section. If you don't want to do the graph, at least do the experiment and notice how the materials behave - that at first they stretch easily and eventually the stop stretching and then break. Be careful about not being under the rubber band when it breaks because sometimes they break when you don't expect them to. Loop the rubber band over a rail or smooth object like a canoe paddle clamped to a wall. Put a bent paper clip on the rubber band and through the top of an old sock. Add weighs to the sock observing and preferably recording how much it stretches. It is a fun experiment and takes no special materials - just be careful not to be under it or close to it when it has a lot of weight in it. Don't get too large of a rubber band either, or you'll be adding weights forever.

Take different materials and ask your student to guess whether they will bounce or not. If the kids are with this, ask them to make a graph of what the materials would look like if we did the graph as we did with the rubber band. Good materials with no stretch and no linear part of the graph would be mud, putty, mashed potatoes, and squishy material. Things with long linear parts and thus lots of stretch would be nylon stockings, panty hose, and bubble gum. You might want to get some silly putty and ask the students to think about what causes the properties this material has.

BIBLICAL CONNECTIONS: Psalm 139:14 beautifully states what this experiment and discussion shows. God has designed the hair on our heads, the bones in our bodies, muscles, skin ligaments, tendons, teeth, gums and all of these have unique properties that allow them to do their jobs. Materials science is a huge new field in science, and wonderful things have been designed following what God did in designing our bodies. We are truly "fearfully and wonderfully made."

WHAT NEXT: Our last experiment is in earth science and not a continuation of this part of our studies.

SESSION 4 GEOLOGY ILLUSTRATION

CONTENT: The basic purpose of this lesson is to say to young people "God has built the earth in a logical understandable way, and you need to build your life in the same way." This is all a part of one of our most fundamental principles - that science and faith are friends and not enemies. The first demonstration involves the way in which sedimentary rock layers are deposited. There are three kinds of rocks: (1) Volcanic rocks which are cooled liquid rocks. (2) Sedimentary rocks, which are rocks laid down in water, either by crystalizing or by sediment being washed into a place where it can settle out in lakes. (3) Metamorphic rocks, which are volcanic and sedimentary rocks that have been changed by pressure and/or heat. This demonstration is of sedimentary rock formation where materials are washed into an ocean or lake and the sediment settles out in layers. The biggest particles form gravel which turns into a rock called conglomerate. Smaller particles settle out as sand - making sandstone, and very fine particles settle out as mud which turns into shale. In the ocean or a lake, shale is always a long way from shore because the larger particles will settle out before going a great distance. When we see a huge shale layer we know this was a lake or ocean a long way from the source of the sediment. When we see a huge conglomerate layer we know it was near the mountain from which the rocks came. We don't look for oil or coal in layers of conglomerate. Geologist use this type of reasoning and evidence to locate the natural resources upon which we all depend. Geology is a friend of man and a friend of the Bible. Don't portray any science as an enemy of faith or belief in the Word of God, because science is just facts and facts never conflict with God's word. There may be things in God's word that we can't find facts to support and have to accept on faith, but those are rare and have no relationship to the way faith and science interact.

The discussion of life and choices and priorities is pretty obvious. I think it has a wonderful message and is a great way to conclude this video series. I hope you will use it and discuss it. You might even want to do it yourself and not use the presentation I made, writing whatever should be of high priorities in your kid's lives on the golf balls.

ACTIVITIES: You can do lots of field trips with students and see what I have been talking about, depending upon where you live. If you want to contact me via e-mail, my address is jnc@aol.com. Tell me where you live and I can give you some suggestions. A local quarry or gravel pit is a likely place. Most places have a museum that will have demonstrations like the one I did in the video. You can just go to a stream and watch what is happening as water runs through rapids and into a pool. This is just an introduction, but looking at fossils and talking about the fact that the history of the earth can be read in the rocks always brings up questions about dinosaurs and the history of the earth. We have a video titled Canyonlands and the Biblical Record which shows a stream table being used to study surface features of the earth. You can use that material to expand on how geographic structures are formed, and you can do the stream table exercise yourself. We have a little booklet titled God's Revelation in His Rocks and His Word which is available on our web site (doesgodxist.org) or can be gotten from us if you want some help in questions that come from this area of study.

BIBLICAL CONNECTIONS: The Bible has stories that can be checked out or understood more fully by looking at the geological evidence. The flood described in the Bible would produce elastic sedimentary rocks like what we did in this demonstration. This is not what the Grand Canyon is made of, so we know the Canyon was not produced by the flood of Noah. We need to make sure kids aren't given straw house explanations that are easily destroyed by skeptics, and this is one of them. There are many flood strata in the world, so we know floods have happened, but the flood of Noah cannot be identified in the rock record. We always need to search out Truth, and God's word is Truth (John 17:17). What the Bible tells us is true, but sometimes the Bible doesn't give us all the information we might like to know. Questions about dinosaurs and the flood fall into this category. Science helps us fill in the details when God's word doesn't explain something to us. The Bible does tell us how to live and how to establish priorities, and the golf ball demonstration shows us logically that what the Bible says about how we should live and make decisions is completely correct and logical.

WHAT NEXT: We have another series of videos called God Made it all Perfect by Jean Weibe and John Clayton. This is a more detailed study and talks more about the Bible. It is especially suited for younger children, but can be used with almost any elementary child with some enrichment. We also have our regular series in apologetics and the archeology series with Harvey Porter that can be used with older and more advanced students. I hope you have found this useful, and thank you for your efforts in teaching kids and building godly Christian lives in your charges.