

SCIENCE

Session 3: Integrating Physical Science and Math

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5/8/2009

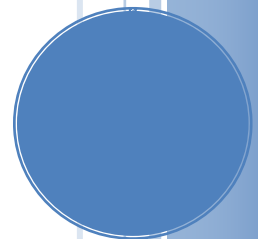


Table of Contents

Physical Science – GED Test.....	3
What Is Physics?	3
What is Chemistry?.....	3
Teaching Physical Science Concepts.....	3
Helping Students Learn Physical Science Better.....	3
Preconceptions and Misconceptions.....	4
Strategy for Successful Implementation of a Conceptual Approach with Physics:	4
Sample Misconceptions and Preconceptions in Physics	4
Falling Bodies.....	4
Inertia	4
Newton’s Laws.....	5
Gravity	5
Conservation of Energy	5
Navigating in Space	5
Temperature and Gas Laws	5
Light	6
Electricity	6
Magnetic Fields.....	6
The Atom	6
Basic Experiments for Physical Science	7
Compare and Contrast	7
Great Balls of Goop.....	7
Ooey Gooey Silly Putty	8
Ooblech	8
Flubber.....	8
Homemade Slime	9
Comparison Alley.....	10
Compare/Contrast.....	10
The Winner Is!	11
Which Lasts Longer?.....	11
Raw or Cooked?.....	12
Friction.....	12
Bernoulli Effect	12

Copper Caper – Teaching Chemical Reactions	13
Can You Score?	14
Galileo’s Free Fall – The Power of Gravity	14
How Large Is an Atom?	15
The Effects of Acid on Calcium	16
Which Paper Towel Absorbs the Most Water	16
Problem Solution	17
The Periodic Table of Elements	20
Anticipation/Reaction Guide	21
Activity Sheet for Assessing Student Understanding	22
Sample KWL Strategy with Inquiry for Physical Science	23
Approaches to Exploring Balls and Ramps	23
Science Websites	24
Hands-On Science Experiment Websites	35

Session 3: Integrating Physical Science and Math

PHYSICAL SCIENCE

PHYSICAL SCIENCE – GED TEST

Remember, the physical science portion of the GED Test comprises 35% of the test questions and includes:

- Structure of atoms
- Structure and properties of matter
- Chemical reactions
- Motions and forces
- Conservation of energy and increase in disorder
- Interactions of energy and matter

What Is Physics?

Physics is the study of motion, matter, energy, and force. Energy and work occupy an important part of our ordinary life and are among the most important topics in physics. Work in terms of physics has quite a different meaning than the work we normally think of. In physics, work is done only when an object is moved in the direction of the applied force. Physics is the science of nature or natural objects which includes the laws and properties of matter, the forces acting upon matter, and the causes that change the general property of matter, such as gravity, heat, light, magnetism, and electricity.

What is Chemistry?

Chemistry, though a branch of general physics, is commonly treated as a separate science. Chemistry includes the scientific study of the composition, structure, properties, and interactions of chemicals.

TEACHING PHYSICAL SCIENCE CONCEPTS

The teaching of physical science is clearly enhanced by the use of demonstrations. Visual examples of abstract concepts help students to understand the different concepts. Demonstrations or experiments also provide students with opportunities to apply the scientific method and to relate experimental observation to scientific theory. Demonstrations and experiments also make the learning of physical science much more fun!

Helping Students Learn Physical Science Better

The Comprehensive Conceptual Curriculum for Physics (C³P) Project. Funded by the National Science Foundation (Grant No. ESI-9254590). Retrieved from the World Wide Web at: <http://phys.udallas.edu/>.

Preconceptions and Misconceptions

Students often do not have correct conceptions about physical science. Sometimes they misunderstood what they heard or read and sometimes they make incorrect assumptions about how something works that is not correct.

As a science teacher, it is important to recognize preconceptions and misconceptions exist. The following is a strategy that you may wish to use in the science classroom to help lessen your students' misconceptions. Following the strategy are some popular preconceptions/misconceptions of high school and college students.

Strategy for Successful Implementation of a Conceptual Approach with Physics:

- Recognize preconceptions that exist.
- Probe for students' misconceptions through demonstrations and questions.
- Ask students to clarify their conceptions.
- Provide contradictions to students' misconceptions through questions, implications, and demonstrations.
- Encourage discussion, urging students to apply physical concepts in their reasoning.
- Foster the replacement of the misconception with new concepts through:
 - questions,
 - thought experiments,
 - hypothetical situations with and without the underlying physical law,
 - experiments or demonstrations designed to test hypotheses.
- Reevaluate students' understanding by posing conceptual questions.

Sample Misconceptions and Preconceptions in Physics

The following is a list of preconceptions and misconceptions that high school physics teachers and college professors have recognized in their students. Use these preconceptions/misconceptions in order to teach some of the basics of physical science.

Falling Bodies

- Heavier objects fall faster than light ones.
- Acceleration is the same as velocity.
- The acceleration of a falling object depends upon its mass.
- Freely falling bodies can only move downward.
- There is no gravity in a vacuum.
- Gravity only acts on things when they are falling.

Inertia

- Inertia deals with the state of motion (at rest or in motion).

- All objects can be moved with equal ease in the absence of gravity.
- All objects eventually stop moving when the force is removed.
- Inertia is the force that keeps objects in motion.
- If two objects are both at rest, they have the same amount of inertia.

Newton's Laws

- There is no connection between Newton's Laws and kinematics.
- The normal force on an object is equal to the weight of the object by the law.
- The normal force on an object always equals the weight of the object.
- Equilibrium means that all the forces on an object are equal.
- Only animate objects (people, animals) exert forces; passive objects (tables, floors) do not exert forces.
- Once an object is moving, heavier objects push more than lighter ones.

Gravity

- The force that acts on an apple is not the same as the force that acts on the moon.
- The gravitational force is the same on all falling bodies.
- There are no gravitational forces in space.
- The gravitational force acting on the space shuttle is nearly zero.
- The moon stays in orbit because the gravitational force on it is balanced by the centrifugal force acting on it.
- Weightlessness means there is no gravity.
- The Earth's spinning motion causes gravity.

Conservation of Energy

- Energy gets used up or runs out.
- Something not moving can not have energy.
- Energy can be recycled.
- Energy is not related to Newton's laws.
- Energy is a force.

Navigating in Space

- Spacecraft travel in straight lines from one planet to another.
- Spacecraft can be launched anytime to travel from one planet to another.
- Spacecraft are not affected by the sun.
- Motion relative to Earth is the same as motion relative to the sun.
- Jets can fly in space.

Temperature and Gas Laws

- A cold body contains no heat.

- Sweaters will make you warmer.
- Gases can be compressed to zero volume.
- Heat and temperature are the same thing.
- Pressure is the same as force.
- Skin is a good thermometer.

Light

- Light just exists and has no origin.
- Light is a particle.
- The speed of light never changes.
- The addition of all colors of light yields black.
- In refraction, the frequency (color) of light changes.
- Refraction is the bending of light waves.

Electricity

- A charged body has only one type of charge.
- The electric field and force are the same thing.
- The electric force is the same as the gravitational force.
- Voltage flows through a circuit.
- There is no connection between voltage and electric field.
- Voltage is energy.
- High voltage by itself is dangerous.
- Sparks occur when an electric field pulls charges apart.

Magnetic Fields

- North and south magnetic poles are the same as positive and negative charges.
- Magnetic field lines start at one pole and end at the other.
- Poles can be isolated.
- Magnetic fields are the same as electric fields.
- Charges at rest can experience magnetic forces.
- Magnetic field lines hold you on the Earth.
- Charges, when released, will move toward the poles of a magnet.

The Atom

- There is only one correct model of the atom.
- Electrons in an atom orbit nuclei like planets orbit the sun.
- Electrons can be in any orbit they wish.
- Hydrogen is a typical atom.
- Electrons are physically larger than protons.
- Atoms can disappear (decay).

BASIC EXPERIMENTS FOR PHYSICAL SCIENCE

Compare and Contrast

Divide the class into groups. Provide each group with a recipe for a surprising new material. Once they have created their new invention, have them identify its properties. Next have them compare and contrast the properties of their material to that of the other groups. Use the Comparison Alley handout to document similarities and differences between the materials. Have the groups share their findings with the class.

Great Balls of Goop

Mix white craft glue and a borax solution together to produce a surprising new material: GOOP! Often when two substances are combined, the properties of the substance will change. A physical or chemical reaction is taking place when this happens. White craft glue is a type of polymer called polyvinyl acetate. Polymers are large molecules made up of many smaller molecules or monomers. These are arranged in a strand-like fashion. When the borax solution is added to the glue, the molecules of the borax bind up the glue "strands" so that the glue no longer flows freely. The properties of this new substance are unlike the original glue or borax solutions. The GOOP behaves in an unusual way. See if you can describe it! Does yours look different than the rest of the "homemade" goodies?

Ingredients:

- 1 Tbs. of white craft glue
- craft stick (for stirring)
- 1 ½ teaspoons of borax
- 2 paper cups
- water
- measuring spoons
- small sheet of plastic wrap or zipper bag (to store goop)

Instructions:

1. Pour 1 tablespoon of white glue into first paper cup. Add 1 tablespoon of water and stir with stick until mixed. Set aside.
2. In a second paper cup, mix 1 ½ teaspoons of borax and 4 tablespoons of water. Stir well, then before the borax settles to the bottom, use a tablespoon to scoop out ONLY one spoonful of the water and borax mixture. Pour into the cup that has the glue and water mixture.
3. Stir with the stick. If mixture doesn't quickly form a gel, add another tablespoonful of the borax mixture and stir again.
4. Remove gel from cup and roll in your hands until substance firms up more.
5. Now it's ready to play with!

Ooey Gooley Silly Putty

Ingredients:

- 1 part liquid starch and 2 parts Elmer's glue

Directions:

Add glue to starch and mix with hands until it forms a ball. Knead 5-10 minutes. If it is too sticky, add a little starch. If it is too runny, add some glue. Did you get the same results as those groups making Homemade Slime? Why or why not? Does yours look different than the rest of the "homemade" goodies?

Ooblech

Ingredients:

- cornstarch
- a small amount of water
- stirring rod
- container
- measuring spoon

Combine a handful of cornstarch with a spoonful of water. Stir and add more water if the substance seems too crumbly. Properly mixed, the substance should seem liquidy on top. Poke it with your finger to make sure. Now pour a little into your hand, squeeze, and release. Have fun, but if the ooblech seems to be drying out, add a little more water.

The forces of attraction between the starch molecules and the water vary with the amount of applied pressure. When are the attractive forces strongest? When are they weakest? Does yours look different than the rest of the "homemade" goodies?

Flubber

Ingredients:

- large container
- 1 cup of water
- white glue
- 2 tsp. borax

Directions:

In the container mix the water and the borax. Add the glue. The more glue you add, the bigger the glob will be. Stir well. After a minute, pick up the glob and mush it in your hand, mixing in any pockets of glue left. If you roll it in a ball, you can bounce it on the floor. Did you get a different result than the GOOP? Does yours look different than the rest of the "homemade" goodies?

Homemade Slime

Ingredients:

- Borax
- White glue
- Water
- Ziploc bag

Directions:

Take one cup of water and add to it 1 tablespoon of borax. Stir until complete dissolved.

Make a 50% water, 50% glue solution. Take $\frac{1}{4}$ cup of each and mix thoroughly.

In a Ziploc bag, add equal parts of the borax solution to equal parts of the glue solution. $\frac{1}{2}$ cup of each will make a cup of slime. Seal bag and knead the mixture. Dig in and have fun.

The borax is acting as a cross-linking agent or connector for the glue (polyvinyl acetate) molecules. Once the glue molecules join together to form even larger molecules called polymers, you get a thickened gel very similar to slime. Look at the other "homemade" goodies. How does yours compare?

The Winner Is!

Find out which chewing gum has the longest lasting flavor. You will need:

- 1 piece of fruity flavored bubble gum
- 1 stick of mint flavored gum
- 1 stick of cinnamon flavored gum
- 1 stopwatch

Step 1 – Observe that your three pieces of gum all have different sizes and smells.

Step 2 – Hypothesize - Based on your observations, make a guess at which flavor of gum will last the longest.

Step 3 – Test the Hypothesis - Conduct an experiment. Have a partner time you while you chew on one piece. Say “stop” when you can’t taste its flavor any longer. Record the time that it took for that particular piece of gum to lose flavor. Repeat Step 3 with the other two pieces of gum and compare the data. Which flavor lasts the longest? Was your hypothesis correct? Why or why not?

You may wish to use the following table for students to document their results.

Which Lasts Longer?

Rate each of the types of chewing gum based on flavor, texture, and long-lasting taste based on a scale of 1 to 5. Where 1 is poor and 5 is excellent. Include the length of time each flavor lasted.

Characteristics	Gum #1	Gum #2	Gum #3
Texture			
Smell			
Flavor			
How long did the flavor last?			

Scale: 1 – 5 where 1 is poor and 5 is excellent

Raw or Cooked?

Find out which spins the longest, a raw egg or a cooked egg. For this experiment, you will need:

- 1 cooked egg
- 1 raw egg
- 1 plate

Step 1 – Observe the two eggs.

Step 2 – Hypothesize - Based on your observations, make a guess as to which egg will spin the longest and why.

Step 3 – Test the Hypothesis - Spin each egg in turn on a plate. The egg that continues to spin for a longer time is the cooked one. Now spin the eggs again, and then quickly stop both of them. Then let go of both eggs. You will see that the cooked egg stays still but the raw one starts spinning again.

Why Does This Happen?

The contents of the egg have more inertia when they are raw, because they are in the form of a liquid. This inertia slows down the raw egg and that is why it stopped spinning before the cooked egg. In step 2, the liquid in the raw egg was still moving when you stopped both eggs, so that movement made the raw egg begin to spin again.

Friction

Which is easier to spin – a smoother ball or a less smooth ball? For this experiment, you will need:

- A bowl of water
- Smooth rubber ball
- Tennis ball

Step 1 – Observe the two types of balls.

Step 2 – Hypothesize - Based on your observations, make a guess as to which ball will spin the longest and why.

Step 3 – Test the Hypothesis - Try spinning the rubber ball in the water. Next spin the tennis ball in the water. Which one is easier to spin? The smoother ball is easier to spin because the smooth surface causes less friction with the water.

Bernoulli Effect

Experiment 1: Flying Paper Strips

Using the ruler, measure and cut out strips of paper about 2 inches wide and 6 inches long.

Hold the shortest end just under your mouth and blow over the paper. What happened?

What do you think will happen if you change the size of the paper?

Do you think the shape of the strip of paper is important? Try experimenting. Do you think the experiment will always work?

Experiment 2: The Swinging Ping-Pong Balls

Step 1: Use the ruler to measure and cut two thin pieces of string 12 inches long.

Step 2: Tape a ping-pong ball to one end of the string.

Step 3: Tape the other end of the string to the ruler.

Step 4: Repeat steps 2 and 3 by taping a second piece of string and the ping-pong ball to the ruler. The ping-pong balls should be hanging about 1 inch apart on the ruler.

Hold the ruler up so that the balls hang freely.

What do you think will happen if you blow in between the two balls? Try it! What did you see happen?

Source: Air and Lift. The Bernoulli Effect. Retrieved from the World Wide Web on at: <http://www.rmsc.org/museum/kidsclub/experiments/airplay/airplay1b.htm>.

Copper Caper – Teaching Chemical Reactions

- 20 dull, dirty pennies
- ¼ cup white vinegar
- 1 teaspoon salt
- Clear shallow bowl (not metal)
- 2 clean steel nails
- Clean steel screw or bolt
- Paper towels

Put the salt and vinegar in the bowl. Stir until the salt dissolves.

Dip one penny halfway into the liquid. Hold it there for about 10 seconds, and then pull it out. Ask students what they see.

Dump all of the pennies into the liquid. You can watch them change for the first few seconds. After that you won't see anything happen.

After 5 minutes, take half of the pennies out of the liquid. Put them on a paper towel to dry.

Take the rest of the pennies out of the liquid. Rinse them really well under running water and put them on a paper towel to dry. Write "rinsed" on the second paper towel.

Put a nail and a screw into the liquid. Lean another nail against the side of the bowl so that only part of it is in the liquid.

After 10 minutes, take a look at the nails. Are they a different color than they were before? Is the leaning nail 2 different colors? If not, leave the nails in the bowl and check on them again in an hour or so.

What's happening to the screw? You may see lots and lots of fizzing bubbles coming from the threads. Leave it in the liquid for a while and see what happens.

After about an hour, look at the pennies on the paper towels. Ask students what happened to the rinsed ones. What happened to the others? What color is the paper towel under the unrinsed pennies?

What's Going On?

Discuss with students that everything is made up of tiny particles called atoms. Some things are made up of one type of atom, such as the copper of a penny is made up of copper atoms. However, sometimes atoms join to make molecules. Copper atoms can combine with oxygen atoms from the air to make a molecule called copper oxide. The pennies looked dull and dirty because they were covered with copper oxide.

Vinegar and salt cleaned the pennies because copper oxide dissolves in acid. The unrinsed pennies turned green because the copper atoms joined oxygen from the air and chlorine from the salt to make a blue-green compound called malachite. The nail and screw got coated with copper because of the action of protons, neutrons, and electrons or to put it another way – the action of positively and negatively charged particles. The bubbles are the result of hydrogen gas – another chemical reaction.

Can You Score?

Take an empty, 2-liter soda bottle and lay it on its side. Ball up a small piece of paper so that it will fit through the mouth of the bottle. Hold a hair dryer so it blows directly on the mouth of the bottle. Try to push the paper into the bottle using the air stream from the hair dryer.

Have students guess what will happen.

Answer: The paper won't go into the bottle because you are aiming the air stream at the mouth of the bottle. The hair dryer pushes air into the bottle, filling it with air. The bottle is so full of air that there is room for nothing else. If you turn off the hair dryer or aim it away, the air can escape the bottle and there is room for the paper

Galileo's Free Fall – The Power of Gravity

Place newspapers on the floor around a chair.

Stand on the chair while your partner lies on the floor peering at the newspaper.

Hold 2 oranges in each hand. Extend your arms straight out in front of your body (and over the newspapers) so that each orange is the same height from the floor. Let go of both oranges at the same time. Did they hit the newspaper at roughly the same time?

Now stand in the same position but this time hold an orange in one hand and a grape (or some other small object) in the other hand. Let go of both of these objects at the same time.

Hypothesize which will hit the newspaper first.

Most people would have guessed that the orange would hit the floor first, but gravity pulls all objects at the same speed regardless of their weight. Note: Air resistance influences this somewhat so for more accurate results you would need to do this experiment in a vacuum.

How Large Is an Atom?

Creating life-size models is an excellent strategy for teaching science concepts. To assist students in comprehending the size of atoms, have them complete the following activity.

Materials:

- 1 strip of paper 28 centimeters (11 inches long)
- 1 pair of scissors

Have students take the strip of paper and cut it into equal halves. Have them cut one of the remaining pieces of the paper into equal halves. Have students continue to cut the strip into equal halves as many times as they can. Make sure that all cuts are parallel to the first one. When the width gets longer than the length, they can cut off the excess, but that does not count as a cut.

How far did they get? Is there anything smaller than an atom? Yes, the size of an atom nucleus would take about 41 cuts. We can not see anything smaller than an atom with our eyes, even with the electron microscope. Yet, scientists use advanced technology to explore the world of electrons and quarks that are 9,000 times smaller than a nucleus.

How Far Did You Get? Here are some comparisons to think about as you are cutting.			
Cut 1	14.0 cm	5.5"	Child's hand, pockets
Cut 2	7.0 cm	2.75"	Fingers, ears, toes
Cut 3	3.5 cm	1.38"	Watch, mushroom, eye
Cut 4	1.75 cm	.69"	Keyboard keys, rings, insects
Cut 6	.44 cm	.17"	Poppy seeds
Cut 8	1mm	.04"	Thread. Congratulations if you are still in!
Cut 10	.25 mm	.01"	Still cutting? Most have quit by now.
Cut 12	.06 mm	.002"	Microscopic range, human hair
Cut 14	.015 mm	.006"	Width of paper, microchip components
Cut 18	1 micron	.0004"	Water purification openings, bacteria
Cut 19	.5 micron	.000018"	Visible light waves
Cut 24	.015 micron	.0000006"	Electron microscope range, membranes
Cut 31	.0001 micron	.000000045"	The size of an atom!

Retrieved from the World Wide Web at: <http://www.miamisci.org/af/>.

The Effects of Acid on Calcium

Have students hypothesize what they think vinegar will do to the following items

- A wishbone from a chicken, a piece of egg shell, or an old baby tooth
- A glass jar
- Vinegar

Put some vinegar into a glass jar.

Add the bone, shell, or tooth to the vinegar and leave it standing for a few days.

After a few days, check on your jar. There will be no egg shell left at all! A tooth will take longer to disappear. A chicken wishbone will become rubbery after about a week. This occurs because vinegar contains acetic acid which dissolves the calcium. Egg shells and teeth are made up of primarily calcium so they will eventually disappear. When the calcium is dissolved from the chicken bone, all that is left is a substance called collagen.

Which Paper Towel Absorbs the Most Water

Have students divide into small groups of three to four students. Provide each student with different rolls of paper towels (different brands and quality) and cups of water. Have them predict which towel will absorb the most water and why. Have them conduct the experiment and develop a short one-minute commercial that delivers their findings.

Hypothesis: Which paper towel will absorb the most water?

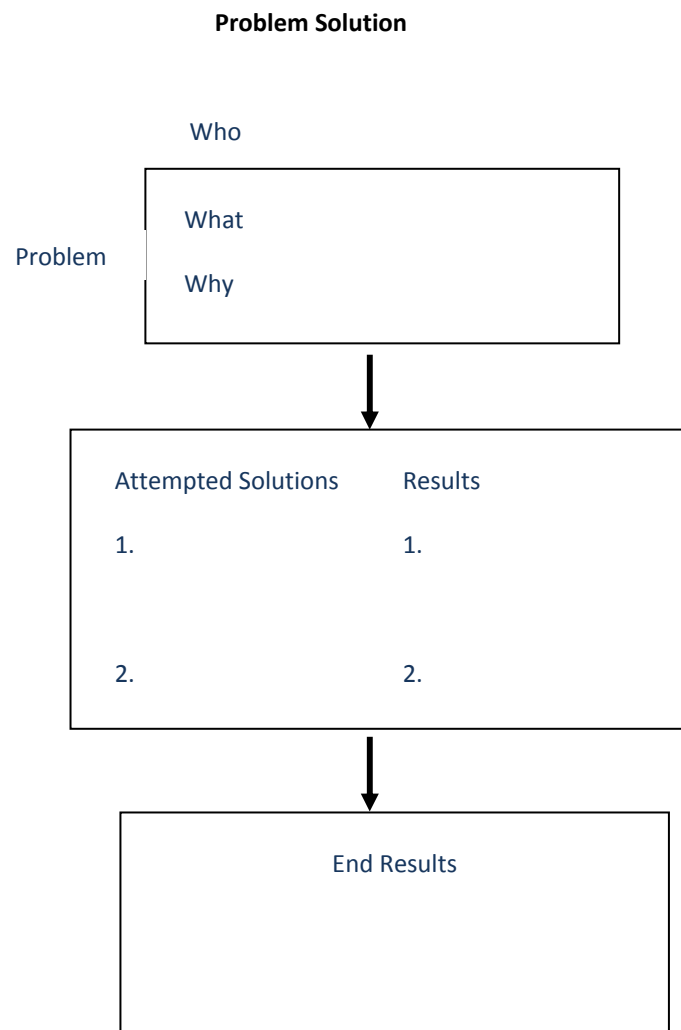
Why?

	Observations
Paper Towel A	
Paper Towel B	
Paper Towel C	

What results can be drawn from the experiment?

Problem Solution

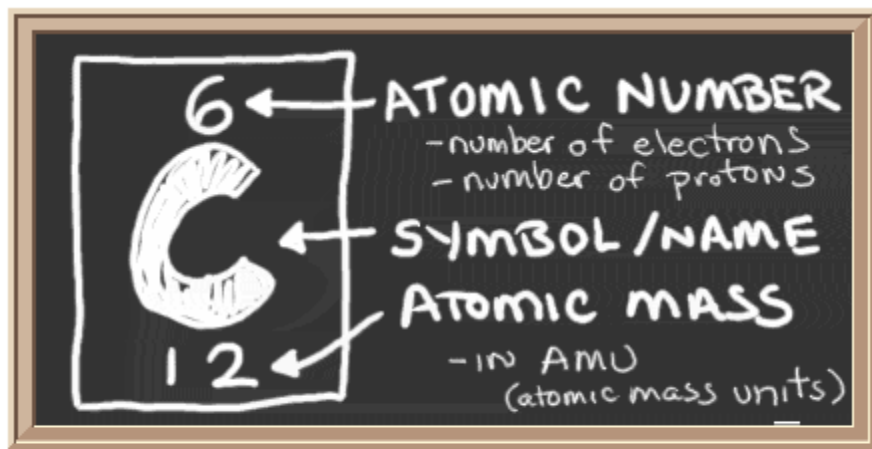
Problem/Solution requires students to identify a problem and consider multiple solutions and possible results. This is a good organizer to use as you are beginning to teach students the Scientific Method.



TEACHING GRAPHICS – THE PERIODIC TABLE

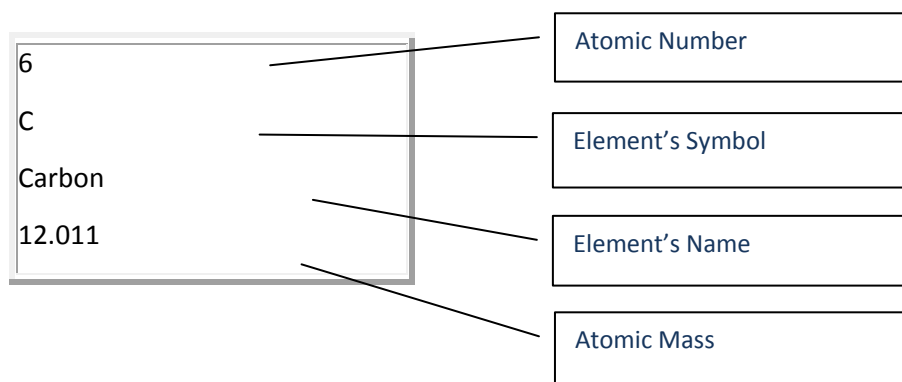
Periodic Table of the Elements

1A (1)	2A (2)												3A (13)	4A (14)	5A (15)	6A (16)	7A (17)	8A (18)
1 H	2 Li												B	C	N	O	F	He
3 Na	4 Mg	3B (3)	4B (4)	5B (5)	6B (6)	7B (7)	8B (8)	9B (9)	10B (10)	11B (11)	12B (12)		Al	Si	P	S	Cl	Ar
4 K	5 Ca	6 Sc	7 Ti	8 V	9 Cr	10 Mn	11 Fe	12 Co	13 Ni	14 Cu	15 Zn		Ga	Ge	As	Se	Br	Kr
5 Rb	6 Sr	7 Y	8 Zr	9 Nb	10 Mo	11 Tc	12 Ru	13 Rh	14 Pd	15 Ag	16 Cd		In	Sn	Sb	Te	I	Xe
6 Cs	7 Ba	8 Lu	9 Hf	10 Ta	11 W	12 Re	13 Os	14 Ir	15 Pt	16 Au	17 Hg		Tl	Pb	Bi	Po	At	Rn
7 Fr	8 Ra	9 Lr	10 Rf	11 Db	12 Sg	13 Bh	14 Hs	15 Mt	16 Uun	17 Uuu	18 Uub		Uut	Uuq	Uup	Uuh	Uus	Uuo
lanthanides		La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb			
actinides		Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No			



Reading a Periodic Table

Reading a Periodic Table can be daunting for students unless they learn the basic format. Each box of the table represents a different element. Each box contains vital information about the element, including its name, symbol, atomic number, and atomic mass. The chart below provides the basics of reading the Periodic Table.



The top number is the atomic number. Every element has its own unique atomic number. The atomic number tells how many protons are in one atom of that element. Since no two elements have the same atomic number, no two elements have the same number of protons.

The large letter is the element's symbol and just below that is the element's name. Each element has its own unique symbol and name. It is often very useful to memorize symbols and names for elements, especially the more commonly used elements.

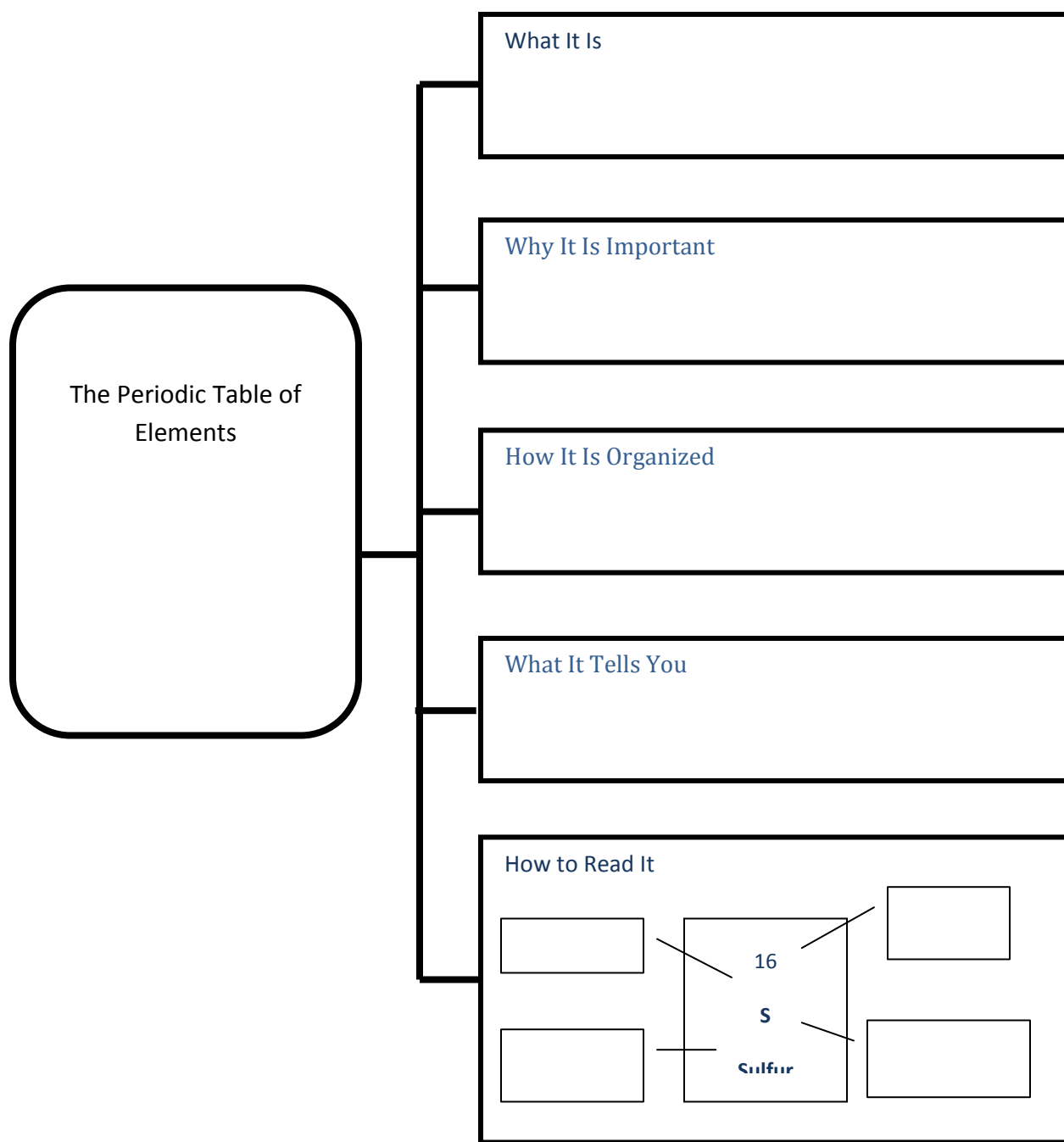
Below the name is the element's atomic mass. The atomic mass is the mass in atomic mass units for all possible isotopes of that element. The atomic mass essentially gives you an estimate of how massive one atom of that element is.

The following page provides a graphic organizer for students to complete to assess their knowledge of the Periodic Table.

The Periodic Table of Elements

Introduction: An element is a substance that contains only one kind of atom. Understanding elements is important to understanding the nature of the universe. Because there are so many elements, scientists use a Periodic Table to organize them.

Directions: Use your notes, textbook, and other appropriate resources to complete the graphic organizer.



Anticipation/Reaction Guide

This type of graphic organizer assists students in assessing their prior knowledge and then revisiting this knowledge after they have read an assignment on the topic. Write in statements about the topic with which you want your students to agree or disagree. Because of so many preconceptions and misconceptions about science, this is a great strategy to see if a student's idea about a topic changes after being presented with science-based information. An example may be the topic of dinosaurs. One statement could be: Some dinosaurs are named for places in which their fossilized remains were found. Students would need to agree or disagree with the statement.

Anticipation/Reaction Guide

Instruction: Respond to each statement twice – once before the science lesson is read and again after reading it. Be prepared to defend your decision.

- Write an A if you agree with the statement.
- Write a D if you disagree with the statement.

Response Before Lesson	Topic:	Response After Lesson

Activity Sheet for Assessing Student Understanding

Activity Sheet

Name: _____

Date: _____

What did you see happening?

What are at least two reasons you can think of for what you observed?

1. _____

2. _____

3. _____

Sample KWL Strategy with Inquiry for Physical Science

Approaches to Exploring Balls and Ramps

Below are some materials and strategies for inviting people to explore the way things roll. A wide range of questions and problems may be explored, depending on the variety of materials provided, the wording of initial questions, and the interests of students.

Materials:

- Variety of balls, marbles, other rolling objects (cylinders, cars, etc.)
- Tubes: cardboard (paper towels, toilet paper, wrapping paper, etc.; some cut lengthwise, some whole); plastic; other
- "Ramps": pieces of foam core, cardboard; boards or long blocks, etc.
- Blocks or other materials for support; masking tape, scissors.

1. K-W-L Strategy:

- a. Ask students what they know about balls and how they roll; record responses on a large chart headed "What we Know." You might ask about the evidence they have for what they know.
- b. Under the next category, "What We Want to Know," record questions students would like to find out about. Ask "How could we find out about that?" "What would be evidence?" "Which questions could we find out about using the materials we have here?"
- c. Students plan and carry out investigations of their questions.
- d. Record results in chart section headed "What We Learned." Encourage students to recognize and record things they're still not sure about, or new questions still to be explored.

2. Problem/Challenge: Use these materials to: make a ball move around a corner, up a hill, down a ramp as slowly as possible. . .

3. Open Inquiry/Exploration: Find out whatever you can about how these materials interact, how balls roll/bounce, what influences the speed and distance of a rolling ball . . .

Reflection

What did you learn from this approach?

How would you compare your feelings/thoughts/experiences during exploration with your feelings/thoughts/experiences during more traditional learning experiences?

What do you think might be advantages and disadvantages of this approach for teachers and students?

SCIENCE WEBSITES

From videos to content knowledge to fun activities and experiments, the Internet is an incredible resource for teachers and for students. The following science sites are filled with great information. It is recommended that teachers review each site to determine whether or not the site meets the needs of the particular learning environment. Please note that some sites are intended specifically for teachers to refresh their own skills in Science or to obtain handouts that can be used as practice activities in the classroom.

All websites reviewed April 2009.

ABC Science	News, video clips, games, and lots of activities for the science classroom from the American Broadcasting Company.	http://www.abc.net.au/science/
Access Excellence	The National Health Museum. Interactive sites about real-life science. Students can hypothesize an answer, watch the clip, and then see whether or not they predicted correctly. Great graphics, a virtual microscope.	http://www.accessexcellence.org/
American Museum of Natural History	Lots of different information on the “ology” of science, such as astronomy, archeology, etc. from the American Museum of Natural History.	http://ology.amnh.org/index.html
Analytical Chemistry from Umeå University, Sweden	Lots of great websites on chemistry, plus some fun ones like the T.W.I.N.K.I.E.S. Project. Includes lectures and materials for all levels of chemistry.	http://www.anachem.umu.se/eks/pointers.htm
Annenberg/CPB Amusement Park Physics	Learn about science behind merry-go-rounds, roller coasters, bumper cars and more.	http://www.learner.org/exhibits/parkphysics/coaster/
Annenberg: The Habitable Planet	The Habitable Planet is a multimedia course for high school teachers and adult learners interested in studying environmental science. The Web site provides access to course content and activities developed by leading scientists and researchers in the field.	http://www.learner.org/channel/courses/envsci/index.html
Annenberg Science in Focus: Force and Motion	Explore science concepts in force and motion and come away with a deeper understanding that will help you engage your students in their own explorations. With science and education experts	http://www.learner.org/channel/workshops/force/

	as your guides, learn more about gravity, friction, air resistance, magnetism, and tension through activities, discussions, and demonstrations.	
Annenberg/CPG Weather	Learn what causes rain, thunder, tornadoes and more.	http://www.learner.org/exhibits/weather
Ask a Biologist	<i>Ask A Biologist</i> began in 1997 in the School of Life Sciences, Arizona State University. The site continues to be developed and is designed as an educational resource for students preK-12, and their teachers and parents. <i>Ask a Biologist</i> is visited by over 2,000 people every day.	http://askabiologist.asu.edu/
Bad Science by Alistair B. Fraser	This page is maintained by Alistair B. Fraser in an attempt to sensitize teachers and students to examples of the bad science often taught in schools, universities, and offered in popular articles and even textbooks.	http://www.ems.psu.edu/~fraser/BadScience.html
BBC Science	From space to the human body to, this interactive site allows learners to discover many different facets of science.	http://www.bbc.co.uk/sn/
Bill Nye the Science Guy	A site devoted to science and Bill Nye's television show	http://www.billnye.com/
Biology 4Kids	This is the place to go to learn about cells, chemistry, physics, and geography. Although the title says for kids, the handouts and information are great for anyone.	http://www.biology4kids.com/index.html
Boston Museum of Science	These online exhibits cover a wide range of science topics, from Aging and Ice to Robots and Weather.	http://www.mos.org/
Brain POP	There are tons of online cartoons videos to watch and fun quizzes to take. <i>There is a fee for this site.</i>	http://www.brainpop.com/
Cells Alive	This site can be used by teachers and students. Lots of great interactivity and resources on the basics of cells.	http://www.cellsalive.com/toc.htm

Chem4Kids /Biology4Kids/Physics for Kids	Designed for students, covering basic topics in the areas of chemistry, biology, and physics. Great overview of the topics with reading materials, activities, and games.	http://www.chem4kids.com/ http://www.biology4kids.com/ http://www.physics4kids.com/
ChemWeb OnLine	An overview of the basics of chemistry as developed by a high school student. Good graphics and easy to understand text.	http://library.thinkquest.org/10429/high/indexh.htm
Discovery Kids	Although the site is developed for kids, there are lots of fun activities and games for all. The Yuckiest Site on the Internet may not be for everyone, but may provide students with a laugh, while learning a little about science.	http://kids.discovery.com/
Delights of Chemistry University of Leeds. Department of Chemistry.	This is a collection of three dozen experiments and demonstrations, two photo libraries and streaming chemistry video.	http://www.chem.leeds.ac.uk/delights/
Discovery Channel	The website has lots more information than even the channel. Lots of interactivity with excellent videos, interactivity, and high-level games.	http://www.discovery.com/
Earth Floor: Biomes	Virtual tour of a tropical rain forest, tropical savannah, mid-latitude deciduous forest, desert, subarctic taiga and polar tundra.	http://www.cotf.edu/ete/modules/mseese/earthsysflr/biomes.html
Educational Innovations	Science teacher materials to use in the classroom.	http://www.teachersource.com/
Educators' Bridge University for Atmospheric Research.	Resources and lessons for all levels of science.	http://www.eo.ucar.edu/educators/index.html
Eisenhower National Clearinghouse	Resources on math and science research and education. <i>Fee based service.</i>	http://www.goenc.com/subscribe/
Environmental News Network	The latest information on the environment. Good source of information and graphics.	http://www.enn.com/
Everyday Chemistry	Information on things that surround us each day from About.com – all from the world of chemistry.	http://chemistry.about.com/od/everydaychemistry/
Exploratorium Online	Since 1993, the Exploratorium was one of the first science museums to build a site on the World Wide Web. The site contains over 15,000 articles and displays including interactivity regarding science.	http://www.exploratorium.edu/ Exploratorium Online Exhibits – Optical Illusions http://www.exploratorium.edu/exhibits/f_exhibits.html

Extreme Science	Ever wondered what the biggest, the baddest, and the best are in the natural world? This is the place to find out and to learn about the latest in science and technology.	http://www.extremescience.com
Fear of Physics Basic	Information on physics concepts with interactive activities. Great site with easy to understand explanations of such things as "Why Satellites Don't Fall!", "First One Down" "the G Factor", etc.	http://www.fearofphysics.com/
First Science	Includes science articles, games, science cams on the web, science crossword puzzles, even science poetry and cartoons.	http://www.firstscience.com/site/home.asp
Franklin Institute	Excellent collection of online resources and activities designed to create curiosity and promote science in everyday life.	http://www.fi.edu/explore.html Math and Computer Science http://sln.fi.edu/tfi/hotlists/math.html Earth Science http://sln.fi.edu/tfi/hotlists/geology.html Health http://sln.fi.edu/tfi/hotlists/health.html Physical Science http://sln.fi.edu/tfi/hotlists/physical.html Space Science http://sln.fi.edu/tfi/hotlists/space.html Weather Science http://sln.fi.edu/tfi/hotlists/weather.html Weekly Science News http://sln.fi.edu/tfi/hotlists/sciencenews.html
Fun Brain	ProTon Don is an online interactive game on the periodic table.	http://www.funbrain.com/periodic/index.html
Fun Science Gallery	Games, activities, and fun things to do with science.	http://www.funsci.com/index.htm
Gallery of Auroras	Fantastic images of the auroral displays.	http://www.teachersdomain.org/3-5/sci/ess/eiu/auroras/index.html
General Chemistry Online	Information from a chemistry course. Includes a free newsletter.	http://antoine.frostburg.edu/chem/senese/101/index.shtml

How Everyday Things Are Made	Developed by the Alliance for Innovative Manufacturing this series of short videos also include questions for students.	http://manufacturing.stanford.edu/hetm.html
How Things Work	This site is geared towards adults and high school students. It shows you how lots of things work, like cds and engines.	http://www.howthingswork.com
Inventions National Geographic	Sponsored by National Geographic, this site invites students to test out the workings of a new contraption while working through five different activities.	http://www.nationalgeographic.com/features/96/inventions/
Invention Dimension from the Massachusetts Institute of Technology	Invention Dimension is a fun-filled and at times wacky approach to making learning about invention exciting for the kid in all of us. Have some fun with the invention games and explore the wealth of inventor and invention resources, including inventor profiles and patent guidelines.	http://web.mit.edu/invent/invent-main.html
Lawrence Hall of Science University of California, Berkeley	Great site for materials, lessons, and even online experiments for all ages.	http://www.lawrencehallofscience.org/lhshome.html
Mad Sci Network	The laboratory that never sleeps! Great database full of questions answered by scientists who are experts in their field from the Washington University at St. Louis. Includes experiments as well.	http://www.madsci.org/
Make a Splash with Color	Information on light theory in three sections: Talking about Color, The Lighter Side of Color, and An Eye on Color.	http://www.thetech.org/exhibits_events/online/color/intro/
Making Waves	Guide to sound and electromagnetic radiation including Sound, Radio, Microwave, Infrared and Ultraviolet Light, Lasers, X - Rays, and Gamma Rays. Created by students.	http://www.smgael.org/physics/home.htm
MEDtropolis/Columbia Virtual Body	A website built for the latest health information that will educate and entertain. Site has information, as well as activities and games for exploration. Excellent Shockwave-based interactive	http://www.medtropolis.com/ Columbia Virtual Body http://www.medtropolis.com/VBody.asp

	tour of the human body includes such activities as “Organize Your Organs” and “Build a Skeleton.”	
Mr. Parks Biology Songs	Includes science songs – listen if you dare.	http://whhs.guhsd.net/park/biosongs.html
Museum of Science, Art and Human Perception	A wealth of hands-on and exploration in the world of science. Displays change frequently.	http://www.exploratorium.edu
Museum of Science, Boston	Visit an electricity, fractal, and electron microscope exhibit, among others, online.	http://www.mos.org/events_activities/virtual_exhibits
Nanoworld Image Gallery	High quality magnified microscopic images of blood, cells, animals, diseases, microbes, pollen, yeast, molds and plant and animal tissue. Fun to test your knowledge about what some of the images are.	http://www.uq.edu.au/nanoworld/images_1.html
Neptune's Web	Sponsored by the Naval Meteorology and Oceanography Command: facts, quizzes, searches, ask an oceanographer, teacher resources.	http://pao.cnmoc.navy.mil/Educate/Neptune/Neptune.htm
NASA Home Page	Offers a wealth of information including information on recent and ongoing space probes such as the Mars and Jupiter explorations.	http://www.nasa.gov/home/index.html
NASA's Origins	Exploration of outer space and “new” planets.	http://origins.jpl.nasa.gov/
NASA's Quest	Made for teachers and students, includes online projects and events which fill your classroom full of excitement and higher level thinking.	http://quest.arc.nasa.gov/
NASA Space Link	More of NASA's wealth: Briefs, Educator's Guides, Educational Programs, Wallsheets, Lithographs, Slide Sets and Videotapes.	http://www.nasa.gov/home/index.html?skipIntro=1
NASA Space Place	NASA's salute to elementary space science with an emphasis on hands-on activities that make sophisticated concepts meaningful.	http://spaceplace.jpl.nasa.gov/index.shtml
National Curriculum Science Resources	Covers all science topics with information, pictures, animations, quizzes, and glossaries.	http://www.schoolscience.co.uk/
National Earthquake Information Center	From U.S.G.S., this is an online archive of current and general earthquake data, as well as station codes and coordinates.	http://wwwneic.cr.usgs.gov/

National Science Teachers Association	The National Science Teachers Association is a professional organization of science teachers from kindergarten through college. Professional development, research, and resources are an integral part of this website.	http://www.nsta.org/
Newton's Apple	NEWTON'S APPLE is a production of Twin Cities Public Television from a grant from the 3M Foundation. The site is filled with free videos for use in many different areas.	http://www.newtonsapple.tv/
NOAA Education Advancing Environment Literacy (National Oceanic and Atmospheric Administration)	Great ideas and websites for teachers and students regarding weather and our world.	http://www.education.noaa.gov/
Science Friday: Making Science User Friendly, National Public Radio (NPR)	NPR's teaching materials to accompany the station's Science on Friday programs.	http://www.sciencefriday.com/
Oregon Museum of Science and Industry	From BusyTown and Engineer It to WaterWorks and Virtual Tours, this site offers all kinds of online experiences for experiencing Science.	http://www.oms.edu/explore/online.cfm
Ocean Planet Home Page	This Smithsonian exhibit looks at the power of the ocean and according to the site's opening comments "plumbs the depths of the watery world.	http://seawifs.gsfc.nasa.gov/ocean_planet.html
PBS: Science & Nature	Highlights and background information on every Science-based PBS program on the air; check out the Science for the Classroom link.	http://www.pbs.org/science/
Periodic Table of Comic Books James Holler and John P. Selegue Department of Chemistry. University of Kentucky	Takes the periodic table and uses comics that use this element in them. Very creative!	http://www.uky.edu/Projects/Chemcomics/
Periodic Table of Elements The University of Nottingham	Takes the periodic table and provides a short video on each element.	http://www.periodicvideos.com/#
Pfizer Fun Zone	A really cool place to learn all about science and people who work in specific fields.	http://www.pfizerfunzone.com/funzone/
pH Factor	This Miami Museum of Science site introduces	http://www.miamisci.org/ph/

	acids and bases to students.	
Physics Central Website of The American Physical Society	This site communicates the importance of latest physics research and the people who are doing it.	http://www.physicscentral.org/
Physics 2000	Beginner level information from ongoing physics workshop through Grants from the Colorado Commission on Higher Education and the National Science Foundation and the University of Colorado at Boulder. An interactive journey through modern physics, including segments on Einstein's Legacy and the Atomic Lab.	http://www.colorado.edu/physics/2000/index.pl
Project SkyMath: Making Mathematical Connections University Corporation for mathematical Research	The site provides ideas for using middle level math skills in science classes.	http://eo.ucar.edu/skymath/#SM
Reekos Mad Scientist Lab	Great experiments to do in the classroom with explanations of basic concepts attached.	http://www.spartechsoftware.com/reeko/
Science and Nature. BBC	This website from the British Broadcasting Company provides different activities and lessons in the area of natural science.	http://www.bbc.co.uk/sn/
Science Education Gateway	Organized lists of lessons and resources from museums and science organizations are included on this site.	http://cse.ssl.berkeley.edu/SEGway/educators.html
Science Friday	A site to "make science friendly" from the National Public Radio (NPR) station. Videos, podcasts, and lots of interesting ideas are available.	http://www.sciencefriday.com/videos/watch/10206
Science Junction North Carolina State University	Billed as a science cyber community for teachers, students, and researchers of science, this site seeks to make connections between science and everyday life. A great website filled with sites on all of the different types of science – from biology to chemistry to physics. Includes freeware and shareware. A nice science site with links for teachers and students alike.	http://www.ncsu.edu/sciencejunction/

Science Learning Network	A site which provides Internet exploration of science museums and resources for science educators. This site is devoted to scientific inquiry.	http://www.sln.org/
Science Man	A hub of science and technology information for student and teachers.	http://www.scienceman.com/
Science Master	Space science information for the classroom.	http://www.sciencemaster.com/space/space.php
Science Museum of Minnesota	Well-designed and nicely formatted original online exhibits and activities covering ten high-interest science topics.	http://www.smm.org/explorescience/websites/
Science Net	A well-compiled list of sites for students in the area of the sciences is provided on this site.	http://sciencenet.tpl.toronto.on.ca/english/welcome/welc_f.html?gatewayNo=11
Science Netlinks	Lesson plans with activities in all areas of science for K-12. Part of the Thinkfinity.	http://www.sciencenetlinks.com/
Science News Online	A science magazine that has been around for over 70 years.	http://www.sciencenews.org/
Science Now	Newsletter for science teachers published by UCAR and SIRS, Inc., an educational publisher.	http://www.proquestk12.com/curr/snow/snowtoc.htm
Science Odyssey	Lots of interactive stuff to do. Definitely visit the "You Try It" link.	http://www.pbs.org/wgbh/aso
Sci-Quest	E-solutions for science. Articles on biological, environmental, and physical science. Registration is required, but it is free.	http://www.sciquest.org.nz/
Science Song Center	Listen only if you dare! Fun science songs that can be downloaded for the classroom.	http://faculty.washington.edu/crowther/Misc/Songs/
Science-Teachers.com	The site is a teaching resource providing lesson plans, worksheets, and activities for upper elementary and middle school science teachers. All resources on this site are copy written, but are free to distribute to students in your classroom.	http://www.science-teachers.com/
Science 10 Resource Materials	This site contains classroom ready lessons on: water quality, chemical change, food additives, human nutrition, and science challenges.	http://www.saskschools.ca/curr_content/science10/index.html
Sea Web	A multimedia public education project designed to	http://www.seaweb.org/

	raise awareness of the world's oceans.	
Seeing, Hearing and Smelling the World	A multitude of science topics explored through an examination of the brain and our senses; sophisticated subject matter. Howard Hughes Medical Institute.	http://www.hhmi.org/senses/
Singing Science Songs	Singing Science Songs. Fun to access for an introduction to a science lesson.	http://www.acme.com/jef/singing_science/
Songs for Teaching Science	Lots of fun songs that can be downloaded for use in the classroom.	http://www.songsforteaching.com/sciencesongs.htm
Strange Matter	A traveling exhibition developed by the Ontario Science Centre and presented by the Materials Research Society with the support of the National Science Foundation. Lots of interesting materials on the "study of stuff."	http://www.strangematterexhibit.com/
Table of Elements	An already prepared drill on the Periodic Table is available.	http://www.edu4kids.com/chem/
Tanner's Topics: General Chemistry	A great overview of the basic areas of atoms, molecules, elements, physical chemistry, images, and solutions.	http://www.tannerm.com/
Teaching Science Matters (Invention Factory)	Supported by the Eisenhower Technology Grant in conjunction with the Science Education Consortium at Princeton University. Good ideas for all science classrooms.	http://www.inventionfactory.com/
Teachers' Domain	Resources for the classroom. Must register to use the site but it is free. Includes short audio and video files for use in the classroom.	http://www.teachersdomain.org/9-12/sci/ess/index.html
The Lab	The Lab is the Australian Broadcasting Corporation's online gateway to science, including original material, news, features and forums.	http://www.abc.net.au/science/default.htm
The Museum of Science and Industry, Chicago	This Web site is simply hours of fun and a wealth of information.	http://www.msichicago.org/
The Particle Adventure	Particle Data Group. U.S. Department of Energy. Available in different languages, this is a fun interactive site for students. Good materials, which	http://particleadventure.org/particleadventure/

	are free to download.	
The Physics Classroom	The Physics Classroom and Mathsoft Engineering & Education, Inc. Great information on how to teach basic physical principles in the classroom.	http://www.physicsclassroom.com/Default2.html
The Science House North Carolina State University.	Lots of materials and ideas from a science teach project.	http://www.science-house.org/
The Top Ten Sites	Choose your topic and go to the top ten sites as identified by the Exploratorium in California.	http://www.exploratorium.edu/learning_studio/sciencesites.html
The Visible Human Site	This is the site of the human man and woman with lots of graphics.	http://www.nlm.nih.gov/research/visible/visible_human.html
The Why Files	University of Wisconsin, Board of Regents. Real world articles to support all areas of science. Click on the "Why Files in Education."	http://whyfiles.org/teach/
Try Science New York Hall of Science	TryScience is a partnership between IBM Corporation, the New York Hall of Science (NYHOS), the Association of Science-Technology Centers (ASTC), and science centers worldwide. The site provides activities from over 400 science centers worldwide, including on and offline activities and experiments.	http://tryscience.org/home.html
USGS Learning Web	Friendly format presenting data and activities from the U.S.G.S.; check out FrogWatch and Exploring Caves.	http://www.usgs.gov/education/
Vision Learning	Lessons for the different competency areas of earth and space science. Lessons include graphics and can be viewed in Spanish.	http://www.visionlearning.com/index.php
Volcano World	Learn all about volcanoes!	http://www.volcanoworld.org
Weather Classroom	The Weather Classroom presents all kinds of online interactive resources for students and teachers; worth investigating.	http://www.weatherclassroom.com/index.php
Windows to the Universe	University Corporation for Atmospheric Research (UCAR) and the University of Michigan provide a great website for beginning, intermediate, and advanced levels of science. In both English and	http://www.windows.ucar.edu/ http://www.windows.ucar.edu/tour/link=/teacher_resources/main/activity.html&edu=high

	Spanish.	
Wonders of Physics	Aimed at generating interest in physics among people of all ages and backgrounds. The heart of the program is a fast-paced presentation of physics demonstrations carefully chosen to be entertaining as well as educational.	http://sprott.physics.wisc.edu/wop.htm
World Weather Project Department of Atmospheric Sciences (DAS) at the University of Illinois Urbana-Champaign (UIUC)	WW2010 (the weather world 2010 project) is a WWW framework for integrating current and archived weather data with multimedia instructional resources using new and innovative technologies.	http://ww2010.atmos.uiuc.edu/(Gh)/home.rxml

HANDS-ON SCIENCE EXPERIMENT WEBSITES

Although many of the websites listed above have experiments, demonstrations, graphics, activities, and lesson plans included, here are a few to get you started on "hands-on" experiences with science.

Dr. Matrix World of Science	This site is a partnership between IBM, the New York Hall of Science and the Association of Science-Technology Centers. It has dozens of experiments you can do at home, on-line interactive adventures, a guide to many science centers and science field trips, and live cams from many science and technology centers worldwide.	http://www.scientium.com/drmatrix/awards/
Edible/Inedible Experiments	Lots of experiments which are easy to use in any type of classroom.	http://www.madsci.org/experiments/
Exploratorium Cow's Eye Dissection	Watch the movies and view information on the eye. Includes directions for doing an actual dissection.	http://www.exploratorium.edu/learning_studio/cow_eye/
Exploratorium Snacks	Different edible experiments for the classroom.	http://www.exploratorium.edu/snacks/
Frog Dissection Net Frog	A free dissection system for use in the classroom.	http://curry.edschool.virginia.edu/go/frog/
Home Experiments	The name says it all as most products for these experiments are found in one's home.	http://scifun.chem.wisc.edu/HOMEEXPTS/HOMEEXPTS.HTML

Fun Science Gallery	The Fun Science Gallery provides practical experiments sure to motivate students to engage in science.	http://www.funsci.com/texts/index_en.htm
Funology Science Experiments	Science experiments that are fun and easy to implement in the areas of physics, chemistry, biology, and weather.	http://www.funology.com/laboratory/index.htm
Institute of Food Technology: Food Science Experiments	Use food to help teach science! The following experiments are designed for use in middle and senior high school science classes.	http://members.ift.org/IFT/Education/EduResources
Jefferson Lab	On line games, activities, and lessons for basic science areas.	http://education.jlab.org/
Little Shop of Physics – The Amazing Physics of Everyday Objects Colorado State University	The Little Shop of Physics is a collection of hands-on science experiments that are designed to be used by students at all grade levels, K-16.	http://littleshop.physics.colostate.edu/
Newton’s Apple	This site includes experiments and even streaming video showing demonstrations of a variety of scientific topics.	http://www.ktca.org/newtons/index.html
Nye Labs.com	This is indeed “Bill Nye, the science guy” with lots of activities and applications for science.	http://www.billnye.com
Reekos Mad Science Lab	Interesting information and applications for science.	http://www.spartechsoftware.com/reeko/
School for Champions	Physical science experiments.	http://www.school-for-champions.com/science/experiments.htm
Science Experiments You Can Do!	Easy science experiments that can be done with materials available around the house.	http://www.west.net/~science/expindx.htm
Science Hobbyist	Science experiments that are easy to do by adult students.	http://www.eskimo.com/~billb/
The Atoms Family Miami Museum of Science	Experiments regarding the study of atoms.	http://www.miamisci.org/af/sln/
TryScience/New York Hall of Science	Experiments online and with directions. Fun activities for all types of science.	http://www.tryscience.org