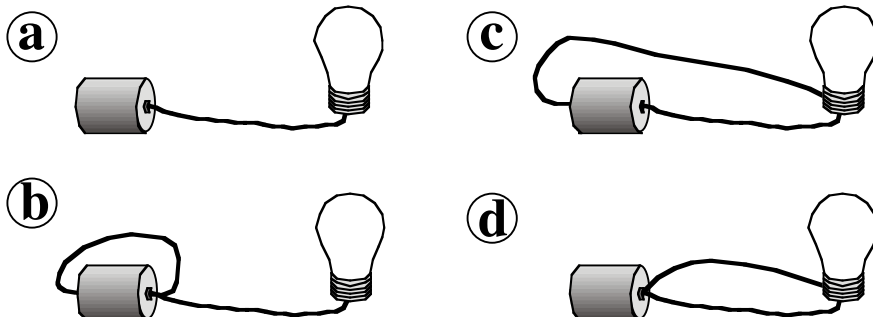


PHYSICAL SCIENCE TEST

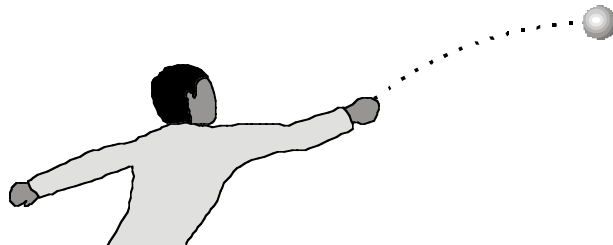
For some questions, there may be more than one correct answer. However, each question has only one best answer. Choose the single best answer from the five choices for each question.

1. Each of the arrangements below includes a battery, light bulb, and wire. Which arrangement will light the bulb?



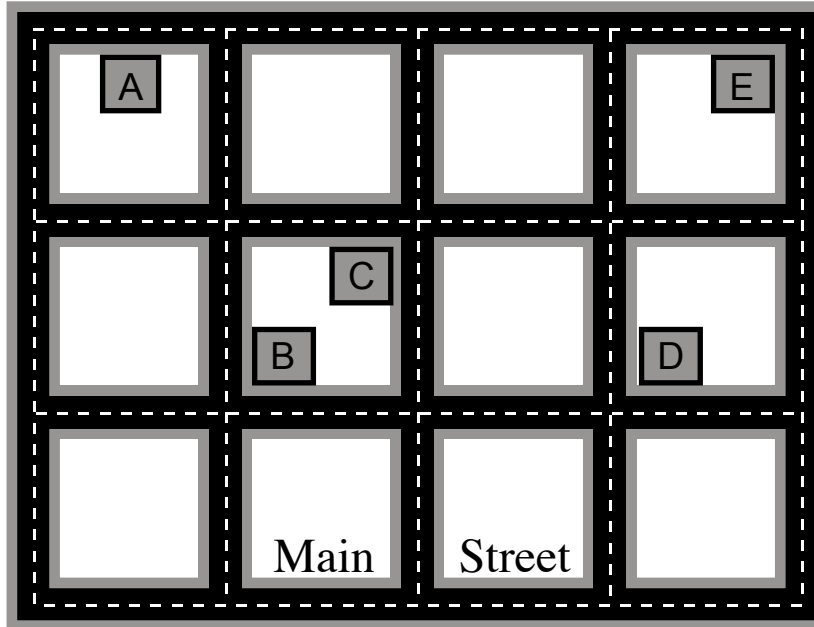
(e) More than one of the above.

2. A solid red block and a solid green block of the same size are placed in a container of water. The red block floats and the green block sinks. From this you know that:
- the two blocks are made of the same material.
 - the red block is heavier than the green block.
 - the green block is heavier than the red block.
 - the two blocks weigh the same.
 - You cannot say anything else about the blocks.
3. A metal pan of water is left on a counter. After a few days, there is less water in the pan. What most likely happened?
- Some water became part of the pan.
 - Movement of the air pulled water out of the pan.
 - Some water turned into oxygen and hydrogen.
 - Some water went into the air as a gas.
 - Some water no longer exists.
4. When a thrown baseball reaches the top of its path (see below), the main push or pull acting on it is:



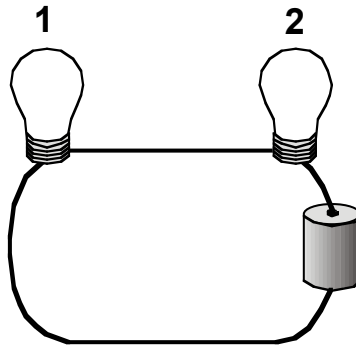
- caused by Earth's magnetic field.
- the force from the person throwing it.
- due to Earth's rotation.
- the pull of gravity.
- No force is acting on the ball.

5. Look at the map below.



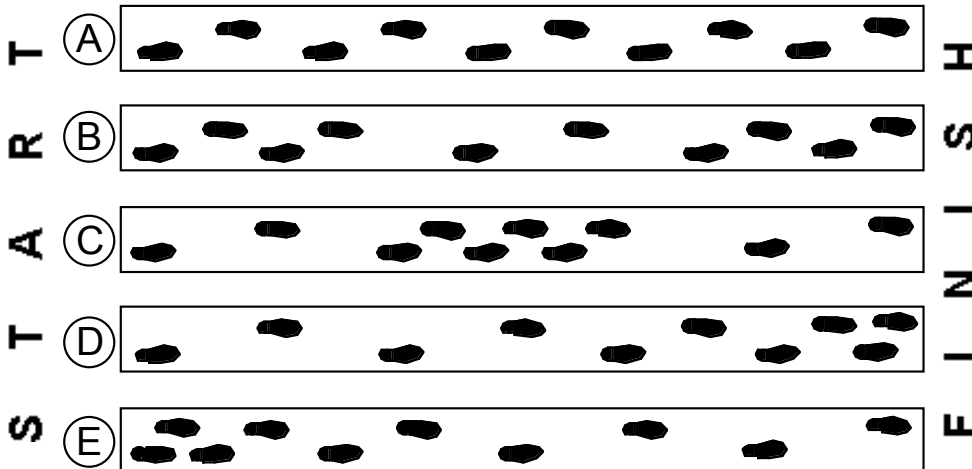
- Which of the houses is located closest to House C along the streets?
- A
 - B
 - D
 - E
 - A and B
6. What is true about the source of any sound?
- A living thing had to be involved.
 - Something had to vibrate.
 - Air had to be involved.
 - More than one of the above.
 - None of the above.
7. Which of these tools is least like a ruler?
- A radio.
 - A clock.
 - A measuring cup.
 - A thermometer.
 - None of these is like a ruler.
8. Scientists say a metal doorknob indoors often feels cold to you because:
- cold from the doorknob goes into your hand.
 - heat from your hand goes into the doorknob.
 - cold moves from the doorknob to your hand.
 - heat is pulled from the doorknob by your hand.
 - metals are always colder than air.

9. Identical lights 1 and 2 are connected to the battery in the circuit below.

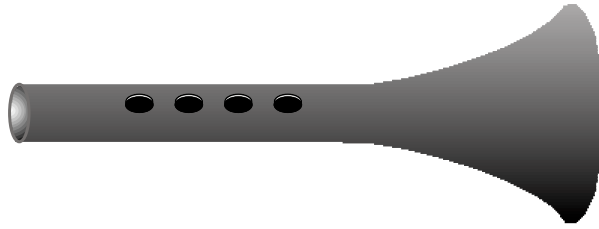


When connected as shown:

- light 1 is brighter than light 2.
 - light 1 is dimmer than light 2.
 - light 1 is the same brightness as light 2.
 - one of the lights remains unlit and the other lights up.
 - There is no way to tell if the lights' brightness would be the same or different.
10. On a hot day, Paul left a glass of ice water outside. After a while, the outside of the glass was wet because:
- the water in the glass seeped through the glass.
 - the ice in the glass became the water on the outside.
 - the water in the air became cooler and became liquid.
 - the ice in the glass melted and overflowed.
 - No one knows why the glass is wet.
11. Jon is walking on a path in a park. He slows down as he passes some flowers then resumes his normal pace. Which pattern of footprints below best represents John's footprints?



12. Michael made a low pitch sound on a horn (below) and wants to make a high pitch sound.



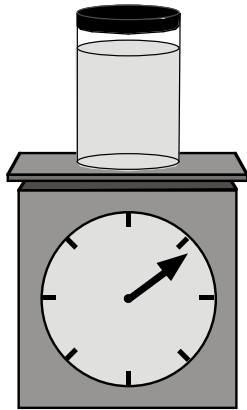
To make the high pitch sound, Michael must:

- a. cover more holes with his fingers.
- b. blow into the horn with more force.
- c. blow into the horn for a longer time.
- d. make the air vibrate faster.
- e. hold the horn more firmly.

13. If you cut a bar magnet in half, each half will:

- a. no longer attract objects.
- b. attract from both ends.
- c. attract objects only at one end.
- d. have two north poles or two south poles.
- e. be more powerful than the original.

14. Hot water in a sealed container is weighed on a scale.



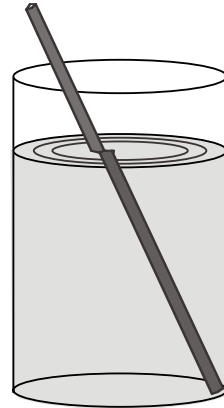
When the water cools to room temperature, the weight of the water:

- a. stays the same.
- b. will change.
- c. depends on how long it takes to cool.
- d. depends on its initial temperature.
- e. depends on the room temperature.

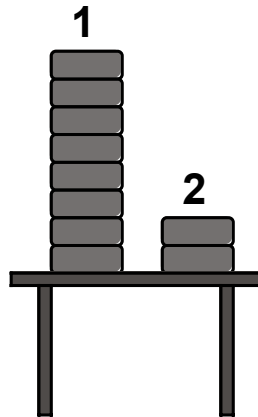
GO TO QUESTION 15 >>

15. When you throw a rubber ball many times at the same spot on a wall, the ball bounces back farthest when you throw it:
- faster than the other times.
 - slower than the other times.
 - at the same speed every time.
 - The speed you throw the ball does not matter.
 - It depends upon how close you are to the wall.

16. If you place a drinking straw in a glass filled halfway with water, the straw looks like it is in two pieces (see picture). This is because water:
- changes the direction of light off the straw.
 - reflects some light back into the straw.
 - increases the amount of light off the straw.
 - actually bends the straw.
 - dissolves light off the straw.



17. The first stack of bricks (stack 1) below is four times taller than the second stack (stack 2).



Which stack is being pushed on harder by the table?

- The table pushes harder on stack 1 than stack 2.
 - The table pushes equally on both stacks.
 - The table does not push on either stack.
 - The table pushes harder on stack 2 than stack 1.
 - It depends upon how closely the bricks are packed.
18. A clean brass rod is made mostly of two metals, copper and zinc. If you cut the rod in half and looked at a newly-cut end, it will look like:
- the brass outside.
 - bits of copper and bits of zinc.
 - copper.
 - zinc.
 - None of the above.

19. A balance is a tool used to directly measure:

- a. momentum.
- b. weight.
- c. density.
- d. volume.
- e. specific gravity.

20. Look at the six objects below.

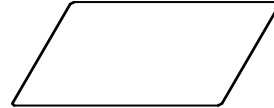
①



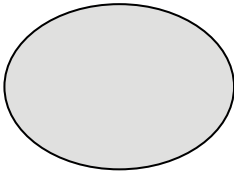
②



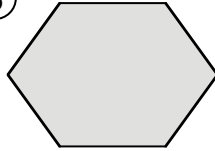
③



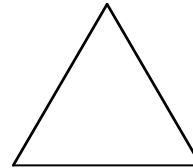
④



⑤



⑥



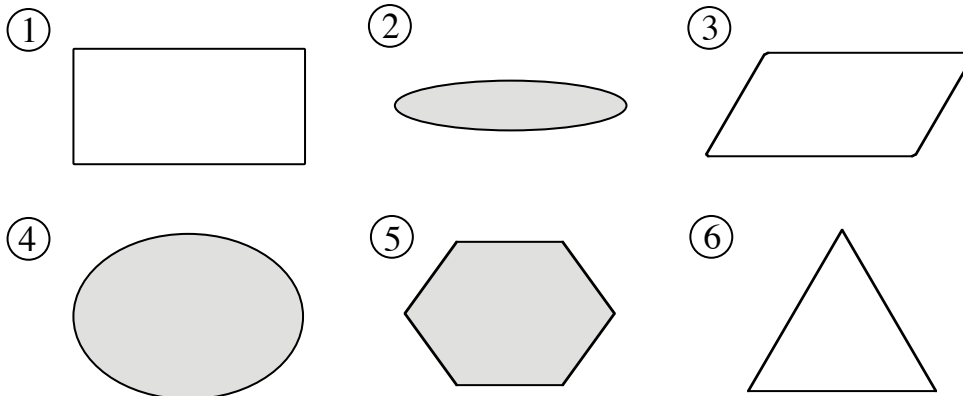
Which of the following pairs of objects are most alike in their shape?

- a. Objects 1 and 2.
- b. Objects 1 and 3.
- c. Objects 1 and 5.
- d. Objects 2 and 3.
- e. Objects 2 and 6.

PHYSICAL SCIENCE TEST

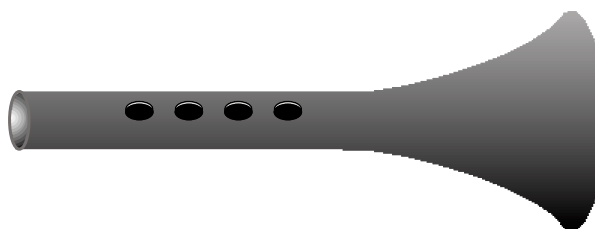
For some questions, there may be more than one correct answer. However, each question has only one best answer. Choose the single best answer from the five choices for each question.

1. Look at the six objects below.



Which of the following pairs of objects are most alike in their shape?

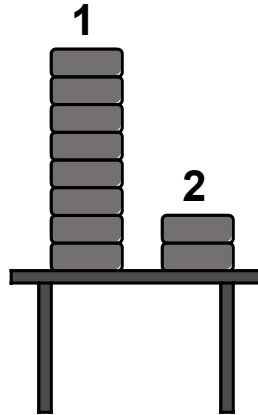
- Objects 1 and 2.
 - Objects 1 and 3.
 - Objects 1 and 5.
 - Objects 2 and 3.
 - Objects 2 and 6.
2. Which of these tools is least like a ruler?
- A radio.
 - A clock.
 - A measuring cup.
 - A thermometer.
 - None of these is like a ruler.
3. Michael made a low pitch sound on a horn (below) and wants to make a high pitch sound.



To make the high pitch sound, Michael must:

- cover more holes with his fingers.
- blow into the horn with more force.
- blow into the horn for a longer time.
- make the air vibrate faster.
- hold the horn more firmly.

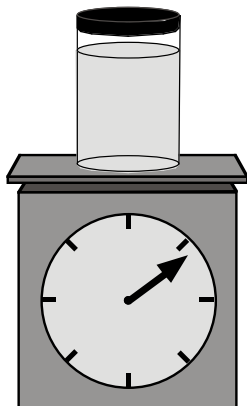
4. Scientists say a metal doorknob indoors often feels cold to you because:
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 - heat from your hand goes into the doorknob.
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 - metals are always colder than air.
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- Which stack is being pushed on harder by the table?
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 - The table pushes harder on stack 2 than stack 1.
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 - Some water turned into oxygen and hydrogen.
 - Some water went into the air as a gas.
 - Some water no longer exists.

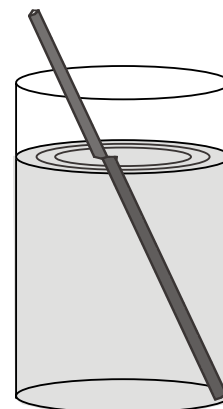
GO TO QUESTION 7 >>

7. Hot water in a sealed container is weighed on a scale.



When the water cools to room temperature, the weight of the water:

- stays the same.
 - will change.
 - depends on how long it takes to cool.
 - depends on its initial temperature.
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8. If you place a drinking straw in a glass filled halfway with water, the straw looks like it is in two pieces (see picture). This is because water:
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 - actually bends the straw.
 - dissolves light off the straw.

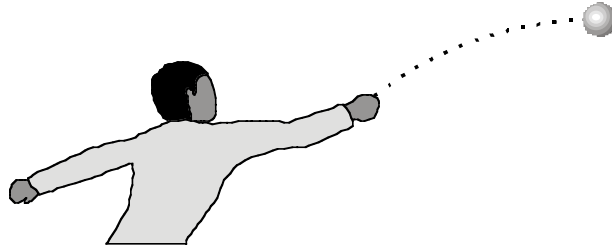


9. A clean brass rod is made mostly of two metals, copper and zinc. If you cut the rod in half and looked at a newly-cut end, it will look like:
- the brass outside.
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10. A balance is a tool used to directly measure:
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 - weight.
 - density.
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 - specific gravity.

11. What is true about the source of any sound?

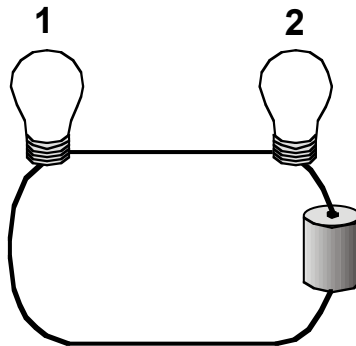
- a. A living thing had to be involved.
- b. Something had to vibrate.
- c. Air had to be involved.
- d. More than one of the above.
- e. None of the above.

12. When a thrown baseball reaches the top of its path (see below), the main push or pull acting on it is:



- a. caused by Earth's magnetic field.
- b. the force from the person throwing it.
- c. due to Earth's rotation.
- d. the pull of gravity.
- e. No force is acting on the ball.

13. Identical lights 1 and 2 are connected to the battery in the circuit below.



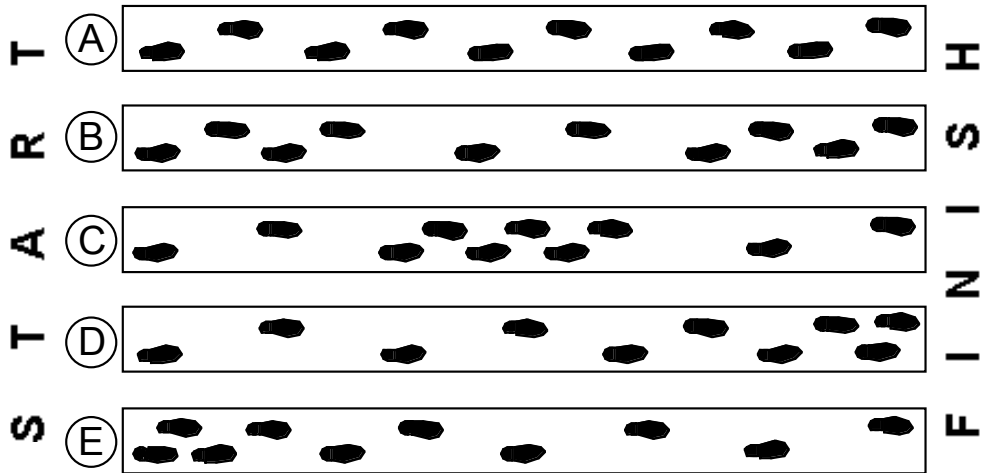
When connected as shown:

- a. light 1 is brighter than light 2.
- b. light 1 is dimmer than light 2.
- c. light 1 is the same brightness as light 2.
- d. one of the lights remains unlit and the other lights up.
- e. There is no way to tell if the lights' brightness would be the same or different.

14. A solid red block and a solid green block of the same size are placed in a container of water. The red block floats and the green block sinks. From this you know that:

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- b. the red block is heavier than the green block.
- c. the green block is heavier than the red block.
- d. the two blocks weigh the same.
- e. You cannot say anything else about the blocks.

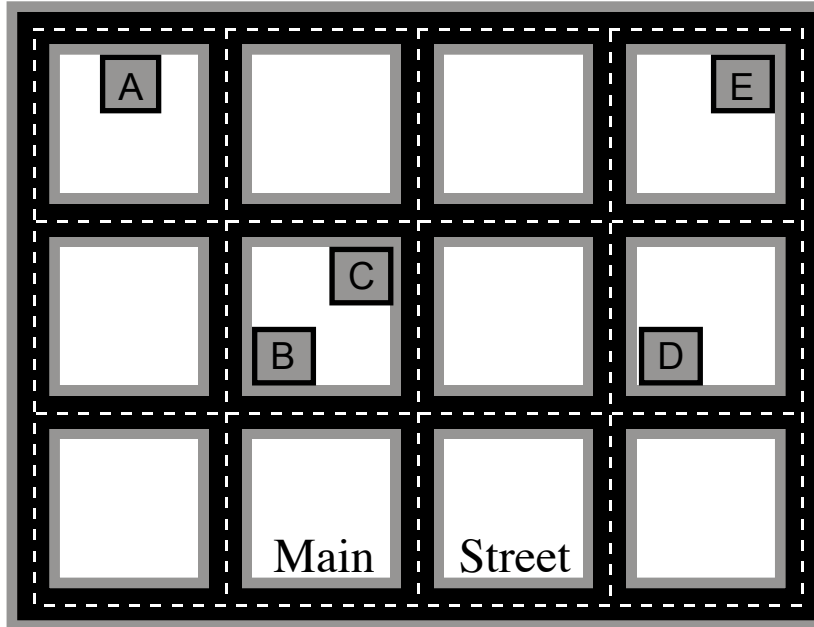
15. If you cut a bar magnet in half, each half will:
- no longer attract objects.
 - attract from both ends.
 - attract objects only at one end.
 - have two north poles or two south poles.
 - be more powerful than the original.
16. Jon is walking on a path in a park. He slows down as he passes some flowers then resumes his normal pace. Which pattern of footprints below best represents John's footprints?



17. On a hot day, Paul left a glass of ice water outside. After a while, the outside of the glass was wet because:
- the water in the glass seeped through the glass.
 - the ice in the glass became the water on the outside.
 - the water in the air became cooler and became liquid.
 - the ice in the glass melted and overflowed.
 - No one knows why the glass is wet.

GO TO QUESTION 18 >>

18. Look at the map below.

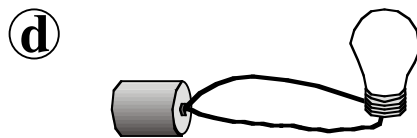
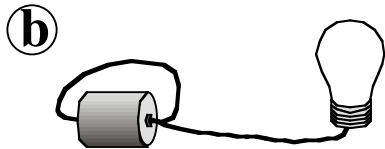
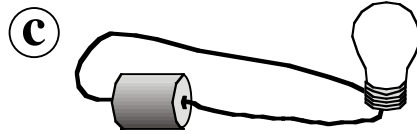
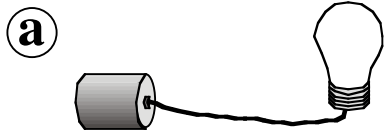


Which of the houses is located closest to House C along the streets?

- a. A
 - b. B
 - c. D
 - d. E
 - e. A and B
19. When you throw a rubber ball many times at the same spot on a wall, the ball bounces back farthest when you throw it:
- a. faster than the other times.
 - b. slower than the other times.
 - c. at the same speed every time.
 - d. The speed you throw the ball does not matter.
 - e. It depends upon how close you are to the wall.

GO TO QUESTION 20 >>

20. Each of the arrangements below includes a battery, light bulb, and wire. Which arrangement will light the bulb?



e More than one of the above.

K–4 Physical Science Tests

The tests in this section contain items related to the 11 K–4 standards in physical science from the NRC's *National Science Education Standards (NSES)*; below are the standards as stated in the *NSES*.

K–4 Physical Science Standard 1:

“Objects have many observable properties, including size, weight, shape, color, temperature, and the ability to react with other substances. Those properties can be measured using tools, such as rulers, balances, and thermometers.”

K–4 Physical Science Standard 2:

“Objects are made of one or more materials, such as paper, wood, and metal. Objects can be described by the properties of the materials from which they are made, and those properties can be used to separate or sort a group of objects or materials.”

K–4 Physical Science Standard 3:

“Materials can exist in different states—solid, liquid, and gas. Some common materials, such as water, can be changed from one state to another by heating or cooling.”

K–4 Physical Science Standard 4:

“The position of an object can be described by locating it relative to another object or the background.”

K–4 Physical Science Standard 5:

“An object’s motion can be described by tracing and measuring its position over time.”

K–4 Physical Science Standard 6:

“The position and motion of objects can be changed by pushing or pulling. The size of the change is related to the strength of the push or pull.”

K–4 Physical Science Standard 7:

“Sound is produced by vibrating objects. The pitch of the sound can be varied by changing the rate of vibration.”

K–4 Physical Science Standard 8:

“Light travels in a straight line until it strikes an object. Light can be reflected by a mirror, refracted by a lens, or absorbed by the object.”

K–4 Physical Science Standard 9:

“Heat can be produced in many ways, such as burning, rubbing, or mixing one substance with another. Heat can move from one object to another by conduction.”

K-4 Physical Science Standard 10:

"Electricity in circuits can produce light, heat, sound, and magnetic effects. Electrical circuits require a complete loop through which an electrical current can pass."

K-4 Physical Science Standard 11:

"Magnets attract and repel each other and certain kinds of other materials."

The items are identical on both test forms, but arranged in different sequences so that the forms can be used as a pretest/post-test pair (either form may be used as the pretest). Either form can be used by itself as a diagnostic test.

The K-4 tests are intended for use primarily with 5th grade students. Project MOSART did not develop tests for use with students in grades K-4 due to the difficulty of writing reliable multiple choice items for students whose reading levels may vary widely. The tests can also be administered to any persons who possess at least a 5th grade reading level fluency in English.

NOTE: Administering the tests to anyone with less than the indicated minimum reading level may result in invalid test results due to the test performing more as a reading comprehension test rather than as a science test.

Item # Form 711	Item # Form 712	Text of item	Std. ¹	Correct response & percent ² responding correctly	Commentary ³
1	20	Each of the arrangements below includes a battery, light bulb, and wire. Which arrangement will light the bulb? See figures on test item.	10	C: 66%	The arrangement of a complete electrical circuit is addressed in this item. 10% chose D, which is not connected to both terminals on the battery, while another 11% indicated several arrangements in the group (E) should work to light the bulb.
2	14	A solid red block and a solid green block of the same size are placed in a container of water. The red block floats and the green block sinks. From this you know that: a. the two blocks are made of the same material. b. the red block is heavier than the green block. c. the green block is heavier than the red block. d. the two blocks weigh the same. e. You cannot say anything else about the blocks.	2	C: 67%	On this item, E was the second most popular response with 15% of students selecting it. The relationship between an object's mass and size with respect to an object's ability to float is a difficult concept. Students who answered this item correctly answered 3 more test items on average on a 20-item test than students who answered it incorrectly.

¹ These test items are valid psychometrically and represent standards commonly included in elementary physical science curricula.

² Students (n=400) were selected randomly in classes to be a nationally representative sample of all grade 5 students in U.S. public and private schools.

³ The commentary reflects item response patterns. Common misconceptions in physical science are discussed in a separate section.

Item # Form 711	Item # Form 712	Text of item	Std. ¹	Correct response & percent ² responding correctly	Commentary ³
3	6	<p>A metal pan of water is left on a counter. After a few days, there is less water in the pan. What most likely happened?</p> <p>a. Some water became part of the pan.</p> <p>b. Movement of the air pulled water out of the pan.</p> <p>c. Some water turned into oxygen and hydrogen.</p> <p>d. Some water went into the air as a gas.</p> <p>e. Some water no longer exists.</p>	3	D: 56%	Although the majority of students responded correctly, 35% chose the very common misconception (C) that the change of state (liquid water becoming water vapor) is a chemical change, in which the water splits into hydrogen and oxygen.
4	12	<p>When a thrown baseball reaches the top of its path (see picture in test item), the main push or pull acting on it is:</p> <p>a. caused by Earth's magnetic field.</p> <p>b. the force from the person throwing it.</p> <p>c. due to Earth's rotation.</p> <p>d. the pull of gravity.</p> <p>e. No force is acting on the ball.</p>	6	D: 48%	Option B represents a common misconception held by many students: 42% of students indicated that the main force acting on the thrown ball in the air is from the person who is throwing.
5	18	<p>Look at the map below (see item on test). Which of the houses is located closest to House C along the streets?</p> <p>a. A</p> <p>b. B</p> <p>c. D</p> <p>d. E</p> <p>e. A and B</p>	4	B: 86%	Very few students chose one of the incorrect responses. None of the incorrect choices drew a 10% response.

Item # Form 711	Item # Form 712	Text of item	Std. ¹	Correct response & percent ² responding correctly	Commentary ³
6	11	<p>What is true about the source of any sound?</p> <p>a. A living thing had to be involved.</p> <p>b. Something had to vibrate.</p> <p>c. Air had to be involved.</p> <p>d. More than one of the above.</p> <p>e. None of the above.</p>	7	B: 22%	The most common response was D, chosen by 43% of students. It seems reasonable that many children know that sound travels through the air. Other ideas vary, but apparently include a requirement of multiple causes. As a consequence, many students may feel air must be involved, as well as some other factor.
7	2	<p>Which of these tools is least like a ruler?</p> <p>a. A radio.</p> <p>b. A clock.</p> <p>c. A measuring cup.</p> <p>d. A thermometer.</p> <p>e. None of these is like a ruler.</p>	1	A: 48%	The most common incorrect response was C (20%), followed by D (15%). Only 6% of students responded with E, suggesting that many students are aware of the basic nature of measuring tools.
8	4	<p>Scientists say a metal doorknob indoors often feels cold to you because:</p> <p>a. cold from the doorknob goes into your hand.</p> <p>b. heat from your hand goes into the doorknob.</p> <p>c. cold moves from the doorknob to your hand.</p> <p>d. heat is pulled from the doorknob by your hand.</p> <p>e. metals are always colder than air.</p>	9	B: 14%	The misconception that "cold" is 'active' in the same sense as heat is common through middle school; 22% of students chose A. No other response was chosen by more than 15% of the students.

Item # Form 711	Item # Form 712	Text of item	Std. ¹	Correct response & percent ² responding correctly	Commentary ³
9	13	<p>Identical lights 1 and 2 are connected to the battery in the circuit below (see picture in test item). When connected as shown:</p> <ol style="list-style-type: none"> light 1 is brighter than light 2. light 1 is dimmer than light 2. light 1 is the same brightness as light 2. one of the lights remains unlit and the other lights up. There is no way to tell if the lights' brightness would be the same or different. 	10	C: 22%	The most popular choice was B; note that light 2 is closer to the battery than light 1, a likely source of the misconception that 1 is dimmer than 2. The only other option to attract students (20%) was E.
10	17	<p>On a hot day, Paul left a glass of ice water outside. After a while, the outside of the glass was wet because:</p> <ol style="list-style-type: none"> the water in the glass seeped through the glass. the ice in the glass became the water on the outside. the water in the air became cooler and became liquid. the ice in the glass melted and overflowed. No one knows why the glass is wet. 	3	C: 34%	Options B and D each attracted more than 20% of students. Lack of understanding about water vapor (i.e., water in the air as a gas) is likely the reason for both of these options being attractive, as both refer to water in its liquid state.
11	16	<p>Jon is walking on a path in a park. He slows down as he passes some flowers then resumes his normal pace. Which pattern of footprints best represents Jon's footprints?</p> <p>See figure choices in item on test.</p>	5	C: 41%	Approximately one fourth (26%) of the students chose B, which features footprints in the middle more spread out than in C (footprints closer to each other in the middle).

Item # Form 711	Item # Form 712	Text of item	Std. ¹	Correct response & percent ² responding correctly	Commentary ³
12	3	<p>Michael made a low pitch sound on a horn (see picture in item on test) and wants to make a high pitch sound. To make the high pitch sound, Michael must:</p> <ol style="list-style-type: none"> cover more holes with his fingers. blow into the horn with more force. blow into the horn for a longer time. make the air vibrate faster. hold the horn more firmly. 	7	D: 23%	Two options gained more responses than the correct one: A (45%) and B (34%). Students do associate the pitch of a note with the player's actions (either covering holes in the horn or blowing with more force), but apparently they do not realize that the differences in pitch result from the differences in the rate of vibrations of air.
13	15	<p>If you cut a bar magnet in half, each half will:</p> <ol style="list-style-type: none"> no longer attract objects. attract from both ends. attract objects only at one end. have two north poles or two south poles. be more powerful than the original. 	11	B: 35%	About one fourth of students chose C. This suggests that students are not very clear about the dipolar nature of all magnets.
14	7	<p>Hot water in a sealed container is weighed on a scale (picture in item on test). When the water cools to room temperature, the weight of the water:</p> <ol style="list-style-type: none"> stays the same. will change. depends on how long it takes to cool. depends on its initial temperature. depends on the room temperature. 	9	A: 42%	The key to this item is recognizing the effect of the container being sealed. As such, the item probes for understanding the conservation of matter. (If the container were unsealed, conceivably some water might evaporate while it cooled to room temperature, in which case B would be correct.)
		<p>When you throw a rubber ball many times at the same spot on a wall, the ball bounces back farthest when you throw it:</p> <ol style="list-style-type: none"> faster than the other times. slower than the other times. at the same speed every time. 			Although the correct response was very popular, option E (which indicates the distance from the wall is the key factor) attracted more than 50% of students. This strong misconception

Item # Form 711	Item # Form 712	Text of item	Std. ¹	Correct response & percent ² responding correctly	Commentary ³
15	19	d. The speed you throw the ball does not matter. e. It depends upon how close you are to the wall.	6	A: 41%	might derive from the shorter roundtrip distance the ball makes in E (students tend to visualize being nearer the wall in E, although relative distance is not indicated), resulting in the need for a faster reaction, often involving backing up to catch the ball, giving the impression that the ball bounces back farther.
16	8	If you place a drinking straw in a glass filled halfway with water, the straw looks like it is in two pieces (see picture in item on test). This is because water: a. changes the direction of light off the straw. b. reflects some light back into the straw. c. increases the amount of light off the straw. d. actually bends the straw. e. dissolves light off the straw.	8	A: 44%	Although the correct response attracted the most students, 28% chose B (reflection of light). It is possible some students might have learned the word 'refraction' and opted for the closest word to it since refraction is not in any choice. No other option attracted more than 15% of students.
17	5	The first stack of bricks (stack 1) below (see figure in item on test) is four times taller than the second stack (stack 2). Which stack is being pushed on harder by the table? a. The table pushes harder on stack 1 than stack 2. b. The table pushes equally on both stacks. c. The table does not push on either stack. d. The table pushes harder on stack 2 than stack 1. e. It depends upon how closely the bricks are packed.	6	A: 53%	A small number of students chose C (18%) or D (14%). According to these responses, about one half of students understand the relationship between the table "pushing" and books not falling to the floor.
		A clean brass rod is made mostly of two metals, copper and zinc. If you cut the rod in half and looked at a newly-cut end, it will look like:			This item represents a common misconception about metals. Over half of the students (53%) chose B, apparently believing

Item # Form 711	Item # Form 712	Text of item	Std. ¹	Correct response & percent ² responding correctly	Commentary ³
18	9	a. the brass outside. b. bits of copper and bits of zinc. c. copper. d. zinc. e. None of the above.	2	A: 22%	that brass was composed of visible bits of copper and zinc. 14% of students chose E and some 6% chose C or D.
19	10	A balance is a tool used to directly measure: a. momentum. b. weight. c. density. d. volume. e. specific gravity.	1	B: 62%	If students do not understand the purpose of basic measurement tools (e.g., a balance), then their understanding of the characteristics of matter is limited. Interestingly, the second most popular response to this question was D.
20	1	Look at the six objects below. Which of the following pairs of objects are most alike in their shape? a. Objects 1 and 2. b. Objects 1 and 3. c. Objects 1 and 5. d. Objects 2 and 3. e. Objects 2 and 6.	1	B: 90%	While this question may be obvious to most elementary school students, it is important to note that students who answered this item incorrectly scored 3 items fewer on average on a 20-item test than students who answered it correctly.

Major Misconceptions in K-4 Physical Science

Listed below are some student physical science misconceptions. The list is not intended to be exhaustive, but rather a summary of some of the more common prior ideas we identified from our analysis of the student response patterns to the items on the tests.

- Matter can be created and destroyed.
- Particles are not conserved in phase changes, e.g., when water evaporates, the evaporated water no longer exists in any form.
- A moving object contains a force given to it by an outside source, and stops moving when the force runs out.

- Air must be involved at some point for sound transmission.
- Energy is an entity contained within substances and can be created and destroyed.
- Heat and cold are substances or entities, and different from one another.
- Electricity flows through hollow wires and is used up by lights or appliances.
- Measurement is only linear.

The following resources are useful for additional background information about students' science misconceptions:

Driver, R. (Ed.), *Children's Ideas in Science*, Philadelphia: Open University Press (1985).

Driver, R., *Pupil as Scientist?*, Philadelphia: Open University Press (1983).

Shapiro, B., *What Children Bring to Light: A Constructivist Perspective on Children's Learning in Science*, New York: Teachers College Press (1994).