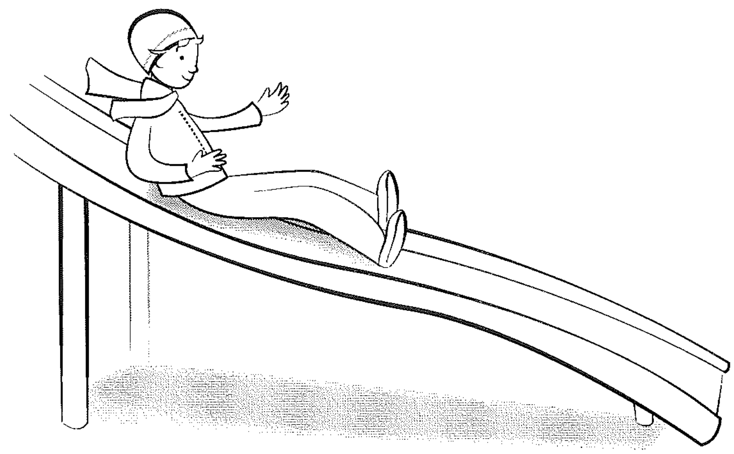
Name: ______________________________ Period: __________ Date: __________

MONDAY 2/22/16	What type of charge does an electron & a proton have? Electron is Negative Proton is Positive
TUESDAY 2/23/16	Explain the difference between charging by Conduction and Induction. Conduction - Objects touch. The charge equally divides between the 2 objects equally. They have the same sign. Induction - Object are brought near but do NOT touch. Polarization occurs. A ground is induced. Objects are different sign.
WEDNESDAY 2/24/16	Explain the Law of Conservation of Charge. The total amount of charge is conserved in any transfer of charge. The net amount will always equal zero.
THURSDAY 2/25/16	How many electrons would be required to have a total charge of 2.5 C on a sphere? (1.56×10^{-19} C) $2.5\ C \left\vert \dfrac{\cancel{6.24 \times 10^{18}\ e}}{1\ C} \right. = 1.56 \times 10^{19}\ e$
FRIDAY 2/26/16	Two objects are each charged with 4.0×10^{-8} C. One has a positive charge, the other negative. The objects are separated by a distance of 35 cm. Which of the following statements correctly portrays the electric force experienced by each charged object? A) The electric force is 4.11×10^{-5} N and it is an attractive force. B) The electric force is 1.18×10^{-8} N and is a repelling force. C) The electric force is 4.11×10^{-7} N and it is a repelling force. D) The electric force is 1.18×10^{-4} N and it is an attractive force.

Where Does the Charge Come From?



Five friends were trying out the new slide on the playground. The new slide is made out of plastic. They noticed that each time they reached the bottom of the slide, they got a small electric shock when they touched the ground. They wondered where the electric charge came from. This is what they said:

Kevin: I think the charge can only come from the plastic slide.

Tanisha: Today I was wearing wool pants. I think the charge can only come from the pants.

Jin-Sang: I think the charge could come from either the slide or the pants.

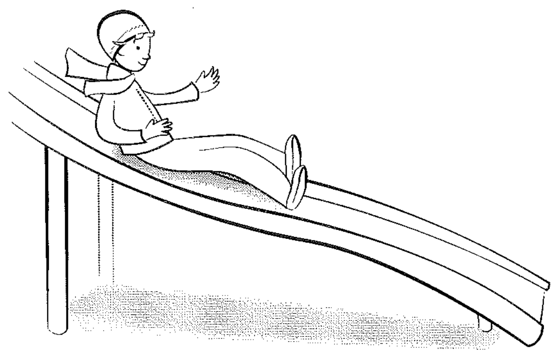
Kerry: My pants rubbed against the plastic slide as I slid down. I think the rubbing creates the charge.

Marsha: Maybe the rubbing creates heat. The heat is what creates the electric charge.

With whom do you agree the most? ______________ Explain your reasoning.

Where Does the Charge Come From?

Teacher Notes



Purpose

The purpose of this assessment probe is to elicit students' ideas about electric charge. The probe is designed to reveal students' thinking about where charge comes from.

Related Concepts

electric charge, electrostatics, conservation of charge, interaction

Explanation

Jin-Sang has the best answer: "I think the charge could come from either the slide or the pants." Charge is not created or destroyed. This means that the excess charge that builds up on the person is from charge transferring between the pants and the plastic slide. "This could be caused by one type of charge moving from the slide to the clothing or from the clothing to the slide."

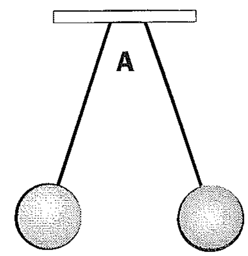
Administering the Probe

This probe is best used with middle and high school students. In addition to having students construct an explanation for why they agree with one of the friends, consider having them write rebuttals explaining why they disagree with the other friends.

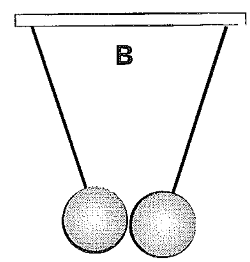
Related Research

- A correct explanation requires that students have an understanding of the particulate nature of matter and an understanding of the principle of charge conservation. One example of research on children's ideas related to conservation laws comes from the research of Jean Piaget. His work included identifying difficulties with number conversation in young children (the idea that five blocks sitting close together is the same as five blocks that are spread far apart).
- Harvard Smithsonian Center for Astrophysics produced a video series called *A*

Does the Example Provide Evidence?



Students in Mr. Miller's class watched a demonstration on electric charge. In the first example of an interaction, Mr. Miller brought two plastic balls together. The balls moved apart when they got near each other, like this (A). In the second example of an interaction, the balls moved toward each other, like this (B). Mr. Miller asked the students if the two examples of interactions provided convincing evidence that both balls in each example were electrically charged. Here is what some students said:



Faith: I think both examples provide evidence that all of the balls in both interactions were electrically charged.

Milo: I think only the first example provides evidence that both balls in an interaction were electrically charged.

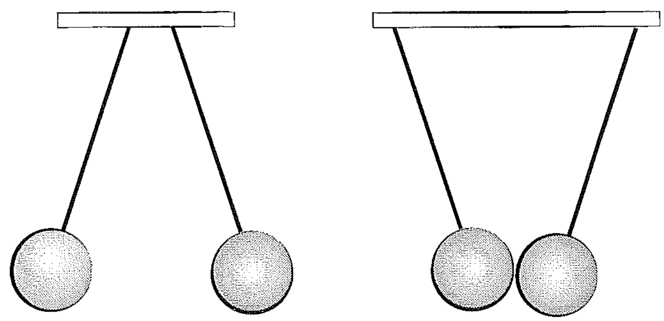
Judd: I think only the second example provides evidence that both balls in an interaction were electrically charged.

Fran: I think neither example provides evidence that both balls in an interaction were electrically charged.

With whom do you agree the most? _______________ Explain why you agree.

Does the Example Provide Evidence?

Teacher Notes



Purpose

The purpose of this probe is to elicit students' ideas about charged objects. The probe is designed to reveal whether students recognize that one can only make a limited conclusion about charge during an interaction where objects are attracted to each other.

Related Concepts

electric charge, electrostatics, interaction

Explanation

The best answer is Milo's: "I think only the first example provides evidence that both balls in an interaction were electrically charged." In the first example, both balls repel each other. This can only happen if both charges are the same. Therefore, because both of the balls move away from each other, this provides conclusive evidence that both balls are charged and that they each have the same charge. However, one cannot conclude whether the charges are negative or positive, only that they both have the same charge. In the second example, the balls move toward each other. There is an attractive force between the two balls. This could happen in two ways: (1) one ball could be charged and the other ball could be neutral, or (2) both balls are charged with opposite charges (opposite charges attract). Thus, the only conclusive evidence is that at least one of the balls in the second example is charged. You cannot say convincingly that both balls in the second example are charged because an attraction can occur if only one ball is charged. Additionally, without further testing you cannot conclusively determine which ball is charged and what the charge is.

Administering the Probe

This probe is best used with middle and high school students. If materials are available, consider demonstrating the probe scenario. Make sure students understand what is meant by "convincing evidence"—the evidence must be conclusive enough to draw a definite

Name: ____________________ Period: __________ Date: __________

Electrostatics

Electrostatics is the study of **ELECTRICAL CHARGES AT REST**.

- An atom is electrically **NEUTRAL** it has the same number of **PROTONS** (positive charges) as it does **ELECTRONS** (negative charges).
- Objects are charged by adding or removing **ELECTRONS** (not protons).
- A positive charge occurs when there are fewer electrons than protons **(Cations)** Ex:
- A negative charge occurs when there are more electrons than protons **(Anions)** Ex:

Law of Conservation of ELECTRICAL CHARGE: The net amount of electric charge produced in any process is **ZERO**. If one region or object acquires a positive charge, then an equal amount of negative charge will be found in neighboring regions or objects.

Chemistry review:

- There are two kinds of electrical charges, positive (+) and negative (-).
- Like charges **REPEL**, unlike charges **ATTRACT**.
- Charged objects can attract some **NEUATRAL** objects by an induced charge separation (called **POLARIZATION**.)

Conductor

- a substance that **ALLOWS** electrons to move easily from one atom to another
- **1-3** valence electrons
- Ex: most metals silver, copper and aluminum

Insulator

- a substance that **DOES NOT ALLOW** electrons to move freely from one atom to another
- **5-8** valence electrons
- plastic, cork, rubber, glass

Semiconductor

- partially **CONDUCTIVE** partially **INSULATIVE**

Electroscope

- an instrument used to detect the presence of an electrostatic charge

1. **METAL LEAF** electroscope: leaves separate when a charge is present.

COULOMB (C) - the SI unit of charge. 1 C = **6.24×10^{18}** electrons

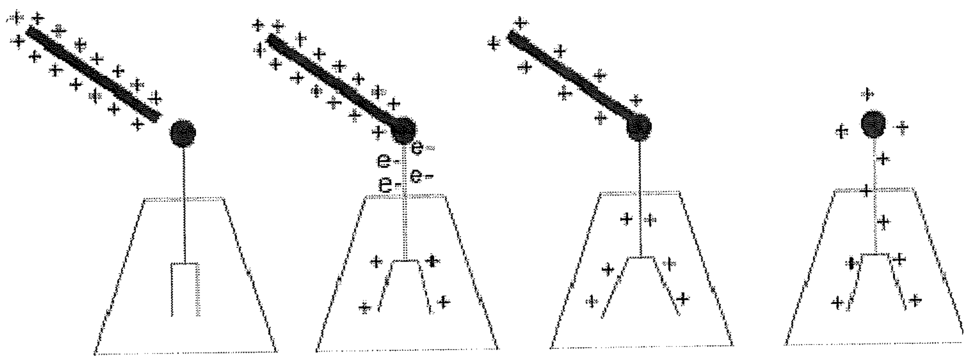
Name: ______________________________ Period: __________ Date: __________

Methods of charging an object:

1. **Charging by <u>FRICTION</u>**
   - two substances are rubbed together
   - electrostatic series indicates the sign of the charge for each of the two substances

Sample: If we rub a fur cloth against a glass rod, which would gain electrons? Which material would lose electrons? <u>**LOOKING BACK AT THE TABLE WE SEE GLASS HOLDS IT'S ELECTRONS LESS THAN THE FUR. THUS GLASS WILL LOSE AND THE FUR WILL GAIN**</u>

2. <u>**CONDUCTION**</u> **or** <u>**CONTACT**</u>
   - a charged object touches another object; the amount of charge between the two objects; the <u>**SAME**</u> sign charge is acquired by each object

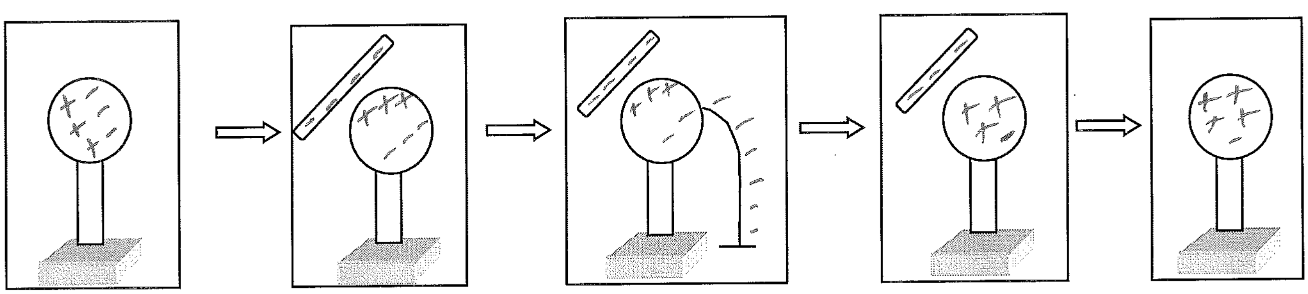


- In our previous question, the rod lost electrons and thus became positively charged. When we touch the rod to the electroscope, the electroscope then ALSO becomes positively charged which is shown when the pieces of metal repel each other (like charges repel.)

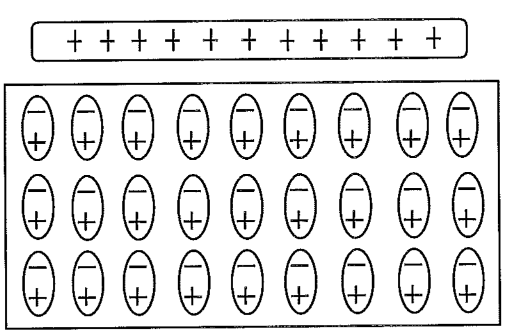
Name: ______________________________ Period: __________ Date: __________

3. **Induction** - inducing charge by bringing a charged object **near** a conductor.
   - If a **negatively charged** rod is held near a **neutral** conductor (metal), the **electrons** on the surface of the neutral conductor will **move away** from the **negatively charged object** to the opposite side of the neutral conductor. **Positive charges** in the neutral conductor will **move toward** the negatively charged rod. There is a separation of charge **induced** on the neutral object.
   - **If** we **touch** the induced object, **negative charge** (same charge as rod) will be **drawn off** the object through **our body** to the ground leaving the object positive.
     Induction by grounding **ALWAYS** leaves the conductor object with a **charge opposite** the first object.
   - **Grounding** - pathway for charge to leave an object to the ground. Ground (the Earth) can take or give an infinite number of electrons. Ground is electrically neutral. Both positive and negative charges will neutralize when grounded. To ground something you can often touch it to a pipe. Metal pipes are good electrical conductors and usually connected to ground somewhere in the building.

Draw in the charges in the diagrams below to show the sequence of induction by grounding below.



- **Polarization** - inducing charge by means of realignment of molecules of insulating material such that its oppositely charged side is next to the charged object that is brought near to it. Example: charged comb attracts uncharged piece of paper, charged balloon near a stream of water, charged balloon on a wall.



What Happens When You Bring a Balloon Near a Wall?

Sumiko rubs a balloon on her hair. She touches the balloon to the wall and lets go. She sees that the balloon stays on the wall. If Sumiko could see what is happening between the balloon and the wall, what would it look like? Draw a picture in the box below to show what you think is happening between the balloon and the wall right before the balloon sticks to the wall. Use pictures or symbols to show the interaction between the balloon and the wall.

Explain what your picture shows. Include how your drawing shows the interaction between the balloon and the wall.

What Happens When You Bring a Balloon Near a Wall?

Teacher Notes

Purpose

The purpose of this assessment probe is to elicit students' ideas about electrical interactions. The probe is designed to find out how students visually represent electrical interactions.

Related Concepts

electric charge, electrostatics, electric fields, electrons, protons, symbolic representation, interaction

Explanation

The most common representation used to account for electric interactions is the use of positive and negative symbols. These symbols are used to represent the two different types of electric charge that exist in all of nature. The positive and negative symbols represent a property of matter that is associated with individual particles, usually electrons (negative) or protons (positive) or pieces of molecules. The best answer would show negative charges on the surface of the balloon that came from rubbing the balloon on her hair. These negative charges on the balloon repel the negative charges on the wall and attract the positive charges in the wall. To show these interactions, students would show positive charges near the surface of the wall (near the balloon) and negative charges further away. To show the wall is neutral, they should draw an equal number of positive and negative charges. Because the positive charges are closer to the balloon, and because opposite charges attract, the negatively charged balloon is attracted to the wall.

Students may have a difficult time differentiating between the cause of the interaction (electric charge) and what is happening between the charges. The interaction between charges is a noncontact force (attraction or repulsion) that is often described as an "electric field." Many students may use symbols to illustrate this "interaction" and not the cause of the interaction. In some cases, even young children will invent a representation for this interaction

Name: ______________________________ Period: __________ Date: __________

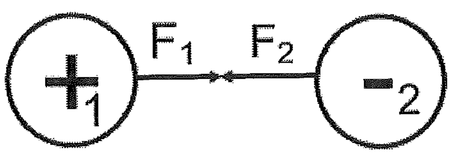
Coulomb's Law:

- calculates the **ELECTROSTATIC FORCE** between two charged objects
- equation for Coulomb's Law:

$$\boxed{F_e = kq_1q_2 / r^2}$$

  - k = Coulomb's constant, or $k = 9 \times 10^9\ Nm^2/C^2$ (approximate value)
  - q = the magnitude (**NOT THE SIGN**) of each charge in coulombs
  - r = the distance of separation in meters (this distance is always center to center)
  - F = the electrostatic force in Newtons. It is either attractive or repulsive.
- The direction of the force is always along a line joining the two objects.
  - If the two objects have the same sign, the force on either object is directed **away** from each other.

  - If the two objects have opposite signs, the force on either object is directed **towards** each other.



Elementary charge (*e*)

- The charge of either an **ELECTRON** or a **PROTON**.
- The charge of a proton is equal in magnitude to that of an electron, but it positive.
- 1 electron = - **1.6×10^{-19} C** 1 proton = +**1.6×10^{-19} C**

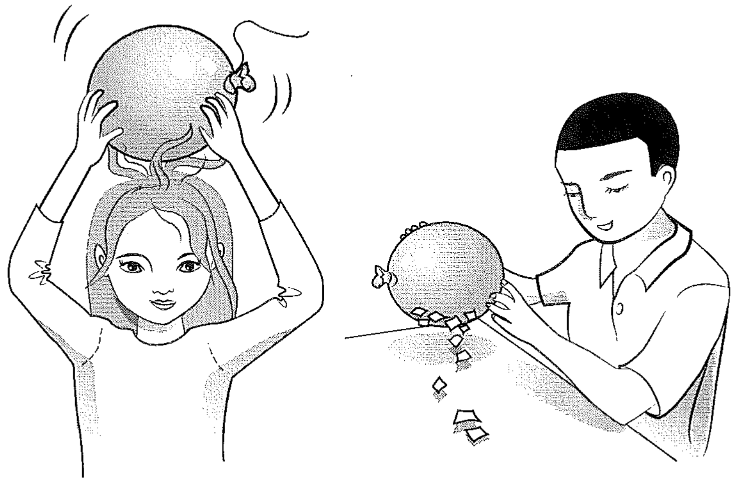
Calculate the force between two positive charges of 5.0×10^{-8} C and 1.0×10^{-7} C if they are 5.0 cm apart **Remember the distance is center-to-center.** (0.018 N repelling)

$Fe = Kq_1q_2 / r^2 = (9\times10^9)(5\times10^{-8})(1\times10^{-7}) / .05^2 = .018$ N

Calculate the force between two charges of $+5.0 \times 10^{-4}$ C and -1.0×10^{-5} C if they are 3.0 cm apart **Remember the distance is center-to-center.** (5×10^{-4} N attracting)

$F_e = Kq_1q_2 / r^2 = (9\times10^9)(5\times10^{-4})(1\times10^{-5}) / .03^2 = 50{,}000$ N

Can It Be Electrically Charged?



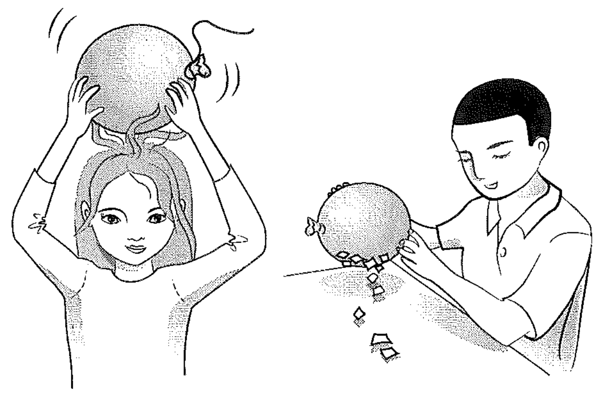
Lillian and Peter rub balloons on their hair and notice that the balloons become electrically charged. They hold the balloons over small bits of paper and see that the bits of paper are attracted to the balloons. They wonder if other materials can also attract small bits of paper either before or after being rubbed. Put an X next to all the materials you think can be electrically charged after rubbing them with another material

_____	Aluminum (metal)	_____	Iron (metal)
_____	Wood	_____	Paper
_____	Glass	_____	Plastic
_____	The positive end of a battery	_____	The negative end of a battery
_____	Balloon	_____	Rubber
_____	Styrofoam	_____	Wax paper
_____	Pencil	_____	Your finger
_____	North pole of a magnet	_____	South pole of a magnet

Explain your thinking. What rule or reasoning did you use to decide which materials or objects can be electrically charged (acquire a static charge)?

Can It Be Electrically Charged?

Teacher Notes



Purpose

The purpose of this assessment probe is to elicit students' ideas about electric charge. The probe is designed to reveal students' thinking about the types of materials that can be electrically charged.

Related Concepts

electric charge, conductors, insulators, interaction

Explanation

The best answer is the items on the list that are made from materials that are insulators: balloon, glass, plastic, Styrofoam and rubber (most types). There are some types of rubber that are made from material that acts more like a conductor and cannot be charged by rubbing. The other items on the list are conductors. Even if charge can be transferred to these items by rubbing with another material, the charge will quickly spread out and dissipate. On the other hand, electric charges will "stick" to the insulators. For example, if you rub a plastic comb through your hair, the comb will sometimes pick up electric charges. You can check this by holding the comb near small pieces of paper to see if the comb will attract the paper. To keep an object from picking up electric charge, the object can be coated with a material that is conductive. "Anti-static" spray is a conductive material that can be applied to wool or polyester pants to keep the charge from building up. (Wool and polyester are both electrical insulators.) Clean dry hair is a good insulator and can easily pick up electric charge. Hair conditioning is a fluid that is conductive and is used to prevent electric charge buildup on the hair, which creates "split ends." Split ends occur because charges of the same type repel each other.

Many students may believe that batteries and magnets are charged and will attract small pieces of paper. These objects have an equal number of both positive and negative charges. When objects have an equal number of both types of charge, they are called neutral or uncharged.

Name: ______________________________________ Period: __________ Date: __________

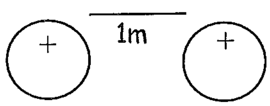
Calculate the force between two positive charges of 4.3×10^{-6} C and 2.7×10^{-8} C if they are 10.0 cm apart **Remember the distance is center-to-center.** (0.1045 N repelling)

$F_e = Kq_1q2 / r^2 = (9\times10^9)(4.3\times10^{-6})(2.7\times10^{-8}) / .10^2 = .1045$ N

Calculate the force between two charges of $+7.1 \times 10^{-2}$ C and -6.1×10^{-3} C if they are 30.0 cm apart **Remember the distance is center-to-center.** (4.3×10^7 N attracting)

$F_e = Kq_1q_2 / r^2 = (9\times10^9)(7.1\times10^{-7})(6.1\times10^{-3}) / .3^2 =$ 4.3x10-7 N

Two positively charged spheres, each with a charge of 4.0×10^{-6} C, are fixed at points in the drawing below. Calculate the magnitude and direction of the net electric force on each sphere.



$(9\times10^9)(4\times10^{-6})(4\times10^{-6}) / 1^2 = .144$ Repelling

Coulomb's law states the force between any two charges depends ________________.

A) directly on the square of the distance between the two charges.

B) inversely on the square of the distance between the two charges.

C) inversely on the magnitude of the charges.

D) none of the above.

The force between two charged object is 80 N. What is the new force if one of the charges is doubled?

$F = kqq/r^2$

$F = (1)(2)(1)/1^2 = 2$

$2(80) = 160$ N

Two charged sphere, 4.0 cm apart, attract each other with a force of 1.2×10^{-9} N. Determine the magnitude of the charge for each, if they both have the same charge.

$F = kqq/r^2$ $\quad 1.2\times10^{-9} = (9\times10^9)(q)(q) / .04^2$ $\quad 1.2\times10^{-9}(.04^2) / 9\times10^9 = q^2$

$q = \sqrt{2.13 \times 10^{-22}}$ $\quad q = 1.46\times10^{-11}$ C

Two objects are each charged with 4.0×10^{-8} C. One has a positive charge, the other negative. The objects are separated by a distance of 35 cm. Find the force.

$F = kqq/r2$ $\quad (9\times10^9)(4\times10^{-8})(4\times10^{-8})/.35^2 = 1.18\times10^{-4}$ N attractive

Name: ______________________________ Period: __________ Date: __________

1. Metals, such as copper and silver, can become charged by induction, while plastic materials cannot. Explain why -

Plastic is an insulator - No free electrons

Metals are conductors - they have free electrons

2. Two identical conducting spheres are placed with their centers 0.30 m apart. One is given a charge of $+12 \times 10^{-9}$ C and the other is given a charge of -18×10^{-9} C. Find the electric force exerted on one sphere by the other.

$F = (9\times10^{9})(12\times10^{-9})(18\times10^{-7})/.3^{2} = 2.16 \times 10^{-5}$ N attractive

4. A small cork with an excess charge of $+6.0\ \mu C$ is placed 0.12 m from another cork, which carries a charge of $-4.3\ \mu C$. ($1\ \mu C = 1 \times 10^{-6}$ C)

a. What is the magnitude of the electric force between the corks?

$F = kqq/r^{2}$ $\quad F = (9\times10^{9})(6\times10^{-6})(4.3\times10^{-6})/\ .12^{2} = \quad 16.13$ N

b. Is this force attractive or repulsive?

Attractive

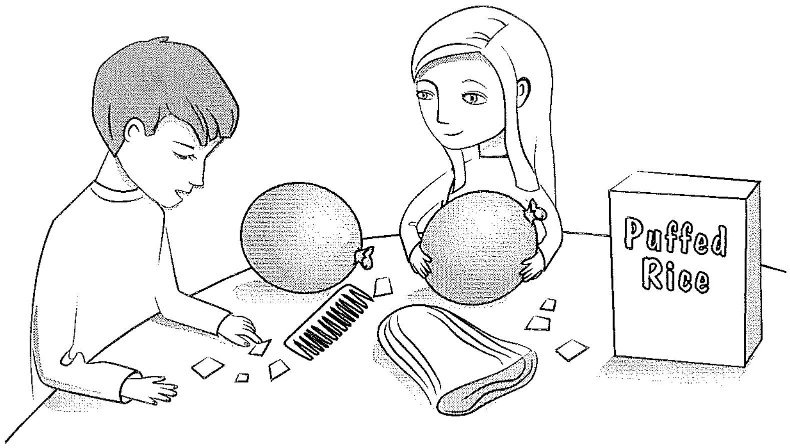
c. How many excess electrons are on the negative cork?

$$4.3\times10^{-6}\ C \left| \frac{1 \text{ electron}}{1.6\times10^{-19}\ C} \right. = 2.68 \times 10^{13} \text{ electrons}$$

d. How many electrons has the positive cork lost?

$$6\times10^{-6} \left| \frac{1 \text{ electron}}{1.6\times10^{-19}\ C} \right. \quad 3.75 \times 10^{13} \text{ electrons}$$

Do the Objects Need to Touch?



Two students were talking about forces between objects when one of the objects is electrically charged. This is what they said:

Henry: I think the two objects need to touch in order for there to be a force between them.

Mia: I think the two objects do not need to touch in order for there to be a force between them.

With whom do you agree the most? ______________ Explain why you agree.

____

____

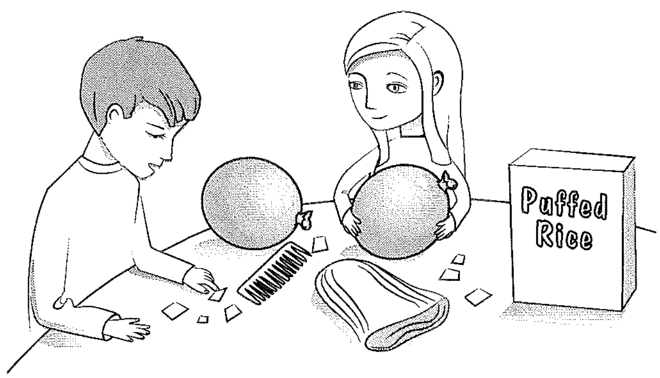
____

____

____

Do the Objects Need to Touch?

Teacher Notes



Purpose
The purpose of this assessment probe is to elicit students' ideas about electric forces. The probe is designed to reveal whether students recognize that electric forces can act at a distance without direct contact.

Related Concepts
electric charge, electric force, action-at-a-distance, interaction

Explanation
The best answer is Mia's: "I think the two objects do not need to touch in order for there to be a force between them." Electric, magnetic, and gravitational forces are examples of action-at-a-distance forces that can act without direct contact between objects. Despite their physical separation, they are still able to exert a push or pull on each other. With objects, such as the ones shown in the probe graphic, the action-at-a-distance electric force can be observed when the comb or plastic ruler is rubbed with the cloth (charged) and then held near the paper bits or puffed rice cereal. The paper or puffed rice is attracted to the charged plastic object and moves toward it even though there is a space between the objects. Objects can also repel (push) from a distance. For example, two charged balloons suspended from a string will move apart when brought near each other. Electric charges interact at a distance because of the electric field that is produced by the individual charges. Although there is no electric charge in the space between the objects, the field that is produced by a charge on one object interacts with the electric charges on the other object. This is similar to the idea that the Earth pulls on a ball that is tossed in the air because of the gravitational field that is produced by the Earth, and not because the Earth is touching the ball.

Administering the Probe
This probe is best used with elementary students. Make sure that students know that one

Name: ______________________________ Period: __________ Date: __________

Electric Fields

Electric field

- The area <u>AROUND</u> a charged object
- This field exerts a <u>FORCE</u> on any <u>CHARGED OBJECT</u> in its vicinity
- The <u>CLOSER</u> the charged object is brought to the charged object creating the field, the <u>GREATER</u> the <u>FORCE</u> exerted on it
-

Test charge

- A <u>POSITIVE</u> charge of very <u>SMALL</u> magnitude
- The test charge is used to determine the <u>DIRECTION</u> of the electric field.
- The electric field is defined as the <u>FORCE</u> on a <u>TEST CHARGE</u> with the test charge being so small that it approaches zero.
- Defining the electric field in this manner means that the electric field only describes <u>THE EFFECT OF THE CHARGES CREATING THE ELECTRIC FIELD</u>.

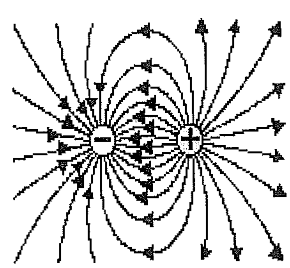
Electric field lines

- The electric field can be represented with <u>ELETRIC FIELD LINES</u>.
- Their <u>DIRECTION</u> is one that a <u>POSITIVE</u> test charge would take in the field.
- The field lines indicate the <u>DIRECTION</u> of the <u>ELECTRIC FIELD</u>; the field points in the direction <u>TANGENT</u> to the field line at any point.
- Electric field lines start on a <u>POSITIVE</u> charge and end on a <u>NEGATIVE</u> charge.
- The <u>AMOUNT OR #</u> of lines starting on a positive charge, or ending on a negative charge, is proportional to the <u>MAGNITUDE</u> of the charge.
- The <u>CLOSER</u> the lines are drawn together, the <u>STRONGER</u> the electric field is in that region.
- The field lines between two parallel plates are <u>PARALLEL</u> and <u>EVENLY</u> spaced, except near the edges. Thus the electric field is <u>UNIFORM</u> between two parallel plates (except at the edges).

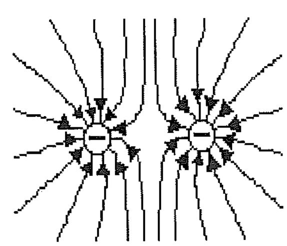
Electric Field Lines for Two Source Charges

Negative Source

Positive Source

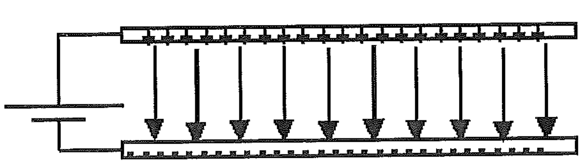


A Positive and a Negatively Charged Object

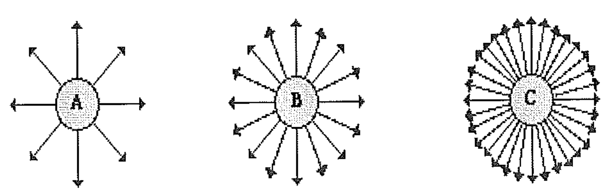


Two Negatively Charged Objects

Uniform Electric Field



Density of Lines in Patterns

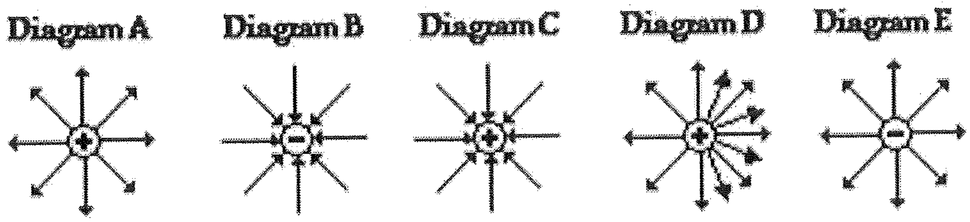


The electric field strength on C is greater than that on B which is greater than that on A.

Name: ______________________ Period: ________ Date: ________

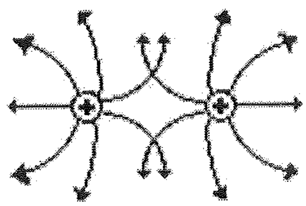
Practice

1. Which of these is correct?



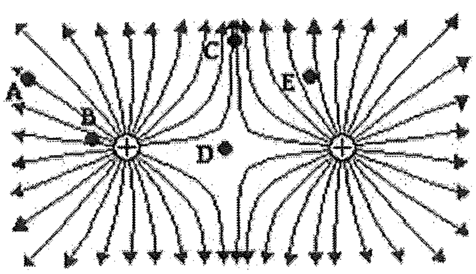
YES YES NO NO NO

2. Erin drew these field lines surrounding two positive charges. What did she do wrong?



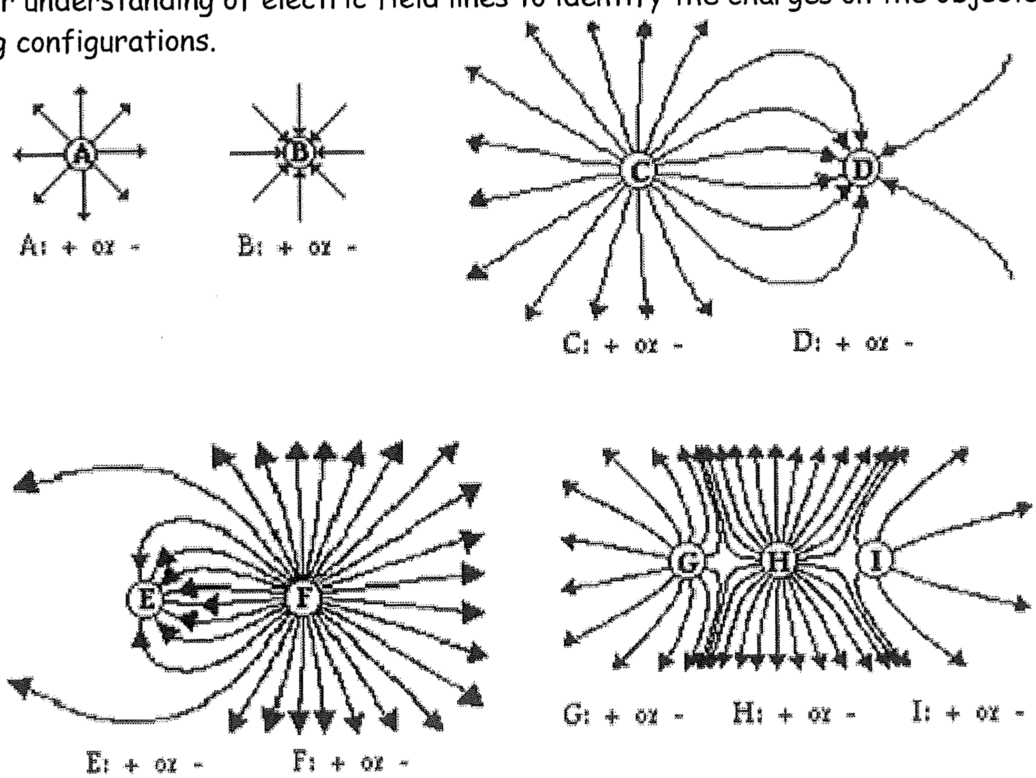
LINES CANNOT CROSS – LIKE CHARGES REPEL

3. Consider the electric field lines drawn in the picture below. Several locations are labeled on the picture. Rate them in order of increasing electric field strength.



D-A-C-E-B
WEAKEST - STRONGEST

4. Use your understanding of electric field lines to identify the charges on the objects in the following configurations.



Name: ______________________________ Period: __________ Date: __________

Electric field strength (or intensity)

- symbol is <u>E</u> and SI unit is <u>N / C</u> the force on a test charge.

$$\boxed{E = F / q}$$

- F_e is the **electric force** in **Newtons (N).**
- q is the **charge** in **Coulombs (C).**

Electric field strength of a point charge:

$$\boxed{E = kq / r^2}$$

- E is the <u>ELECTRIC FIELD</u>
- <u>K</u> is Coulomb's constant
- r is the <u>DISTANCE</u> between the <u>CHARGE</u> and the <u>TEST CHARGE</u> .
- Note: the force depends only upon the <u>MAGNITUDE</u> of the <u>POINT CHARGE</u> producing the field, not on the <u>VALUE</u> of the <u>TEST CHARGE</u>.
- Electric field is a <u>VECTOR</u> quantity; it has both magnitude and direction.

<u>SUPER POSITION</u> **principle for electric fields:** If the field is due to more than one charge, the resultant field at a point is found by <u>ADDING</u> the <u>INDIVIDUAL FIELDS</u> due to each charge at that point by <u>VECTOR ADDITION</u>.

Sample Problems:

1. Find the electric force on an electron inside of an electric field with strength 1.2 N/C. (q_e = 1.6×10^{-19} C) Answer: 1.92×10^{-19} N

   $F = q E = (1.6X10^{-19})(1.2) = 1.92X10^{-19}$ N

2. What is the electric field intensity 0.50 m away from a small sphere with a positive charge of 1.6×10^{-8} C? Answer: 5.8×10^{2} N/C [outward]
   $E = Kq/r^2 = (9X10^9)(1.6x10^{-8}) / .502 = 576$ N/C

3. Calculate the electric field intensity midway between two negative charges of 3.2×10^{-9} C and 6.4×10^{-9} C that are 30. cm apart. Answer: 1.3×10^{3} N/C [right]

$q=3.2x10^{-9}$	$E1 = kq_1/r^2$	E2 =Kq2/r2
$q=6.4x10^{-9}$	$(9x10^9)(3.2x10^{-9})/.15^2$	$(9x10^9)(6.4x10^{-9})/.15^2$
r=1/2 (.30) = .15 m	= 1280 N/c	= 2560 N/c

Since they are both negative they repel. E1 left E2 right ***I chose direction!!

Can Magnets Push or Pull Without Touching?

Four friends were talking about magnets. This is what they said:

Troy: I think magnets can pull on objects without touching them.

Nellie: I think magnets can push on objects without touching them.

Omar: I think magnets can pull or push on objects without touching them.

Paz: I think a magnet has to touch an object before it can push or pull it.

With whom do you agree the most? ______________ Explain your thinking.

____

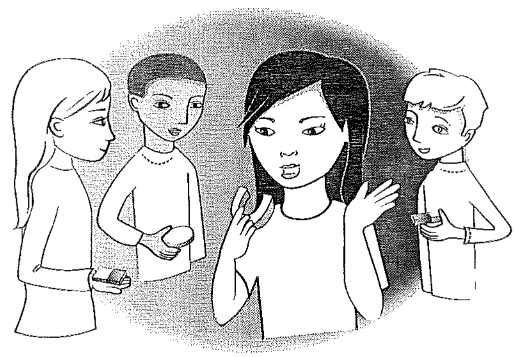
____

____

____

Can Magnets Push or Pull Without Touching?

Teacher Notes



Purpose

The purpose of this assessment probe is to elicit students' ideas about magnetic force. The probe is designed to find out whether students recognize that magnets can push (repel) or pull (attract) certain objects at a distance without touching the object.

Related Concepts

push, pull, magnetic force, attraction, repulsion, action-at-a-distance, interaction

Explanation

The best answer is Omar's: "I think magnets can pull or push on some objects without touching them." Magnets can interact with objects made of magnetic materials in two ways: (1) they can attract the object (pull) or (2) repel the object (push). The push or pull is the result of a magnetic force. This force can act at a distance, meaning the two objects do not have to be in direct contact with one another in order to interact.

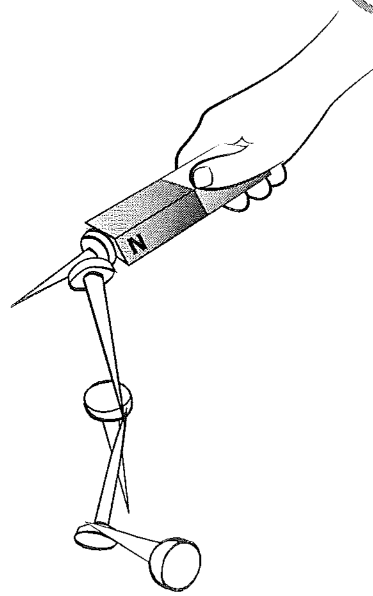
Administering the Probe

This probe is best used at the elementary level when students are learning about forces as pushes or pulls. Make sure students know what is meant by a push or a pull before using the probe. For upper elementary students, consider replacing the words *push* and *pull* with *attract* and *repel.*

Related Research

- A study of children ages 3 through 9 found that students initially thought of magnetism in terms of linking events. At a more sophisticated level, students began to conceptualize the idea of an unseen force and talked about magnets working by "pulling on things" (Driver et al. 1994).
- The idea of an object acting on another object without touching is counterintuitive for young children; likewise it is difficult for children to understand that a magnet can both attract and repel other

Can You Pick It up With a Magnet?



Some things can be picked up by magnets. Some things cannot. Put an X next to the things on the list you think can be picked up by a magnet.

____ cloth	____ silver (metal)	____ wood
____ steel (metal)	____ aluminum (metal)	____ leather
____ copper (metal)	____ other magnets	____ plastic
____ iron (metal)	____ glass	____ tin (metal)
____ pencil lead (graphite)	____ paper	____ mirror

Explain your thinking. What rule or reasoning did you use to decide if something can be picked up by a magnet?

____

____

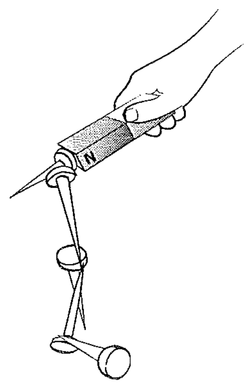
____

____

____

Can You Pick It up With a Magnet?

Teacher Notes



Purpose

The purpose of this assessment probe is to elicit students' ideas about magnetic materials. The probe is designed to find out which types of materials students think interact with magnets and whether they think all metals interact with magnets.

Related Concepts

magnetic force, magnetic materials, interaction

Explanation

The best answer is steel (but not some types of stainless steel[1]), other magnets, and iron. Generally magnets pick up iron, nickel, cobalt, and alloys made of these materials (such as steel). Neodymium is a rare Earth element that is also strongly magnetic. These metals are called ferromagnetic. Ferromagnetic materials become magnetized in the presence of a magnetic field and will sometimes keep their magnetic properties even after the source of that magnetic field are removed. However, not all metals interact strongly with magnets or magnetic fields. For example, a magnet does not interact with a penny which is made up of zinc and copper or a dime made of silver. Although there are some nonmetals that weakly interact with magnets, objects made up of the other materials on the list would typically not be picked up by a magnet. In addition to ferromagnetic materials, there are also paramagnetic and diamagnetic materials. These interactions are typically quite weak and difficult to observe.

Administering the Probe

This probe is best used with elementary and middle school students. Additional metals can be added to the list for high school students.

1. Stainless steel contains a mixture of metals. Some mixtures are non-magnetic. The atoms that make up metals act like tiny magnets themselves. With some mixtures (called an alloy), the atoms will line up together when near another magnet causing attraction. With other mixtures, the atoms do not line up. When they do not line up, they do not interact with other magnets and are called "non-magnetic." Most (but not all) types of stainless steel are non-magnetic.

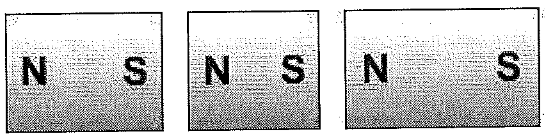
Name: ______________________ Period: __________ Date: __________

Magnetic Fields and Magnetic Forces

Properties of magnets:

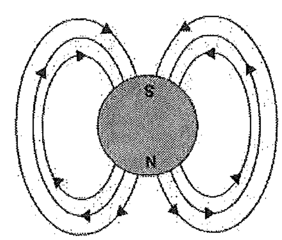
1. A magnet has polarity - it has a NORTH and a SOUTH pole
2. Like poles REPEL; unlike poles ATTRACT
3. A compass is a suspended magnet (its north pole is attracted to a MAGNETIC SOUTH pole); the earth's magnetic south pole is within 200 miles of the earth's **geographic north** pole (that is why a compass points "NORTH")
4. Some metals can be turned in to TEMPORARY magnets by bringing them close to a magnet; magnetism is induced by aligning areas called DOMAINS within a magnetic field.
5. Permanent magnets are formed of metallic alloys or metals such as IRON, NICKEL, or COLBALT.
6. If you break a magnet in half, each half becomes a bar magnet with TWO poles.

A magnetic piece of material is classified as SOFT or HARD, depending on the extent to which it maintains its MAGNETISM. Soft magnetic materials, such as iron, are EASILY magnetized but also tend to LOSE their magnetism easily. In contrast, hard magnetic materials are difficult to magnetize, but once they are magnetized they tend to RETAIN their magnetism.



Magnetic field (symbol is B and SI unit is the TESLA "T"

- the environment around a magnet in which the magnetic forces act



Magnetic field lines

- represent the area around a magnet; magnetic field lines outside of the magnet flow from the NORTH to the SOUTH pole
- The magnetic field of a bar magnet is similar to the Earth's magnetic field.

Comparing electricity and magnetism:

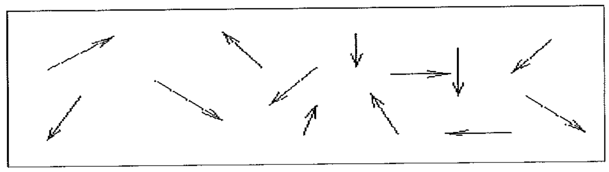
Electricity	Magnetism
+ and - charges	N and S poles
like charges repel	like POLES repel
unlike charges attract	unlike POLES attract
electric field lines flow from + to -	magnetic field lines flow from N to S
density of lines equals strength of E	density of lines equals strength of B
SI unit: ampere, 1 A = 1 C/s	SI unit: TESLA, 1 T = 1 N/A·m
E exerts force on a charge, or E = F/q	Field exerts force on a moving charge, or B = F/(qv)

Name: ______________________________ Period: __________ Date: __________

Domain Theory of Magnetism

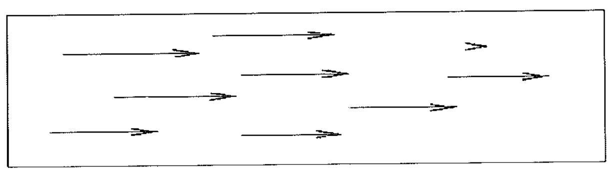
- Atoms of ferromagnetic materials act in groups called DOMAINS.
- Atomic magnets in each domain are ALIGNED so that each domain is a microscopic bar MAGNET.
- In un-magnetized materials, the domains are randomly arranged.

un-magnetized



- The domains align themselves with an external magnetic field.
- Each domain behaves like a tiny magnet and has a north and a south pole
- In magnetized materials, the domains are ALIGNED.

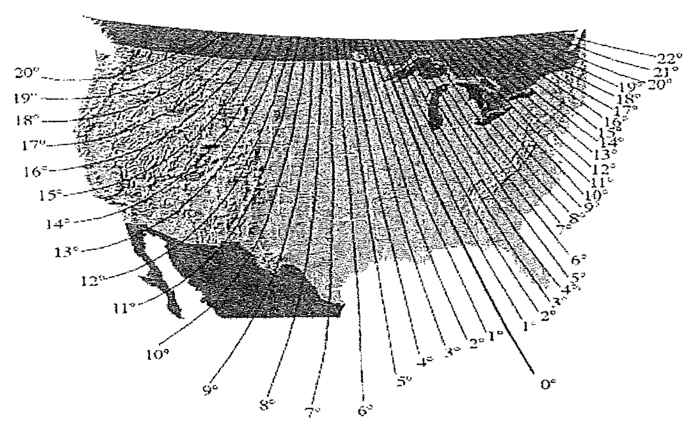
magnetized



- Anything that randomizes the alignment of the domains DESTROYS the magnetic properties of a material (DROPPING a magnet or HEATING it)

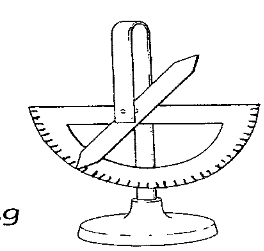
Magnetic Declination

- Angle between the MAGNETIC S pole and the GEOGRAPHIC N pole.
- Line of zero declination runs through Lake Superior and the western panhandle of Florida.
- Maps are based on GEOGRAPHIC N pole because it does not change over time.



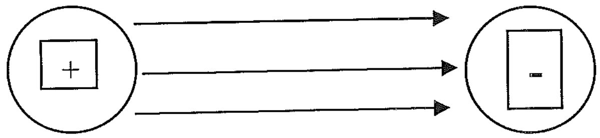
Magnetic Inclination

- Angle between the HORIZONTAL and the MAGNETIC pole.
- It is measured with a DIPPING NEEDLE

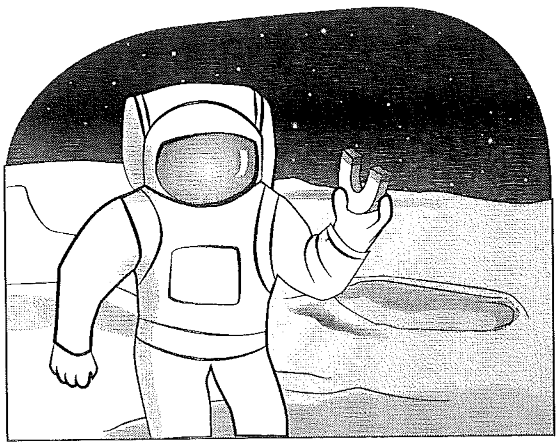


Magnetic dipping needle

Name: ______________________________ Period: __________ Date: __________

MONDAY 2/29/16	Draw the electric fields between a positively charged object and a negatively charged object 
TUESDAY 3/1/16	# QUIZ
WEDNESDAY 3/2/16	An object accumulates 8×10^{-8} C of positive charge. What is the magnitude and direction of the electric field at a location .08 m away? **E= kq/r2** $(9\times10^{9})(8\times10^{-8})/.08^{2}$ $=1.13\times10^{5}$ N/C outward
THURSDAY 3/3/16	NO WARM UP
FRIDAY 3/4/16	What does your fingers and thumb represent in Rt hand rule 1? Fingers are the Magnetic Field - symbol B unit Tesla Thumb is current - symbol I unit Amps

How Would a Magnet Work on the Moon?



Four friends were wondering if gravity had an effect on magnets. They each had different ideas about how a magnet would work on the moon. Here is what they said:

Leif: A magnet would work the same as it does on Earth.

Imani: A magnet would work but it wouldn't be as strong as it is on Earth.

Jasmine: A magnet would work the opposite way on the Moon. It would repel rather than attract iron.

Nate: A magnet wouldn't work at all on the Moon.

With whom do you agree the most? ______________ Explain why you agree.

____

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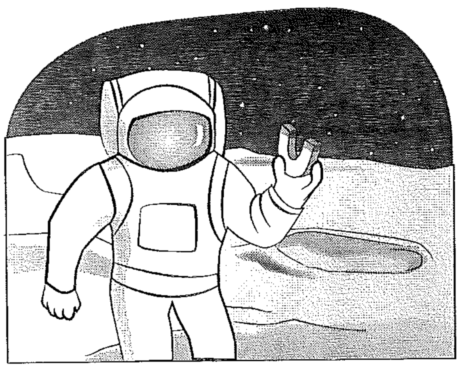
How Would a Magnet Work on the Moon?

Teacher Notes



Purpose

The purpose of this assessment probe is to elicit students' ideas about magnetism. The probe is designed to reveal whether students think gravity has an effect on magnetism.

Related Concepts

magnetic force, magnets and gravity, interaction

Explanation

The best answer is Leif's: "A magnet would work the same as it does on Earth." Magnetism is a force that is independent of gravity. Although the gravitational force on an object on the Moon is less than the gravitational force on the object on Earth, it does not affect the magnetic attraction.

Administering the Probe

This probe is best used with middle and high school students. Before using this probe, first make sure students know how conditions on the moon (e.g., less gravitational force, no atmosphere) are different from conditions on Earth.

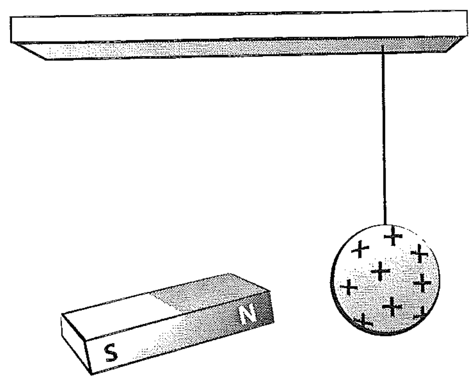
Related Research

- Researchers have found that some students link magnetism with gravity. Students sometimes describe gravity as a magnetic force drawing objects toward the Earth. Conversely, some students refer to magnetism as a type of gravity (Driver et al. 1994).
- Borges and Gilbert (1998) found that among secondary, university, and graduate students, the majority retained naïve and scientifically flawed concepts about magnetism, even after long periods of study.
- A study of students ages 9 to 14 found that 20% connected magnetism to gravity (Bar and Zinn 1989).

Suggestions for Instruction and Assessment

- Provide additional examples to challenge students beliefs about the connection

What Happens When a Magnet Is Brought Near a Charged Ball?



Four friends observed a bar magnet held near a suspended, charged ball. The north pole of the magnet is facing the ball. The ball is positively charged. They each had different ideas about the interaction between the ball and the magnet. This is what they said:

Adhita: I think the ball will be attracted to the north pole of the magnet.

Claire: I think the ball will be repelled by the north pole of the magnet.

Brandon: I think the ball will interact with the magnet if the pole is switched so the south pole is facing the positive charges.

Jerome: I think the magnet will neither attract nor repel the ball.

With whom do you agree the most? ______________ Explain why you agree.

____

____

____

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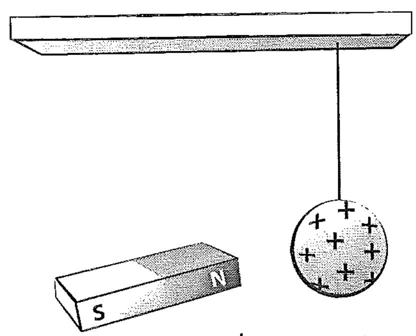
____

____

What Happens When a Magnet Is Brought Near a Charged Ball?

Teacher Notes



Purpose

The purpose of this assessment probe is to elicit students' ideas about magnetic interactions. The probe is designed to find out whether students confuse electrostatic effects with magnetic effects.

Related Concepts

magnetic force, interaction, electric charge

Explanation

The best answer is Jerome's: "I think the magnet will neither attract nor repel the ball." Magnetic interactions are related, but different from electric interaction. Because magnets are not "charged" they are neutral and do not interact with other stationary electric charges. In other words, magnetic poles are not positively or negatively charged.

Administering the Probe

This probe is best used with middle and high school students. Before using this probe, it is important to understand that many students do not differentiate between electric and magnetic effects.

Related Research

- Research shows that some students predict that north magnetic poles repel positively charged objects (Maloney 1985).
- Student often do not differentiate between magnetic poles and electric charge (Arons 1997).
- Borges and Gilbert (1998) found that among secondary, university, and graduate students, the majority retained naïve and scientifically flawed concepts about magnetism, even after long periods of study.

Suggestions for Instruction and Assessment

- Consider combining this probe with "What Happens When You Hold a Magnet Near a Refrigerator?" (p. 143) and "What Makes It Stick?" (p. 151). Each of

Name: ______________________ Period: ________ Date: ________

PRACTICE PROBLEMS

1. Give the value of the elementary electric charge. What does this number represent?
   e= 1.6×10^{-19} C The amount of charge (q) on a particle. Proton or electron

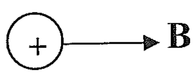
2. A negatively charged object has a total electric charge of 2.375 C.
   A) Does the object have an excess or deficiency of elections?
   Excess, because it has a negative charge

   B) Determine the number of excess or deficit electrons on the object. **[1.484×10^{19} electrons]**
   $$2.375\ C \times \frac{1e}{1.6\times10^{-19}\ C} = 1.484 \times 10^{19}$$

3. Two objects are charged to -8 μC (1μC = 10^{-6} C). If the two objects are separated by a distance of 30 cm, what is the electric force acting on one of the spheres? **[6.4 N]**
   $F = kqq/r^2$
   $(9\times10^9)(8\times10^{-6})(8\times10^{-6})/.30^2$
   6.4 N

4. What is the magnitude of the electric force a 1.5×10^{-6} C charge exerts on a 3.2×10^{-4} C charge that is located 1.5 m away? **[1.92 N]**
   F = kqq/r2
   $(9\times10^9)(1.5\times10^{-6})(3.2\times10^{-4})/1.5^2$
   1.92 N

5. Point B is located 3 m away from a positive charge as seen below. What is the magnitude and direction of the electric field at B if the magnitude of the positive charge is 4.5×10^{-9} C? **[4.5 N/C Right]**



E=kq/r2
$(9\times10^9)(4.5\times10^{-9})/3^2$
4.5 N/C Right

Name: ______________________________ Period: __________ Date: __________

6. Two charge spheres, 2 cm apart, repel each other with a force of 2×10^{-8} N. Determine the magnitude of the charge on each if the charge on both is the same. **[$2.98\times10^{-11}C$]**

F= kqq/r2

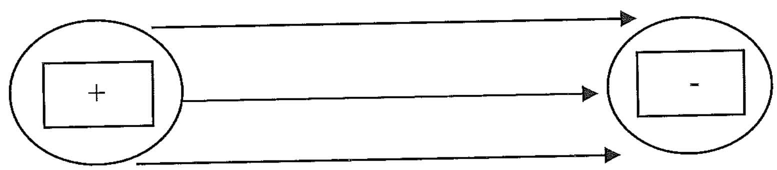
$2\times10^{-8} = (9\times10^{9})(q)(q)/.02^{2}$

$(2\times10^{-8})(.02^{2})/9\times10^{9} = q^{2}$

$\sqrt{8.88\times10^{-22}} = q$

2.98×10^{-11} C

7. Draw the electric fields between a positively charged object and a negatively charged object.



8. A positive ion is called a(an) CATION and a negative ion is called a(an) ANION

9. The proton and electron of a helium atom is separated by a distance of 2.2×10^{-14} m? Find the magnitude of the electric force between the proton and electron. Is it an attractive or repulsive force? **[.476 N attract]**

F= kqq/r2

$F= (9\times10^{9})(1.6\times10^{-19})(1.6\times10^{-19})/2.2\times10^{-14}$

.476 N attract

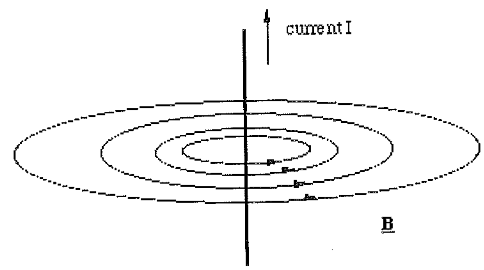
Name: ______________________________ Period: __________ Date: __________

Rt Hand rule 1

- Oersted (1820) found that an electric current in a wire produces a <u>MAGNETIC FIELD</u> around it; a stationary charge does <u>NOT</u> create a magnetic field. The faster the current the stronger the magnetic field.
- Right-hand rules predict the direction of magnetic fields produced by a current. They are used for <u>CONVENTIONAL</u> current flow. Use the **BACK** of your **RIGHT** hand to predict the direction an electron or negative charge would follow.

Conventions for representing the direction:

- • <u>MOVING OUT OF THE PAPER</u>
- X <u>MOVING INTO THE PAPER</u>
- ⇧ <u>MOVING LEFT, RIGHT, NORTH, SOUTH, EAST, WEST OR TOP OF THE PAGE, BOTTOM OF THE PAGE</u>

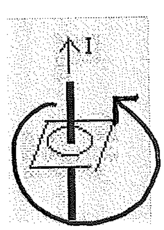


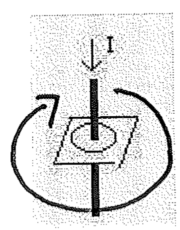
RHR #1 - Straight Wire Conductor

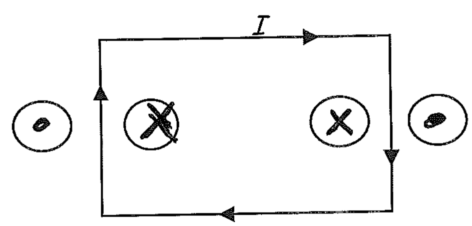
- Curl the fingers of the right hand into the shape of a circle. Point the thumb in the direction of the <u>CURRENT</u> and the curled fingers will point in the direction of the <u>MAGNETIC FIELD</u>.

Samples:

1. Find the direction of B

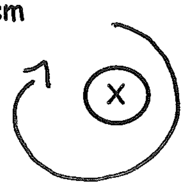


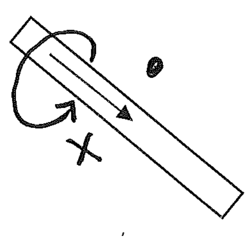


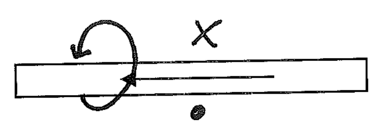


Practice: Electromagnetism

1. Three conductors are illustrated, with the direction of current indicated. Draw the magnetic field lines around each.







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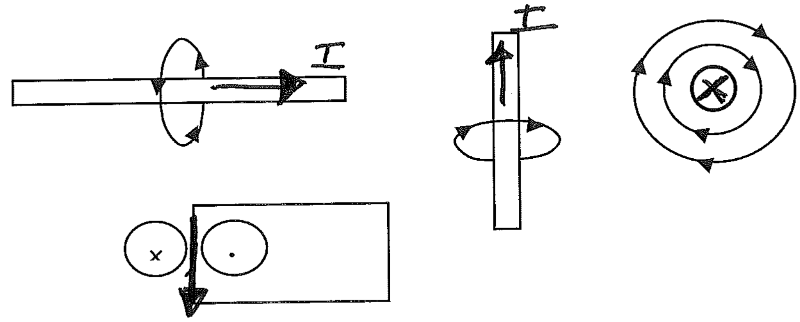
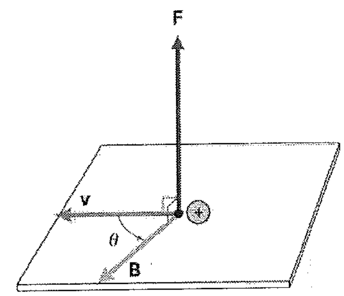
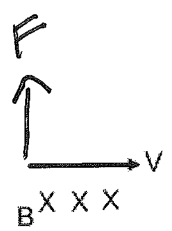
2. Four current-carrying conductors are illustrated, with their magnetic fields. Indicate the direction of current in each wire.

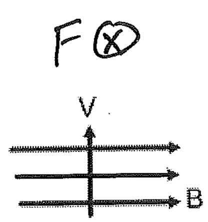


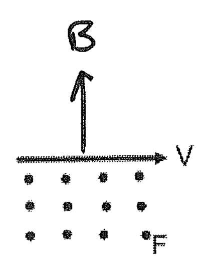
Magnetic Force Rt Hand Rule 2

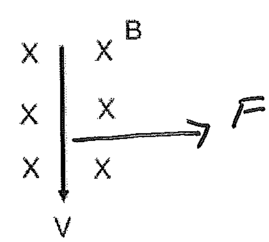
Extend the right hand so that the fingers point in the direction of the **MAGNETIC FIELD** and the thumb points in the direction of the **VELOCITY**. The palm of the hand then pushes in the direction of the **MAGNETIC FORCE.**

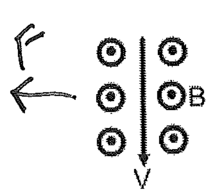


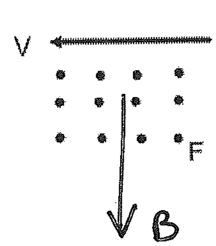


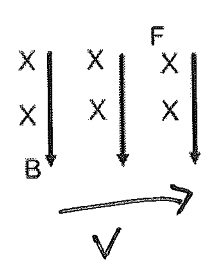


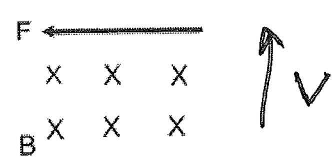












Name: ______________________________ Period: __________ Date: __________

A charge moving through a magnetic field experiences a force

- The force produced by a magnetic field on a single charge depends upon the speed of the charge (v), the strength of the field (B), and the magnitude of the charge (q).

$$\boxed{F = qvB\cos\theta}$$

  - **If $\Theta = 90$, then $F = q\,v\,B$**

Samples:

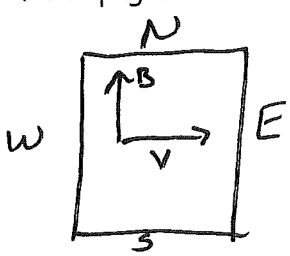
1. Determine the magnitude and direction of the magnetic force on a proton moving horizontally to the north at 8.6×10^4 m/s, as it enters a magnetic field of 1.2 T, pointing vertically upward. **Note: since a proton is a positive particle, the current it represents as it moves is in the same direction as its velocity.**

$F=qvB = (1.6\text{x}10^{-19})(8.6\text{x}10^{4})(1.2) = 1.65\text{x}10^{-14}$ N East

2. What is the magnitude and direction of a magnetic field if an electron moving through it at 2.0×10^6 m/s experiences a maximum magnetic force of 5.1×10^{-14} N [to the left] when moving vertically straight up? **Note: since the particle is an electron, the current it represents would be straight down.**

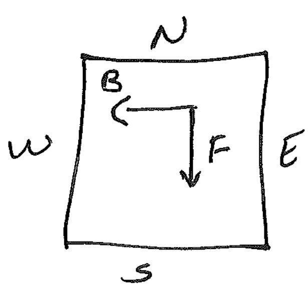
$F=qvB$ rearrange: $B=F/qV$ $\quad$ $531\text{x}10^{-4}/(1.6\text{x}10^{-19})(2\text{x}10^{6})$ $\quad$ .156 T

3. A proton is traveling to the east of the page where there is a magnetic field directed to the north of the page. In what direction is the force? **[out of the page]**



F ⊙

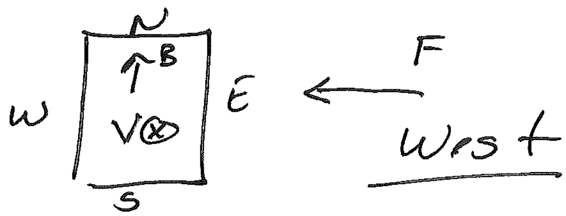
4. If an electron experiences a force to the south of the page while traveling in a magnetic field directed to the west, what is the direction of its velocity? **[into the page]**



V ⊗

Name: ______________________________ Period: __________ Date: __________

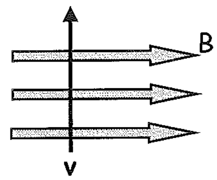
5. A uniform magnetic field points to the north of the page. If an electron moves vertically downward into the paper, what is the direction of the force acting on it? **[West]**



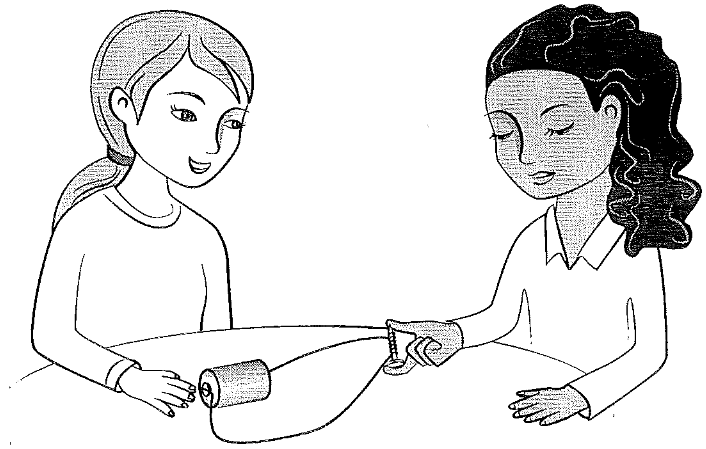
6. A charge is at rest in a magnetic field pointing north with a strength of 3 T, what is the force felt by the charge of 10 *C*? **[0 N]**

F=qvB (10)(0)(3) = 0 N - charge must be moving

Name: ______________________ Period: __________ Date: __________

MONDAY 3/7/16	Determine the magnitude and direction of the magnetic force on a proton moving horizontally to the north at 8.6×10^{4} m/s as it enters a magnetic field of 1.2 T that is vertically upwards. (1.65×10^{-4} N East) **F=qvB** **F = $(1.6\times10^{-19})(8.6\times10^{4})(1.2)$ = 1.65×10^{-14} N East**
TUESDAY 3/8/16	Find the direction of the force on an **electron** moving through the magnetic field in the diagram  F ⊙ out of the Page
WEDNESDAY 3/9/16	# TEST
THURSDAY 3/10/16	NO WARM UP
FRIDAY 3/11/16	Voltage, Current, or Resistance? A __I__ Flowing electrons B __V__ Pushes electrons thru circuits C __V__ Is like a pump for water D __R__ Measured in Ohms E __I__ Measured in Amps F __V__ A battery gives this G __R__ Slows down the electricity H __V__ Does work in the circuit I __V__ Measured in volts J __R__ 12 ohms K __I__ 5 amps

How Can You Make an Electromagnet?



Two friends made a magnet by wrapping a nail around a wire and connecting the wire to a battery. They each had different ideas about why the magnet worked. Here is what they said:

Kathryn: I think the nail makes the magnet. If we pull the nail out, the magnet won't work any more.

Yi Min: I think it is the wire loops that make the magnet. If you take the nail away, it would still work.

With whom do you agree the most? ______________ Explain why you agree.

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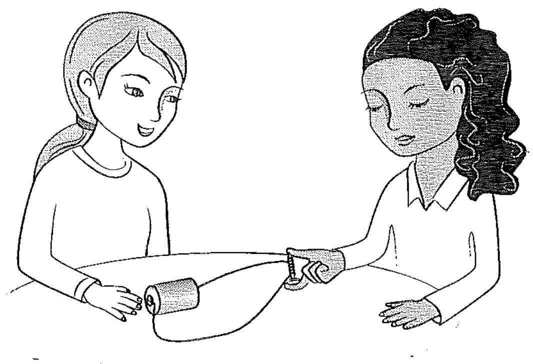
How Can You Make an Electromagnet?

Teacher Notes



Purpose

The purpose of this assessment probe is to elicit students' ideas about electromagnets. The probe is designed to reveal where students think the magnetic effect comes from when wire is wrapped around a nail to make a magnet.

Related Concepts

electromagnet, magnetic field, interaction

Explanation

The best answer is Yi Min's: "I think it is the wire loops that make the magnet. If you take the nail away, it would still work." The magnetic effects come from the electric current in the wire loops. Because the nail is made from iron (a ferromagnetic material), the magnetic effect will be stronger with the nail inside the wire coil, but the effect will still be present even without the nail.

Administering the Probe

This probe is best used with middle and high school students. If materials are available, consider showing students an electromagnet like the one in the probe scenario. This probe can be used with the P-E-O strategy described on page xii by having students make an electromagnet and testing it with and without the nail. Because the magnetic field without the nail is weak, try using a magnetic compass needle to show that the magnetic field is coming from the wire coils even when the nail is not present.

Related Research

- In a study of students' awareness of magnets and magnetism, few students recognized the magnetic effect of an electric current (Barrow 1987).
- A study of children in grades 3 through 9 found that some focused on the wire as the active agent while others referred to electricity as the explanation of electromagnetism (Driver et al. 1994).

Does the Type of Wire Make a Difference in an Electromagnet?

Two students wondered if the type of wire made a difference when making an electromagnet. Here is what they said:

Hakim: I think we need to use this copper wire that is coated with an insulating material.

Beth: I think we need to use this bare copper wire that isn't coated with an insulating material.

With whom do you agree the most? _____________ Explain why you agree.

____

____

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Does the Type of Wire Make a Difference in an Electromagnet?

Teacher Notes

Purpose

The purpose of this assessment probe is to elicit students' ideas about electromagnets. The probe is designed to reveal whether students recognize that an electromagnetic effect can pass through an insulated wire.

Related Concepts

electromagnet, magnetic field, interaction

Explanation

The best answer is Hakim's: "I think we need to use this copper wire that is covered with an insulating material." It is best to use insulated wire, as a "bare" uninsulated wire will short out as the coils touch. When current flows through a wire, it produces a magnetic effect. This magnetic effect is able to pass through the insulating material that coats a wire. The insulation prevents the flow of current outside of the wire but does not affect the magnetic force. Most wires commonly used to make electromagnets look like "bare" wire, but are really covered with a thin, insulating paint (lacquer). The reason this type of wire for electromagnets is used is that the coils can get much closer together without shorting out. The strength of the magnetic field depends on the density of the coils, so a thin insulating material works best.

Administering the Probe

This probe is best used with middle and high school students once they have a basic concept of an electromagnet. Listen carefully for ideas about the insulation preventing a magnetic effect.

Related Research

- In a study of students' awareness of magnets and magnetism, few students recognized the magnetic effect of an electric current (Barrow 1987).
- A study of children in grades 3 through 9 found that some focused on the wire as the active agent while others referred to elec-

How Can You Make a Stronger Electromagnet?

Four friends made an electromagnet by coiling wire around a nail and connecting it to a battery. They tried to pick up a metal washer with their electromagnet. The electromagnet was not strong enough to hold on to the washer. They disagreed about what they could do to increase the strength of their electromagnet. This is what they said:

Diego: I think increasing the number of coils is the way to make it stronger.

Cary: I think adding another battery is the way to make it stronger.

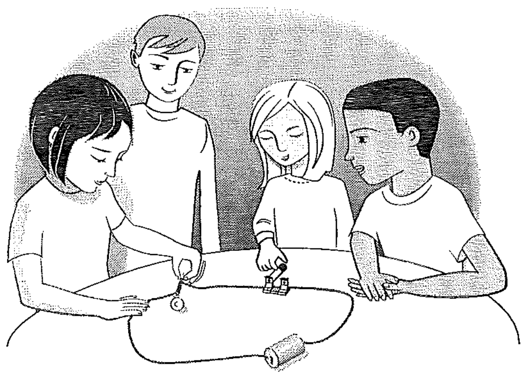
Anh: I think increasing the number of coils and adding another battery are both ways to make it stronger.

Signe: I think neither of those ways will make it stronger. We need to try something else.

Whom do you think has the best idea? ______________ Explain how that will make the electromagnet stronger.

How Can You Make a Stronger Electromagnet?

Teacher Notes



Purpose

The purpose of this assessment probe is to elicit students' ideas about electromagnets. The probe is designed to reveal what variables students think affect the strength of an electromagnet.

Related Concepts

electromagnet, magnetic field, interaction

Explanation

The best answer is Anh's: "I think increasing the number of coils and adding another battery are both ways to make it stronger." While A and B are both correct, C is a better idea, as it identifies more than one variable that affects the strength of an electromagnet. The strength of an electromagnet depends on the amount of current in the wire and the density of the coils. Each wire loop creates a magnetic field inside the coil. Having more loops creates a stronger magnetic field. The magnetic field produced by each loop also depends on the current through that loop. More current will also create a stronger magnetic field. Adding a battery increases the voltage across the coil and will result in more current through the wire.

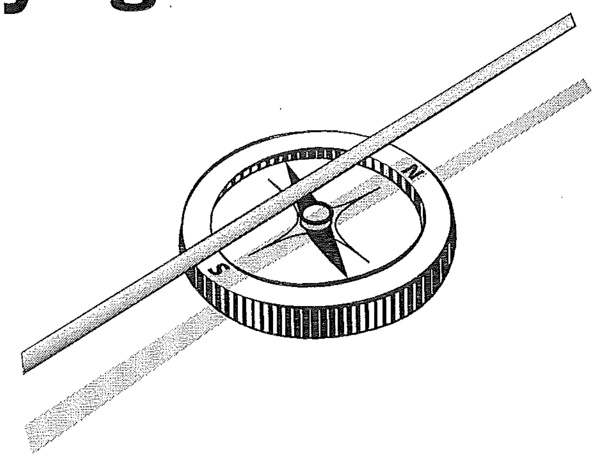
Administering the Probe

This probe is best used with middle and high school students. If materials are available, consider modeling the probe scenario. This probe can be used with the P-E-O strategy described on page xii.

Related Research

- In a study of students' awareness of magnets and magnetism, few students recognized the magnetic effect of an electric current (Barrow 1987).
- Separating electricity and magnetism initially, and connecting them later (as with electromagnets), may cause confusion if not handled carefully (Stepans 2007).

What Happens When You Bring a Compass Near a Current-Carrying Wire?



Three students placed a compass needle directly underneath a long straight, current-carrying wire and notice that the needle deflected away from the wire. They wondered what made the compass needle do that. This is what they said:

Bao: This shows that the current-carrying wire is like a north pole of a magnet.

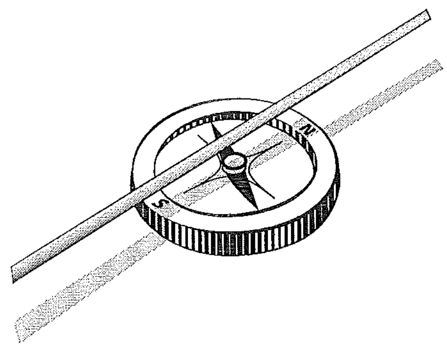
Erik: I disagree, I think this shows that the current-carrying wire creates a south pole of a magnet.

Bianca: I think no magnetic poles are created. There is a magnetic field, but no poles.

With whom do you agree the most? ______________ Explain why you agree.

What Happens When You Bring a Compass Near a Current-Carrying Wire?

Teacher Notes



Purpose

The probe of this probe is to elicit student ideas about magnetic poles. The probe is designed to reveal whether students think a magnetic field must always have magnetic poles.

Concepts

magnetic field, magnetic poles, interaction

Explanation

The best answer is Bianca's: "I think no magnetic poles are created. There is a magnetic field, but no poles." The magnet field lines produced by a current-carrying wire are in the shape of a circle around the wire. Because the field lines are evenly spaced around the wire, there are no magnetic poles. To create a magnetic pole, the field lines must get closer together or farther apart. Magnetic poles can be created by current-carrying wires if the wire is in the shape of a circle (called a current loop).

Administering the Probe

This probe is best used with high school students. If materials are available, consider modeling the probe scenario with a compass. This probe can be used with the P-E-O strategy described on page xii.

Related Research

- Separating electricity and magnetism initially, and connecting them later (as with electromagnets), may cause confusion if not handled carefully (Stepans 2007).
- There is no research available that specifically targets this probe.

Suggestions for Instruction and Assessment

- Make sure students have an opportunity to build this circuit and observe the compass deflection.
- Have students discuss the difference in the magnetic field of the straight wire versus a coiled wire.

Name: ______________________ Period: __________ Date: __________

RIGHT HAND RULE REVIEW

Part of Hand?	RHR #2			
	Symbol	Definition	Symbol	Definition
FINGERS	$_B$X	INTO PAGE	$_B$O	OUT OF PAGE
	$_B$↑	TOP OF PAGE	$_B$↓	BOTTOM OF PAGE
	$_B$←	LT OF PAGE	$_B$→	RT OF PAGE
THUMB	$_V$X	INTO PAGE	$_V$O	OUT OF PAGE
	$_V$↑	TOP OF PAGE	$_V$↓	BOTTOM OF PAGE
	$_V$←	LT OF PAGE	$_V$→	RT OF PAGE
FORCE PALM = PROTON BACK OF HAND = ELECTRON	$_F$X	INTO PAGE	$_F$O	OUT OF PAGE
	$_F$↑	TOP OF PAGE	$_F$↓	BOTTOM OF PAGE
	$_F$←	LT OF PAGE	$_F$→	RT OF PAGE

Name: ______________________________ Period: __________ Date: __________

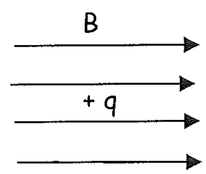
PRACTICE DAY PROBLEMS

Practice: Magnetic Forces

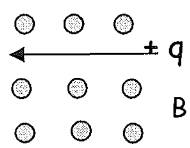
1. The direction of the force on a current-carrying wire in an external magnetic field is
   a. perpendicular to the current only.
   b. perpendicular to the magnetic field only.
   c. perpendicular to the current and to the magnetic field.
   d. parallel to the current and to the magnetic field.

2. What is the path of an **electron** moving perpendicular to a uniform magnetic field?
   a. A straight line
   b. A circle
   c. An ellipse
   d. A parabola

3. A stationary **positive** charge, q, is located in a magnetic field, B, which is directed toward the right, as shown. Determine the direction of the magnetic force on q. None (Not moving)



4. Find the direction of the force on a proton moving through the magnetic field.



↑F

5. Find the direction of the force on an **electron** moving through the magnetic field in the two diagrams.

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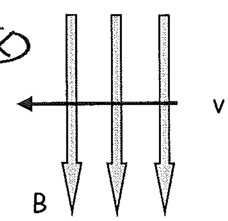

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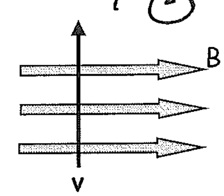


6. A <u>**proton**</u> moves perpendicularly to a magnetic field that has a magnitude of 4.20×10^{-2} T. What is the speed of the particle if the magnitude of the magnetic force on it is 2.40×10^{-14} N?
   [3.57×10^{6} m/s]

$F=qvB$ rearrange = $V=F/qB$ $\quad$ $V = 2.4\times10^{-14}/(1.6\times10^{-19})(4.20\times10^{-2}) = 3.57\times10^{6}$ m/s

Name: ______________________________ Period: __________ Date: __________

7. If an **electron** in an electron beam experiences a downward (toward the ground) force of 2.0×10^{-14} N while traveling in a magnetic field of 8.3×10^{-2} T horizontally west, what is the direction and magnitude of the velocity? **[1.5×10^{6} N [N]]**

$F=qvB$ rearrange $V = F/qB$ $\quad$ $2.0\times10^{-14} / (1.6\times10^{-19})(8.3\times10^{-2}) = 1.5\times10^{6}$ N North

8. A uniform 1.5 T magnetic field points horizontally north. If an **electron** moves vertically downward (toward the ground) with a speed of 2.5×10^{7} m/s through this field, what force (magnitude and direction) will act on it? **[6.0×10^{-12} N [W]]**

$F=qvB = (1.6\times10^{-19})(2.5\times10^{-7})(1.5) = 6\times10^{-12}$ N West

9. An airplane flying through the earth's magnetic field at a speed of 200 m/s acquires a charge of 100 C. What is the maximum magnetic force on it in a region where the magnitude of the Earth's magnetic field is 5.0×10^{-5} T? **[1 N]**

$F=qvB = (100)(200)(5\times10^{-5}) = 1$ N

10. If a wire is carrying a strong steady current, the magnetic field is

   a. Proportional to the current and inversely proportional to the distance from the wire

   b. Proportional to the current and proportional to the distance from the wire

   c. Inversely proportional to the current and inversely proportional to the distance from the wire

   d. Inversely proportional to the current and proportional to the distance from the wire

11. Current is moving from South to North in a wire. What is the direction of the magnetic field at a point directly above the wire?

   a. North $\qquad$ b. South $\qquad$ c. East $\qquad$ d. West

Name: ______________________________ Period: __________ Date: __________

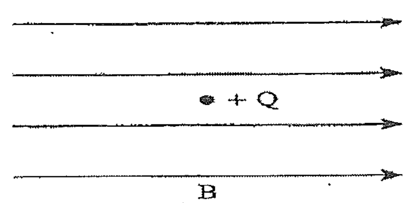
12. The direction of the force on a current-carrying wire in an external magnetic field is

a. Perpendicular to the current only
b. Perpendicular to the magnetic field only
c. Perpendicular to the current and to the magnetic field
d. Parallel to the current and to the magnetic field

13. What is the path of an electron moving perpendicular to a uniform magnetic field?

a. a straight line
b. a circle
c. an ellipse
d. a parabola

14 . A stationary positive charge, Q is located in a magnetic field, B, which is directed toward the right, as shown in the figure. The Direction of the magnetic force on Q is

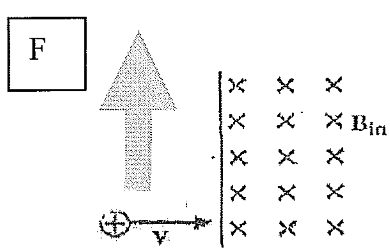


a. toward the right
b. down
c. up
d. There is no magnetic force

15. A current carrying conductor in and perpendicular to a magnetic field experiences a force that is

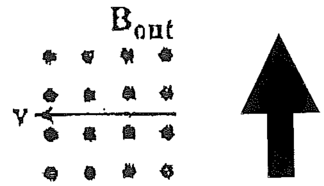
a. perpendicular to the current.
b. parallel to the current.
c. inversely proportional to the potential difference.
d. inversely proportional to the velocity.

16. Find the direction of the force on the proton moving through the magnetic field shown



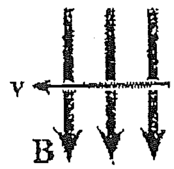
Name: ________________________ Period: __________ Date: __________

17. Find the direction of the force on a proton moving through the magnetic field



FORCE

18. Find the direction of the force on an electron moving through the magnetic field



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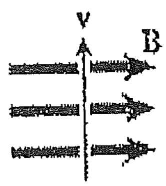
19. Find the direction of the force on an electron moving through the magnetic field



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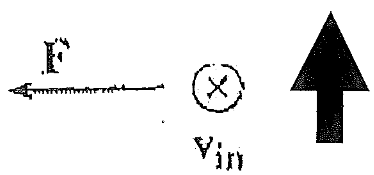
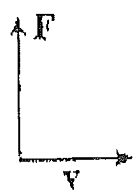
20. A negative charge I moving through a magnetic field. The direction of motion and the direction of the force acting on it are shown in the figure below. Find the direction of the magnetic field.



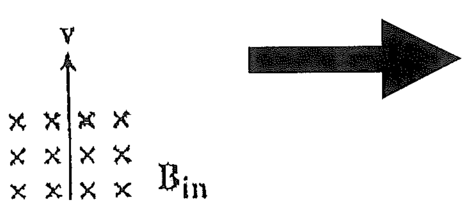
B

21. A negative charge is moving through a magnetic field. The direction of motion and the direction of the force acting on it are shown below. Find the direction of the magnetic field.



B – INTO THE PAGE

22. Find the direction of the force on an electron moving through the magnetic field shown below.

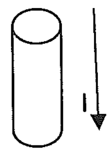


F

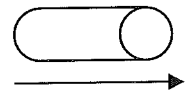
Name: ______________________________ Period: __________ Date: __________

RIGHT HAND RULES

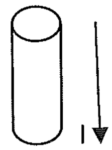
What is the direction of the magnetic field to the left of this wire?
INTO PAGE



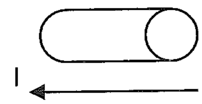
What is the direction of the magnetic field below this wire?
INTO PAGE



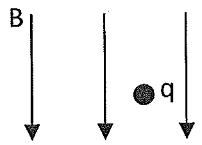
What is the direction of the magnetic field to the right of this wire?
OUT OF PAGE



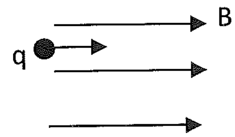
What is the direction of the magnetic field below this wire?
OUT OF PAGE



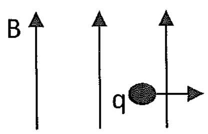
What is the direction of the magnetic force on the proton in this magnetic field? **ZERO – IT ISN'T MOVING**



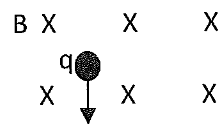
What is the direction of the magnetic force on the electron in this magnetic field? **ZERO – IT'S PARALLEL**



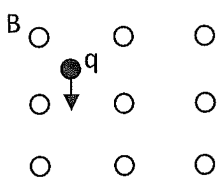
What is the direction of the magnetic force on a proton in this magnetic field? **OUT OF PAGE**



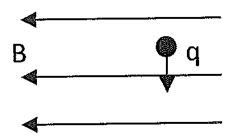
What is the direction of the magnetic force on the electron in this magnetic field? **LEFT**



What is the direction of the magnetic force on a proton in this magnetic field? **LEFT**

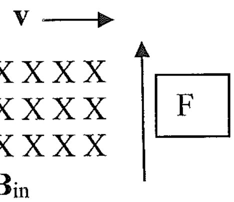


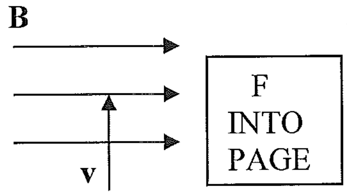
What is the direction of the magnetic force on the electron in this magnetic field? **OUT OF PAGE**

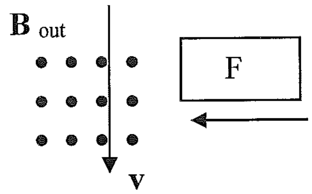


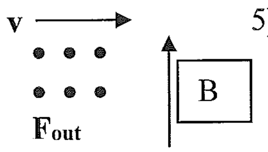
Name: ______________________________ Period: __________ Date: __________

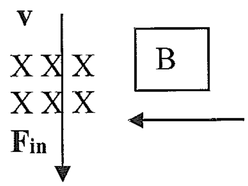
Determine the direction of the unknown quantity…

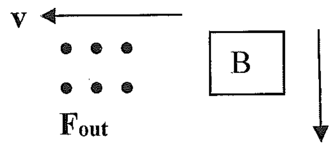
1) 

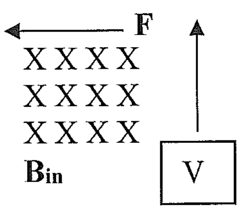
2) 

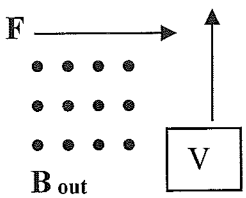
3) 

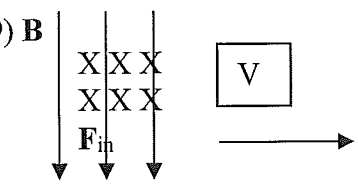
4) 

5) 

6) 

7) 

8) 

9) 

10) Make your own. One of each type: finding **B**, **F**, and **v**.

Name: ______________________________ Period: __________ Date: __________

Ohm's law

- For a given resistance, the potential difference is **DIRECTLY RELATED** to the current flow

$$\boxed{V = IR}$$

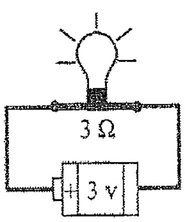
  - V = voltage in volts (V)
  - I = current in amps (A)
  - R = resistance in ohms (Ω)

Current

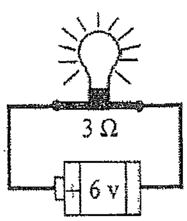
Current is moving electrons, moving charge.

Increasing current causes more electricity to move through a device.

Increasing electricity through a device causes it to work faster (in a motor) or be brighter (in a lightbulb).



Using Ohm's Law: $I = V/R$
$I = 3v/3\Omega$
$I = 1\ A$



Using Ohm's Law: $I = V/R$
$I = 6v/3\Omega$
$I = 2\ A$

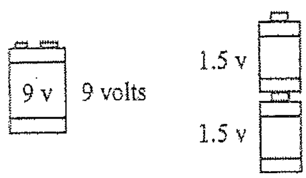
More current = brighter light.

Voltage

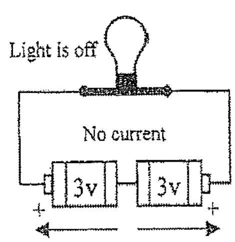
Voltage is electrical potential: how much work a battery can do.

Voltage is linked to energy:
1 volt of voltage = 1 joule of energy per coulomb of charge

To increase voltage you could use a stronger battery OR add batteries.



More voltage is like a stronger pump, giving more force and more current.

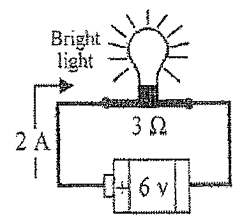


The lightbulb doesn't light here, because the two batteries are pushing *opposite directions*. To add together, batteries must be facing the same direction.

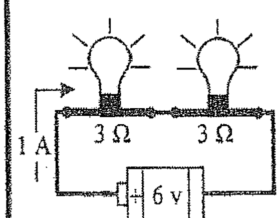
Resistance

Resistance slows down current. Think of resistance like a dam holding back water.

Adding devices in a circuit increases resistance.



$I = V/R$
$= 6v/3\Omega = 2\ A$
The light is bright because the 6 volts only have one light to run.



$I = V/R$
$= 6v/6\Omega = 1\ A$
Both lights are dimmer because the 6 volts have two lights to run.

More resistance = less current
Less current = less light

Voltage: Push of electrons - Cause electrons to move
Current: Flow of electrons (# of electrons passing a point per second)
Resistance: The opposition to the flow of electrons.

How Fast Do the Charges Move?

Three classmates decide they want to find out how fast electric charge can move. They connect a battery to a switch. The switch is connected to a lightbulb with a very long wire. They try to use a stopwatch to measure the time from when the switch is closed to when the lightbulb goes on. The problem is that the light goes on almost instantly! They each had different ideas why this happened. This is what they said:

Lindsay: This means that the charges coming from the battery must be moving extremely fast.

Tavon: Maybe the charges are already in the wire and the lightbulb. The battery just pushes the charges really quickly.

Will: I think that the charges are created in the lightbulb when you close the switch. That is why the lightbulb goes on so quickly.

Whom do you think has the best explanation? _______________ Explain why you think that person has the best explanation.

How Fast Do the Charges Move?

Teacher Notes

Purpose
The purpose of this assessment probe is to elicit students' ideas about electric charge. The probe is designed to determine how fast students think electric charges in a wire move.

Related Concepts
electric charge, current, battery, movement of charge

Explanation
Tavon has the best answer: "Maybe the charges are already in the wire and the lightbulb. The battery just pushes the charges really quickly." The interactions between the charges at the ends of the battery and the charges in the wire and bulb happen very quickly. However the charges themselves move very slowly. The speed of an electric charge in a wire is typically only a few centimeters per minute! The reason the charges feel the electric force so quickly is that the force is caused by the electric field produced by the battery. It is the electric field that pushes on the charges in the wire. The field itself moves almost at the speed of light (very, very fast).

Administering the Probe
This probe is best used with high school students. If materials are available, consider demonstrating the probe scenario. In addition to having students construct an explanation for why they agree with one of the classmates, consider having them make rebuttals explaining why they disagree with the other classmates.

Related Research
There currently is no research available that specifically targets the ideas in this probe.

Suggestions for Instruction and Assessment
- One effective teaching strategy is to use a piece of rope or string tied in a circle. Have a couple of students hold the rope loosely in their hands so the rope can slide through

Name: ______________________________ Period: __________ Date: __________

Practice Problems:

1. When a 10 V battery is connected to a resistor, 2 A of current flows in the resistor. What is the resistors value? **[5 Ω]**
   V=IR reaarange = R=V/I   10/2 = 5 OHMS

2. A 10 ohm resistor has 5 A current in it. What is the voltage across the resistor? **[50 V]**
   V=IR (5)(10) = 50 V

VOLTAGE (V)	CURRENT (I)	RESISTANCE (R)	SHOW ALL WORK!!
50 V	10 Amps	5 Ohms	V=IR
	10 Amps	8 Ohms	V = 10x8 = 80V
15 V		3 Ohms	I = V/R I = 15/3 = 5 A
90 V	6 Amps		R=V/I R = 90/6 = 15 OHMS
	8 Amps	6.5 Ohms	V=IR V=8X6.5 = 52V
25 V		10 Ohms	I=V/R I = 25/10 = 2.5 A
	3.6 Amps	28.5 Ohms	V=IR V=3.6X28.5 = 102.6

Name: ______________________________ Period: __________ Date: __________

1. A resistance of 30 ohms is placed across a 90 volt battery. What current flows in the circuit?
I = V/R 90/30 = 3 Amps

2. A voltage of 75 volts is placed across is 15 ohm resistor. What current flows through the resistor?
I = V/R 75/15 = 5 Amps

3. A current of 0.5 amps flow through a lamp when it is connected to a 120 volt source. What is the resistance of the lamp?
R = V/I 120/.5 = 60 Ohms

4. A motor with an operating resistance of 30 ohms is connected to a voltage source. 4 amps of current flow in the circuit. What is the voltage of the source?
V= IR 4x30 = 120 Volts

5. A resistance of 60 ohms allows 0.4 amps of current to flow when it is connected across a battery. What is the voltage of the battery?
V=IR .4x60 = 24 Volts

8. A 60 ohm resistor is connected in a series across a 120 volt generator. What current flows in the circuit?
I=V/R 120/60 = 2 Amps

9. The current passing through an electric outboard motor is 6 amps. The voltage is 12 volts. What is the resistance of the motor?
R=V/I 12/6 = 2 Ohms

10. Suppose a toaster uses 5 amps of current at 120 volts. A) What is the resistance of the toaster?
R= V/I 120/5 = 24 Ohms

Name: ____________________ Period: ________ Date: ________

Electric Power, Energy, and Cost

Electricity Formulas: $I = \frac{V}{R}$ or P=VI or E = Pt or \$ = E X \$/kwh

Variables	STANDS FOR:	UNIT	SYMBOL
1. P	POWER	WATTS	w
2. V	VOLTAGE	VOLTS	V
3. I	CURRENT	AMPS	A
4. R	RESISTANCE	OHMS	Ω
5. E	ELECTRICAL ENERGY	JOULES	J
6. t	TIME	SEC	s

VARIABLES	FORMULA	ANSWER
1. P=?; V=110 volts; I=2.0 amps	P=VI	P=110 x 2 = 220 W
2. P=3 watts; V=?; I=0.5 amps	V=P/I	V= 3/.5 = 6 V
3. P=75 watts; V=120 volts; I=?	I = P/V	I = 75/120 = .625 A

Example: A coffee pot operates on 2 amperes of current on a 110 volt circuit for 3 hours. Calculate the total Kwh used?

1. Determine power: P=VI
   = 110 v X 2 A
   = 220 watts

$$\text{Kwh} = \text{P X hours} = \frac{\text{V X I X hours}}{1000}$$

2. Convert watts to kilowatts:

$$220 \text{ watts X } \frac{1 \text{ kilowatt}}{1\,000} = 0.22 \text{ Kw}$$

3. Multiply by the hours given in the problem:
   0.22 Kw X 3 h = 0.66 Kwh

Name: ______________________________ Period: __________ Date: __________

A coffee pot uses 220 watts of power.

A. How many kilowatts is this?

220 W | 1Kw / 1000 W .22 Kw

$$220\text{ W} \times \frac{1\text{ Kw}}{1000\text{ W}} = .22\text{ Kw}$$

B. Calculate the total Kwh s used if a coffee pot is left on for 3 hours.

.22 kW x 3 hrs = .66 Kwh

An electric stove needs 120 volts, 12 amps, and has 10 ohms of resistance.

How much power does it use?

P = VI P=120 x 12 =1440 watts

Convert the wattage for the above stove to kilowatts.

$$1440\text{ watts} \times \frac{1\text{ kw}}{1000\text{ watts}} = 1.44\text{ Kw}$$

How much energy is used by the stove during 5 hours of use?

E = Pt E = 1.44 x 5 = 7.2 J

Your power company charges $0.20 per kilowatt hour. Determine the cost to run this stove for 5 hours.

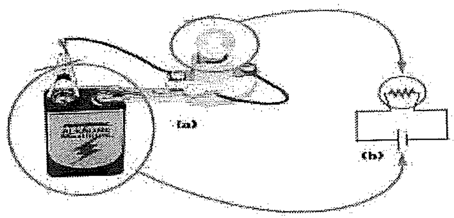
$ = E x $/Kwh $ = 72 x .20 = $1.44

Name: ______________________________ Period: __________ Date: __________

MONDAY 3/21/16	A resistance of 30 ohms is placed across a 90 volt battery. What current flows in the circuit? I = V/R = 90/30 = 3 amps
TUESDAY 3/22/16	In a series circuit what is constant across each resistor? The current stays the same in a series circuit
WEDNESDAY 3/23/16	What pushes the electron's thru the circuit? What do we call moving electrons? The voltage pushes the electrons Moving electrons is called Current
THURSDAY 3/24/16	In a parallel Circuit what is constant in each branch? The Voltage stays constant in a parallel circuit
FRIDAY 3/25/16	**HOLIDAY**

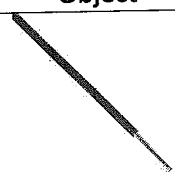
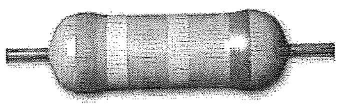
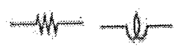
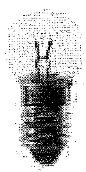
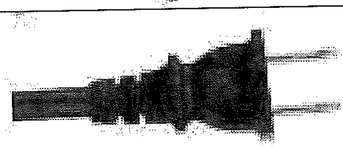
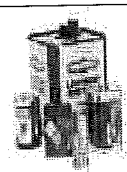
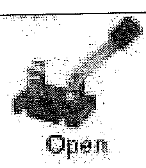
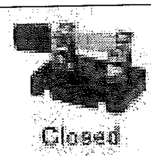
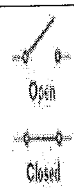
Name: ______________________________ Period: __________ Date: __________

CIRCUITS



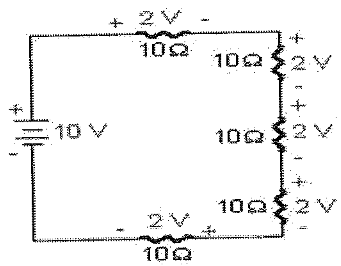
A circuit is defined as a complete PATH of an ELETRICAL CURRENT. Universally, symbols are used to represent the parts which can make up a circuit. Complete the chart below.

Schematic Diagram –

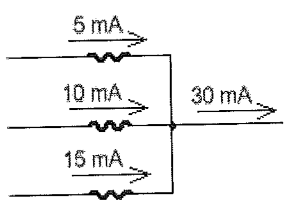
Component	Object	Symbol	Explanation
Wire			Wires that connect components. Very small resistance.
Resistor			Wires with multiple bends has resistance to moving charges.
Bulb			Multiple bends indicate the bulb has resistance.
Plug			A container for 2 prongs. The potential difference is the lines uneven height. Allows electrons to make a complete loop.
Battery; Voltage Source			Differences in height indicate potential differences. Taller one is positive.
Switch	 		Small circles indicate points of contact.

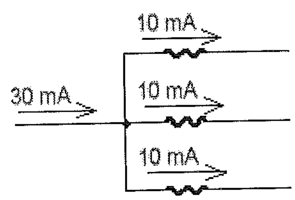
Name: ______________________________ Period: __________ Date: __________

Kirchhoff's <u>VOLTAGE</u> Law (KVL): Around any complete path through an electric circuit, the total **increase** in electric potential is equal to the total **<u>DECREASE</u>** in electric potential. (also Conservation of Energy)



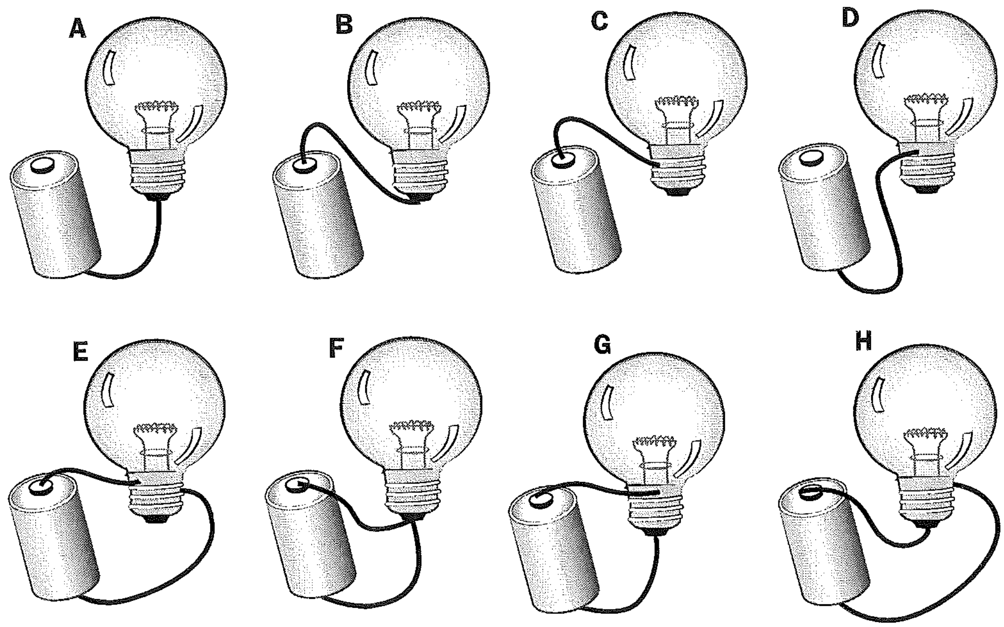
Kirchhoff's <u>CURRENT</u> Law (KCL): At any junction point in an electric circuit, the total current **<u>INTO</u>** the junction is equal to the total current **<u>OUT</u>** of the junction.





How Can You Light the Bulb?

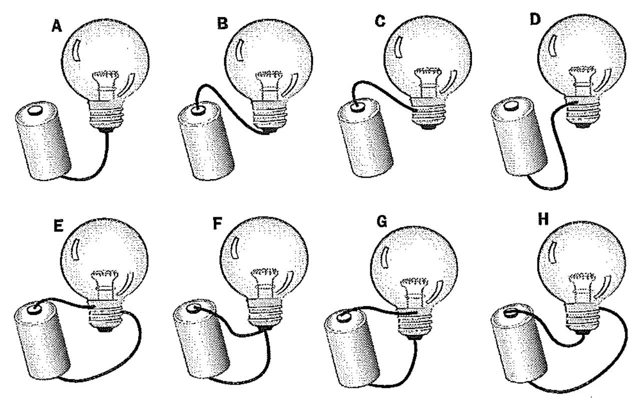
Tessa wonders how many different ways she can light a lightbulb. Circle all the ways you think will work.



Explain your thinking. How did you decide which ways would light the bulb?

How Can You Light the Bulb?

Teacher Notes



Purpose

The purpose of this assessment probe is to elicit students' ideas about complete circuits and the structure of a lightbulb. The probe is designed to reveal how students think a battery and bulb need to be connected in order to complete a circuit

Related Concepts

circuit, battery, lightbulb structure, transfer of energy

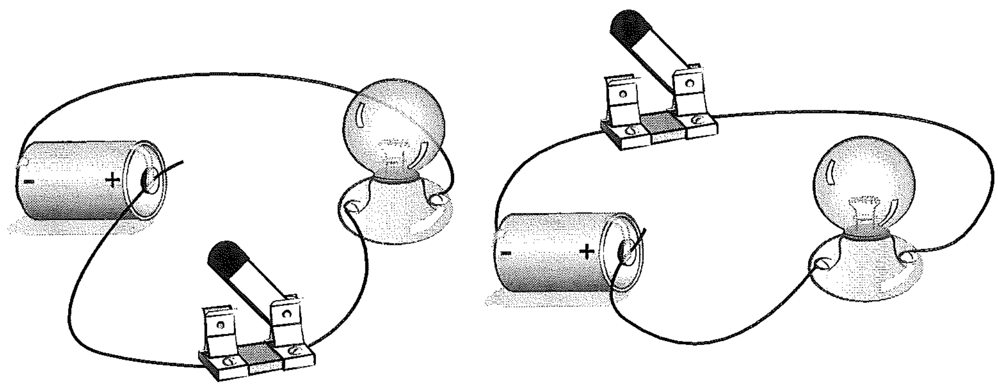
Explanation

The best answer is G and H. If you closely examine a flashlight bulb, you will see two small wires sticking up in the bulb that are connected by a very fine wire called a *filament*. The two wires on either side of the filament extend downward into the base of the bulb where you cannot see them through the metal casing that surrounds the base of the bulb. One of these wires goes down to the very bottom of the base (the pointed end). The other wire is connected to the side of the metal base (sometimes the side is ridged so that it can screw into a socket). Knowing where these wires end up on the base of the bulb (the tip and the side) is necessary in order to complete a circuit.

The battery, wires, and bulb need to be connected in such a way that it forms a complete circuit. To do this, one end of the wire must touch the negative terminal (the smooth end of the battery) and either the side of the metal casing on the bulb or the tip of the bulb. The other wire must touch the positive terminal of the battery (bumpy end) and the part of the bulb, either the side of the metal casing or the tip of the bulb that is not connected to the other wire. Configurations G and H show two ways to do this.

The lightbulb lights because the electricity flows from the negative terminal, through the wire, into one of the wires inside the bulb that is connected to either the side of the metal casing or the tip, up through the wire inside the bulb, across the filament, and down the other

Where Do I Put the Switch?



A

B

Three students are building a complete circuit in their science class. They want to turn the lightbulb on and off with a switch. They disagreed about where the switch should go. This is what they said:

Keenan: I think the switch needs to be between the + end of the battery and the bulb, like Circuit A.

Felicia: I think the switch needs to be between the – end of the battery and the bulb, like Circuit B.

Bruno: I think it doesn't matter which side of the battery the switch is on.

With which student do you agree the most? ______________ Explain why you agree.

____

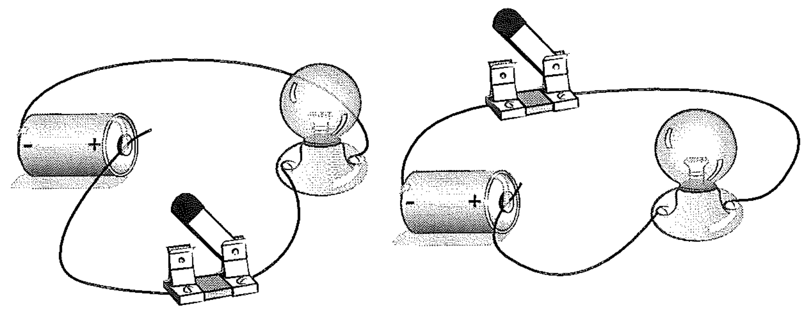
____

____

____

Where Do I Put the Switch?

Teacher Notes



A B

Purpose

The purpose of this assessment probe is to elicit students' ideas about complete circuits. The probe is designed to reveal how students think current flows in a circuit.

Related Concepts

circuit, switch, current, transfer of energy

Explanation

The best answer is Bruno's: "I think it doesn't matter which side of the battery the switch is on." Current flows from one end of the battery to the other and then back through the battery. Even though electricity flows in one direction throughout all parts of the circuit, it does this at the same time, not sequentially, so it doesn't matter where you place the switch. As soon as you open the switch, you interrupt the pathway and turn the circuit "off."

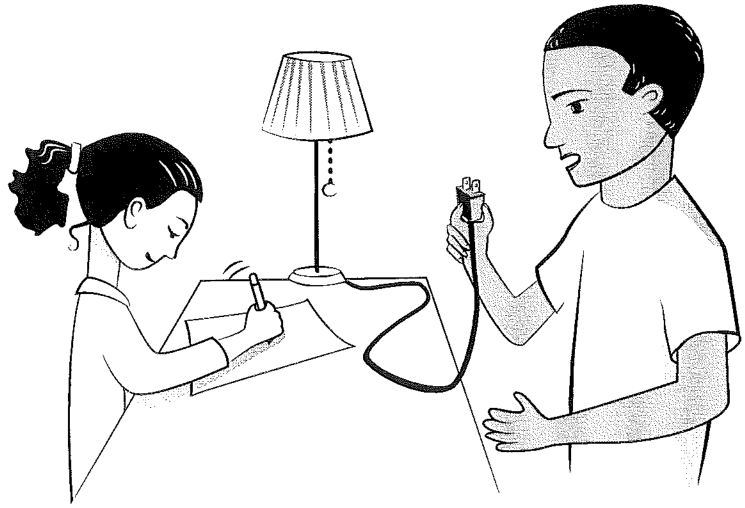
Administering the Probe

This probe is best used with students in grades 3–8. Make sure students are familiar with how a switch operates and that they can distinguish between the two different configurations shown on the probe. This probe can be used with the P-E-O strategy described on page xii by providing students with the materials to test the two different switch configurations (Keeley 2008).

Related Research

- Shipstone (1984) found that 80% of 13-year-olds had a sequential model of a circuit in which electricity comes out of the positive end of the battery and goes through each part of the circuit in turn, returning to the battery, so that the switch needs to be on the positive side in order to not light the lamp. This model is supported by many life experiences involving cause and effect (Driver et al. 1994).
- Students who use a sequential model tend to think of electricity as standing, but not flowing, in unconnected wires (Driver et al. 1994).

Why Two Prongs?



Dan is about to plug in a lamp so he and his friends can see better while they read. Dan notices there are two prongs on the end of the cord. He asks his friends why there are two prongs. This is what they said:

Chris: There must be two prongs because the electricity goes in one prong and then comes back out the other prong.

Aliyah: I think there are two prongs because there are two types of electricity. The positive electricity comes in one prong and the negative electricity comes in the other prong.

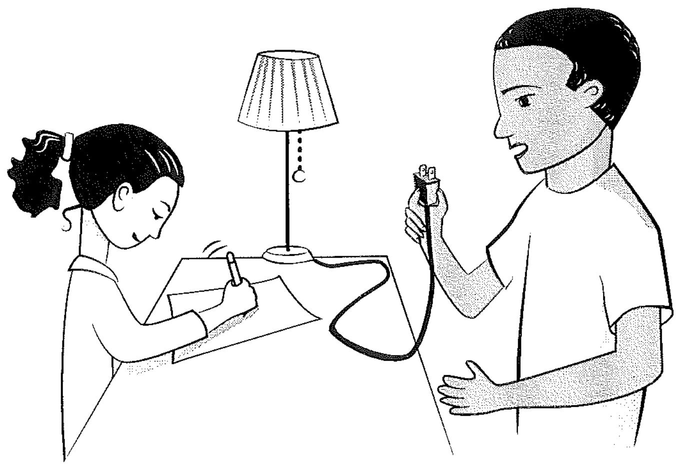
Sanjay: I think that positive electricity comes in one prong and then after it is used by the lightbulb, it becomes negative electricity and goes out the other prong.

Maria: I don't agree with any of you. I think there is a different reason why there are two prongs.

With whom do you most agree the most? _____________ Explain why you agree.

Why Two Prongs?

Teacher Notes



Purpose

The purpose of this assessment probe is to elicit students' ideas about household (AC) current. The probe is designed to reveal students' ideas about what happens when a two-pronged plug is placed in an outlet.

Related Concepts

current, alternating current (AC)

Explanation

The best answer is Chris's: "There must be two prongs because the electricity goes in one prong and then comes back out the other prong." The electrical outlet that you plug your appliances into provides alternating current (AC) electricity. AC electricity switches directions, going back and forth very rapidly. The electric power plant uses energy to push the electric charges back and forth through the power lines. You access the electricity when you plug into an outlet. The prongs reach into the outlet and make electrical contact. The electricity flows through one of the prongs and through the wire connected to the prong to provide energy for the appliance, and then flows back to the second prong through another wire which completes the circuit. It is interesting to note that because household electricity uses alternating current, the electric charges in the wires never move very far. In fact, in the United States, they move back and forth 60 times each second! (In some countries, like China, they move back and forth 50 times each second.) This means the power plant is not supplying electric charge; it is only supplying the energy to move the charges that are already in the wires.

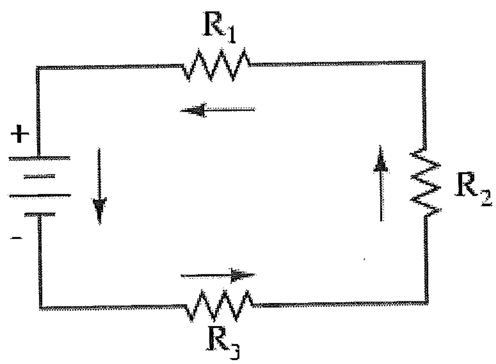
Administering the Probe

This probe is best used with middle and high school students. If a two-pronged plug is available, show students the plug. Make sure students know that they can choose Maria if they have a different reason. If they choose Maria, remind them that they must provide their

Name: ______________________________ Period: __________ Date: __________

1st Type of Circuits

Series



The current flowing through each electric device is the **same** because the current has only **one** pathway through the circuit.

Equivalent Resistance in a Series Circuit

$R_{eq} = R_1 + R_2 + R_3$

Voltage in a Series Circuit

$V_T = V_1 + V_2 + V3$

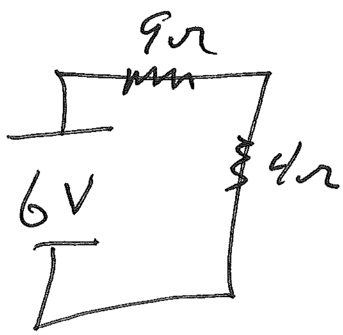
Steps in simplifying series circuits:

1. Find the equivalent resistance, R_{eq}, of the circuit
2. Use Ohm's law to find the total current, I
3. Apply Ohm's law to each resistor to find the voltage drop across the individual resistor using the total current, I

Name: ______________________ Period: __________ Date: __________

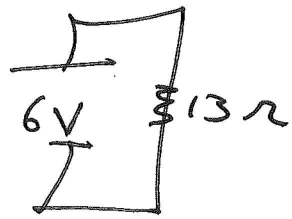
1. Two resistors of 9.0 Ω and 4.0 Ω are connected in series across a 6.0 V battery.
   a. Draw the circuit.
   b. What is the equivalent resistance of the circuit? [13 Ω]
   c. What is the current through the 9.0 Ω resistor? [.46 A]
   d. What is the current through the 4 Ω resistor? [.46 A]
   e. What is the voltage drop across each resistor? [4.15 V, 1.85 V]

A



B $R_{eq} = 9 + 4 = 13\Omega$

C & D



$I_T = V/R = 6/13 = \underline{.46A}$

Series – I is constant in a series circuit. Both get $\underline{.46A}$

E $V_{9\Omega} = IR$
$= (.46)(9)$
$= 4.15V$

$V_{4\Omega} = IR$
$= (.46)(4)$
$= 1.85V$

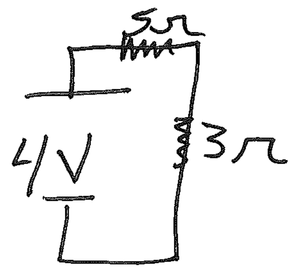
$4.15 + 1.85 = \underline{6V}$

Name: ______________________________ Period: __________ Date: __________

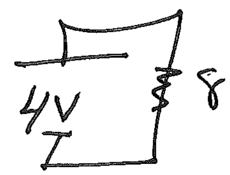
Two resistors of 5.0 Ω and 3.0 Ω are connected in series across a 4.0 V battery.

a. Draw the circuit.
b. What is the equivalent resistance of the circuit?
c. What is the current through the 5 Ω resistor?
d. What is the current through the 3 Ω resistor?
e. What is the voltage drop across each resistor?

A



B $R_{eq} = 5 + 3 = 8\Omega$



$I_T = V/8$

C $= 4/8 = .5A$

D Series circuits get equal current. Both Get .5 Amps

E $V = IR$

$V_{5\Omega} = (.5)(5)$
$= 2.5\,V$

$V = IR$

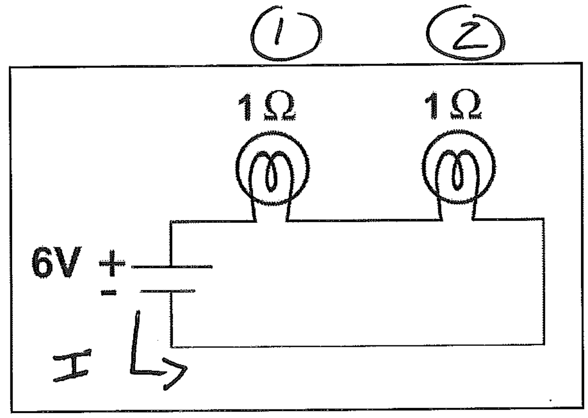
$V_{3\Omega} = (.5)(3)$
$= 1.5\,V$

$2.5 + 1.5 = 4V$

Name: ______________________ Period: __________ Date: __________

(Series Circuits)

1. Use the series circuit pictured to the right to answer questions (a)-(e).



a. What is the total voltage across the bulbs?

6 Volts

b. What is the total resistance of the circuit?

$R_{eq} = 1 + 1 = 2\Omega$

c. What is the current in the circuit?

$I = V/R = 6/2 = 3A$

d. What is the voltage drop across each light bulb? (Remember that voltage drop is calculated by multiplying current in the circuit by the resistance of a particular resistor: *V = IR.*)

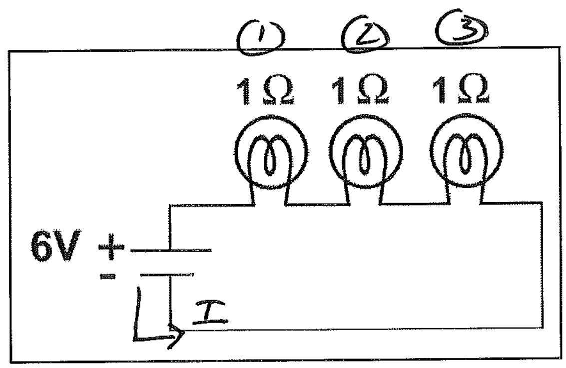
$V_{1} = IR = (3)(1) = 3V$

$V_{2} = IR = (3)(1) = 3V$

6V

e. Draw the path of the current on the diagram

2. Use the series circuit pictured to the right to answer questions (a)-(e).



a. What is the total voltage across the bulbs?

6 Volts

b. What is the total resistance of the circuit?

$R_{eq} = 1 + 1 + 1 = 3\Omega$

c. What is the current in the circuit?

$I = V/R = 6/3 = 2A$

$2 + 2 + 2 = 6V$

d. What is the voltage drop across each light bulb?

$V_{1} = IR = (2)(1) = 2V$ $V_{2} = IR = (2)(1) = 2V$ $V_{3} = IR = (2)(1) = 2V$

e. Draw the path of the current on the diagram.

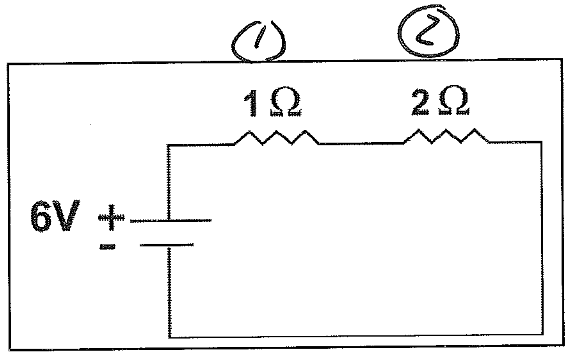
3. What happens to the current in a series circuit as more light bulbs are added? Why?

It decreases! Because the resistence Increases Inverse!

4. What happens to the brightness of each bulb in a series circuit as additional bulbs are added? Why? It will decrease bc the voltage is lower.

Name: ______________________ Period: __________ Date: __________

5. Use the series circuit pictured to the right to answer questions (a), (b), and (c).



a. What is the total resistance of the circuit?

$R_{eq} = 1 + 2 = 3\Omega$

a. What is the current in the circuit?

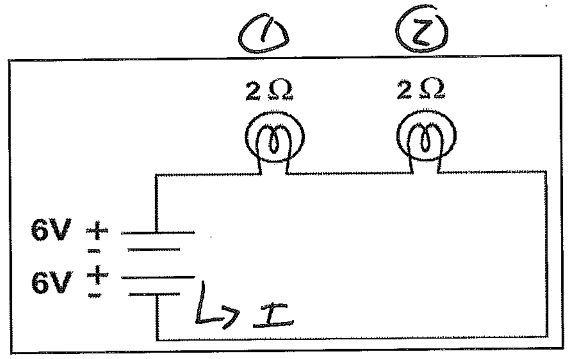
$I = V/R \quad 6/3 = 2A$

b. What is the voltage drop across each resistor?

$2 + 4 = 6V$

$V_{1} = IR = (2)(1) = 2V$ $\quad V_{2} = IR = (2)(2) = 4V$

6. Use the series circuit pictured to the right to answer questions (a)-(e).



a. What is the total voltage of the circuit?

12V

b. What is the total resistance of the circuit?

$R_{eq} = 2 + 2 = 4\Omega$

c. What is the current in the circuit?

$I = V/R \quad 12/4 = 3A$

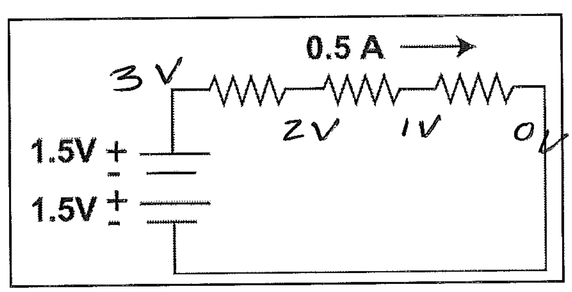
$6 + 6 = 12V$

d. What is the voltage drop across each light bulb?

$V_{1} = IR = (3)(2) = 6V$ $\quad V_{2} = IR = (3)(2) = 6V$

e. Draw the path of the current on the diagram.

7. Use the series circuit pictured right to answer questions (a), (b), and (c). Consider each resistor equal to all others.



a. What is the resistance of each resistor?

$R = V/I \quad 3/.5 = 6\Omega \quad 6/3 = 2\Omega$ each

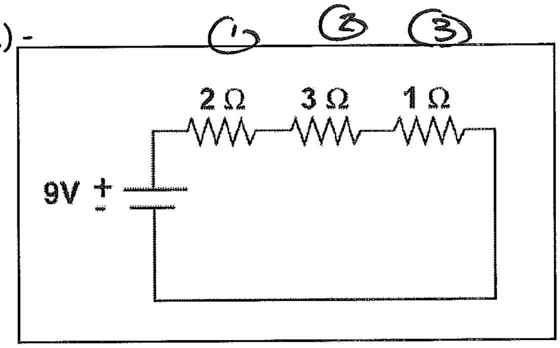
b. What is the voltage drop across each resistor?

$V = IR \quad (.5)(2) = 1V$ for all 3

c. On the diagram, show the amount of voltage in the circuit before and after each resistor.

Name: ______________________ Period: ________ Date: ________

8. Use the series circuit pictured right to answer questions (a) - (d).



a. What is the total resistance of the circuit?

$R_{eq} = 2+3+1 = 6\Omega$

b. What is the current in the circuit?

$I = 9/6 = 1.5\ A$

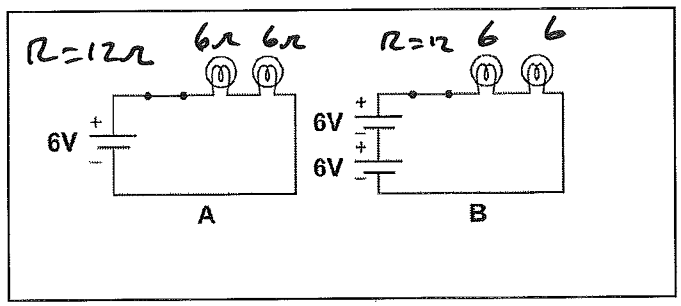
c. What is the voltage drop across each resistor?

$V_1 = IR = (1.5)(2) = 3V$ $V_2 = IR = (1.5)(3) = 4.5V$ $V = IR$ $V_3 = (1.5)(1) = 1.5V$

d. What is the sum of the voltage drops across the three resistors? What do you notice about this sum?

$3 + 4.5 + 1.5 = 9V$ 9V out 9V used up

9. Use the diagram to the right to answer questions (a), (b), and (c).



a. How much current would be measured in each circuit if each light bulb has a resistance of 6 ohms?

$I_A = 6/12 = .5A$ | $I_B = 12/12 = 1A$

b. How much current would be measured in each circuit if each light bulb has a resistance of 12 ohms?

$I_A = 6/24 = .25A$ $I_B = 12/24 = .5A$

c. What happens to the amount of current in a series circuit as the number of batteries increases?

Current Increases!

I & V are a direct Relationship

How Bright Will the Bulbs Be?

Two students made a circuit with a battery, wires, and two identical lightbulbs. Before they connected their circuit, they made a prediction about the brightness of the two bulbs. This is what they said:

Herman: I think both bulbs will have the same brightness.

Molly: I think one lightbulb will be brighter than the other.

With which student do you agree the most? ______________ Explain why you agree with one student and not the other.

____

____

____

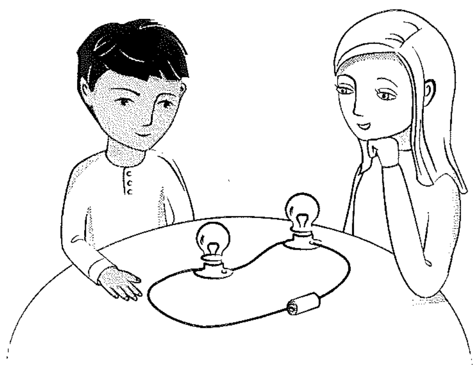
____

____

____

How Bright Will the Bulbs Be?

Teacher Notes



Purpose
The purpose of this assessment probe is to elicit students' ideas about series circuits. The probe is designed to determine what students think will happen to the brightness of lightbulbs as more lightbulbs are added to a circuit.

Related Concepts
current, series circuit, resistance, circuit

Explanation
The best answer is Herman's: "I think both bulbs will have the same brightness." The circuit shown is a series circuit. A series circuit is a circuit in which resistors (i.e., the lightbulbs) are arranged in a chain, so the current has only one path to take. All the current that goes through the first bulb must also go through the second bulb, so the bulbs are the same brightness. (*Note:* It is important that the two bulbs must be identical for the same current to create the same brightness. Bulbs with different ratings could have a different brightness with the same current.) In a series circuit, every lightbulb (or other device) must function for the circuit to be complete. A burned out bulb in a series circuit breaks the circuit and acts like an open switch, which turns the circuit off. The concept of "current" in electric circuits refers to the number of electric charges that pass through the wire in a given amount of time. A lot of charges moving slowly or a few charges moving fast could be the same "current." This is different from the flow of water where "current" usually refers to the speed of the water.

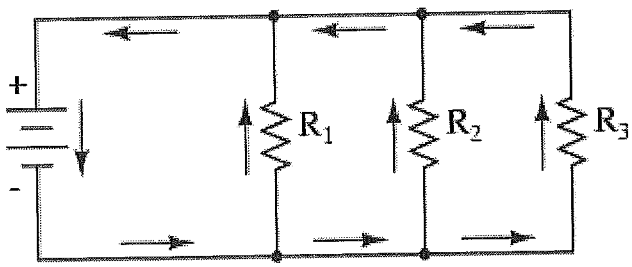
Although the two bulbs will have the same brightness when compared to each other, they will be dimmer than the brightness of a single bulb circuit. This is because adding a second bulb in series will increase the resistance in the circuit, which decreases the current through the circuit.

Administering the Probe
This probe is best used with upper elementary, middle, and high school students. Make sure

Name: ______________________ Period: __________ Date: __________

2^{nd} Type of circuits

Parallel



The total current in the circuit **divides** among the parallel branches

$$\boxed{I_T = I_1 + I_2 + I_3}$$

$$\boxed{1/R_{eq} = 1/R_1 + 1/R_2 + 1/R_3}$$

Equivalent Resistance in a Parallel Circuit

$$\boxed{V_T = V_1 = V_2 = V_3}$$

Voltage is the same in each branch

Steps in simplifying parallel circuits:

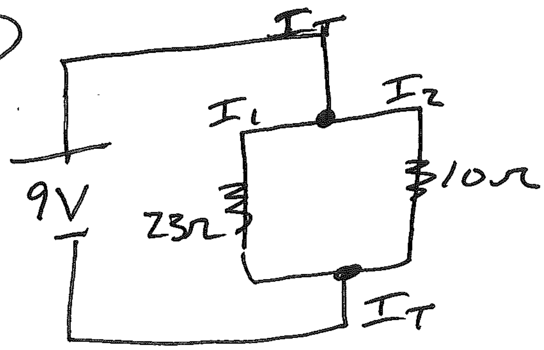
1. Find the equivalent resistance, R_{eq}, of the circuit
2. Use Ohm's law to find total current, I
3. Apply Ohm's law to each resistor to find the current in each branch using the total voltage, V

Name: ______________________ Date: ____________ Period: _____

Two resistances, one 23 Ω and the other 10 Ω are connected in parallel with a 9 V battery.

- Draw the circuit
- What is the equivalent resistance of the parallel combination?
- What is the Total Current?
- How many volts travel down each branch?
- How much Current travels down each Branch?

(A)



(B)

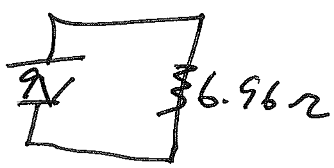
$$\frac{1}{R_{eq}} = \frac{1}{23} + \frac{1}{10}$$

$$\frac{10}{230} + \frac{23}{230} = \frac{33}{230}$$

$$\frac{1}{R_{eq}} = \frac{33}{230} \rightarrow R_{eq} = \frac{230}{33}$$

$$= 6.96\Omega$$

(C)



$$I_T = 9/6.96 = 1.3A$$

(D) Voltage in parallel Branches are equal!

Both get 9V

(E) current splits in Parallel

$$I_1 = V/R_1 = 9/23 = .39\ A$$

$$I_2 = V/R_2 = 9/10 = .9A$$

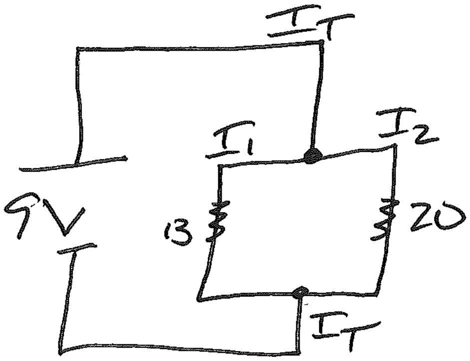
$$.39 + .9 = 1.29A$$

Name: ______________________ Date: ______________ Period: _____

Two resistances, one 13 Ω and the other 20 Ω are connected in parallel with a 9V battery.

- Draw the circuit
- What is the equivalent resistance of the parallel combination?
- What is the Total Current?
- How many volts travel down each branch?
- How much Current travels down each Branch?

(A)



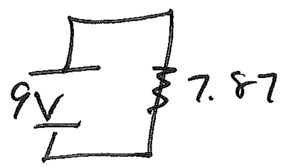
(B) $\frac{1}{R_{eq}} = \frac{1}{13} + \frac{1}{20}$

$\frac{20}{260} + \frac{13}{260} = \frac{33}{260}$

$\frac{1}{R_{eq}} = \frac{33}{260}$ $\quad R_{eq} = \frac{260}{33}$

$\underline{= 7.87\,\Omega}$

(C)



$I_T = 9/7.87 = \underline{1.14A}$

(D) Voltage is <u>equal</u> in each branch of a parallel circuit

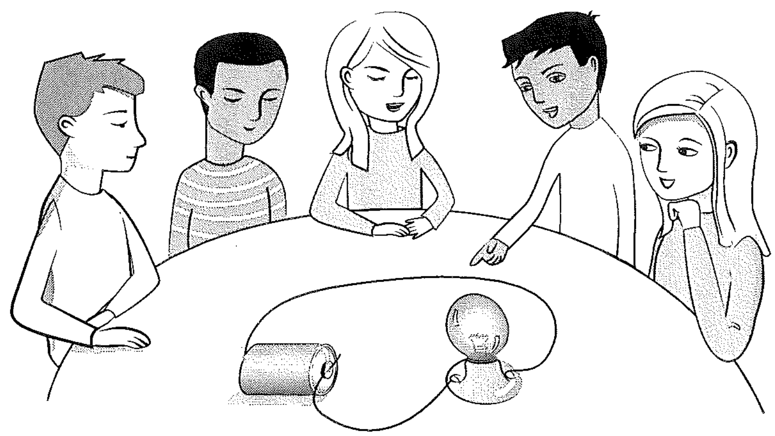
Both get <u>9V</u>

(E) $I_1 = V/R_1 = 9/13 = .69A$

$I_2 = V/R_2 = 9/20 = .45$

$\left.\begin{matrix} I_1 \\ I_2 \end{matrix}\right\} \underline{1.14A}$

How Do You Think About the Flow of Electric Current Through a Circuit?



Five students were asked to describe their mental model for the flow of electric current through a simple circuit as shown above. These are the mental models they described:

Perez: Current comes from the battery. When it flows to the bulb, the bulb uses up some of the current. Less current flows back to the battery.

Mina: The current flows from the battery to the bulb where it gets used up by the bulb. Some current does not return to the battery.

Hans: Current flows continuously through the battery as well as through the bulb. Current doesn't get used up and is the same in all parts of the circuit.

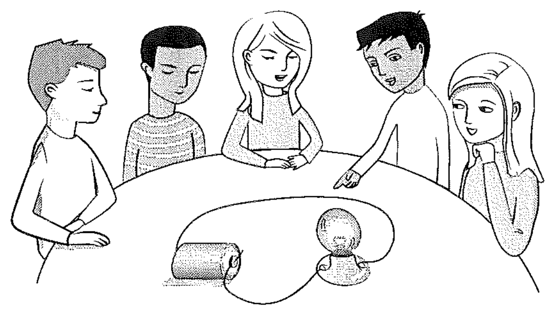
Dennis: Current comes from both ends of the battery and flows to the bulb where it eventually gets used up.

Tricia: My model isn't like any of yours. It is completely different.

Whose mental model is most like yours? ______________ Explain why that model best matches your thinking about current in a simple circuit.

How Do You Think About the Flow of Electric Current Through a Circuit?

Teacher Notes



Purpose
The purpose of this assessment probe is to elicit students' ideas about electric current. The probe is designed to identify the mental models students' use to explain how electric current flows in a simple circuit.

Related Concepts
current, circuit, models

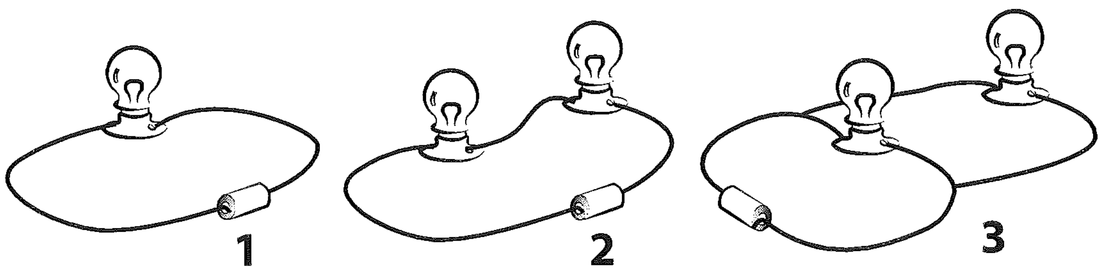
Explanation
The best answer is Hans's: "Current flows continuously through the battery as well as through the bulb. Current doesn't get used up and is the same in all parts of the circuit." A flow of electrical charges is called a current. Current flows through the circuit from one end of the battery to the other end of the battery and then back through the battery in a complete circle. The current is the same along any single pathway in a circuit.
(*Note:* Electrons move in the opposite direction of what is called electric current. This can be confusing but comes from the fact the Benjamin Franklin thought the particles moving in the wire were positively charged. Later it was found that the moving particles were negative. This idea is not important for beginning science students.)

The concept of "current" in electric circuits refers to the number of electric charges that pass through a particular place in the circuit in a given amount of time. A lot of charges moving slowly or a few charges moving fast could be the same "current." This is different from the flow of water where "current" usually refers to the speed of the water.

Administering the Probe
This probe is best used with middle and high school students. If materials are available, consider showing students the simple circuit. While students' mental models may not be exactly like the ones described, encourage them to pick the mental model that is most similar to their own, unless they have a completely

How Does the Current in Each Battery Compare?

The same types of lightbulbs are connected to the same kind of batteries in the three circuit pictures shown below. A circuit diagram is included next to each circuit picture. The batteries are labeled 1, 2, and 3.



Three friends are talking about the three electric circuits shown above.

Casey: I think the current through each of the batteries is the same. Each of the batteries is 1.5 V and they are made by the same company.

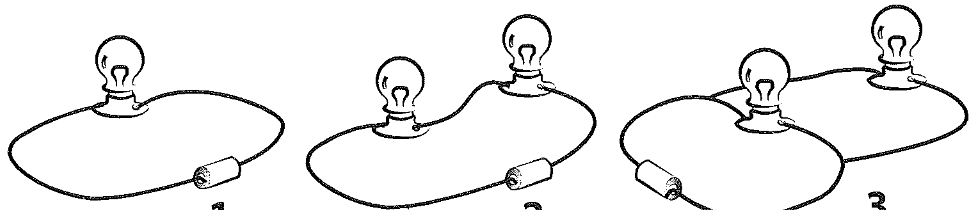
Kara: I think there is less current through battery #1 because there is only one lightbulb in that circuit. The other circuits have two lightbulbs, so they must have more current.

Alyssa: I think the current is different in all three batteries. Battery #3 has the most electric current and battery #2 has the least because of how the lightbulbs are connected.

Whom do you think has the best explanation? ______________ Explain why you think that person has the best explanation.

How Does the Current in Each Battery Compare?

Teacher Notes



Purpose

The purpose of this assessment probe is to elicit students' ideas about batteries. The probe is designed to reveal students' ideas about how the flow of current through a battery is affected by the type of circuit.

Related Concepts

circuit, series circuit, parallel circuit, current, voltage, battery, resistance

Explanation

The best answer is Alyssa's: "I think the current is different in all three batteries. Battery #3 has the most electric current and battery #2 has the least because of how the lightbulbs are connected." In the third circuit, the bulbs are connected in parallel. This means that the current through the battery for each bulb is independent of the current through the battery for the other bulb. This results in more current flowing through the battery, twice as much current as for a single bulb. In the second circuit, the two bulbs are connected in series, one after the other. In this circuit, the extra bulb is an obstacle to the flow and decreases the current through the battery as compared to the single-bulb circuit.

Voltage can be thought of as the "push" that the battery exerts on the charges in the wire. When there is more resistance, the flow will be less with the same "push." If there is less resistance, the flow (current) will increase even though the "push" from the battery stays the same.

Administering the Probe

This probe is best used with middle or high school students and can be used in conjunction with the probe "How Would You Rank the Brightness of These Bulbs?" (p. 79).

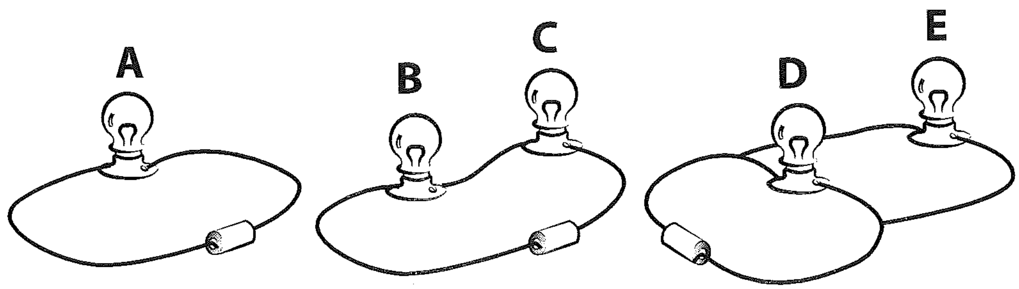
Related Research

- Student difficulties with understanding the role of the battery have been identified across grade levels and cultures. Many

How Would You Rank the Brightness of These Bulbs?

The same types of lightbulbs are connected to the same kind of batteries in the three circuits pictures shown below. The letters indicate the bulbs in each circuit.

How would you rank the brightness of the bulbs from brightest to dimmest? Place the letters of the bulbs on the blanks below. Put a > symbol between bulbs if one bulb is brighter than the other. Put a = sign between bulbs that have the same brightness.



brightest ____ ____ ____ ____ ____ *dimmest*

Explain your thinking. Justify why you ranked the bulbs in that order.

____

____

____

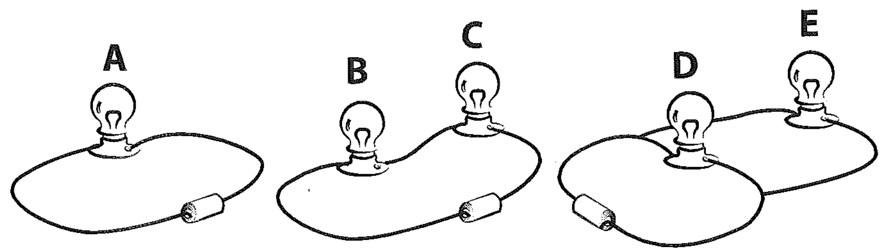
____

____

____

How Would You Rank the Brightness of These Bulbs?

Teacher Notes



Purpose

The purpose of this assessment probe is to elicit students' ideas about different types of circuits. The probe is designed to find out the reasons students use to rank the brightness of bulbs in three different types of circuits.

Related Concepts

circuit, current, series circuit, parallel circuit, resistance

Explanation

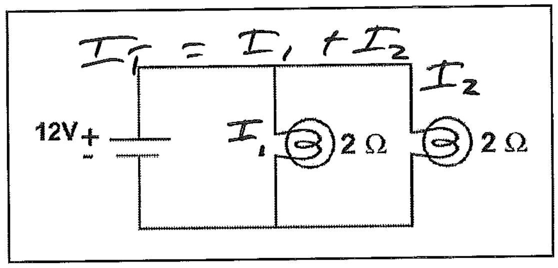
The best answer should show bulbs A, D, and E being of equal brightness and brighter than bulbs B and C, which are of equal brightness but less bright than A, D, and E. For example: A = D = E > B = C, note that the A, D, Es and the B and C can be in any order as long as students show or explain that A, D, E are of equal brightness but brighter than B and C, which are of equal brightness. These rankings can be explained using the current model or using a voltage model:

- Using the current model, the bulbs connected in parallel each have their own direct connections to the battery. Because each of these pathways contains only one bulb, they will have the same current as the single bulb circuit. The bulbs connected in series represent a greater obstacle to the flow (more resistance). Therefore the current through the two-bulb series circuit will be less than the single-bulb circuit. Therefore, these two bulbs will be less bright than the single bulb (or the other two bulbs connected in parallel).
- Using the voltage model, the bulbs connected in parallel and the bulb in the single-bulb circuit each have their own connection to the battery, so they will each have the same voltage as the battery. Therefore, they will be the same brightness. (The rule is that elements connected in parallel have the same voltage.) The voltage across each bulb connected in series must add up to the total voltage across that pathway, which is

Name: ______________________________ Date: ______________ Period: _____

(Parallel Circuits)

1. Use the parallel circuit pictured right to answer questions (a) - (d).



a. What is the voltage across each bulb?

12 volts Parallel set equal volts

b. What is the current in each branch?

$I_1 = V/R_1 \quad 12/2 = 6A$

$I_2 = V/R_2 = 12/2 = 6A$

c. What is the total current provided by the battery?

$I_{Total} = I_1 + I_2$

$= 6 + 6 = 12A$

d. Use the total current and the total voltage to calculate the total resistance of the circuit.

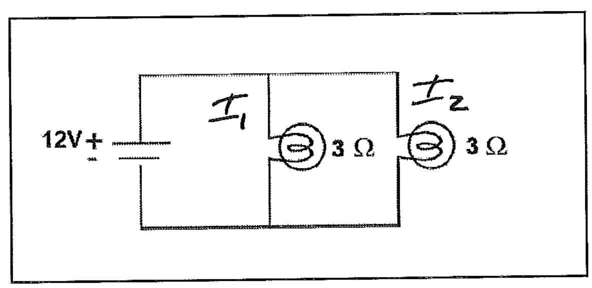
$R_T = V_T / I_T = 12/12 = \underline{1\Omega}$ or $1/R_{eq} = 1/2 + 1/2 = 2/2$

$= \underline{1\Omega}$

2. Use the parallel circuit pictured right to answer questions (a) - (d).

a. What is the voltage across each bulb?

12 volts Parallel Rule



b. What is the current in each branch?

$I_1 = V/R = 12/3 = 4A$

$I_2 = V/R = 12/3 = 4A$

c. What is the total current provided by the battery?

$I_T = I_1 + I_2$

$= 4 + 4 = 8A$

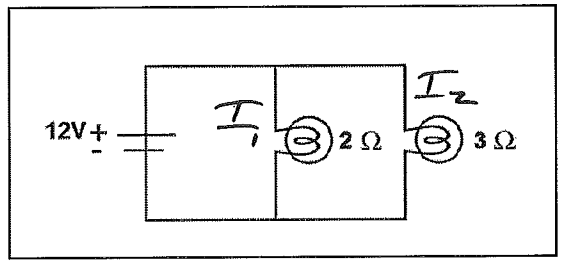
d. Use the total current and the total voltage to calculate the total resistance of the circuit.

$R = V/I \quad 12/8 = \underline{1.5\Omega}$ $1/R_{eq} = 1/3 + 1/3 = 2/3$

$R_{eq} = 3/2 = \underline{1.5}$

Name: ______________________ Date: ____________ Period: _____

3. Use the parallel circuit pictured right to answer questions (a) - (d).



a. What is the voltage across each resistor?

12V Parallel Rule

b. What is the current in each branch?

$I_1 = V/R = 12/2 = \underline{6A}$

$I_2 = V/R = 12/3 = \underline{4A}$

c. What is the total current provided by the batteries?

$I_T = I_1 + I_2$

$= 6 + 4 = \underline{10A}$

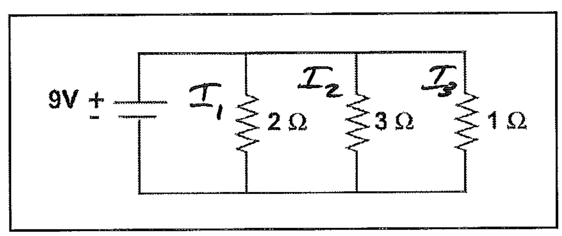
d. Use the total current and the total voltage to calculate the total resistance of the circuit.

$R = V/I \quad 12/10 = \underline{1.2A}$

$R_{eq} = 6/5 = \underline{1.2}$

$1/R_{eq} = 1/2 + 1/3 = 3/6 + 2/6 = 5/6$

4. Use the parallel circuit pictured right to answer questions (a) - (c).



a. What is the voltage across each resistor?

9V Parallel Rule

b. What is the current in each branch?

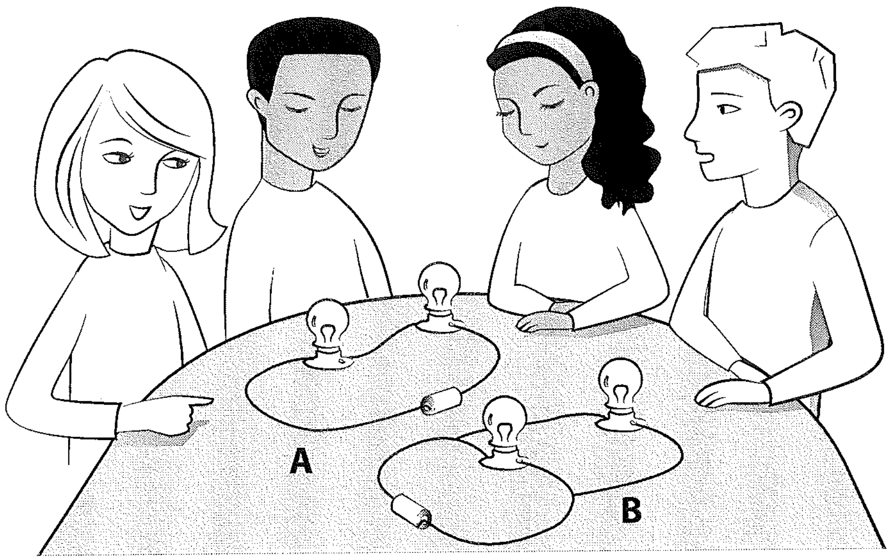
$I_T = I_1 + I_2 + I_3$

$I_1 = V/R \quad 9/2 = 4.5 \quad I_2 = 9/3 = 3A \quad I_3 = 9/1 = 9A$

c. What is the total current provided by the battery?

$I_T = 4.5 + 3 + 9 = \underline{16.5A}$

Which Burns Brighter?



A group of students built two different types of circuits in their science class. They wondered if the type of circuit made a difference in how brightly the bulbs burned. This is what they said:

Carlos: I think the bulbs in circuit A will burn the brightest.

Margaret: I think the bulbs in circuit B will burn the brightest.

Gwen: I think the first bulb in circuit A will burn as bright as the bulbs in circuit B, but the second bulb in circuit A will be dimmer.

Olaf: I think both bulbs will be the same brightness.

With which student do you agree the most? ______________ Explain why you agree.

____

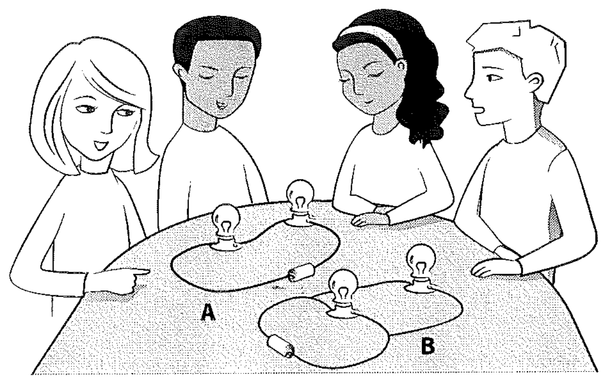
____

____

____

Which Burns Brighter?

Teacher Notes



Purpose

The purpose of this assessment probe is to elicit students' ideas about types of circuits (series and parallel). The probe is designed to reveal students' thinking about the effect of circuit configuration on bulb brightness.

Related Concepts

circuit, current, parallel circuit, series circuit, resistance

Explanation

The best answer is Margaret's: "I think the bulbs in circuit B will burn the brightest." Bulbs connected side by side in this way are described as being connected "in parallel." In circuit A the bulbs are connected one after the other. In this circuit, the bulbs are described as being connected "in series." Each lightbulb represents an obstacle to the electric current when connected in series. As a result, light bulbs connected in series will be dimmer than lightbulbs connected in parallel, but both bulbs within the circuit will have the same brightness. When connected in parallel to the battery, each bulb has its' own connection to the battery and burns with the same brightness as other identical bulbs connected with their own paths directly to the battery.

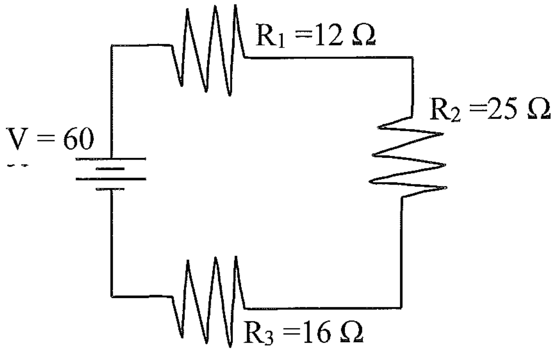
Administering the Probe

This probe is best used with middle and high school students. If materials are available, consider showing each of the circuits (without lighting the bulbs). Make sure students know that the same type of battery is used in both circuits. This probe can be used with the P-E-O strategy described on pages xii.

Related Research

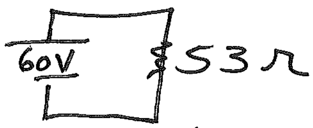
- Some students initially believe that bulbs in a parallel circuit would be less bright than a single bulb (Chang, Liu, and Chen 1998).
- Students who choose Gwen see some of the current being used up by the first bulb in

Name: ______________________ Date: ______________ Period: _____



Resistance (Ω)	Voltage (V)	Current (A)	Power (W)
R_{eq}= 53	60	1.13	67.8
R_1= 12	13.56	1.13	15.32
R_2= 25	28.25	1.13	31.92
R_3= 16	18.08	1.13	20.43

$R_{eq} = 12 + 25 + 16$
$= 53\,\Omega$



$I = V/R \quad 60/53 = \underline{1.13\,A}$

☆ Series Rule - current is constant

$P_{Total} = VI$
$= (60)(1.13)$
$= 67.8\,W$

$V_1 = IR$
$= (1.13)(12)$
$= 13.56$

$V_3 = IR$
$= (1.13)(16)$
$= 18.08$

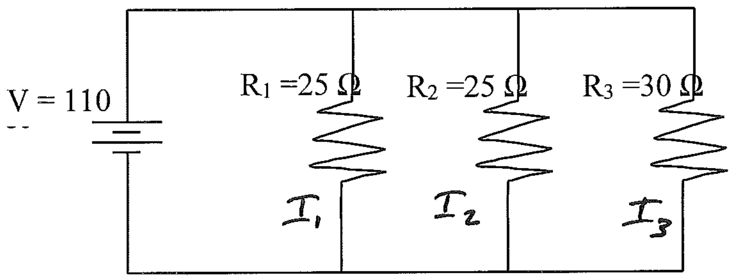
$V_2 = IR$
$= (1.13)(25)$
$= 28.25$

$P_1 = (13.56)(1.13)$
$= 15.32$

$P_2 = (28.25)(1.13)$
$= 31.92$

$P_3 = (18.08)(1.13)$
$= 20.43$

Name: ______________________ **Date:** ______________ **Period:** _____



Resistance (Ω)	Voltage (V)	Current (A)	Power (W)
R_{eq}= 8.82	110	12.47	1371
R_1= 25	110	4.4	484
R_2= 25	110	4.4	484
R_3= 30	110	3.6	396

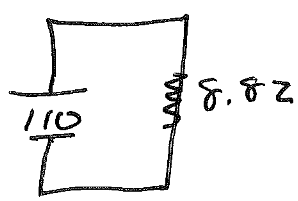
Parallel Rule - voltage is equal in all branches

$$\frac{1}{R_{eq}} = \frac{1}{25} + \frac{1}{25} + \frac{1}{30}$$

$$= \frac{30}{750} + \frac{30}{750} + \frac{25}{750}$$

$$\frac{1}{R_{eq}} = \frac{85}{750}$$

$$R_{eq} = \frac{750}{85} = \underline{8.82\,\Omega}$$



$$I_T = V/R = 110/8.82 = \underline{\underline{12.47A}}$$

$$I_1 = V/R = 110/25 = 4.4A$$

$$I_2 = V/R = 110/25 = 4.4\ A$$

$$I_3 = V/R = 110/30 = 3.6\ A$$

12.4 ☆

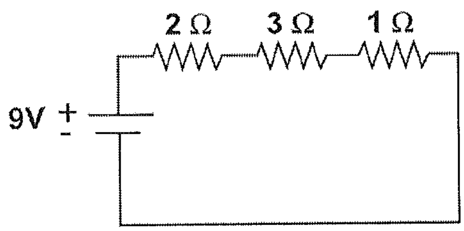
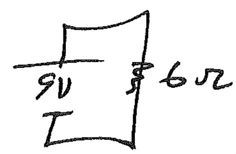
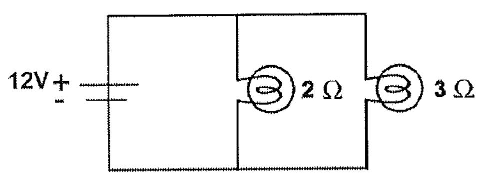
$$P_T = VI$$
$$= (110)(12.47)$$
$$= 1371$$

$$P_1 = VI$$
$$= (110)(4.4) =$$
$$= 484$$

$$P_2 = VI$$
$$= (110)(4.4$$
$$= 484$$

$$P_3 = VI$$
$$= (110)(3.6)$$
$$= 396$$

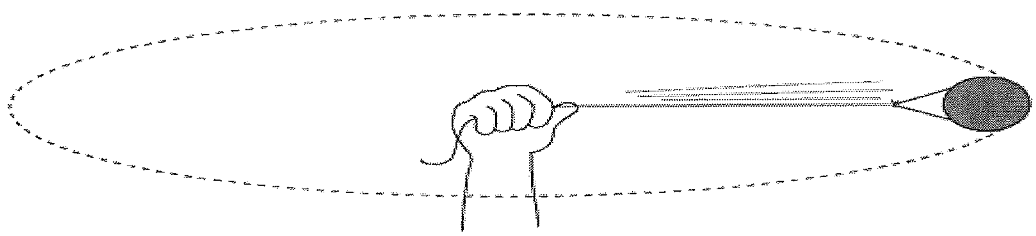
Name: ______________________ Date: ____________ Period: _____

MONDAY 3/28/16	QUIZ
TUESDAY 3/29/16	Find the Current for this circuit  $R_{eq} = 2 + 3 + 1 = \underline{\underline{6}}$  $I_T = 9/6 = 1.5\,A$
WEDNESDAY 3/30/16	Find the current in each branch.  $I_1 = 12/2 = 6\,A$ $= 12/3 = 4\,A$
THURSDAY 3/31/16	No warm up
FRIDAY 4/1/16	TEST

Name: ______________________ Date: ______________ Period: ______

MONDAY 4/4/16

A 0.040 kg ball tied to a string moves in a circle that has a radius of 0.700 m.



If the ball is accelerating at 43.2 m/s^2, what is the tangential velocity of the ball?

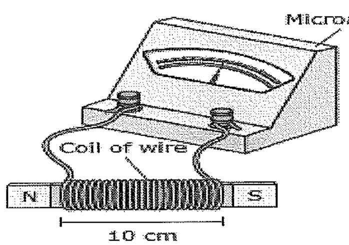
- F 5.50 m/s
- G 30.2 m/s
- H 1.73 m/s
- J 61.7 m/s

$a_c = \frac{V_t^2}{r}$ $\sqrt{(43.2)(.7)} = V_t$

$(a_c)(r) = V_t^2$

TUESDAY 4/5/16

A student wants to generate an electric current using a bar magnet and a coil of wire.



Possible Laboratory Setups

Lab Setup	Wire Diameter	Number of Loops
K	Thin	200
L	Thin	100
M	Thick	200
N	Thick	100

Which experimental setup will generate the greatest electric current?

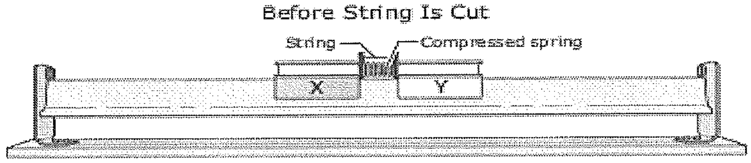
- A Setup K
- B Setup L
- C Setup M
- D Setup N

more loops
&
Bigger wire

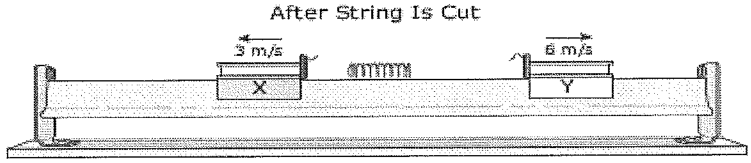
WEDNESDAY 4/6/16

The first diagram shows two gliders, X and Y, on a nearly frictionless air track. A spring is compressed between the two gliders. The gliders are tied together tightly by a piece of string. The second diagram shows what happens to the gliders when the string is cut.

Before String Is Cut



After String Is Cut



Which of the following quantities is the same for both gliders while the spring is pushing them apart?

- A Magnitude of acceleration
- B Kinetic energy
- C Mass
- D Magnitude of momentum

↳ Diff velocities