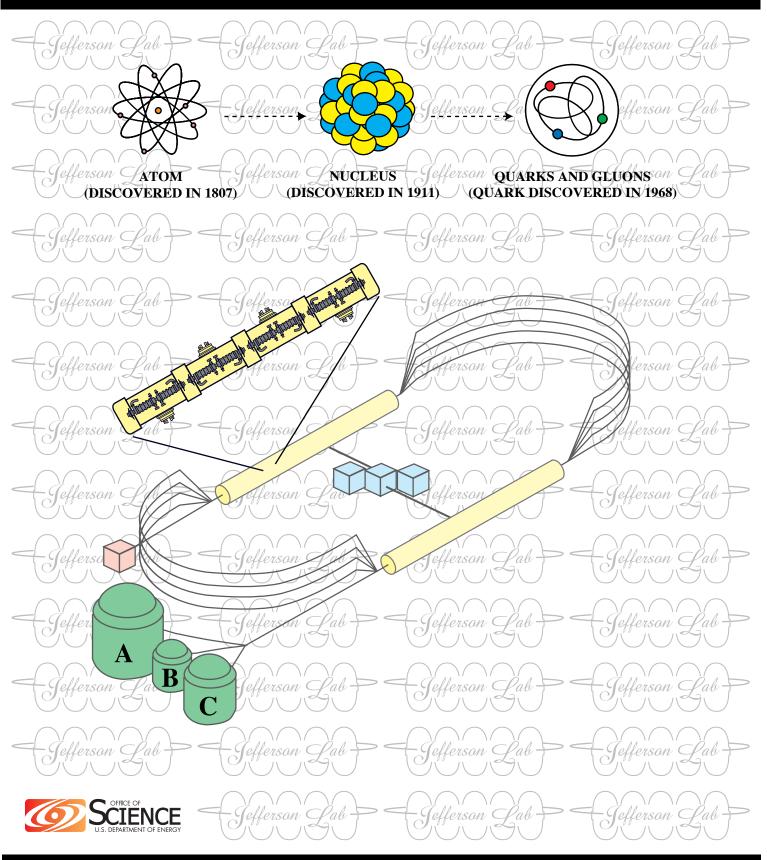
THOMAS JEFFERSON NATIONAL ACCELERATOR FACILITY



BEAMSBecoming Enthusiastic About Math and Science

_Teacher Handbook

What is BEAMS?

BEAMS stands for **B**ecoming **E**nthusiastic **A**bout **M**ath and **S**cience. This program is a partnership between your school district and Jefferson Lab.

You, your class and your teacher will visit Jefferson Lab everyday for one week. While here, you will conduct special science and math activities with some of the people who work at Jefferson Lab: scientists, engineers and technicians. You will also use other school subjects, like reading and writing.

- You should wear comfortable clothes and shoes to Jefferson Lab each day.
- Come prepared to have fun, work hard and be ready for a few surprises!
- We hope you enjoy your visit!

How to contact Jefferson Lab:

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BEAMS Week Companion Activities

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List of Activities

Activity	Description	Virginia State Standards of Learning
Atoms and Jefferson Lab	This is an overview of the structure of matter and Jefferson Lab's part in its exploration.	Science 6.5 Matter PS.2 Investigate and Understand the Basic Structure of Matter PS.3 Investigate and Understand Various Models of Atomic Structure
Vocabulary	Use these activities to familiarize your students with words and terms they will hear and use at Jefferson Lab.	English 6.3 Reading/Literature Science 6.5 Matter PS.4 Periodic Table of Elements
Pre-Visit Activities (Magnet Racing)	This is an activity in which students guide a set of marbles around a track with magnets.	Science 6.1 Plan and Conduct Investigations LS.1 Plan and Conduct Investigations PS.1 Plan and Conduct Investigations PS.11 Investigate and Understand Basic Principles of Electricity and Magnetism
Pre-Visit Activities (What's in the Bag?)	This is an activity in which students probe and identify a hidden object.	Science 6.1 Plan and Conduct Investigations Science 6.2 Demonstrate Scientific Reasoning and Logic LS.1 Plan and Conduct Investigations PS.1 Plan and Conduct Investigations
The Shape of Things	This is an activity in which students determine the shape of a hidden object	English 6.1 Oral Language Math 6.14 Geometry Math 6.16 Geometry Science 6.1 Plan and Conduct Investigations Science 6.2 Demonstrate Scientific Reasoning and Logic LS.1 Plan and Conduct Investigations PS.1 Plan and Conduct Investigations
Hot and Cold	This is an activity in which students observe the effects of temperature extremes.	Science 6.5 Matter Science 6.7 Matter PS.2 Investigate and Understand the Basic Structure of Matter PS.5 Investigate and Understand Changes in Matter PS.7 Investigate and Understand Temperature Scales, Heat and Heat Transfer PS.9 Investigate and Understand the Nature and Technological Applications of Light
Human Accelerator	This is an activity in which students simulate Jefferson Lab's accelerator by passing tennis balls down a straight line.	Math 6.1 Number and Number Sense Math 6.4 Number and Number Sense Science 6.1 Plan and Conduct Investigations Science 6.2 Demonstrate Scientific Reasoning and Logic LS.1 Plan and Conduct Investigations PS.1 Plan and Conduct Investigations
Cold Stuff	This is an activity in which students investigate different materials to determine which makes the best insulator.	Math 6.2 Number and Number Sense Math 6.18 Probability and Statistics Science 6.1 Plan and Conduct Investigations Science 6.2 Demonstrate Scientific Reasoning and Logic LS.1 Plan and Conduct Investigations PS.1 Plan and Conduct Investigations C/T8.1 Communicate Through Application Software

Activity	Description	Virginia State Standards of Learning
Jefferson Lab Treasure Hunt	This is an activity in which students take a tour of Jefferson Lab.	NA
Microscopes	This is an activity in which students observe objects with a microscope.	Science 6.1 Plan and Conduct Investigations
Technology	This is an activity in which students learn how the Internet can be used for different purposes.	C/T8.3 Understanding of Electronic Communications C/T8.4 Ability to Access, Retrieve and Analyze Data
Looking for the Top Quark	This is an activity in which students practice locating coordinates on a grid.	Math 6.5 Number and Number Sense Math 7.12 Geometry
Oobleck	This is an activity in which students explore the properties of a strange substance.	English 6.1 Oral Language English 6.7 Writing Science 6.1 Plan and Conduct Investigations LS.1 Plan and Conduct Investigations PS.1 Plan and Conduct Investigations PS.2 Matter PS.5 Matter
Electrostatics	This is an activity in which students observe the behavior of electrical charges.	Science 6.4 Matter PS.1 Plan and Conduct Investigations PS.11 Investigate and Understand Basic Principles of Electricity and Magnetism
Design and Engineering	This is an activity in which students work in teams to design and build aluminum boats that will carry the most cargo.	English 6.1 Oral Language Math 6.8 Computation and Estimation Science 6.1 Plan and Conduct Investigations LS.1 Plan and Conduct Investigations PS.1 Plan and Conduct Investigations
Magnets and Electromagnets	This is an activity in which students construct and test the strengths of two electromagnets.	Math 6.18 Probability and Statistics Science 6.1 Plan and Conduct Investigations LS.1 Plan and Conduct Investigations PS.1 Plan and Conduct Investigations PS.11 Investigate and Understand Basic Principles of Electricity and Magnetism
Role Model Visits	This is an activity in which students learn about careers at Jefferson Lab by interviewing Lab staff members.	NA

Atoms and Jefferson Lab

This is an overview of the structure of matter and Jefferson Lab's part in its exploration.

Objectives:

In this activity students will:

- learn how matter was understood in the past
- learn the structure of matter as it is understood today
- learn what Jefferson Lab is and how it studies matter

Travel Book Activities:

- What is Matter? p.4
- Introduction to Jefferson Lab p.6

Virginia State Standards of Learning

Science 6.4 Matter

• by understanding that atoms are made up of electrons, protons and neutrons

PS.2 Investigate and Understand the Basic Nature of Matter

• by understanding the particle theory of matter

PS.3 Investigate and Understand Various Models of Atomic Structure

• by understanding modern and historical models of the atom

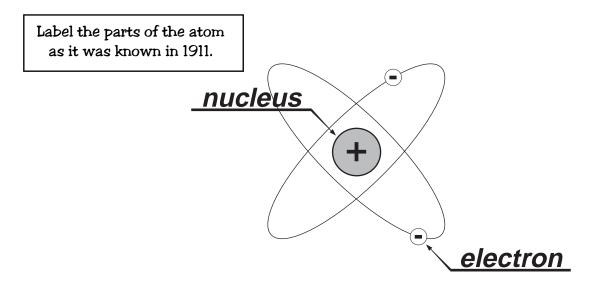
What is Matter?

Matter is anything that has mass. All objects are made of matter. Air, water, a brick, even you are made of matter!

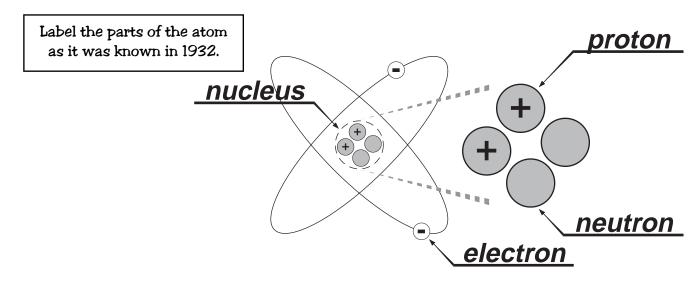
Matter is made up of smaller pieces.

Over ninety years ago, scientists thought that the atom was the smallest piece of matter. At that time, the atom was thought to be 'the building block of matter.'

In 1911, a scientist named Ernest Rutherford discovered that atoms are really made of a positively charged center called the **nucleus** orbited by negatively charged particles called **electrons**.

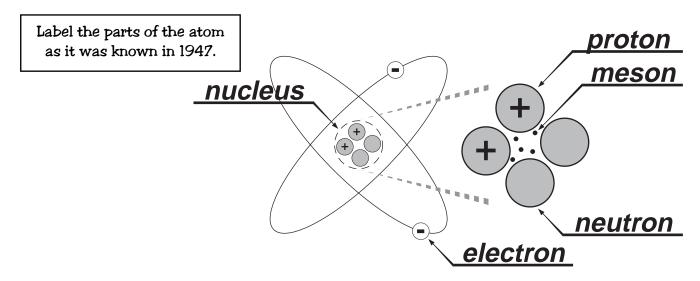


In 1932, scientists discovered that the nucleus of an atom is made of smaller particles called **protons** and **neutrons**. Protons carry a positive charge while neutrons have no charge at all. Protons and neutrons are each called nucleons since they are found in the nucleus. When they were discovered, scientists thought they were the smallest piece of matter.



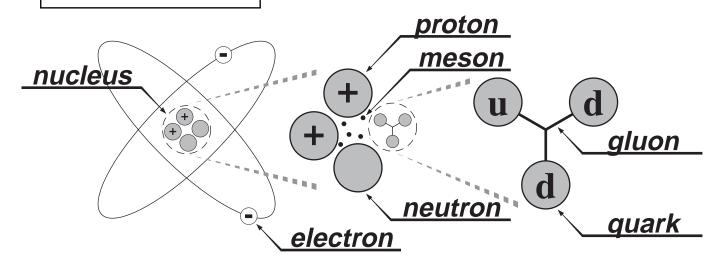
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Scientists know that opposite charges attract and like charges repel, so they wondered why the protons in the nucleus didn't fly apart. They found the answer in 1947 when they discovered other particles that they named **mesons**. Mesons hold the protons and neutrons together to form the nucleus.



As scientists did more experiments, they began to realize that there was something funny about protons and neutrons. In 1968 they discovered that protons and neutrons are made up of smaller particles they called **quarks**. Scientists discovered six different types of quarks: Up, Down, Strange, Charm, Top and Bottom. Protons have two Up quarks and one Down quark while neutrons have two Down quarks and one Up quark. Quarks are held to each other by particles scientists called **quons**.

Label the parts of the atom as it was known in 1968.



Some scientists now think that the quark is the smallest piece of matter. Scientists used to think that atoms were the smallest bit of matter, but they discovered that it wasn't. Do you think that the quark is the smallest piece of matter or do you think that there might be something smaller inside the quark?

Introduction to Jefferson Lab

What is Jefferson Lab?

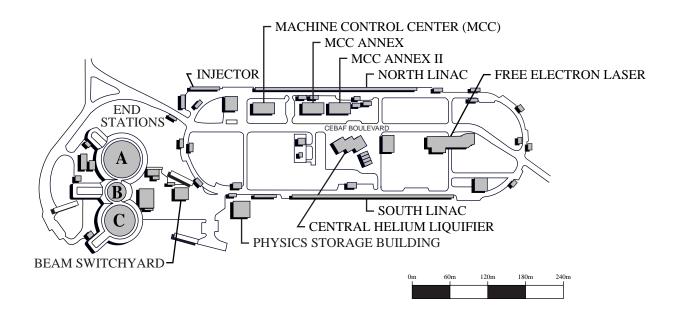
Jefferson Lab is a laboratory for basic research in nuclear physics. Nuclear physics is the science of studying the nucleus of the atom. Jefferson Lab also works with industry to develop technologies for businesses to use and with schools to motivate students and assist teachers.

Jefferson Lab's mission is to provide scientists around the world with opportunities to experiment with and learn more about nucleons.

Jefferson Lab's main instrument is a machine, called an accelerator, that is able to make electrons go really fast. The accelerator is in an underground, racetrack-shaped tunnel, 1.4 km around, that delivers a beam of electrons to experiments in three large experimental halls called end stations.

The facility is owned by the government's Department of Energy (DOE) and is managed by the Southeastern Universities Research Association (SURA). SURA is a group of 61 universities in fifteen southeastern states and the District of Columbia. SURA also manages other large research projects in the southeastern region of the United States.

About \$600 million was spent over ten years to build the facility in Newport News, Virginia. Scientists from around the world are currently using Jefferson Lab's accelerator for experiments to study the nucleus of the atom. These experiments can take months to run. Once scientists complete their work at the lab they must analyze the data they have gathered. What they find out may change what we know about the structure of nuclear matter, making Jefferson Lab a vital instrument of the scientific world.



Exploring Nuclei at Jefferson Lab

Over ninety years ago, scientists described the atom as a nucleus with orbiting electrons. Later, the nucleus was found to contain protons and neutrons (nucleons). Now each nucleon is seen as a collection of three quarks.

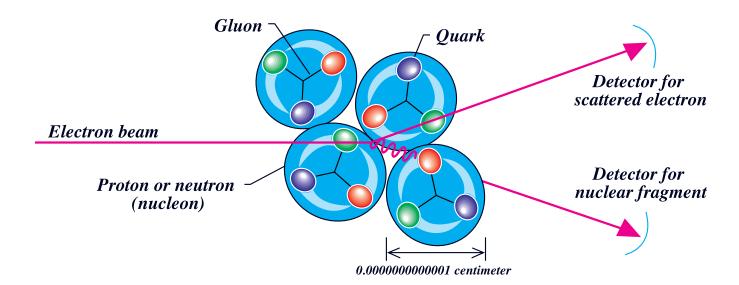
Scientists need Jefferson Lab to broaden their understanding of how quarks interact in the nucleus. Jefferson Lab provides scientists with beams of electron probes to explore the quark structure of the nucleus.

Point-like electrons can probe the nucleus with extreme accuracy. They interact cleanly with quarks in nuclear matter. The 'fingerprint' of each interaction - a deflected electron and one or more nuclear fragments - provides clues about the subnuclear world (see diagram below).

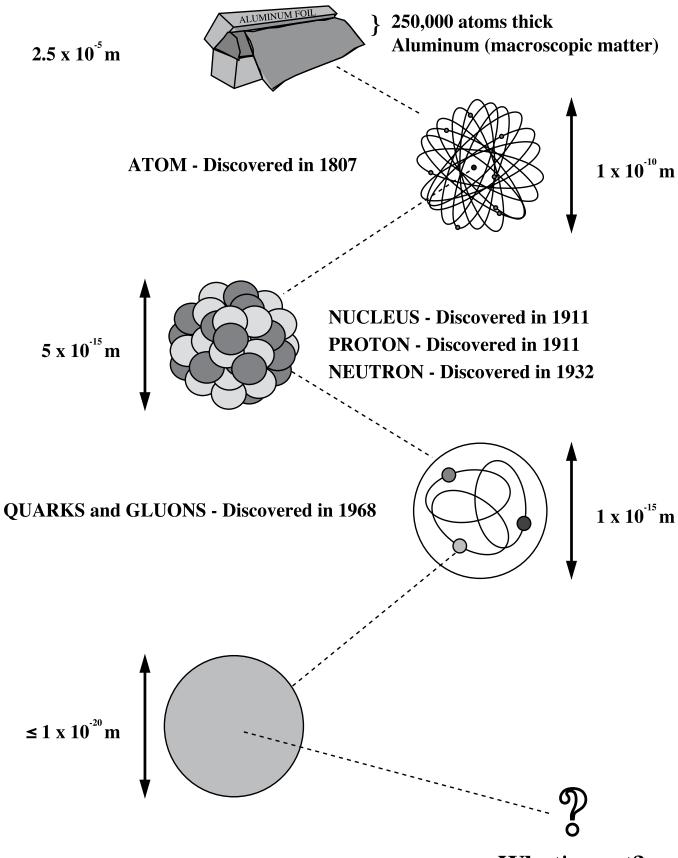
When the beam is directed through an experiment's target - typically a small, thin sheet of material whose nuclei are under study - unimaginably tiny electron-quark interactions result. The exact interactions are the 'fingerprints' of the experiment. These interactions are recorded automatically by spectrometers and detectors in the end stations. Collecting the thousands to millions of fingerprints required for each experiment may take weeks or even months. Later, aided by computers, nuclear physicists use this data to understand the mysteries of nuclear structure.

Studying the world of the very small requires equipment that is very large. Jefferson Lab's electron accelerator is 1.4 km around. The detectors used to 'watch' the experiments weigh thousands of tons each. Scientists use these huge machines to 'see' the quarks and gluons inside an atom's nucleus - particles that are less than 0.0000000000001 cm across!

The main goal of Jefferson Lab's scientific program is to understand the structure and behavior of the nucleus and its parts. Scientists use the electron accelerator to study how the nucleus and its pieces are put together and interact with each other. Jefferson Lab is like a powerful microscope used for studying the atom's nucleus.



How Scientists' Ideas About Matter Have Changed



Vocabulary

Use the following activities to familiarize your students with words and terms they will hear and use at Jefferson Lab.

Travel Book Activities:

- Vocabulary List p.16
- BEAMS BINGO p.23
- Element BINGO p.24
- Math Vocabulary BINGO p.26
- BEAMS Crossword Puzzle p.28
- BEAMS Cryptograph p.30
- BEAMS Word Search p.36
- Element Word Search p.37
- BEAMS Fractions p.38
- Scrambled Science Words p.39
- BEAMS Spelling Search p.40

Virginia State Standards of Learning

English 6.3 Reading/Literature

• by learning the meanings of unfamiliar words

Science 6.4 Matter

- by understanding that atoms are made up of electrons, protons and neutrons
- by understanding that atoms of any element are alike but are different from atoms of other elements

PS.4 Periodic Table of Elements

• by understanding symbols, atomic numbers and atomic mass

Vocabulary List

- Accelerate to speed up
- **Accelerator -** a machine which accelerates charged particles to high energies
- **Antimatter -** a form of matter that is composed of antiparticles
- Antiparticle a particle that has the same mass as another particle but has opposite values for other properties, such as electric charge (The positron is the antimatter counterpart to the electron. Positrons have the same mass as electrons, but carry a positive electric change.)
- **Atom -** the smallest unit of a chemical element, made up of a nucleus surrounded by electrons
- **Atomic Number -** the number of protons in the nucleus of an atom
- **Atomic Weight -** the average mass of an atom of an element measured relative to the mass of an atom of carbon-12
- **Beam -** a ray of light; a group of particles traveling together along a well-defined path
- **BEAMS** the acronym for Becoming Enthusiastic About Math and Science
- **Boiling Point -** the temperature at which a substance changes from a liquid to a gas
- **CEBAF** former name of Jefferson Lab; stands for Continuous Electron Beam Accelerator Facility
- **Celsius -** a temperature scale on which water freezes at 0° and boils at 100°
- **Charge** the amount of electricity carried by a body (A charge can be negative, like an electron, or positive, like a proton. Objects with opposite charges attract one another, while objects with like charges repel one another.)

- Chemical Change a change in the chemical composition of a substance to produce a new material with new properties (An example of a chemical change is wood turning to ash and smoke when it burns.)
- **Chemical Property -** a characteristic of a substance that determines how it will react with other substances
- **Chemical Reaction -** a chemical change in which one or more substances are changed into one or more new substances
- **Circuit -** a closed path through which an electric current flows
- **Colloidal Suspension -** a material that has properties of more than one state of matter, such as Jell-O
- **Compound** a substance composed of two or more elements, such as water (H_2O) , carbon dioxide (CO_2) , or table sugar $(C_{12}H_{22}O_{11})$
- **Computer -** a programmable machine that inputs, processes and outputs data
- **Coordinate -** a set of numbers that determines the location of a point in space
- **Condensation -** the process by which a gas changes to a liquid
- **Conduction -** the transportation of heat or electricity from one place to another directly through an object (A frying pan is warmed by a hot stove due to conduction.)
- **Conductor -** a material (like a metal) through which electricity and heat flow easily
- Continuous steady; uninterrupted
- **Convection -** the transportation of heat from one place to another by the movement of a liquid or gas (A classroom is warmed by a hot air blower due to convection.)
- **Cryogenics -** the science of very low temperatures, far below the freezing point of water

- **Data -** a group of measurements, facts or statistics
- **Density -** the amount of mass per unit volume (An object's density is calculated by dividing the object's mass by the object's volume. For example, a 10 gram object that occupies 2 cubic centimeters of space has a density of 5 g/cm³.)
- **Dependent Variable -** the responding variable; the variable that may change as a result of a change in the independent variable
- **Dew Point -** the temperature at which a gas condenses to form a liquid
- **Electric Current** movement of electricity, measured in charges per second (just as river current is measured in liters per second)
- **Electromagnet -** a wire coil around a metal core (usually iron) that acts like a magnet when an electric current flows through it
- **Electron -** a tiny particle with a negative charge which orbits an atom's nucleus
- Element any substance that cannot be broken up into simpler substances by chemical means (Currently 115 elements have been observed and are displayed on the Periodic Table of Elements. Gold, silver, iodine, oxygen and nickel are examples of elements.)
- **Energy** the capacity to do work
- **Engineer -** a person who uses science and math to design, build or operate equipment, structures and systems (A person who receives a college degree in engineering might be an electrical, mechanical, industrial, chemical, environmental, biochemical or aeronautical engineer.)
- **Evaporation -** the process by which a liquid changes to a gas
- **Experiment -** a series of actions carried out to test a theory, demonstrate a fact or find out what happens

- **FEL** stands for Free Electron Laser; a tunable laser made by wiggling a beam of electrons (Jefferson Lab's FEL is the most powerful in the world.)
- **Fahrenheit -** a temperature scale at which water freezes at 32° and boils at 212°
- **Force -** a push or pull (There are four basic forces: gravitational, electromagnetic, strong nuclear and weak nuclear.)
- **Freezing Point** the temperature at which a substance changes from a liquid to a soild
- **Gas -** a state of matter with no definite shape or volume, like air
- **Gluons** particles that hold quarks together
- **Graph -** information represented in the form of a picture, diagram or drawing
- **Grid** a pattern of horizontal and vertical lines forming squares of uniform size on a map or chart
- **Heat -** energy in the form of the random motion of an object's molecules
- **Helium -** a colorless, odorless, tasteless gas (Helium becomes a liquid near absolute zero. Liquid helium is used to cool Jefferson Lab's accelerator components.)
- **HTML** an acronym for HyperText Markup Language; the programming language or code used for the creation of internet web pages
- **Hypothesis -** an educated guess that can be tested or investigated
- **Independent Variable -** the manipulated variable; the variable that is changed on purpose in an experiment
- **Injector -** the first section of an accelerator, where electrons are torn away from atoms and accelerated to an energy sufficient for them to be injected into the cavities of the accelerator

Insulator - a material through which electricity or heat does not flow easily (like many plastics, glasses and ceramics)

Interact - act with each other

Internet - a worldwide network of computers linked together for the purpose of exchanging information (also sometimes called the Information Superhighway or Cyberspace)

Ion - an atom or molecule that has an electric charge because it has either gained or lost electrons

Jefferson Lab - a nuclear physics research facility built to explore quarks in the nucleus of the atom, located in Newport News, Virginia

Kelvin - a temperature scale that begins at absolute zero, where there is no molecular movement (Water freezes at 273 K and boils at 373 K.)

Laboratory - a place equipped for scientific research, experiments or testing

Lepton - one of the two basic building blocks of matter (An electron is a lepton.)

LINAC - an abbreviation for Linear Accelerator

Linear Accelerator - a machine used in physics experiments that makes particles go faster in a straight line

Liquid - a state of matter with definite volume but no definite shape, like water

Magnet - a piece of iron or other material that attracts other pieces of iron or steel

Magnification - the process of making something look bigger

Mass - the measure of the amount of matter an object has in it; measured in grams or kilograms

Mass Number - the total number of protons and neutrons in an atom's nucleus

Matter - something that has mass which can exist in the form of a solid, liquid, gas or plasma

Mean - the sum of the items in a set of data divided by the number of items in the set; the average (The mean of $\{1,1,1,2,4,6,6\}$ is 3 since $(1+1+1+2+4+6+6) \div 7 = 3$.)

Median - the middle number in a set of ordered data (The median of {1,1,1,2,4,6,6} is 2 since 2 is the middle number when all of the numbers are placed in order. If there are an even number of numbers, the median is the mean of the two middle numbers.)

Melting Point - the temperature at which a substance changes from a solid to a liquid

Meson - particle made of a quark and an antiquark that is thought to bind protons and neutrons together inside the nucleus of an atom

Microscope - an optical instrument that uses a combination of lenses to produce magnified images of very small objects

Mixture - a substance composed of two or more components, each of which retain its own properties (A salad is a mixture of vegetables.)

Mode - the data item that occurs the most often in a set of data (The mode of {1,1,1,2,4,6,6} is 1 since 1 is the number that appears most often.)

Molecule - two or more elements that are chemically joined (Water is a molecule made from two atoms of Hydrogen and one atom of Oxygen.)

Negative - having a minus charge (Negative charges are attracted to positive charges and are repelled by other negative charges.)

Neutral - having no charge

Neutron - a neutral particle made of three quarks found in the nucleus of an atom

Nitrogen - a colorless, odorless, tasteless gas which makes up 78% of the air (Nitrogen is a gas at room temperature and becomes a liquid at about 77 K, -196°C or -321°F.)

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Nuclear Physics - the science of studying the nucleus of the atom

Nucleon - a proton or a neutron

Nucleus - the central part of an atom, which makes up 99.9% of the atom's mass

Observation - the use of one's senses to learn something new

Orbit - the path an object follows as it travels around another object

Particle - a very small piece or part; an indivisible object

Physical Change - a change that affects the size, shape or color of a substance but does not affect its composition

Physical Property - a characteristic of a substance that can be observed with the senses, such as size, weight, color or odor, without altering the substance's molecular make-up

Physics - the study of matter, energy and force

Plasma - a very hot, gas-like state of matter

Pole - the place on a magnet where the magnetic field is strongest

Positive - having a plus charge (Positive charges are attracted to negative charges and are repelled by other positive charges.)

Probe - an object or device used to investigate the unknown

Property - any characteristic or attribute of an object or substance

Proton - a positively charged particle found in the nucleus of an atom

Prototype - an original type that serves as a model for later examples

Quadrant - one quarter of the coordinate plane (The x- and y-axes divide the coordinate plane into four quadrants.)

Qualitative - observations that do not involve measurements and numbers ("My brother is shorter than my sister," is a qualitative observation.)

Quantitative - observations that involve measurements and numbers ("My brother is 30cm shorter than my sister," is a quantitative observation.)

Quark - one of the two basic building blocks of matter (Scientists have discovered six different kinds of quarks: Top, Bottom, Up, Down, Strange and Charm.)

Radiation - the transportation of heat from one place to another by waves or particles (The Earth is warmed by the Sun due to radiation.)

Range - the difference between the largest number and the smallest number in a set of data (The range of $\{1,1,1,2,4,6,6\}$ is 5 since 6 - 1 = 5.)

Resistance - a measurement of how much a material opposes the flow of electricity (Wood has high resistance so it is a poor conductor of electricity. Copper has low resistance, so it is a good conductor of electricity.)

Scatter - to go in many directions

Science - the study of the natural world

Scientific Method - the 'tool' that scientists use to find the answer to questions (The Scientific Method allows scientists to solve complicated problems by taking a series of smaller steps:

- identify the problem a scientific problem to be solved
- research the process of collecting information and data about a topic being studied
- **hypothesis** an idea about the solution to a problem, based on knowledge and research
- **experimentation** the process of testing a hypothesis by collecting data under controlled, repeatable conditions

- data analysis organizing and examining the collected data using narratives, charts, graphs or tables
- **conclusion** a summary of the results of the experimentation and a statement of how the results relate to the hypothesis

Scientist - a person who uses observation, experimentation and theory to learn about a subject (Biologists, physicists, chemists, geologists and astronomers are all scientists.)

Solid - a state of matter with definite shape and volume, like ice**Speed** - a measurement of distance traveled over time (example: 100 kilometers per hour)

Spreadsheet - a computer program used for organizing and analyzing data (Spreadsheets are arranged in **rows** and **columns**. A **cell** is a box in a spreadsheet where a row and column meet. The names of the row and column determine the name of the cell. For example, in the spreadsheet shown below, column C and row 2 meet at cell C2, the shaded box. The value in C2 is 1.23.)

	A	В	C	D	E
1	0.71	0.70	0.52	1.12	4.01
2	0.02	4.45	1.23	0.74	3.11
3	9.58	1.87	6.19	3.13	0.93

Static Electricity - a collection of unbalanced charges on an object

Superconductivity - the flow of electric current without any resistance in certain metals at temperatures near absolute zero (The superconductors used at Jefferson Lab are cavities made of niobium that are cooled to 2 K by liquid Helium.)

SURA - the acronym for Southeastern Universities Research Association (Jefferson Lab is managed by SURA.) **Teamwork -** joint action by a group to complete a given task

Technician - a person who is an expert in doing certain technical jobs

Temperature - a measure of heat energy in an object, body or environment (Temperature can be measured using Fahrenheit, Celsius or Kelvin scales.)

Theory - a general principle that explains or predicts facts or events

Variable - something that does not remain constant (In an experiment, a variable is something that can change. Usually, an experimentor will change only one variable in an experiment while keeping everything else the same.)

Voltage - electrical force or pressure (measured in volts)

Volume - the amount of space an object occupies (The volume of a rectangular box can be found by multiplying the box's length, width and height together. For example, a box that is 8 cm long, 3 cm wide and 2 cm high has a volume of 48 cm³. Other formulas exist for calculating the volumes of objects with other shapes.)

Weight - a measure of the gravitational force pulling objects to the earth, moon or other celestial body (The more mass a planet has, the greater the gravitational pull of that planet will be. An object weighs more on the earth than it does on the moon because the earth has more mass than the moon.)

Puzzles and Games

Directions: Fill in each space with a different element from the list. When an element's chemical symbol is called out, cover that element until you have five in a row diagonally, horizontally or vertically. The first person to call out "BEAMS!" and have five matching elements wins! E A M S **Choose 24 different elements** from the following list: ALUMINUM NIOBIUM ANTIMONY NITROGEN ARGON OXYGEN BERYLLIUM PALLADIUM PHOSPHORUS BORON CALCIUM PLATINUM PLUTONIUM CARBON CHLORINE POTASSIUM FREE COPPER RADIUM RADON GOLD SPAC® HELIUM SILICON HYDROGEN SILVER IODINE SODIUM IRON SULFUR KRYPTON TIN TITANIUM LEAD LITHIUM TUNGSTEN MERCURY URANIUM NEON ZINC ZIRCONIUM NICKEL **Student Travel Book** Page 24

Puzzles and Games

Directions: Fill in each space with a different chemical symbol from the list. When an element's name is called out, cover that chemical symbol until you have five in a row diagonally, horizontally or vertically. The first person to call out "BEAMS!" and have five matching chemical symbols wins! E **Choose 24 different chemical** symbols from the following list: Al Ne Ni Ar \mathbf{o} Au Be Pb C Pd Ca Pt FREE ClPu Cu SPACE Fe Rn н S He Sb Hg Si Sn K Ti Kr U Li w N Zn Zr **Student Travel Book**

Page 25

Aluminum Al Sb Antimony Argon Ar Beryllium Be Boron В Calcium Ca C Carbon Chlorine Cl Copper Cu Gold Au Helium He Hydrogen Н Iodine Fe Kr Krypton Ph Lead Lithium Li Mercury Hg Neon Ne Nickel Ni Niobium Nb Nitrogen N Oxygen \mathbf{o} Palladium Pd Phosphorus P Pt Platinum Plutonium Pu K Potassium Radium Ra Radon Rn Silicon Si Silver Ag Sodium Na Sulfur S Tin Sn Titanium Ti Tungsten w U Uranium Zinc Zn

Zr

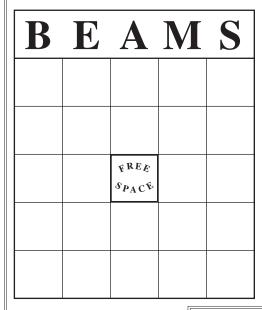
Zirconium

Silver Ag Al Aluminum Ar Argon Gold В Boron Beryllium Be C Carbon Ca Calcium Cl Chlorine Cu Copper Fe Iron Н Hydrogen He Helium Hg Mercury Iodine K Potassium Kr Krypton Li Lithium Nitrogen Na Sodium Nb Niobium Ne Neon Ni Nickel \mathbf{o} Oxygen P Phosphorus Pb Lead Pd Palladium Pt Platinum Pu Plutonium Radium Ra Rn Radon Sulfur Sb Antimony Silicon Si Tin Sn Ti Titanium Uranium w Tungsten Zinc Zn

Zirconium

Zr

Directions: Fill in each space with a different math term from the list. As definitions or examples are given, cover each term until you have five in a row diagonally, horizontally or vertically. The first person to call out "BEAMS!" and have five matching terms wins!



Choose 24 different terms from the following list:

ANGLE AREA NUMERATOR ORDERED PAIR ORIGIN PARALLEL LINES ASSOCIATIVE PROPERTY OF ADDITION BINOMIAL CIRCLE PERCENT PERIMETER COMMUTATIVE PROPERTY PERPENDICULAR LINES OF ADDITION COMPOSITE NUMBER DENOMINATOR PLANE POINT POLYNOMIAL DIAMETER PRIME NUMBER DISTRIBUTIVE PROPERTY FACTOR PROBABILITY PRODUCT PYTHAGOREAN THEOREM HYPOTENUSE IDENTITY PROPERTY OF ADDITION INTEGERS IRRATIONAL NUMBER QUADRANT QUOTIENT RADIUS RATIO LEAST COMMON MULTIPLE (LCM) LINE MEAN RATIONAL NUMBER RECIPROCAL SEGMENT SEGMENT SQUARE ROOT VERTICAL ANGLES VOLUME WHOLE NUMBER MEDIAN MIDPOINT MIXED NUMBER MULTIPLE

Student Travel Book Page 26

Angle - two rays with a common endpoint

Area - The number of square units inside a figure

Associative Property of Addition - Changing the grouping of the addends does not change the sum (example: (a+b)+c=b+(a+c))

Binomial - a polynomial with two terms (example: $3x^2 - I$)

Circle - the set of points in a plane that are all the same distance from a given point, called the

Commutative Property of Addition - changing the order of the addends does not change the sum (example: a+b=b+a)

Composite Number - an integer that has factors other than one or itself

Denominator - the 'bottom' number of a fraction

Diameter - a segment that passes through the center and has both endpoints on the circle

Distributive Property - if a, b, and c are any numbers, then $a \cdot (b + c) = ab + ac$

Factor - a number that divides another number with no remainder

Hypotenuse - the longest side of a right triangle, the side opposite the right angle

Identity Property of Addition - the sum of zero and any number a is a (example: a + 0 = a)

Integers - the set of whole numbers and their opposites (example: ...,-2, -1, 0, 1, 2,...)

Irrational Number - a number that is represented by a nonrepeating, nonterminating decimal (example: $\pi = 3.1415926...$)

Least Common Multiple (LCM) - the least number that is a multiple of both (example: the LCM of 10 and 20 is 2)

Line - a straight path that is endless in both directions

Mean - the sum of the items in a set of data divided by the number of items in the set; the average (example: the mean of $\{1,1,1,2,4,6,6\}$ is 3)

Median - the middle number in a set of ordered data (examples: the median of $\{1,1,1,2,4,6,6\}$ is 2, the median of $\{1,2\}$ is 1.5)

Midpoint - the point that divides a segment into two congruent segments

Mixed Number - the sum of a whole number and a fraction

Mode - the data item that occurs the most often in a set of data (example: the mode of $\{1,1,1,2,4,6,6\}$ is I)

Multiple - the product of a number and a nonzero whole number (example: 5 and 7 are multiples of 35)

Numerator - the 'top' number of a fraction

Ordered Pair - a pair of numbers that describe a location of a point on a coordinate plane (example: (3,4) locates a point 3 units away from the origin on the x-axis and 4 units away on the y-axis)

Origin - the point of intersection of the x- and y-axes on a coordinate plane

Parallel Lines - lines in the same plane that do not intersect

Percent - a ratio that compares a number to 100; the symbol for percent is %

Perimeter - the distance around a figure

Perpendicular Lines - lines that intersect to form right angles

Plane - a surface such that a straight line that joins any two of its points lies entirely in that surface

Point - a single, exact location, often represented by a dot

Polynomial - one term or the sum or difference of two or more terms (example: $4x^2 - 3x + 7$)

Prime Number - a number that has exactly two factors, 1 and the number itself (examples: 2,3,5,7 and 11 are prime numbers)

Probability - used to describe how likely it is that an event will happen

Product - the result produced by multiplying two numbers

Pythagorean Theorem - In any right triangle, the sum of the squares of the length of legs (a and b) is equal to the square of the length of the hypotenuse (c): $a^2 + b^2 = c^2$

Quadrant - one quarter of the coordinate plane

Quotient - the result produced by dividing two numbers

Radius - a segment that has one endpoint at the center and the other endpoint on the circle

Ratio - a comparison of two numbers by division; you can write 72 to 100, 72:100, and 72/100

Rational Number - a number that can be written in the form a/b, where a is an integer and b is a non zero integer

Reciprocal - two numbers are reciprocals if their product is 1; dividing by a number is the same as multiplying by the reciprocal of that number

Segment - a line with two endpoints

Square Root - the square root of a number is a number which when multiplies by itself equals the given number (example: the square root of 9 is 3)

Vertical Angles - two pairs of vertical angles are formed by intersecting lines; vertical angle are congruent

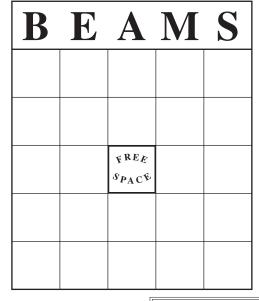
Volume - the number of cubic units needed to fill the space inside the figure

Whole Number - a number that can be written as an integer

X-axis - the horizontal number line that, together with the y-axis, forms the coordinate plane

Y-axis - the vertical number line that, together with the x-axis, forms the coordinate plane

Directions: Fill in each space with a different math term from the list. As definitions or examples are given, cover each term until you have five in a row diagonally, horizontally or vertically. The first person to call out "BEAMS!" and have five matching terms wins!



Choose 24 different terms from the following list:

ACUTE ANGLE
ACUTE TRIANGLE
ADDITION
ANGLE
AREA
AVERAGE
CENTIMETER
CHORD
CIRCUMFERENCE
COORDINATES
DECIMAL
DECIMAL POINT
DENOMINATOR
DIAMETER
DIFFERENCE
DIVIDEND
DIVISOR
EQUIVALENT
ESTIMATE
EVEN NUMBER
FACTOR
FRACTION
FRACTION
HORIZONTAL
INTERSECTING LINES
LINE
LINE OF SYMMETRY

LINE SEGMENT LINE SYMMETRY MEAN MEDIAN MODE MULTIPLE NUMBER LINE NUMERATOR OBTUSE ANGLE ODD NUMBER ORDERED PAIR ORIGIN PARALLEL LINES PERIMETER POINT PRODUCT QUOTIENT RADIUS RANGE RAY REMAINDER RIGHT ANGLE SUM SYMMETRY VERTICAL X-COORDINATE Y-COORDINATE

Student Travel Book Page 27

 $\boldsymbol{Acute\ Angle}$ - an angle that measures less than 90°

Acute Triangle - a triangle that has three acute angles

Addition - the process of finding the total number of items when two groups of items are joined

Angle - a figure formed where two line segments cross or meet

Area - the number of square units needed to cover the surface of a figure

Average - the number found by dividing the sum of a set of numbers by the number of addends

Centimeter - a metric unit equal to one onehundreth of a meter

Chord - a line segment with endpoints on a circle

Circumference - the perimeter of a circle

Coordinates - an ordered pair of integers that name a point on a coordinate plane

Decimal - a number that uses place value and a decimal point to show tenths, hundredths, and so on

Decimal Point - a period that separates the whole numbers from the fractional part of a number

Denominator - the bottom part of a fraction

Diameter - a line segment that passes through the center of a circle and has its endpoints on the circle

Difference - the answer in a subtraction problem

Dividend - the number that is being divided in a division problem

Divisor - the number that divides the dividend

Equation - a number sentence that uses an equals sign to show that two amounts are equal

Equivalent - two or more sets that name the same amount

Estimate - to find an answer that is close to the exact answer

Even Number - a whole number that has 0, 2, 4, 6 or 8 in the ones place

Factor - a number that is multiplied by another number to find a product

Fraction - a number that names part of a whole or part of a group

Horizontal - the direction from left to right

Intersecting Lines - two or more lines that cross at exactly one point

Line - a straight path in a plane, extending in both directions with no endpoints

Line of Symmetry - a line that divides a figure into two congruent parts

Line Segment - part of a line bounded by two endpoints

Line Symmetry - when a figure can be folded on a line so that its two parts are congruent

Mean - another name for average

Median - the middle number in an ordered series of numbers

Mode - the number that occurs most often in a list of data

Multiple - a number that is the product of a given number and a whole number

Number Line - a line with equally spaced ticks named by numbers

 $\mbox{\bf Numerator}$ - the top part of a fraction

 $\textbf{Obtuse}\,\textbf{Angle}$ - an angle whose measure is greater than 90° and less than 180°

 $\boldsymbol{Odd}\;\boldsymbol{Number}$ - a whole number that has 1,3,5,7 or 9 in the ones place

Ordered Pair - a pair of numbers used to locate a point on a grid

Origin - the point on a coordinate plane where the x-axis and the y-axis intersect

Parallel Lines - lines that stay exactly the same distance apart

Perimeter - the distance around a figure

Point - the name of a location on an object and in space

Product - the answer to a multiplication problem

Quotient - the answer to a division problem

Radius - a line segment with one endpoint at the center of a circle and the other endpoint on the circle

Range - the difference between the greatest and the least numbers in a set of numbers

Ray - a part of a line that begins at one endpoint and extends forever in only one direction

Remainder - the number that is left over after dividing

Right Angle - an angle whose measure is exactly 90°

 \mathbf{Sum} - the answer to an addition problem

Symmetry - when one half of a figure looks like the mirror image of the other half

Vertical - the direction from top to bottom

x-coordinate - the first number in an ordered pair

y-coordinate - the second number in an ordered pair

SCOCK-18OC BCOCK-18OC South Linear Accelerator PUZZLES AND GAMES PACCEICITION AND THE REST ACCEICITION AND THE Student Travel Book Page 29 East Arc 3/EFFERISIONLAB North Linear Accelerator

PUZZLES AND GAMES

Piece of iron, steel or other material that attracts other pieces of iron or steel How far an object goes in an amount of time is a measurement of the object's A wire coil that acts like a magnet when electric current flows through it Basic building block of matter which cannot be detected in isolation A material through which electricity and heat cannot move easily Made up of a nucleus with electrons orbiting around the nucleus **BEAMS Crossword Puzzle** 1. A material through which electricity and heat can move easily Positively charged particle found in the nucleus of an atom The laboratory in Newport News used to study the nucleus Student Travel Book Directions: Complete the puzzle using terms from the vocabulary list. 11. Holds together protons and neutrons in the nucleus Uncharged particle found in the nucleus of an atom Excited about, or what the E in BEAMS stands for ACROSS Page 28 DOWN Family of particles that electrons belong to The study of the nucleus is called nuclear What the B in CEBAF stands for To change in velocity or energy Made of protons and neutrons Anything that has mass Orbit the nucleus Electrons have a Having no charge ∞ 12 13 15. 18 9 9 4. 16. 17. 21. 19.

BEAMS Cryptograph Directions: Use the code below to find the secret words.

10 11 12 13 **H** 02 **M** 8 21 22 0 H **८**| ∞ ∞ 18 19 20 Z S 9 5 N O P O 14 15 16 17 4 **⊘** ∞ **⊘** ∑ ~

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PUZZLES AND GAMES

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() (2) 22 **S**| 4 **-**|6 - 6 **လ** ව **T**|-**P** 8 25 **I**∞ **⊘** ∾ $\mathbf{I}|_{\infty}$ **८** ∞ ы В **2** 8 **Q** 9 **⊘** ∞ **D** 4 ы В 7 2 **S**|4 **>**|8 **S**|4 A - 10 0 51 **Œ**|8 **≥**|4 **>**|2 **T**-A - O 21 - 0 **H** 8 - 0 U m 3 0 25 **™** ∞ **™** ∞ **™** ∞ **™** ∞ - | e O | 4 O | 0 O | ∞ E | 2 |

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Student Travel Book Page 31

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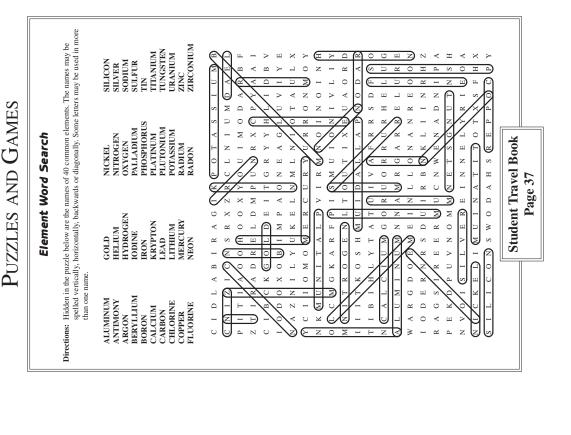
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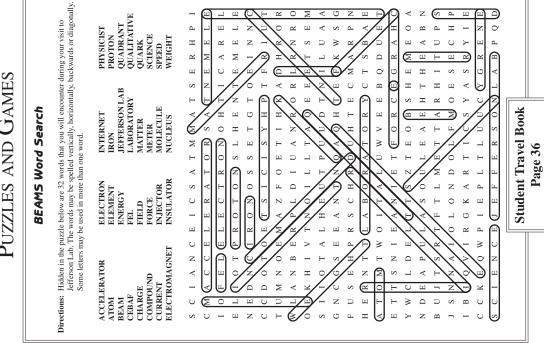
M R

 $\mathbf{Z}|\mathbf{z}$ $\mathbf{Z}|\mathbf{z}$ $\mathbf{F}|\mathbf{z}$ $\mathbf{O}|\mathbf{z}$ $\mathbf{Z}|\mathbf{z}$ $\mathbf{O}|\mathbf{z}$

≥|4 **2**|~

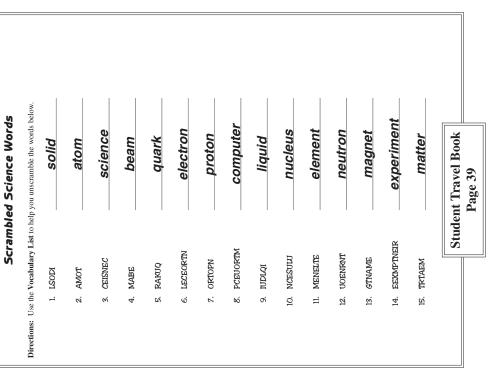
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	f the 6			E 12/12					
	id the names of	2/9=S 0=R		G		M 7/42			
ns	the code to fin	2/5 P 3/8 = 0		N		0	M 9/54		000k
BEAMS Fractions	rms. Then use	1/3 = N 1/6 = M		A 50/100	N	10/50	B		nt Travel B Page 38
BEAMS	to its lowest te	3/4=6 1=E 2/7=W	P 20/50	8	W 8/28	3/15	A		Student Travel Book Page 38
	e each fraction	1/4 = D 1/7 = B		7	0	0 21/26	H 16/20	P 12/30	
	Directions: Reduce each fraction to its lowest terms. Then use the code to find the names of the 6 quarks.	1/2=A 1/8=U	1	S 8/36	D	8/56	14/18	6/48	

PUZZLES AND GAMES



Puzzles and Games

	BEAMS Spelling Search	,
Directions: Circle the misspel end of the sentence	led word in each sentence. Write the corre e.	ct spelling on the line at the
1. It is great to spend an g	entir week at Jefferson Lab!	<u>entire</u>
2. I really enjoyed the liqu	aid nytrogen show.	_nitrogen_
3. I can't beleive the effec	ts of liquid nitrogen on a flower.	believe
4. It was interesting to to	ur Jefferson Lab and see the sientists a	t work _ scientists _
5. One of my favrite activ	ities was making Oobleck.	favorite
6. We had to decide if Oo	bleck was a solid, liqiud , gas or plasma.	liquid
7. I just liked playing with	a the Oobleck and sliming my neighbho	neighbor
8. I used the intenet to do	research on the computer.	internet
9. We made a hypotheis t	hat cotton would be the best insulator.	hypothesis
10. We use the scientific m	nethod to do the <u>experment</u> .	experiment
11. Everyday we rote a jou	rnal entry in our books.	wrote
12. I defenately didn't miss	a week of school to attend BEAMS!	definitely
	Student Travel Book	
	Page 40	

Pre-visit Activities

Magnet Racing is an activity in which students guide a set of marbles around a track with magnets.

Objectives:

In this activity students will:

- · work in groups
- guide sets of marbles around a track with magnets
- use a stopwatch to measure time
- · record data

Questions to Ask:

- 1. Which set of marbles was the easiest to guide? Why?
- 2. Does is matter how you hold the magnets?
- 3. How well did your group work as a team?

Virginia State Standards of Learning

Science 6.1 Plan and Conduct Investigations

- by recording precise and approximate measurements
- by devising methods to test the validity of inferences
- by manipulating one variable with many repeated trials

LS.1 Plan and Conduct Investigations

• by constructing a model to illustrate and explain phenomena

PS.1 Plan and Conduct Investigations

• by using research methods to investigate practical problems

PS.11 Investigate and Understand Basic Principles of Electricity and Magnetism

• by understanding magnetic fields

Magnet Racing

HOW DIFFICULT IS IT TO STEER ONE TINY ELECTRON AROUND AN ACCELERATOR TRACK USING MAGNETS?

- 1. It is your job to guide a set of magnetic marbles around a track as quickly as possible using a pair
- Begin with a four-electron set of magnetic marbles. Line up the set of electrons at the INJECTOR (starting line).
- Using the two bar magnets, steer the set of electrons through the first LINAC (straight section) around the arc (curved section) and down the second LINAC until you reach the TARGET. Use a stopwatch to time how long it takes to reach the TARGET.
- 4. Do not allow the magnetic marbles to attach themselves to the steering magnets. If this occurs, stop the marbles and break them loose from the steering magnets, but do not stop the timer! Keep the electrons inside the track as much as possible.
- Record how much time it took to bring the electrons from the INJECTOR to the TARGET in the data chart below.
- 6. Try guiding a three-electron set around the track and record the time in the chart.
- 7. Try guiding a two-electron set around the track and record the time in the chart.
- 8. Try guiding a one-electron set around the track and record the time in the chart.
- 9. After you have collected your data, answer the questions on the next page.

Data Chart

Dava Citato	Time (seconds)	10.03 s	12.51 s	14.95 s	<i>24.13 s</i>
mmor	Electron Set	Four-electron set	Three-electron set	Two-electron set	One-electron set

Student Travel Book Page 12

QUESTIONS TO THINK ABOUT

1. Of all the races, which electron beam was the easiest to steer? Why do you think this

Usually the four-electron set since it can roll like a log.

2. Of all the races, which electron-set was the most difficult to steer? Why do you think this was the case?

Usually the one-electron set since there is no 'front' or 'back'.

3. Through which part(s) of the track was it most difficult to steer?

The arcs.

4. List some difficulties you encountered.

Marbles sticking to the magnets, lack of co-operation, etc...

- 5. How could you solve the problems you had?

Better teamwork, more practice, etc...

6. Who is the person from Jefferson Lab that is visiting with your class today? What do they do at Jefferson Lab?

Answers will vary.

Student Travel Book Page 13

What's in the Bag is an activity in which students probe and identify a hidden object.

Objectives:

In this activity students will:

- · work in groups
- use their senses to gather information
- · record data
- reach a conclusion based on their data

Questions to Ask:

- 1. What are some ways you and your partner helped each other?
- 2. What does the size of the bag tell you about your object?
- 3. How could you determine the color of the object in your bag?

Virginia State Standards of Learning

Science 6.1 Plan and Conduct Investigations

- by making observations involving fine discrimination between similar objects
- by devising methods to test the validity of inferences
- by collecting, recording and analyzing data
- by organizing and communicating data through charts

LS.1 Plan and Conduct Investigations

• by evaluating and defending interpretations from the same set of data

PS.1 Plan and Conduct Investigations

• by using research methods to investigate practical problems

What's in the Bag?	
HOW CAN YOU STUDY SOMETHING YOU CAN'T SEE?	EE?
Probe your bag using all of your senses (except taste) to determine what's in your bag. Paccent your observations in the left column of the Date Chart.	ı your bag.
3. Exchange bags with a partner. Record your partner's bag number in the right column. Record your observations of the object in this bag in the right column of the chart.	t column. Record
4. Discuss with your partner how you probed the objects and what you observed.	.pq.
Based on your observations and talking with your partner, make predictions about what you think is in each bag.	about what you
6. Be prepared to discuss your observations and conclusions with the class.	
Data Chart	
My Bag My Partner's Bag	ag
I believe the object in my bag is a, because	
DO NOT OPEN THE BAG UNTIL DIRECTED TO DO SO!	os o
Student Travel Book	
D. c. 14	

QUESTIONS TO THINK ABOUT

1. How did you determine what objects were in the bags?

Use of senses, relating information to known objects, etc...

2. List some difficulties you encountered.

Couldn't see it, had no unique features, etc...

- 3. How could you solve the problems you had?
- Experimentation, trial and error, discussion with partner, etc...
- 4. List some ways scientists study what they cannot see.

Effects on items that can be seen, indirect observation, etc...

- 5. What were the objects?
- My bag contained a
- My partner's bag contained a
- 6. What other observations or clues could have helped you identify the object(s) correctly?

Answers will vary.

7. Who is the person from Jefferson Lab that is visiting with your class today? What do they do at Jefferson Lab?

Answers will vary.

Student Travel Book Page 15

The Shape of Things

This is an activity in which students determine the shape of a hidden target.

Objectives:

In this activity students will:

- · work in groups
- roll a marble under a pie pan and observe where it comes out
- record the path the marble took under the pie pan on a sheet attached to the top of the pie pan
- find the wall the marble bounced off of by constructing a line perpendicular to the path's bisector
- collect additional data by repeatedly rolling the marble under the pie pan
- form a hypothesis as to what shape is hidden under the pie pan based on the data collected
- prove their hypothesis by predicting the outcome of additional marble rolling experiments

Questions to Ask:

- 1. What was the most difficult part of this experiment?
- 2. What can you do in your experiment that the scientists at Jefferson Lab can't?
- 3. Which was the easiest shape to find?

Travel Book Activities:

- Reading About Looking for Quarks Inside the Atom p.42
- Reading About Ernest Rutherford p.44

Virginia State Standards of Learning

English 6.1 Oral Language

• by oral participation in small group activities

Math 6.16 Geometry

• by estimating an angle's bisector in order to create a perpendicular line

Science 6.1 Plan and Conduct Investigations

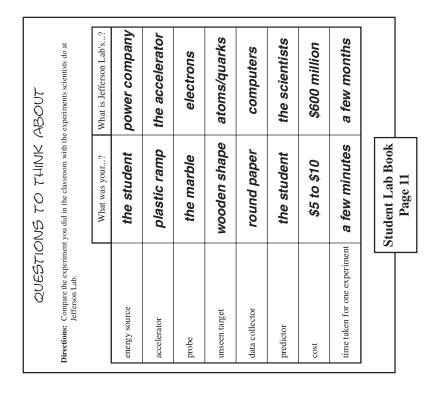
- by making observations involving fine discrimination between similar objects
- by devising methods to test the validity of inferences
- by collecting, recording and analyzing data
- by organizing and communicating data through diagrams

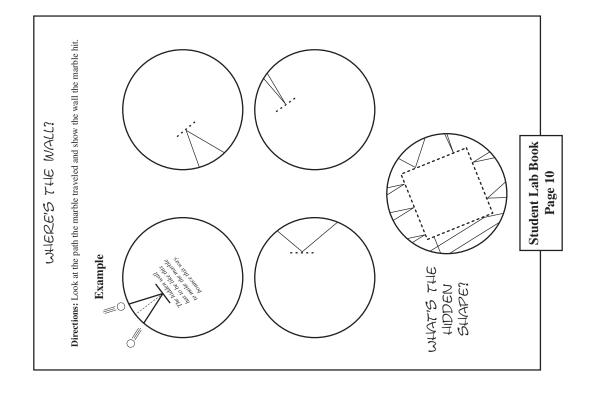
LS.1 Plan and Conduct Investigations

- by establishing criteria for evaluating a prediction
- by identifying sources of experimental error
- by evaluating and defending interpretations from the same set of data

PS.1 Plan and Conduct Investigations

• by using research methods to investigate practical problems





READING COMPREHENSION

Reading About Looking for Quarks Inside the Atom

THE SHAPE OF THINGS EXPERIMENT SHOWS HOW SCIENTISTS CAN TEST THEIR THEORIES ABOUT ATOMS.

Directions: Read the following passage. Fill in the blanks with words that make sense. Remember to use context clues that come before and after the blanks.

About thirty years ago, three scientists ran some accelerator experiments to study the nucleus at the $\frac{1}{2}$ of the atom. They ran the experiments because they wanted to know more about the structure of the $\frac{2}{2}$. They found that the protons and neutrons in the nucleus are made of quarks. The discovery of $\frac{3}{2}$ raised new questions about the nucleus.

The three scientists are Richard Taylor, Henry Kendall and Jerome Friedman. They did their experiments from 1967 to 1973 in California at the Stanford Linear Accelerator Center, called SLAC for such. These scientists won the 1990 Nobel Prize in Physics, one of the world's greatest honors for 4...

In the 1960's some scientists, like Murray Gell-Mann, were beginning to think that each nucleon might really be made up of even smaller particles. Gell-Mann even had a name for the smaller <u>§</u>. He called them quarks.

Taylor, Kendall and Friedman used beams of high-energy electrons at SLAC to explore deep inside atoms. Inside the two mile long accelerator the electrons gained energy as they moved along in a beam almost as fast as light. At the end of the accelerator, some hydrogen was the target for the electrons. Somethines an electron would $\overline{\mathbf{c}}$ into the proton inside of the hydrogen atoms. These carashes were far too thuy to see directly or even with a microscope. The three experimenters used spectrometers to $\overline{\mathbf{z}}$ what happened.

Each spectrometer consisted of huge electromagnets, about the **8** of a bus, and some detectors. When electrons crash into a target nucleus, a spectrometer measures their angles and energies as they bounce away. The electrons were not striking solid protons. They were striking vibrating clusters of quarks. Each proton is a cluster or three **9** each neutron is too.

This new discovery led to new questions. Experiments at Jefferson Lab will answer new 10 about quarks and nuclei. That's how scientific research works. There is always something new to find out

Student Travel Book Page 43

In fact, that's why Alfred B. Nobel started the Nobel II in 1901. In December, 1990, Taylor, Kendall and Friedman went to Stockholm, Sweden, to receive their Nobel Prize in Physics. The three winners shared not only the honor of the Nobel, but the 12 that comes with it: \$710,000.

Student Travel Book Page 42

READING COMPREHENSION

d. perimeter	d. spectrometer	d. electron	d scientists	d. gell	d. fall	d. argue	d. strength	d. protons	d. statements	d. certificates	d. money
center	electromagnet	nuclei	farmers	particles	glip	question	purpose	clusters	discoveries	prizes	paper
히	ပ်	ઇ	ರ	히	ບ່	ບ່	ರ	ij	ರ	히	ರ
b. edge	accelerator	quarke	engineers	quarks	glide	observe	color	ponuces	questions	trophies	b. certificate
4	Ą	<u>"ď</u>	Ą	Ą	Ą	<u>"ď</u>	Ą	Ą	.	Ą	Ą
a. outside	nucleus	alpha	teachers	nucleon	crash	wonder	sise	quarks	inventions	medals	book
ą	ď	ą	4	ą	œ	ą	di	ત્ત્વી	ą	4	ą
-:	<i>i</i> 9	w.	4;	rv.	9	7.	∞	9	10.	∺	2

33

READING COMPREHENSION

Reading About Ernest Rutherford

THE SHAPE OF THINGS ACTIVITY SIMULATES THE EXPERIMENTS SCIENTISTS DO IN EXPLORING THE ATOM.

Directions: Read the passage. Locate the paragraph that contains the answer to each question on the next page.

- Emest Rutherford (1871-1937) was a scientist who wanted to learn about atomic structure. The best way to learn about the inside of the atom, he decided, was to blow it apart.
- Rutherford chose the nucleus of the helium atom as the bullet to shoot at the atom. The helium nucleus, which is called an alpha particle, contains two protons and two neutrons. The "gun" to fire the alpha particle was the element radium. Radium is radioactive. It is continually shooting out atomic particles. He placed the radium in a heavy lead contained with just a small opening to direct the escaping alpha particles.
- The target for the alpha particles was a very thin sheet of gold foil, less than 1/100,000
 of an inch thick This is even thinner than the aluminum foil you use to cover food. Yet
 atoms are so small that the gold foil still had a thickness of more than 2,000 atoms.
- i. For his first experiment, he set the foil in front of the radium container. Behind the foil, he placed a fluorescent screen. The screen would show a spark of light whenever it was struck by an alpha particle. Thus, he could see whether any alpha particles were able to pass through the atoms in the gold foil.
- The actual results were amazing. Rutherford got flashes of light from the screen.Somehow the alpha particles were able to get through.
- 6. The scientist moved the screen to the sides and even in front, facing the foil. To his amagement he found light flashes at all angles. Some particles were even bouncing off to the side as well as straight back at the radium.
- 7. In 1911, Rutherford explained what had happened. He suggested that the atom consists of a very small, heavy central core called the nucleus. Very far out from the nucleus are the rapidly swirling electrons.
- 8. The atom was largely an empty shell. That explained how the alpha particles were able to get through the gold foil. Within the shell, there was a small but heavy nucleus with a positive charge. That is what deflected some of the positive alpha particles and bounced back the few that actually hit the nucleus of the gold atoms.
- 9. Rutherford performed another experiment similar to the first to check his picture of the atom. This time he used nitrogen as a target. Most of the particles went straight through the empty specie of the nitrogen atoms. A few bumped into the nucleus and bounced off. He also discovered the presence of hydrogen nuclei (more than one nucleus) that had a positive charge. Then he realized that the hydrogen nuclei had to come from within the nitrogen atoms. Rutherford concluded that the atoms of every element contain one or more of these positively charged nuclei. These positive hydrogen nuclei are called protons.

Student Travel Book Page 44

READING COMPREHENSION

10. On the basis of these results, he set forth a complete model of the atom. The nucleus is made up of heavy, positively charged protons. It has a positive electrical charge Very far out from this nucleus are the much lighter electrons. Their negative charge balances the positive charge of the nucleus.

Directions: Read each question carefully. Locate the paragraph that contains the information needed to answer each question. Write the number of the paragraph on the blank.

- 1. What is an alpha particle?
- 2. What was the thickness of the gold foil?
- 4 3. What was the target for the alpha particle?
- 5 4. How did Rutherford conduct his first experiment to study the inside of an atom?
- $\overline{5}$ 5. Why did Rutherford put a fluorescent screen behind the foil?
- 6. What happened when Rutherford moved the screen to the side?
- 10 7. What did Rutherford discover when he used nitrogen as a target?
- 9 8. Why did the nucleus deflect some of the alpha particles?
- 10 9. What does the word "nuclei" mean?
 10 10. How did Rutherford check his picture of the atom?
- 10 11. What are positive hydrogen nuclei called?

Student Travel Book

Page 45

Hot and Cold

This is an activity in which students observe the effects of temperature extremes.

Objectives:

In this activity students will:

- make predictions of the outcomes of several experiments
- observe experiments
- · record their outcomes

Questions to Ask:

- 1. How do you change a material from one state of matter to another?
- 2. Why did the three balls act differently?
- 3. How many states of matter are there?

Travel Book Activities:

- Reading About Superconductivity p.46
- Writing About Liquid Nitrogen p.47

Virginia State Standards of Learning

Science 6.4 Matter

- by understanding that atoms are made up of electrons, protons and neutrons
- by understanding that atoms of any element are alike but are different from atoms of other elements

PS.2 Investigate and Understand the Basic Nature of Matter

• by understanding the particle theory of matter

PS.5 Investigate and Understand Changes in Matter

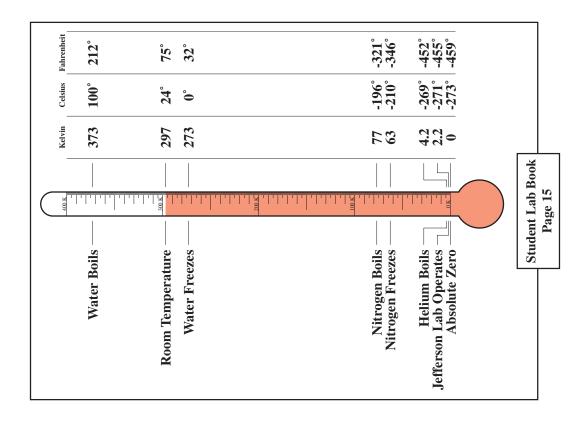
- by observing physical changes
- by observing changes in the state of matter
- by understanding the physical properties of matter

PS.7 Investigate and Understand Temperature Scales, Heat and Heat Transfer

• by understanding the concepts of phase change, freezing point, melting point, boiling point, vaporization and condensation

PS.9 Investigate and Understand the Nature and Technological Applications of Light

• by understanding the electromagnetic spectrum



Experiment	What's your hypothesis?	What happened?	Why did it do this?
A balloon is filled with air and then made very cold. What will it do?	I think the balloon will pop.	lt shrank.	The air in the balloon got so cold it turned into a liquid.
A ping-pong ball is made very cold and then bounced. How will it bounce?			
A super ball is made very cold and then bounced. How will it bounce?			
A racquetball is made very cold and then bounced. How will it bounce?			
A burning match is slowly lowered into the vapor of a very cold substance. What will happen?			
A tube of Helium gas is heated to 3000° Centigrade (~5000° Fahrenheit). What will it look like?			
	Student Lab Book	ok	-
	Student Lab Bo Page 14	0k	

Reading About Superconductivity

IEFFERSON LAB'S ACCELERATOR CAVITIES ARE COOLED WITH LIQUID HELIUM TO BECOME SUPERCONDUCTORS.

In 1911 Heike Onnes, a Dutch scientist, was conducting experiments to learn how metals were affected by very cold temperatures. While working with the metal mercury, he discovered something new. When mercury was cooled to the extremely cold temperature of liquid helium, it allowed electricity to flow through it without any loss of energy.

Onnes and other scientists continued investigating other metals to learn if they would reach the same as the meroury to the extremely cold temperature. They found that many of the metals had the same reaction. In one experiment, a metal wire loop was cooled in liquid helium removed, the current continued to flow. Onnes was not able to explain this discovery, but he called it superconductivity. and electricity was allowed to flow into the loop. When the source of the electricity was

In a normal conductor, the current stops flowing when the source of electricity is removed. If a superconducting metal is kept at the supercool temperature of liquid helium, the current can flow for years without becoming weaker.

ways, because liquid helium and the equipment needed to cool superconducting materials are very expensive and difficult to handle. Today, the use of superconducting technology is being researched and applied in such fields as medicine, physics, transportation, communication and It was many years before the discovery of superconductivity could be used in practical

Directions: Answer the questions in complete sentences.

1. How many years ago was superconductivity discovered?

Current year - 1911 = 91 years in 2002, 90 years in 2001, etc...

2. How could you test a metal to see if it is a superconducton

An electric current will continue to flow after the source of electricity has been removed.

3. How does a superconductor differ from a normal conductor?

An electric current will not flow in a conductor without a source for the electricity.

Bonus Question: How are superconductors used in the cryomodules at Jefferson Lab?

Jefferson Lab's Niobium cavities become superconductive when cooled with liquid Helium.

Student Travel Book Page 46

WRITING PROMPT

Writing About Liquid Nitrogen

REMEMBER THE LIQUID NITROGEN PRESENTATION YOU SAW AT JEFFERSON LAB.

What if you found a thermos of liquid nitrogen ...?

Thy to imagine where you might find a thermos of liquid nitrogen. Would it be by your bed, under a tree, in your locker at school or another interesting place? Would you take the liquid nitrogen to class? How would you transport it? What would you do with the liquid introgen? What would you transport it? What would you do with the liquid intogen? What would happen when you used it? Write a creative story about what would happen if you found some liquid nitrogen.

Human Accelerator

This is an activity in which students simulate Jefferson Lab's accelerator by passing tennis balls down a straight line.

Objectives:

In this activity students will:

- cooperate with their partners to complete a task
- pass tennis balls down a line of students to simulate a linear accelerator
- record the number of tennis balls that successfully made it to the end of the line
- calculate the fraction of tennis balls that successfully made it to the end of the line
- use division and multiplication to convert each fraction into a percent
- create a pie graph for each fraction

Questions to Ask:

- 1. Which method of passing the tennis balls was the most difficult?
- 2. What are some ways your team worked well together?
- 3. Where are some places you use percents?

Travel Book Activities:

• Reading About Materials in the Earth's Crust - p.48

Virginia State Standards of Learning

Math 6.1 Number and Number Sense

• by writing the equivalence relationship between fractions and percents

Math 6.4 Number and Number Sense

• by comparing fractions and percents using pie graphs

Science 6.1 Plan and Conduct Investigations

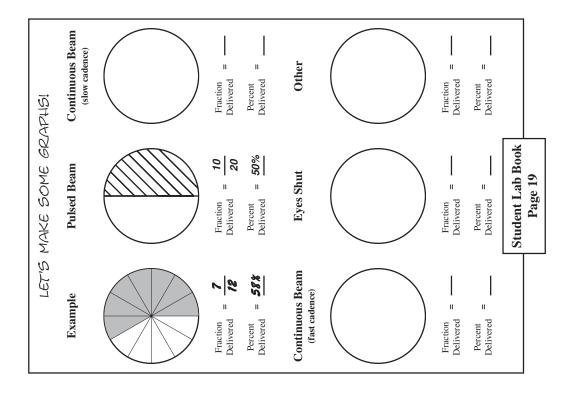
- by recording precise and approximate measurements
- by devising methods to test the validity of predictions and inferences
- by manipulating one variable over time with repeated trials
- by collecting, recording and analyzing data
- by organizing and communicating data through graphical representations
- by analyzing alternative scientific explanations
- by basing conclusions on scientific evidence

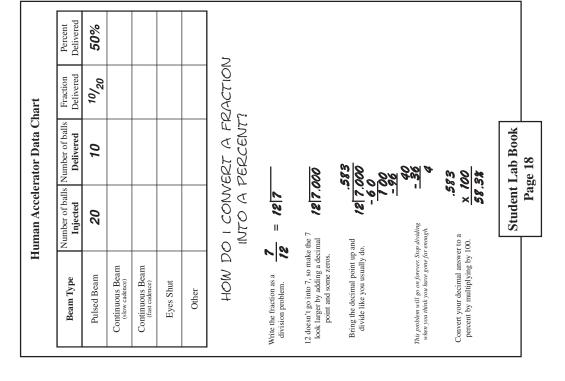
SLS.1 Plan and Conduct Investigations

- by organizing data into tables showing repeated trials
- by defining variables
- by constructing models to illustrate and explain phenomena
- by identifying sources of experimental error
- by identifying independent variables, dependent variables and constants
- by controlling variables with repeated trials to test the hypotheses

PS.1 Plan and Conduct Investigations

- by identifying independent and dependent variables, constants, controls and repeated trials
- by analyzing data to form valid conclusions





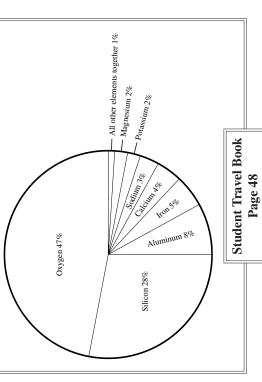
Reading About Materials in the Earth's Crust

IN THE HUMAN ACCELERATOR ACTIVITY YOU DID AT THE LAB. YOU USED PIE GRAPHS TO SEE THE PERCENTAGE OF TENNIS BALLS THAT ARRUPED AT THE TRAGET USE THE FIE GRAPH BELOW TO HELP YOU UNDERSTAND THE FOLLOWING PASSAGE.

Directions: Read the following passage about minerals and the materials that make up the earth's crust. Fill in the blanks with words that make sense. Remember to use context clues that come before and after the blanks. The earth's crust is made up of a number of different materials. Solid 1 that are found in the crust are minerals. There are hundreds of different minerals. Each 2 has its own properties. Scientists identify minerals by testing their 3. One property is magnetism; magnetite has 4 properties. The shape of crystals can identify minerals such as salt, which has 2 that look like cubes. The color, shine and hardness of minerals are other properties used to classify and 6 minerals in the crust.

The $\overline{2}$ chart below shows the elements that make up most minerals. The graph shows that $\overline{8}$ makes up 47% of the minerals in the crust. Both potassium and magnesium make up $\overline{9}$ of the crust. The graph alog qives us information about other elements, such as carbon. Carbon makes up $\overline{10}$ 1% of the crust.





READING COMPREHENSION

d. numbers	d. layer	d. scientists	d. identify	d. crystals	d. clarify	d pie	d. iron	4 2%	d. unknown
c. crusts	c. property	properties	c. properties	c. minerals	c. identify	percentage	uabhxo	over 8%	c. equal to
છં	ઇ	히	છં	ઇ	히	ઇ	히	ပ်	ΰ
b. materials	b. material	b. materials	b. quality	saltiness	mine	bar	b. aluminum	b. 3%	b. less than
. 4	4	ন	ন	Ą	4	Ą	ন	৸	۵,
a. minerals	mineral	minerals	magnetic	properties	hush	line	silicon	4%	more than
4	œİ	ą	d	4	ą	ą	ą	4	ą
 i	<i>i</i>	w	4;	rų.	9	7.	∞	9.	10

Cold Stuff

This is an activity in which students investigate different materials to determine which makes the best insulator.

Objectives:

In this activity students will:

- work in groups
- be responsible for specific tasks within their groups
- · measure liquid
- measure time using a stopwatch
- measure temperature change over time
- · record data
- test and compare the effectiveness of different insulators
- create a line graph to depict the temperatures recorded at 30 second intervals using each insulator

Questions to Ask:

- 1. How could the way you hold the container affect the data?
- 2. What is different about the insulators that may have caused them to retain heat differently?
- 3. What are some other materials frequently used as insulators?
- 4. How are insulators useful? When might you use one? When might you not?

Travel Book Activities:

- Reading About Heat Transfer p.50
- Statistical Analysis p.51

Virginia State Standards of Learning

Math 6.18 Probability and Statistics

• by interpreting data using graphical methods (line graph and chart)

Science 6.1 Plan and Conduct Investigations

- by making observations involving fine discrimination between similar objects
- by developing a multiple attributes classification system
- by recording precise and approximate measurements
- by stating hypotheses in a way that identifies the independent and dependent variables
- by devising methods to test the validity of predictions and inferences
- by manipulating one variable over time with repeated trials
- by collecting, recording and analyzing data using appropriate metric measures
- by organizing and communicating data through graphical representations

LS.1 Plan and Conduct Investigations

- by organizing data into tables showing repeated trials and means
- by defining variables
- by using SI (metric) units
- by establishing criteria for evaluating a prediction
- by identifying sources of experimental error
- by identifying independent variables, dependent variables and constants
- by controlling variables with repeated trials to test the hypotheses
- by constructing, interpreting and using continuous line graphs to make predictions
- by evaluating and defending interpretations from the same set of data

PS.1 Plan and Conduct Investigations

- by accurately measuring and reporting data using SI (metric) units
- by using thermometers to gather data
- by identifying independent and dependent variables, constants, controls and repeated trials
- by making valid conclusions after analyzing data

PS.7 Investigate and Understand Temperature Scales, Heat and Heat Transfer

• by understanding and identifying convection, conduction and radiation

C/T8.1 Communicate Through Application Software

• by communicating through application software with spreadsheets by entering and analyzing data, and creating graphs and charts to visually represent data

- 3 different materials to test

- A bowl filled with 500 milliliters of ice water

- Record the Initial Temperature on the chart on the next page.
- 6. Measure and record the insulator's temperature every 30 seconds for 5 minutes. DO NOT STOP THE STOPWATCH UNTIL 5 MINUTES HAVE PASSED!! If you stop the stopwatch early, you won't know how long the insulator has been in the ice water.
- 7. At the end of five minutes, get ready to test the next insulator. Your team will have to:

Conduction, convection and radiation are ways that heat can move around.

A good insulator will make an object get warmer.

True/False True/False

Insulators don't allow heat to pass through them easily.

Most metals make good insulators.

True/False

True/False

Answer the following True or False questions about insulators:

Research

- 10. Make certain that everyone on your team has all of the temperatures written down.

Student Lab Book Page 23

Procedure

- 1. To do this experiment, your team will need:

WHAT MATERIALS MAKE GOOD INSULATORS?

Cold Stuff

Which substance makes the best insulator: cotton, air or steel wool?

Problem

- 2. There are three jobs to do:
- Time Keeper tells the Temperature Reader when to read the temperature
- · Temperature Reader tells the Data Recorder what the temperature is at that time Data Recorder - writes the temperature in the data chart
- Put the thermometer in one of the three insulators and measure its Initial Temperature. This should be somewhere near 20° Centigrade. It might take the thermometer a few minutes to read the correct temperature. Give it time to get used to its new home.
- Put the insulator in the ice water and start the stopwatch. Hold the insulator in the ice water by the lid. Keep the insulator in the water for 5 minutes.
- - Reset the stopwatch
- Get 500 milliliters of new ice water
- Put the thermometer in the next insulator to measure its initial temperature (Remember: the initial temperature should be somewhere near 20° Centigrade!)
- · Put the insulator in the ice water after you have recorded its initial temperature
- 8. Put the second insulator in the ice water and measure its temperature **every 30 seconds** for 5 minutes, just like you did with the first one. **Don't forget to record your data!**

will be the best insulator.

(cotton, air or steel wool)

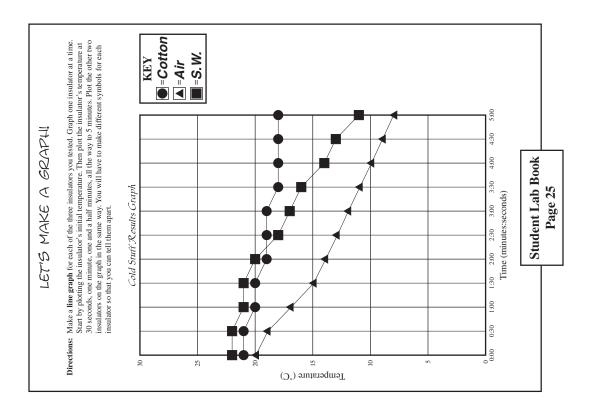
I think that

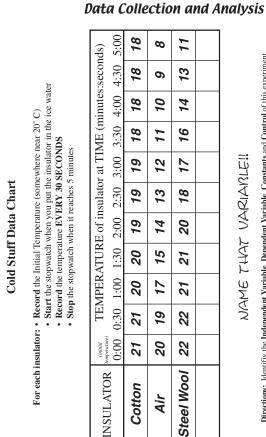
Hypothesis

Student Lab Book

Page 22

- 9. Test the third insulator when you finish with the second one.
- - 11. Make a line graph for each insulator on the Cold Stuff Results Graph.





Directions: Identify the Independent Variable, Dependent Variable, Constants and Control of this experiment.

NAME THAT VARIARLE!!

Reading About Heat Transfer

THE COLD STUFF ACTIVITY YOU DID AT JEFFERSON LAB WAS AN EXPERIMENT IN THE TRANSFER OF HEAT.

Heat can be transferred by three different means:

- · Convection the transfer of heat by the movement of a gas, like air, or a liquid, like water · Conduction - the transfer of heat through two or more materials that are touching
 - Radiation the transfer of heat by means of rays

Which method of heat transfer best defines each scenario: conduction, convection or radiation?

have to go to school. You sit outside in the sun because you don't really feel like doing anything at all. The heat from the 1. You wake up on a Saturday morning and are glad you don't

sun is starting to make you sweat.

Last night you went to the store and bought fruit punch, so you have a big glass of it to help cool you off.

Conduction

Radiation

weather. The temperature in the house is rising too so you 3. The news is on and the forecast calls for hot and muggy turn on the air conditioner.

Convection

4. It's boring sitting in the house on your day off, so you go to the pol to meet your friends. You jump in and the water is freezing but you don't want to look like a wimp so you try to get used to it. Your lips are turning blue and your skin now feels cold.

Conduction

Conduction

- 5. You climb out of the pool and lie on the warm concrete to warm your body back up.
- 6. You're beginning to feel comfortable again but don't want to get too warm, so you move to a place in the shade. It's getting hotter and hotter now and you're starting to sweat again, even though you are in the shade.
- 7. You decide that it wasn't so bad at home after all and you're getting hungry anyway so you go back home and cool off in the air conditioning, on the sofa, with a good book.

Conduction*

Conduction*

* Conduction if there is no movement of air, convection if hot/cold air is moving.

Student Travel Book Page 50

Conclusion

THE REST INSULATOR APPEARS TO RE

QUESTIONS TO THINK ABOUT

1. Which container cooled the fastest?

Usually air, but steel wool can come very close.

2. Which container took the longest to cool?

Cotton

3. Where did the heat inside the containers go as they were cooling?

Into the ice and water.

4. Which material that your team tested is the best insulator? How can you tell?

Cotton, since it didn't change temperature quickly.

5. What other materials do you think might make good insulators?

Answers vary. Wool, polyester, fur, etc...

6. What materials would make poor insulators?

Answers vary. Copper, steel, iron, etc...

Student Lab Book Page 26

MATH EXERCISE

Statistical Analysis

SCIENTISTS CALCULATE THE MEAN, MEDIAN, MODE AND RANGE OF THEIR DATA TO LEARN HOW THE DATA IS DISTRIBUTED.

Directions: Use the sample data chart to answer the questions.

- Mean the sum of all of the numbers in a set of data divided by the number of numbers in the set of data
- Median the middle number in a set of data when all of the numbers are written in order
- Mode the number or numbers which appear the most in a set of data
- Range the difference between the largest number and the smallest number in a set of data

INSULATOR	(initial temperature)	TE	MPER	ATUR	E of ir	isulato	r at TI	ME (n	ninutes	s:secor	ids)
INSULATOR	0:00	0:30	1:00	1:30	2:00	2:30	3:00	3:30	4:00	4:30	5:00
Cotton	21	21	20	20	19	19	19	18	18	18	18
Air	20	18	16	15	14	13	12	Ш	9	8	7
Steel Wool	22	22	21	21	20	18	17	16	14	13	11

1. Which insulator has the greatest range? What is that range?

Air, with a range of 13.

2. Which insulator has a median of 19?

Cotton

3. What is air's mean temperature?

143 ÷ 11 = 13

4. What is steel wool's mode?

22 and 21

5. Which insulator has a range of 3?

Cotton

Jefferson Lab Treasure Hunt

This is activity in which students take a tour of Jefferson Lab.

Objectives:

In this activity students will:

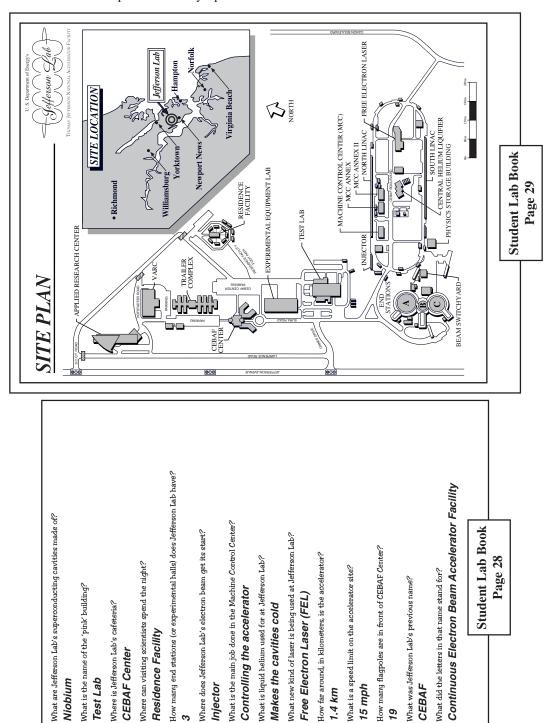
- · tour Jefferson Lab
- collect information to answer questoins in the BEAMS Lab Book

Travel Book Activities:

• Jefferson Lab Site Map Scale Activity - p.52

Test Lab

Injector



CEBAF

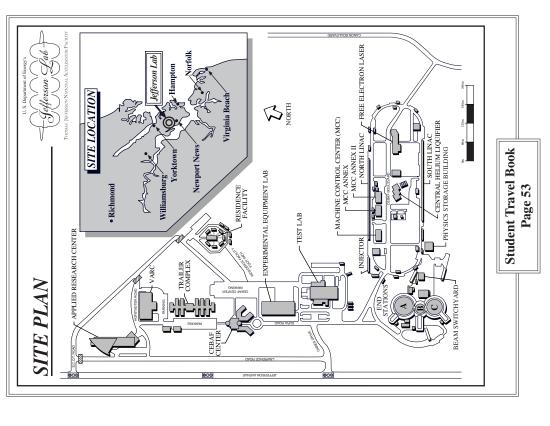
15 mph

MATH EXERCISE

WHEN YOU WERE AT IEFERSON LAB YOU TOOK A TOUR AROUND THE SITE. SEE IF YOU CAN ESTIMATE THE DISTANCES BETWEEN SOME OF THE PLACES YOU VISITED. **Directions:** Use the scale on the site plan on the next page to calculate the shortest distance between each pair of buildings listed below. **Hint:** You can make a large ruler to help you measure the distances between buildings by copying the map's scale over and over again onto a scrap piece of paper. ~ 1000 m ~ 250 m ~ 230 m ~ 530 m ~ 270 m ~ 900 m ~ 530 m Jefferson Lab Site Map Scale Activity ~ 50 m ~ 50 m ~ 90 m Student Travel Book 10. Applied Research Center and Free Electron Laser 7. Machine Control Center and CEBAF Center 8. Experimental Equipment Lab and Test Lab 9. North LINAC and Central Helium Liquifier 5. Residence Facility and Trailer Complex 2. Injector and Machine Control Center 1. Hall A and CEBAF Center 4. CEBAF Center and VARC 3. Hall Cand Injector 6. Hall Cand VARC

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MATH EXERCISE



Microscopes

This is an activity in which students observe objects with a microscope.

Objectives:

In this activity students will:

- choose two objects from home to observe with a microscope
- describe what each object looks like to the unaided eye
- form a hypothesis for each object explaining what they think the objects will look like when
- learn how to use two different types of microscopes
- · record their observations by sketching what they see
- calculate the magnification used to view an object

Questions to Ask:

- 1. Did the objects look like you thought they would when magnified?
- 2. How do smooth objects, like paper, look when magnified?
- 3. What most surprised you when using the microscopes?

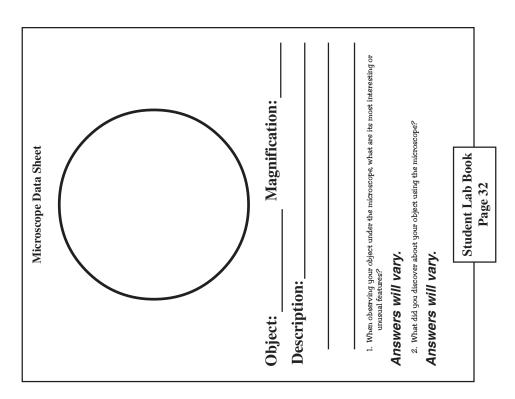
Travel Book Activities:

- Reading About Microscopes p.54
- Writing About Size p.55
- Microscope Homework p.77

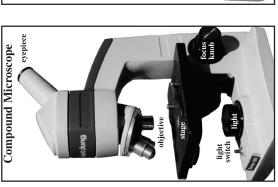
Virginia State Standards of Learning

Science 6.1 Plan and Conduct Investigations

- by making observations involving fine discrimination between similar objects and organisms
- by recording precise and approximate measurements
- by communicating visual data through graphical representation (diagram)



Dissecting Microscope evepieces (focus) knob



Student Lab Book Page 31

Homework

Microscope Homework

BRING IN OBJECTS TO EXPERIMENT WITH TOMORROW!

Directions: Find two objects to use tomorrow. Each object you decide to use cannot be:

• dangerous or forbidden at school

- more than two inches tall
- For each object, write what the object is, what it looks like and what you think it will look like

3. Put your object on the microscope's stage and look through the eyepiece(s). Does it look fuzzy? Try turning the focus knob. Is it really dark? Make certain that the microscope's lights are on. Try experimenting with different magnifications.

4. Draw what your object looks like on the next page.

· A Dissecting Microscope if your object is big or if you can't see through it

(things like rocks, baseball cards or your hand)

(things like strands of hair, glass slides or blades of grass)

2. There are two different types of microscopes that you can use. Which type should you use with your object? In general, you should use:
 A Compound Microscope if your object is very thin and you can see through it

1. Choose an object to look at with a microscope.

HOW DO DIFFERENT OBJECTS LOOK WHEN MAGNIFIED?

Microscopes

when magnified.

Reading About Microscopes

YOU USED MICROSCOPES IN THE CLASSROOM AT JEFFERSON LAB.

Directions: Read the following passage. Fill in the blanks with words that make sense. Remember to use context clues that come before and after the blanks.

It happened over 300 years 1 in Holland. Anton van Leeuwenhoek (AN+un van LAV-vun-hook) had a new microscope that he had 2. One day he 3 through it at a drop of lake water. What he saw surprised him. The water was alive with what Leeuwenhoek called "wee beasties." The microscope made tiny organisms look 200 times. 4 than life size. Leeuwenhoek was one of the first scientists to see living things that were that 5. His work was a giant 6 for science.

Today, microscopes are much stronger. An electron microscope can make this organisms look 200,000 times $\frac{7}{2}$ size. A few electron microscopes can see individual aroms. Pictures can be made to show the objects or organisms much bigger. The pictures add greatly to what we know about this pobjects and $\frac{8}{8}$. Microscopes have come a long way in 300

Directions: Choose the word that fits the context of the passage

d. after	d. delivered	went	larger	larger	tower	d life	microscopes
Ą	Ą	Ġ.	궉	Ą	Ą.	권	Ą
before	previewed	looked	darker	darker	step	under	electricity
ರ	ů	d	ರ	ರ	히	ರ	ΰ
obe	lost	broke	smaller	Ilems	gorilla		gravity
4	Ą	4	Ą.	<u>.ď</u>	Ä	Ä	ىز
since	made	fell	a. farther	life	turtle	small	organisms
ą	di	ď.	ą	ą	ď.	ą	ď
ij	61	ю	4;	เง	9	7.	∞

Student Travel Book Page 54

Writing Prompt

Writing About Size

LOOKING THROUGH THE MICROSCOPES AT JEFFERSON LAB. YOU WERE ABLE TO GET A CLOSE LOOK AT VERY SMALL OBJECTS.

If you woke up one morning and discovered that you had been shrunken to microscopic size, what would you do? Write a story about how you got that way, where you would go, what you would est, and other challenges you would face.

Student Travel Book Page 55

Instruments Used for Scientific Observations

Label the instrument

Name an object that can be seen with each instrument.



human eye

people, houses, etc...





cells, bacteria, etc...



atoms, quarks, etc....

particle accelerator

1. What is the relationship between the instruments and the size of the objects that can be

The larger the instrument, the smaller the observed object.

Student Lab Book Page 33

Technology

This is an activity in which students learn how the Internet can be used for different purposes.

Objectives:

In this activity students will:

- · work in groups
- be responsible for specific tasks within their groups
- become familiar with the Internet and its uses
- visit various web sites by entering their URL's
- use search engines to research specific subjects
- record and analyze data

Questions to Ask:

- 1. Should you believe everything you find on the Internet?
- 2. Why should you use more than one search engine?
- 3. What can you use the Internet for?

Travel Book Activities:

- Writing About Internet Safety p.56
- Writing About the Internet p.57

Virginia State Standards of Learning

C/T8.3 Understanding of Electronic Communications

• by having a basic understanding of computer processing, storing, retrieval, and transmission technologies and practical appreciation of the relevant advantages and disadvantages of various processing, storage, retrieval, and transmission technologies

C/T8.4 Ability to Access, Retrieve and Analyze Data

- by using search strategies to retrieve electronic information
- by using local and wide-area networks and modem-delivered services to access and retrieve information from electronic databases
- by using databases to perform research

Technology

WHAT CAN YOU DO WITH THE INTERNET?

Networks

When two or more computers are connected to each other, they become a **network**. People who use networked computers can share information with each other, exchange messages, and even run the same programs at the same time on many different computers.

The Internet

The Internet is like a network, only much bigger. In fact, the Internet is made up of many different networks combined.

In 1980, a large group of scientists found themselves working on the same projects, but from different parts of the world. They needed a faster way to share information than sending messages through the mail. The scientists set up a special network that connected not only computers in one building, but computers around the world.

This world-wide network was called the Internet. Today anyone can explore the Internet. It connects more than 60,000 networks, each with its own collection of articles, pictures, and sounds.

Jses of the Internet

You can do many things on the Internet. Two of the most popular things are electronic mail or e-mail and browsing pages on the World Wide Web.

E-mail is one of the most common use of the Internet. With e-mail you can write an electronic letter on your computer and send it to another person almost instantly, even if that person is halfway around the world. You can also attach pictures or sounds to an e-mail message.

E-mail addresses look like this: mrsteve@jlab.org. In this example, "mrsteve" is the name of the person who gets the letter. The name is followed by an "at" sign (@), which tells the network that a server name is coming next. In this case "jlab.org" is the e-mail server address for Jefferson Lab.

The World Wide Web, also known as the Web or WWW, is made up of millions of documents called Web pages. These pages can include text, still and moving pictures, and sound. When you are done looking at one Web page, you can click on a short-cut called a hyperlink to connect to other Web

Most organizations on the Web have sets of pages that are linked together called Web sites.

WHAT ARE SOME OTHER USES FOR THE INTERNET!

Student Lab Book Page 35

How Does it Work?

Each of the thousands of individual networks that make up the Internet has set aside one or more computers to act as a server. These computer servers play host to linernet sites, and serve their information to computer users the loway a waiter serves food in a restaurant. And, like a restaurant, each of these servers has its own address.

nternet Addresses

Internet addresses are called **URLs** (Uniform Resource Locators). Some look long and complicated, while others are quite short, but they all follow the same simple rules. A typical URL looks something like this:



- ① The first group of letters on every address tells the network which **protocol** to use. A protocol is like a language you have to know which one to speak. One common protocol is http, which stands for HyperText Transport Protocol.
- ② Next comes the domain name. The domain name is the name of the computer that you are trying to contact. You can sometimes tell what kind of a site you will be visiting by looking at the end of the domain name. Adomain name ending in .org usually means that the site is run by a non-profit organization. Sites ending with .gov are run by the government while sites ending with .cdu are usually educational sites if ike colleges or universities.
- The next part of the URL is the **file path**. This tells the computer where the file you want is located.
- (4) The last part of the URL is the file name, which is the name of the file you want. Files ending with ...html are text files written in HyperText Markup Language and are used in web browsers. Files ending with .gif or .jpg are graphic files while files ending with .wav or .mp3 are sound files.

Internet Safety

Be careful what information you give out in e-mails and on the World Wide Web!

Never give your address, telephone number, or even your name over the Internet
to anyone you don't know!

Student Lab Book Page 36

REAMS INTERNET SCAVENGER HUNT

Directions: Using ONLY the following websites, can you find answers to the questions below?

www.amazon.com	www.disney.com	www.kodak.com
www.apple.com	www.espn.com	www.sbo.nn.k12.va
www.buschgardens.com	www.fritolay.com	

a.us

1. Name two sports teams that played each other yesterday. What was the final score of

Answers will vary.

2. Who produced the first simple camera to be sold to the public? When?

George Eastman, 1888.

3. Who founded the Frito Lay company? When? Where?

Elmer Doolin in 1932 in San Antonio, Texas.

4. Name three snacks that Frito Lay sells.

Answers will vary.

5. Name two Disney items you can buy on the Internet. What is the price of each?

Answers will vary.

6. Name two different items for sale at www.amazon.com. What does each item cost?

Answers will vary.

7. How much do iMac computers currently cost? Which website did you use?

8. What is your school's telephone number? Answers will vary.

591-4900 (Crittenden), 928-6846 (Huntington), 888-3310 (Reservoir)

9. How tall is the first drop on Apollo's Chariot?

210 feet.

Student Lab Book Page 37

BEAMS COLLEGE INTERNET SCAVENGER HUNT

Directions: Using ONLY the following websites, can you find answers to the questions below?

www.tncc.cc.va.us	www.vcu.edu	www.vmi.edu	www.vt.edu	www.wm.edu
www.nsu.edu	www.odu.edu	www.richmond.edu	www.rmwc.edu	www.tc.cc.va.us
www.cnu.edu	www.gmu.edu	www.hamptonu.edu	www.hsc.edu	www.jmu.edu

1. What is the full name of Virginia Tech?

Virginia Polytechnic Institute and State University

2. What is the full-time undergraduate in-state tuition at Christopher Newport University?

\$ 2,300.00 (Fall 2003 semester)

3. How many students are enrolled in James Madison University?

~15,000

4. Where is Thomas Nelson Community College located?

99 Thomas Nelson Dr., Hampton, VA

5. Name three student organizations at the University of Richmond.

Answers will vary.

6. Name two of George Mason University's libraries.

Arlington Campus, Fenwick, Johnson Center, Prince William Campus, GMU Law Library, Washington Research Library, Institute for Humane Studies

7. Who founded Hampton University?

Brigadier General Samuel Chapman Armstrong

8. Which college only allows women to attend? Which college only allows men to attend?

Randolph-Macon Woman's College, Hampden-Sydney College

9. What is the mascot of Norfolk State University?

The Spartans.

10. Name three sports that both men and women play at Virginia Commonwealth University.

Basketball, cross country, soccer, tennis, track and field.

Student Lab Book Page 38

Reading About Internet Safety

THE INTERNET IS A PLACE WHERE ANYONE CAN POST ANY KIND OF INFORMATION.

Directions: Read the following passage. Fill in the blanks with words that make sense. Remember to use context clues that come before and after the blanks.

Twenty 1 ago, kids in school had never even heard of the internet. Now, I'll bet you can't find a single person in your school who hasn't at least heard of it. In fact, many of us use it on a regular basis and even have access to it from our homes! The 'net' in 2 really stands for network. A 3 is two or more computers connected together so that information can be 4 , or sent from one computer to another. The internet is a vast resource for all types of information. You may enjoy using it to do research for a school project, downloading your favorite songs or communicating with friends and family. Information is accessed through web pages that companies, organizations and individuals create and post. It's kind of like a giant bulletin board that the whole world uses! But since anyone can put anything on the internet, you also have to be careful and use your best judgement and a little common sense.

Just because you read something on a piece of paper someone sticks on a bulletin board doesn't mean it's good information, or even correct, for that matter. So you have to be sure that whoever posted the ___S__ knows what they're talking about, especially if you're doing ___S__! But what if you're just emailing people? You still have to be very careful. If you've never met the person that you're communicating with online, you could be on dangerous ground! You should never give out any personal information to someone you don't know, not even your name! And just like you can't _____ the information on every website out there, you can't rely on what strangers you 'meet' on the internet tell you either. Just like you could make up things about yourself to tell someone, someone else could do the same to you!

Directions: Choose the word that fits the context of the passage.

1.	a.	hours	Ъ.	days	c.	weeks	<u>d.</u>	years
2.	<u>a.</u>	internet	Ъ.	fishnet	c.	network	d.	netting
3.	a.	computer	Ъ.	internet	<u>c.</u>	network	d.	wire
4.	a.	hidden	Ъ.	lost	c.	created	₫.	shared
5.	a.	internet	Ъ.	bulletin board	c.	information	d.	stamp
6.	<u>a.</u>	research	Ъ.	lunch	c.	recess	d.	sports
7	a	read	Ъ	find	c	understand	1.	believe

Student Travel Book Page 56

WRITING PROMPT

Writing About the Internet

WHILE USING THE INTERNET AT JEFERSON LAB. YOU WERE ABLE TO FIND INFORMATION ON ALL KINDS OF PEOPLE, PLACES AND THINGS.

Imagine that a famous person asks you to design a web page for them. Who would your person be and what would you put on their page? Think about what topics you would want to be sure to include on the site's home page. Would you have links to other sites? If so, what types of sites would they be? What age group would you have in mind? Why would they want to visit this site?

Looking for the Top Quark

This is an activity in which students practice locating coordinates on a grid.

Objectives:

In this activity students will:

- · work in groups
- learn the names of the six quarks
- pick a coordinate on a grid and call out the corresponding ordered pair
- hear an ordered pair and find the corresponding point on a grid

Questions to Ask:

- 1. Why is the order of a coordinate pair important?
- 2. How would you plot the coordinate (3,2,6)?
- 3. How many different types of graphs are there?

Travel Book Activities:

- Mystery Picture p.32
- Advanced Mystery Picture p.34
- Writing About a Loss p.58

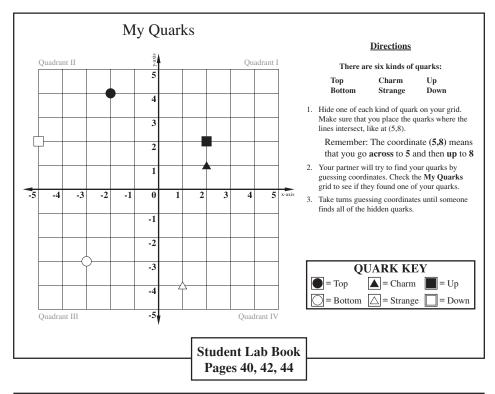
Virginia State Standards of Learning

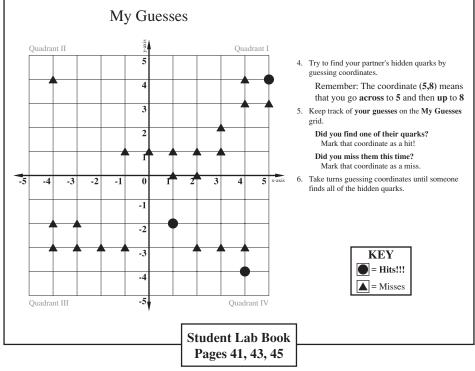
Math 6.5 Number and Number Sense

• by identifying and representing integers on a number line

Math 7.12 Geometry

• by identifying and graphing ordered pairs in the four quadrants of a coordinate plane





WRITING PROMPT

Writing About a Loss

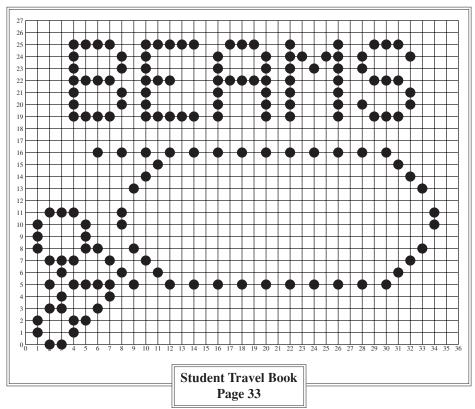
IN PLAYING LOOKING FOR THE TOP QUARK, YOU AND YOUR PARTNER WERE TRYING TO FIND EACH OTHER'S 'LOST' QUARKS.

Write about losing something important to you. When was the last time you saw it before it was lost? Do you know how it became lost? How did you feel about it being lost or gone? Did you ever find what it was that you lost? If so, describe how you found it and how you reacted to finding it. If not, describe how you felt about realizing you would never see it again.

Puzzles and Games

			11	Travel Book			
Directions:	(16,21)	(20,5)	(20,19)	(4,25)	(29,25)	(32,24)	(28,24)
ons	(7,5)	(20,24)	(11,5)	(6,25)	(7,7)	(14,16)	(30,22)
	(26,16)	(8,20)	(22,16)	(25,24)	(26,25)	(20,23)	(6,19)
ot the y ore	(12,22)	(16,20)	(8,16)	(8,23)	(8,21)	(26,5)	(31,15)
e coc der, b	(18,5)	(5,5)	(4,22)	(3,3)	(20,22)	(32,20)	(10,25)
Mystery Picture Plot the coordinates on the grid to find the mystery picture. You can plot the coordinates in any order, but do not connect any of the points until you have plotted all of the coordinates.	(14,5)	(16,19)	(6,22)	(16,16)	(22,22)	(30,19)	(7,4)
nates lo no	(5,10)	(7,25)	(5,25)	(20,16)	(4,1)	(29,22)	(28,16)
on t	(30,16)	(10,7)	(33,8)	(19,22)	(6,16)	(3,4)	(10,20)
Be g	(33,13)	(9,8)	(32,7)	(18,25)	(26,20)	(14,19)	(5,9)
Mystery e grid to find t nect any of the	(11,19)	(10,16)	(11,15)	(24,23)	(31,25)	(17,22)	(28,5)
ber of fire y of	(10,24)	(18,16)	(2,5)	(28,23)	(4,2)	(16,5)	(3,6)
rd th	(5,22)	(11,25)	(22,19)	(6,5)	(11,22)	(28,20)	(30,5)
e m.	(8,10)	(31,6)	(18,22)	(26,19)	(6,3)	(5,8)	(3,0)
Picture ie mystery pi points until y	(4,24)	(4,23)	(9,5)	(1,9)	(12,25)	(6,8)	(24,16)
y pig	(7,22)	(4,11)	(22,25)	(31,19)	(16,23)	(24,5)	(10,14)
e picture. You can plot the coordinates in I you have plotted all of the coordinates	(4,19)	(34,11)	(10,22)	(26,23)	(22,20)	(3,11)	(26,21)
. Yo	(10,19)	(1,2)	(23,24)	(31,22)	(16,24)	(13,25)	(8,11)
u ca ploti	(5,19)	(2,7)	(3,7)	(29,19)	(4,5)	(8,6)	(32,21)
n plc ed a	(11,6)	(34,10)	(19,25)	(26,22)	(10,21)	(9,13)	(2,3)
II of	(14,25)	(8,24)	(17,25)	(5,2)	(12,19)	(4,7)	(2,0)
coc	(4,21)	(32,14)	(20,21)	(12,5)	(7,19)	(1,8)	(22,23)
rdin	(13,19)	(12,16)	(22,24)	(30,25)	(16,22)	(22,5)	(1,10)
g; g	(4,20)	(1,1)	(20,20)	(26,24)	(10,23)	(2,11)	(22,21)

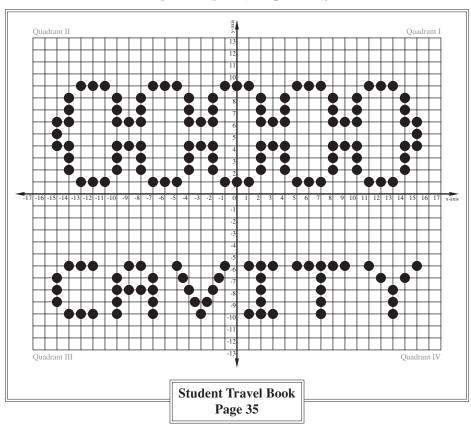
Puzzles and Games



Puzzles and Games

				ravel Book se 34]		
Advanced Mystery Pictu Directions: Plot the coordinates on the grid to find the mystery picture.	in (2,-8) in (11,-6) (4,3) (-4,8)	(14,3) (-13,-10) (-7,9) (-4,6)	(-9,6) (-12,-6) (-3.5,-9) (6,9)	(-8,6) (14,4) (7,-9) (14,6)	(-11,1) (-6,9) (-4.5,-7) (13,9)	(1,9) (-12,9) (7,-10)	(6,1) (-15,5) (12,1)
coord	ਰ (4,4)	(-3,6)	(2,8)	(8,8)	(-5,1)	(9,-6)	(15,4)
linate	를 (0,-0) 를 (11,1)	(0,1)	(-12,-10)	(-4,3)	(-7,-8)	(3,6)	(-14,2)
Advanced ates on the grid to	(6,-6)	(-7,-10)	(11,9)	(0,-0) (-14,7)	(7,1)	(8,7)	(10,2)
a a l	(15,5)	(-13,1) (-14,-10)	(12,-7)	(8,-6)	(-4,-0) (-4,4)	(2,7)	(-0,2) (-10,6)
grid	e (-0,7) 2 (-10,-8)	(-3,9) (-13,1)	(10,6)	(-10,- 9) (-1.5,-7)	(-4,-8)	(9,4)	(-8,2)
d C	ਰ (14,-7) ਵੇਂ (-8,7)	(-14,3) (-5,9)	(-15,-8) (10,6)	(-10,7) (-10,-9)	(-10,2) (5,1)	(-5,-6) (9,4)	(8,4) (-15,-9)
ind Z	eg (-2,6)	(-2,-8)	(-2,3)	(3,-6)	(-2,2)	(10,7)	(-14,8)
Mystery find the myster	(2,4)	(-7,-7)	(-10,-7)	(7,9)	(-7,-9)	(2,-10)	(2,6)
yste 3	in (3,4)	(-10,8)	(4,8)	(14,8)	(12,9)	(15,-6)	(13,-10
Ø ₽	(2,-7)	(4,6)	(-15,-7)	(2,3)	(13,-8)	(-8,8)	(-9,-6)
Picture You	(-2,4)	(-10,4)	(8,2)	(14,7)	(-13,-6)	(-1,1)	(-15,6)
ur.) (10,8)	(7,-8)	(-10,-10)	(2,2)	(-11,9)	(5,9)	(-9,-8)
re You can plot the coordinates in	린 (0,9)	(-14,4)	(-2,7)	(-2.5,-9)	(13,-9)	(-13,9)	(-15,4)
ld m	ତ୍ଥି (10,3)	(13,1)	(3,-10)	(-3,4)	(-14,6)	(-4,2)	(5,-6)
of th	(-14,-6)	(-1,-6)	(4,7)	(2,-6)	(1,-10)	(-8,-8)	(10,4)
000	≝ (-8,3)	(8,3)	(7,-6)	(-7,1)	(14,2)	(-6,1)	(7,-7)
ordii	§ (15,6)	(4,2)	(-9,4)	(-8,-6)	(1,1)	(-3,-10)	(-4,7)
ıaı	∄ (-10,3)	(-1,9)	(1,-6)	(-12,1)	(8,6)	(-8,4)	(-2,8)

Puzzles and Games



Oobleck

This is an activity in which students explore the properties of a strange substance.

Objectives:

In this activity students will:

- · work in groups
- follow a recipe to make Oobleck
- measure the proper amounts of each ingredient
- use all of their senses, except taste, to discover as many properties of Oobleck as they can
- record their observations on the Oobleck Investigation Sheet
- classify each property they find as being a property shared by solids, liquids or gases
- determine Oobleck's state of matter

Questions to Ask:

- 1. What are some properties of solids, liquids and gases?
- 2. What are some physical properties of Oobleck?
- 3. What types of changes took place when you made Oobleck?

Travel Book Activities:

- Reading About Properties and Changes p.59
- Reading About Changes p.60
- Writing About Physical Properties p.61
- Elements, Compounds and Mixtures p.62

Virginia State Standards of Learning

English 6.1 Oral Language

• by oral participation in small group activities

English 6.7 Writing

• by describing the properties they discover

Science 6.1 Plan and Conduct Investigations

- by making observations involving fine discrimination between similar objects
- by developing a multiple attributes classification system
- by devising methods to test the validity of predictions and inferences
- by collecting, recording and analyzing data using appropriate metric measures

LS.1 Plan and Conduct Investigations

- by evaluating and defending interpretations from the same set of data
- by constructing models to illustrate and explain phenomena

PS.1 Plan and Conduct Investigations

• by making valid conclusions after analyzing data

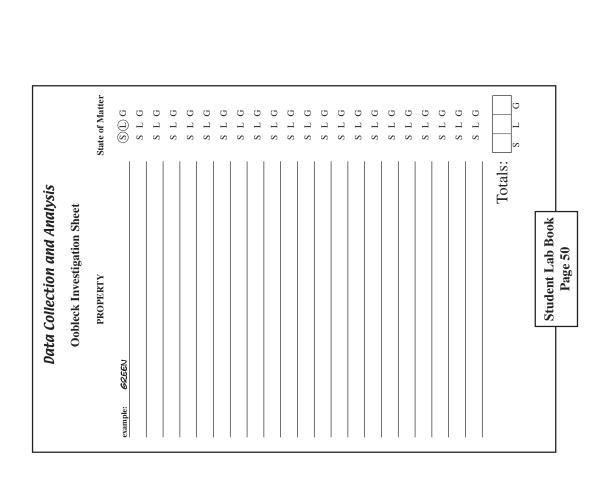
PS.2 Matter

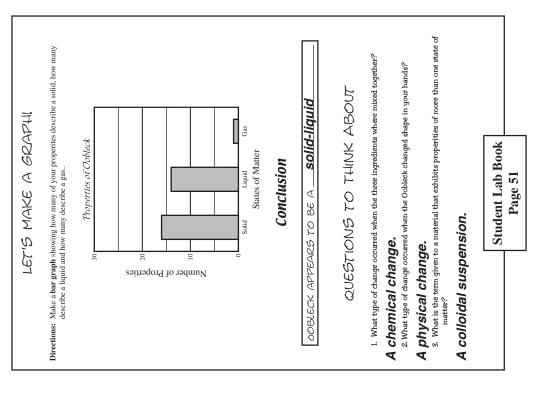
- by describing solids, liquids and gases
- by identifying physical properties

PS.5 Matter

• by understanding physical and chemical changes

Decide if each observation is a property of a solid, liquid or gas. Circle one or more of the State of Matter letters on the right hand side of the Oobleck Investigation Sheet to show what 8. Record your observations about the properties of Oobleck on the Oobleck Investigation Sheet. 7. Once 2 minutes have passed, take the Oobleck out of the bag and experiment with it. What state of matter 3. Carefully measure two teaspoons of the clear liquid into the plastic bag. is Oobleck??? Student Lab Book Procedure 6. Close the bag and knead the mixture well for 2 minutes. Page 49 5. Carefully add two tablespoons of the white liquid. All of your senses, except for taste 1. To do this experiment, your team will need: 4. Next, add two drops of the green liquid. 10. Answer the blob's question. A green liquid · A white liquid A plastic bag A clear liquid Open the plastic bag.





Reading About Properties and Changes

OOBLECK HAS SPECIFIC PROPERTIES.

Directions: Read the following passage. Fill in the blanks with words that make sense. Remember to use context clues that come before and after the blanks.

Matter can be described and identified by physical and chemical properties. Physical

Lhave to do with appearance. You can observe many physical properties with your
senses and by measuring the length, 2 height, mass and density of a substance. 3

preperties include colon; shape, small texture, taste and size. The state of matter (whether its a solid, 4 or gas) and the 5 at which the substance boils melts or freezes are also physical properties. Nagment properties as well.

6 properties, on the other hand, have more to do with the atomic or molecular composition of matter. Chemical properties deal with how substances react with other 7 such as water, air or fire.

Chemical changes are sometimes represented by a chemical formula:

ZH2 + 02 = ZH20

This formula states that two hydrogen gas molecules react with one oxygen gas molecule to produce two molecules of water.

Directions: Choose the word that fits the context of the passage

i.	4	1. a. chemicals	ائم	b. properties	ರ	c. substances	Ą	d. textures
6,	di	width	Ä	density	ರ	c. height	ď.	d. property
w	ą	chemical	Ą.	matter	ರ	described	귕	d. physical
4,	ą	water	Ą.	b. molecule	ij	c. liquid	Ą	atom
ξĊ	4	time	اک	temperature	ರ	design	Ą	d. cylinder
9	œi	chemical	Ą.	physical	ij	substance	Ą.	gaseous
7.	ą	properties	Ä	physicals	ರ	c. degrees	ಳ	d. substances
∞	ą	temperature	4	physical	đ	chemical	Ą	color
6	ą	similar	ړ.	different	ઇ	familiar	Ą	original
10.	d	battery	Ą	qlnq	ರ	c. change	Ą.	switch

Student Travel Book Page 59

READING COMPREHENSION

Reading About Changes

THE OOBLECK YOU MADE AT JEFFERSON LAB WAS AN EXPERIMENT INVOLVING CHANGE.

Look at the picture of the candle burning. The wax of a candle burns and changes into ash and smoke. The original materials are changing into something different. Changes that create a new material are called **chanical changes**.



Look at the picture of water boiling and changing into steam. Steam is another form of water, Heating the water did not create a new material. In changing the water from a liquid to a gas, only the state of the water changed. Changes in the shape, size or state of a material are called physical changes.

Directions: Study the changes that are occurring in each picture below. Tell what is changing. Then decide if the change is a chemical change or a physical change.

What kind of change?	Physical	Physical	Chemical
What is changing?	The shape/size of the car	The shape and state of the ice cream.	The wood to ash and smoke
	A CHI WIECK	Melting for cream	Woodburning

Challenge! List three changes you observe at home. Tell what is changing and what kind of change is occurring in each. Can some changes be both physical and chemical?

WRITING PROMPT

Writing About Physical Properties

REMEMBER WHEN YOU OBSERVED THE PROPERTIES OF OOBLECK.

Write about your favorite food. Try to describe your favorite food to someone, without telling them what it is! Be sure to use words that appeal to the senses (sight, touch, hearing, smell and taste) so that you will be describing the physical properties of your favorite food. Think about and be sure to explain why this is your favorite food.

Student Travel Book Page 61

SCIENCE EXERCISE

Elements, Compounds and Mixtures

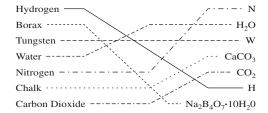
DIFFERENT SUBSTANCES WERE COMBINED WHEN YOU MADE OOBLECK.

Directions: Determine if the following substances are elements, compounds or mixtures.

- Element any substance that can not be broken up into simpler substances by chemical
- $\boldsymbol{Compound}$ a substance formed when atoms of two or more elements join together
- Mixture a material consisting of two or more substances that are not chemically bound to each other and can be separated

Elmer's Glue	mixture
Borax	compound
Food Coloring	mixture
Water	compound
Nitrogen	element
Chalk	compound
Air	mixture

Directions: Elements and compounds have specific chemical formulas. Match each element or compound in the list on the left with its matching formula in the list on the right.



Electrostatics

This is an activity in which students discover how charges behave.

Objectives:

In this activity students will:

- make predictions of the outcomes of several experiments
- observe experiments
- record their outcomes

Questions to Ask:

- 1. Why did the foam fly out of the container when placed on the Van de Graaff generator?
- 2. What charge do electrons have?
- 3. How do opposite charges react to one another? Like charges?
- 4. Why does a person's hair stand on end only while they are standing on the stool?

Travel Book Activities:

• Reading About Charges and Electricity - p.64

Virginia State Standards of Learning

Science 6.4 Matter

• by understanding that atoms are made up of electrons, protons, and neutrons

PS.1 Plan and Conduct Investigations

• by making valid conclusions after analyzing data

PS.11 Investigate and Understand Basic Principles of Electricity and Magnetism

• by understanding static, current, and circuits

Electrostatics Data Chart

The Experiment: A container full of packing foam is placed on the Van de Graaff generator.

Your Hypothesis: I think the packing foam will spark.

What happened? The foam flew out of the container.

Why did this happen? Electrons gathered on the foam, making them repel each other.

The Experiment: A bunch of string is placed on the Van de Graaff generator.

Your Hypothesis:

What happened?

Why did this happen?

The Experiment: A person touches the Van de Graaff generator.

Your Hypothesis:

What happened?

Why did this happen?

Student Lab Book Page 53

Reading About Charges and Electricity

THE DEMONSTRATIONS WITH THE VAN DE GRAAFF GENERATOR SHOWED HOW CHARGES BEHAVE.

Directions: Read the following passage. Fill in the blanks with words that make sense. Remember to use context clues that come before and after the blanks.

Atoms, the basic building blocks of matter, are made of three basic components: protons, neutrons and electrons. The protons and neutrons cluster together to form the nucleus, the central part of the atom, and the <u>1</u> orbit about the nucleus. Protons and electrons both carry an electrical charge. The charges they carry are opposite to each other; protons carry a <u>2</u> electrical charge while electrons carry a negative electrical charge. Neutrons are <u>3</u> charged - they carry no charge at all.

Electricity is the movement of charged particles, usually electrons, from one place to another. Materials that electricity can move through easily are called conductors. Most metals, such as iron, copper and \$\frac{4}{2}\$ are good \$\frac{5}{2}\$ of electricity. Other materials, such as rubber, wood and glass, block the flow of electricity. Materials which \$\frac{6}{2}\$ the flow of electricity are called insulators. Electrical cords are usually made with both conductors and \$\frac{7}{2}\$. Electricity flows through a \$\frac{8}{2}\$ in the center of the cord. A layer of insulation \$\frac{9}{2}\$ the conductor and \$\frac{10}{2}\$ the electricity from 'leaking' out.

Objects usually have equal numbers of positive and negative charges, but it isn't too hard to temporarily create an imbalance. One way scientists can create an imbalance is with a machine called a __ll___ generator. It creates a large static charge by placing electrons on a metal dome using a motor and a big rubber band. Since like charges ___l2__ the electrons push away from each other as they collect on the dome. Eventually, too many electrons are placed on the dome and they leap off, creating a spark that looks like a bolt of lightning.

Have you ever received a <a>13 after having walked across a carpet? This shock was caused by extra electrons you collected while walking across the carpet. Your body became like the done of the Van de Graaff generator, full of extra electrons looking for a way to get away. The path back to the carpet was blocked by the <a>14 you were wearing, but they were able to move through your hand and into the object that you touched, causing the shock. So, the next time you shuffle across a carpet and shock your friend on the ear, tell them you were just trying to be a Van de Graaff generator!

Student Travel Book Page 64

READING COMPREHENSION

Directions: Choose the word that fits the context of the passage a. neutrons b. protons c. electrons a. negative b. positive c. neutral d. strong a. negatively b. positively c. neutrally d. strongly b. paper c. nitrogen d. aluminum b. protectors c. insulators d. conductors b. create c. help d. prevent a. conductors b. insulators c. metals d. plugs a. conductor b. insulator c. neutron d. cord a. surrounds b. warms c. looks at d. hears b. replaces 10. a. speeds up c. prevents d. allows 11. a. Rube Goldberg b. Van de Graaff c. Big Bad d. Einstein 12. a. jump b. join c. repel d. attract 13. a. dollar b. book c. shock d. cat 14. a. freckle b. shirt c. pants

Design and Engineering

This is an activity in which students work in teams to design and build aluminum boats that will carry the most cargo.

Objectives:

In this activity students will:

- work in teams
- · design four boats from squares of aluminum foil
- build the boats they designed
- test their boats by floating them and loading them with cargo (dice) to measure their strength
- · record data
- place a value on their best boat
- create a bar graph depicting how many dice each of their boats held
- compare the cost effectiveness of their best boat with the boats of other teams using the amount of cargo held, how many of their boats it would take to deliver a specified amount of cargo, and the cost of all the boats that would be needed
- create a bar graph depicting how many dice each team's best boat held

Questions to Ask:

- 1. How did the way you loaded your cargo affect the stability of your boats?
- 2. Can you see a pattern in your boats and how many dice they held?
- 3. If you owned the company that needed to transport cargo by sea, would you purchase the best boat your team was able to build? Why or why not?

Travel Book Activities:

• Writing About Inventions - p.63

Virginia State Standards of Learning

English 6.1 Oral Language

• by oral participation in small group activities

Math 6.8 Computation and Estimation

• by solving multi-step consumer application problems

Science 6.1 Plan and Conduct Investigations

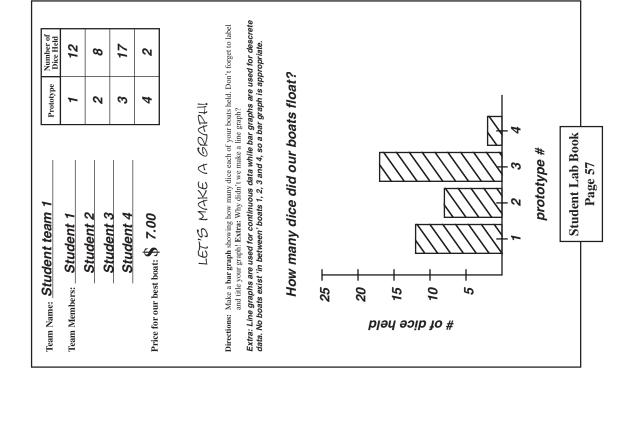
- by recording precise and approximate measures
- by stating hypotheses in a way that identifies the independent and dependent variables
- by manipulating one variable over time with many repeated trials
- by collecting, recording and analyzing data
- by organizing and communicating data through graphical representations

LS.1 Plan and Conduct Investigations

- by organizing data into tables showing repeated trials and means
- by defining variables
- by identifying sources of experimental error
- by identifying independent variables, dependent variables and constants
- by controlling variables with repeated trials to test hypotheses

PS.1 Plan and Conduct Investigations

- by identifying independent and dependent variables, constants, controls and repeated trials
- by using research methods to investigate practical problems



WRITING PROMPT

WHAT COULD OUR BOAT LOOK LIKE!

(Draw some sketches here)

Student Lab Book

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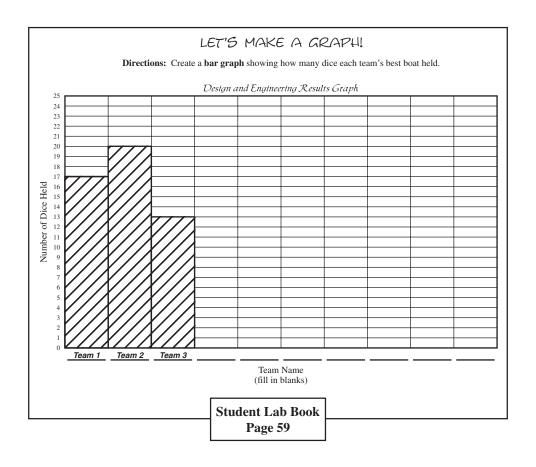
Writing About Inventions

DURING THE DESIGN AND ENGINEERING ACTIVITY AT IEFFERSON LAB. YOU USED CREATIVITY TO DESIGN A BOAT TO HOLD AS MANY DICE AS YOU COULD.

Write about a new invention designed to make life easier. You may already have an original idea about an invention you wish you could have, or you might have some good ideas about how to make an invention that already exists, better. Write about what your invention would be able to do. How much would it cost? Who would be most interested in your invention? Write about what you would do with this invention if you had it. How would it change the way you live? After you finish describing your invention, draw a picture of what it would look like. You may want to label any special parts or features that it has, and be sure to give it a name!

	Design and	Engineering	Cost Analysis (Chart	
Team Name	How many dice do we need to carry?	How many dice did the team's best boat hold?	How many boats will it take to hold all of the dice?	How much does the team's best boat cost?	How much will it cost to buy all of the boats needed?
Student team 1	100	17	6	\$7.00	\$42.00
Student team 2	100	20	5	\$8.50	\$42.50
Student team 3	100	13	8	\$4.30	\$34.40
			<u> </u>		

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Magnets and Electromagnets

This is an activity in which students construct and test the strengths of two electromagnets.

Objectives:

In this activity students will:

- work in teams
- build an electromagnet with 25 turns of wire
- test the 25-turn electromagnet's strength at 4 different voltages by using it to pick up paperclips
- build an electromagnet with 50 turns of wire
- test the 50-turn electromagnet's strength at 4 different voltages by using it to pick up paperclips
- · record data
- calculate the average number of paperclips each electromagnet lifted at each voltage
- create a line graph to depict each electromagnet's strength

Questions to Ask:

- 1. Does it matter what direction you wind the wire?
- 2. How can you tell which end of the electromagnet is north and which is south?
- 3. Where are some places you can find electromagnets at home?

Travel Book Activities:

- Reading About Magnets and Electromagnets p.66
- Averaging p.68
- Writing About Magnetism p.70

Virginia State Standards of Learning

Math 6.18 Probability and Statistics

• by collecting, analyzing, displaying, and interpreting data about electromagnets of varying strengths as they relate to the voltage applied to them

Science 6.1 Plan and Conduct Investigations

- by identifying differences in descriptions and the construction of working definitions
- by recording precise and approximate measurements
- by stating hypotheses in a way that identifies the independent and dependent variables
- by devising methods to test the validity of predictions and inferences
- by manipulating one variable over time with repeated trials
- by collecting, recording and analyzing data using appropriate metric measures
- by organizing and communicating data through graphical representations

LS.1 Plan and Conduct Investigations

- by organizing data into tables showing repeated trials and means
- by defining variables
- by using SI (metric) units
- by establishing criteria for evaluating a prediction
- by identifying sources of experimental error
- by identifying independent variables, dependent variables and constants
- by controlling variables with repeated trials to test the hypotheses
- by constructing, interpreting and using continuous line graphs to make predictions
- by evaluating and defending interpretations from the same set of data

PS.1 Plan and Conduct Investigations

- by recording and interpreting data from line graphs
- by identifying independent and dependent variables, constants, controls and repeated trials
- by making valid conclusions after analyzing data

PS.11 Investigate and Understand Basic Principles of Electricity and Magnetism

- by understanding the concepts of current and circuits
- by understanding magnetic fields and electromagnets

Magnets and Electromagnets

CAN YOU MAKE A MAGNET FROM A NAIL. SOME BATTERIES AND SOME WIRE?

Problems

Can the strength of an electromagnet be changed by changing the voltage of the power source? Can the strength of an electromagnet be changed by changing the amount of wire wrapped around its core?

Research

Answer the following True or False questions about magnets and electromagnets:

Heating or hitting a permanent magnet can ruin it. True/False Iron is a good metal to use to make an electromagnet. True/False The north pole of one magnet will attract the north pole of another magnet. True/False

Magnets and electromagnets are used in many devices. True/False

Hypotheses

the electromagnet's strength. I think that increasing the voltage will

I think that increasing the wire coils will ______the crease or not chan ______the

the electromagnet's strength.

Student Lab Book Page 61

Procedure

How to make the electromagnet:

- 1. To make an electromagnet, you will need:
- · A length of wire
- 2. Take the wire and straighten it.
- 3. One end of the wire has a clip attached. Hold the clip in your hand and measure off an arm's length of wire. This splits the wire into two sections, one much longer than the other.
- the nail and work your way towards the nail's point.

4. Take the long section of wire and wrap it neatly around the nail. Start wrapping at the flat part of

5. Wrap the wire around the nail 25 times to build the first electromagnet. Later, you will wrap the wire around the nail another 25 times to make a larger electromagnet.

How to use the electromagnet:

- 1. To test your electromagnet you will need:
 - A battery pack
- Some paper clips
- There are four different settings on the battery pack. They are labeled 1.5V, 3.0V, 4.5V and 6.0V.
 The "V" stands for volts. A volt is a unit used to measure the amount of electricity in something, like meters is a unit used to measure the length of something.
- Your team will test your electromagnet by seeing how many paper clips it can pick up at each voltage. Test each voltage two times.
- 4. There are two jobs to do:
- Power Operator turns the electromagnet on and off
- Crane Operator dunks the electromagnet into the container of paper clips
- 5. How do you turn the electromagnet on? Both ends of the wire have to be attached to the battery pack correctly so that electricity can flow:
 - Clip one end of the wire to the screw on the battery pack labeled TOP
- · Hold the other end of the wire onto the metal near the voltage label that you want to test REMEMBER: Metal has to touch metal for electricity to flow!

Touch the wire to the metal screws, not to the plastic battery case!

6. Once the Power Operator has turned on the electromagnet, the Crane Operator should put the nail in the container of paper clips.

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7. Gently mix the paper clips with the electromagnet.

- 8. Carefully lift the electromagnet out of the paper clip container and move it to a clean spot over
- 9. Turn the electromagnet off by removing the wire from the battery pack and let the paper clips
 - 10. Count how many paper clips the electromagnet picked up and record that number on the Electromagnets Data Chart. 11. Keep testing your electromagnet until you have tried each voltage twice.
- 12. Once you have completely tested the electromagnet with 25 wraps of wire, build one with 50 wraps of wire and test it.
- 13. After you have finished testing the second electromagnet, make certain that everyone on your team has all of the data.

14. Average each voltage's tests together. If you don't remember how to average, look at the

 Use the Electromagnets Results Graph to show the average number of paper clips each electromagnet picked up at each voltage. example below.

HOW DO I AVERAGE 31, 22 AND 43 TOGETHER?

Add up all the numbers that need to be averaged.

w 60000 Divide by the number of

numbers you added.

You added three numbers together, so you divide by three. If you had added how numbers together, you would have divided by two. If you had added 1000 numbers together, you would have divided by 1000.

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Data Collection and Analysis

Electromagnets Data Chart

Directions: Record the number of paperclips picked up by each electromagnet for each try. **After** you have collected all of the data for both of the electromagnets, average the number of paper clips picked up at each voltage.

For the 25-turn Electromagnet

$(1^{14} + 2^{16})$	Average = $\frac{1}{2}$	9	12	15.5	23
Number of paper clips picked up	Second try	7	12	17	26
Number of pape	First try	2	12	14	20
Battery	Voltage	1.5V	3.0V	4.5V	V0.9

For the 50-turn Electromagnet

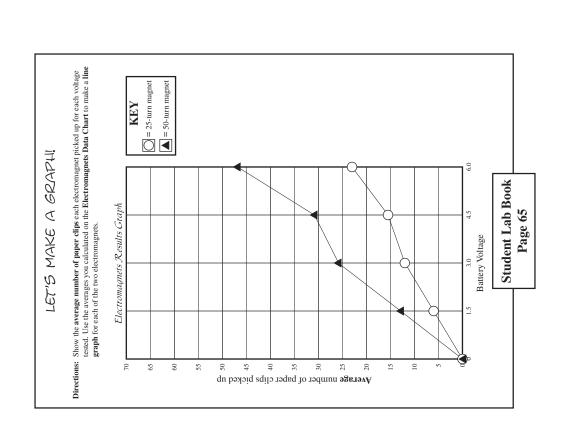
(1 ^{ss} + 2 nd	Average = 2	13	26	31	47
Number of paper clips picked up	Second try	16	24	32	20
Number of paper	First try	10	28	30	44
Battery	Voltage	1.5V	3.0V	4.5V	6.0V

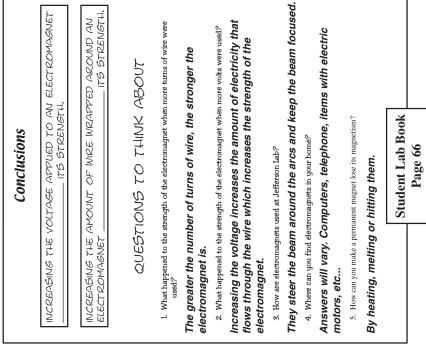
NAME THAT VARIABLE!!

Directions: Identify the Independent Variables, Dependent Variable, Constants and Control of

independent Variables battery voltage, turns of wire	number of paper clips picked up	length of wire, weight of clips, etc	bare nail
iables	Dependent Variable		

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READING COMPREHENSION

Reading About Magents and Electromagnets

JEFFERSON LAB USES MANY POWERFUL ELECTROMAGNETS IN ITS ELECTRON ACCELERATOR.

Directions: Read the following passage. Fill in the blanks with words that make sense. Remember to use context clues that come before and after the blanks.

Magnets are materials that attract pieces of iron or steel. In ancient times, people first discovered magnetism when they found some naturally pieces of rook in the earth. They called these rocks lodestone. Loadstones have a lot of iron in them, but we now know that other materials can be magnetized as well. Nickel, cobalt, certain types of ceramics and certain blends of magnetis can also magnetized.

If you could look at a magnet at the atomic level, you would notice that the magnet was divided into a number of smaller regions called domains. All of the $2 \over 2$ in a domain point in the same direction and, since each atom acts like a little $2 \over 3$, all of their little magnetic fields add together to make a largen. $4 \over 4$ field. A magnet can be weakened if some of its atoms are thrown out of alignment. Hitting or heating a magnet is usually enough to scramble some of its atoms.

Magnets have north and south poles. The north pole of one magnet will repel or push away, the north pole of another magnet, and the south pole of one magnet will repel the south pole of another magnet. But, if you but the north pole of one magnet near the south pole of another magnet you'll feel an attactive force. You may have heard the saying "opposites ______. This is just one of the rules of nature that scientists have discovered.

Everyone knows that magnets stick to refrigerators, but did you know that magnets are used in all sorts of things? Most of the magnets we are used to seeing are made from metals rich in ______. The kind we use to hold our school work to the refrigerator are called permanent magnets. They are magnets today and they! I've magnets tomorrow. They just hang there and continue to be magnets today and they! I've magnets tomorrow. They just hang there and continue to be magnets without us doing anything to them. Can you think of anywhere else you might find permanent magnets in your house? Did you know there's a ampare in the seal on the inside of your refrigerator door? You don't use that one to hold your sampen which we have procribed the door closed when you're not looking for a snack or a cold drink. Some cabinet doors have magnetical taches too. Can you think of any other places where magnets have practical uses?

Permanent magnets are one kind of magnet but there's another kind of magnet called an electromagnet.

I are made from metal and electricity! When the

E is on, you have a magnet, but turn the power off, and you just have a hunk of metal and some wire. Unlike permanent magnets, the extength of an electromagnet is easy to change. One way to do this is to change the amount of current used. Another way is to change the amount of wire you have wrapped around the metal core. You see, when you wind wire in coils around a piece of metal that has a lot of inon in it, and then you wind wire it wought wire, it creates a magnetic field. More coils of wire or more electric current creates a stronger magnetic field. Anote the atoms in the core to align, giving the metal

9 properties.

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READING COMPREHENSION

Electromagnets are used in many devices. Think of things that use power and have moving parts. Chances are, an electromagnet is causing the motion! Power windows in a car, automatic doors at the grovery store, and the little motor in a CD player that makes the CD spin so you can listen to your favorite mists all contain electromagnets! Electromagnets really make our lives. 10., and more fun tool

Directions: Choose the word that fits the context of the passage.

.i. e	_	<u>.</u>	b. magnetic	ri i	c. rough	4 -	d. rocky
nall o	atoms	9 4	magnets	ن ر	nngers	d 7	arrows
i d		نہ ن		ં ં	green	4	stronger
ą	. repel	.	attract	છં	sing	Ą	əsoddo
ą	. carbon	Ą	aluminum	히	iron	Ą	oxygen
ď,	a. electromagnets	Ä	magnets	히	Electromagnets	Ġ	domains
ą	. light	٦	television	છં	radio	႕	electricity
લી	. magnetic	٦	magical	vi	physical	Ą	chemical
œ	a. easier	<u>ب</u>	b. long	ರ	miserable	Ġ	hard

MATH EXERCISE

Averaging

WHEN YOU BUILT ELECTROMAGNETS AT IFFERSON LAB YOU AVERAGED THE NUMBER OF PAPER CLIPS YOUR MAGNET LIFTED. SEE IF YOU CAN FIND THE AVERAGE. OR MEAN, OF SOME OTHER NUMBERS.

Finding the mean.

and then dividing that answer by how many numbers were added. For example, the average of 2, 4, 6 and 8 is found by adding 2, 4, 6, and 8 together (2 + 4 + 6 + 8 + 20) and then dividing that answer by 4 (since four numbers were added) to get 5(20 + 4 = 5). The average, or mean, of a group of numbers is found by adding all of the numbers together

Find the mean of 78, 81, 82 and 79.

Step 1: Find the sum of the numbers.

78 + 81 + 82 + 79 = 320

Step 2: How many numbers were added?

Step 3: Divide the sum by the number of numbers added.

 $320 \div 4 = 80$

Your answer should be 80.

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Writing Prompt

Writing About Magnetism

THE ELECTROMAGNETS YOU MADE AT JEFFERSON LAB ATTRACTED METAL.

Write about having a 'magnetic touch.' Think about what you know about magnets. As you are thinking remember the story of King Midas (a king whose wish for everything he touched to become gold was granted). Use your imagination and decide what objects you would want to be attracted to you. What would the objects be made of? Would you be able to use the magnetic touch to solve problems? Could it create problems for you?

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MATH EXERCISE

Directions: Find the mean. Show your work

1. Lakeisha's grades on her science quizzes were 85, 90, 60, 75 and 95. What was her average quiz grade?

85 + 90 + 60 + 75 + 95 = 405

- $405 \div 5 = 81$
- The fifth grade had five students participate in a jump rope contest. Their number of jumps were 80, 50, 30, 65 and 45. What was their average number of jumps? *i*0

80 + 50 + 30 + 65 + 45 = 270

 $207 \div 5 = 54$

Jacqueline and her friends were experimenting with electromagnets. Jacqueline picked up 14 paper clips, Marcus picked up 19, Carlos picked up 21 and Jasmine picked up 26. What was the average number of paper clips picked up? wi

14 + 19 + 21 + 26 = 80

 $80 \div 4 = 20$

4. Below are the ages of students in Miss Taylor's class and the number of students at each age. Find the average age.

Number of students at each age

Age 10 Ξ 12

(10 * 4) + (11 * 7) + (12 * 4) + (13 * 1) = 178 $178 \div 16 = 11.125$ 5. A motorcycle went 865 km on 20 liters of gasoline. What is the average number of kilometers per liter?

865 km ÷ 20 l = 43.25 km/l

Role Model Visits

Students see and learn about many people and careers while at Jefferson Lab.

Objectives:

In this activity students will:

• learn about various jobs at Jefferson Lab

Travel Book Activities:

- Career Opportunities at Jefferson Lab p.9
- Writing About Jobs at Jefferson Lab p.71
- Graphing p.72
- Writing About a Career Choice p.74

CAREERS AT JEFFERSON LAB

Career Opportunities at Jefferson Lab

You might be interested to know more about high-technology jobs with scientific organizations like Jefferson Lab.

will earn more dollars per hour than they would in minimum wage jobs or many nontechnical These jobs can be very rewarding in job satisfaction, pay and benefits. In the years ahead, many more well trained people will be needed for technical and scientific jobs. These people

more are visiting scientists. People working at Jefferson Lab got their technical or scientific Several hundred people work at Jefferson Lab. About 650 are Lab employees and many training, education and experience in many different ways. But they all have one thing in common; they all studied math and science in school. Early in their careers, many found jobs that gave them valuable experience. They knew that a person's first job often isn't what one ends up doing later on Some Lab employees started out doing simple jobs for little pay. They learned more and more about the things they worked with and gradually gained technical experience. Often they continued their education after work by going to college or by taking special classes. Formal education is important for some jobs. A scientist, for instance, almost always earns both a four-year college degree and a doctorate, or PhD., degree. A PhD. can take several years to earn. You have to do research to find new knowledge that no one already knew.

Most other technical and scientific professionals have four-year degrees and many have master's degrees. A master's degree may take an additional year or two to earn.

year associate degrees or other special training. Most such workers at Jefferson Lab also have a good deal of practical work experience. Even as early as high school, they may have studied Still other technical professionals and highly skilled workers have community college twocomputers, electronics, machine tools or other technical equipment. Many of them take more courses from time to time after they 'finish' school to improve or update their skills and knowledge. They know they must always be learning if they want to be successful.

organizations like Jefferson Lab need to be able to read and write effectively, communicate well In addition to scientific and technical education, training and experience, employees of and work cooperatively with others.

They also need to be able to adapt old knowledge and skills to new job demands. Many Jefferson Lab employees had to learn on the job. They were able to do so because they prepared themselves to be flexible and to take on new kinds of technical challenges. Often, these challenges make their work interesting and exciting. Any large organization needs accountants, bookkeepers, maintenance workers, secretaries and others who help keep the organization going. There are many nonscientific jobs at Jefferson Lab. These workers need good math, reading writing speaking and teamwork skills and a general appreciation of science to succeed at Jefferson Lab.

Student Travel Book

CAREERS AT JEFFERSON LAB

Here are some examples of technical and scientific jobs at Jefferson Lab

Drafters and Designers

Drafters and designers use computer equipment to make drawings of high-technology

Mechanical, electrical, electronic and civil (construction) engineers are important technical managers and decision makers in an organization that builds and operates complex equipment. Often, an engineer gets to build something no one has ever built. At a equipment and components. Some drafters learn their trade mainly through experience after they leave high school. But many, especially those who become designers, have a formal technical education from a two-year community college.

may be responsible for the equipment, trained electricians install, operate and maintain it. A typical electrician might have a two-year degree, lots of practical experience or both. Much of the equipment at Jefferson Lab is electrical. Although engineers and physicists university.

minimum, an enqineer usually has an enqineerinq degree from a four-year college or

Nuclear physicists study the atom's nucleus. An important job for them is preparing and operating the equipment used in accelerator experiments. Accelerator physicists design,

Operating an accelerator requires good safety. Health physicists and safety and build and operate the accelerator. Physicists have Ph.D. degrees. fealth Physicists and Safety and Environmental Specialists

environmental specialists make sure that the people who operate the machine are

protected from the dangers that can be involved if people are not careful. They also make sure the operation of Jefferson Lab does not harm the public and the environment. Formal education for these kinds of jobs can range through and beyond a four-year college

Skilled technicians build, operate and maintain equipment. Many are graduates of apprentice schools or special programs at community colleges. Often they have Electronics and Mechanical Technicians

Computer Systems Technicians and Program

substantial college-level education.

make sure all the computer hardware runs smoothly and programmers help the scientists use computers. Most computer workers have college education through the four-year The scientists use computers to do much of their work. Computer systems technicians

WRITING PROMPT

WRITING PROMPT

Writing About a Career Choice

REMEMBER ALL THE PEOPLE WHO VISITED YOUR CLASS DURING BEAMS.

What do you want to do for a living when you grow up? Write about the job you would choose if you had to make a career choice today. Explain why you would choose that job. What kind of training would you need? How and where would you get it? Describe what you think spending a typical day at your job would be like. (You may refer to, but are not limited to, the Who Did I Meet at Jefferson Lab page in your Lab Book or the Career Opportunities at Jefferson Lab page in this book.)

Math Exercise

Graphing

WHEN YOU WERE AT JEFFERSON LAB. YOU MET PEOPLE FROM ALL DIFFERENT PARTS OF THE LAB.

Directions: Use the information in the following paragraphs to make a bar graph of the number of employees in each of Jefferson Lab's major divisions.

Jefferson Lab is a basic physics research laboratory located in Newport News, Virginia. It takes many different kinds of people to run Jefferson Lab. The Director of the Lab and the other 27 people in the Director's Office help plan the future of Jefferson Lab.

The Accelerator Division is responsible for the maintenance and operation of Jefferson

Lab's electron accelerator. It takes 344 technicians, accelerator operators, drafters and other Jefferson Lab was built to do physics experiments. The 163 members of the Physics Division make certain that experiments can be done in the three dorned end stations. They make certain that the detectors are working properly and that all of an experiment's data is collected and stored. engineers, and administrative personnel to keep things running smoothly.

Who does experiments at Jefferson Lab? Scientists from other labs, universities and countries come to the Lab to do experiments. There can be as many as 325 users on-site at one

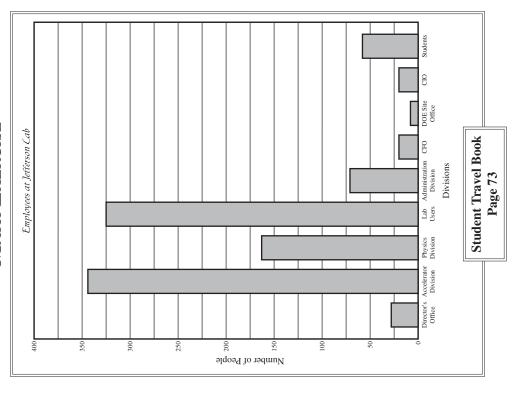
time doing experiments.

It takes more than scientists and engineers to run Jefferson Lab. The 71 employees of the Administration Division do all of the accounting purchasing and hiring for the Lab. The 20 people in the 70-thef Financial Office (CFO) are responsible for the budgeting tracking and reporting of all of the Lab's financial transactions while the 20 people in the Chief Information Office (CIO) make certain that all of the lab information stored in the Lab's computer systems is available to anyone who needs it.

Jefferson Lab is funded by the United States Department of Energy. There are 8 people in the DOE Site Office who make certain that everything is going well There are 58 students working in the various divisions at Jefferson Lab. Some are in college and others are in high school, but all help the Lab with its mission. Students help scientists with their experiments, help fix the accelerator when it breaks down and help with other day to day jobs that keep the Lab running. Once you are 16 years old, you can apply for a job to work at Jefferson Lab too!

Student Travel Book Page 72

MATH EXERCISE



Who Did I Meet at Jefferson Lab?

KEEP A RECORD OF THE PEOPLE THAT YOU MEET THIS WEEK!

exper	his week, a number of people from Jefferson Lab will be helping your class with the iments you will be doing. Before you start, take a minute or two to learn a little bit about the helping you. Use the space below to record some of the things you learn.
perso	in helping you. Ose the space below to record some of the timigs you ream.
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Student Lab Book Page 8

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Student Daily Logs and Homework

STUDENT LOG

Day 1

Directions: Please write your responses in complete sentences.

- 1. What do you expect to learn at BEAMS this week?
- 2. What job do you want to have in 15 years?
- 3. What did you learn from today's visit?
- 4. If you could change one thing about today's visit, what would it be?

Student Travel Book Page 78

STUDENT LOG

Day 2

Directions: Please write your responses in complete sentences.

- 1. Why is school important in your life?
- 2. What did you learn from today's visit?
- 3. If you could change one thing about today's visit, what would it be?

Student Travel Book Page 79

STUDENT LOG

Day 3

Directions: Please write your responses in complete sentences.

- I. If you could work at Jefferson Lab, which job would you like to have? Whu?
- 2. What skills do you think a scientists needs?
- 3. What did you learn from today's visit?
- 4. If you could change one thing about today's visit, what would it be?

Student Travel Book Page 80

STUDENT LOG

Day 4

Directions: Please write your responses in complete sentences.

- 1. How do you feel about math since you came to BEAMS?
- 2. How do you feel about science since you came to BEAMS?
- 3. What did you learn from today's visit?
- 4. If you could change one thing about today's visit, what would it be?

Student Travel Book Page 81

STUDENT LOG

Writing About Your Visit to Jefferson Lab

REMEMBER THE WEEK YOU SPENT AT JEFFERSON LAB.

Write two paragraphs telling what you will remember most a year from now about your visit to Jefferson Lab.

Student Travel Book Page 82

END OF THE WEEK WRITING

Writing About BEAMS

REMEMBER ALL THE EXPERIMENTS YOU DID AT JEFFERSON LAB.

Write a paragraph describing your favorite BEAMS activity. Explain why you enjoyed it

Write a paragraph describing your least favorite BEAMS activity. Explain why you didn't enjoy it as much as the other activities.

You Are Invited!

BEAMS Family Night

Who? You, your family, your friends and anyone else you want to bring!

What? A night to show your family all of the things you have been doing at Jefferson Lab this week!

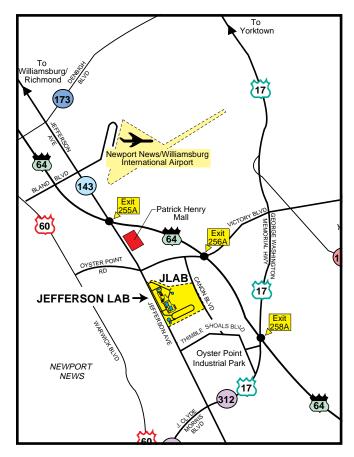
When?

Where? The BEAMS classrooms, rooms 72A and 72B in the VARC building (building 28) at Jefferson Lab. (See the map on the back.)

So you can show your family liquid nitrogen, look at your class photo on the computers, do some experiments, eat some cookies, drink some soda and have fun!

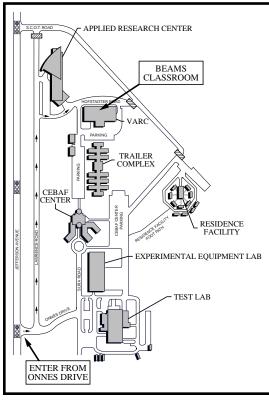
How Much \$? Free! Free! Free!

How to Find Jefferson Lab



Jefferson Lab is located on Jefferson Avenue between J. Clyde Morris Boulevard and Oyster Point Road near Patrick Henry Mall.

Our street address is 12000 Jefferson Avenue.

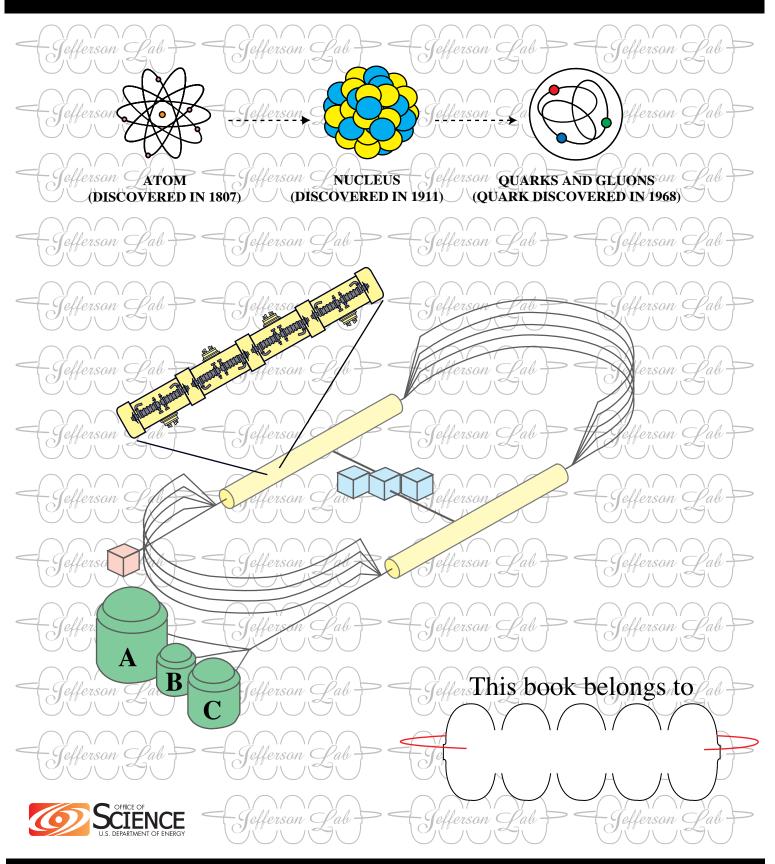


The BEAMS classrooms are located in rooms 72A and 72B in the VARC building, building 28. Parking can be found in front of and behind the VARC building.

Enter the VARC building through the front door. A staff member will unlock the door for you.

All adults attending Family Night must bring a photo ID.

THOMAS JEFFERSON NATIONAL ACCELERATOR FACILITY



BEAMSBecoming Enthusiastic About Math and Science

_ Student Lab Book

What is BEAMS?

BEAMS stands for **B**ecoming **E**nthusiastic **A**bout **M**ath and **S**cience. This program is a partnership between your school district and Jefferson Lab.

You, your class and your teacher will visit Jefferson Lab everyday for one week. While here, you will conduct special science and math activities with some of the people who work at Jefferson Lab: scientists, engineers and technicians. You will also use other school subjects, like reading and writing.

- You should wear comfortable clothes and shoes to Jefferson Lab each day.
- Come prepared to have fun, work hard and be ready for a few surprises!
- We hope you enjoy your visit!

How to contact Jefferson Lab:

Jefferson Lab Science Education Group Thomas Jefferson National Accelerator Facility 12000 Jefferson Avenue Newport News, VA 23606

telephone: (757) 269-7567 fax: (757) 269-5065

e-mail: BEAMS@jlab.org

world wide web: http://education.jlab.org/

The Southeastern Universities Research Association (SURA) operates the Thomas Jefferson National Accelerator Facility for the United States Department of Energy under contract DE-AC05-84ER40150.

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Introduction to Jefferson Lab

What is Jefferson Lab?

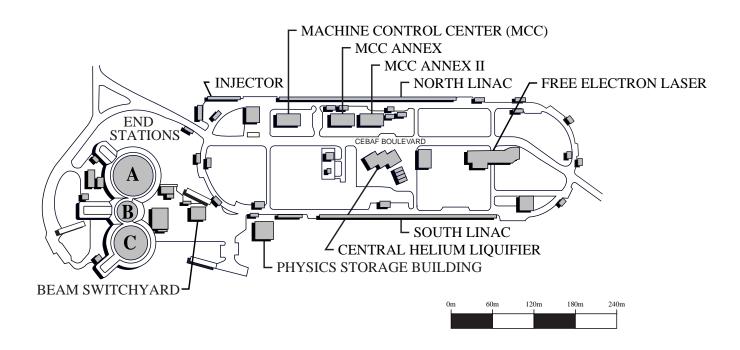
Jefferson Lab is a laboratory for basic research in nuclear physics. Nuclear physics is the science of studying the nucleus of the atom. Jefferson Lab also works with industry to develop technologies for businesses to use and with schools to motivate students and assist teachers.

Jefferson Lab's mission is to provide scientists around the world with opportunities to experiment with and learn more about nucleons.

Jefferson Lab's main instrument is a machine, called an accelerator, that is able to make electrons go really fast. The accelerator is in an underground, racetrack-shaped tunnel, 1.4 km around, that delivers a beam of electrons to experiments in three large experimental halls called end stations.

The facility is owned by the government's Department of Energy (DOE) and is managed by the Southeastern Universities Research Association (SURA). SURA is a group of 61 universities in fifteen southeastern states and the District of Columbia. SURA also manages other large research projects in the southeastern region of the United States.

About \$600 million was spent over ten years to build the facility in Newport News, Virginia. Scientists from around the world are currently using Jefferson Lab's accelerator for experiments to study the nucleus of the atom. These experiments can take months to run. Once scientists complete their work at the lab they must analyze the data they have gathered. What they find out may change what we know about the structure of nuclear matter, making Jefferson Lab a vital instrument of the scientific world.



Exploring Nuclei at Jefferson Lab

Over ninety years ago, scientists described the atom as a nucleus with orbiting electrons. Later, the nucleus was found to contain protons and neutrons (nucleons). Now each nucleon is seen as a collection of three quarks.

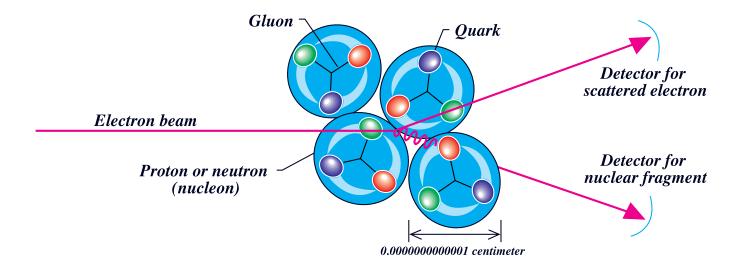
Scientists need Jefferson Lab to broaden their understanding of how quarks interact in the nucleus. Jefferson Lab provides scientists with beams of electron probes to explore the quark structure of the nucleus.

Point-like electrons can probe the nucleus with extreme accuracy. They interact cleanly with quarks in nuclear matter. The 'fingerprint' of each interaction - a deflected electron and one or more nuclear fragments - provides clues about the subnuclear world (see diagram below).

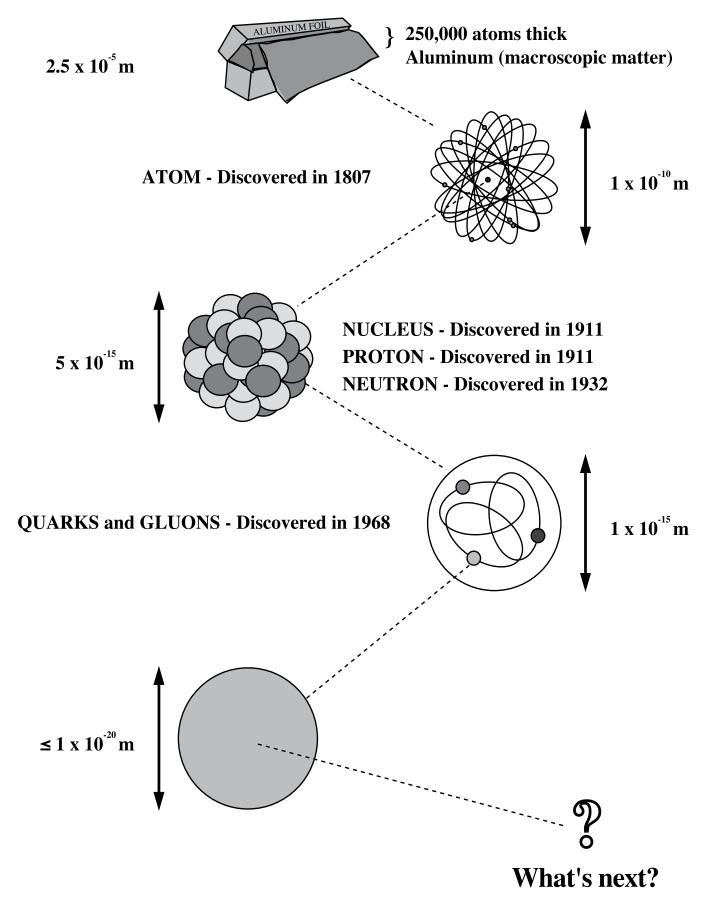
When the beam is directed through an experiment's target - typically a small, thin sheet of material whose nuclei are under study - unimaginably tiny electron-quark interactions result. The exact interactions are the 'fingerprints' of the experiment. These interactions are recorded automatically by spectrometers and detectors in the end stations. Collecting the thousands to millions of fingerprints required for each experiment may take weeks or even months. Later, aided by computers, nuclear physicists use this data to understand the mysteries of nuclear structure.

Studying the world of the very small requires equipment that is very large. Jefferson Lab's electron accelerator is 1.4 km around. The detectors used to 'watch' the experiments weigh thousands of tons each. Scientists use these huge machines to 'see' the quarks and gluons inside an atom's nucleus - particles that are less than 0.0000000000001 cm across!

The main goal of Jefferson Lab's scientific program is to understand the structure and behavior of the nucleus and its parts. Scientists use the electron accelerator to study how the nucleus and its pieces are put together and interact with each other. Jefferson Lab is like a powerful microscope used for studying the atom's nucleus.



How Scientists' Ideas About Matter Have Changed



Who Did I Meet at Jefferson Lab?

KEEP A RECORD OF THE PEOPLE THAT YOU MEET THIS WEEK!



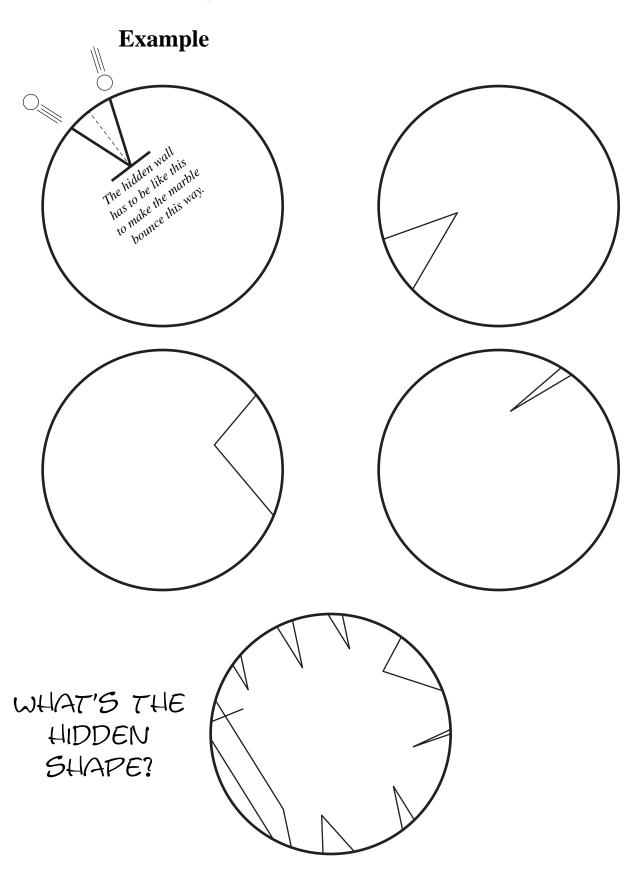
The Shape of Things

CAN YOU SEE A HIDDEN SHAPE WITHOUT USING YOUR EYES?

- 1. To do this experiment, your team will need:
 - A pie pan with a hidden shape under it (Don't peek!)
 - A marble
 - A plastic ramp
- 2. It is your team's mission to discover the shape under the pie pan, but you **cannot**:
 - Peek under the pie pan
 - Feel under the pie pan
 - Tilt the pie pan
- 3. Use the plastic ramp to roll the marble under the pie pan.
- 4. Watch what the marble does. Does it hit something and bounce back out? Does it not hit anything? You can use these clues to discover what is hidden under the pie pan.
- 5. Keep track of what the marble does by drawing its path on top of the pie pan. Remember, you can't actually see what the marble is doing, so you will have to estimate what path it took.
- 6. If the marble looks like it hit something under the pie pan, draw what it could have bounced off of on top of the pie pan. See the example on the next page.
- 7. Roll the marble under the pie pan many different times from many different directions.
- 8. Once all of your team members think they know what shape is hidden under the pie pan, call someone over to test you. **Don't turn the pie pan over until your group has been tested!**

WHERE'S THE WALL?

Directions: Look at the path the marble traveled and show the wall the marble hit.



QUESTIONS TO THINK ABOUT

Directions: Compare the experiment you did in the classroom with the experiments scientists do at Jefferson Lab.

	What was your?	What is Jefferson Lab's?
energy source		
accelerator		
probe		
unseen target		
data collector		
predictor		
cost		
time taken for one experiment		

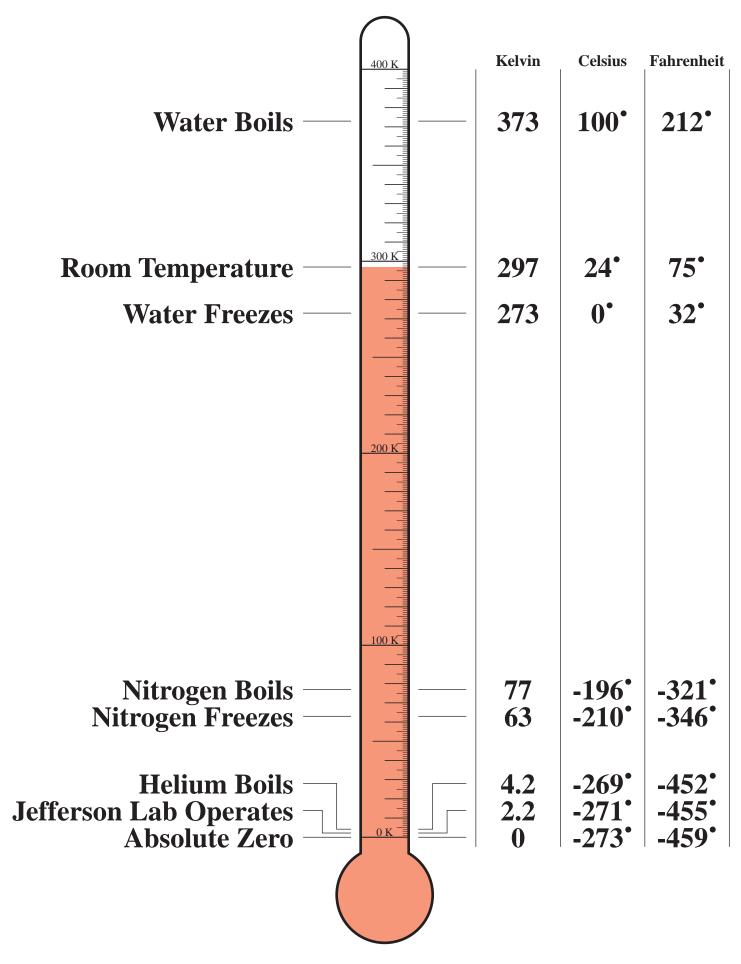


Hot and Cold

DO THINGS ACT DIFFERENTLY WHEN THEY GET REALLY HOT OR REALLY COLD?

- 1. In this experiment, some things will be made very hot and some things will be made very cold. Use the chart on the next page to predict the outcome of some of the experiments. When a scientist makes an educated guess about an experiment, it is called a **hypothesis**.
- 2. Watch what actually happens and record the outcome in the chart.
- 3. Ask bunches of questions and have fun!

Experiment	What's your hypothesis?	What happened?	Why did it do this?
A balloon is filled with air and then made very cold. What will it do?			
A ping-pong ball is made very cold and then bounced. How will it bounce?			
A super ball is made very cold and then bounced. How will it bounce?			
A racquetball is made very cold and then bounced. How will it bounce?			
A burning match is slowly lowered into the vapor of a very cold substance. What will happen?			
A tube of Helium gas is heated to 3000° Centigrade (~5000° Fahrenheit). What will it look like?			





HUMAN

Accelerator

8

Human Accelerator

HOW EASY IS IT TO WORK TOGETHER AS A TEAM?

- 1. Stand side by side, shoulder to shoulder with your class. Your class is now a linear accelerator that will help deliver the electron beam to its target.
- 2. The first person in the line will act as the injector. Every other person in the line is a cavity. The last person in line will hit the target with the electrons.
- 3. Cup your hand that is closest to the injector in the upward direction and the other hand downward.
- 4. As the electrons that make up the beam are injected you will transfer them along the accelerator by bringing your hands together and then moving them back to their original position as a leader calls "in...out..." in constant rhythm. When your hands come together, or in, you will transfer the electrons from one hand to the other. When your hands go out you will transfer them to the next cavity in line.
- 5. You must continue to do your job **even if you don't have any electrons** so that the accelerator may continue operating.
- 6. Do not pick up any lost electrons.
- 7. After the beam has been delivered to its target, use the **Human Accelerator Data Chart** on the next page to record your data.

Human Accelerator Data Chart

Beam Type	Number of balls Injected	Number of balls Delivered	Fraction Delivered	Percent Delivered
Pulsed Beam				
Continuous Beam (slow cadence)				
Continuous Beam (fast cadence)				
Eyes Shut				
Other				

HOW DO I CONVERT A FRACTION INTO A PERCENT?

Write the fraction as a division problem.

$$\frac{7}{12} = 12 \boxed{7}$$

12 doesn't go into 7, so make the 7 look larger by adding a decimal point and some zeros.

Bring the decimal point up and divide like you usually do.

This problem will go on forever. Stop dividing when you think you have gone far enough.

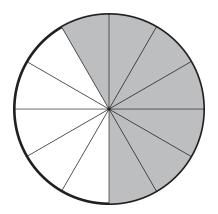
LET'S MAKE SOME GRAPHS!

Example

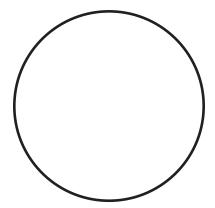
Pulsed Beam

Continuous Beam

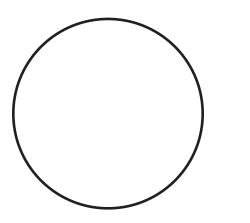
(slow cadence)



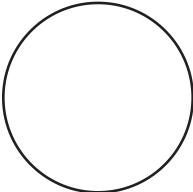
$$\frac{\text{Fraction}}{\text{Delivered}} = \frac{7}{12}$$



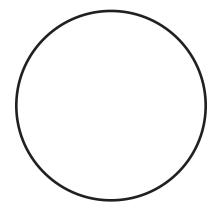
Continuous Beam (fast cadence)



Eyes Shut



Other





Cold Stuff

WHAT MATERIALS MAKE GOOD INSULATORS?

Problem

Which substance makes the best insulator: cotton, air or steel wool?

Research

Answer the following True or False questions about insulators:

True/False	Insulators don't allow heat to pass through them easily.
True/False	Most metals make good insulators.
True/False	Conduction, convection and radiation are ways that heat can move around.
True/False	A good insulator will make an object get warmer.

Hypothesis

I think that		will be the best insulator.
	(cotton, air or steel wool)	

Procedure

- 1. To do this experiment, your team will need:
 - 3 different materials to test
 - A thermometer
 - A stopwatch
 - A bowl filled with 500 milliliters of ice water
- 2. There are three jobs to do:
 - **Time Keeper** tells the Temperature Reader when to read the temperature
 - **Temperature Reader** tells the Data Recorder what the temperature is at that time
 - **Data Recorder** writes the temperature in the data chart
- 3. Put the thermometer in one of the three insulators and measure its **Initial Temperature**. This should be somewhere near 20° Centigrade. It might take the thermometer a few minutes to read the correct temperature. Give it time to get used to its new home.
- 4. Record the Initial Temperature on the chart on the next page.
- 5. Put the insulator in the ice water and start the stopwatch. Hold the insulator in the ice water by the lid. Keep the insulator in the water for **5 minutes**.
- 6. Measure and record the insulator's temperature **every 30 seconds** for 5 minutes. **DO NOT STOP THE STOPWATCH UNTIL 5 MINUTES HAVE PASSED!!** If you stop the stopwatch early, you won't know how long the insulator has been in the ice water.
- 7. At the end of five minutes, get ready to test the next insulator. Your team will have to:
 - Reset the stopwatch
 - Get 500 milliliters of new ice water
 - Put the thermometer in the next insulator to measure its initial temperature (Remember: the initial temperature should be somewhere near **20** * Centigrade!)
 - Put the insulator in the ice water **after** you have recorded its initial temperature
- 8. Put the second insulator in the ice water and measure its temperature **every 30 seconds** for 5 minutes, just like you did with the first one. **Don't forget to record your data!**
- 9. Test the third insulator when you finish with the second one.
- 10. Make certain that everyone on your team has all of the temperatures written down.
- 11. Make a line graph for each insulator on the **Cold Stuff Results Graph**.

Cold Stuff Data Chart

For each insulator: • Record the Initial Temperature (somewhere near 20° C)

Start the stopwatch when you put the insulator in the ice water

Record the temperature EVERY 30 SECONDS

Stop the stopwatch when it reaches 5 minutes

TNSTIT ATOR	(initial temperature)	TE	TEMPERATURE of insulator at TIME (minutes:seconds)	ATUR	E of ir	sulato	r at TI	ME (n	ninutes	:secon	(spi
$\begin{array}{ c c c c c c c c c c c c c c c c c c c$	0:00	0:30	30 1:00 1:30 2:00 2:30 3:00 3:30 4:00 4:30 5:00	1:30	2:00	2:30	3:00	3:30	4:00	4:30	5:00

Data Collection and Analysis

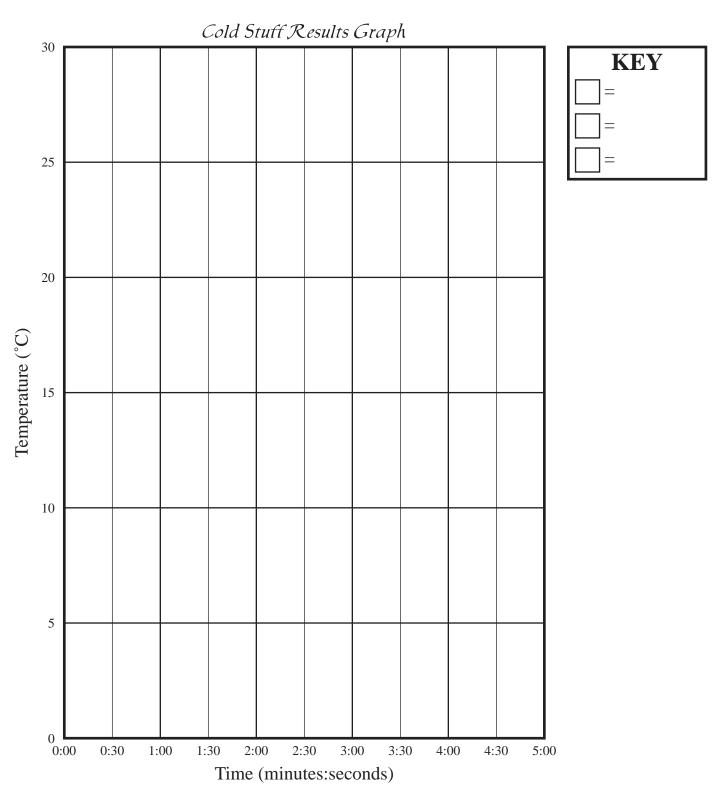
NAME THAT VARIARLE!!

Directions: Identifiy the Independent Variable, Dependent Variable, Constants and Control of this experiment.

Independent Variable	
Dependent Variable	
Constants	
Control	

LET'S MAKE A GRAPH!

Directions: Make a **line graph** for each of the three insulators you tested. Graph one insulator at a time. Start by plotting the insulator's initial temperature. Then plot the insulator's temperature at 30 seconds, one minute, one and a half minutes, all the way to 5 minutes. Plot the other two insulators on the graph in the same way. You will have to make different symbols for each insulator so that you can tell them apart.



Conclusion

TILE	NECT	INSULATOR	ADDEADC	TA	NI
しせし	17621	INSULATOR	HTTEHKS	$\iota \circ$	135

QUESTIONS TO THINK ABOUT	
1. Which container cooled the fastest?	
2. Which container took the longest to cool?	
3. Where did the heat inside the containers go as they were cooling?	
4. Which material that your team tested is the best insulator? How can you tell?	
5. What other materials do you think might make good insulators?	
5. What other materials do you think might make good insulators?	
6. What materials would make poor insulators?	





Treasure Hunt



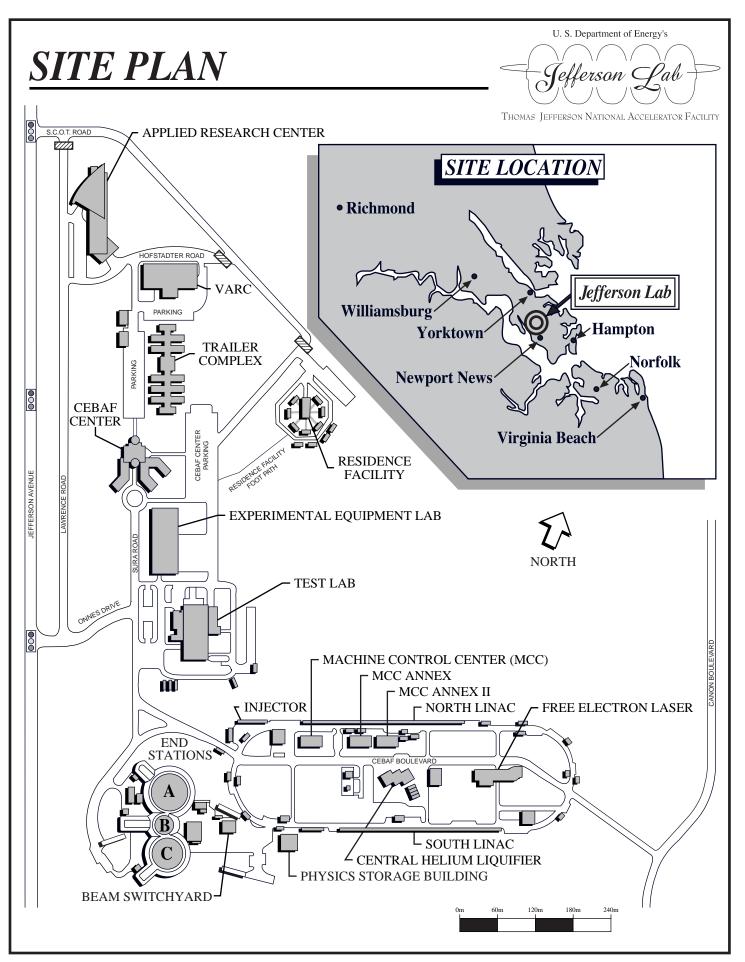


Jefferson Lab Treasure Hunt

HOW MUCH DO YOU KNOW ABOUT JEFFERSON LAB?

Answer the questions below by:

- Looking at signs posted around Jefferson Lab
- Watching carefully during your tour
- **Listening** carefully to your guide
- What are Jefferson Lab's superconducting cavities made of?
- What is the name of the 'pink' building?
- · Where is Jefferson Lab's cafeteria?
- · Where can visiting scientists spend the night?
- How many end stations (or experimental halls) does Jefferson Lab have?
- · Where does Jefferson Lab's electron beam qet its start?
- What is the main job done in the Machine Control Center?
- What is liquid helium used for at Jefferson Lab?
- What new kind of laser is being used at Jefferson Lab?
- How far around, in kilometers, is the accelerator?
- What is a speed limit on the accelerator site?
- How many flaqpoles are in front of CEBAF Center?
- · What was Jefferson Lab's previous name?
- What did the letters in that name stand for?



Microscopes

(3)

Microscopes

Microscopes



Microscopes



Microscopes





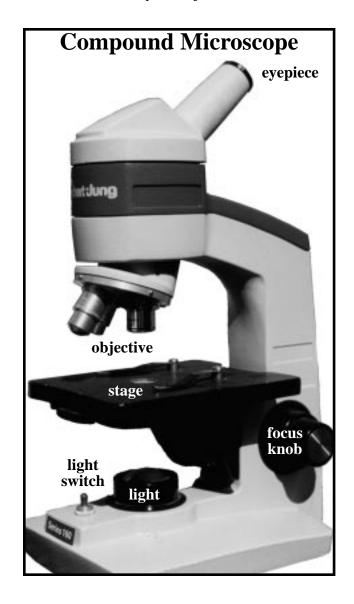
Microscopes

Microscope

Microscopes

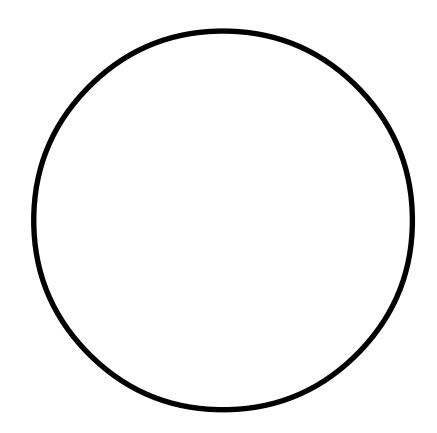
HOW DO DIFFERENT OBJECTS LOOK WHEN MAGNIFIED?

- 1. Choose an object to look at with a microscope.
- 2. There are two different types of microscopes that you can use. Which type should you use with your object? In general, you should use:
 - A Compound Microscope if your object is very thin and you can see through it (things like strands of hair, glass slides or blades of grass)
 - A **Dissecting Microscope** if your object is **big** or if **you can't see through it** (things like rocks, baseball cards or your hand)
- 3. Put your object on the microscope's *stage* and look through the *eyepiece(s)*. Does it look fuzzy? Try turning the *focus knob*. Is it really dark? Make certain that the microscope's *lights* are on. Try experimenting with different magnifications.
- 4. Draw what your object looks like on **Microscope Data Sheet**.





Microscope Data Sheet



Object: _____ Magnification: _____
Description: _____

1. When observing your object under the microscope, what are its most interesting or unusual features?

2. What did you discover about your object using the microscope?

Instruments Used for Scientific Observations

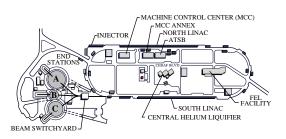
Label the instrument

Name an object that can be seen with each instrument.

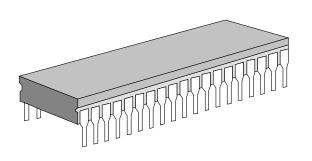






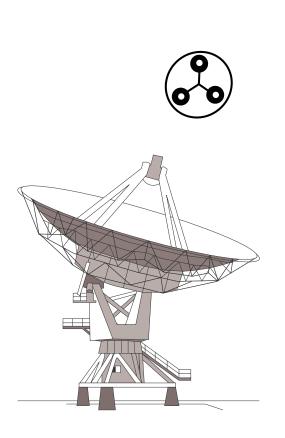


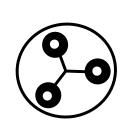
1. What is the relationship between the instruments and the size of the objects that can be seen with them?

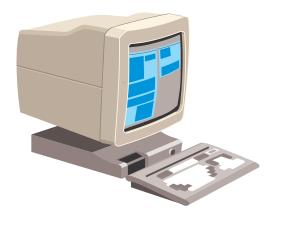




TECHOOLOGY







Technology

WHAT CAN YOU DO WITH THE INTERNET?

Networks

When two or more computers are connected to each other, they become a **network**. People who use networked computers can share information with each other, exchange messages, and even run the same programs at the same time on many different computers.

The Internet

The **Internet** is like a network, only much bigger. In fact, the Internet is made up of many different networks combined.

In 1980, a large group of scientists found themselves working on the same projects, but from different parts of the world. They needed a faster way to share information than sending messages through the mail. The scientists set up a special network that connected not only computers in one building, but computers around the world.

This world-wide network was called the Internet. Today anyone can explore the Internet. It connects more than 60,000 networks, each with its own collection of articles, pictures, and sounds.

Uses of the Internet

You can do many things on the Internet. Two of the most popular things are **electronic mail** or **e-mail** and browsing pages on the **World Wide Web**.

E-mail is one of the most common use of the Internet. With e-mail you can write an electronic letter on your computer and send it to another person almost instantly, even if that person is halfway around the world. You can also attach pictures or sounds to an e-mail message.

E-mail addresses look like this: **mrsteve@jlab.org**. In this example, "mrsteve" is the name of the person who gets the letter. The name is followed by an "at" sign (@), which tells the network that a server name is coming next. In this case "jlab.org" is the e-mail server address for Jefferson Lab.

The World Wide Web, also known as the Web or WWW, is made up of millions of documents called Web pages. These pages can include text, still and moving pictures, and sound. When you are done looking at one Web page, you can click on a short-cut called a **hyperlink** to connect to other Web pages.

Most organizations on the Web have sets of pages that are linked together called Web sites.

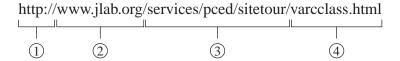
WHAT ARE SOME OTHER USES FOR THE INTERNET?

How Does it Work?

Each of the thousands of individual networks that make up the Internet has set aside one or more computers to act as a server. These computer servers play host to Internet sites, and serve their information to computer users the way a waiter serves food in a restaurant. And, like a restaurant, each of these servers has its own **address**.

Internet Addresses

Internet addresses are called **URLs** (**Uniform Resource Locators**). Some look long and complicated, while others are quite short, but they all follow the same simple rules. A typical URL looks something like this:



- ① The first group of letters on every address tells the network which **protocol** to use. A protocol is like a language you have to know which one to speak. One common protocol is http, which stands for **HyperText Transport Protocol**.
- ② Next comes the **domain name**. The domain name is the name of the computer that you are trying to contact. You can sometimes tell what kind of a site you will be visiting by looking at the end of the domain name. A domain name ending in .org usually means that the site is run by a non-profit organization. Sites ending with .gov are run by the government while sites ending with .edu are usually educational sites like colleges or universities.
- ③ The next part of the URL is the **file path**. This tells the computer where the file you want is located.
- 4 The last part of the URL is the **file name**, which is the name of the file you want. Files ending with .html are text files written in HyperText Markup Language and are used in web browsers. Files ending with .gif or .jpg are graphic files while files ending with .wav or .mp3 are sound files.

Internet Safety

Be careful what information you give out in e-mails and on the World Wide Web!

Never give your address, telephone number, or even your name over the Internet to anyone you don't know!

www.kodak.com

BEAMS INTERNET SCAVENGER HUNT

www.disney.com

Directions: Using **ONLY** the following websites, can you find answers to the questions below?

www.amazon.com

	www.apple.com www.buschgardens.com	1	www.sbo.nn.k12.va.us
1.	-	·	ay. What was the final score of the
2.	Who produced the first simple	camera to be sold to the	public? When?
3.	Who founded the Frito Lay con	mpany? When? Where?	
4.	Name three snacks that Frito I	Lay sells.	
5.	Name two Disney items you c	an buy on the Internet. W	hat is the price of each?
6.	Name two different items for s	sale at www.amazon.com.	What does each item cost?
7.	How much do iMac computers	currently cost? Which w	rebsite did you use?
8.	What is your school's telephor	ne number?	
9.	How tall is the first drop on A	pollo's Chariot?	

BEAMS COLLEGE INTERNET SCAVENGER HUNT

Directions: Using **ONLY** the following websites, can you find answers to the questions below?

www.cnu.edu www.gmu.edu www.hamptonu.edu www.hsc.edu www.jmu.edu	www.nsu.edu www.odu.edu www.richmond.edu www.rmwc.edu www.tc.cc.va.us	www.tncc.cc.va.us www.vcu.edu www.vmi.edu www.vt.edu www.wm.edu
l. What is the full name of Vir	ginia Tech?	
2. What is the full-time underg	graduate in-state tuition at C	Christopher Newport University?
3. How many students are enr	olled in James Madison Univ	versity?
4. Where is Thomas Nelson Co	mmunity College located?	
5. Name three student organiz	ations at the University of F	Richmond.
6. Name two of George Mason	University's libraries.	
7. Who founded Hampton Univ	versity?	
8. Which college only allows w	vomen to attend? Which col	lege only allows men to attend?
9. What is the mascot of Norfo	olk State University?	

10. Name three sports that both men and women play at Virginia Commonwealth University.



for the



Duark



A Graphing Game

My Quarks

Directions

There are six kinds of quarks:

Quadrant I

y-axis

Quadrant II

5

Down Strange Charm Bottom Top

Make sure that you place the quarks where the Hide one of each kind of quark on your grid. ines intersect, like at (5,8).

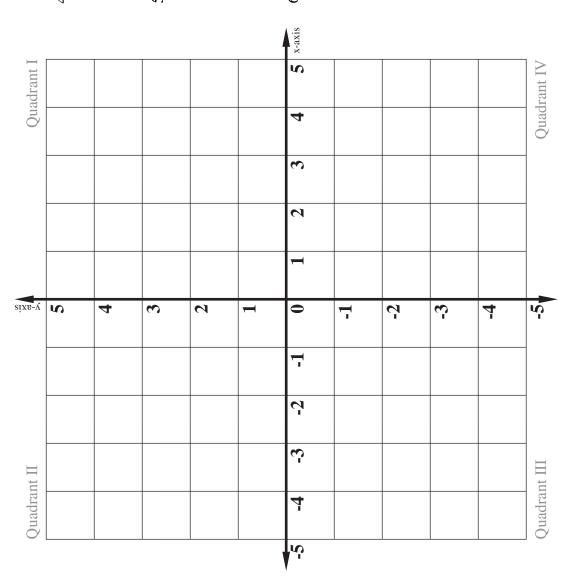
that you go across to 5 and then up to 8 Remember: The coordinate (5,8) means

- guessing coordinates. Check the My Quarks grid to see if they found one of your quarks. Your partner will try to find your quarks by
- Take turns guessing coordinates until someone inds all of the hidden quarks.

1Ò	UARK KEY	
$dol = \square$	= Charm	$\square = Up$
= Bottom	= Strange	= Down

1. H	Z :I		2. Y & & &	3. E. T. &	3				╝
				x-axis					
				w					Quadrant IV
				4					Quadr
				m					
				7					
				 					
4	m	7	—	0	7	7-	ů.	4	-5-
4	m	7	1	-1 0	-1	-2	Ę.	4	
4	e e	7	1		1.	-2	ķ.	4	- K
4	e e	7	1	1.	7	-2	£-	4	
4	e e	7	1	-2 -1	-1	-2	£-	4-	Quadrant III -5

My Guesses



4. Try to find your partner's hidden quarks by guessing coordinates.

that you go across to 5 and then up to 8 Remember: The coordinate (5,8) means

5. Keep track of your guesses on the My Guesses grid.

Did you find one of their quarks? Mark that coordinate as a hit!

Did you miss them this time?

Mark that coordinate as a miss.

Take turns guessing coordinates until someone finds all of the hidden quarks. 9



My Quarks

Directions

There are six kinds of quarks:

Up Down Strange Charm Bottom

fake sure that you place the quarks where the lide one of each kind of quark on your grid. nes intersect, like at (5,8).

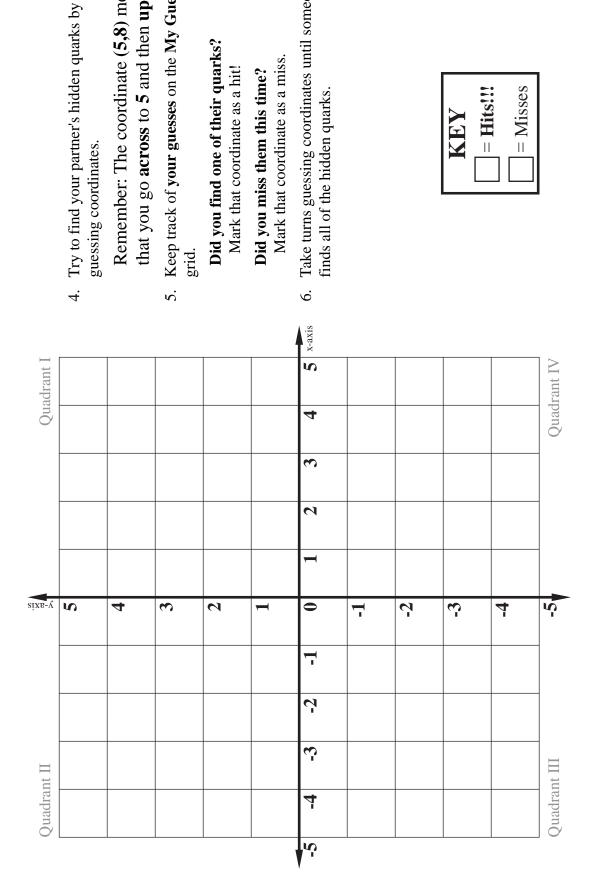
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0	UARK KEY
$dot = \Box$	\Box = Charm \Box = Up
= Bottom	= Strange = Down

		1. Hi	M ril	_ -	2. Yc	gr 3. Ta	Ħ				
						x-axis					
Quadrant I						w					Quadrant IV
Qua						4					Quadr
						6					
						71					
						 					
sixa-y	w	4	6	7	H	0	7	-2	۴-	4	3.
						<u> </u>					
						-2					
П						6					
Quadrant II						4					Quadrant III
\bigcirc						10					

My Guesses



that you go across to 5 and then up to 8 Remember: The coordinate (5,8) means 5. Keep track of your guesses on the My Guesses grid. Take turns guessing coordinates until someone Did you find one of their quarks? Mark that coordinate as a miss. Mark that coordinate as a hit! Did you miss them this time? finds all of the hidden quarks. guessing coordinates.

My Quarks

Directions

There are six kinds of quarks:

Quadrant I

y-axis

Quadrant II

Down Strange Charm Bottom Top

Make sure that you place the quarks where the Hide one of each kind of quark on your grid. ines intersect, like at (5,8).

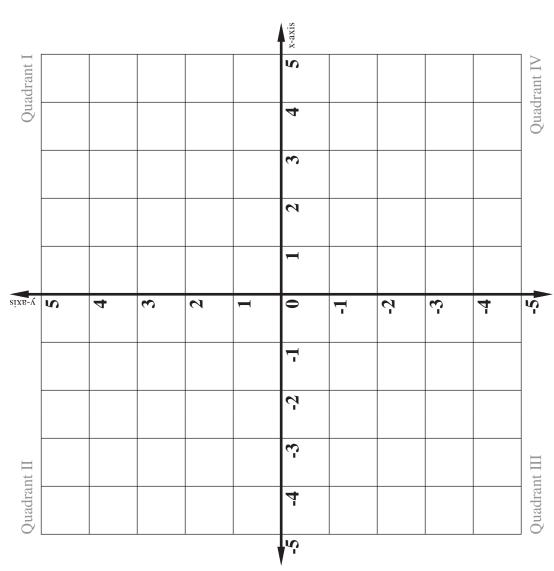
that you go across to 5 and then up to 8 Remember: The coordinate (5,8) means

- guessing coordinates. Check the My Quarks grid to see if they found one of your quarks. Your partner will try to find your quarks by
- Take turns guessing coordinates until someone inds all of the hidden quarks.



	1.	2 :1		2.		4		L		╝
					x-axis					
					w					Quadrant IV
					4					Quadi
					m					
					7					
					-					
i w	4	m	7	1	0	1-	-2	۴.	4	-5-
S W	4	m	7	1	-1 0	-1	-2	۴.	4	-5 _v
S W	4	г	7	1		1-	7-	£-	4	- S-
2 W	4	es .	7	1	1-	1-	-2	٤-	4	√ S-
S W	4	es -	7	1	-2 -1	-1	-2	£-	4	Quadrant III -5v

My Guesses



4. Try to find your partner's hidden quarks by guessing coordinates.

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Mark that coordinate as a miss.

Take turns guessing coordinates until someone finds all of the hidden quarks. 9





What is Oobleck?

CAN YOU USE THE SCIENTIFIC METHOD AND YOUR SENSES TO SOLVE THE MYSTERY OF OOBLECK?

Problem

Three liquids are mixed together in a plastic bag. Using your senses (except for taste) can you determine if the substance that is formed is a solid, liquid or gas?

Research

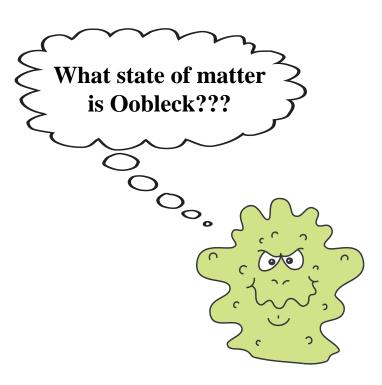
J	List three	properities	of solids,	liquids a	ind	gases.

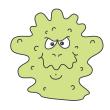
Solid	
Liquid	
Gas	

Hypothesis

Procedure

- 1. To do this experiment, your team will need:
 - A plastic bag
 - A clear liquid
 - A green liquid
 - A white liquid
 - All of your senses, except for taste
- 2. Open the plastic bag.
- 3. Carefully measure two teaspoons of the clear liquid into the plastic bag.
- 4. Next, add two drops of the green liquid.
- 5. Carefully add two tablespoons of the white liquid.
- 6. Close the bag and knead the mixture well for 2 minutes.
- 7. Once 2 minutes have passed, take the Oobleck out of the bag and experiment with it.
- 8. Record your observations about the properties of Oobleck on the **Oobleck Investigation Sheet**.
- 9. Decide if each observation is a property of a solid, liquid or gas. Circle one or more of the **State of Matter** letters on the right hand side of the **Oobleck Investigation Sheet** to show what you decided.
- 10. Answer the blob's question.





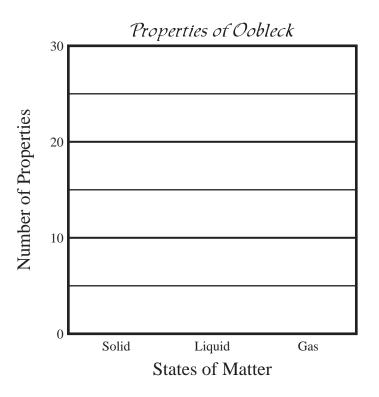
Data Collection and Analysis

Oobleck Investigation Sheet

		PROPERTY	State of Matter
example:	GREEN		<u>S</u> L G
			S L G
			S L G
			S L G
			S L G
			S L G
			S L G
			S L G
			S L G
			S L G
			S L G
			S L G
			S L G
			S L G
			S L G
			S L G
			S L G
			S L G
			S L G
			S L G
			S L G
			S L G
		Totals	s:
		Total	S L G

LET'S MAKE A GRAPH!

Directions: Make a **bar graph** showing how many of your properites describe a solid, how many describe a liquid and how many describe a gas..



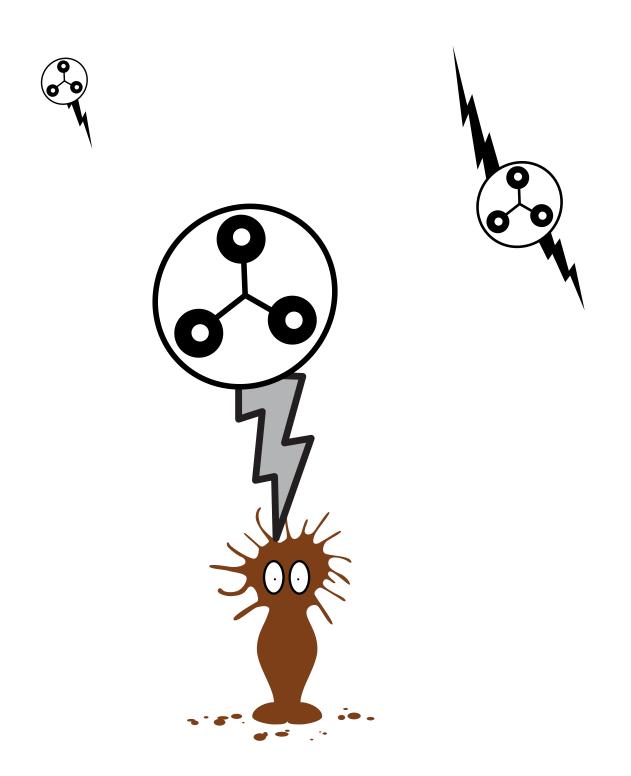
Conclusion

OOBLECK APPEARS TO BE A _____

QUESTIONS TO THINK ABOUT

- 1. What type of change occurred when the three ingredients where mixed together?
- 2. What type of change occurred when the Oobleck changed shape in your hands?
- 3. What is the term given to a material that exhibits properities of more than one state of matter?

Electrostatics



Electrostatics

WHAT HAPPENS TO DIFFERENT OBJECTS WHEN THEY ARE ELECTRICALLY CHARGED?

- 1. In this experiment, a device called a Van de Graaff generator will be used to place extra electrons on different objects, giving them a negative charge. Use the **Electrostatics Data Chart** to predict the outcome of some of the experiments.
- 2. Watch what actually happens and record the outcome on the **Electrostatics Data Chart**.
- 3. Ask bunches of questions and have fun!

Electrostatics Data Chart

The Experiment: A container full of packing foam is placed on the Van de Graaff generator.
Your Hypothesis:
What happened?
Why did this happen?
The Experiment: A bunch of string is placed on the Van de Graaff generator.
Your Hypothesis:
What happened?
Why did this happen?
The Experiment: A person touches the Van de Graaff generator.
Your Hypothesis:
Tour 11, potnesis.
What happened?
···
Why did this happen?
Tr.





and





ENERGIA

Design and Engineering

HOW MANY DICE CAN YOUR ALUMINUM FOIL BOAT FLOAT?

- 1. Your team's job is to design and build four boats from four squares of aluminum foil. Only one square of aluminum foil can be used per boat. No other materials, such as tape, paper or staples, can be added to the foil.
- 2. Talk with you teammates about how different boats look. What kinds of boats can your team make from the foil? How might they look? Draw some plans for your boats before you start to build them.
- 3. **As a team**, build **one** boat at a time.
- 4. When one boat is complete, test it by first floating it in the water, then carefully load the boat with dice until it sinks. Count the number of dice the boat **successfully** floated and record that number on the data sheet.
- 5. Remove the boat from the water, label it and put it in a safe place. **DO NOT PLAY WITH IT!!** Your team may need it later!
- 6. Use what you learned from the last boat to make a new, better boat. Use a new square of foil for each new boat.
- 7. After your team has built and tested all four boats, decide on a price for the best one.
- 8. Write your team's name and the price for your team's best boat on the bid slip.
- 9. The best boats will be demonstrated in front of the class, so make sure you **keep your boats** safe!

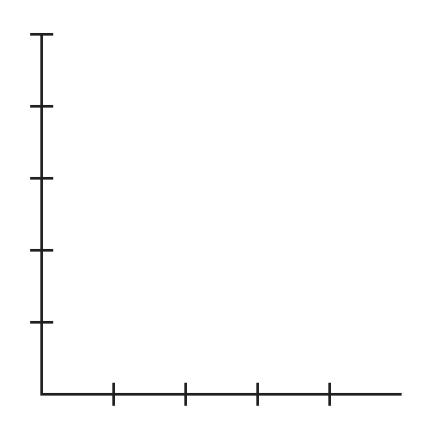
WHAT COULD OUR BOAT LOOK LIKE?

(Draw some sketches here)

Team Name:	_	Prototype	Number of Dice Held
Team Members:	-		
	-		
	-		
Price for our best boat: \$	-		

LET'S MAKE A GRAPH!

Directions: Make a **bar graph** showing how many dice each of your boats held. Don't forget to label and title your graph! **Extra:** Why didn't we make a line graph?

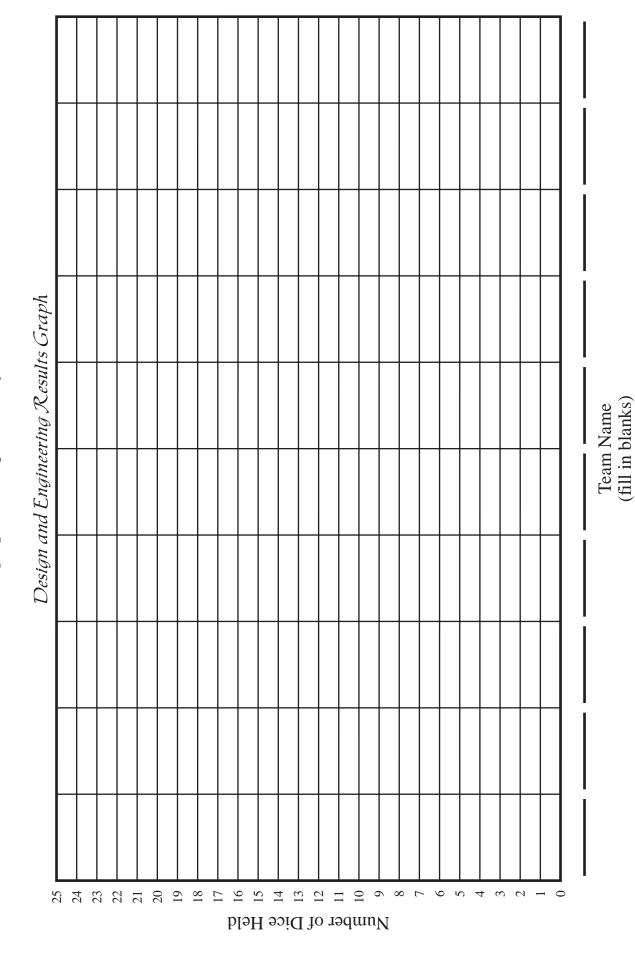


Design and Engineering Cost Analysis Chart

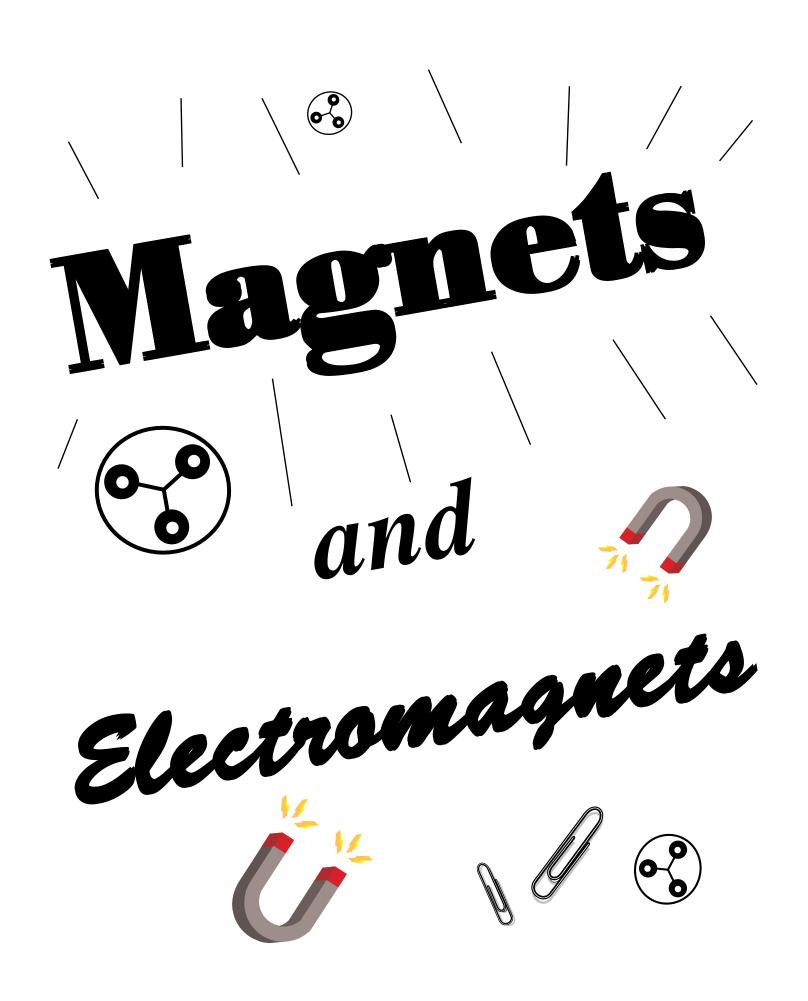
How much will it cost to buy all of the boats needed?					
How much does the team's best boat cost?					
How many boats will it take to hold all of the dice?					
How many dice did the team's best boat hold?					
How many dice do we need to carry?					
Team Name					

LET'S MAKE A GRAPH!

Directions: Create a bar graph showing how many dice each team's best boat held.



59



Magnets and Electromagnets

CAN YOU MAKE A MAGNET FROM A NAIL. SOME BATTERIES AND SOME WIRE?

Problems

Can the strength of an electromagnet be changed by changing the voltage of the power source? Can the strength of an electromagnet be changed by changing the amount of wire wrapped around its core?

Research

Answer the following True or False questions about magnets and electromagnets:

True/False	Heating or hitting a permanent magnet can ruin it.
True/False	Iron is a good metal to use to make an electromagnet.
True/False	The north pole of one magnet will attract the north pole of another magnet.
True/False	Magnets and electromagnets are used in many devices.

Hypotheses

I think that increasing the voltage wi	ill ncrease, decrease or not ch	the electromagnet's strength.
I think that increasing the wire coils	,	the electromagnet's strength.
	(increase, aecrease or noi c	nange)

Procedure

How to make the electromagnet:

- 1. To make an electromagnet, you will need:
 - A length of wire
 - A nail
- 2. Take the wire and straighten it.
- 3. One end of the wire has a clip attached. Hold the clip in your hand and measure off an arm's length of wire. This splits the wire into two sections, one much longer than the other.
- 4. Take the **long** section of wire and wrap it neatly around the nail. Start wrapping at the flat part of the nail and work your way towards the nail's point.
- 5. Wrap the wire around the nail 25 times to build the first electromagnet. Later, you will wrap the wire around the nail another 25 times to make a larger electromagnet.

How to use the electromagnet:

- 1. To test your electromagnet you will need:
 - A battery pack
 - Some paper clips
- 2. There are four different settings on the battery pack. They are labeled 1.5V, 3.0V, 4.5V and 6.0V. The "V" stands for volts. A volt is a unit used to measure the amount of electricity in something, like meters is a unit used to measure the length of something.
- 3. Your team will test your electromagnet by seeing how many paper clips it can pick up at each voltage. **Test each voltage two times**.
- 4. There are two jobs to do:
 - **Power Operator** turns the electromagnet on and off
 - Crane Operator dunks the electromagnet into the container of paper clips
- 5. How do you turn the electromagnet on? Both ends of the wire have to be attached to the battery pack correctly so that electricity can flow:
 - Clip one end of the wire to the screw on the battery pack labeled **TOP**
 - Hold the other end of the wire onto the metal near the voltage label that you want to test
 REMEMBER: Metal has to touch metal for electricity to flow!

Touch the wire to the metal screws, not to the plastic battery case!

6. Once the Power Operator has turned on the electromagnet, the Crane Operator should put the nail in the container of paper clips.

- 7. Gently mix the paper clips with the electromagnet.
- 8. Carefully lift the electromagnet out of the paper clip container and move it to a clean spot over your desk.
- 9. Turn the electromagnet off by removing the wire from the battery pack and let the paper clips fall.
- 10. Count how many paper clips the electromagnet picked up and record that number on the **Electromagnets Data Chart**.
- 11. Keep testing your electromagnet until you have tried each voltage twice.
- 12. Once you have completely tested the electromagnet with 25 wraps of wire, build one with 50 wraps of wire and test it.
- 13. After you have finished testing the second electromagnet, make certain that everyone on your team has all of the data.
- 14. Average each voltage's tests together. If you don't remember how to average, look at the example below.
- 15. Use the **Electromagnets Results Graph** to show the **average** number of paper clips each electromagnet picked up at each voltage.

HOW DO I AVERAGE 31, 22 AND 43 TOGETHER?

Add up all the numbers that need to be averaged.

22
+ 43
96

Divide by the number of numbers you added.

You added three numbers together, so you divide by three. If you had added two numbers together, you would have divided by two. If you had added 1000 numbers together, you would have divided by 1000.

Data Collection and Analysis

Electromagnets Data Chart

Directions: Record the number of paperclips picked up by each electromagnet for each try. **After** you have collected all of the data for both of the electromagnets, average the number of paper clips picked up at each voltage.

For the 25-turn Electromagnet

Battery	Number of paper clips picked up		$(1^{st} + 2^{nd})$
Voltage	First try	Second try	Average = $\frac{(1^{st} + 2^{nd})}{2}$
1.5V			
3.0V		 	
4.5V		 	
6.0V		 	

For the 50-turn Electromagnet

Battery	Number of pape	r clips picked up	$(1^{st} + 2^{nd})$
Voltage	First try	Second try	Average = $\frac{(1^{st} + 2^{nd})}{2}$
1.5V		 	
3.0V		 -	
4.5V		 	
6.0V		 	

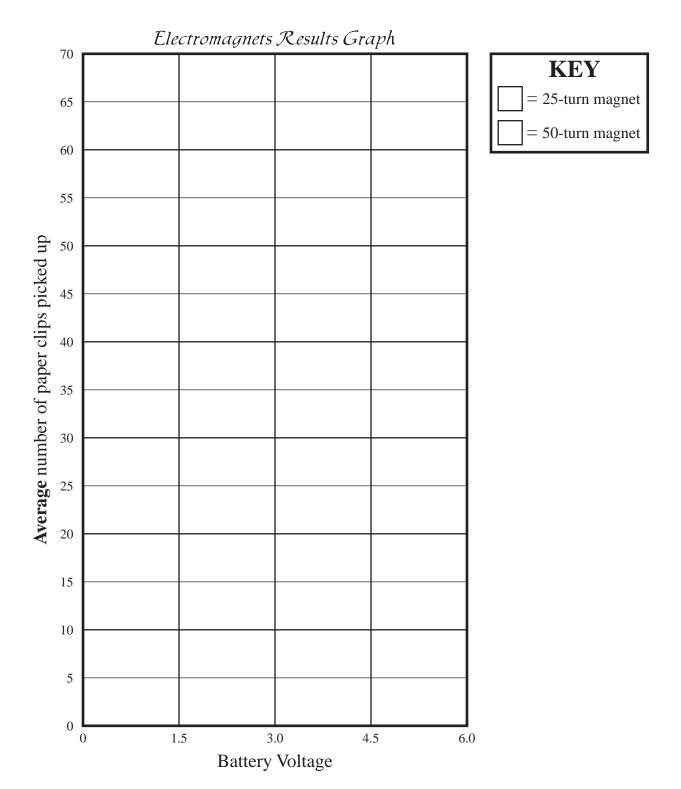
NAME THAT VARIABLE!!

Directions: Identify the **Independent Variables**, **Dependent Variable**, **Constants** and **Control** of this experiment.

Independent Variables	
Dependent Variable	
Constants	
Control	

LET'S MAKE A GRAPH!

Directions: Show the **average number of paper clips** each electromagnet picked up for each voltage tested. Use the averages you calculated on the **Electromagnets Data Chart** to make a **line graph** for each of the two electromagnets.



Conclusions

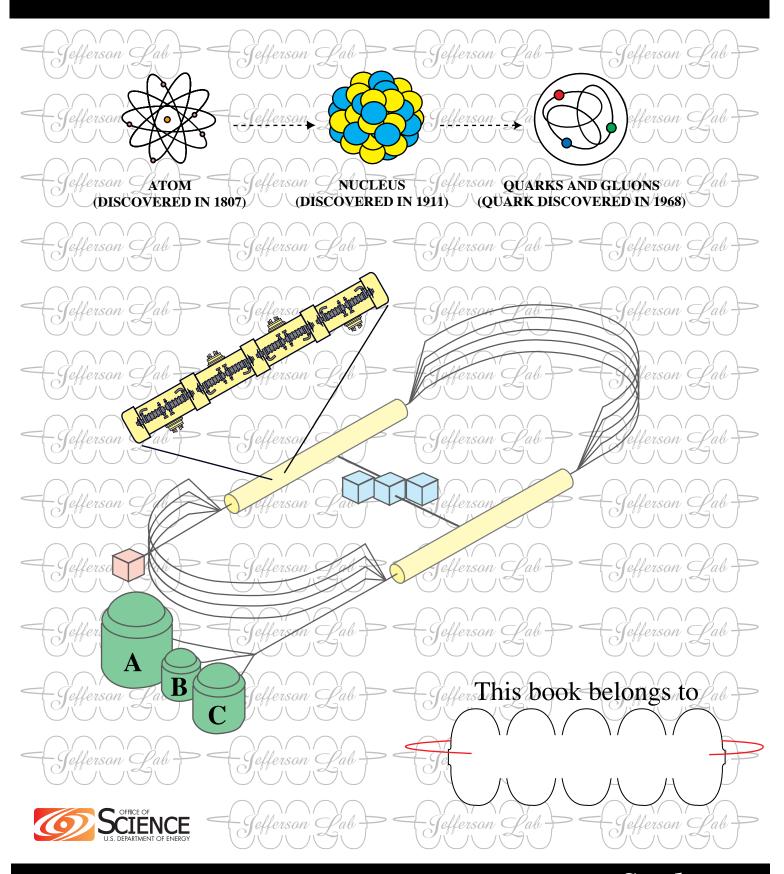
INCREASING THE VOLTAGE APPLIED TO AN ELECTROMAGNET _____ ITS STRENGTH.

INCREASING THE AMOUNT OF WIRE WRAPPED AROUND AN ELECTROMAGNET ______ ITS STRENGTH.

	QUESTIONS TO THINK ABOUT
1.	What happened to the strength of the electromagnet when more turns of wire were used?
2.	What happened to the strength of the electromagnet when more volts were used?
3.	How are electromagnets used at Jefferson Lab?
4.	Where can you find electromagnets in your home?

5. How can you make a permanent magnet lose its magnetism?

THOMAS JEFFERSON NATIONAL ACCELERATOR FACILITY



BEAMS

__ Student Travel Book

What is BEAMS?

BEAMS stands for **B**ecoming **E**nthusiastic **A**bout **M**ath and **S**cience. This program is a partnership between your school district and Jefferson Lab.

You, your class and your teacher will visit Jefferson Lab everyday for one week. While here, you will conduct special science and math activities with some of the people who work at Jefferson Lab: scientists, engineers and technicians. You will also use other school subjects, like reading and writing.

- You should wear comfortable clothes and shoes to Jefferson Lab each day.
- Come prepared to have fun, work hard and be ready for a few surprises!
- We hope you enjoy your visit!

How to contact Jefferson Lab:

Jefferson Lab Science Education Group Thomas Jefferson National Accelerator Facility 12000 Jefferson Avenue Newport News, VA 23606

telephone: (757) 269-7567 fax: (757) 269-5065

e-mail: BEAMS@jlab.org

world wide web: http://education.jlab.org/

The Southeastern Universities Research Association (SURA) operates the Thomas Jefferson National Accelerator Facility for the United States Department of Energy under contract DE-AC05-84ER40150.

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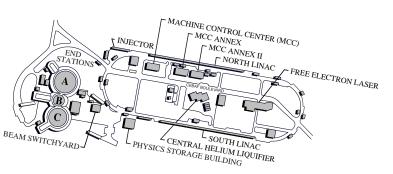
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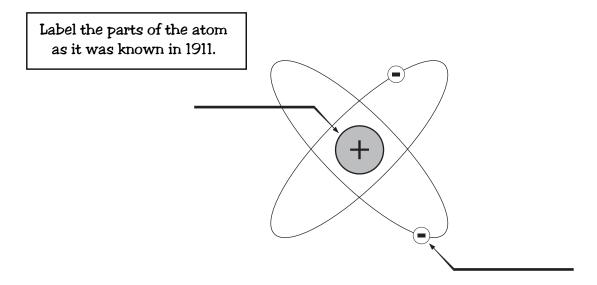
What is Matter?

Matter is anything that has mass. All objects are made of matter. Air, water, a brick, even you are made of matter!

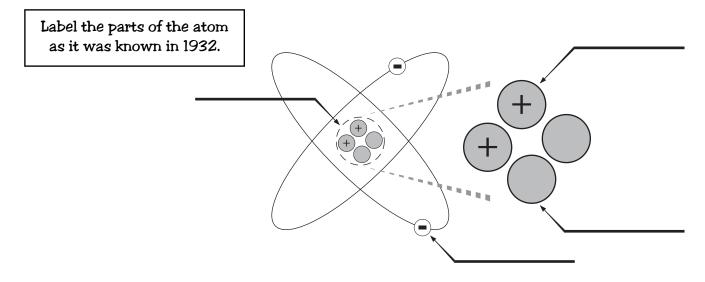
Matter is made up of smaller pieces.

Over ninety years ago, scientists thought that the atom was the smallest piece of matter. At that time, the atom was thought to be 'the building block of matter.'

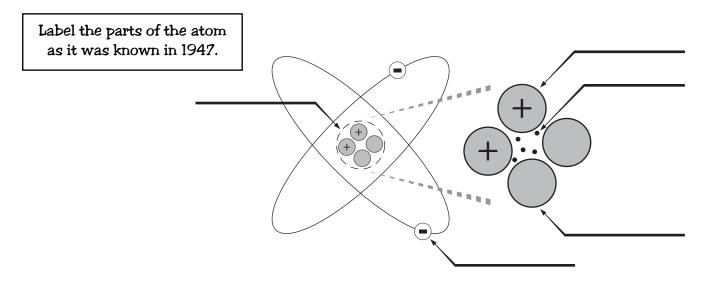
In 1911, a scientist named Ernest Rutherford discovered that atoms are really made of a positively charged center called the **nucleus** orbited by negatively charged particles called **electrons**.



In 1932, scientists discovered that the nucleus of an atom is made of smaller particles called **protons** and **neutrons**. Protons carry a positive charge while neutrons have no charge at all. Protons and neutrons are each called nucleons since they are found in the nucleus. When they were discovered, scientists thought they were the smallest piece of matter.

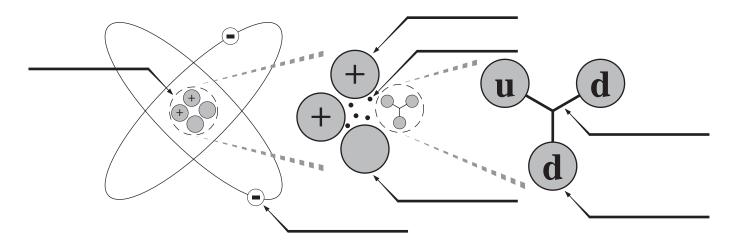


Scientists know that opposite charges attract and like charges repel, so they wondered why the protons in the nucleus didn't fly apart. They found the answer in 1947 when they discovered other particles that they named **mesons**. Mesons hold the protons and neutrons together to form the nucleus.



As scientists did more experiments, they began to realize that there was something funny about protons and neutrons. In 1968 they discovered that protons and neutrons are made up of smaller particles they called **quarks**. Scientists discovered six different types of quarks: Up, Down, Strange, Charm, Top and Bottom. Protons have two Up quarks and one Down quark while neutrons have two Down quarks and one Up quark. Quarks are held to each other by particles scientists called **quons**.

Label the parts of the atom as it was known in 1968.



Some scientists now think that the quark is the smallest piece of matter. Scientists used to think that atoms were the smallest bit of matter, but they discovered that it wasn't. Do you think that the quark is the smallest piece of matter or do you think that there might be something smaller inside the quark?

Introduction to Jefferson Lab

What is Jefferson Lab?

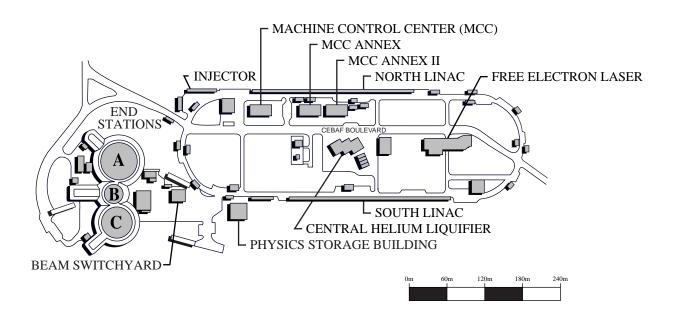
Jefferson Lab is a laboratory for basic research in nuclear physics. Nuclear physics is the science of studying the nucleus of the atom. Jefferson Lab also works with industry to develop technologies for businesses to use and with schools to motivate students and assist teachers.

Jefferson Lab's mission is to provide scientists around the world with opportunities to experiment with and learn more about nucleons.

Jefferson Lab's main instrument is a machine, called an accelerator, that is able to make electrons go really fast. The accelerator is in an underground, racetrack-shaped tunnel, 1.4 km around, that delivers a beam of electrons to experiments in three large experimental halls called end stations.

The facility is owned by the government's Department of Energy (DOE) and is managed by the Southeastern Universities Research Association (SURA). SURA is a group of 61 universities in fifteen southeastern states and the District of Columbia. SURA also manages other large research projects in the southeastern region of the United States.

About \$600 million was spent over ten years to build the facility in Newport News, Virginia. Scientists from around the world are currently using Jefferson Lab's accelerator for experiments to study the nucleus of the atom. These experiments can take months to run. Once scientists complete their work at the lab they must analyze the data they have gathered. What they find out may change what we know about the structure of nuclear matter, making Jefferson Lab a vital instrument of the scientific world.



Exploring Nuclei at Jefferson Lab

Over ninety years ago, scientists described the atom as a nucleus with orbiting electrons. Later, the nucleus was found to contain protons and neutrons (nucleons). Now each nucleon is seen as a collection of three quarks.

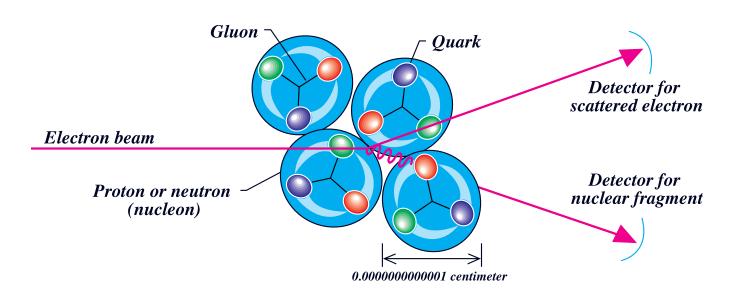
Scientists need Jefferson Lab to broaden their understanding of how quarks interact in the nucleus. Jefferson Lab provides scientists with beams of electron probes to explore the quark structure of the nucleus.

Point-like electrons can probe the nucleus with extreme accuracy. They interact cleanly with quarks in nuclear matter. The 'fingerprint' of each interaction - a deflected electron and one or more nuclear fragments - provides clues about the subnuclear world (see diagram below).

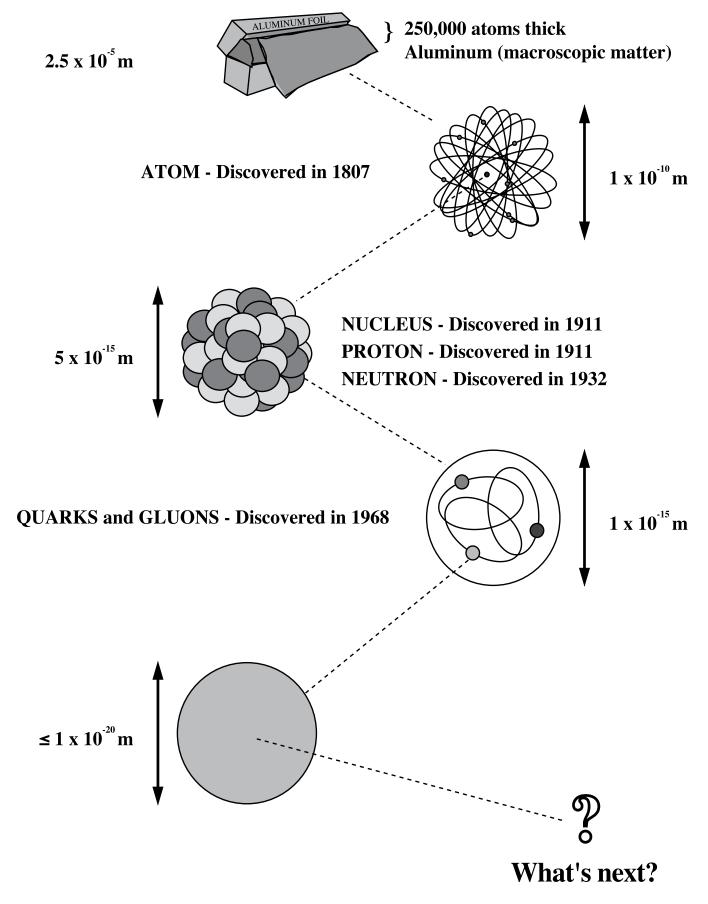
When the beam is directed through an experiment's target - typically a small, thin sheet of material whose nuclei are under study - unimaginably tiny electron-quark interactions result. The exact interactions are the 'fingerprints' of the experiment. These interactions are recorded automatically by spectrometers and detectors in the end stations. Collecting the thousands to millions of fingerprints required for each experiment may take weeks or even months. Later, aided by computers, nuclear physicists use this data to understand the mysteries of nuclear structure.

Studying the world of the very small requires equipment that is very large. Jefferson Lab's electron accelerator is 1.4 km around. The detectors used to 'watch' the experiments weigh thousands of tons each. Scientists use these huge machines to 'see' the quarks and gluons inside an atom's nucleus - particles that are less than 0.0000000000001 cm across!

The main goal of Jefferson Lab's scientific program is to understand the structure and behavior of the nucleus and its parts. Scientists use the electron accelerator to study how the nucleus and its pieces are put together and interact with each other. Jefferson Lab is like a powerful microscope used for studying the atom's nucleus.



How Scientists' Ideas About Matter Have Changed



Career Opportunities at Jefferson Lab

You might be interested to know more about high-technology jobs with scientific organizations like Jefferson Lab.

These jobs can be very rewarding in job satisfaction, pay and benefits. In the years ahead, many more well trained people will be needed for technical and scientific jobs. These people will earn more dollars per hour than they would in minimum wage jobs or many nontechnical jobs.

Several hundred people work at Jefferson Lab. About 650 are Lab employees and many more are visiting scientists. People working at Jefferson Lab got their technical or scientific training, education and experience in many different ways. But they all have one thing in common; they all studied math and science in school.

Early in their careers, many found jobs that gave them valuable experience. They knew that a person's first job often isn't what one ends up doing later on. Some Lab employees started out doing simple jobs for little pay. They learned more and more about the things they worked with and gradually gained technical experience. Often they continued their education after work by going to college or by taking special classes.

Formal education is important for some jobs. A scientist, for instance, almost always earns both a four-year college degree and a doctorate, or Ph.D., degree. A Ph.D. can take several years to earn. You have to do research to find new knowledge that no one already knew.

Most other technical and scientific professionals have four-year degrees and many have master's degrees. A master's degree may take an additional year or two to earn.

Still other technical professionals and highly skilled workers have community college twoyear associate degrees or other special training. Most such workers at Jefferson Lab also have a good deal of practical work experience. Even as early as high school, they may have studied computers, electronics, machine tools or other technical equipment. Many of them take more courses from time to time after they 'finish' school to improve or update their skills and knowledge. They know they must always be learning if they want to be successful.

In addition to scientific and technical education, training and experience, employees of organizations like Jefferson Lab need to be able to read and write effectively, communicate well and work cooperatively with others.

They also need to be able to adapt old knowledge and skills to new job demands. Many Jefferson Lab employees had to learn on the job. They were able to do so because they prepared themselves to be flexible and to take on new kinds of technical challenges. Often, these challenges make their work interesting and exciting.

Any large organization needs accountants, bookkeepers, maintenance workers, secretaries and others who help keep the organization going. There are many nonscientific jobs at Jefferson Lab. These workers need good math, reading, writing, speaking and teamwork skills and a general appreciation of science to succeed at Jefferson Lab.

Here are some examples of technical and scientific jobs at Jefferson Lab:

Drafters and Designers

Drafters and designers use computer equipment to make drawings of high-technology equipment and components. Some drafters learn their trade mainly through experience after they leave high school. But many, especially those who become designers, have a formal technical education from a two-year community college.

Engineers

Mechanical, electrical, electronic and civil (construction) engineers are important technical managers and decision makers in an organization that builds and operates complex equipment. Often, an engineer gets to build something no one has ever built. At a minimum, an engineer usually has an engineering degree from a four-year college or university.

Electricians

Much of the equipment at Jefferson Lab is electrical. Although engineers and physicists may be responsible for the equipment, trained electricians install, operate and maintain it. A typical electrician might have a two-year degree, lots of practical experience or both.

Physicists

Nuclear physicists study the atom's nucleus. An important job for them is preparing and operating the equipment used in accelerator experiments. Accelerator physicists design, build and operate the accelerator. Physicists have Ph.D. degrees.

Health Physicists and Safety and Environmental Specialists

Operating an accelerator requires good safety. Health physicists and safety and environmental specialists make sure that the people who operate the machine are protected from the dangers that can be involved if people are not careful. They also make sure the operation of Jefferson Lab does not harm the public and the environment. Formal education for these kinds of jobs can range through and beyond a four-year college degree.

Electronics and Mechanical Technicians

Skilled technicians build, operate and maintain equipment. Many are graduates of apprentice schools or special programs at community colleges. Often they have substantial college-level education.

Computer Systems Technicians and Programmers

The scientists use computers to do much of their work. Computer systems technicians make sure all the computer hardware runs smoothly and programmers help the scientists use computers. Most computer workers have college education through the four-year level and beyond.



Pre-visit



ACTIVITIES



Magnet Racing

HOW DIFFICULT IS IT TO STEER ONE TINY ELECTRON AROUND AN ACCELERATOR TRACK USING MAGNETS?

- 1. It is your job to guide a set of magnetic marbles around a track as quickly as possible using a pair of bar magnets.
- 2. Begin with a four-electron set of magnetic marbles. Line up the set of electrons at the INJECTOR (starting line).
- 3. Using the two bar magnets, steer the set of electrons through the first LINAC (straight section), around the arc (curved section) and down the second LINAC until you reach the TARGET. Use a stopwatch to time how long it takes to reach the TARGET.
- 4. **Do not allow the magnetic marbles to attach themselves to the steering magnets**. If this occurs, stop the marbles and break them loose from the steering magnets, but **do not stop the timer!** Keep the electrons inside the track as much as possible.
- 5. Record how much time it took to bring the electrons from the INJECTOR to the TARGET in the data chart below.
- 6. Try guiding a three-electron set around the track and record the time in the chart.
- 7. Try guiding a two-electron set around the track and record the time in the chart.
- 8. Try guiding a one-electron set around the track and record the time in the chart.
- 9. After you have collected your data, answer the questions on the next page.

Data Chart

Electron Set	Time (seconds)
Four-electron set	
Three-electron set	
Two-electron set	
One-electron set	

QUESTIONS TO THINK ABOUT

1.	Of all the races, which electron beam was the easiest to steer? Why do you think this was the case?
2.	Of all the races, which electron-set was the most difficult to steer? Why do you think this was the case?
3.	Through which part(s) of the track was it most difficult to steer?
4.	List some difficulties you encountered.
5.	How could you solve the problems you had?
6.	Who is the person from Jefferson Lab that is visitng with your class today? What do they do at Jefferson Lab?

What's in the Bag?

HOW CAN YOU STUDY SOMETHING YOU CAN'T SEE?

- 1. Probe your bag using all of your senses (except taste) to determine what's in your bag.
- 2. Record your observations in the left column of the Data Chart.
- 3. Exchange bags with a partner. Record your partner's bag number in the right column. Record your observations of the object in this bag in the right column of the chart.
- 4. Discuss with your partner how you probed the objects and what you observed.
- 5. Based on your observations and talking with your partner, make predictions about what you think is in each bag.
- 6. Be prepared to discuss your observations and conclusions with the class.

Data Chart

My Bag	My Partner's Bag

I believe the object in my bag is a	, because	
I believe the object in my partner's bag is a _	, because	

DO NOT OPEN THE BAG UNTIL DIRECTED TO DO SO!

QUESTIONS TO THINK ABOUT

1.	How did you determine what objects were in the bags?
2.	List some difficulties you encountered.
3.	How could you solve the problems you had?
4.	List some ways scientists study what they cannot see.
5.	What were the objects? My bag contained a
	My partner's bag contained a
6.	What other observations or clues could have helped you identify the object(s) correctly?
7.	Who is the person from Jefferson Lab that is visitng with your class today? What do they do at Jefferson Lab?



Pocabulary





Vocabulary List

- Accelerate to speed up
- **Accelerator -** a machine which accelerates charged particles to high energies
- **Antimatter -** a form of matter that is composed of antiparticles
- Antiparticle a particle that has the same mass as another particle but has opposite values for other properties, such as electric charge (The positron is the antimatter counterpart to the electron. Positrons have the same mass as electrons, but carry a positive electric change.)
- **Atom -** the smallest unit of a chemical element, made up of a nucleus surrounded by electrons
- **Atomic Number -** the number of protons in the nucleus of an atom
- **Atomic Weight -** the average mass of an atom of an element measured relative to the mass of an atom of carbon-12
- **Beam -** a ray of light; a group of particles traveling together along a well-defined path
- **BEAMS** the acronym for Becoming Enthusiastic About Math and Science
- **Boiling Point -** the temperature at which a substance changes from a liquid to a gas
- **CEBAF** former name of Jefferson Lab; stands for Continuous Electron Beam Accelerator Facility
- **Celsius -** a temperature scale on which water freezes at 0° and boils at 100°
- **Charge** the amount of electricity carried by a body (A charge can be negative, like an electron, or positive, like a proton. Objects with opposite charges attract one another, while objects with like charges repel one another.)

- Chemical Change a change in the chemical composition of a substance to produce a new material with new properties (An example of a chemical change is wood turning to ash and smoke when it burns.)
- **Chemical Property -** a characteristic of a substance that determines how it will react with other substances
- **Chemical Reaction -** a chemical change in which one or more substances are changed into one or more new substances
- **Circuit -** a closed path through which an electric current flows
- **Colloidal Suspension -** a material that has properties of more than one state of matter, such as Jell-O
- **Compound** a substance composed of two or more elements, such as water (H_2O) , carbon dioxide (CO_2) , or table sugar $(C_{12}H_{22}O_{11})$
- **Computer -** a programmable machine that inputs, processes and outputs data
- **Coordinate -** a set of numbers that determines the location of a point in space
- **Condensation -** the process by which a gas changes to a liquid
- **Conduction -** the transportation of heat or electricity from one place to another directly through an object (A frying pan is warmed by a hot stove due to conduction.)
- **Conductor -** a material (like a metal) through which electricity and heat flow easily
- Continuous steady; uninterrupted
- **Convection -** the transportation of heat from one place to another by the movement of a liquid or gas (A classroom is warmed by a hot air blower due to convection.)
- **Cryogenics -** the science of very low temperatures, far below the freezing point of water

- **Data -** a group of measurements, facts or statistics
- **Density** the amount of mass per unit volume (An object's density is calculated by dividing the object's mass by the object's volume. For example, a 10 gram object that occupies 2 cubic centimeters of space has a density of 5 g/cm³.)
- **Dependent Variable -** the responding variable; the variable that may change as a result of a change in the independent variable
- **Dew Point -** the temperature at which a gas condenses to form a liquid
- **Electric Current** movement of electricity, measured in charges per second (just as river current is measured in liters per second)
- **Electromagnet -** a wire coil around a metal core (usually iron) that acts like a magnet when an electric current flows through it
- **Electron -** a tiny particle with a negative charge which orbits an atom's nucleus
- Element any substance that cannot be broken up into simpler substances by chemical means (Currently 115 elements have been observed and are displayed on the Periodic Table of Elements. Gold, silver, iodine, oxygen and nickel are examples of elements.)
- **Energy** the capacity to do work
- **Engineer -** a person who uses science and math to design, build or operate equipment, structures and systems (A person who receives a college degree in engineering might be an electrical, mechanical, industrial, chemical, environmental, biochemical or aeronautical engineer.)
- **Evaporation -** the process by which a liquid changes to a gas
- **Experiment -** a series of actions carried out to test a theory, demonstrate a fact or find out what happens

- **FEL** stands for Free Electron Laser; a tunable laser made by wiggling a beam of electrons (Jefferson Lab's FEL is the most powerful in the world.)
- **Fahrenheit -** a temperature scale at which water freezes at 32° and boils at 212°
- **Force -** a push or pull (There are four basic forces: gravitational, electromagnetic, strong nuclear and weak nuclear.)
- **Freezing Point** the temperature at which a substance changes from a liquid to a soild
- **Gas -** a state of matter with no definite shape or volume, like air
- **Gluons** particles that hold quarks together
- **Graph -** information represented in the form of a picture, diagram or drawing
- **Grid** a pattern of horizontal and vertical lines forming squares of uniform size on a map or chart
- **Heat -** energy in the form of the random motion of an object's molecules
- **Helium -** a colorless, odorless, tasteless gas (Helium becomes a liquid near absolute zero. Liquid helium is used to cool Jefferson Lab's accelerator components.)
- **HTML** an acronym for HyperText Markup Language; the programming language or code used for the creation of internet web pages
- **Hypothesis -** an educated guess that can be tested or investigated
- **Independent Variable -** the manipulated variable; the variable that is changed on purpose in an experiment
- **Injector -** the first section of an accelerator, where electrons are torn away from atoms and accelerated to an energy sufficient for them to be injected into the cavities of the accelerator

Insulator - a material through which electricity or heat does not flow easily (like many plastics, glasses and ceramics)

Interact - act with each other

Internet - a worldwide network of computers linked together for the purpose of exchanging information (also sometimes called the Information Superhighway or Cyberspace)

Ion - an atom or molecule that has an electric charge because it has either gained or lost electrons

Jefferson Lab - a nuclear physics research facility built to explore quarks in the nucleus of the atom, located in Newport News, Virginia

Kelvin - a temperature scale that begins at absolute zero, where there is no molecular movement (Water freezes at 273 K and boils at 373 K.)

Laboratory - a place equipped for scientific research, experiments or testing

Lepton - one of the two basic building blocks of matter (An electron is a lepton.)

LINAC - an abbreviation for Linear Accelerator

Linear Accelerator - a machine used in physics experiments that makes particles go faster in a straight line

Liquid - a state of matter with definite volume but no definite shape, like water

Magnet - a piece of iron or other material that attracts other pieces of iron or steel

Magnification - the process of making something look bigger

Mass - the measure of the amount of matter an object has in it; measured in grams or kilograms

Mass Number - the total number of protons and neutrons in an atom's nucleus

Matter - something that has mass which can exist in the form of a solid, liquid, gas or plasma

Mean - the sum of the items in a set of data divided by the number of items in the set; the average (The mean of $\{1,1,1,2,4,6,6\}$ is 3 since $(1+1+1+2+4+6+6) \div 7 = 3$.)

Median - the middle number in a set of ordered data (The median of {1,1,1,2,4,6,6} is 2 since 2 is the middle number when all of the numbers are placed in order. If there are an even number of numbers, the median is the mean of the two middle numbers.)

Melting Point - the temperature at which a substance changes from a solid to a liquid

Meson - particle made of a quark and an antiquark that is thought to bind protons and neutrons together inside the nucleus of an atom

Microscope - an optical instrument that uses a combination of lenses to produce magnified images of very small objects

Mixture - a substance composed of two or more components, each of which retain its own properties (A salad is a mixture of vegetables.)

Mode - the data item that occurs the most often in a set of data (The mode of {1,1,1,2,4,6,6} is 1 since 1 is the number that appears most often.)

Molecule - two or more elements that are chemically joined (Water is a molecule made from two atoms of Hydrogen and one atom of Oxygen.)

Negative - having a minus charge (Negative charges are attracted to positive charges and are repelled by other negative charges.)

Neutral - having no charge

Neutron - a neutral particle made of three quarks found in the nucleus of an atom

Nitrogen - a colorless, odorless, tasteless gas which makes up 78% of the air (Nitrogen is a gas at room temperature and becomes a liquid at about 77 K, -196°C or -321°F.)

Nuclear Physics - the science of studying the nucleus of the atom

Nucleon - a proton or a neutron

Nucleus - the central part of an atom, which makes up 99.9% of the atom's mass

Observation - the use of one's senses to learn something new

Orbit - the path an object follows as it travels around another object

Particle - a very small piece or part; an indivisible object

Physical Change - a change that affects the size, shape or color of a substance but does not affect its composition

Physical Property - a characteristic of a substance that can be observed with the senses, such as size, weight, color or odor, without altering the substance's molecular make-up

Physics - the study of matter, energy and force

Plasma - a very hot, gas-like state of matter

Pole - the place on a magnet where the magnetic field is strongest

Positive - having a plus charge (Positive charges are attracted to negative charges and are repelled by other positive charges.)

Probe - an object or device used to investigate the unknown

Property - any characteristic or attribute of an object or substance

Proton - a positively charged particle found in the nucleus of an atom

Prototype - an original type that serves as a model for later examples

Quadrant - one quarter of the coordinate plane (The x- and y-axes divide the coordinate plane into four quadrants.)

Qualitative - observations that do not involve measurements and numbers ("My brother is shorter than my sister," is a qualitative observation.)

Quantitative - observations that involve measurements and numbers ("My brother is 30cm shorter than my sister," is a quantitative observation.)

Quark - one of the two basic building blocks of matter (Scientists have discovered six different kinds of quarks: Top, Bottom, Up, Down, Strange and Charm.)

Radiation - the transportation of heat from one place to another by waves or particles (The Earth is warmed by the Sun due to radiation.)

Range - the difference between the largest number and the smallest number in a set of data (The range of $\{1,1,1,2,4,6,6\}$ is 5 since 6 - 1 = 5.)

Resistance - a measurement of how much a material opposes the flow of electricity (Wood has high resistance so it is a poor conductor of electricity. Copper has low resistance, so it is a good conductor of electricity.)

Scatter - to go in many directions

Science - the study of the natural world

Scientific Method - the 'tool' that scientists use to find the answer to questions (The Scientific Method allows scientists to solve complicated problems by taking a series of smaller steps:

- identify the problem a scientific problem to be solved
- research the process of collecting information and data about a topic being studied
- **hypothesis** an idea about the solution to a problem, based on knowledge and research
- **experimentation** the process of testing a hypothesis by collecting data under controlled, repeatable conditions

- data analysis organizing and examining the collected data using narratives, charts, graphs or tables
- **conclusion** a summary of the results of the experimentation and a statement of how the results relate to the hypothesis

Scientist - a person who uses observation, experimentation and theory to learn about a subject (Biologists, physicists, chemists, geologists and astronomers are all scientists.)

Solid - a state of matter with definite shape and volume, like ice**Speed** - a measurement of distance traveled over time (example: 100 kilometers per hour)

Spreadsheet - a computer program used for organizing and analyzing data (Spreadsheets are arranged in **rows** and **columns**. A **cell** is a box in a spreadsheet where a row and column meet. The names of the row and column determine the name of the cell. For example, in the spreadsheet shown below, column C and row 2 meet at cell C2, the shaded box. The value in C2 is 1.23.)

	A	В	C	D	E
1	0.71	0.70	0.52	1.12	4.01
2	0.02	4.45	1.23	0.74	3.11
3	9.58	1.87	6.19	3.13	0.93

Static Electricity - a collection of unbalanced charges on an object

Superconductivity - the flow of electric current without any resistance in certain metals at temperatures near absolute zero (The superconductors used at Jefferson Lab are cavities made of niobium that are cooled to 2 K by liquid Helium.)

SURA - the acronym for Southeastern Universities Research Association (Jefferson Lab is managed by SURA.) **Teamwork -** joint action by a group to complete a given task

Technician - a person who is an expert in doing certain technical jobs

Temperature - a measure of heat energy in an object, body or environment (Temperature can be measured using Fahrenheit, Celsius or Kelvin scales.)

Theory - a general principle that explains or predicts facts or events

Variable - something that does not remain constant (In an experiment, a variable is something that can change. Usually, an experimentor will change only one variable in an experiment while keeping everything else the same.)

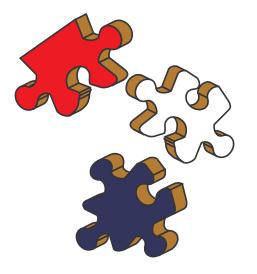
Voltage - electrical force or pressure (measured in volts)

Volume - the amount of space an object occupies (The volume of a rectangular box can be found by multiplying the box's length, width and height together. For example, a box that is 8 cm long, 3 cm wide and 2 cm high has a volume of 48 cm³. Other formulas exist for calculating the volumes of objects with other shapes.)

Weight - a measure of the gravitational force pulling objects to the earth, moon or other celestial body (The more mass a planet has, the greater the gravitational pull of that planet will be. An object weighs more on the earth than it does on the moon because the earth has more mass than the moon.)

PUZZ/E5

and



GAMES



Directions: Fill in each space with a different term from the vocabulary list. As definitions or examples are given, cover each term until you have five in a row diagonally, horizontally or vertically. The first person to call out "BEAMS!" and have five matching terms

S			
E A M			
A		FREE	
H			
B			
S			
M			
AN		FREE	
P			23

Directions: Fill in each space with a different element from the list. When an element's chemical symbol is called out, cover that element until you have five in a row diagonally, horizontally or vertically. The first person to call out "BEAMS!" and have five matching elements wins!

FREE

erent elements	lowing list:	NIOBIUM	NITROGEN	OXYGEN	PALLADIUM	PHOSPHORUS	PLATINUM	PLUTONIUM	POTASSIUM	RADIUM	RADON	SILICON	SILVER
Choose 24 different elements	from the following list:	ALUMINUM	ANTIMONY	ARGON	BERYLLIUM	BORON	CALCIUM	CARBON	CHLORINE	COPPER	GOLD	HELIUM	HYDROGEN

ZIRCONIUM

NICKEL

NEON

TUNGSTEN TITANIUM

SODIUM SULFUR

IODINE

IRON

IIN

KRYPTON

URANIUM

MERCURY

LITHIUM

LEAD

ZINC

Zn Zr

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symbol until you have five in a row diagonally, horizontally or vertically. The first person to call out "BEAMS!" and have five Directions: Fill in each space with a different chemical symbol from the list. When an element's name is called out, cover that chemical matching chemical symbols wins!

E A M S FREE

Pd Pt Pu Ra Ra

> Cl Cu Fe

Ca

S Sb

He

H

Hg

Sn Ti

Choose 24 different chemical symbols from the following list:

Z

Ar Au

Al

0 P Pb

Be

Directions: Fill in each space with a different math term from the list. As definitions or examples are given, cover each term until you have five in a row diagonally, horizontally or vertically. The first person to call out "BEAMS!" and have five matching terms wins!

BEAMS

D L A IVI D §REE §REE SPACE

Choose 24 different terms from the following list:

PYTHAGOREAN THEOREM PERPENDICULAR LINES RATIONAL NUMBER PARALLEL LINES PRIME NUMBER ORDERED PAIR PROBABILITY **POLYNOMIAL** NUMERATOR RECIPROCAL PERIMETER OUADRANT OUOTIENT PRODUCT PERCENT RADIUS **PLANE** POINT RATIO **LEAST COMMON MULTIPLE (LCM)** COMMUTATIVE PROPERTY DISTRIBUTIVE PROPERTY ASSOCIATIVE PROPERTY RRATIONAL NUMBER COMPOSITE NUMBER **IDENTITY PROPERTY OF ADDITION OF ADDITION OF ADDITION** DENOMINATOR HYPOTENUSE DIAMETER **BINOMIAL** INTEGERS FACTOR CIRCLE ANGLE AREA

VERTICAL ANGLES

SQUARE ROOT

SEGMENT

WHOLE NUMBER

X-AXIS Y-AXIS

VOLUME

MIXED NUMBER

MIDPOINT

MEDIAN

MEAN

MULTIPLE

MODE

Directions: Fill in each space with a different math term from the list. As definitions or examples are given, cover each term until you have five in a row diagonally, horizontally or vertically. The first person to call out "BEAMS!" and have five matching terms wins!

EREE

Choose 24 different terms from the following list:

LINE SYMMETRY PARALLEL LINES X-COORDINATE Y-COORDINATE **OBTUSE ANGLE LINE SEGMENT** ORDERED PAIR NUMBER LINE ODD NUMBER RIGHT ANGLE NUMERATOR REMAINDER PERIMETER SYMMETRY MULTIPLE QUOTIENT VERTICAL PRODUCT MEDIAN RADIUS ORIGIN RANGE MODE **POINT** MEAN SUM RAY NTERSECTING LINES LINE OF SYMMETRY **ACUTE TRIANGLE** CIRCUMFERENCE DECIMAL POINT **DENOMINATOR** ACUTE ANGLE COORDINATES EVEN NUMBER CENTIMETER HORIZONTAL DIFFERENCE **EQUIVALENT** DIAMETER **EQUATION ESTIMATE** FRACTION DIVIDEND **ADDITION** AVERAGE DECIMAL DIVISOR FACTOR CHORD ANGLE AREA

BEAMS Crossword Puzzle

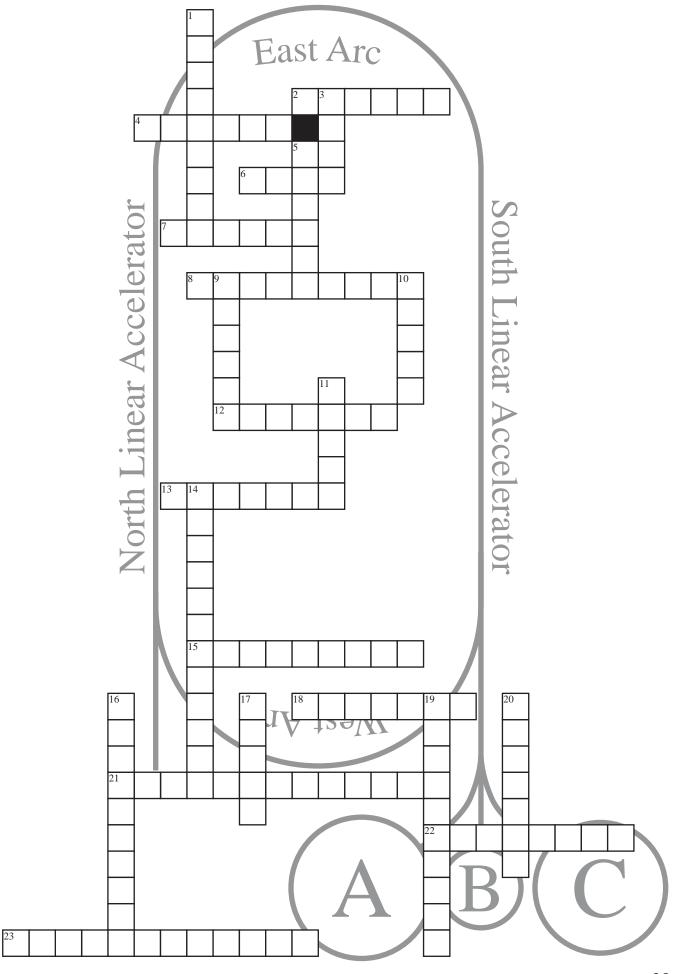
Directions: Complete the puzzle using terms from the vocabulary list.

ACROSS

- 2. Anything that has mass4. Holds quarks together
- 6. What the B in CEBAF stands for
- 7. Positively charged particle found in the nucleus of an atom
- 8. Orbit the nucleus
- 12. Made of protons and neutrons
- 13. Uncharged particle found in the nucleus of an atom
- 15. A material through which electricity and heat cannot move easily
- 18. The study of the nucleus is called nuclear _____.
- 21. A wire coil that acts like a magnet when electric current flows through it
- 22. Electrons have a _____ charge.
- 23. The laboratory in Newport News used to study the nucleus

DOWN

- 1. A material through which electricity and heat can move easily
- 3. Made up of a nucleus with electrons orbiting around the nucleus
- 5. Piece of iron, steel or other material that attracts other pieces of iron or steel
- 9. Family of particles that electrons belong to
- 10. How far an object goes in an amount of time is a measurement of the object's _____
- 11. Holds together protons and neutrons in the nucleus
- 14. Excited about, or what the E in BEAMS stands for
- 16. To change in velocity or energy
- 17. Basic building block of matter which cannot be detected in isolation
- 19. Uninterrupted or steady
- 20. Having no charge



BEAMS Cryptograph

Directions: Use the code below to find the secret words.

A	В	C	D	E	F	G	H	Ι	J	K	L	$ \mathbf{M} $
1	2	3	4	5	6	7	8	9	10	11	12	13

N	O	P	Q	R	S	T	U	\mathbf{V}	W	X	\mathbf{Y}	Z
14	15	16	17	18	19	20	21	22	23	24	25	26

6.
$$\frac{}{22}$$
 $\frac{}{15}$ $\frac{}{12}$ $\frac{}{20}$ $\frac{}{1}$ $\frac{}{7}$ $\frac{}{5}$

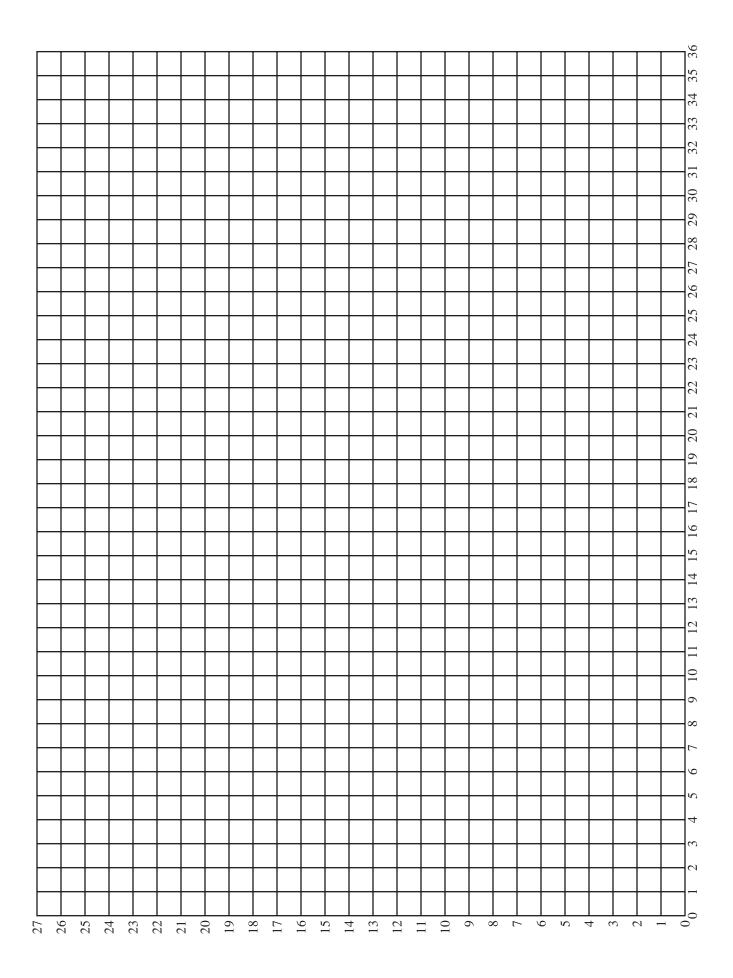
- 11. <u>14 21 3 12 5 1 18 16 8 25 19 9 3 19</u>
- 13. $\frac{}{14}$ $\frac{}{5}$ $\frac{}{7}$ $\frac{}{1}$ $\frac{}{20}$ $\frac{}{9}$ $\frac{}{22}$ $\frac{}{5}$
- 14. <u>7</u> 18 1 16 8
- 15. <u>20</u> 8 5 15 18 25

- 19. <u>22 5 12 15 3 9 20 25</u>

Mystery Picture

Directions: Plot the coordinates on the grid to find the mystery picture. You can plot the coordinates in any order, but **do not** connect any of the points until you have plotted all of the coordinates.

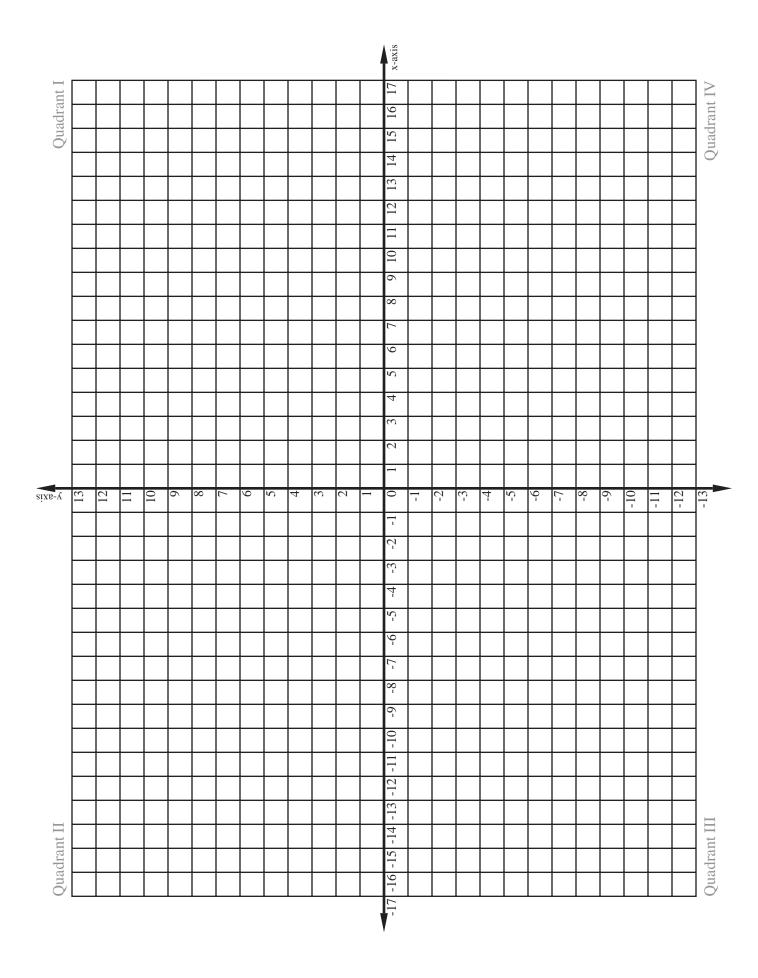
	•					
,20)	(1,1)	(20,20)	(26,24)	(10,23)	(2,11)	(22,21)
3,19)	(12,16)	(22,24)	(30,25)	(16,22)	(22,5)	(1,10)
,21)	(32,14)	(20,21)	(12,5)	(7,19)	(1,8)	(22,23)
4,25)	(8,24)	(17,25)	(5,2)	(12,19)	(4,7)	(2,0)
1,6)	(34,10)	(19,25)	(26,22)	(10,21)	(9,13)	(2,3)
(61,	(2,7)	(3,7)	(29,19)	(4,5)	(8,6)	(32,21)
0,19)	(1,2)	(23,24)	(31,22)	(16,24)	(13,25)	(8,11)
(61,	(34,11)	(10,22)	(26,23)	(22,20)	(3,11)	(26,21)
(7,22)	(4,11)	(22,25)	(31,19)	(16,23)	(24,5)	(10,14)
,24)	(4,23)	(6,5)	(1,9)	(12,25)	(8,8)	(24,16)
,10)	(31,6)	(18,22)	(26,19)	(6,3)	(2,8)	(3,0)
,22)	(11,25)	(22,19)	(6,5)	(11,22)	(28,20)	(30,5)
0,24)	(18,16)	(2,5)	(28,23)	(4,2)	(16,5)	(3,6)
1,19)	(10,16)	(11,15)	(24,23)	(31,25)	(17,22)	(28,5)
3,13)	(8,8)	(32,7)	(18,25)	(26,20)	(14,19)	(2,9)
0,16)	(10,7)	(33,8)	(19,22)	(6,16)	(3,4)	(10,20)
,10)	(7,25)	(5,25)	(20,16)	(4,1)	(29,22)	(28,16)
4,5)	(16,19)	(6,22)	(16,16)	(22,22)	(30,19)	(7,4)
8,5)	(5,5)	(4,22)	(3,3)	(20,22)	(32,20)	(10,25)
2,22)	(16,20)	(8,16)	(8,23)	(8,21)	(26,5)	(31,15)
6,16)	(8,20)	(22,16)	(25,24)	(26,25)	(20,23)	(6,19)
,5)	(20,24)	(11,5)	(6,25)	(7,7)	(14,16)	(30,22)
6,21)	(20,5)	(20,19)	(4,25)	(29,25)	(32,24)	(28,24)



Advanced Mystery Picture

Directions: Plot the coordinates on the grid to find the mystery picture. You can plot the coordinates in any order, but **do not** connect any of the points until you have plotted all of the coordinates.

(-10,3)	(-1,9)	(1,-6)	(-12,1)	(8,6)	(-8,4)	(-2,8)
(15,6)	(4,2)	(-9,4)	(-8,-6)	(1,1)	(-3,-10)	(-4,7)
(-8,3)	(8,3)	(2,-6)	(-7,1)	(14,2)	(-6,1)	(2,-7)
(-14,-6)	(-1,-6)	(4,7)	(2,-6)	(1,-10)	(-8,-8)	(10,4)
(10,3)	(13,1)	(3,-10)	(-3,4)	(-14,6)	(-4,2)	(2,-6)
(6,0)	(-14,4)	(-2,7)	(-2.5,-9)	(13,-9)	(-13,9)	(-15,4)
(10,8)	(2,-8)	(-10,-10)	(2,2)	(-11,9)	(6,5)	(8-,6-)
(-2,4)	(-10,4)	(8,2)	(14,7)	(-13,-6)	(-1,1)	(-15,6)
(2,-7)	(4,6)	(-15,-7)	(2,3)	(13,-8)	(-8,8)	(9-'6-)
(3,4)	(-10,8)	(4,8)	(14,8)	(12,9)	(15,-6)	(13,-10)
(2,4)	(-1,-1)	(-10,-7)	(6,2)	(-1,-6)	(2,-10)	(5,6)
(-2,6)	(-2,-8)	(-2,3)	(3,-6)	(-2,2)	(10,7)	(-14,8)
(14,-7)	(-14,3)	(-15,-8)	(-10,7)	(-10,2)	(-2,-6)	(8,4)
(-8,7)	(-2,9)	(10,6)	(-10,-9)	(5,1)	(9,4)	(-15,-9)
(-10,-8)	(-13,1)	(12,-7)	(-1.5,-7)	(-4,-8)	(9,6)	(-8,2)
(15,5)	(-14,-10)	(5,-9)	(8,-6)	(-4,4)	(2,7)	(-10,6)
(9,-6)	(-7,-10)	(11,9)	(-14,7)	(7,1)	(8,7)	(10,2)
(11,1)	(0,1)	(-12,-10)	(-4,3)	(-7,-8)	(3,6)	(-14,2)
(4,4)	(-3,6)	(2,8)	(8,8)	(-5,1)	(9,-6)	(15,4)
(2,-8)	(14,3)	(-9,6-)	(-8,6)	(-11,1)	(1,9)	(6,1)
(11,-6)	(-13,-10)	(-12,-6)	(14,4)	(6,9-)	(-12,9)	(-15,5)
(4,3)	(-2,6)	(-3.5,-9)	(6-,7)	(-4.5,-7)	(7,-10)	(12,1)
(-4,8)	(-4,6)	(6,9)	(14,6)	(13,9)		



BEAMS Word Search

Directions: Hidden in the puzzle below are 32 words that you will encounter during your visit to Jefferson Lab. The words may be spelled vertically, horizontally, backwards or diagonally. Some letters may be used in more than one word.

ATO BE CE CH CO CU	CEI OM AM BAF ARO MPO RRE	GE OUN	ND		T]]]]	ELE ELE FEL FIEI FOR INJE	MENRGY LD CE	NT Y	ł.]	INTI IRO JEFI LAB MAT MET MOI NUC	N FER ORA TEI CER LEC	SON ATO R ULE	RY	В	P C C S S	PHYS PROZ QUAZ QUAZ QUAZ CIE PEE	TON DRA LITA RK NCI D	I ANT ATIV	Æ
S	C	Ι	A	N	C	Е	Ι	C	S	A	T	M	M	A	T	S	Е	R	Н	P	Ι
C	M	A	C	C	E	L	E	R	A	T	О	R	S	A	T	N	E	M	E	L	E
I	О	F	E	L	Е	L	Е	C	T	R	О	N	O	Н	T	I	C	A	R	Е	L
Е	L	I	O	T	P	R	O	T	O	N	S	L	Н	E	N	T	E	M	E	L	E
N	Е	D	N	C	I	R	О	N	O	S	S	E	T	G	T	О	E	I	N	N	C
C	C	D	O	T	О	E	T	S	I	C	I	S	Y	Н	P	T	F	R	I	U	T
T	U	M	N	О	Е	M	A	Z	F	O	E	T	Ι	Н	K	A	D	Н	R	Ο	R
W	L	A	N	В	E	R	P	L	D	Ι	U	A	N	R	O	R	L	R	N	R	O
О	Е	K	Н	I	V	T	N	O	I	L	L	T	A	Q	Е	Е	E	T	S	Е	M
S	Ι	Ι	O	T	A	L	Н	Е	U	T	P	U	U	D	T	N	I	L	U	A	A
G	N	C	G	S	E	E	A	N	T	N	Q	A	Q	Н	T	Е	F	K	W	S	G
F	U	S	Е	Н	P	R	S	C	Н	R	D	U	Н	T	Е	C	M	A	R	P	N
Н	E	R	N	T _	T	L	A	В	0	R	A	T	0	R	Y _	C	T	S	В	A _	E
A	T	O	M	T	W	0	I	T	A	L	U	W	V	Е	E	В	Q	D	U	Е	T
Е	T	T	S	N	I	E	A			E			0		C		G	R	A	Н	C
	W		L			L			S			Е			S	Н	Е	M	E	0	A
N	D	E		P	U	L		S			L			E	Н	Т	Н	E	A	В	N
В	U	J	T	S	R	T	F	T	L	M		T	Т	A	R	Н	I	Т	U	Р	S
J I	S B	N I	N Q	A V	I	O R	L G	O K	N A	D R	O T	L I	F C	M S	O Y	E A	S S	E R	C Y	H I	P E
C	С	I K	Q E	V Q	W	R P	I		A P	K L	T	L	U	S U	C	A Y	S G	R R	E	n N	E
S	C	I	E	N	C	r E	J	E	F	F	E	R	S	0	N	L		В	P	Q	D
D	\sim	1	L	T.4		L	J	L	1	1	-	1/	D	\cup	T 4	L	11	ע	1	V	ע

Element Word Search

Directions: Hidden in the puzzle below are the names of 40 common elements. The names may be spelled vertically, horizontally, backwards or diagonally. Some letters may be used in more than one name.

ALUI ARG BERY BORG CALG CARG CHLG	IMC ON YLL ON CIU BON ORI PER	ONY LIUN M N INE				IOE IRC KR' LEA LIT	LIU DR(DINI DN YPT AD THIU RCU	OGE E ON				NI OZ PA PI PI PI P(RA	IOS LAT	OGI SEN ADI PHO INU ONI SSI UM	IUM ORU IM IUM UM	JS			SILV SOD SUL SUL SITA SUN JRA ZINO	.NIU	I R UM FEN
C	I	D	L	A	В	Ι	R	A	G	Ι	K	P	О	T	A	S	S	I	U	M	В
C	N	I	Z	I	C	N	S	R	X	Z	R	C	L	N	I	U	M	D	A	E	L
P	I	T	I	A	O	O	Н	О	O	X	Y	O	U	I	M	О	D	A	R	В	F
Z	T	I	R	A	D	R	E	L	D	M	P	U	N	R	X	C	P	Y	A	A	I
C	I	В	C	K	G	О	L	D	Е	I	T	G	R	Y	Y	Н	L	I	D	В	V
I	Ο	D	Ο	X	O	В	I	M	P	A	Ο	N	E	A	G	L	U	V	I	Y	E
N	A	Z	N	I	L	Y	U	K	Е	L	N	M	L	N	I	Ο	T	A	U	L	X
Y	C	I	I	О	M	O	M	Е	R	C	U	R	Y	U	R	R	O	N	M	О	Y
N	K	M	U	N	Ι	T	A	L	P	V	I	R	M	N	Ο	I	N	Ο	I	N	Н
O	L	C	M	G	K	A	R	F	P	I	S	M	U	I	О	N	Ι	V	L	Ι	Y
M	N	I	T _	R	0	G	E	N	L	T	0	U	T	I	X	E	U	A	0	R	D
I	I	I	T	K	0	S	Н	M	U	I	D	A	L	L	A	P	N	0	D	A	R
T N	I	B A	I L	H C	L I	Y	T	A G	T	U R	I U	V	A R	F R	R U	R R	S H	D E	F L	S U	O G
	C L					U	M M		O			O			R						G E
W		R	G	D	0	E			I				0				R	E	0	0	N
I	0	D	Е	R	N	R	S		U	I	R	В	N	K		I	I	N	R	Н	Z
R		G	S	I	R	E	E			U		N		E	N	A	D	N	I	P	A
P	Е	K	D	P	U	V	N	0			N	E	T	S	G	N	U	T	N	S	Н
N	V	0	I	S	I	L	V	E	R	Е	Ι	N	N	E	L	Y	R	I	E	0	A
N	Ι		K	Е	L	Ι		U			A		Ι	T	О	T	X	S	F	Н	X
S	Ι	L	I	C	О	N		W			A			R		P	P	О	С	P	Y

BEAMS Fractions

Directions: Reduce each fraction to its lowest terms. Then use the code to find the names of the 6 quarks.

5/25	6/16	20/50				
8/36	9/45	0/5	50/100	4/12	75/100	12/12
12/48	15/40	8/28	9/27			
8/56	21/56	3/15	10/50	12/32	7/42	
14/18	16/20	14/28	0/65	9/54		
6/48	12/30					

Scrambled Science Words

Directions: Use the **Vocabulary List** to help you unscramble the words below.

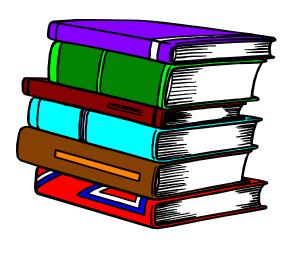
1.	LSODI	
0	AMOT	
Z .	AMOT	
3.	CEISNEC	
4.	MABE	
5.	RAKUQ	
6.	LECEORTN	
7.	ORTOPN	
8.	PCEUORTM	
9.	IUDLQI	
lO.	NCESULU	
11.	MENELTE	
12.	UOENRNT	
13.	GTNAME	
14.	EEXMPTNEIR	
15.	TRTAEM	

BEAMS Spelling Search

Directions: Circle the misspelled word in each sentence. Write the correct spelling on the line at the end of the sentence.

1.	It is great to spend an entir week at Jefferson Lab!	
2.	I really enjoyed the liquid nytrogen show.	
3.	I can't beleive the effects of liquid nitrogen on a flower.	
4.	It was interesting to tour Jefferson Lab and see the sientists at work.	
5.	One of my favrite activities was making Oobleck.	
6.	We had to decide if Oobleck was a solid, liqiud, gas or plasma.	
7.	I just liked playing with the Oobleck and sliming my neighbhor.	
8.	I used the intenet to do research on the computer.	
9.	We made a hypothsis that cotton would be the best insulator.	
IO.	We use the scientific method to do the experment.	
11.	Everyday we rote a journal entry in our books.	
12.	I defenately didn't miss a week of school to attend BEAMS!	

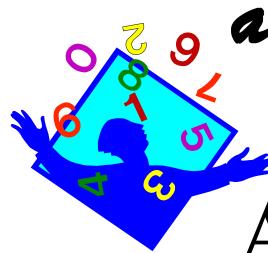
Reading,





Writing





Arithmetic

Reading About Looking for Quarks Inside the Atom

THE SHAPE OF THINGS EXPERIMENT SHOWS HOW SCIENTISTS CAN TEST THEIR THEORIES ABOUT ATOMS.

Directions: Read the following passage. Fill in the blanks with words that make sense. Remember to

use context clues that come before and after the blanks. About thirty years ago, three scientists ran some accelerator experiments to study the nucleus at the _____ of the atom. They ran the experiments because they wanted to know more about the structure of the 2. They found that the protons and neutrons in the nucleus are made of quarks. The discovery of _____ are raised new questions about the nucleus. The three scientists are Richard Taylor, Henry Kendall and Jerome Friedman. They did their experiments from 1967 to 1973 in California at the Stanford Linear Accelerator Center, called SLAC for short. These scientists won the 1990 Nobel Prize in Physics, one of the world's greatest honors for ____4___. In the 1960's some scientists, like Murray Gell-Mann, were beginning to think that each nucleon might really be made up of even smaller particles. Gell-Mann even had a name for the smaller ____5__. He called them quarks. Taylor, Kendall and Friedman used beams of high-energy electrons at SLAC to explore deep inside atoms. Inside the two mile long accelerator the electrons gained energy as they moved along in a beam almost as fast as light. At the end of the accelerator, some hydrogen was the target for the electrons. Sometimes an electron would 6 into the proton inside of the hydrogen atoms. These crashes were far too tiny to see directly or even with a microscope. The three experimenters used spectrometers to _____ what happened. Each spectrometer consisted of huge electromagnets, about the _____8__ of a bus, and some detectors. When electrons crash into a target nucleus, a spectrometer measures their angles and energies as they bounce away. The electrons were not striking solid protons. They were striking vibrating clusters of quarks. Each proton is a cluster or three ____9__; each neutron is too. This new discovery led to new questions. Experiments at Jefferson Lab will answer new 10 about quarks and nuclei. That's how scientific research works. There is always something new to find out! In fact, that's why Alfred B. Nobel started the Nobel _____ in 1901. In December, 1990, Taylor, Kendall and Friedman went to Stockholm, Sweden, to receive their Nobel Prize in Physics. The three winners shared not only the honor of the Nobel, but the _____ that comes with it: \$710,000.

Directions: Choose the word that fits the context of the passage.

1.	a.	outside	Ъ.	edge	c.	center	d.	perimeter
2.	a.	nucleus	Ъ.	accelerator	c.	electromagnet	d.	spectrometer
3.	a.	alpha	Ъ.	quarks	c.	nuclei	d.	electron
4.	a.	teachers	Ъ.	engineers	c.	farmers	d.	scientists
5.	a.	nucleon	Ъ.	quarks	c.	particles	d.	gell
6.	a.	crash	Ъ.	glide	c.	slip	d.	fall
7.	a.	wonder	Ъ.	observe	c.	question	d.	argue
8.	a.	size	Ъ.	color	c.	purpose	d.	strength
9.	a.	quarks	Ъ.	bounces	c.	clusters	d.	protons
10.	a.	inventions	Ъ.	questions	c.	discoveries	d.	statements
11.	a.	medals	Ъ.	trophies	c.	prizes	d.	certificates
12.	a.	book	Ъ.	certificate	c.	paper	d.	money

Reading About Ernest Rutherford

THE SHAPE OF THINGS ACTIVITY SIMULATES THE EXPERIMENTS SCIENTISTS DO IN EXPLORING THE ATOM.

Directions: Read the passage. Locate the paragraph that contains the answer to each question on the next page.

- 1. Ernest Rutherford (1871-1937) was a scientist who wanted to learn about atomic structure. The best way to learn about the inside of the atom, he decided, was to blow it apart.
- 2. Rutherford chose the nucleus of the helium atom as the bullet to shoot at the atom. The helium nucleus, which is called an alpha particle, contains two protons and two neutrons. The "gun" to fire the alpha particle was the element radium. Radium is radioactive. It is continually shooting out atomic particles. He placed the radium in a heavy lead container with just a small opening to direct the escaping alpha particles.
- 3. The target for the alpha particles was a very thin sheet of gold foil, less than 1/100,000 of an inch thick. This is even thinner than the aluminum foil you use to cover food. Yet atoms are so small that the gold foil still had a thickness of more than 2,000 atoms.
- 4. For his first experiment, he set the foil in front of the radium container. Behind the foil, he placed a fluorescent screen. The screen would show a spark of light whenever it was struck by an alpha particle. Thus, he could see whether any alpha particles were able to pass through the atoms in the gold foil.
- 5. The actual results were amazing. Rutherford got flashes of light from the screen. Somehow the alpha particles were able to get through.
- 6. The scientist moved the screen to the sides and even in front, facing the foil. To his amazement he found light flashes at all angles. Some particles were even bouncing off to the side as well as straight back at the radium.
- 7. In 1911, Rutherford explained what had happened. He suggested that the atom consists of a very small, heavy central core called the nucleus. Very far out from the nucleus are the rapidly swirling electrons.
- 8. The atom was largely an empty shell. That explained how the alpha particles were able to get through the gold foil. Within the shell, there was a small but heavy nucleus with a positive charge. That is what deflected some of the positive alpha particles and bounced back the few that actually hit the nucleus of the gold atoms.
- 9. Rutherford performed another experiment similar to the first to check his picture of the atom. This time he used nitrogen as a target. Most of the particles went straight through the empty space of the nitrogen atoms. A few bumped into the nucleus and bounced off. He also discovered the presence of hydrogen nuclei (more than one nucleus) that had a positive charge. Then he realized that the hydrogen nuclei had to come from within the nitrogen atoms. Rutherford concluded that the atoms of every element contain one or more of these positively charged nuclei. These positive hydrogen nuclei are called protons.

11. On the basis of these results, he set forth a complete model of the atom. The nucleus is made up of heavy, positively charged protons. It has a positive electrical charge. Very far out from this nucleus are the much lighter electrons. Their negative charge balances the positive charge of the nucleus.

Directions: Read each question carefully. Locate the paragraph that contains the information needed to answer each question. Write the number of the paragraph on the blank.

 1.	What is an alpha particle?
 2.	What was the thickness of the gold foil?
 3.	What was the target for the alpha particle?
 4.	How did Rutherford conduct his first experiment to study the inside of an atom?
 5.	Why did Rutherford put a fluorescent screen behind the foil?
 6.	What happened when Rutherford moved the screen to the side?
<i>7</i> .	What did Rutherford discover when he used nitrogen as a target?
8.	Why did the nucleus deflect some of the alpha particles?
 9.	What does the word "nuclei" mean?
10.	How did Rutherford check his picture of the atom?
11.	What are positive hydrogen nuclei called?

Reading About Superconductivity

JEFFERSON LAB'S ACCELERATOR CAVITIES ARE COOLED WITH LIQUID HELIUM TO BECOME SUPERCONDUCTORS.

In 1911 Heike Onnes, a Dutch scientist, was conducting experiments to learn how metals were affected by very cold temperatures. While working with the metal mercury, he discovered something new. When mercury was cooled to the extremely cold temperature of liquid helium, it allowed electricity to flow through it without any loss of energy.

Onnes and other scientists continued investigating other metals to learn if they would react the same as the mercury to the extremely cold temperature. They found that many of the metals had the same reaction. In one experiment, a metal wire loop was cooled in liquid helium and electricity was allowed to flow into the loop. When the source of the electricity was removed, the current continued to flow. Onnes was not able to explain this discovery, but he called it superconductivity.

In a normal conductor, the current stops flowing when the source of electricity is removed. If a superconducting metal is kept at the supercool temperature of liquid helium, the current can flow for years without becoming weaker.

It was many years before the discovery of superconductivity could be used in practical ways, because liquid helium and the equipment needed to cool superconducting materials are very expensive and difficult to handle. Today, the use of superconducting technology is being researched and applied in such fields as medicine, physics, transportation, communication and the military.

Directions: Answer the questions in complete sentences.

- 1. How many years ago was superconductivity discovered?
- 2. How could you test a metal to see if it is a superconductor?
- 3. How does a superconductor differ from a normal conductor?

Bonus Question: How are superconductors used in the cryomodules at Jefferson Lab?

Writing About Liquid Nitrogen

REMEMBER THE LIQUID NITROGEN PRESENTATION YOU SAW AT JEFFERSON LAB.

What if you found a thermos of liquid nitrogen \dots ?

ler a	to imagine where you might find a thermos of liquid nitrogen. Would it be by your be tree, in your locker at school or another interesting place? Would you take the liquid
	to class? How would you transport it? What would you do with the liquid nitroger
	ould happen when you used it? Write a creative story about what would happen if
nd s	ome liquid nitrogen.
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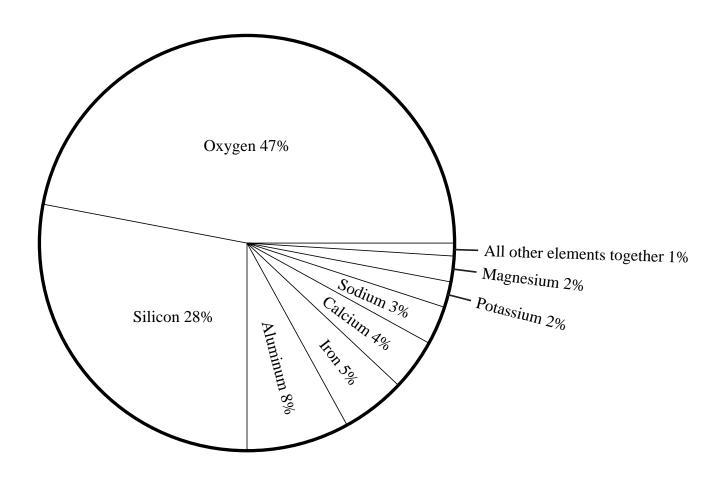
Reading About Materials in the Earth's Crust

IN THE HUMAN ACCELERATOR ACTIVITY YOU DID AT THE LAB. YOU USED PIE GRAPHS TO SEE THE PERCENTAGE OF TENNIS BALLS THAT ARRIVED AT THE TARGET. USE THE PIE GRAPH BELOW TO HELP YOU UNDERSTAND THE FOLLOWING PASSAGE.

Directions: Read the following passage about minerals and the materials that make up the earth's crust. Fill in the blanks with words that make sense. Remember to use context clues that come before and after the blanks

The earth's crust is made up of a number of different materials. Solid __1__ that are found in the crust are minerals. There are hundreds of different minerals. Each __2_ has its own properties. Scientists identify minerals by testing their __3__. One property is magnetism; magnetite has __4__ properties. The shape of crystals can identify minerals such as salt, which has __5__ that look like cubes. The color, shine and hardness of minerals are other properties used to classify and __6__ minerals in the crust.

The __7__ chart below shows the elements that make up most minerals. The graph shows that __8__ makes up 47% of the minerals in the crust. Both potassium and magnesium make up __9__ of the crust. The graph also gives us information about other elements, such as carbon. Carbon makes up __10__ 1% of the crust.



Directions: Use the context of the passage and the graph to select the best word for each blank.

1.	a.	minerals	Ъ.	materials	C.	crusts	d.	numbers
2.	a.	mineral	Ъ.	material	c.	property	d.	layer
3.	a.	minerals	Ъ.	materials	c.	properties	d.	scientists
4.	a.	magnetic	Ъ.	quality	c.	properties	d.	identify
5.	a.	properties	Ъ.	saltiness	c.	minerals	d.	crystals
6.	a.	push	Ъ.	mine	c.	identify	d.	clarify
7.	a.	line	Ъ.	bar	c.	percentage	d.	pie
8.	a.	silicon	Ъ.	aluminum	c.	oxygen	d.	iron
9.	a.	4%	Ъ.	3%	c.	over 8%	d.	2%
10.	a.	more than	Ъ.	less than	c.	equal to	d.	unknown

Reading About Heat Transfer

THE COLD STUFF ACTIVITY YOU DID AT JEFFERSON LAB WAS AN EXPERIMENT IN THE TRANSFER OF HEAT.

Heat can be transferred by three different means:

- Conduction the transfer of heat through two or more materials that are touching
- Convection the transfer of heat by the movement of a gas, like air, or a liquid, like water
- **Radiation** the transfer of heat by means of rays

Which method of heat transfer best defines each scenario: conduction, convection or radiation?

1.	You wake up on a Saturday morning and are glad you don't have to go to school. You sit outside in the sun because you don't really feel like doing anything at all. The heat from the sun is starting to make you sweat.	
2.	Last night you went to the store and bought fruit punch, so you have a big glass of it to help cool you off.	
3.	The news is on and the forecast calls for hot and muggy weather. The temperature in the house is rising too so you turn on the air conditioner.	
4.	It's boring sitting in the house on your day off, so you go to the pool to meet your friends. You jump in and the water is freezing but you don't want to look like a wimp so you try to get used to it. Your lips are turning blue and your skin now feels cold.	
5.	You climb out of the pool and lie on the warm concrete to warm your body back up.	
6.	You're beginning to feel comfortable again but don't want to get too warm, so you move to a place in the shade. It's getting hotter and hotter now and you're starting to sweat again, even though you are in the shade.	
7.	You decide that it wasn't so bad at home after all and you're getting hungry anyway so you go back home and cool off in the air conditioning, on the sofa, with a good book.	

Statistical Analysis

SCIENTISTS CALCULATE THE MEAN. MEDIAN. MODE AND RANGE OF THEIR DATA TO LEARN HOW THE DATA IS DISTRIBUTED.

Directions: Use the sample data chart to answer the questions.

- **Mean** the sum of all of the numbers in a set of data divided by the number of numbers in the set of data
- Median the middle number in a set of data when all of the numbers are written in order
- **Mode** the number or numbers which appear the most in a set of data
- Range the difference between the largest number and the smallest number in a set of data

INSULATOR	(initial temperature) TEMPERATURE of insulator at TIME (minutes:seconds)										
INSULATOR	0:00	0:30	1:00	1:30	2:00	2:30	3:00	3:30	4:00	4:30	5:00
Cotton	21	21	20	20	19	19	19	18	18	18	18
Air	20	18	16	15	14	13	12	11	9	8	7
Steel Wool	22	22	21	21	20	18	17	16	14	13	11

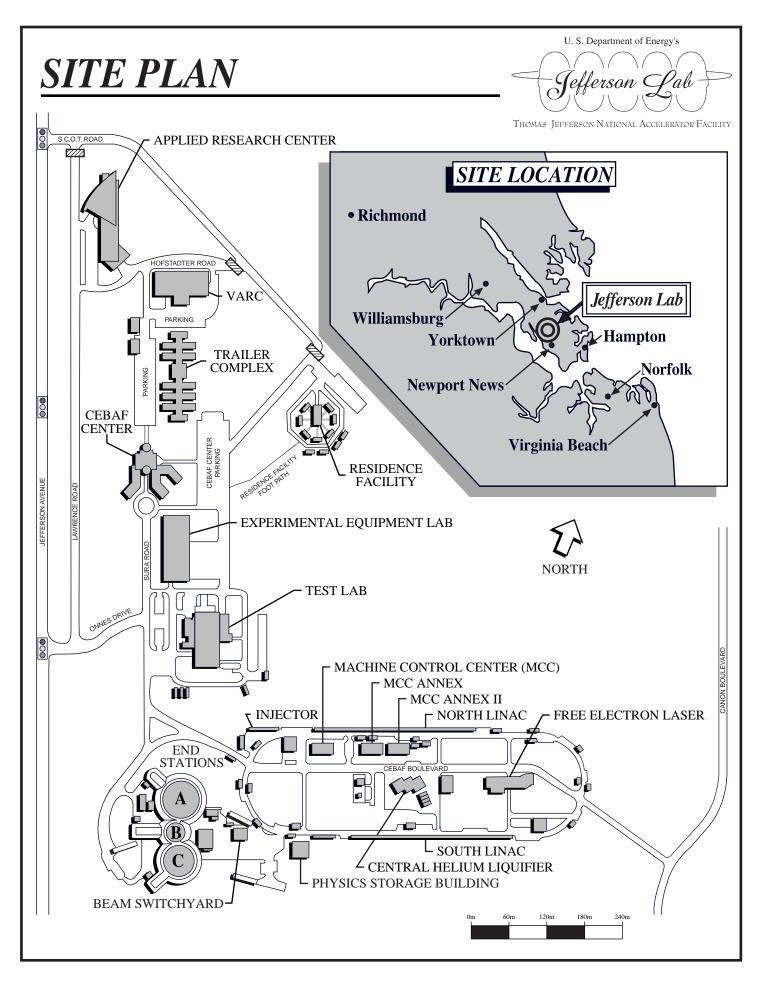
- 1. Which insulator has the greatest range? What is that range?
- 2. Which insulator has a median of 19?
- 3. What is air's mean temperature?
- 4. What is steel wool's mode?
- 5. Which insulator has a range of 3?

Jefferson Lab Site Map Scale Activity

WHEN YOU WERE AT JEFFERSON LAB YOU TOOK A TOUR AROUND THE SITE. SEE IF YOU CAN ESTIMATE THE DISTANCES BETWEEN SOME OF THE PLACES YOU VISITED.

Directions: Use the scale on the site plan on the next page to calculate the shortest distance between each pair of buildings listed below. Hint: You can make a large ruler to help you measure the distances between buildings by copying the map's scale over and over again onto a scrap piece of paper. 1. Hall A and CEBAF Center 2. Injector and Machine Control Center 3. Hall C and Injector 4. CEBAF Center and VARC 5. Residence Facility and Trailer Complex 6. Hall C and VARC 7. Machine Control Center and CEBAF Center 8. Experimental Equipment Lab and Test Lab 9. North LINAC and Central Helium Liquifier

10. Applied Research Center and Free Electron Laser



Reading About Microscopes

YOU USED MICROSCOPES IN THE CLASSROOM AT JEFFERSON LAB.

Directions: Read the following passage. Fill in the blanks with words that make sense. Remember to use context clues that come before and after the blanks. It happened over 300 years ____ in Holland. Anton van Leeuwenhoek (AN-tun van LAYvun-hook) had a new microscope that he had ______. One day he ______ through it at a drop of lake water. What he saw surprised him. The water was alive with what Leeuwenhoek called "wee beasties." The microscope made tiny organisms look 200 times ___ 4 __ than life size. Leeuwenhoek was one of the first scientists to see living things that were that ______. His work was a giant ______6___ for science. Today, microscopes are much stronger. An electron microscope can make tiny organisms look 200,000 times ____ size. A few electron microscopes can see individual atoms. Pictures can be made to show the objects or organisms much bigger. The pictures add greatly to what we know about tiny objects and ______. Microscopes have come a long way in 300 years! **Directions:** Choose the word that fits the context of the passage. c. before 1. a. since b. ago d. after 2. a. made b. lost c. previewed d. delivered 3. a. fell b. broke c. looked d. went 4. a. farther b. smaller c. darker d. larger 5. a. life b. small c. darker d. larger 6. a. turtle b. gorilla c. step d. tower 7. a. small b. over c. under d. life

c. electricity

d. microscopes

b. gravity

8.

a. organisms

Writing About Size

LOOKING THROUGH THE MICROSCOPES AT JEFFERSON LAB. YOU WERE ABLE TO GET A CLOSE LOOK AT VERY SMALL OBJECTS.

If you woke up one morning and discovered that you had been shrunken to microscopic size, what would you do? Write a story about how you got that way, where you would go, what you would eat, and other challenges you would face.

Reading About Internet Safety

THE INTERNET IS A PLACE WHERE ANYONE CAN POST ANY KIND OF INFORMATION.

Directions: Read the following passage. Fill in the blanks with words that make sense. Remember to use context clues that come before and after the blanks.

Twenty ago, kids in school had never even heard of the internet. Now, I'll bet you
can't find a single person in your school who hasn't at least heard of it. In fact, many of us use
it on a regular basis and even have access to it from our homes! The 'net' in 2 really
stands for network. A is two or more computers connected together so that
information can be, or sent from one computer to another. The internet is a vast
resource for all types of information. You may enjoy using it to do research for a school project,
downloading your favorite songs or communicating with friends and family. Information is
accessed through web pages that companies, organizations and individuals create and post. It's
kind of like a giant bulletin board that the whole world uses! But since anyone can put
anything on the internet, you also have to be careful and use your best judgement and a little
common sense.
Just because you read something on a piece of paper someone sticks on a bulletin board doesn't mean it's good information, or even correct, for that matter. So you have to be sure that whoever posted the5 knows what they're talking about, especially if you're doing6! But what if you're just emailing people? You still have to be very careful. If you've never met the person that you're communicating with online, you could be on dangerous
ground! You should never give out any personal information to someone you don't know, not even your name! And just like you can't

Directions: Choose the word that fits the context of the passage.

1.	a.	hours	Ъ.	days	c.	weeks	d.	years
2.	a.	internet	Ъ.	fishnet	c.	network	d.	netting
3.	a.	computer	Ъ.	internet	c.	network	d.	wire
4.	a.	hidden	Ъ.	lost	c.	created	d.	shared
5.	a.	internet	Ъ.	bulletin board	c.	information	d.	stamp
6.	a.	research	Ъ.	lunch	c.	recess	d.	sports
7.	a.	read	Ъ.	find	c.	understand	d.	believe

Writing About the Internet

WHILE USING THE INTERNET AT JEFERSON LAB. YOU WERE ABLE TO FIND INFORMATION ON ALL KINDS OF PEOPLE. PLACES AND THINGS.

Imagine that a famous person asks you to design a web page for them. Who would your person be and what would you put on their page? Think about what topics you would want to be sure to include on the site's home page. Would you have links to other sites? If so, what types of sites would they be? What age group would you have in mind? Why would they want to visit this site?

Writing About a Loss

IN PLAYING LOOKING FOR THE TOP QUARK, YOU AND YOUR PARTNER WERE TRYING TO FIND EACH OTHER'S 'LOST' QUARKS.

Write about losing something important to you. When was the last time you saw it before it was lost? Do you know how it became lost? How did you feel about it being lost or gone? Did you ever find what it was that you lost? If so, describe how you found it and how you reacted to finding it. If not, describe how you felt about realizing you would never see it again.

Reading About Properties and Changes

OOBLECK HAS SPECIFIC PROPERTIES.

Directions: Read the following passage. Fill in the blanks with words that make sense. Remember to use context clues that come before and after the blanks.

Matter can be described and identified by physical and chemical properties. Physical
have to do with appearance. You can observe many physical properties with your
senses and by measuring the length, 2, height, mass and density of a substance. 3
properties include color, shape, smell, texture, taste and size. The state of matter (whether it's a
solid,, or gas) and the at which the substance boils, melts or freezes are also physical properties. Magnetic properties are physical properties as well.
6 properties, on the other hand, have more to do with the atomic or molecular composition of matter. Chemical properties deal with how substances react with other 7
such as water, air or fire.
A physical change has occurred when a substance changes color, size, shape, temperature
or state. A change has occurred when a substance has changed into something new or
so that the original substance is gone. Digestion, combustion and radioactive decay
are examples of chemical changes. A chemical change takes place in a10 to produce
electricity when you turn on a flashlight.

Chemical changes are sometimes represented by a chemical formula:

$$2H_2 + O_2 = 2H_2O$$

This formula states that two hydrogen gas molecules react with one oxygen gas molecule to produce two molecules of water.

Directions: Choose the word that fits the context of the passage.

1.	a.	chemicals	Ъ.	properties	c.	substances	d.	textures
2.	a.	width	Ъ.	density	c.	height	d.	property
3.	a.	chemical	Ъ.	matter	c.	described	d.	physical
4.	a.	water	Ъ.	molecule	c.	liquid	d.	atom
5.	a.	time	Ъ.	temperature	c.	design	d.	cylinder
6.	a.	chemical	Ъ.	physical	c.	substance	d.	gaseous
7.	a.	properties	Ъ.	physicals	c.	degrees	d.	substances
8.	a.	temperature	Ъ.	physical	c.	chemical	d.	color
9.	a.	similar	Ъ.	different	c.	familiar	d.	original
10.	a.	battery	Ъ.	bulb	c.	change	d.	switch

Reading About Changes

THE OOBLECK YOU MADE AT JEFFERSON LAB WAS AN EXPERIMENT INVOLVING CHANGE.

Look at the picture of the candle burning. The wax of a candle burns and changes into ash and smoke. The original materials are changing into something different. Changes that create a new material are called **chemical changes**.



Look at the picture of water boiling and changing into steam. Steam is another form of water. Heating the water did not create a new material. In changing the water from a liquid to a gas, only the state of the water changed. Changes in the shape, size or state of a material are called **physical changes**.



Directions: Study the changes that are occurring in each picture below. Tell what is changing. Then decide if the change is a chemical change or a physical change.

	What is changing?	What kind of change?
A car wreck		
Melting ice cream		
Wood burning		

Challenge! List three changes you observe at home. Tell what is changing and what kind of change is occurring in each. Can some changes be both physical and chemical?

Writing About Physical Properties

REMEMBER WHEN YOU OBSERVED THE PROPERTIES OF OOBLECK.

Write about your favorite food. Try to describe your favorite food to someone, without telling them what it is! Be sure to use words that appeal to the senses (sight, touch, hearing, smell and taste) so that you will be describing the physical properties of your favorite food. Think about and be sure to explain why this is your favorite food.

Elements, Compounds and Mixtures

DIFFERENT SUBSTANCES WERE COMBINED WHEN YOU MADE OOBLECK.

Directions: Determine if the following substances are elements, compounds or mixtures.

- **Element** any substance that can not be broken up into simpler substances by chemical means
- Compound a substance formed when atoms of two or more elements join together
- **Mixture** a material consisting of two or more substances that are not chemically bound to each other and can be separated

Elmer's Glue	
Borax	
Food Coloring	
Water	
Nitrogen	
Chalk	
Air	

Directions: Elements and compounds have specific chemical formulas. Match each element or compound in the list on the left with its matching formula in the list on the right.

Hydrogen	N
Borax	$\mathrm{H_{2}O}$
Tungsten	W
Water	CaCO ₃
Nitrogen	CO_2
Chalk	Н
Carbon Dioxide	$Na_{2}B_{4}O_{7}\cdot 10H_{2}O$

Writing About Inventions

DURING THE DESIGN AND ENGINEERING ACTIVITY AT JEFFERSON LAB. YOU USED CREATIVITY TO DESIGN A BOAT TO HOLD AS MANY DICE AS YOU COULD.

Write about a new invention designed to make life easier. You may already have an original idea about an invention you wish you could have, or you might have some good ideas about how to make an invention that already exists, better. Write about what your invention would be able to do. How much would it cost? Who would be most interested in your invention? Write about what you would do with this invention if you had it. How would it change the way you live? After you finish describing your invention, draw a picture of what it would look like. You may want to label any special parts or features that it has, and be sure to give it a name!

Reading About Charges and Electricity

THE DEMONSTRATIONS WITH THE VAN DE GRAAFF GENERATOR SHOWED HOW CHARGES BEHAVE.

Directions: Read the following passage. Fill in the blanks with words that make sense. Remember to use context clues that come before and after the blanks.

Atoms, the basic building blocks of matter, are made of three basic components: protons, neutrons and electrons. The protons and neutrons cluster together to form the nucleus, the central part of the atom, and the1 orbit about the nucleus. Protons and electrons both carry an electrical charge. The charges they carry are opposite to each other; protons carry a2 electrical charge while electrons carry a negative electrical charge. Neutrons are
electrical charge while electrons carry a negative electrical charge. Neutrons are charged - they carry no charge at all.
Electricity is the movement of charged particles, usually electrons, from one place to
another. Materials that electricity can move through easily are called conductors. Most metal
such as iron, copper and 4, are good 5 of electricity. Other materials, such as
rubber, wood and glass, block the flow of electricity. Materials which6 the flow of
electricity are called insulators. Electrical cords are usually made with both conductors and
7 Electricity flows through a 8 in the center of the cord. A layer of insulation
9 the conductor and 10 the electricity from 'leaking' out.
Objects usually have equal numbers of positive and negative charges, but it isn't too hard
to temporarily create an imbalance. One way scientists can create an imbalance is with a
machine called a 11 generator. It creates a large static charge by placing electrons on a
metal dome using a motor and a big rubber band. Since like charges, the electrons
push away from each other as they collect on the dome. Eventually, too many electrons are
placed on the dome and they leap off, creating a spark that looks like a bolt of lightning.
II
Have you ever received a 13 after having walked across a carpet? This shock was
caused by extra electrons you collected while walking across the carpet. Your body became
like the dome of the Van de Graaff generator, full of extra electrons looking for a way to get
away. The path back to the carpet was blocked by the you were wearing, but they
were able to move through your hand and into the object that you touched, causing the shock So, the next time you shuffle across a carpet and shock your friend on the ear, tell them you
were just trying to be a Van de Graaff generator!
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Directions: Choose the word that fits the context of the passage.

1.	a.	neutrons	b.	protons	C.	electrons	d.	quarks
2.	a.	negative	Ъ.	positive	c.	neutral	d.	strong
3.	a.	negatively	Ъ.	positively	c.	neutrally	d.	strongly
4.	a.	wood	Ъ.	paper	c.	nitrogen	d.	aluminum
5.	a.	keepers	Ъ.	protectors	c.	insulators	d.	conductors
6.	a.	allow	Ъ.	create	c.	help	d.	prevent
7.	a.	conductors	Ъ.	insulators	c.	metals	d.	plugs
8.	a.	conductor	Ъ.	insulator	c.	neutron	d.	cord
9.	a.	surrounds	Ъ.	warms	c.	looks at	d.	hears
10.	a.	speeds up	Ъ.	replaces	c.	prevents	d.	allows
11.	a.	Rube Goldberg	Ъ.	Van de Graaff	c.	Big Bad	d.	Einstein
12.	a.	jump	Ъ.	join	c.	repel	d.	attract
13.	a.	dollar	Ъ.	book	c.	shock	d.	cat
14.	a.	freckle	Ъ.	shirt	c.	pants	d.	shoes

Reading About Magnets and Electromagnets

JEFFERSON LAB USES MANY POWERFUL ELECTROMAGNETS IN ITS ELECTRON ACCELERATOR.

Directions: Read the following passage. Fill in the blanks with words that make sense. Remember to use context clues that come before and after the blanks.

Magnets are materials that attract pieces of iron or steel. In ancient times, people first discovered magnetism when they found some naturally ___1__ pieces of rock in the earth. They called these rocks lodestone. Loadstones have a lot of iron in them, but we now know that other materials can be magnetized as well. Nickel, cobalt, certain types of ceramics and certain blends of metals can also make good magnets. If you could look at a magnet at the atomic level, you would notice that the magnet was divided into a number of smaller regions called domains. All of the _____ in a domain point in the same direction and, since each atom acts like a little ____3__, all of their little magnetic fields add together to make a larger, ____4__ field. A magnet can be weakened if some of its atoms are thrown out of alignment. Hitting or heating a magnet is usually enough to scramble some of its atoms. Magnets have north and south poles. The north pole of one magnet will repel, or push away, the north pole of another magnet, and the south pole of one magnet will repel the south pole of another magnet. But, if you put the north pole of one magnet near the south pole of another magnet, you'll feel an attractive force. You may have heard the saying "opposites _____5__." This is just one of the rules of nature that scientists have discovered. Everyone knows that magnets stick to refrigerators, but did you know that magnets are used in all sorts of things? Most of the magnets we are used to seeing are made from metals rich in ___6__. The kind we use to hold our school work to the refrigerator are called permanent magnets. They are magnets today and they'll be magnets tomorrow. They just hang there and continue to be magnets without us doing anything to them. Can you think of anywhere else you might find permanent magnets in your house? Did you know there's a magnet in the seal on the inside of your refrigerator door? You don't use that one to hold your school work, but it does hold the door closed when you're not looking for a snack or a cold drink. Some cabinet doors have magnetic latches too. Can you think of any other places where magnets have practical uses? Permanent magnets are one kind of magnet, but there's another kind of magnet called an electromagnet. ____ are made from metal and electricity! When the ___ 8 __ is on, you have a magnet, but turn the power off, and you just have a hunk of metal and some wire. Unlike permanent magnets, the strength of an electromagnet is easy to change. One way to do this is to change the amount of current used. Another way is to change the amount of wire you have wrapped around the metal core. You see, when you wind wire in coils around a piece of metal that has a lot of iron in it, and then you run electricity through the wire, it creates a magnetic field. More coils of wire or more electric current creates a stronger magnetic field. This magnetic field causes the atoms in the core to aliqn, giving the metal ____9__ properties.

Electromagnets are used in many devices. Think of things that use power and have moving parts. Chances are, an electromagnet is causing the motion! Power windows in a car, automatic doors at the grocery store, and the little motor in a CD player that makes the CD spin so you can listen to your favorite music all contain electromagnets! Electromagnets really make our lives ____10___, and more fun, too!

Directions: Choose the word that fits the context of the passage.

1.	a.	heavy	Ъ.	magnetic	C.	rough	d.	rocky
2.	a.	atoms	Ъ.	magnets	c.	fingers	d.	arrows
3.	a.	atom	Ъ.	electron	c.	proton	d.	magnet
4.	a.	weaker	Ъ.	electric	c.	green	d.	stronger
5.	a.	repel	Ъ.	attract	c.	sing	d.	oppose
6.	a.	carbon	Ъ.	aluminum	c.	iron	d.	oxygen
7.	a.	electromagnets	Ъ.	magnets	c.	Electromagnets	d.	domains
8.	a.	light	Ъ.	television	c.	radio	d.	electricity
9.	a.	magnetic	Ъ.	magical	c.	physical	d.	chemical
10.	a.	easier	Ъ.	long	c.	miserable	d.	hard

Averaging

WHEN YOU BUILT ELECTROMAGNETS AT JEFFERSON LAB YOU AVERAGED THE NUMBER OF PAPER CLIPS YOUR MAGNET LIFTED. SEE IF YOU CAN FIND THE AVERAGE, OR MEAN, OF SOME OTHER NUMBERS.

Finding the mean...

The average, or mean, of a group of numbers is found by adding all of the numbers together and then dividing that answer by how many numbers were added. For example, the average of 2, 4, 6 and 8 is found by adding 2, 4, 6, and 8 together (2 + 4 + 6 + 8 = 20) and then dividing that answer by 4 (since four numbers were added) to get 5 $(20 \div 4 = 5)$.

Find the mean of 78, 81, 82 and 79.

Step 1: Find the sum of the numbers.

Step 2: How many numbers were added?

Step 3: Divide the sum by the number of numbers added.

Your answer should be 80.

Directions: Find the mean. Show your work.

- 1. Lakeisha's grades on her science quizzes were 85, 90, 60, 75 and 95. What was her average quiz grade?
- 2. The fifth grade had five students participate in a jump rope contest. Their number of jumps were 80, 50, 30, 65 and 45. What was their average number of jumps?
- 3. Jacqueline and her friends were experimenting with electromagnets. Jacqueline picked up 14 paper clips, Marcus picked up 19, Carlos picked up 21 and Jasmine picked up 26. What was the average number of paper clips picked up?
- 4. Below are the ages of students in Miss Taylor's class and the number of students at each age. Find the average age.

<u>Age</u>	Number of students at each age
10	4
11	7
12	4
13	1

5. A motorcycle went 865 km on 20 liters of gasoline. What is the average number of kilometers per liter?

Writing About Magnetism

THE ELECTROMAGNETS YOU MADE AT JEFFERSON LAB ATTRACTED METAL.

		_

Writing About Jobs at Jefferson Lab

REMEMBER THE PEOPLE YOU MET DURING BEAMS. YOU MAY EVEN WANT TO REFER TO THE 'WHO DID I MEET AT JEFFERSON LAB' PAGE IN YOUR BEAMS LAB BOOK.

This	job seems most interesting because _	
	n Lab that I found least interesting wa	
This	job seems least interesting because _	
This		
This	job seems least interesting because _	
This	job seems least interesting because _	
This	job seems least interesting because _	
This	job seems least interesting because _	
This	job seems least interesting because _	
This	job seems least interesting because _	

Graphing

WHEN YOU WERE AT JEFFERSON LAB, YOU MET PEOPLE FROM ALL DIFFERENT PARTS OF THE LAB.

Directions: Use the information in the following paragraphs to make a bar graph of the number of employees in each of Jefferson Lab's major divisions.

Jefferson Lab is a basic physics research laboratory located in Newport News, Virginia. It takes many different kinds of people to run Jefferson Lab. The Director of the Lab and the other 27 people in the Director's Office help plan the future of Jefferson Lab.

The Accelerator Division is responsible for the maintenance and operation of Jefferson Lab's electron accelerator. It takes 344 technicians, accelerator operators, drafters and other engineers, and administrative personnel to keep things running smoothly.

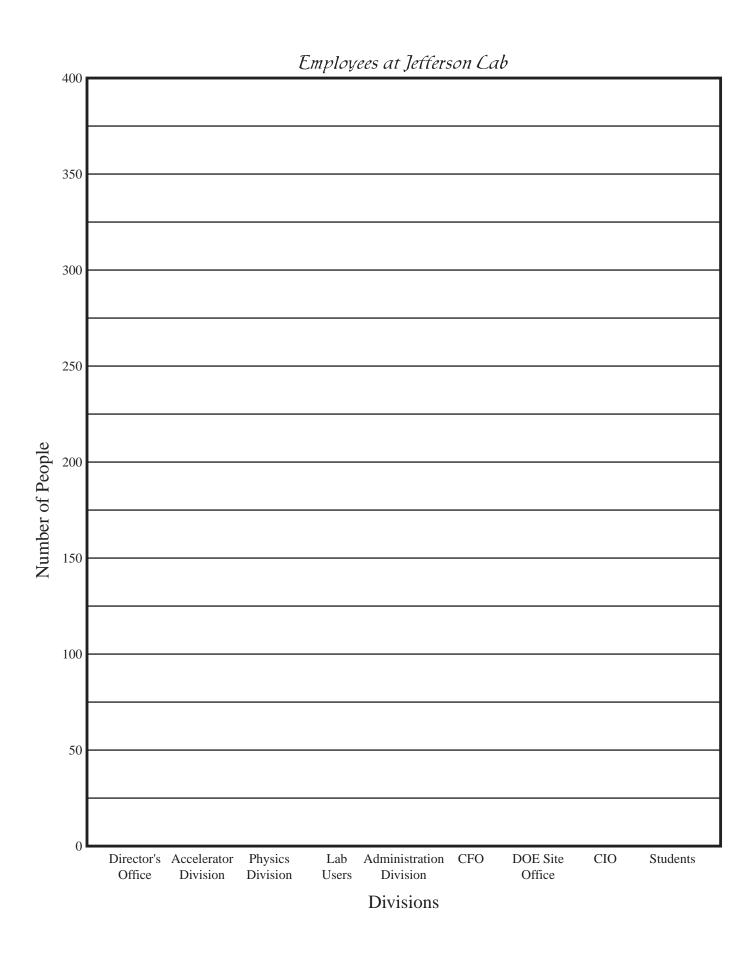
Jefferson Lab was built to do physics experiments. The 163 members of the Physics Division make certain that experiments can be done in the three domed end stations. They make certain that the detectors are working properly and that all of an experiment's data is collected and stored.

Who does experiments at Jefferson Lab? Scientists from other labs, universities and countries come to the Lab to do experiments. There can be as many as 325 users on-site at one time doing experiments.

It takes more than scientists and engineers to run Jefferson Lab. The 71 employees of the Administration Division do all of the accounting, purchasing and hiring for the Lab. The 20 people in the Chief Financial Office (CFO) are responsible for the budgeting, tracking and reporting of all of the Lab's financial transactions while the 20 people in the Chief Information Office (CIO) make certain that all of the information stored in the Lab's computer systems is available to anyone who needs it.

Jefferson Lab is funded by the United States Department of Energy. There are 8 people in the DOE Site Office who make certain that everything is going well.

There are 58 students working in the various divisions at Jefferson Lab. Some are in college and others are in high school, but all help the Lab with its mission. Students help scientists with their experiments, help fix the accelerator when it breaks down and help with other day to day jobs that keep the Lab running. Once you are 16 years old, you can apply for a job to work at Jefferson Lab too!



Writing About a Career Choice

REMEMBER ALL THE PEOPLE WHO VISITED YOUR CLASS DURING BEAMS.

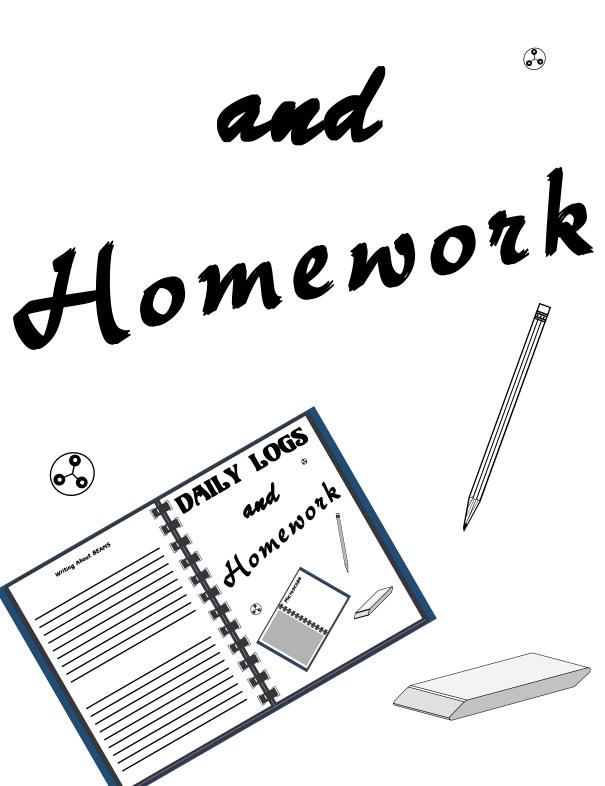
What do you want to do for a living when you grow up? Write about the job you would choose if you had to make a career choice today. Explain why you would choose that job. What kind of training would you need? How and where would you get it? Describe what you think spending a typical day at your job would be like. (You may refer to, but are not limited to, the Who Did I Meet at Jefferson Lab page in your Lab Book or the Career Opportunities at Jefferson Lab page in this book.)

Writing About BEAMS

REMEMBER ALL THE EXPERIMENTS YOU DID AT JEFFERSON LAB.

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	graph describ	st favorite l	BEAMS activ	rity. Explair	ı why you d
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DAILY LOGS



Microscope Homework

BRING IN OBJECTS TO EXPERIMENT WITH TOMORROW!

Directions: Find two objects to use tomorrow. Each object you decide to use **cannot** be:

- dangerous or forbidden at school
- more than two inches tall

For each object, write what the object is, what it looks like and what you think it will look like when magnified.

My first object is		
Description:		
Hypothesis:		
209f ograden		
My second object is		
Description:		
Hypothesis:		

Directions: Please write your responses in complete sentences.	
1. What do you expect to learn at BEAMS this week?	
2. What job do you want to have in 15 years?	
3. What did you learn from today's visit?	
4. If you could change one thing about today's visit, wh	nat would it be?
May Novee	
My Name:	TONIGHT'S HOMEWORK Page 78, Page 77
Today's Date:	

·	
Directions: Please write your responses in complete sentences.	
1. Why is school important in your life?	
C. TATI at 1:1 and 1 and	
2. What did you learn from today's visit?	
3. If you could change one thing about today's visit, wh	aat would it be?
My Name:	TONIGHT'S HOMEWORK Page 79
My Teacher:	Tage 15

Today's Date:

Dir

irect	ions: Please write your responses in complete sentences.	
1.	If you could work at Jefferson Lab, which job would	you like to have? Why?
2.	What skills do you think a scientist needs?	
3	What did you learn from today's visit?	
J.	What are you learn nom today's visit.	
4.	If you could change one thing about today's visit, where the state of	hat would it be?
M	y Name:	TONIGHT'S HOMEWORK
N /	Tao aham	TONIGHT'S HOMEWORK Page 80
wy	Teacher:	

Today's Date:

	Juy .	
irections:	Please write your responses in complete sentences.	
1. How	do you feel about math since you came to BEAN	MS?
2. How	do you feel about science since you came to BE	AMS?
3. Wha	t did you learn from today's visit?	
4. If yo	u could change one thing about today's visit, wh	at would it be?
My Nan	ne:	TONIGHT'S HOMEWOOK
		TONIGHT'S HOMEWORK Page 81
My Teach	er:	

Today's Date:

Writing About Your Visit to Jefferson Lab

REMEMBER THE WEEK YOU SPENT AT JEFFERSON LAB.

	I
	TONIGHT'S HOMEWO

You Are Invited!

BEAMS Family Night

Who? You, your family, your friends and anyone else you want to bring!

What? A night to show your family all of the things you have been doing at Jefferson Lab this week!

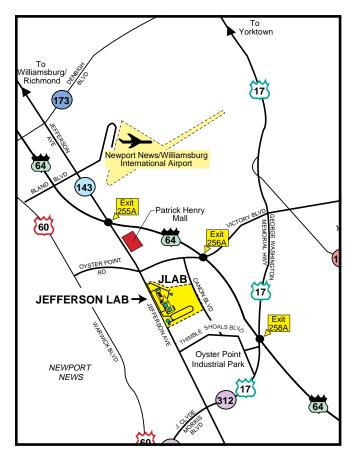
When?

Where? The BEAMS classrooms, rooms 72A and 72B in the VARC building (building 28) at Jefferson Lab. (See the map on the back.)

So you can show your family liquid nitrogen, look at your class photo on the computers, do some experiments, eat some cookies, drink some soda and have fun!

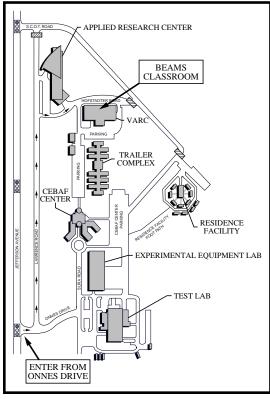
How Much \$? Free! Free! Free!

How to Find Jefferson Lab



Jefferson Lab is located on Jefferson Avenue between J. Clyde Morris Boulevard and Oyster Point Road near Patrick Henry Mall.

Our street address is 12000 Jefferson Avenue.



The BEAMS classrooms are located in rooms 72A and 72B in the VARC building, building 28. Parking can be found in front of and behind the VARC building.

Enter the VARC building through the front door. A staff member will unlock the door for you.

All adults attending Family Night must bring a photo ID.

What Did You Think About BEAMS?

1.	Please use the computers to rate the activities you did this week. Use a number from 1 to 5 to tell us how much you liked an activity. A '1' means that you didn't like an activity at all. A '2' means that you didn't like an activity much. A '3' means that you thought an activity was OK. A '4' means that you liked an activity some. A '5' means that you liked an activity a lot.	}
2.	What did you especially like about BEAMS this week? Why?	
3.	If you could change one of this week's activities, which would it be? Why?	
Name	e: Teacher's Name:	_

BEAMS Parent Evaluation

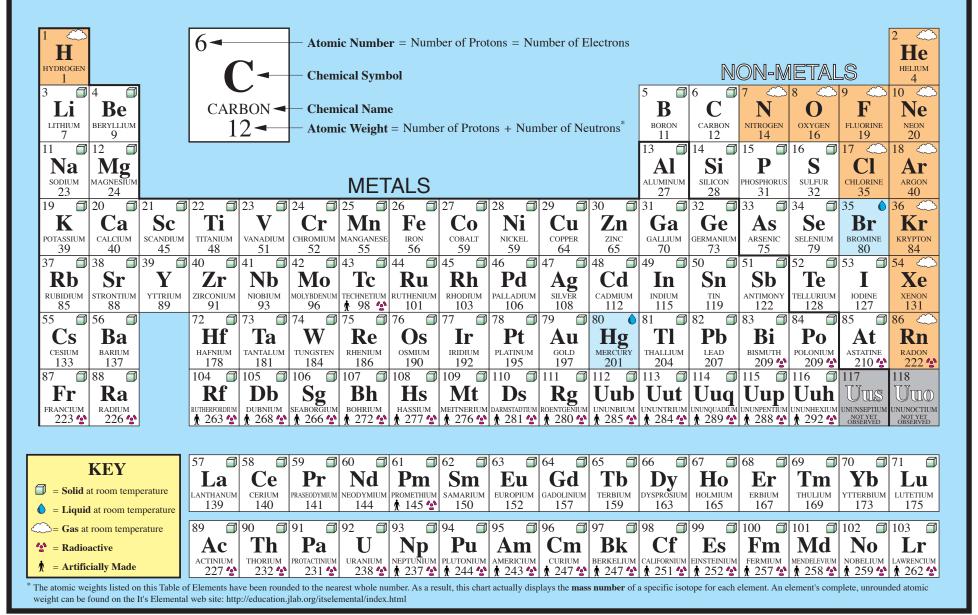
Thank you for allowing your child to participate in the BEAMS program at Jefferson Lab!

We are very interested in knowing how you think we can improve BEAMS. Please answer the questions below. All of your answers will be kept confidential. If you have more than one child, please answer the questions for the child that came to BEAMS.

1.	Have you noticed your child talking about the BEAMS experience at home? If so, how?
2.	Please check the statement below that is closest to the truth.
	 My child talked about BEAMS <u>more</u> than he/she normally talks about school. My child talked about BEAMS <u>less</u> than he/she normally talks about school. My child talked about BEAMS <u>the same amount</u> as he/she normally talks about school.
3.	Would you recommend BEAMS to other parents? Yes No Not Sure Why or why not?
4.	What goals are you encouraging your child to pursue for his/her future?
5.	How do you think attending BEAMS will help your child achieve these goals?
6.	What suggestions do you have for improving the BEAMS experience?

Thank you for your feedback!

The Periodic Table of Elements



http://education.jlab.org/