APS physics
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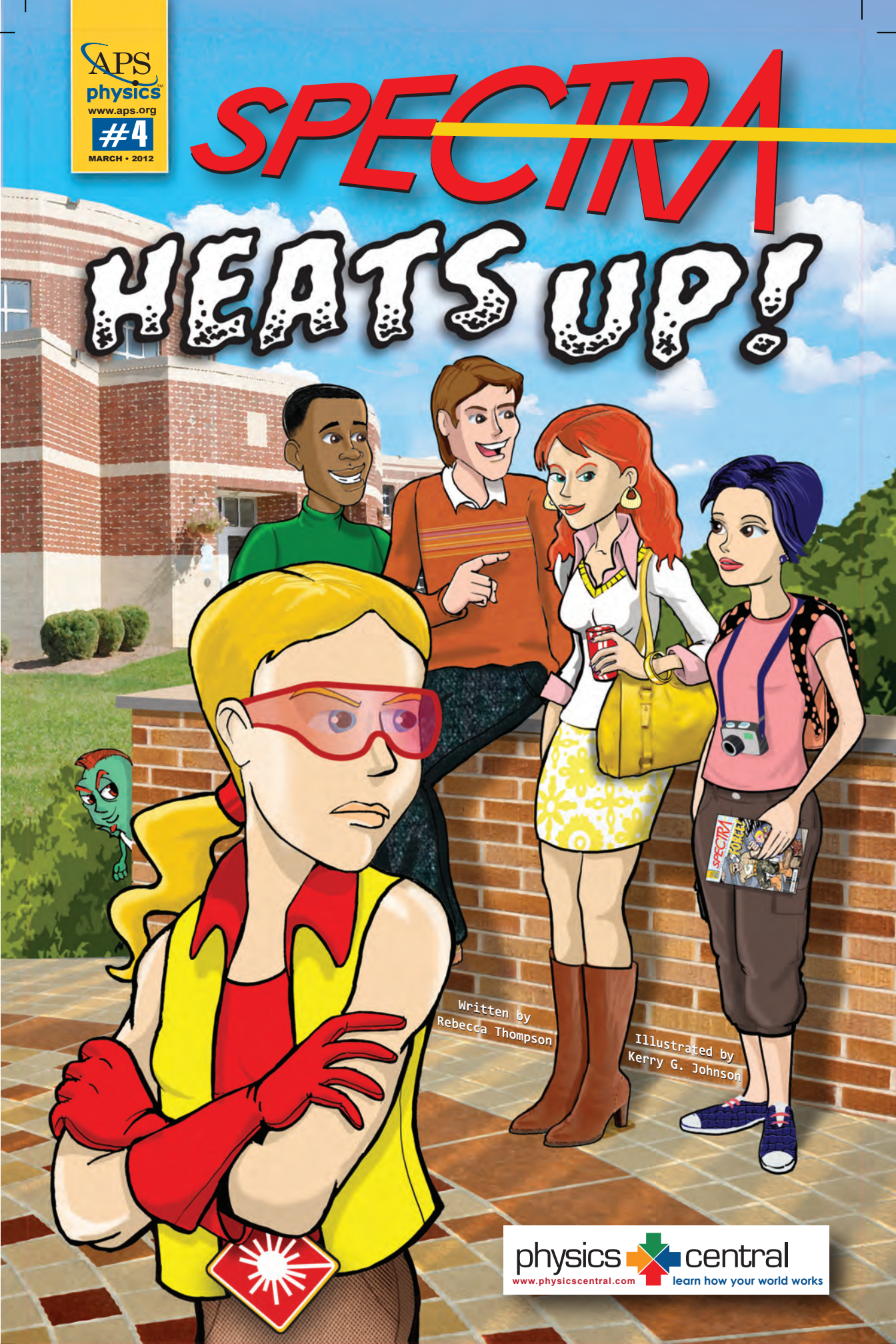
#4
MARCH • 2012

SPECTRA

HEATS UP!



Written by
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Kerry G. Johnson

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WELCOME TO PHYSICSQUEST

History of the PhysicsQuest Program

As part of the World Year of Physics 2005 celebration, the American Physical Society (APS Physics) produced *PhysicsQuest: The Search for Albert Einstein's Hidden Treasure.* Designed as a resource for middle school science classrooms and clubs, the quest was received enthusiastically by nearly 10,000 classes during the course of 2005. Feedback indicated that this activity met a need within the middle school science community for fun and accessible physics material, so the American Physical Society has decided to continue this program. APS is pleased to present this seventh kit, *PhysicsQuest: Spectra Heats Up.*

In the past, each PhysicsQuest kit has followed a mystery-based storyline and requires students to correctly complete four activities in order to solve the mystery and be eligible for a prize drawing. For the third year in a row students will be following laser superhero Spectra. Past years have seen the downfall of the evil Miss Alignment and the unfortunate demise of General Relativity. This year, students will learn about heat as they help Spectra defend her status at Nikola Tesla Junior High from "mean girl" Tiffany Maxwell who has a "little" help on her side.

About the American Physical Society (APS Physics)

APS is the professional society for physicists in the United States. APS works to advance and disseminate the knowledge of physics through its journals, meetings, public affairs efforts, and educational programs. Information about APS and its services can be found at www.aps.org.

APS also runs PhysicsCentral, a website aimed at communicating the excitement and importance of physics to the general public. At this site, www.physicscentral.com, you can find out about APS educational programs, current physics research, people in physics and more.

PhysicsQuest: Spectra Heats Up!

Written by Rebecca Thompson

Illustrations by Kerry G. Johnson

Activity illustrations by Nancy Bennett-Karasik

PhysicsQuest: Spectra Heats Up! - Issue #4
is published by the American Physical Society

WELCOME TO PHYSICSQUEST

About PhysicsQuest

PhysicsQuest is a set of four activities designed to engage students in scientific inquiry. The 2011-2012 activities are linked together via a storyline and comic book that follows Spectra, a laser super hero and her battles with "mean girl" Tiffany Maxwell and her impish demon. Spectra's super power is her ability to turn into a laser beam. Her powers are all real things that a laser beam does so in addition to learning via the 4 activities students will also learn through the comic book.

PhysicsQuest is designed with flexibility in mind – it can be done in one continuous session or split up over a number of weeks. The activities can be conducted in the classroom or as an extra credit or science club activity. The challenges can be completed in any order, but to get the correct final result all of the challenges must be completed correctly.

About the PhysicsQuest Competition

APS sponsors an optional PhysicsQuest competition designed to encourage students to invest in the project. If you chose to participate in the competition, your class must complete the four activities and you must submit their answers online by May 17th, 2012. All classes that submit answers online will receive a certificate of completion and be entered into a prize drawing. Details on the prizes will be posted on the PhysicsQuest website as they become available.

The online results submission form does not require the answers to all of the questions on the Final Report. If your class only has time to complete some of the activities, they can still submit their answers, be eligible for prizes and receive a certificate of participation. Each class can only submit one entry form, so class discussions of results are encouraged.

Answers can be submitted online through the PhysicsQuest website beginning **March 15, 2012**

The PhysicsQuest Materials

The PhysicsQuest kit includes this manual and most of the hardware your students need to complete the activities. There is also a corresponding website, www.physicscentral.com/physicsquest, which has supplemental material such as extension activities.

The comic book

Each activity will be preceded by several pages of a comic book that will follow the adventures of Spectra. The comic is also available online. Students will complete the activity and in the end they will need their answers to all four answers to help Spectra save her friends from Maxwell's Demon.

The Materials List

For more information on these items and where they can be purchased, please visit the PhysicsQuest website. If your kit is missing any of these materials, please contact Educational Innovations, www.teachersource.com or (203) 229-0730

Included in this kit:

6 Hershey's kisses
1 Steel wire
1 Copper wire
1 Aluminum wire
2 Drinking birds
6 Rubbing alcohol pads
1 Large plastic bag
4 Packets of vinegar
1 Steel wool pad
1 Liquid crystal thermometer
1 Tart pan
1 Heat changing pencil
4 Birthday candles
1 Block of modeling clay

Not included in this kit:

Hot water
Room temperature water
Cup
Tape
Stopwatch
Ruler
Lighter or matches

WELCOME TO PHYSICSQUEST

The Teacher Guide includes:

· Key Question: This question highlights the goal of the activity.

· Key Terms
This section lists terms related to the activity that the students will encounter in the Student Guide.

· Before the Activity:
Students should be familiar with these concepts and skills before tackling the activity.

· After the Activity:
By participating in the activity, students are practicing the skills and studying the concepts listed in this section.

· The Science Behind…
This section includes the science behind the activity, and some historical background. The Student Guide does not include most of this information; it is left to you to decide what to discuss with your students.

· Safety
This section highlights potential hazards and safety precautions.

· Materials
This section lists the materials needed for the activity. Materials that are provided in the kit are in bold type; you will need to provide the rest.

· Extension Activities
Extension activities related to each activity can be found on the PhysicsQuest website. This section gives a brief description of those related to the activity.

· Bibliography and Suggested Resources
This section lists the books and other resources used to create this activity and recommended resources for more information on the topics covered.

The Student Guide
Each activity has a Student Guide that you will need to copy and hand out to all of the students.

The Student Guide includes:

· Key Question
This question highlights the goal of the activity.

· Materials
This section lists the materials students will need for the activity.

· Getting Started
This section includes discussion questions designed to get students thinking about the key question, why it's important, and how they might find an answer.

· The Experiment
This section leads students step-by-step through the set-up and data collection process.

· Analyzing your Results
This section leads students through data analysis and has questions for them to answer based on their results.

PhysicsQuest Website

The PhysicsQuest website, www.physicscentral.com/physicsquest, has supplemental material for teachers, such as extension activities. Periodic updates on the program will also be posted on this site.

PhysicsQuest Logistics

Materials
The PhysicsQuest kit comes with only one set of materials. This means that if your students are working in four small groups (recommended), all groups should work simultaneously on different activities and then rotate activities, unless you provide additional materials. The Materials List on the PhysicsQuest website includes specific descriptions of the materials and where they can be purchased. All materials can be reused.

Safety
While following the precautions in this guide can help teachers foster inquiry in a safe way, no manual could ever predict all of the problems that might occur. Good supervision and common sense are always needed. Activity-specific safety notices are included in the Teacher Guide when appropriate.

Time Required
The time required to complete the PhysicsQuest activities will depend on your students and their lab experience. Most groups will be able to complete one activity in about 45-minutes.

NEXT PAGE >>

WELCOME TO PHYSICSQUEST

Small Groups
Working effectively in a group is one of the most important parts of scientific inquiry. If working in small groups is challenging for your students, you might consider adopting a group work model such as the one presented here.

Group Work Model
Give each student one of the following roles. You may want to have them rotate roles for each activity so they can try many different jobs.

· Lab Director
Coordinates the group and keeps students on task.

· Chief Experimenter
Sets up the equipment and makes sure the procedures are carried out correctly.

· Measurement Officer
Monitors data collection and determines the values for each measurement.

· Report Writer
Records the results and makes sure all of the questions in the Student Guide are answered.

· Equipment Manager
Collects all equipment needed for the experiment. Makes sure equipment is returned at the end of the class period and that the lab space is clean before group members leave.

PhysicsQuest in the Classroom

This section suggests ways to use PhysicsQuest in the classroom. Since logistics and goals vary across schools, please read through the suggestions and then decide how best to use PhysicsQuest. Feel free to be creative!

· PhysicsQuest as a stand-alone activity
PhysicsQuest is designed to be self-contained – it can be easily done as a special project during the day(s) following a test, immediately preceding/following winter break, or other such times. PhysicsQuest also works well as a science club activity and extra credit opportunity.

· PhysicsQuest as a fully integrated part of regular curriculum
The topics covered in PhysicsQuest are covered in many physical science classes, so you might have students do the PhysicsQuest activities during the corresponding units.

· PhysicsQuest as an all-school activity
Some schools set up PhysicsQuest activity stations around the school gym for one afternoon. Then small groups of students work through the stations at assigned times.

· PhysicsQuest as a mentoring activity
Some teachers have used PhysicsQuest as an opportunity for older students to mentor younger students. In this case, 8th or 9th grade classes first complete the activities themselves, and then go into 6th or 7th grade classrooms and help students with the activities.

WELCOME TO PHYSICSQUEST

A Note about Maxwell's Demon

James Clerk Maxwell was one of the world's most accomplished physicists. He is best known for his research into electricity and magnetism. If you participated in *PhysicsQuest: Nikola Tesla and the Electric Fair* you may have learned about some of the things he studied. Though many physicists will always associate him with the famed "Maxwell's Equations" which describe how electricity and magnetism behave together and how they make up light, he also studied how groups of particles move together.

The "demon" in this story is based on a thought experiment that Maxwell came up with to discuss how one might get around the natural laws of the universe. As you will learn in both the comic and the PhysicsQuest activities, things in contact with each other like to be the same temperature. This is called "thermal equilibrium." Thermal means heat and equilibrium means the same, the heat is the same in the whole system. You will never have a room where all the cold particles are on one side and all the hot particles are on the other. Or where all the air particles decide they want to go up to one corner of the room. But when Maxwell started thinking about all of this, he thought to himself "Huh, what if there was a little demon that could control where the particles go and what they do?"

He first thought about what would happen to a room if there were a divider and the demon could open and close a door to keep the hot particles on one side and the cold ones on the other. Then he thought about what would happen if the demon let particles go through the door one way but not the other. How was the demon violating the laws of nature? If it took no effort for him to do this, why didn't this just happen in real life? Thinking about this seems a weird way to do science, but such "thought experiments" often help scientists have a better understanding of what is going on in the system. Sometimes when you step back from a complicated problem, and there isn't much more complicated that looking at hundreds of billions of particles at once, you can get a better understanding of how it all works.

This comic takes the idea of "Maxwell's Demon" and brings it to life. Only this time instead of being a thought experiment by the famous James Clerk Maxwell, the demon is an imp controlled by the mean Tiffany Maxwell. He does all the things that he is supposed to do, only this time it doesn't just teach physics, it could cost Spectra's friends their lives.

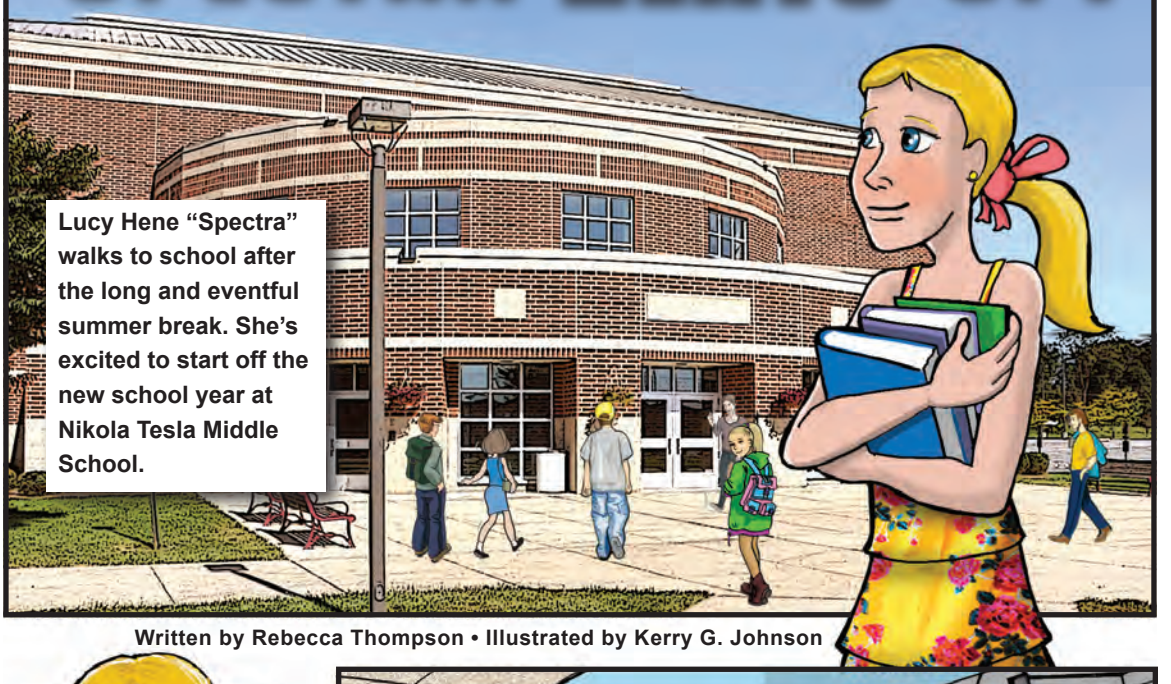
Some good websites on Maxwell's Demon:

http://www.imsc.res.in/~sitabhra/research/persistence/maxwell.html

http://www.auburn.edu/~smith01/notes/maxdem.htm

http://splasho.com/blog/essays/maxwell-thermodynamics-meets-the-demon/

SPECTRA HEATS UP!



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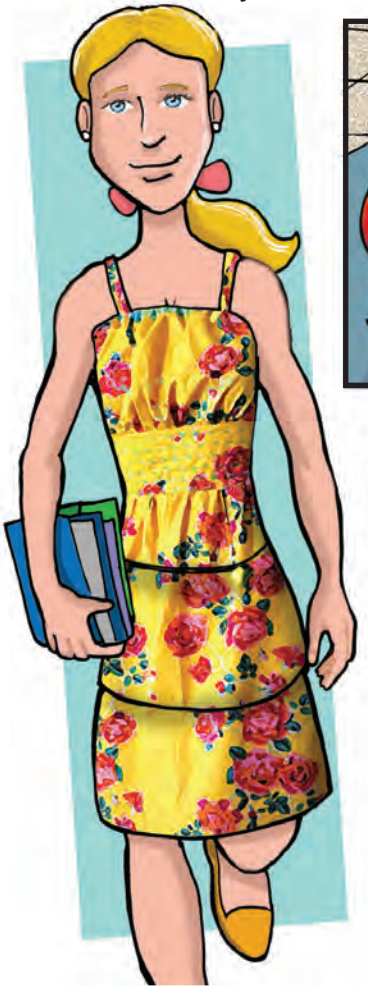
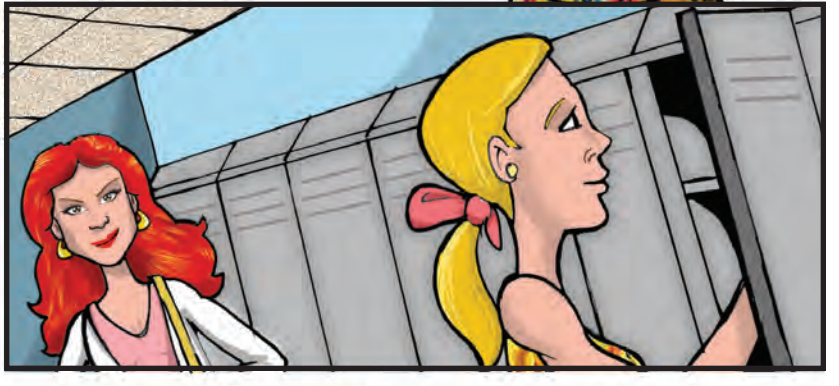
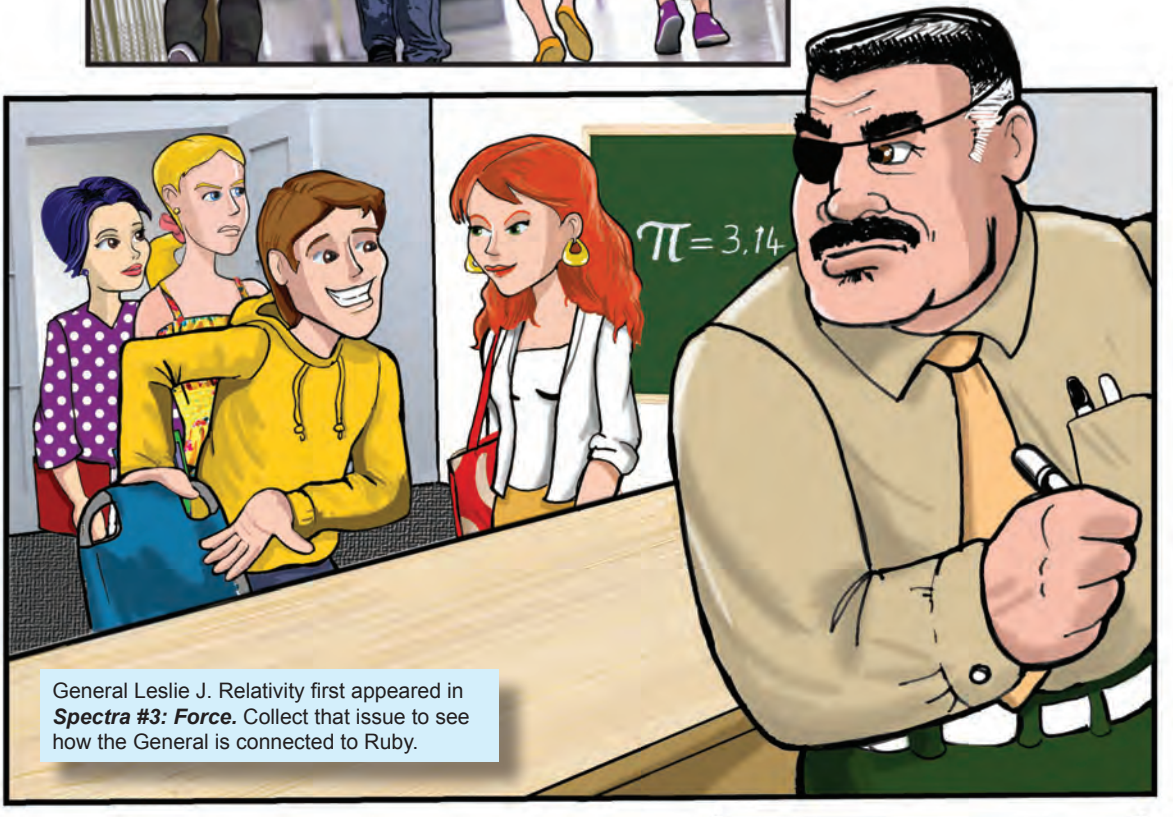





RUBY, WHO'S THAT? DO YOU KNOW HER?
OH, THAT'S TIFFANY MAXWELL. OVER THE SUMMER SHE MOVED IN NEXT DOOR TO ME. SHE'S FROM LOS ANGELES AND IS REALLY COOL.
SHE HAS THE MOST AMAZING SHOE COLLECTION AND FABULOUS CLOTHES.
I WISH THAT I COULD BORROW THEM. HER ROOM IS PROFESSIONALLY DECORATED AND SO BEAUTIFUL. I GUESS SHE DIDN'T SEE ME WAVE.
RUBY, YOU *HAVE* TO INTRODUCE ME TO TIFFANY! SHE'S... UH, I MEAN, HER... SHOES ARE REALLY HOT!
WELL, I DON'T LIKE *HER!*
LUCY, DON'T BE THAT WAY. I'M SURE SHE DIDN'T MEAN TO PUSH YOU. SHE REALLY IS NICE AND SHE'S ON THE SWIM TEAM LIKE YOU. AFTER YOU SPEND SOME TIME TOGETHER, I KNOW YOU TWO WILL HIT IT OFF.
GREAT, JUST GREAT! I CAN'T WAIT FOR THAT.

C'MON, LET'S GET TO CLASS.

I WONDER WHO OUR PHYSICS TEACHER IS THIS YEAR?



General Leslie J. Relativity first appeared in ***Spectra #3: Force.*** Collect that issue to see how the General is connected to Ruby.

WHAT'S UP WITH THAT? SHE'S SITTING IN ***MY*** SPOT! WHO DOES SHE THINK SHE IS SITTING NEXT TO MY BOYFRIEND! GRRR! NOW THERE'S NOWHERE TO SIT!

RELAX! KAS IS JUST BEING A GENTLEMAN. THERE'S A CHAIR IN THE BACK. WE'LL SEE YOU AFTER CLASS.

ACTIVITY 1: Meltdown

TEACHER GUIDE

INTRO

Everyone knows that metal conducts heat. You never want to touch a hot car or lick a cold metal flag pole. But are all metals the same? Is there a huge difference between one type of metal or another? Why do we use copper bottom pots or iron skillets? This activity will show the difference in conduction between three types of metals, iron, copper and aluminum. This activity is fairly quick but very fun and it's packed with physics. Its also quite tasty!

KEY TERMS

Conduction: Energy in the form of heat moving from one thing to another.

Kinetic energy: Energy of motion. When things are moving, they have kinetic energy.

Temperature: Temperature is a measure of how fast the average molecule is moving. It is related to the molecules' kinetic energy. The faster they move, the higher the kinetic energy and therefor the higher the temperature.

Melting: The process of changing from a solid to a liquid

MATERIALS

- 3 Hershey's kisses
  (or 6 and change step 1 to 'eat 3 Hershey's kisses')
- 1 steel wire
- 1 Copper wire
- 1 Aluminum wire
- Hot water
- Cup
- Tape
- Stopwatch or watch with a second hand*
  **Not included in the PhysicsQuest Kit*

BEFORE THE ACTIVITY STUDENT SHOULD KNOW

- When solids such as chocolate get hot, they melts.
- Metals conduct heat.

AFTER THE ACTIVITY STUDENTS SHOULD SHOULD BE ABLE TO

- Explain how different metals react to heat
- Explain the difference in heat conduction in different metals

KEY QUESTION

How do different metals conduct heat?

THE SCIENCE BEHIND CONDUCTION

Metals are generally good at transferring, or conducting, heat. We know not to touch a cookie sheet without a pot holder and that putting a bare hand on your metal car in the winter won't exactly feel nice. But do all metals conduct the same?

There are really two things going on in this experiment, conduction and melting. Most of us can explain melting without too much difficulty. Melting is when something changes from a solid to a liquid. This happens when there is enough energy, usually in the form of heat, to raise the temperature to the melting point make the ordered atoms or molecules in the solid become less ordered and move around. At that point it becomes a liquid. (*Figure 1)*

In this experiment conduction in metal moves energy in the form of heat from the hot water up to the chocolate and causes it to melt. Temperature is really a measure of the average kinetic energy in some space, in this case the metal rod. The molecules in the hot water are moving much faster than the molecules in the metal rods. When the fast moving water molecules come in contact with the molecules of the metal they crash into them and transfer some of their energy, making the metal heat up. (*Figure 2)*. Then the faster moving metal molecules in the bottom of the metal start jiggling the ones above them and so on right up to the top of the wire and the chocolate. Which gets hot, melts, and slides down the rod to the water.

The reason metals conduct heat well is that it is easy for them to get their molecules moving and transfer the energy to other molecules in the metal. Even though metals as a group are good conductors, some are better conductors than others. One of the places this is easy to see is in cookware. Before the new fancy-dancy pots and pans we have now, most good cookware had copper bottoms. This is because copper is extremely good at conducting heat. Now think of an iron skillet. Unlike other pots, the handle of the skillet is also iron, but we don't have a problem grabbing it without a pot holder. This is because iron is not a good conductor at all. Important thing to note is that steel is mostly iron. For this experiment it is ok to assume the steel wire is really an iron wire. This experiment is a really tasty and fun way to show that not all metals conduct equally.

ACTIVITY 1: Meltdown

TEACHER GUIDE

THE SCIENCE BEHIND CONDUCTION

Be careful when handling hot water. Do not touch it, it may burn.

CORRESPONDING EXTENSION ACTIVITIES

- Corresponding Extension Activities
- Physical Insulation
- Sweet and Salty Ice

BIBLIOGRAPHY AND SUGGESTED RESOURCES

http://www.jce.divched.org/JCESoft/CCA/CCA2/MAIN/DIAMOND2/CD2R1.HTM

http://www.infinitepower.org/pdf/09-Lesson-Plan.pdf

http://www.youtube.com/watch?v=77R4arwD8G8&feature=related

Figure 1

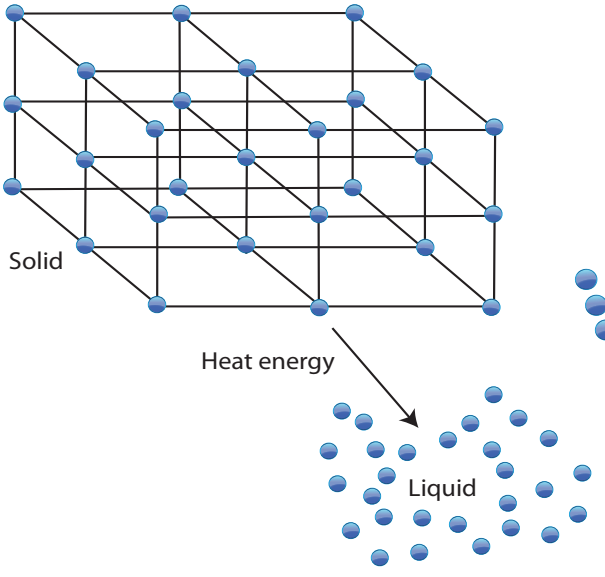
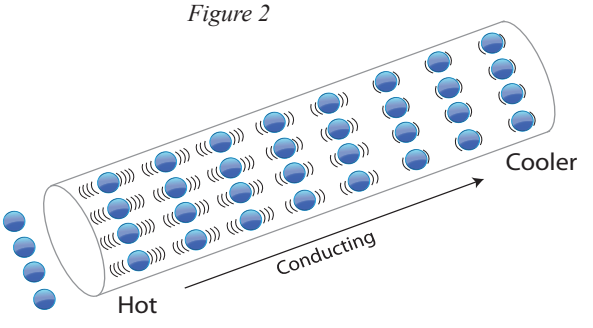


Figure 2



ACTIVITY 1: Meltdown

STUDENT GUIDE

INTRO

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KEY QUESTION

How do different metals conduct heat?

KEY TERMS

Conduction: Energy in the form of heat moving from one thing to another.

Kinetic energy: Energy of motion. When things are moving, they have kinetic energy.

Temperature: Temperature is a measure of how fast the average molecule is moving. It is related to the molecules' kinetic energy. The faster they move, the higher the kinetic energy and therefor the higher the temperature.

Melting: The process of changing from a solid to a liquid

MATERIALS

- 3 Hershey's kisses
  (or 6 and change step 1 to 'eat 3 Hershey's kisses')
- 1 steel wire
- 1 Copper wire
- 1 Aluminum wire
- Hot water
- Cup
- Tape
- Stopwatch or watch with a second hand*
  **Not included in the PhysicsQuest Kit*

GETTING STARTED

1. How many different types of metal can you think of? What are some of the differences between all of these metals?

_____

_____

_____

_____

_____

_____

2. What does it mean for something to be 'hot' and 'heat up'?

_____

_____

3. How can you tell if chocolate has melted

_____

_____

_____

_____

4. Predict which metal you think would conduct heat best, steel (mostly iron), copper, or aluminum. Think about where you have seen these metals before and what they are often used for when making your predictions.

_____

_____

_____

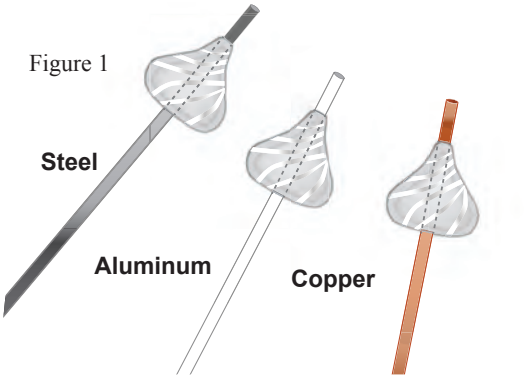
SETTING UP THE EXPERIMENT

1. Unwrap 3 Hershey's kisses.

2. Skewer each kiss with one of the three metal wires. It is easiest to go through the middle of the bottom and out of the top. There are extra kisses in case one or more break during this process (Figure 1).

3. Tape the wires to the inside edge of the cup, kiss end up. There should be two inches between the lip of the cup and the bottom of the kiss (Figure 2).

Figure 1



ACTIVITY 1: Meltdown

STUDENT GUIDE

COLLECTING DATA

1. Fill the cup with hot water and start the stopwatch. Make sure the water is high enough to cover the bottoms of the wires.

2. Record the time it takes for each kiss to fall into the water

Aluminum	_____seconds
Steel	_____ seconds
Copper	_____seconds

3. Stop after 2 min even if all kisses have not yet hit the water.

ANALYZING YOUR DATA

1. What happened when the hot water was poured in the cup?

_____

_____

_____

_____

2. List the in order of their ability to conduct heat, fro highest to lowest (1 means it conducts the best).

Aluminum	_____
Steel	_____
Copper	_____

3. How did this compare to your predictions?

_____

_____

_____

_____ _____

_____

4. Did all the kisses melt and slide down the wires? If not, why do you think they didn't?

_____

_____

_____

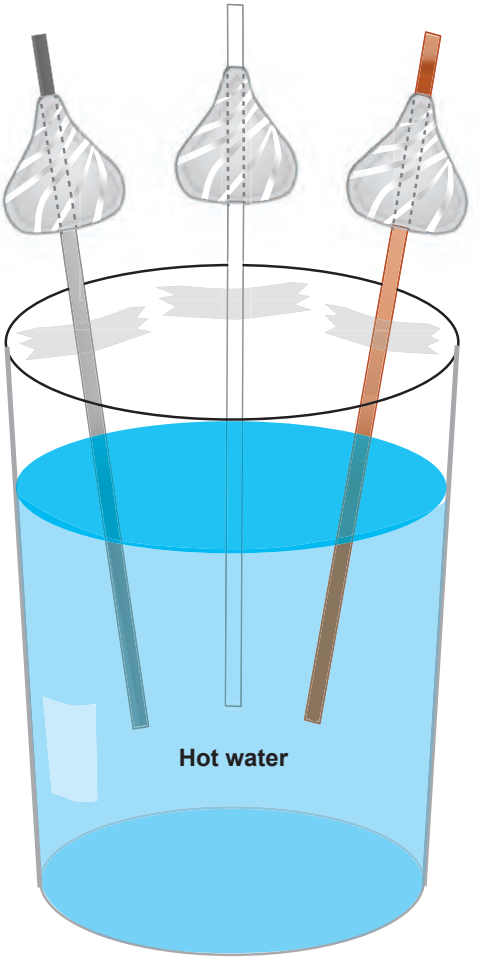
USING YOUR RESULTS TO HELP SPECTRA SAVE HER FRIENDS

Which metal is the most conductive *(circle one)*

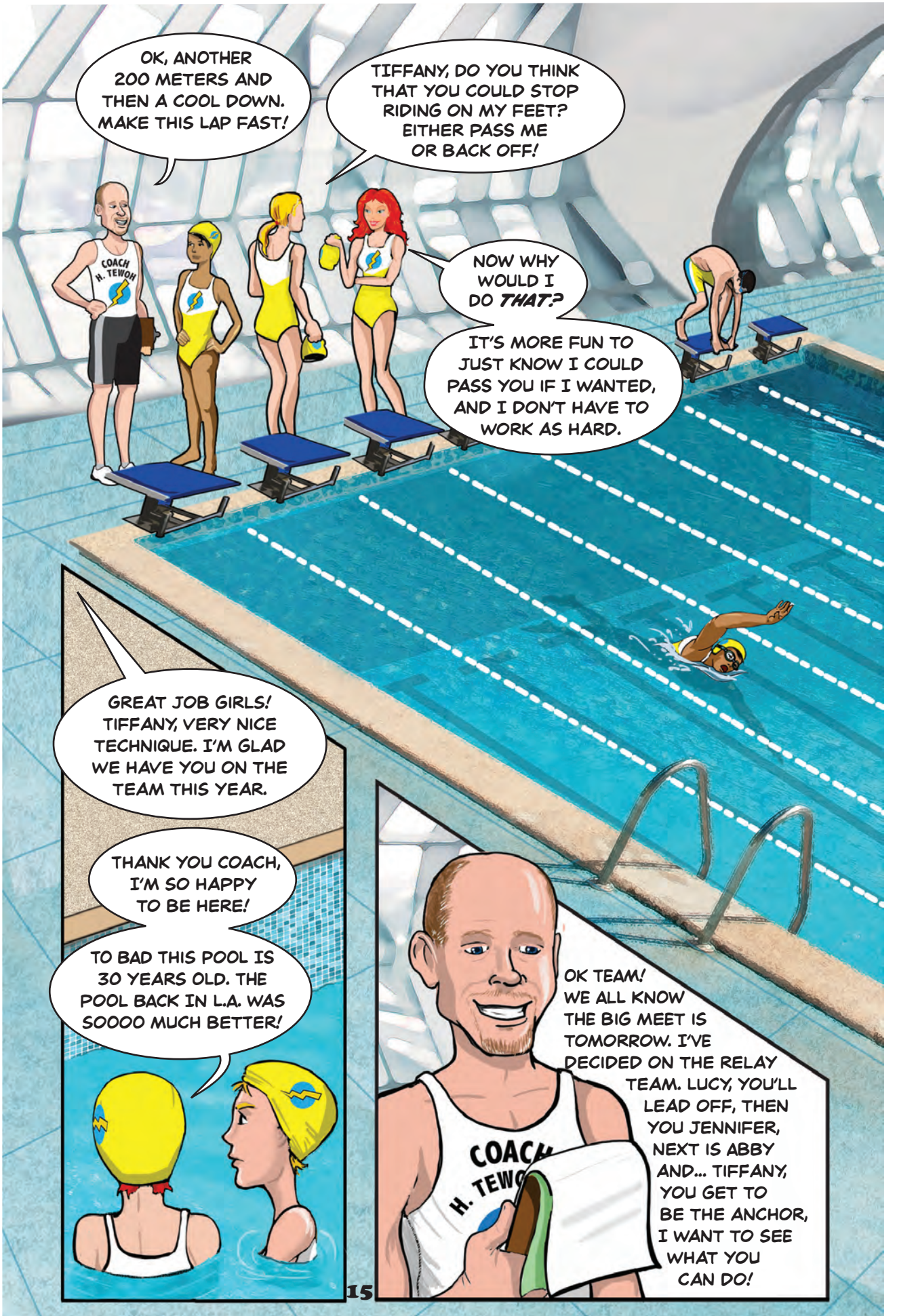
1. Copper
2. Steel
3. Aluminum
4. Both steel and aluminum conduct the same

This number is the first digit in the number of the room in which Spectra's friends are trapped.

Figure 2



*See ***Spectra #3: Force.***


OK, ANOTHER 200 METERS AND THEN A COOL DOWN. MAKE THIS LAP FAST!
TIFFANY, DO YOU THINK THAT YOU COULD STOP RIDING ON MY FEET? EITHER PASS ME OR BACK OFF!
COACH H. TEWOH
NOW WHY WOULD I DO THAT?
IT'S MORE FUN TO JUST KNOW I COULD PASS YOU IF I WANTED, AND I DON'T HAVE TO WORK AS HARD.
GREAT JOB GIRLS! TIFFANY, VERY NICE TECHNIQUE. I'M GLAD WE HAVE YOU ON THE TEAM THIS YEAR.
THANK YOU COACH, I'M SO HAPPY TO BE HERE!
TO BAD THIS POOL IS 30 YEARS OLD. THE POOL BACK IN L.A. WAS SOOOO MUCH BETTER!
OK TEAM! WE ALL KNOW THE BIG MEET IS TOMORROW. I'VE DECIDED ON THE RELAY TEAM. LUCY, YOU'LL LEAD OFF, THEN YOU JENNIFER, NEXT IS ABBY AND... TIFFANY, YOU GET TO BE THE ANCHOR, I WANT TO SEE WHAT YOU CAN DO!

ACTIVITY 2: Drinking Bird Races

TEACHER GUIDE

INTRO

Everyone has seen the famous "dippy bird," a particularly favorite toy of Homer Simpson, but have you ever thought about why it works? Why does it need water? What powers it? Would it go on forever? What exactly does the tail add? This experiment will investigate what drives this unusual bird to drink.

KEY TERMS

Periodic Motion: When the motion of an object is periodic it follows a set path repeatedly. It always ends up back where it started. The motion of the planets or pedaling on a bicycle are examples of periodic motion.

Period: The period is the amount of time it takes for an object undergoing periodic motion to return to its starting place.

Evaporation: Evaporation is a process that cools things off. Molecules of a liquid that have the highest temperature (most kinetic energy) fly off of a surface leaving only the cooler molecules behind.

Evaporative Cooling: As liquid evaporates off of something such as skin, the molecules that leave take a lot of energy with them leaving the skin cooler than it started. This is why sweat is an effective was of cooling the body down.

Condensation: Changing from a gas to a liquid.

MATERIALS

- 2 x Drinking Birds
- Alcohol pads
- Large plastic bag
- Cup of room temperature or hotter water
- Stopwatch or watch with a second hand

**Not included in the PhysicsQuest Kit*

BEFORE THE ACTIVITY STUDENT SHOULD KNOW

- Evaporation cools things down.
- Periodic motion means an object follows the same path repeatedly..

KEY QUESTION

How can the speed of a drinking bird be changed?

AFTER THE ACTIVITY STUDENTS SHOULD SHOULD BE ABLE TO

- Explain how a drinking bird works.
- Explain how different liquids change the rate of evaporation.
- Explain what other factors affect evaporation.

THE SCIENCE BEHIND THE DRINKING BIRDS

There is a whole lot of physics going on inside this little bird. It is often confused with a perpetual motion device, which it is not. Temperature, pressure, condensation, balance and evaporation all play crucial roles in driving this bird to constantly drink.

The first thing to look at is the bird's construction. It may seem like two bulbs connected by a tube (or "neck"), but look more closely. The tube extends down into the bottom bulb and isn't simply attached *(Figure 1)*. All of the air in the bird has been removed so the bird is filled only with the colored liquid and vapor from the liquid. The neck of the bird has a metal cuff attached to the "legs" which allows the bird to pivot. This cuff must be in the middle or the balance will be off and the bird will not be able to move both up and down. The head of the bird is covered in felt and has an attached beak and the rear half has a feather attached as a tail. Though these may look like simple decoration, the feather helps the bird balance and the beak and felt are need to keep the bird going.

When the bird's head is dunked in water the water begins to evaporate, causing the bird's head to cool off. This is just like when we sweat during exercise. The sweat evaporates and leaves us feeling cooler. The bird's head is filled with the vapor of the purple liquid and as it cools off it begins to condense. When the gas becomes a liquid again it takes up much less space. This means that the pressure in the birds head is less than in other parts of the bird.

ACTIVITY 2: Drinking Bird Races

TEACHER GUIDE

The liquid in the bottom begins to move up the bird's neck to fill the space left when the gas condensed. As the liquid moves up, it makes the head of the bird heavier and causes it to tip forward. When that happens, the tube that extends into the bird's bottom half ends up above the level of the liquid and a gas bubble can now move up the neck. This bubble of vapor pushes the liquid back down the neck which causes the bird to tip back. Then the whole thing starts over again. Notice that the bird rocks back and forth a bit when it pops back up. This is not the periodic motion we are talking about. In this experiment a period of drinking is from when the bird is horizontal and back to that point.

The felt in the head is important because it will absorb the water and allow it to evaporate slowly. Most times you will see a bird dipping into a cup of water with every tip. The bird will go for a long time without needing a glass of water, but once all of the water evaporates from the head the bird will stop unless it can get more. The beak of the bird soaks up water every time it dips into the glass and this allows the bird to continue its drinking.

As the bird dips and comes back up it is undergoing periodic motion. It continues to return to where it started. But what can affect the period of the bird's motion? Really the only thing we as experimenters have control over is the process of evaporation. In the first experiment the students will look at how the period changes when alcohol is used instead of water. Because the alcohol evaporates more quickly, the whole drinking process will speed up and the bird will have a shorter period. If you have time, you could also try using water of different temperatures. In the second experiment the students will place a bag over the bird and watch it stop. This happens because the air inside the bag become saturated and no more alcohol can evaporate from the birds head so there is nothing left to drive the motion. When the bag is removed the bird again starts to drink.

If you have time, soak one bird's head in water and one in alcohol and let them go. In addition to seeing which one drinks more quickly let the birds go until they stop moving. Don't add any water or alcohol to the birds' heads. The bird covered in alcohol moves more quickly because the alcohol evaporates more quickly but this also means the bird will stop moving sooner as it loses its "fuel" at a faster rate. The bird dunked in water may be slow but he will go forever.

SAFETY

Be careful not to crack the drinking bird. The glass can be sharp and the liquid is flammable and harmful if consumed.

CORRESPONDING EXTENSIONS ACTIVITIES

- Liquid rainbow
- Evaporation bags
- Slurpy physics

BIBLIOGRAPHY AND SUGGESTED RESOURCES

http://science.howstuffworks.com/innovation/science-questions/question608.htm

http://hyperphysics.phy-astr.gsu.edu/hbase/thermo/sweat.html

http://www.newton.dep.anl.gov/askasci/gen06/gen06190.htm

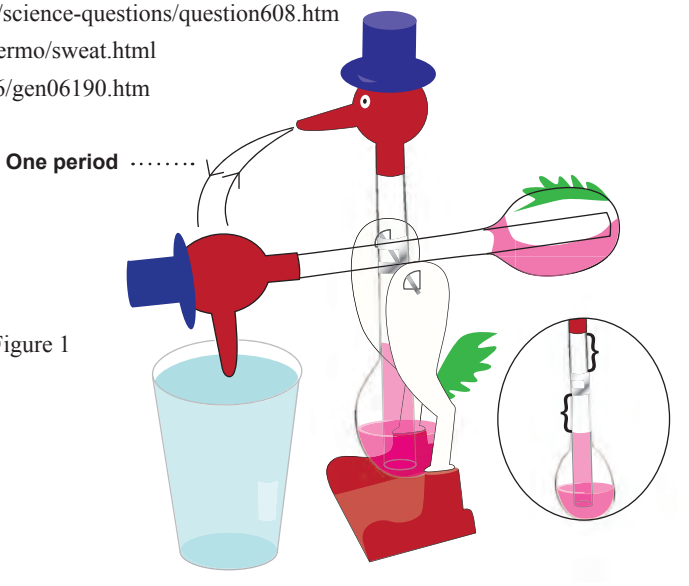


Figure 1

ACTIVITY 2: Drinking Bird Races

STUDENT GUIDE

INTRO

Everyone has seen the famous "dippy bird," a particularly favorite toy of Homer Simpson, but have you ever thought about why it works? Why does it need water? What powers it? Would it go on forever? What exactly does the tail add? This experiment will investigate why this unusual bird drinks.

MATERIALS

- 2 x Drinking Birds
- Alcohol pads
- Large plastic bag
- Cup of water*
- Stopwatch*

**Not included in PhysicsQuest kit*

GETTING STARTED

1. What does "evaporation" mean?

_____

_____

_____

_____

2. How does it feel when water or sweat evaporates from your skin? What about rubbing alcohol? How might you use rubbing alcohol?

_____

_____

_____

3. What types of things undergo "periodic motion?" How would describe this kind of motion?

_____

_____

_____

SETTING UP THE EXPERIMENT

Take both birds out of their boxes and set them side by side. Label them "alcohol" and "water." Or, if you want to, feel free to name them. Alfred and Walter have a nice ring to them (Figure 1).

Slide the bird in the metal cuff till it's in the middle of the bird. This will allow the bird to balance correctly REMOVED.

KEY QUESTION

How can the period of a drinking bird be changed?

Open the bag and make sure it can fit over the drinking bird without touching it or getting in the way of it's "drinking." (Figure 2)

Place a cup of room temperature water in front of the "water" bird.

COLLECTING DATA

You will be doing two experiments, both using your drinking birds. At the end of the two experiments you will have a better understanding of what makes a drinking bird "drink."

EXPERIMENT 1

In this experiment you will look at what drives a bird to "drink" and what things can affect how fast it "drinks."

1. Give your "water" bird a tap on the back of the head and see what happens.

_____

_____

_____

_____

2. Take the bird marked "water" and dip his or her head in the water, getting the beak and head a bit wet. Let go and watch what happens.

_____

_____

_____

_____

ACTIVITY 2: Drinking Bird Races

STUDENT GUIDE

3. As the bird moves, it dips all the way down to "drink", pops back up, rocks back and forth for a bit till it dips all the way down again to "drink." We're going to measure the period of the bird's drinking by measuring the time between "sips." A 'sip' is when the bird is completely horizontal. (Figure 2) Let the bird "drink" a few times then start the timer when it is taking a "sip." Let the bird "sip" 5 times and write down the time. To find the period of the birds "drinking" take the time for 5 "sips" and divide by 5.

Time for 5 "sips" of water _____
Period of "drinking" water _____

You've already seen what happens when you dip a bird in water, now you are going to see what happens when you soak one in alcohol.

4. Let your first bird continue drinking and put it next to the bird labeled "alcohol."

5. Take two alcohol pads and soak the head of the bird marked "alcohol" with the rubbing alcohol.

6. Repeat step 3 and measure the period of the bird's drinking.

Time for 5 "sips" of water _____
Period of "drinking" water _____

EXPERIMENT 2

You have already seen how two different liquids affect how fast the birds "drink" and now we are going to see what happens when the bird is put in a smaller space.

1. Again take the bird marked "alcohol" and soak wrap two alcohol pads around its head till it is soaked.

2. Allow the bird to "drink" a few times.

3. Place the plastic bag over the bird making sure not to touch any part of the bird (Fig. 3).

4. Record what happens.

5. Remove the bag and record what happens.

6. Repeat steps 1-4 two more times.

ANALYZING YOUR RESULTS

1. What happened when the bird's head got wet?

_____

_____

_____

_____

2. What was the period for the bird dunked in water? How was this different than the period of the bird dunked in alcohol?

_____

_____

_____

_____

3. What happened when the bag was placed over the bird? Were you surprised? Why do you think the bag affected the bird?

_____

_____

_____

_____

4. Why do you think the bird dipped in alcohol had a different period than the bird dipped in water?

_____

_____

_____

_____

5. Thinking about the differences between alcohol and water as well as what happened when you places the bag over the bird's head, what to you think is causing the bird to "drink?"

_____

_____

_____

ACTIVITY 2: Drinking Bird Races

STUDENT GUIDE

5. What do you think would happen if water of two different temperatures was used? Would the hot water or the cold water make the bird drink faster?

_____

_____

USING YOUR RESULTS TO HELP SPECTRA SAVE HER FRIENDS

Which of the birds "drank" with a shorter period? *(Circle your guess)*

1. The bird with his head dipped in water

2. The bird with his head dipped in alcohol

3. They had the same period

This number is the second digit in the number of the room in which Spectra's friends are trapped.

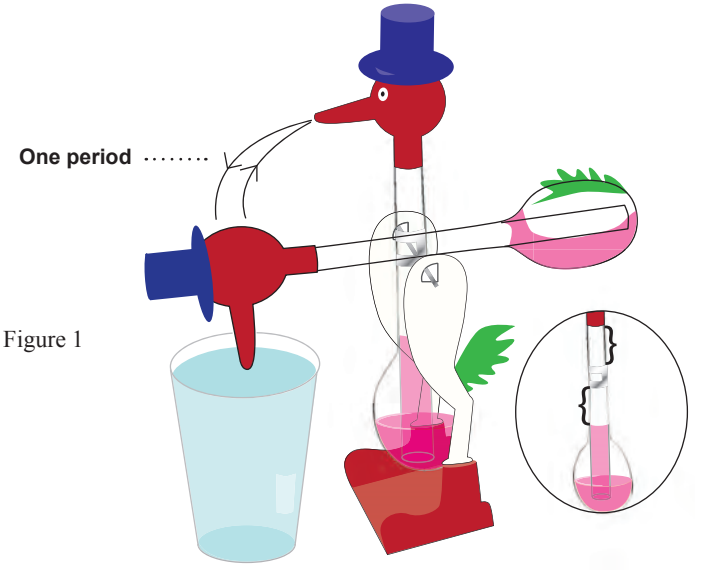


Figure 1

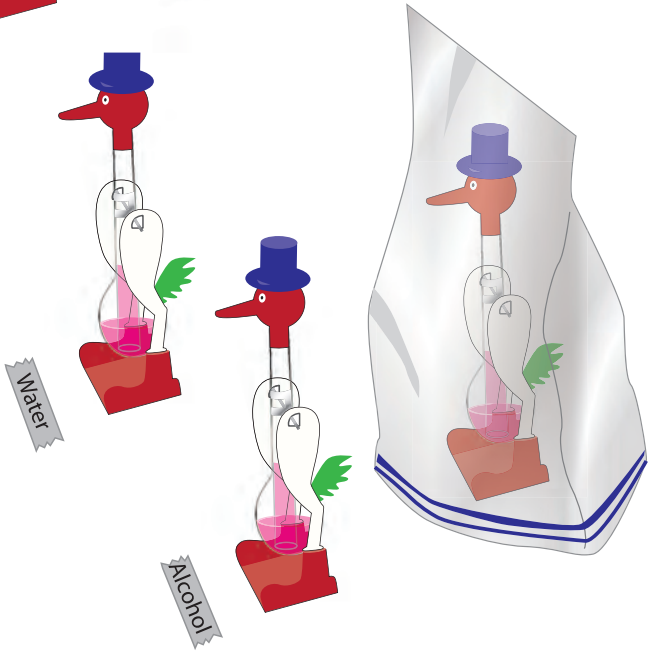
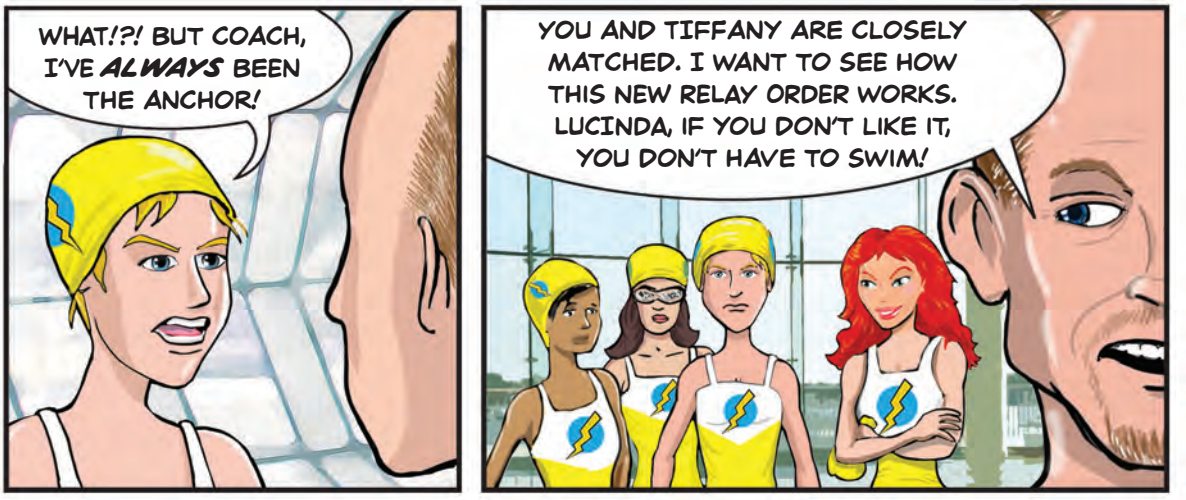
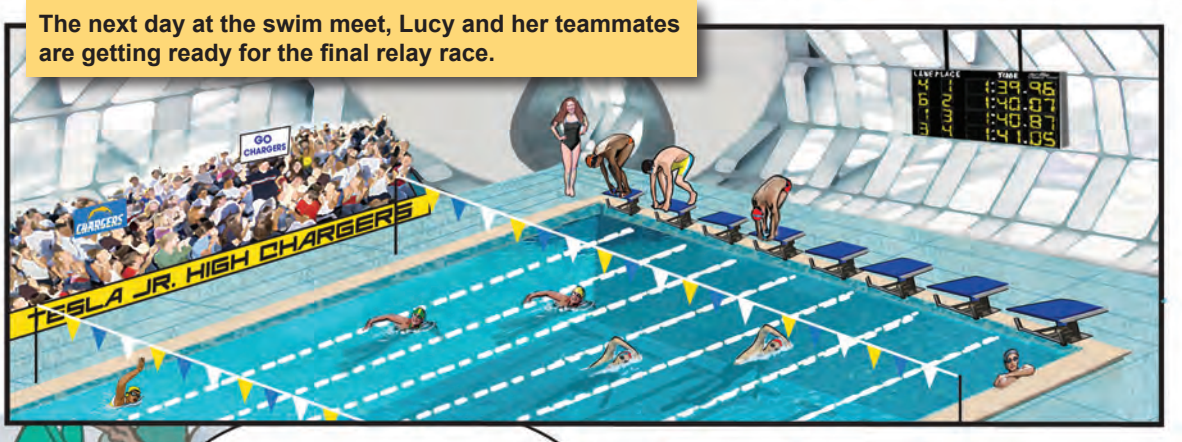
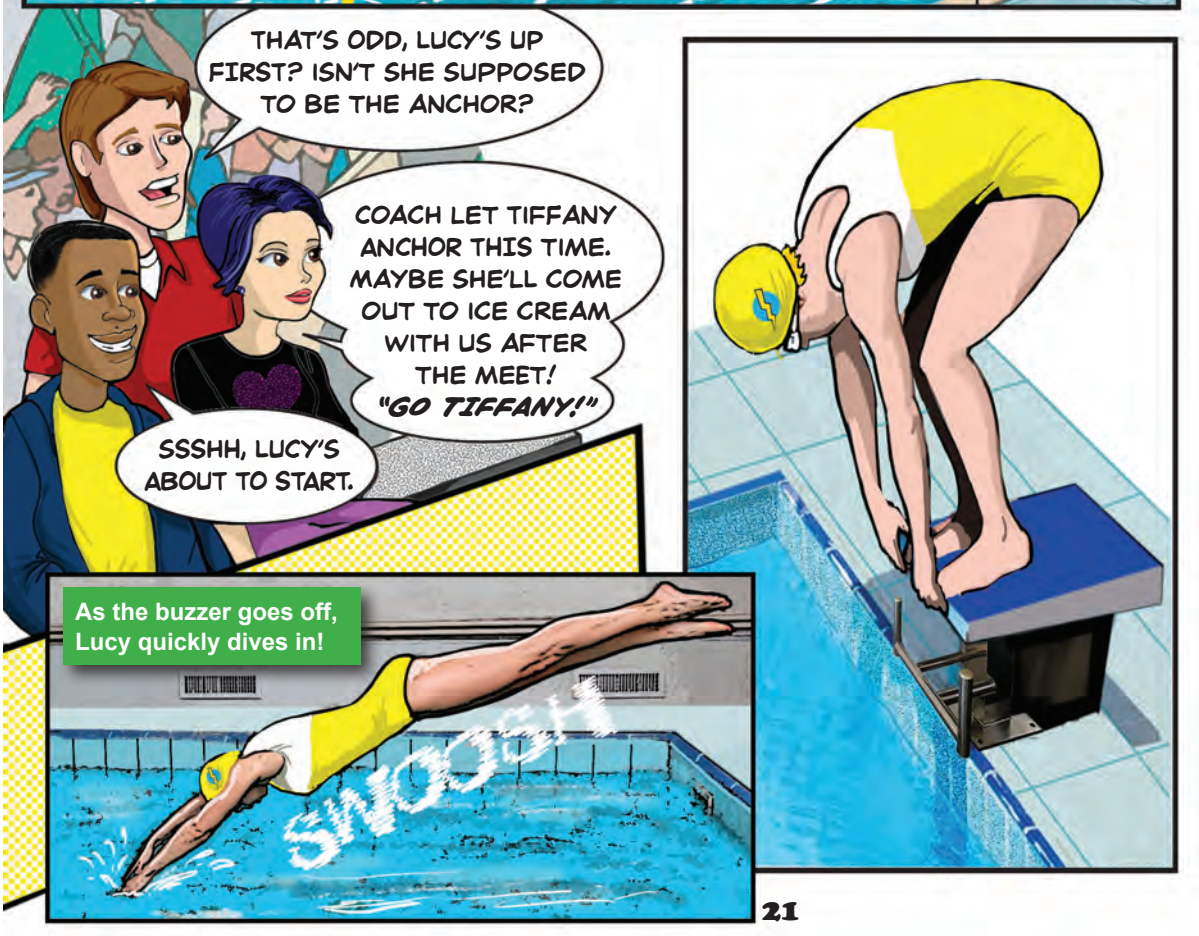
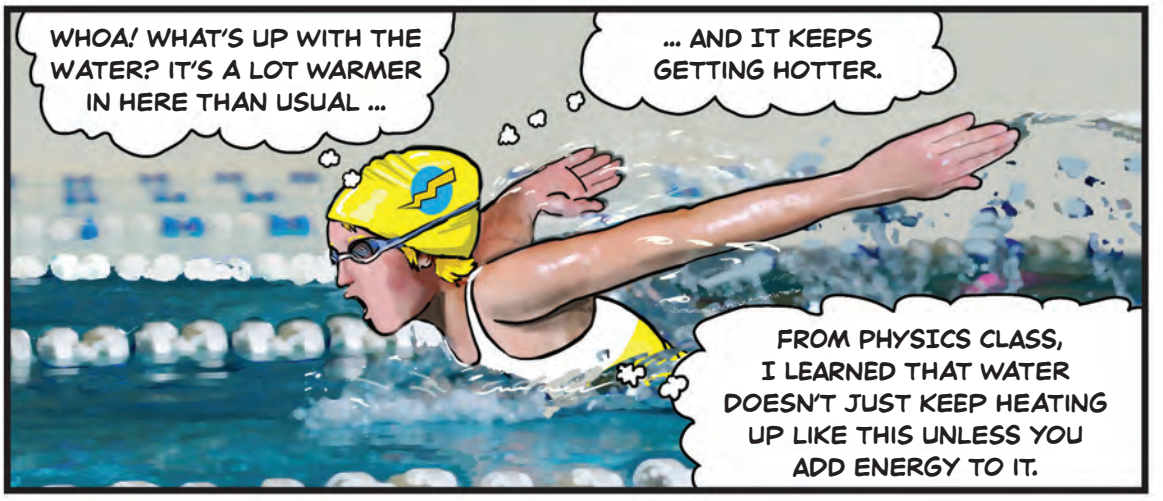


Figure 2


WHAT!?! BUT COACH, I'VE ALWAYS BEEN THE ANCHOR!
YOU AND TIFFANY ARE CLOSELY MATCHED. I WANT TO SEE HOW THIS NEW RELAY ORDER WORKS. LUCINDA, IF YOU DON'T LIKE IT, YOU DON'T HAVE TO SWIM!


The next day at the swim meet, Lucy and her teammates are getting ready for the final relay race.
GO CHARGERS
CHARGERS
TESLA JR. HIGH CHARGERS

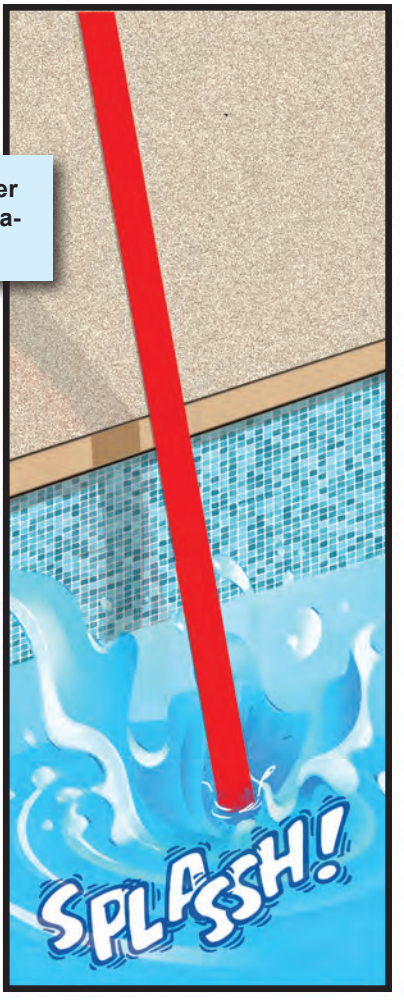

THAT'S ODD, LUCY'S UP FIRST? ISN'T SHE SUPPOSED TO BE THE ANCHOR?
COACH LET TIFFANY ANCHOR THIS TIME. MAYBE SHE'LL COME OUT TO ICE CREAM WITH US AFTER THE MEET! "GO TIFFANY!"
SSSHH, LUCY'S ABOUT TO START.
As the buzzer goes off, Lucy quickly dives in!
SNOOZE

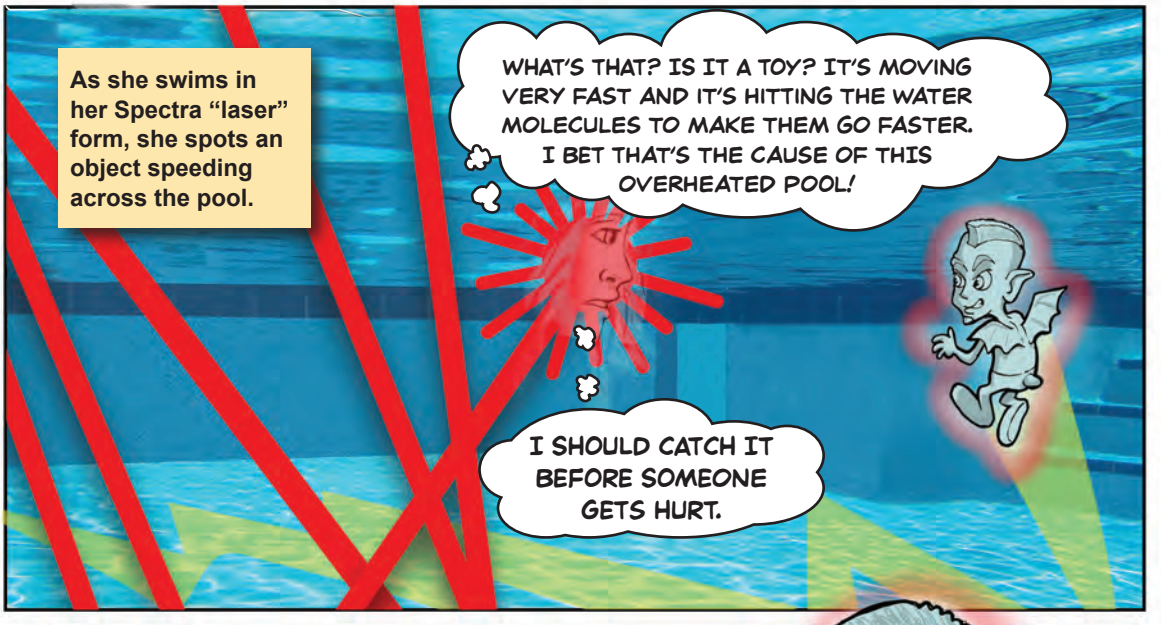

WHOA! WHAT'S UP WITH THE WATER? IT'S A LOT WARMER IN HERE THAN USUAL ...
... AND IT KEEPS GETTING HOTTER.
FROM PHYSICS CLASS, I LEARNED THAT WATER DOESN'T JUST KEEP HEATING UP LIKE THIS UNLESS YOU ADD ENERGY TO IT.

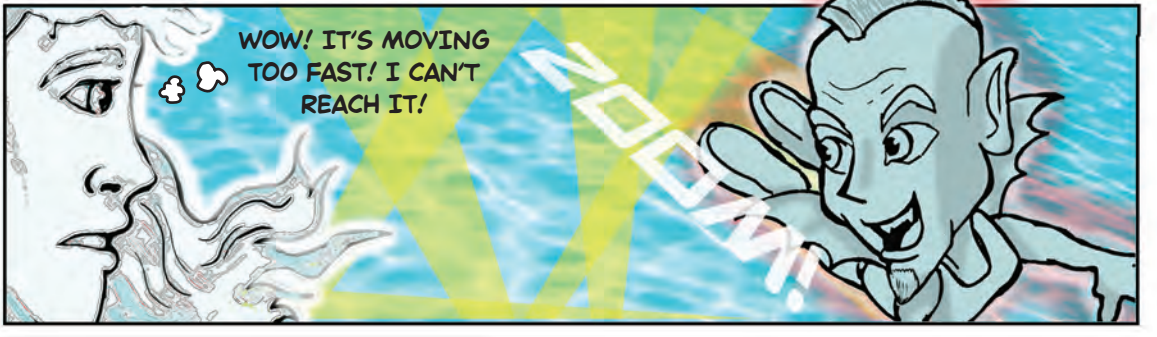

BUT THEY WOULDN'T HAVE TURNED THE HEATERS UP THIS HIGH. SOMETHING ISN'T RIGHT. WHEN I'M DONE, I'LL GO CHECK IT OUT...
...BECAUSE I KNOW LASERS CAN BE USED TO LOOK AT MOLECULES.
Lucy finishes her part of the race. As she touches the wall, Jennifer dives in.


When she's certain no one is looking, Lucy transforms into Spectra mode...

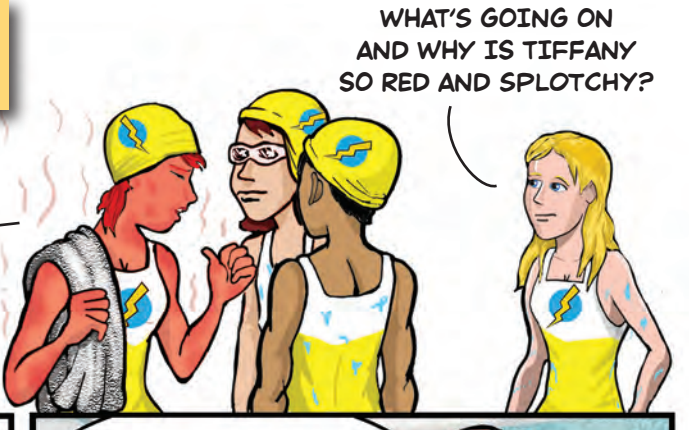

... and goes back in the water to see what's causing the water molecules to speed up.
BZZZAHH
22

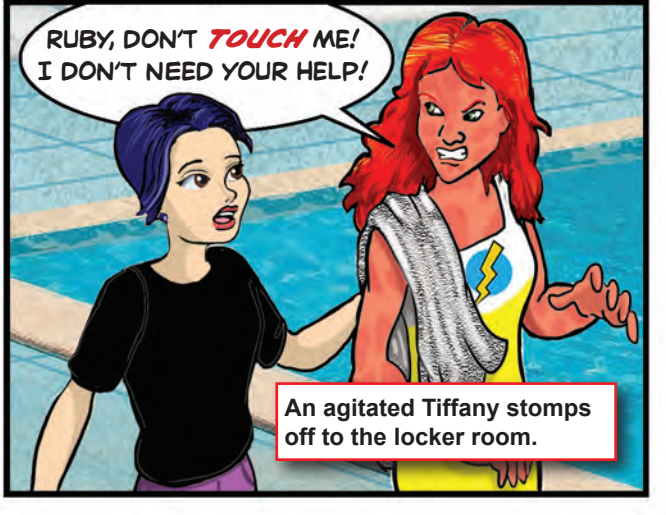

SPLASSH!





Spectra exerted all her strength trying to catch the object. She needs to take a break so she heads back up to the deck.





ACTIVITY 3: Rusted Out

TEACHER GUIDE

INTRO

Everyone has seen something rust, a nail, a bike, or even your car. Rusting seems like a long drawn out process and generally not very interesting. However, there is a whole lot of physics going on as you watch your salt-covered car turn from blue to an unfortunate orange. As something rusts it gives off heat because rusting is an exothermic reaction. It usually happens so slowly that this fact often goes unnoticed. In this activity the students will use steel wool and vinegar to explore the chemical reaction of rusting in a much more exciting way.

KEY TERMS

Exothermic: Meaning "outside heating," exothermic reaction is one that releases energy. In this experiment the energy is released in the form of heat.

Chemical Reaction: In a chemical reaction molecules interact to create a new substance. They can combine, separate or change they way they are bound together.

Kinetic energy is energy of motion. When things move they have kinetic energy.

MATERIALS

- Packets of vinegar
- Steel wool
- Clear plastic bag
- Liquid crystal thermometer
- Cup*
- Paper towels*
- Stopwatch or watch with a second hand*

**Not included in PhysicsQuest kit*

BEFORE THE ACTIVITY STUDENT SHOULD KNOW

- That iron and oxygen can combine to form rust.
- That some chemical reactions produce energy that can be felt as heat.
- How to read a liquid crystal thermometer

AFTER THE ACTIVITY STUDENTS SHOULD SHOULD BE ABLE TO

- Explain an exothermic and endothermic reaction and classify rusting as one or the other.
- Explain, on a molecular level, what it means to "heat up."

KEY QUESTION

What happens when an object rusts?

THE SCIENCE BEHIND RUSTING

Everyone has seen something rust. If asked to describe the rusting process we would all say something like "metal left out in air turns brownish and falls apart. Air is combining with the metal and turning it into rust." This is exactly what happens but there is a little more going on. In this experiment we are making something rust extremely quickly and because of that we can learn even more about the process.

Chemical reactions can be either endothermic or exothermic. In an endothermic reaction heat from the surrounding material is used to make the reaction go and the temperature drops. In an exothermic reaction energy is released during the reaction. If this reaction happens quickly the heat released can be easily felt. But if it is a slowly occurring reaction, not enough heat is produced at one time to be felt. Rusting is usually a very slow reaction.

Rust is formed when three oxygen atoms bind with two iron atoms. There are a lot of steps in between and the reaction needs water to help it out, but in the end, there are three oxygen atoms with to iron atoms. This reaction is exothermic so every time it happens, a little bit of heat is released. If the reaction happens very slowly, only a very tiny amount of heat is released each time the reaction occurs, too little heat to be felt by us. This is why your neighbor's yard-car doesn't feel hot as it slowly rusts up on its blocks. But, if there is a way to make the reaction happen very, very fast, it is easy to feel the heat.

Steel is made of iron with some carbon atoms thrown in the mix. If you use steel wool around the house you know that it doesn't usually rust quickly, but that it will after using it for a long time. Steel wool has a coating on it that makes it very difficult for oxygen atoms to get to the iron in the steel at bind with them. But, because steel wool is made of a lot of fine strands of steel there is a lot of surface area exposed to air and if the coating wasn't there, the wool would rust extremely quickly. That is what we are doing in this experiment, we remove the coating with vinegar are watch the wool rust. Because it rusts so fast, it is possible to feel the heat released from the reaction.

ACTIVITY 3: Rusted Out

TEACHER GUIDE

FURTHER RESOURCES

For an explanation and video on flaming steel, visit our blog:

http://physicsbuzz.physicscentral.com/2011/10/bule-steel-or-i ss-red-hot-flaming.html

To learn more about he reaction that causes rust:
http://www.chemicalformula.org/rust

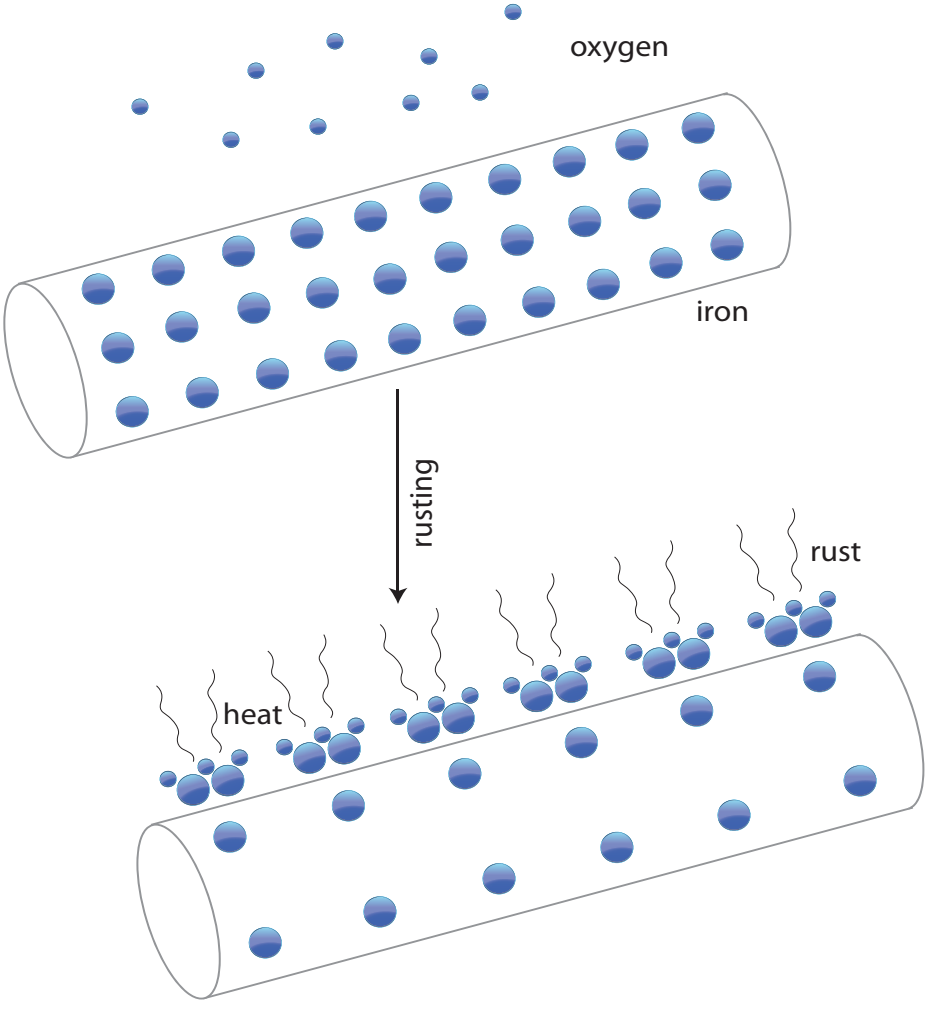
To learn more about exothermic and endothermic reactions and find other examples of each:
http://www.kentchemistry.com/links/Matter/EndoExo.htm

SAFETY

There are no serious safety concerns with this experiment.

CORRESPONDING EXTENSION ACTIVITIES

- Corresponding extension activities
- Secret message
- Hot and cold rubber band



ACTIVITY 3: Rusted Out

STUDENT GUIDE

INTRO

We've all watched something rust. Not very exciting and it takes a long time. But what would happen if you could make something rust very quickly? In this experiment you will see what really happens when something rusts. It is actually quite fun, really!

MATERIALS

- Packets of vinegar
- Steel wool
- Clear plastic bag
- Liquid crystal thermometer
- Cup*
- Paper towels*
- Stopwatch or watch with a second hand*

**Not included in PhysicsQuest kit*

GETTING STARTED

1. Have you ever seen things rust? What does it look like? Sketch a rusting object.

_____

_____

_____

_____

2. What changes happen with something rusts?

_____

_____

_____

_____

KEY QUESTION

What happens when an object rusts?

3. Predict three things that you will see when you watch something rust quickly.

_____

_____

_____

4. What things can make something rust faster?

_____

_____

_____

_____

_____

SETTING UP THE EXPERIMENT

1. Open the zip lock bag

2. Stick the liquid crystal thermometer to the inside of the bag so that you can see it through the bag. (Figure 1)

3. Pour all the vinegar packets into a cup.

COLLECTING DATA

1. Place the steel wool in the vinegar and make sure it is completely covered in vinegar.

2. Let the steel wool soak in the vinegar for 5 minutes.

3. Pull the steel wool from the cup and very quickly blot the vinegar off with the paper towel then quickly place it in the bag and seal the bag. (Figure 2)

4. Record the temperature on the thermometer every 3 seconds.

5. Make sure you also have a hand on the bag so that you can feel the temperature change.

ACTIVITY 3: Rusted Out

STUDENT GUIDE

ANALYZING YOUR RESULTS

1. How did the appearance of the steel wool change?

_____

_____

2. What other changes happened?

_____

_____

3. What happened to the temperature of the steel wool?

_____

_____

4. Why did you need to soak the steel wool in vinegar?

_____

_____

5. Look back at your predictions. How does what you saw compare with what you thought you would see?

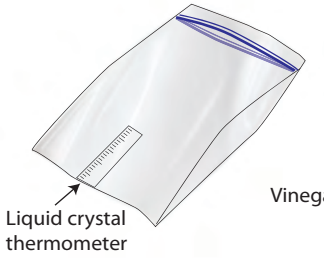
_____

_____

_____

6. Make a graph of temperature vs. time

Figure 1



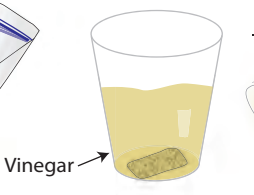
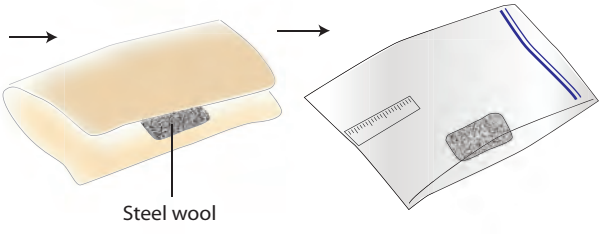


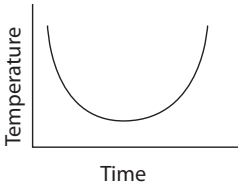
Figure 2



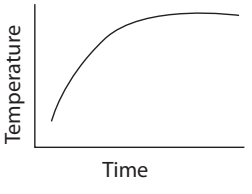
USING YOUR RESULTS TO HELP SPECTRA SAVE HER FRIENDS

Circle the graph that most looks like your graph of temperature vs. time.

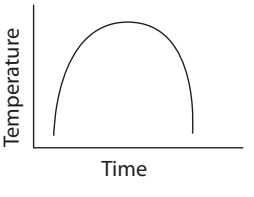
1.



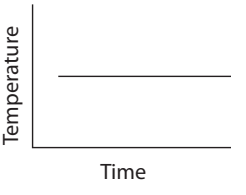
2.



3.

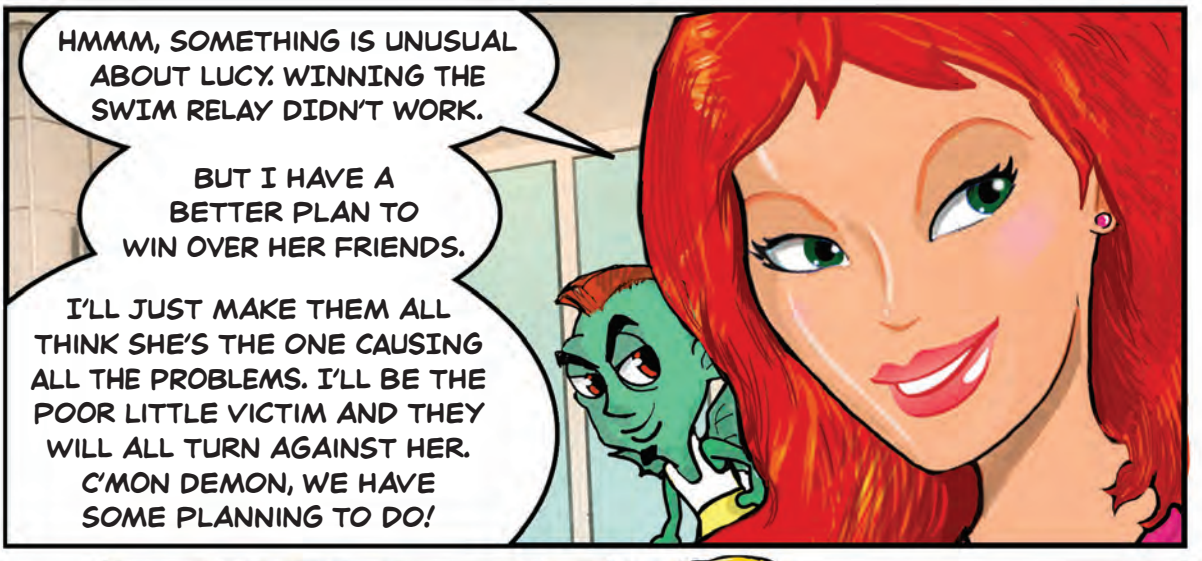


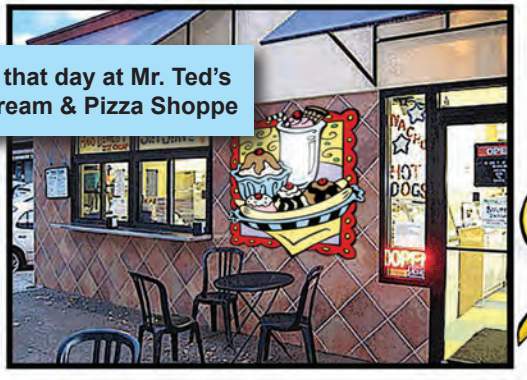
4.



This number is the third digit in the number of the room in which Spectra's friends are trapped.


Back in the locker room.
HOW COULD YOU DO THAT TO ME!
YOU WERE JUST SUPPOSED TO HEAT UP THE OTHER TEAM SO OUR RELAY COULD WIN AND I WOULD LOOK LIKE A HERO!
INSTEAD YOU... WAIT, SHH... BE QUIET! DO YOU HEAR THAT?
HOW COULD YOU DO THAT TO TIFFANY?
I KNOW YOU'RE JEALOUS BUT THAT JUST WASN'T RIGHT!
WHAT ARE YOU TALKING ABOUT? I ADMIT THE POOL GETTING HOT WAS CRAZY, BUT THAT WASN'T CAUSED BY ME!
YEAH, RIGHT. I DIDN'T SEE YOU WHEN THE POOL GOT HOT! THE GUYS AND I THOUGHT SPECTRA CAUSED THE CHAOS.
IN UNCLE LESLIE'S PHYSICS CLASS WE LEARNED THAT LASERS ARE USED TO MAKE THINGS VERY HOT.
LASERS USE THEIR ENERGY TO PUSH MOLECULES AROUND AND HEAT THEM UP.
I DON'T KNOW OF ANYONE ELSE IN THE POOL THAT COULD HAVE DONE THAT!
A BIT OF A COINCIDENCE, DON'T YOU THINK?
I DON'T KNOW WHAT'S HAPPENING. SO SPECTRA WENT TO INVESTIGATE. THAT'S WHY I WAS MISSING. BLAMING ME JUST ISN'T FAIR!
WHATEVER! WE, AND I MEAN TIFFANY TOO, ARE ALL GOING OUT FOR ICE CREAM. JOIN US IF YOU'RE WILLING TO APOLOGIZE TO HER!


HMMM, SOMETHING IS UNUSUAL ABOUT LUCY. WINNING THE SWIM RELAY DIDN'T WORK.
BUT I HAVE A BETTER PLAN TO WIN OVER HER FRIENDS.
I'LL JUST MAKE THEM ALL THINK SHE'S THE ONE CAUSING ALL THE PROBLEMS. I'LL BE THE POOR LITTLE VICTIM AND THEY WILL ALL TURN AGAINST HER. C'MON DEMON, WE HAVE SOME PLANNING TO DO!


Later that day at Mr. Ted's Ice Cream & Pizza Shoppe
HOT DOGS


HEY LUCY! YOUR FRIENDS ARE ALREADY HERE.
Ice Cream
Ice Cream
TED


LUCY! WHAT DO YOU THINK YOU'RE DOING?
HEY, GUYS. WHAT'S UP?
AND THERE YOU ARE, YOU LITTLE BEAST!
POWW!

ACTIVITY 4: Hot Shot Spinner

TEACHER GUIDE

INTRO

Heat rises! If you have ever put your hand over a candle or been on the 14th floor of a building without air conditioned in Texas in August you know this. But did you know this neat property can be used to entertain party dinner guests? In this experiment students will create their own version of a "Spinning Holiday Pyramid" and learn what makes it spin.

KEY QUESTION

How does rising heat and blade tilt affect a pinwheel?

KEY TERMS

Pressure: How much push (or force) something gives per a particular area. You often here pressure with the unit "pounds per square inch."

Density: The amount of stuff (or mass) per volume. If there is more matter in the same volume the density is higher.

MATERIALS

- Tart pan
- Pencil (sharpened)
- 4 birthday candles
- Molding clay
- Lighter or matches*

**Not included in PhysicsQuest kit*

BEFORE THE ACTIVITY STUDENT SHOULD KNOW

- Heat rises
- Moving air can cause something to move, just like dust in the wind.

AFTER THE ACTIVITY STUDENTS SHOULD BE ABLE TO

- Explain how heat can power a pinwheel.
- Explain why windmill or pinwheel blades must be tilted

THE SCIENCE BY SPINNING PINWHEELS DRIVEN BY CANDLES

The physics behind the candle pinwheel is actually pretty simple. There are two components, heat rising and how this causes the pinwheel to turn. This neat yet simple physics is used for many things but one of my favorites is this "holiday pyramid" where carved wooden figures such a reindeer and angels are set on tiers and attached a central axle. There are candle holders throughout the structure and when they are lit, the rising heat causes a propeller on top to rotate and the reindeer to spin around. (Figure 1)

When a gas such as air gets hot the particles in the gas start moving faster. Their average kinetic energy increases. Because the molecules now have the energy to move around more, they do and as they do they spread out and the gas becomes less dense. This lighter gas now rises up away from the heat source.

If a propeller is free to move and constructed correctly, the rising heat can now make it turn. The heat rises relatively straight up so to get the pinwheel to turn the blades need to be oriented in a way that causes the moving air to push them. Rising air will first strike the edge tilted down toward the ground. The air continues to rise and moves along the slope of the blade. As this happens the pressure on the side of the blade tilted toward the ground increases and the moving air pushes the blade. The pressure on the back side of the blade decreases which also helps the blade to move (Figure 2). This is very, very similar to an airplane wing. You can see that the direction of spinning is changed when the tilt of the blade is changed by roughly 180 degrees.

In this experiment students will change the number of candles and therefore the amount of rising heat see how the speed of the spinning is affected. The will also see how different blade orientations affect the direction in which the pinwheel spins.

SAFETY

Always be careful when working with flame

ACTIVITY 4: Hot Shot Spinner

TEACHER GUIDE

CORRESPONDING EXTENSION ACTIVITIES

- Oily Ice Bubbles
- Cloud in a bottle
- Water Cycle in a Box

BIBILIOGRAPHY AND SUGGESTED RESOURCES

http://en.wikipedia.org/wiki/Christmas_pyramid

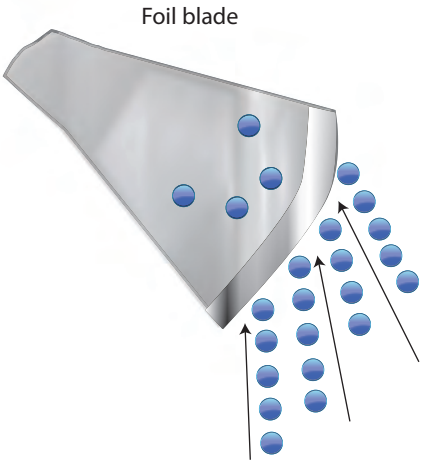
http://www.ehow.com/about_6162631_fan-mill-pin-wheels-work.html#ixzz1mGw6YvlX

http://answers.askkids.com/How_Stuff_Works/why_does_heat_rise

Figure 1

Christmas pyramid *(Wilkipedia)*

Figure 2



ACTIVITY 4: Hot Shot Spinner

STUDENT GUIDE

INTRO

I'm sure you have seen many pinwheels turn. Usually you spin them by putting them in the wind or blowing on them. If you did *PhysicsQuest: Nikola Tesla and the Electric Fair* you even used magnets and a battery to turn pinwheels. You have also probably heard that heat rises. But how do you know? In this experiment you will test this by using birthday candles to make a pinwheel spin.

KEY TERMS

Pressure: How much push (or force) something gives per a particular area. You often here pressure with the unit "pounds per square inch."

Density: The amount of stuff (or mass) per volume. If there is more matter in the same volume the density is higher.

MATERIALS

- Tart pan
- Pencil (sharpened)
- 4 birthday candles
- Molding clay
- Lighter or matches*

**Not included in PhysicsQuest kit*

GETTING STARTED

1. Why is it hotter on the second floor of a building as compared to the first?

_____

_____

_____

_____

2. What causes a windmill or pinwheel to turn?

_____

_____

_____

_____

3. Why does hot air rise?

_____

_____

_____

_____

KEY QUESTION

How does rising heat and blade tilt affect a pinwheel?

SETTING UP THE EXPERIMENT

1. Sharpen pencil and secure it point side up with the clay.

2. Put clay on the bottom of the four birthday candles and secure close to pencil.

3. You will be making a pinwheel/windmill out of the tart pan. Make six, 2-inch radial cuts in the tart pan making sure to leave the middle in tact to hold the "windmill" together.

4. Twist the blades 45 degrees counter-clockwise.

5. Carefully balance the tart pan windmill on top of the point of the pencil.

COLLECTING DATA

You will be doing two different but related experiments. First, you will look at what happens when rising heat hits the windmill and how it is affected by the amount of heat rising. Second, you will be investigating how the twist of the blades affects the spinning.

EXPERIMENT A

1. Very carefully light one of the birthday candles. Record what happens to the pinwheel.

_____

_____

_____

2. Now light the second, third and fourth candles, each time recording how the motion of the pinwheel changes.

_____

_____

_____

ACTIVITY 4: Hot Shot Spinner

STUDENT GUIDE

EXPERIMENT 2

1. Again light one or more of the candles with the blades twisted counter-clockwise as they were for the first experiment. Which direction is the pinwheel spinning?

2. Now twist the blades in the opposite direction, changing their orientation by 180 degrees. Light one or more candles. Which way is the pinwheel spinning now?

ANALYZING YOUR RESULTS

1. What happened to the pinwheel when you lit the first candle?

_____

_____

_____

_____

2. How did the pinwheel's motion change when you lit more candles?

_____

_____

_____

_____

3. What is happening to the air about the candles? How do you think this causes the pinwheel to move? What is pushing the pinwheel blades?

_____

_____

_____

4. Why do you think the orientation of the blades affects the direction of the pinwheel?

_____

_____

_____

_____

5. How are the direction of the pinwheel blades and the direction of the spinning related?

_____

_____

_____

_____

USING YOUR RESULTS TO HELP SPECTRA SAVE HER FRIENDS

With 4 candles and the blades of the pinwheel twisted clockwise relative to the ground, which direction did the pinwheel spin?

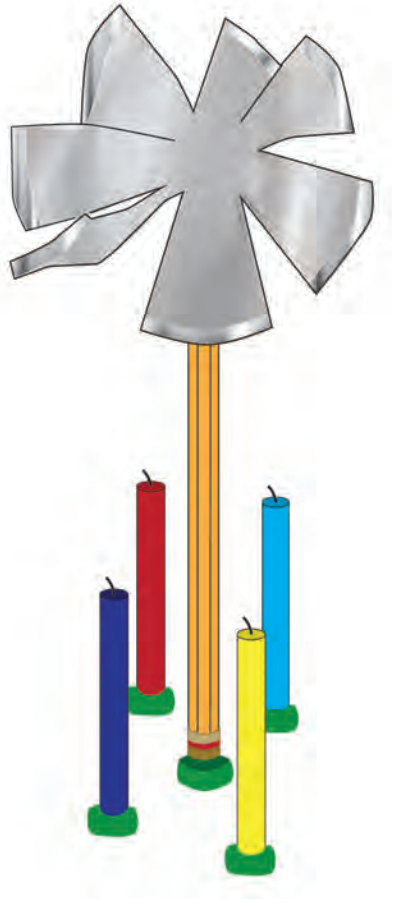
A. Clockwise and more quickly than with two candles

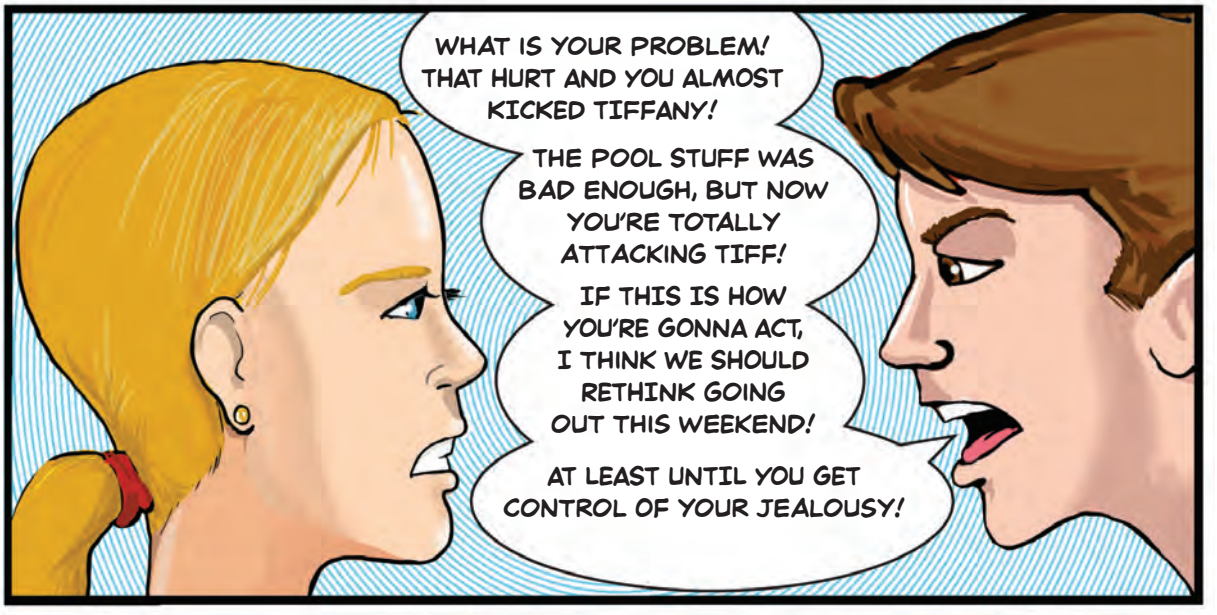
B. Counterclockwise and more slowly than with two candles.

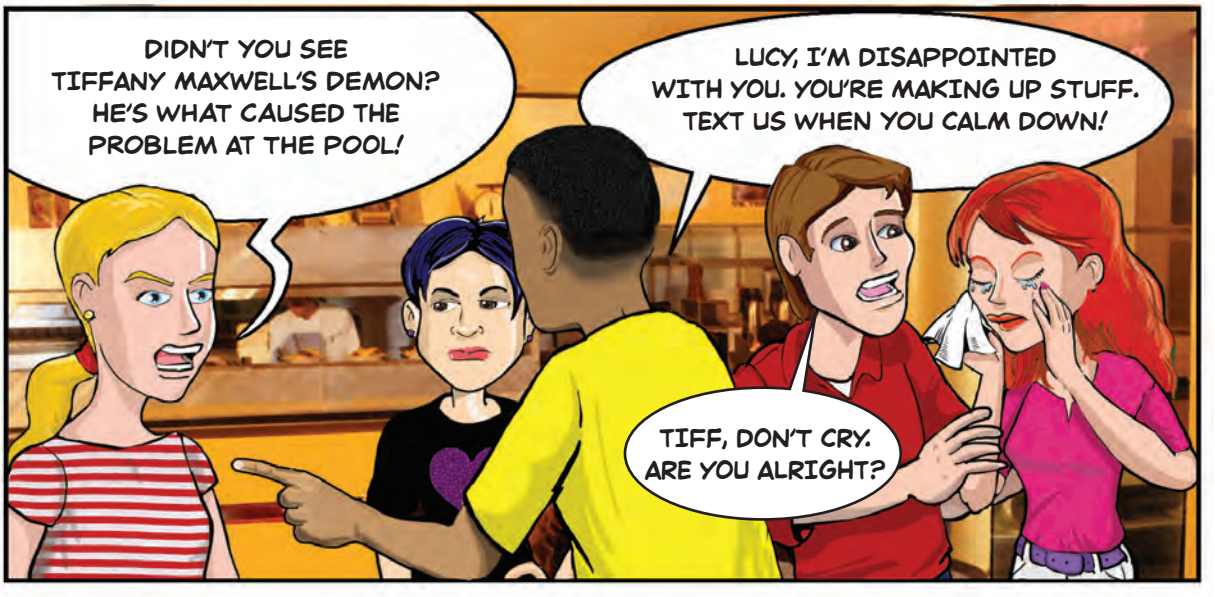
C. Clockwise and more slowly than with two candles

D. Counterclockwise and more quickly than with two candles.

This letter goes at the end of the room number.







The gang leaves the shoppe with Tiffany, and without Lucy.

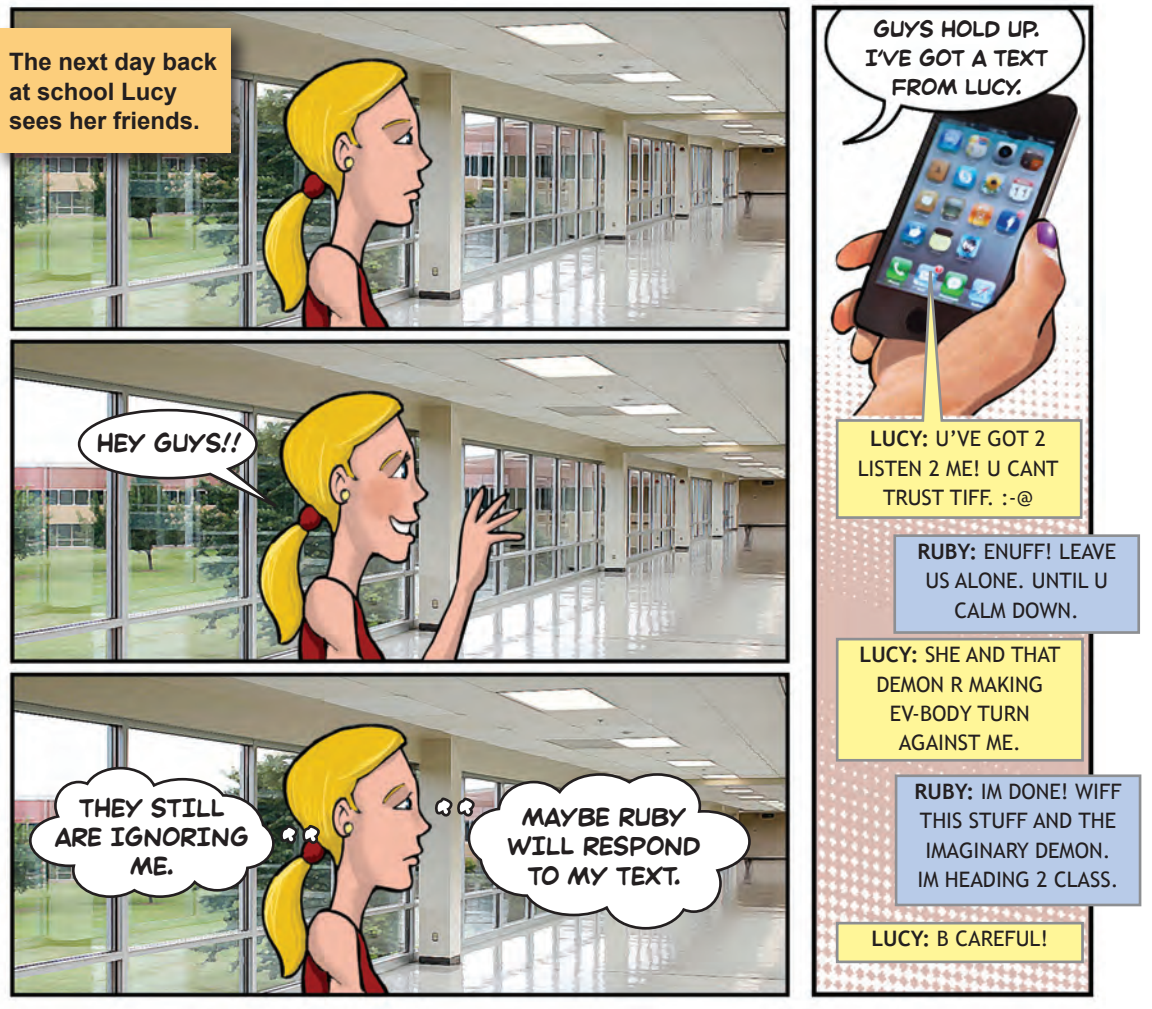
I CAN'T BELIEVE THIS IS HAPPENING. THEY ACTUALLY LEFT ME BEHIND.

TIFFANY IS BEHIND ALL OF THIS! SHE'S TRYING TO TAKE MY PLACE WITH MY FRIENDS, JUST LIKE SHE DID ON THE SWIM TEAM.

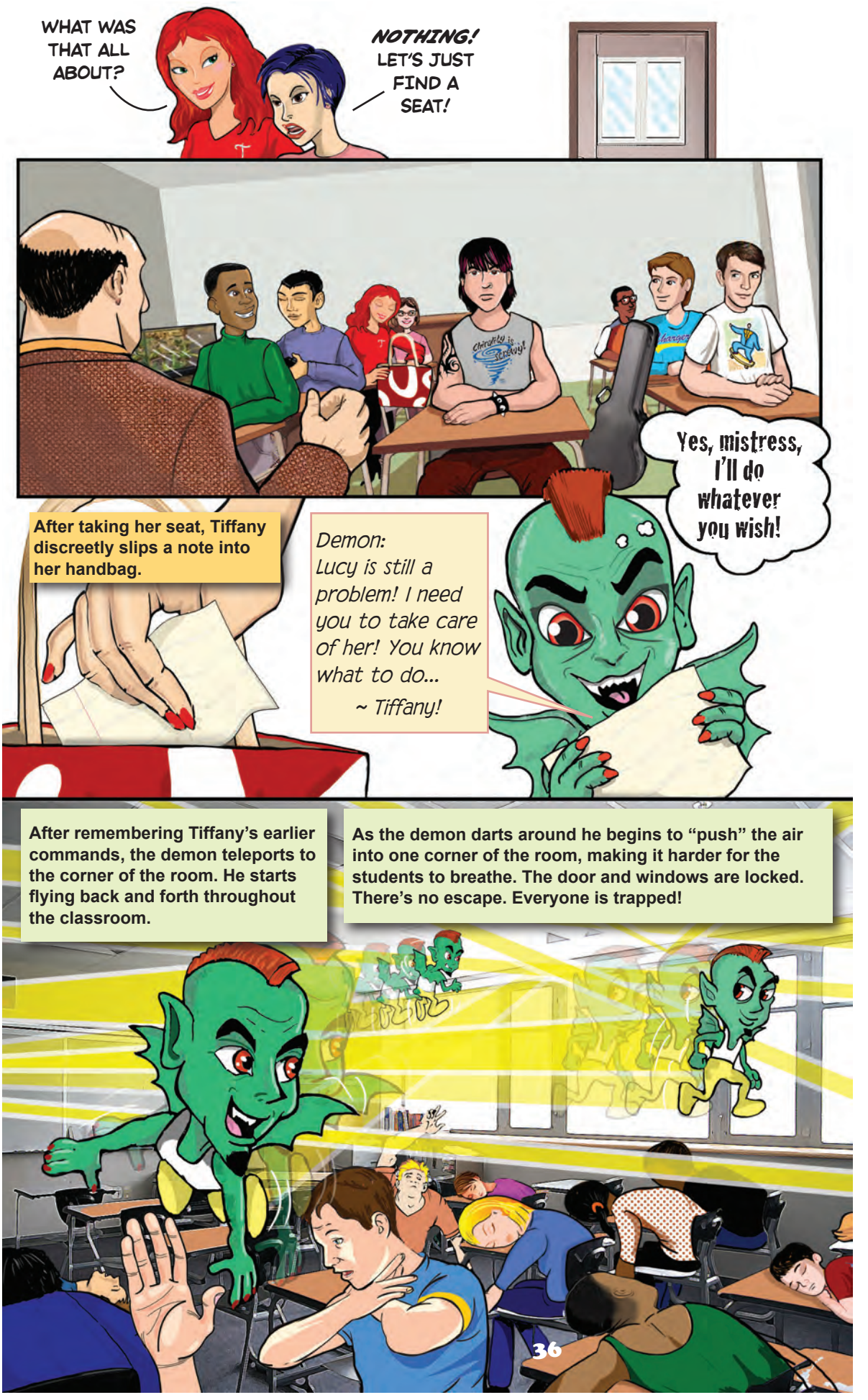
AND I KNOW SHE MUST HAVE SOMETHING TO DO WITH THAT DEMON.

WHEN I WAS SPECTRA AND EXPLORING WHAT WAS HAPPENING IN THE POOL, I SAW HIM MOVING AROUND AND PUSHING MOLECULES. HE WAS ADDING ENERGY AND MAKING THEM HEAT UP.

HE WAS SO QUICK! I'M GLAD I CHASED HIM AWAY. SO THAT THE WATER COULD COOL DOWN ON ITS OWN.


The next day back at school Lucy sees her friends.
HEY GUYS!!
THEY STILL ARE IGNORING ME.
MAYBE RUBY WILL RESPOND TO MY TEXT.
GUYS HOLD UP. I'VE GOT A TEXT FROM LUCY.
LUCY: U'VE GOT 2 LISTEN 2 ME! U CANT TRUST TIFF. :-@
RUBY: ENUFF! LEAVE US ALONE. UNTIL U CALM DOWN.
LUCY: SHE AND THAT DEMON R MAKING EV-BODY TURN AGAINST ME.
RUBY: IM DONE! WIFF THIS STUFF AND THE IMAGINARY DEMON. IM HEADING 2 CLASS.
LUCY: B CAREFUL!


Everyone heads to their next period, Mrs. Hardy's English class.
C'MON RUBY, YOU CAN SIT NEXT TO ME.
Insert your answers in here.
Room Number
NOW SHE'S TRYING TO TAKE MY "RED" LOOK!
TIFFANY, THANKS FOR WAITING AND FOR BEING A TRUE FRIEND!


WHAT WAS THAT ALL ABOUT?
NOTHING! LET'S JUST FIND A SEAT!
Yes, mistress, I'll do whatever you wish!
After taking her seat, Tiffany discreetly slips a note into her handbag.
Demon:
Lucy is still a problem! I need you to take care of her! You know what to do...
~ Tiffany!
After remembering Tiffany's earlier commands, the demon teleports to the corner of the room. He starts flying back and forth throughout the classroom.
As the demon darts around he begins to "push" the air into one corner of the room, making it harder for the students to breathe. The door and windows are locked. There's no escape. Everyone is trapped!

Since Lucy's not in the classroom, she'll get the blame!

I screwed up at the pool. This time I'm gonna make Mistress Tiffany proud! Everyone dies! Sorry Mistress, that you got trapped. I guess you'll die, too.

While resting in her glass tank, Jiggles* the iguana, senses something is wrong with the class. She knows she must get help.

*Jiggles first appeared in ***Spectra #2: Power.*** Who is Jiggles owner?

Jiggles finds Lucy in the hallway.

WHAT IS IT JIGGLES AND HOW DID YOU GET OUT OF YOUR TANK?

IS TIMMY STUCK IN THE WELL? WAIT, NO WRONG SHOW, BUT THERE IS SOMETHING WRONG! ***SHOW ME!***

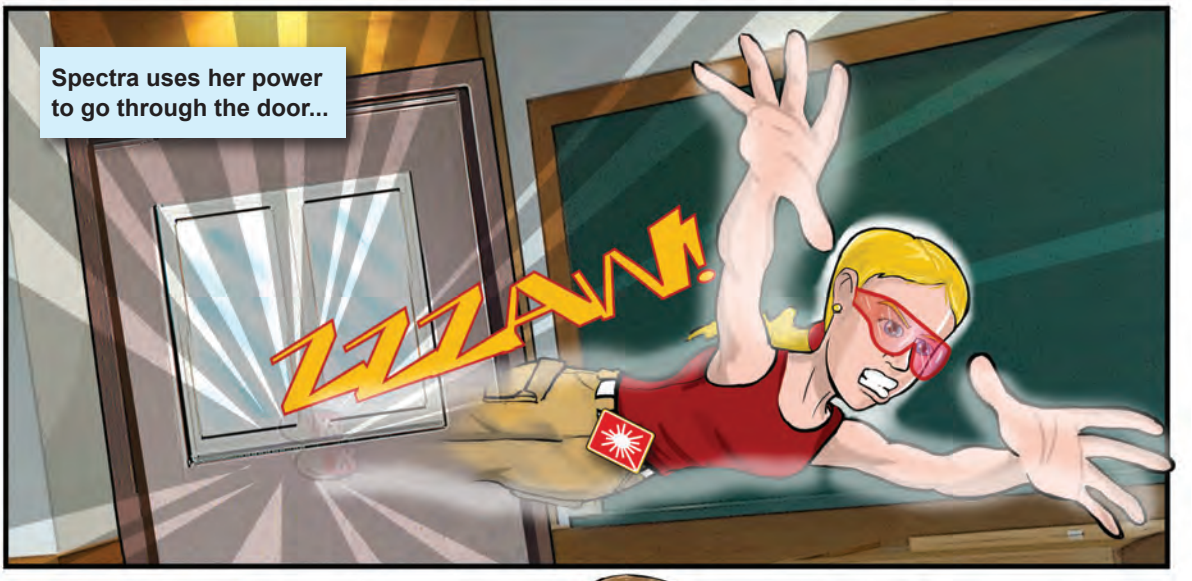
Lucy follows Jiggles back to the classroom.

WOW, ITS THE SAME ROOM NUMBER AS OUR LAST TEST ANSWERS. I'M GLAD WE ALL DID WELL ON THAT TEST.

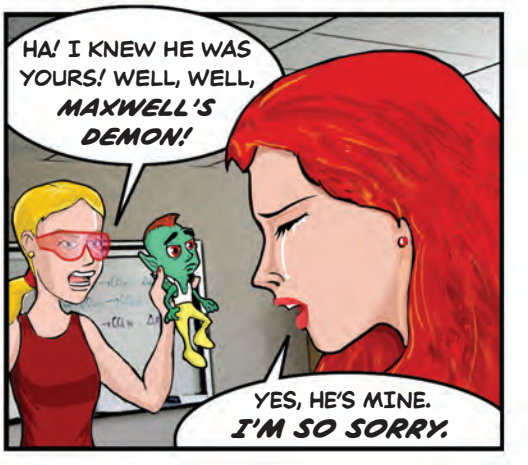
OMG!! THE CLASS NEEDS HELP AND THE DOOR IS LOCKED! IF ONLY I COULD GO THROUGH GLASS!

WHAT AM I TALKING ABOUT? I CAN DO THIS! I HAVE THE POWER OF A ***LASER!***

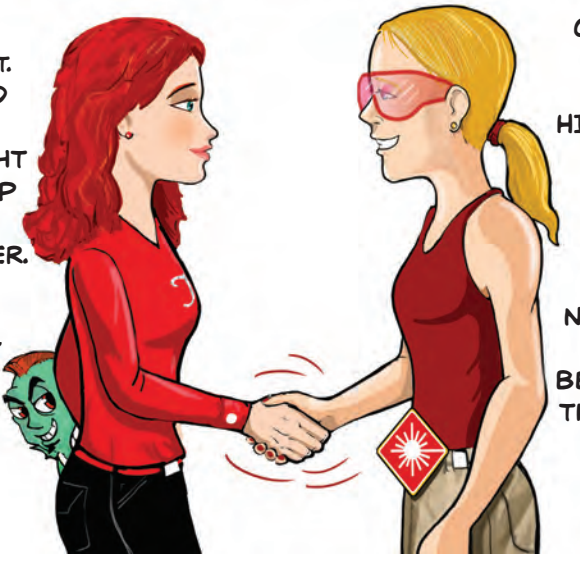
FBUZZ!



... and she opens the door that lets fresh air back into the classroom. Everyone wakes up; they're saved!



I DIDN'T MEAN FOR ANYONE TO GET HURT. I JUST WANTED TO FIT IN. MOVING IS HARD AND I THOUGHT IF I HAD SOME HELP MAKING FRIENDS, IT WOULD BE BETTER. REGARDLESS OF MY LAST NAME, MY DEMON REALLY IS A NICE GUY.



OK! I GUESS EVERYONE DESERVES A SECOND CHANCE. HI, MY NAME IS SPECTRA, YOUR FRIENDLY NEIGHBORHOOD MIDDLE SCHOOL SUPERHERO. WELCOME TO NIKOLA TESLA JR. HIGH. THINGS HERE MAY BE WEIRD, BUT AT LEAST THEY'RE NEVER BORING!

THE END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