Name: _____ _____
First Name *Last Name*

Name: _____ _____
First Name *Last Name*

School: _____
Full School Name, No Abbreviations

SHOCK VALUE

Pembroke Hill Invitational
December 7, 2013

EXAM BOOKLET

INSTRUCTIONS

- By marking your names and school on the lines above and on your Answer Sheet, you are agreeing to the Science Olympiad Code of Ethics Students' Pledge: "[I/We] will compete with integrity, respect, and sportsmanship towards my fellow competitors. [I/We] will display courtesy towards Event Supervisors and Tournament Personnel. My actions will exemplify the proud spirit of my school." The Shock Value Event Supervisor can deduct points from a team's final score at her discretion if they fail to uphold the Student's Pledge.

- You are only allowed to use a calculator and any notes and references secured within a three-ring binder. All other materials are prohibited. (You can use either pencil or blue or black pen to complete the exam.)

- An illegible response will be an incorrect response. Thus, write neatly.

- Be sure you have ten pages in the Exam and eight pages in the Answer Sheet. If you do not have all of the pages in the Exam or Answer Sheet, alert the Event Supervisor immediately.

- When using the computer, only visit the assigned website, and all responses should be copied onto the Answer Sheet. A team will be disqualified for visiting a non-test website.

FORMAT

- The exam consists of four sections: Multiple Choice (30 points, 1 point per question), Fill-In (10 points, 1 point per question), Free Response (30 points, varying points per question), and Document-Based Short Answer (10 points, 5 points per question). The exam is 80 points total.

- You will have fifty-minutes to complete the entire exam. You can pace yourself and divide the exam however you choose. There are "suggested times" for how long to spend on each section, but you can follow or ignore these suggestions. (Tip: Skip questions you don't immediately know the answer to or you think might take a long time to figure out. Return to those questions later. The questions are NOT arranged by difficulty level.)

- Ties will first be broken by the highest score on the Multiple Choice section, followed by the highest score on the Document-Based Short Answer section, followed by the highest score on the Free Response section, followed by the highest score on the Fill-In section.

Exam by Jeffrey Rubel (Williams College (MA), Class of 2017) and Supervised by Dr. Kim Cho (Pembroke Hill Science)

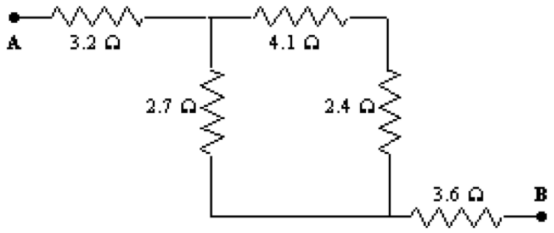
SECTION I: MULTIPLE CHOICE

Suggested Time: 15 Minutes
30 Questions, 30 Points

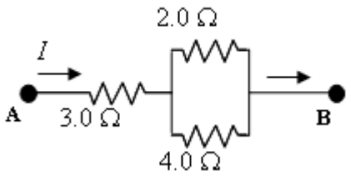
Directions: *For each question, select the best answer from among the choices (A-E) given, and mark the appropriate corresponding letter on your Answer Sheet. Pay close attention to any provided figures found alongside their corresponding question(s).*

1. Which of the following most accurately describes the current location of the Magnetic South Pole?
   (A) Center of the Arctic Ocean and Arctic Circle.
   (B) Northern area of the Canadian province of Nunavut.
   (C) South Pacific Ocean between Australia and Antarctica.
   (D) The center of the Antarctic continent.
   (E) Scientists do not have enough information to accurately determine the pole's location.

2. In a circuit with a 20 V battery and a current flow of 10 A, there are three resistors wired in series: one is 1.0 Ω, one is 0.75Ω, and the final resistor is:
   (A) 0.15 Ω
   (B) 0.25 Ω
   (C) 0.65 Ω
   (D) 0.75 Ω
   (E) None of the above.

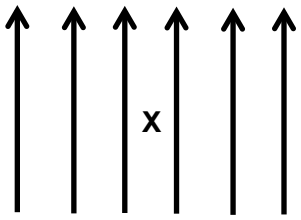


3. Consider the circuit shown above. If the current flow between points A and B is 15 A, determine the voltage drop between points A and B.
   (A) 14.55 V
   (B) 21.04 V
   (C) 35.40 V
   (D) 125.2 V
   (E) 130.7 V



4. Consider the circuitry shown above. What is the equivalent resistance between points A and B?
   (A) 9.0 Ω
   (B) 3.8 Ω
   (C) 4.3 Ω
   (D) 5.1 Ω
   (E) 6.8 Ω

5. Consider the circuitry shown above. The voltage drop between points A and B is 26 V. Calculate the magnitude and direction of the magnetic field around the wire at a distance of one meter (1.0 m).
   (A) 1.02×10^{-6} T, out of the page (above wire).
   (B) 1.02×10^{-6} T, into the page (above wire).
   (C) 1.20×10^{-6} T, out of the page (above wire).
   (D) 1.20×10^{-6} T, into the page (above wire).
   (E) 1.37×10^{-6} T, out of the page (above wire).



6. Consider the magnetic field diagram shown above. The arrows indicate the direction of the field, and the "x" indicates the direction a proton is moving through the field. Determine the direction of the force acting upon the proton.
   (A) The force is going to the left.
   (B) The force is going to the right.
   (C) The force is going into the page.
   (D) The force is going out of the page.
   (E) The force is going up.

7. You recently purchased a new 20 Horsepower engine for your boat (with a current of 450 A). Determine the voltage of this engine when it is running on full power if your engine to the nearest units digit. (Hint: The ratio of horsepower to watts is 1:476.)
   (A) 1 V
   (B) 12 V
   (C) 21 V
   (D) 28 V
   (E) 42 V

8. One day, a car mechanic comes up to you carrying a very large wrench. He says: "This wrench became magnetized after I accidently set it near a large magnet. This wrench is very annoying, attracting nails and small metal items from all around my shop. Please help me demagnetize my wrench!" Which of the following responses would be correct?
   (A) "I'm sorry, but there's nothing you can do about your wrench. You might as well buy a new one."
   (B) "The best solution is just to wait a really long time. I'd give it a few years, and your wrench will be good to use again."
   (C) "You should place your wrench in an electrolyte solution—like very salty water—and run a current through this water."
   (D) "You should place your wrench next to the same magnet but in the opposite direction to reverse the magnetization in the wrench."
   (E) "The best solution is to connect the wrench to a circuit with at least twenty volts running through it, and viola! Problem solved!"

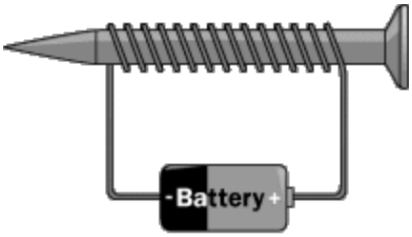
9. Science Olympiad added a new section to the Shock Value rules where participants construct an electromagnet and then bring it in for testing. You have a working electromagnet, but you want to increase its strength. Which of the following should you do?

   I. Pass a greater electrical current through the coil.
   II. Use more turns of wire in the coil.
   III. Replace the iron core with an aluminum core.

   (A) I only
   (B) III only
   (C) I and II only
   (D) II and III only
   (E) I, II and III

10. You wire two circuits: One with three 10Ω light bulbs in parallel connected to a 20V battery, and one with three 10Ω light bulbs in series connected to a 20V battery. You set up both circuits at the same time. Which battery will die first?
   (A) The battery in the parallel circuit will die first.
   (B) The battery in the series circuit will die first.
   (C) Both batteries should die at the same time.
   (D) Both batteries should never stop running because of the given voltage and light bulb resistances.
   (E) What a silly question! There is not enough information to tell.

11. You find a resistor like the one pictured above around your house with the band colors (from left to right): Yellow, Orange, Red. The fourth band is too dirty to be read. What is the resistance of the resistor you found?
   (A) 1200 Ω
   (B) 3200 Ω
   (C) 4300 Ω
   (D) 5900 Ω
   (E) 8700 Ω



12. Your friend has a compass and the electromagnet shown above, and he wants to know which side of the nail the North needle in the compass will point towards. So, you decide to help your friend and answer his question: Which end of the nail will the North needle on the compass point towards?
   (A) The North needle will point towards the right end of the nail.
   (B) The North needle will point towards the left end of the nail.
   (C) The North needle will point towards the center of the nail.
   (D) The North needle will spin wildly, and your compass will break.
   (E) The North needle will not point towards either end but instead start doing the Chicken Dance.

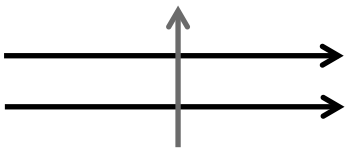
13. If you were an electrical engineer or a science nerd in the late 1880s, you heard about the War of the Currents (i.e., the debate over AC and DC current and which is better). Which of the following people were involved in this debate?

    I. Thomas Edison
    II. Nikola Tesla
    III. Gustav Kirchhoff
    IV. The band AC/DC

    (A) I and II only
    (B) II and III only
    (C) I and III only
    (D) I, II and III
    (E) IV only

14. In which of the following scenarios will a force **not** be exerted on the particle?
    (A) A proton moving to the right through a magnetic field going to the left.
    (B) An electron moving into the page through a magnetic field going to the left.
    (C) An electron moving out of the page through a magnetic field going to the right.
    (D) A proton moving up through a magnetic field going into the page.
    (E) An electron moving up through a magnetic field going out of the page.

15. If you double the radius of a copper wire, what will happen to the resistance of the wire? Assume resistivity and length do not change.
    (A) The new resistance will be half of the original resistance.
    (B) The new resistance will be one fourth of the original resistance.
    (C) The resistance will be double the original resistance.
    (D) The new resistance will be four times greater than the original resistance.
    (E) There is not enough information to answer the question.

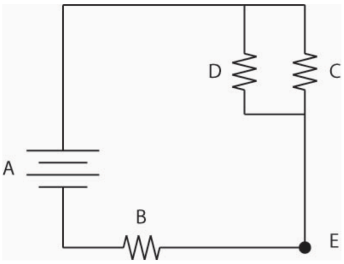


16. Consider the diagram above. A particle with a charge of 4.0 C is moving upward at 2.0 m/s in a 6.0 T electric field going to the right. What is the magnitude of the force on the particle moving through the field?
    (A) 6 N
    (B) 12 N
    (C) 24 N
    (D) 32 N
    (E) 48 N

17. Which of the following are Kirchhoff's circuit laws? (Pictured to the right.)

    I. The sum of the currents flowing into a junction is equal to the sum of the current flowing out of the junction.
    II. The current flowing through two branches in parallel circuitry will always be equal.
    III. The total voltage around a closed circuit loop will always equal zero.

    (A) I and II only
    (B) II and III only
    (C) I and III only
    (D) I, II, and III
    (E) None of the above.

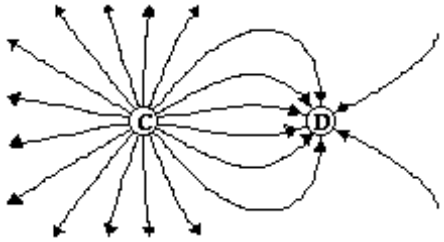


18. Consider the circuit shown above. In what direction (from the battery) is electron (e^-) flow going in the circuit, and in what direction is conventional current going?

	e^- flow	*conventional current*
(A)	Up	Up
(B)	Down	Up
(C)	Up	Down
(D)	Down	Down

    (E) Not enough information to tell.

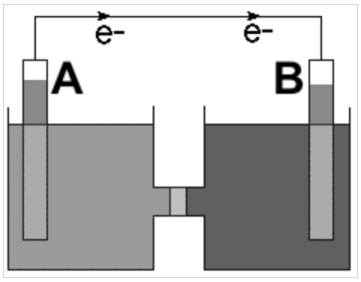
19. Consider the circuit shown above. If the voltage of A is 30 V, the resistance of B is 5 Ω, the resistance of C is 8 Ω, and the resistance of D is 4 Ω, what is the current flow at E?
    (A) 1.7 A
    (B) 3.9 A
    (C) 7.6 A
    (D) 8.5 A
    (E) 230 A



20. In the diagram above, field lines are drawn between two particles. Which of the following are possible charges for particles C and D? Assume all charges given are in μC.

	Particle C	*Particle D*
(A)	9	4
(B)	-18	8
(C)	24	-18
(D)	36	-16

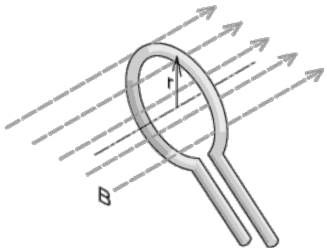
(E) Not enough information to tell.



21. Consider the voltaic cell pictured above. Which electrode is the anode, and which electrode would carry a positive charge?

	Anode	*Positive Charge*
(A)	A	A
(B)	A	B
(C)	B	A
(D)	B	B

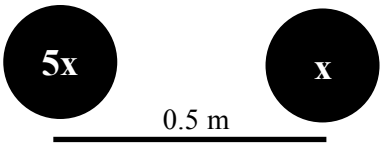
(E) Not enough information to tell.



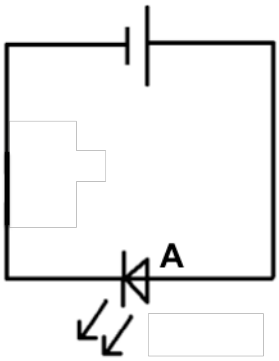
22. You create a loop of wire with radius r=5 and attach it to a 12 V battery. You then place this loop of wire in a 20 T magnetic field (*B*). The set-up is shown above. What happens?
    (A) The coil will fall in on itself to a radius of r=0.
    (B) The coil will begin to rotate within the magnetic field.
    (C) The coil will be pushed out of the magnetic field and move to the right.
    (D) The radius of the coil will increase to r=20.
    (E) None of the above.

23. Which of the following situations would result in a conventional current that flows eastward?
    (A) A beam of protons moving eastward.
    (B) A beam of electrons moving eastward.
    (C) A beam of protons moving westward.
    (D) A beam of electrons moving westward.
    (E) More than one of the above would result in the desired situation.

24. Which of the following situations would result in a short circuit?
    (A) A 100 Ω resistor is wired in parallel with a 0.01Ω resistor and attached to a 12V battery.
    (B) A 10 Ω resistor is wired in series with a 10 μF capacitor and attached to a 12 V battery.
    (C) A 8 Ω resistor is wired in parallel with a 4 Ω resistor and attached to a 12 V battery.
    (D) A 12 V battery is wired in parallel with a 5 V battery and attached to two 10Ω resistors in parallel.
    (E) A 12 V battery is wired in parallel with a 10 Ω resistor and in series with a 10 μF capacitor and attached to another 10 Ω resistor.



25. Consider two particles 0.5 m apart from each other, with charges of 5x C and x C. Coulomb's Law is: $F=k\frac{|q_1||q_2|}{r^2}$, where F is force, k is Coulomb's constant, q is the charge on the particle, and r is the distance between the particles. Using Coulomb's Law, determine (1) the direction of the force exerted on the two particles, and, (2) if the distance between the two particles was doubled, what would be the magnitude of the new force? (Hint: You don't need your calculator!)
    (A) 1: To the right.
        2: The new force will be four times larger than the original force.
    (B) 1: To the right.
        2: The new force will be half the original force.
    (C) 1: To the left.
        2: The new force will be four times smaller than the original force.
    (D) 1: To the left.
        2: The new force will be half the original force.
    (E) 1: To the left.
        2: The new force will be four times larger than the original force.



26. Consider the circuitry shown above. What direction is the magnetic field *inside* of the circuit, and what does symbol A represent?

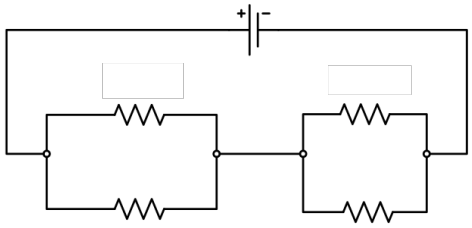
	Magnetic Field	*Symbol A*
(A)	Into the page	Ammeter
(B)	Into the page	LED light
(C)	Out of the page	Ammeter
(D)	Out of the page	LED light

(E) Don't pick answer choice (E).

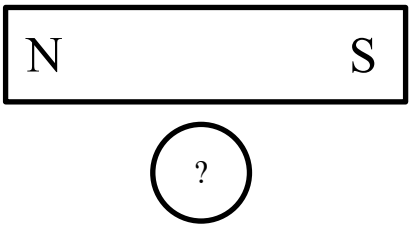
27. Which pair of particles below would create an electric dipole?

I. -5 μC and 5 μC
II. 12 μC and -6 μC
III. 9 μC and 18 μC

(A) I only
(B) II only
(C) III only
(D) I and II only
(E) II and III only

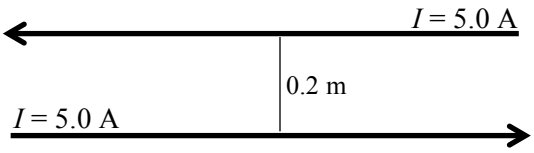


28. Consider the circuit shown above with a 30 V battery and four 5Ω resistors. Determine the potential difference of the circuit (ignoring units).
(A) 2.5
(B) 5
(C) 6
(D) 30
(E) 180



29. Consider the compass and magnet set-up shown above. The blank circle represents the location of the compass. Which of the diagrams below shows the proper direction of the North needle in the compass in association with the given magnet?

(A) 
(B) 
(C) 
(D) 
(E) 



30. Consider the diagram shown above. The top wire is carrying a current of 5.0 A to the left, and the bottom wire is carrying a current of 5.0 A to the right. The wires are 0.2 m apart. What will happen to the two wires? (Hint: Remember a wire carrying current creates a magnetic field.)
(A) The wires will be attracted to each other.
(B) The wires will be repelled from each other.
(C) The wires will be neither attracted nor repelled from each other.
(D) If the distance between the wires was less than 0.2 m, the wires would be attracted, but if the distance was greater than 0.2 m, the wires would be repelled.
(E) How silly! This situation is impossible!

• CONTINUE TO SECTION II •

SECTION II: FILL-IN

Suggested Time: 5 Minutes
10 Questions, 10 Points

Directions: *Each phrase below is missing a vocabulary term; this missing term is marked by a* ***[--]*** *in the sentence. Complete each phrase with the appropriate word, and mark your answer in the corresponding blank on the Answer Sheet. Do not give abbreviations for any terms (e.g., spell out "ohm" instead of writing "Ω").*

1. A(n) **[--]** is an equivalent unit to a watt per volt. In other words, a watt divided by a volt is equivalent to this unit (i.e., 1 **[--]** = 1 W ÷ 1 V).

2. You have two bar magnets, like the ones shown to the right. You hold the two bar magnets so their South ends are close together. These two magnets will **[--]** each other.

3. The **[--]** of a specific conductor is the ratio of the voltage across the conductor to the current running through it.

4. The term **[--]** describes a strong magnetic effect exhibited by the atoms of certain elements (most notably iron), and it forms the basis for most magnetism in commonly used magnets.

5. A coil of wiring carrying a current is most often called a(n) **[--]**.

6. A magnetic field going into the page is exerting a downward force on a particle moving to the right. This particle must have a(n) **[--]** charge.

7. Also known as magnetite, **[--]** is a naturally occurring "permanent" magnetic mineral. The Chinese first used this mineral in the twelfth century to assist with navigation. Later, explorers like Columbus carried this mineral to "recharge" their other compasses.

8. The magnetic force exerted on a wire is affected by the length of the wire, the **[--]** in the wire, the angle between the wire and the magnetic field, and the magnitude of the magnetic field.

9. Plastic and glass are examples of **[--]**, materials in which charge does not flow freely.

10. In a(n) **[--]** circuit, the flow of electrons is disrupted by a break or an interruption such as a switch or a broken wire. (This term is the opposite of the term used to describe a complete circuit with no interruptions, which would allow electrons to easily flow.)

• CONTINUE TO SECTION III •

SECTION III: FREE RESPONSE

Suggested Time: 20 Minutes

5 Questions, 30 Points

Directions: *Each question in this section has a different point value given in parentheses following the question. Mark all responses on your Answer Sheet, and, in order to get partial credit for any mathematical questions, be sure to show your work. You do not need to use complete sentences to answer any of these questions. All questions in this section will require you to use the computer. When doing so, only visit the listed websites and simulations to answer the questions. If you are having trouble with the computer or simulations, alert the Event Supervisor for assistance.*

1. Using the computer, go to: **bit.ly/shockv1** (or go to **bit.ly/shockv6** and download this simulation if the other simulation does not open). Use one of these circuit simulations to answer the questions below.

   (A) Create a circuit with two 4 Ω, 10 W light bulbs in parallel with a 2 V battery. What do the dots moving through the wire represent? *(1 point)*

   (B) Change the resistance of the light bulb closest to the battery to 2 Ω, 10 W (leaving the other at 4 Ω, 10 W). How does the flow of the dots change? Why? *(2 points)*

   (C) Add a 0.5 Ω, 10 W resistor in series to the circuit between the battery and the two light bulbs. Diagram this set-up using proper circuitry symbols. *(2 points)*

   (D) Consider the same circuit in (C). Calculate the current flow through the 2 Ω, 10 W light bulb and the 4 Ω, 10 W light bulb. Show your work when making the calculation. *(2 points)*

   (E) Change the resistance of the resistor from 0.5 Ω to 2.0 Ω. What happens to the 4 Ω, 10 W light bulb? To support your answer, calculate the current flow and voltage drop for this 4 Ω, 10 W light bulb. *(3 points)*

2. Using the computer, go to: **bit.ly/shockv2**. Use this resistance equation simulation to answer the questions below.

   (A) What does the "ρ" stand for? In addition to giving the term, define it and explain how it affects the conductivity of a material. (Hint: These black dots do not represent the same thing as the black dots in #1A.) *(2 points)*

   (B) If the length of a wire increases, what must happen to the area of the wire in order to keep the resistance the same? (Assume all other variables are held constant.) *(1 point)*

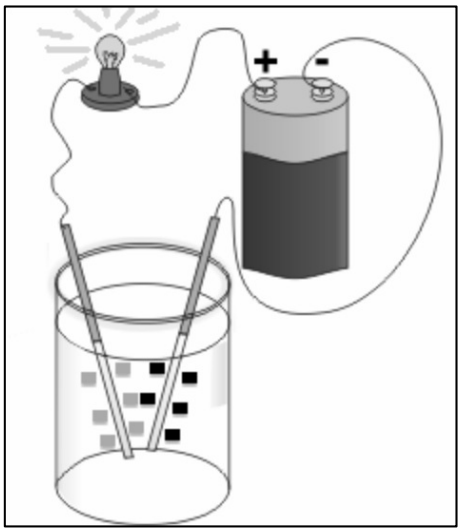
   (C) If a wire has a R of 6.9 Ω, ρ of 0.5 Ωcm, and a L of 20 cm, determine the radius (in m) of the wire. Show *all* work for partial credit. *(2 points)*

3. Using the computer, go to: **bit.ly/shockv3**. Use this electric field simulation to answer the questions below.

   (A) Check the "Show E-field" and "Show lo-res V" boxes. Place a + 1nC particle on the left side of the screen and a – 1 nC particle on the right side of the screen. Also, add an E-Field Sensor on the screen and move it around. What does the red arrow attached to the orange E-Field Sensor represent? *(1 point)*

   (B) Press the "Clear All" button. Place two + 1 nC charges on top of each other on the left side of the screen (to create a + 2 nC particle). On the right side of the screen, place an E-Field Sensor. Press the "Show numbers" and then the "Tape measure" boxes. Determine the magnitude and direction of the electric field at the point of the E-Field Sensor. *(3 points)*

   (C) Press the "Clear All" button. Place a few particles at various places around the screen. Move the Equipotential box (in the bottom left corner) around the screen and press the "Plot" button at various places on the screen. What do the lines that form when the "Plot" button is pressed mean? Define equipotential. *(2 points)*



4. Using the computer, go to: **bit.ly/shockv4**. Use this electrolyte solution simulation to answer the questions below. Or, if the simulation does not work or you do not want to use the simulation, use the image shown above.

   (A) If you use the simulation, press the "On/Off" button on the monitor; do *not* change the concentration, cation, or anion buttons. Which of the two molecule types—the red or the white in the simulation, or the gray or the black in the picture—represents the cation? Answers for the image and simulation will both be accepted. *(1 point)*

   (B) The given solutions in the simulation and the image are able to pass electric currents. Again, if you are using the simulation, do *not* change the concentration, cation or anion buttons. Define electrolyte solution and explain how it can carry a current and how it differs from a wire carrying current. How does the change in concentration affect the conductivity (do *not* actually change the concentration)? *(4 points)*

5. Using the computer, go to: **bit.ly/shockv5**. Use this magnetic domain video simulation to answer the questions below.

   (A) Before starting the video, define magnetic domain, and explain how domains give rise to magnetism. *(2 points)*

   (B) How can magnetic domains be induced within a nonmagnetic material? Consider the beginning of the video (0:00-0:30) when answering. *(1 point)*

   (C) Consider the domains shown at 1:10 in the video. The black part of the compass needle represents North. If these compass needles were all within one large magnet, which end of the magnet (up, down, right, left) would be North? Also, consider the domains shown at 1:45 in the video. If these compass needles were all within one large magnet, which end of the magnet (up, down, right, left) would be North? *(1 point)*

• CONTINUE TO SECTION IV •

SECTION IV: DOCUMENT-BASED SHORT ANSWER

Suggested Time: 10 Minutes
2 Questions, 10 Points

Directions: *For each of the questions below, review the corresponding sources before answering the question. Use complete sentences following Standard Written English when writing your answer, and, in your answer, be sure to reference the sources. Write your responses in the appropriate space on your Answer Sheet.*

1. Consider Sources 1 and 2. Explain the phenomenon Grace is experiencing in the context of static electricity and why the balloon caused her hair to stand on end. *(5 points)*

2. Consider Sources 3 and 4. Explain how paleomagnetism (magnetic evidence preserved in rocks) supports Marie Tharp's idea of continental drift and how this paleomagnetic evidence would have originally formed. *(5 points)*

Source 1: *A (fake) newspaper clipping from the* Shock Value Herald *on June 5, 2011 by SueAnn Wright.*

Girl Rubs Balloon on Hair, Says result is "magical"

WILLIAMSTOWN, MA: 12-year old Grace Firestone was playing with a party balloon on Friday when she rubbed it against her hair. As Firestone pulled the balloon away from her hair, the hair began to stand on end and spread out.

Firestone explains the experience was "magical." She said: "I'm not sure what happened. I was just playing with the balloon and then my hair just started to follow the balloon! It was freaky!" Grace's mother, Kim, was also surprised by what was happening; she called an ambulance to help her daughter because "she was afraid the damage to the hair by the balloon could be permanent," Kim Firestone said. After a few minutes, Grace Firestone's hair fell back into place, and Kim bought ice cream to celebrate. ■

Source 2: *Sketch of Grace Firestone published alongside the* Herald *article on June 5, 2011.*

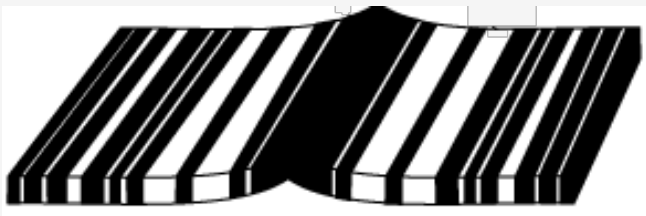
Source 3: *A (real) newspaper clipping from the* New York Times *on August 26, 2006 by Margalit Fox.*

Marie Tharp, Oceanographic Cartographer, Dies at 86

NEW YORK, NY: With Bruce C. Heezen, Ms. Tharp compiled the first comprehensive map of the entire ocean bottom, illuminating a hidden world of rifts and valleys, volcanic ranges stretching for thousands of miles and mountain peaks taller than Everest.

Ms. Tharp's work in plotting the ocean's bottom would also help gain acceptance for the theory of continental drift, still a fairly subversive proposition when she and Mr. Heezen began their collaboration in the late 1940's. Charting the soundings in 1953, she observed what seemed to be a depression in the mid-Atlantic Ridge, a volcanic chain that traverses the ocean from north to south. She wondered whether the depression was evidence of a continuous rift — a crack in the world — down the middle of the ridge. And she wondered in turn whether that rift might be evidence of what scientists now call seafloor spreading. *(bit.ly/mtharp)* ■

Source 4: *Paleomagnetic data from a mid-ocean ridge found by later scientists to support continental drift. (Note the symmetric black and white stripes.)*



• END OF EXAM •