Discovering Newton's Laws of Motion and Gravity through the Solar System

Sherri Bernier-Lucien

Overview

Think back to your first experience with Newton's laws of motion or his law of gravity. What grade were you in? Ninth grade? Tenth? My first school experience with physics was in a general science class in ninth grade followed by high school physics in eleventh, and that was considered the advanced placement in science for North Carolina. Times have changed drastically since then. Now fifth graders are being asked to understand such complicated and abstract concepts, and they are being asked to grasp them, not in a year's worth of teaching and experience, but in one quarter. This is a task even Newton himself did not accomplish!

When attempting to teach the concepts of inertia and gravity to elementary students we are asking them to understand concepts that do not match the frame of reference in which they perceive them. They do not see any examples on Earth of objects that when set in motion actually remain in motion without the assistance of an outside force. From the perspective of the Earthbound the natural state of an object appears to be at rest. Gravity can be tricky as well. Even though objects on Earth do fall at the same rate many children clearly watching a golf ball and a ping-pong ball hit the ground together will swear the golf ball hit the ground first! How then do we help students understand these concepts if the examples are unobservable or, to their young minds, unbelievable? We have to find credible data for their minds to absorb. Facts they believe whole-heartedly already that will help them access or develop the background knowledge they need to comprehend these difficult topics.

So what already in their experience does remain in motion forever? The planets! Any child can tell you that the Earth rotates and does not stop, that it revolves around the sun unceasingly. In this unit we will use what students know about the Solar System and some new things they will learn to help them understand Newton's laws of motion and Newton's law of gravity.

Demographics

I teach at a suburban elementary school serving students K-5. The school is located in Charlotte, North Carolina in the urban school district of the Charlotte-Mecklenburg School System, which is the nineteenth largest school district in the nation. The school has a diverse population of international students from Europe and Asia, with a large portion of this population coming from India. Our free and reduced lunch population is less than 1%. The parent community is extremely supportive and has the financial capabilities to keep the school updated with the latest in technology. All classrooms are outfitted with Smart Boards, and my room also has an airliner and Smart Response remotes. I will refer to the use of this technology in my activities for this unit. However, I will also provide alternative venues for teachers who do not have access to such technology in their rooms.

I am a full time fifth grade teacher responsible for the instruction of 30 students in all content areas. My class is made up of one ESL student from Korea, one severely dyslexic child, in addition to two LD children with disabilities in reading comprehension, and 14 students in the Talent Development program. I have no students on free and reduced lunch. I am the lead science teacher for PSE, which means I am responsible for working with CMS to train and conduct in-service for the teachers at my school. I have also worked for McMillan-McGraw Hill to lead in-service for all elementary science teachers in the CMS district for several years.

I teach Science using the North Carolina Standard Course of Study (NCSCoS) focusing on a hands-on experimental approach to teaching. I also rely heavily on computer simulations, animations and resources such as Discovery Education to help my students gain the background knowledge and experiences that so many of them are lacking due to the sparse science education received in earlier elementary school classrooms. Once the concepts have been grasped my students use technology like flip cameras, web 2.0 application, and wikis to create student products that are memorable and will help cement the learning that is taking place in the classroom into their long term memory rather than being available only in their short term memory for the test!

Rationale

It is essential for students to have adequate experiences in science so that Newton's laws are a part of their understanding and not some fleetingly glimpsed moment of inspiration that is soon forgotten. This necessity is primarily for the student's own knowledge and benefit. This is the main goal of education in general- the academic advancement of the individual, which will open up future opportunities to them. However in North Carolina, and many other states across the nation, students must take an end-of-grade test in science to accompany their state tests in reading and math. Results of these tests are often used to make promotion decisions as well as to determine the level of academic rigor the student will receive in middle school. Making their ability to perform well in science of immediate impact on their educational opportunities.

A school's reputation also hinges on their performance on end-of-grade testing. Scores are reported in the newspaper and schools are ranked by that performance. The public in general has limited opportunities to view how effective their schools are in educating children. Although test scores are an extremely limited view of a school's success, they are in many cases the only, or at least the primary way, schools are judged by the public.

In North Carolina a teacher's scores are compiled by the state and students' growth and success, or lack thereof, on these tests become a part of a teacher's evaluation. In the future they will be used to assess teachers' pay as we in CMS and other districts move to a pay-for-performance model. It is my hope that this will force teachers to bring more science into the elementary classroom. In my district the current goal for science at the elementary level is two forty-five minute lessons per week. It is ludicrous to believe students could possibly make significant gains in scientific understanding of such principals as gravity in such a limited time frame. If we intend to properly instruct students in science and open up the opportunities that await them in the burgeoning field of science careers we will need to devote time daily to the instruction of science in every grade level.

Background

Newton

Understanding physics is no easy task for most people. Even Newton stated, (1) "If I have seen farther (than other people) it is by standing on the shoulders of giants." To understand how to teach Newton's Laws of Motion and Gravity you must first understand them yourself. In this section I will give a brief overview of each law and resources you can use to gain a deeper understanding if necessary.

(1) (Krull, Kathleen (2006). Isaac Newton, *10*)

Newton's First Law

Newton's first law, also known as the law of inertia, states that an object in motion will remain in motion at a constant velocity unless acted upon by an outside force. It further states that an object at rest will remain at rest unless acted on by an outside force. Students easily understand the latter part of the law. It is the former portion of the law that is a little difficult for them to reconcile with their experiences. Simply put the law states that if an object is already moving it will continue moving in a straight line at the same speed forever unless another force changes its motion. We do not experience this on Earth because there are always other forces acting on Earth's objects; namely gravity and friction. To make this concept more visible to the student examples where friction is greatly reduced are beneficial. Ice-skating and air hockey tables are two activities students have perhaps had a personal experience with or have at least seen.

Newton's Second Law

Newton's second law is often expressed merely as the equation **F = ma** where **F**= force, typically measured in newtons (N); **m**= mass, measured in kilograms (kg); and **a**= acceleration, measured in meters per second squared (m/s^2). Simply stated this law says that the acceleration of an object is dependent on two variables: force and mass. There is a direct relationship between force and acceleration meaning that as the force increases so does the acceleration. There is an inverse relationship between mass and acceleration. As the mass increases the acceleration decreases.

Newton's Third Law

This law is probably the easiest for students to understand as it correlates nicely with their past experiences. The law states that for every action there is an equal and opposite reaction. Simply stated when one object collides with another object the other object pushes back. That is why when someone runs into a wall the wall knocks him or her backward! Examining the propulsion of jet engines or rockets is a good way to gain hands on experience for the comprehension of this law. You can use materials as simple as letting go of a blown up balloon or as complex as building model rockets.

Newton's Universal Law of Gravitation

This law states that two objects will exert a gravitational force on each other that is directly related to their mass and inversely related to the square of their distance. In simpler terms all objects exert the force of gravity on other objects, more massive objects exert a larger force, and the force becomes weaker with distance.

$$F = G\frac{m_1 m_2}{r^2}$$

In Newton's equation F is equal to the force of gravity between two objects, m_1 and m_2 are the masses of the two objects, and r is the distance between the two objects. As you can see from the formula the two masses are multiplied causing the gravitational force to increase where as the distance is squared and then used to divide the masses causing the gravitational force to decrease. G is the gravitational constant. It is very small, equal to approximately 6.674×10^{-11} N m^2 kg^{-2}. Newton did not have the gravitational constant when making his calculations. Although this formula was refined with Einstein's theory of general relativity it still gives a very accurate calculation of gravitational forces except where extreme precision is required or extreme masses or densities exist.

Students generally understand that gravity exists on planets and other celestial objects like stars. They are rarely aware that all objects exert a gravitational force. In this unit we explore the fact that gravity accelerates all objects at the same rate regardless of mass. In other words, two objects dropped from the same height at the same time with limited air resistance will hit the ground at the same time. This is because all objects on Earth, with minimal air resistance, will fall to Earth at a rate of 9.8 m/s^2. We will do a simple lab to help students discover this number for themselves.

For further information regarding these laws check out the resources listed in the bibliography.

Memory

In creating this unit I have developed lessons based on the concepts of memory in John Medina's book *Brain Rules*. His research shows that there are four major categories of memory: semantic, procedural, emotional, and episodic. The more categories of memory one lesson can trigger the more likely the memory will not only be stored, but the more easily it can be retrieved later. I have tried to create lessons that hit many if not all of these categories so students will have maximum retention with minimum effort. The goal is for them to remember this unit as they endeavor to take more complicated physics classes so they will have a firm background to fall back on rather than having to restart the learning process all over.

The semantic category encompasses words, symbols, facts, and figures. It is the most used and if it is the only category stimulated than around 90% of the information is lost after 30 minutes. Looking at data from an experiment or reading, viewing, or listening to information about a topic will stimulate the formation of this kind of memory.

The second category is procedural. This is triggered when doing something interactive like using manipulatives, or employing other hands-on tactics. Most teachers are aware of how effective it is to use hands-on techniques when we want students to retain information. We generally see this strategy emphasized in mathematics, but it can be powerful in any subject area. It is obvious that science gives plentiful opportunities for the creation of this type of memory through experimentation and demonstration. Sadly many teachers forego such experiences due to lack of time, materials, or difficulty in preparing the materials for student use. When these excuses prevail in science class you are left with the 10% retention rate most students experience after creating semantic memories through reading textbooks or viewing films.

Emotional memories are among the strongest and most memorable. Everyone knows where he or she was and what he or she was doing when the space shuttle Challenger exploded or the World Trade Center was attacked. However, you do not need a tragedy to spark a memory in this center of the brain. Even raising a chuckle in students can help to make the lesson more memorable. It is worth the effort to work on your rapport with students, as it will be easier to create emotional experiences if you do. There are many moments that lend themselves to creating an emotional memory. If we have students read that all objects fall at the same rate most will not register what that even means let alone remember it tomorrow, but if you allow them to experiment and discover the concept for themselves there will be a moment of shock as their perspective of the world shifts and understanding dawns. When you experience something that alters your perspective of the world it triggers an emotional response. This then becomes a moment they will not forget.

Finally, to create episodic memories the activity must connect to an event in their life, or be an event in and of itself. You can elicit an episodic event by tying information to something in their lives they have experienced, like going to the beach, or by creating an event that they can take part in. If you have an exciting event going on as you teach a lesson it will increase retention, this is what makes field trips memorable, or if you allow them to create something they are truly excited about with their new knowledge like a video or presentation to be given at the next PTA meeting you will have helped to create long lasting episodic memories.

Strategies and Activities

Technology

To help make the unit more engaging and to help students build competence in technology I will be using many different types of technology including hardware such as the SmartBoard and web 2.0 applications. In North Carolina teachers are expected to reach 21st century learners using 21st century technology. Science class is a perfect pairing for this as science and technology have always gone hand in hand. The benefits to memory in using such experiences in the classroom are clearly stated in the sections on emotional and episodic memory building, both of which create memories with the highest rate of retention. However, there are other reasons for using such technologies. One very valid reason is because the students are largely already familiar with it. Students born after 2000 have been surrounded by this technology all their life. While it can be intimidating and overwhelming to us older folk it is second nature to most of them. The opportunity to learn in a way they are so familiar with, but little utilized in school, is comforting and exciting at the same time. Many students who do not excel in other areas do excel at their ability to use technology. You do not need to be an expert to use web 2.0 applications, which are just websites where you can interact and create products rather than merely read material presented. Just provide the students with the appropriate site and they will teach you how! Here are just a few of my favorites:

Wordle is a site where students can create a “word cloud”. Students can use an existing piece of writing such as a speech, their writing, or a list of descriptive words.
http://www.wordle.net

A glog is an online poster that students can create as a product to show what they have learned. They can upload and embed video, images, or sounds that pertain to their topic and choose from a large gallery of text bubbles, frames, and wallpapers to showcase their work
http://edu.glogster.com/

Animoto takes photos or images you upload and turns it into a music video of sorts. Students can also include text.
http://animoto.com/education

Museum boxes is a fun format for putting together presentations on people or events. Much like glogs students can upload images, videos, and sounds as part of their presentation and the site places the information into an attractive presentation based on the theme of being in a museum display case.
http://museumbox.e2bn.org

This is an incredibly small sampling of what is available. Googling web 2.0 will bring thousands of these sites to your fingertips.

Read Aloud/Seminar

Prior to teaching the unit on Newton’s Laws I conduct a read aloud on a biography on Newton titled, *Isaac Newton*, by Kathleen Krull. This biography walks the delicate balance between being easy for fifth grade students to comprehend and being advanced enough to impart useful information. The book is entertaining and will help students create a mental map of Newton to which they can later tie their expanding concepts of physics. There is one section of the book, Chapter 9 pages 90-91, where the author presents the possibility that Newton had a homosexual relationship. As this is not a subject we are permitted to discuss in my district I discreetly skip the few paragraphs where the relationship is discussed. It is an insignificant detail as there is no good evidence that Newton ever had an intimate relationship with anyone throughout his entire life.

The questions for this seminar were developed using the Paideia method as put forth by the National Paideia Center. This strategy for teaching was developed by Mortimer

Adler along with other scholars and educators in 1982. In my school we take extensive in-service on this method of teaching, and it is more involved than can be gone into in this paper. Interested parties can learn more about this teaching style by going to the National Paideia Center's website at www.paideia.org. However, you do not need to strictly use this style of seminar to use this unit. Most teachers are more familiar with the terms "Socratic Seminar" or "Seminar discussion". The important thing to remember is that these discussions are for students to share their ideas. Teachers should refrain from sharing their views as these will most likely be taken as gospel and squelch any contradictory opinions from students. The teacher's role is to pose the questions and correct any misconceptions, but never to share views. It is one of the more challenging things I do in my profession because I do love my own opinions, but it is also the most rewarding as students start taking ownership of their own learning and look to me less to be the provider of answers.

When I hold seminar I have students sit in a circle, and they share in an adult style dialogue where we forego raising hands. I try to split my class with another seminar facilitator, such as our talent development teacher or literacy facilitator, so we each have about 15 students in the discussion circle. If your class is not trained to hold seminars in this style then any format for class discussion you are comfortable with will work as well.

To develop questions for seminar I use the Paideia model. The first question in a seminar is called an opening question. It will have to do with the major themes and ideas in the piece. The next 3-5 questions will be core questions. These questions will be text specific and are meant to make students refer to the text to support their answers. However they must be ambiguous enough to have multiple interpretations. If they are not then the students will quickly identify the "right" answer and no further dialogue will develop. The final question in a seminar is a closing question. Closing questions are personal and help relate the text to the individual.

Prior to holding a seminar there are pre-seminar activities. These activities require students to have read the text at least twice. We do one reading together as a class, and the second reading will be in a small group or independently. Other activities will relate to comprehension such as categorizing events or character traits, or understanding vocabulary. After seminar students participate in a post-seminar activity that requires students to create a product in response to the text. This could take the form of a letter, visual art piece or drama.

Activity One: Seminar On Isaac Newton

Objective

Students will investigate the conditions of Newton’s life and evaluate their impact on his discoveries.

Procedure

Pre-seminar- To prepare students for seminar I read the novel, *Isaac Newton* by Kathleen Krull, aloud to students over the course of a week. I then provide students with a printed excerpt of Chapter 8: The Greatest Science Book in the World. I chose this chapter because in it all three of Newton’s laws of motion are discussed as well as his Universal Law of Gravitation. Students are assigned to read it and highlight at least three ideas in the chapter that they want to know more about. Then students are put in groups of three and assigned one of the four laws to illustrate. They are to choose an example they believe fits this law and draw a picture of it with a caption explaining how the picture fits the law.

Seminar

<u>Opening Question</u>: What idea in the chapter do you believe you understand the best? What idea do you think you understand the least?

Opening questions can be open to the entire group, but in this case I would pose this question as a think-pair-share. Each person in the circle would turn to the person next to them and discuss these two questions for a period of time. After the think-pair-share I would open up this question for general discussion.

<u>Core Questions</u>:

1. How might our life be different if Newton’s concerns over criticism had prevented him from printing his book, *Philosophiae Naturalis Principia Mathematica*?
2. Newton’s accomplishments were achieved in relative isolation. Many would argue his accomplishments might have been because of his isolation. How do you think his accomplishments might have changed if he had been more collaborative?
3. On page 81 Newton’s law of inertia is explained. What do you think is meant by this law? You may reference the text and/or students’ drawings to help you.
4. (Repeat question 3 using the other three laws)
5. What do you think it would be like to have an 11 year-old Newton in our classroom?

<u>Closing Question</u>: Do you respect Newton? Why or why not?

Post -seminar

For post-seminar in groups of three students will design an experiment to test one of Newton’s four laws. To facilitate this I will set out simple supplies like a variety of small balls, toy cars, ramps etc. Do not be too strict on scientific method in this activity. It is really designed for them to explore the concepts and build some background experiences for the remainder of the unit.

Inertia

To better help students understand the concept of inertia we will start by exploring rotational inertia. Children know that planetary bodies rotate without stopping, but many attribute that continuous motion to gravity mistakenly believing that gravity is spinning the planet or that the planets have gravity because they are spinning. We will explore what force set the planets in motion and that due to inertia it would take a force to stop them from spinning. To help see this concept inaction we will view the YouTube video Richard Garriott Space Video Blog: Rotational Inertia. We can then talk about inertia in general by looking at the expansion of the universe. Most students have heard the universe is spreading out, or expanding, we will talk about what set it in motion and why it still moves billions of years later, inertia! We will use a YouTube video Newton's Laws Of Motion (1): The Law of Inertia and The United Streaming video, Newton's Laws of Motion to help illustrate this concept. Lastly, we will look at the revolution of the planets around the sun and combine what we learned about inertia and what we know about gravity to determine why the planets rotate. To help explain this I will use Newton's explanation of firing a gun on a mountaintop as expressed in *Gravity*, by George Gamow.

Activity Two: Inertia

YouTube video Richard Garriott Space Video Blog: Rotational Inertia http://www.youtube.com/watch?v=fPI-rSwAQNg If the link does not work put the title in a Google search and it will pull it up as well. This is a one-minute video that gives a demonstration of rotational inertia.

After viewing this video give each pair of students a coin to spin. Eventually their coin will begin to wobble and eventually it will fall over and stop spinning. Discuss how at the space station the cards were not being pulled by gravity so they continued to spin while on Earth our coins are eventually slowed by friction between the coin and the surface it is spinning on and eventually toppled by gravity.

YouTube video Newton's Laws Of Motion (1): The Law of Inertia http://www.youtube.com/watch?v=Q0Wz5P0JdeU This video lasts six and a half minutes. After they view these demonstrations of inertia I would again give them materials to reenact some of the demonstrations on their own. Skate boards, Barbie dolls, eggs are fun but messy, apples make a good substitute. I would discourage you using rollerblades or allowing students to ride skateboards for obvious safety issues.

After a few minutes have a quick discussion on friction and allow them to retry some of their demonstrations on different surfaces such as carpet, tile, or a sidewalk.

Next I pull up a great site by Discovery called Discovery Education at http://streaming.discoveryeducation.com/ Many school systems have purchased a license for this site, but if your school has not you can get a 30 day free trial. Once on the site put the title of the video “Laws of Motion” in the search engine and several videos will come up. It will show a close up of an apple tree. I do not show the whole 17-minute video at this time, but only the first six segments on Newton’s first law. They last about 8 minutes total. After this video is a good place to discuss ways to reduce friction in Earth like ice-skating or air hockey. Bringing in a small electric air hockey table for students to experiment on is a great way for them to create an episodic memory for this law.

After this have the students brainstorm a list of everything in our solar system that they know to be in constant motion. They are likely to come up with things like the planets revolve around the Sun, the Moon revolves around the Earth, and the Earth rotates. They may even be able to come up with: the universe expands, comets come back in cycles or our galaxy spins. If students are thinking, they should realize that these objects remain in motion because an outside force that would stop them is not acting them on. However, especially in the case of the planets revolving around the Sun, they are not moving in a straight line as the law states they should. What force could be acting on them to cause them to change their direction? Gravity! (2) Gamow gives a good explanation of this in his book, *Gravity*. You can explain it to students like this:

Pretend you fire a canon from the highest mountain. If the canon ball was traveling fast enough it would continue traveling in a straight line, as it was passing the curve of Earth gravity would pull down on it causing it to change directions. It would continue in this new direction in a straight line until it again passed the curve of Earth and gravity would again pull it towards Earth changing its direction. To illustrate this explanation I draw a simple sketch of it on the board for students drawing each change in direction as I point out the pull of gravity until the canon ball has completed one orbit of the Earth (See Figure 1.)

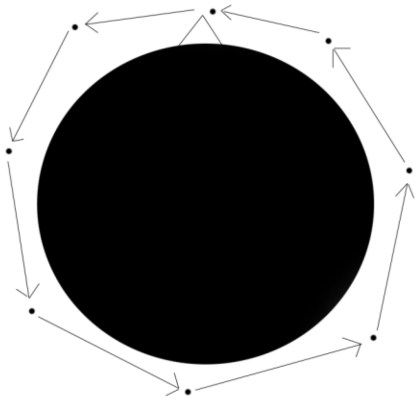

Figure 1

Of course gravity is not pulling on the canon ball only as it travels past the Earth's curve but constantly. It is as if the cannon ball is traveling while attached to a string. As the canon ball tries to travel straight gravity, the string, keeps it orbiting around the Earth. That is why the orbit of objects is smooth and not choppy as it would be in the above illustration. In this way the planets are like that canon ball. If we could suddenly turn off the gravity of the Sun and the planets the planets would all go shooting out into space in a straight line at a constant velocity!

(2) (Gamow, George (1962). Gravity, *80*)

After these experiences students should grasp Newton's first law of motion. However, it is a complicated concept so before moving on I would have students write a simple essay paragraph explaining the law that includes a statement of the law, an explanation in their own words and an example that illustrates the law. That way any misconceptions can be cleared up before moving on. I would use the following rubric to assess their paragraphs.

0. Student cannot state the law or explain it.
1. Student can state the law but explanation and example is flawed.
2. Student can state the law but explanation or example is flawed.
3. Students can state the law giving a clear explanation and example.

Activity Three: F=MA

For Newton's second law play the next segment in the video from Discovery education.
http://streaming.discoveryeducation.com/
The segment is only about 2 minutes. Then follow up with the YouTube video Newton's Laws Of Motion (2): Force, Mass, and Acceleration
http://www.youtube.com/watch?v=WzvhuQ5RWJE&feature=related

Get the materials back out from the activity on Newton’s first law. This time have them experiment by moving things with the same amount of force, but different masses. The example in the video where they use strong magnets to push the skates apart is a good way to do this. An easier way is to use a ramp. If you roll the object from the same ramp positioned at the same slope and height each time you will be accelerating the object with an equal force. Next make sure they experiment with objects being accelerated with the same mass, but different forces. Again, by rolling objects of the same mass, like ping pong balls down ramps of differing slopes you can achieve this goal. In the end students should grasp the basics of the equation F=MA which can also be written as A =F/M. This may help them see that when mass increases acceleration decreases and when force increases acceleration increases as well. I always tell my students that this means force and acceleration have a direct relationship while mass and acceleration have an inverse relationship.

Activity Four: Action and Reaction

For Newton’s third law play the last segment in the video from Discovery education.
http://streaming.discoveryeducation.com/
The segment is only about 2 minutes. Then follow up with the YouTube video Newton’s Laws Of Motion (3): Action and Reaction
http://www.youtube.com/watch?v=cP0Bb3WXJ_k&feature=related

A simple activity you can do in class to give the students a hands on experience with this law is to give them basketballs. The harder they bounce them against the floor the harder the floor pushes back sending the ball higher into the air. If you want to create a stronger episodic memory hang a string in your room with a straw threaded on it. Allow students to tape a blown up balloon to the string and then release it so the air blows out the back pushing their balloon rocket forward. You can relate this to the examples of the rocket’s engines that were shown in the video. Of course if time and expense permit building and launching model rockets would be a day they would never forget!

Activity Five: Student Presentations

After having read about Newton and examining his three laws of motion I now assign students to begin creating a project on Newton. I give them a variety of web 2.0 applications to choose from. Students may use Glogs, Animoto, or Museum Boxes to create their presentations. A link to each of these can be found in the *Technology* section above. Each presentation must give a brief overview of Newton’s life, state each of the four laws, and give student created examples for each law. I assign the presentations now so students have time to complete them as we finish going over Newton’s Universal Law of Gravitation in class. I use the following rubric to assess their work (See Figure 2.)

Expectations	**Possible points**	**Points Earned**
Statement of Laws	30	
Explanation of Laws	30	
Clear Examples	15	
Multiple Graphics/Images	10	
At least on embedded video	5	
Appropriate background/music	5	
Correct spelling and grammar	5	
Totals	100	**Grade:** __________

Figure 2

Gravity

Again we will move out to space to get a grasp on the concept. By exploring gravity between objects in space we can explore the differences between weight and mass and the measurement of force in Newtons. We can do this by using gravity multipliers for each planet to find out what their weight, or the weight of a particular object, would be on different moons or planets in our solar system. We will collect data on Earth as it applies to this concept by measuring the force of gravity in Newtons of five every day objects, like a shoe or a pencil case. We will then mass the objects in kilograms and graph the results. Using a calculator we will discover the magic number 9.8. Then we will do Newton's famous experiment of dropping items off the leaning tower of Pisa, in our case a ladder! Because students stubbornly hang on to the idea that heavier objects fall faster I will start with a slightly different premise. I will give students a ping pong ball and a tennis ball and ask them to discover what they have to do to get them to hit the ground at exactly the same time. After some experimentation they will discover they must drop them at the same time. We will then use the ladder to drop various objects off our Leaning Tower to see our conclusion at work.

Activity Six: Weight in the Solar System

The YouTube video Newton's Laws Of Motion (2): Force, Mass, and Acceleration briefly discussed the difference between mass and weight. In this activity students will determine the weight of objects on Earth compared to their weight on other planets and Earth's moon (See Figure 3.) I bring in a bathroom scale form home for this activity. I give the students the option of doing their own weight, but I also allow them to use other objects. I tell them they can use anything around the classroom they want or they can bring anything from home they can fit in their backpack. They can also bring in the weight of something, like their dog. I do this because students in fifth grade are often just becoming very weight conscious, and I do not want this fun lab to become an embarrassing moment for anyone! They simply take the weight of the object on Earth and multiply it by the gravity multiplier and it will give them the weight of that object on that planet. It is also fun to find out how much they can lift and then compare what types of things they could lift on earth compared with other planets. They will be amazed at how strong they would be on the moon and how weak they would be on Jupiter!

Object: ______________________ Weight on Earth: ______________pounds

I can lift approximately: ____________________pounds

Planet/Moon	**Gravity Multiplier**	**Weight**	**Can I Lift It?**
Earth	1		
Earth's moon	0.17		
Mercury	0.38		
Venus	0.9		
Mars	0.38		
Jupiter	2.36		
Saturn	0.92		
Uranus	0.89		
Neptune	1.13		
Pluto	0.07		

Figure 3

Activity Seven: What Is So Special About 9.8?

For this activity you will need spring scales that measure force in newtons and a balance scale to mass objects. If you do not have one you can likely borrow them from your local high school. Spring scales that measure in newtons can also be purchased for about $5 each at the link below.
http://www.carolina.com/category/equipment+and+supplies/measuring+equipment/spring+scales.do?s_cid=ppc_gl_spring+scales&gclid=CMnrut7Tj6UCFYft7QodtU1kNA
If you do not have a balance scale to mass objects most bathroom scales have a setting for massing in kilograms. I just bring in my bathroom scale from home and set it for kilograms!

Students will need five everyday objects that can fit on the spring scale. It makes no difference what they are just that they give you different measurements. They could try a textbook, their shoe, a chair, etc. You can put these on a graph if you want to but in fifth grade I find it is just as effective to put them on a table like the one below (See Figure 4.)

Use your calculator to fill out the table below:

Object	**Newtons**	**Divided by**	**Kilograms**	**?**
		divided by		=
		divided by		=
		divided by		=
		divided by		=
		divided by		=

Figure 4

Students should get a number close to 9.8 every time. Do you recognize this formula? It is the formula for acceleration. F=MA. We have calculated it as A = F/M. Newtons is the measure of force caused by gravity (also known as weight!) and kilograms is the mass. What the students have found is the rate at which gravity causes objects on Earth to accelerate which is 9.8 m/s^2! You can use this in the final activity to help students understand why all objects on Earth fall at the same rate.

Activity Eight: Falling Objects

Most people have done the lab where students have dropped two objects of varying masses to show that all objects on Earth fall at the same rate. You probably have also had students swear that the heavier object hit the ground first despite the evidence before their eyes. Some even sabotage the experiment by dropping the heavier object slightly sooner to get the results they expect. Instead of doing this lab I change the question slightly and get great results. I challenge the students to find out what they have to do to get the objects to hit the ground at the same time!

They generally start out putting the heavy object higher so it will have farther to fall. Soon they realize they have over calculated and try to adjust. As they adjust and refine their heights based on previous trials they eventually come to the “ah ha“ moment that they have to drop them from the same height at the same time! After this we take several minutes to drop all kinds of objects to watch this amazing phenomenon.

I also like to bring in a ladder for them to drop things from because it is more exciting and creates a stronger memory, but you must be cautious when students are on the ladder and make sure the supervision is adequate. I have also gone outside to allow them to drop things from the monkey bars or have allowed them to drop things from the second story window. One note of advice when working outside, do not use light weight items like ping pong balls. Even a slight breeze will affect their fall.

Activity Nine: Presenting

After setting a deadline for completion students present the products they created on Newton and his Laws.

Bibliography

Acedemic!, Ace. "Wordle - Beautiful Word Clouds." Wordle - Beautiful Word Clouds. http://www.wordle.net (accessed November 30, 2010).

Web 2.0 application to create word clouds.

"Animoto - For education." Animoto - The End of Slideshows. http://animoto.com/education (accessed November 30, 2010).

Web 2.0 application for creating picture/music videos.

Asimov, Isaac. *Isaac Asimov's Guide to Earth and Space*. 1991. Reprint, Robbinsdale, Minnesota: Fawcett, 1992.

This book is a good source to have available for students as you study this unit. It has a series of very short articles each answering a specific question. Of particular interest to this unit would be the sections entitled “What is Mass?”, “Does the Earth Move?”, and “When You Jump Up, Why Don’t You Come Down in a Different Place?” It is a good resource for teachers for when students ask questions you do not know the answer to!

Couper, Heather, and Nigel Henbest. *How The Universe Works*. Pleasantville: Readers Digest, 1994.

This DK book has great graphics and illustrations to accompany its student friendly text. It is a good resource for students who want more information on our solar system. Topics include: Earth, the Moon, The Solar System, The Sun, The Stars, and The Cosmos.

"Discovery Education Homepage." Discovery Education. streaming.discoveryeducation.com/ (accessed November 30, 2010).

This site has thousands of useful videos in many subject areas. It is a general tool for teachers. I particularly like that you can show segments of videos rather than entire videos. You do have to pay to use the site, but many schools systems have already purchased a license for this site.

ESOcast. " YouTube - Newton's Laws Of Motion (1) : The Law Of Inertia ." YouTube - Broadcast Yourself. . http://www.youtube.com/watch?v=Q0Wz5P0JdeU (accessed November 30, 2010).

YouTube video on Newton’s Law of Inertia.

ESOcast. " YouTube - Newton's Laws Of Motion (3): Action And Reaction ." YouTube - Broadcast Yourself. http://www.youtube.com/watch?v=cP0Bb3WXJ_k&feature=related (accessed November 30, 2010).

YouTube video on Newton’s third law.

Friedhoffer, Robert. *Physics Lab in a Housewares Store (Physical Science Labs)*. United States: Franklin Watts, 1997.

This book gives good activities to use with simple machines, which may need to be covered in your physics unit, but were not covered in this unit. It also has brief but student friendly sections on “friction” and “mass and weight”

Gamow, George. *Gravity* . Garden City, N.Y.: Anchor Books, 1962.

This is a great resource for people who want a more in-depth understanding of gravity. It is written at an advanced level.

Gibilisco, Stan. *Advanced Physics Demystified*. 1 ed. New York: McGraw-Hill Professional, 2007.

This book like Gamow’s is for teachers who want a deeper understanding of the physics they are teaching. Chapter 1 gives good explanations of motion including the concepts of velocity, acceleration, mass, force, and momentum. Chapter 8 is on gravity. This book will be easier to understand and uses fewer mathematical formulas than Gamow’s more complete explanation.

Gleick, James. *Isaac Newton*. New York: Vintage, 2004.

This book is a biography on the life of Isaac Newton. It is a great teacher resource that could be used so you can give more details about Newton's beyond what is given in the easier read aloud book by Katherine Krull.

"Glogster EDU - 21st century multimedia tool for educators, teachers and students | Text, Images, Music and Video ." Glogster EDU - 21st century multimedia tool for educators, teachers and students | Text, Images, Music and Video . http://edu.glogster.com (accessed November 30, 2010).

Web 2.0 application to create online posters.

Hawking, Lucy and Stephen Hawking. *George's Secret Key to the Universe*. New York: Simon and Schuster, 2007.

A fun read for students. The book is written as a narrative about a young boy, George, who follows his escaped pet pig and ends up on an adventure that takes him into outer space. Through George's adventures students will learn about topics like mass, the planets, the moon, black holes and much more!

Krull, Kathleen. *Isaac Newton: Giants of Science (Giants of Science (Viking))*. New York: Viking Juvenile, 2006.

This book is written at a fifth grade students general reading level and is the book used as a read aloud in the unit. I do not recommend it for independent reading by students because of the reference to possible homosexual activities referenced in chapter 9 on pages 90 and 91.

"Museum Box Homepage." Museum Box Homepage. http://museumbox.e2bn.org (accessed November 30, 2010).

Web 2.0 application for creating student presentations.

"Paideia Homepage." The National Paideia Center. www.paideia.org. (accessed November 30, 2010).

This site will give more information on Paideia seminar instruction for those interested in learning more about the Paideia philosophy or seminar format.

"Spring Scales- Measuring Equipment." Carolina. www.carolina.com/category/equipment+and+supplies/measuring+equipment/spring+scales.do?s_cid=ppc_gl_spring+scales&gclid=CMnrut7Tj6UCFYft7QodtU1kNA

(accessed November 30, 2010).

This site sells science supplies. It is a good place to purchase inexpensive spring scales needed for measuring the force of gravity in newtons.

Ward, Alan. *Forces and Energy (Project Science)*. Franklin Watts library ed ed. United States: Franklin Watts, 1992.

This is another student friendly book to help students who need an additional resource. It covers the topics of forces, gravity and weight, the force of gravity, and friction.

ccsse. " YouTube - Richard Garriott Space Video Blog: Rotational Inertia ." YouTube - Broadcast Yourself. . http://www.youtube.com/watch?v=fPI-rSwAQNg (accessed November 30, 2010).

YouTube video on the concept of rotational inertia. The video was filmed in the ISS.