SciGirls®

pbskidsgo.org/scigirls

PBS KIDS GO!

SciGirls Get Tech
Activity Guide

Izzie

Watch companion videos on Season 1 DVD or online.

tpt NATIONAL PRODUCTIONS

NSF

ExxonMobil

Technically Speaking

These days the idea of digital natives—kids who have grown up using technology—is well accepted. So it might surprise people to know that computer science and engineering are some of the STEM (science, technology, engineering, and mathematics) careers in which women still lag behind men.

The activities in this book are designed to help curb that trend with girl-friendly, hands-on projects that serve as entrees to tech. The projects are based on the PBS Kids television series **SciGirls**, which features groups of middle school girls designing, prototyping, and building their own tech-based investigations.

You'll notice these activities:

- follow the Engineering Design Process (found on page 2),
- incorporate the **SciGirls Seven** strategies for engaging girls in STEM (outlined on page 3),
- connect to **SciGirls** videos and mentors from the show, and
- align to national standards.

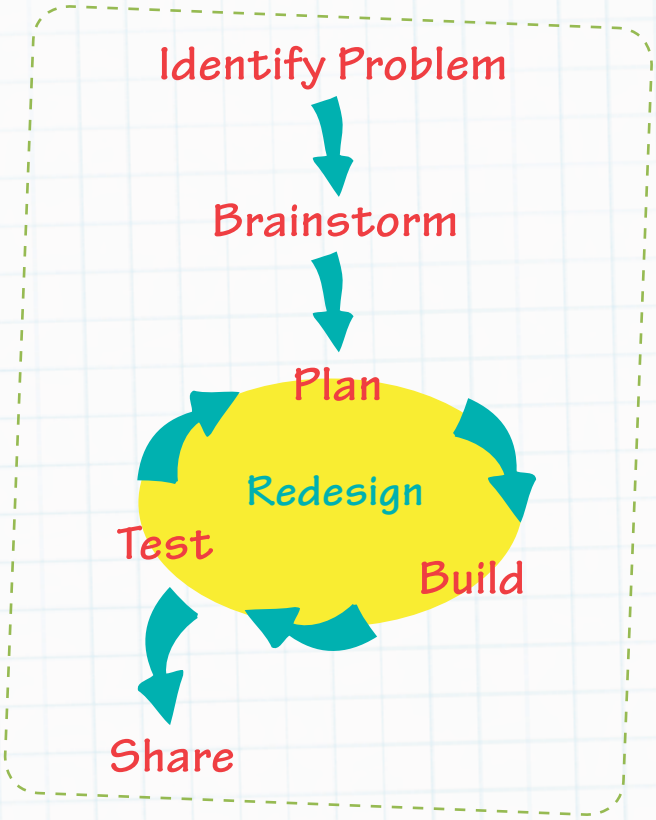
All activities can be used alone, but we encourage you to use our video to excite, inspire, and fuel discussion. Then, take your activities to the next level by logging on to the **SciGirls** website at pbskidsgo.org/scigirls. Your girls can create their own profiles and upload their projects to share with SciGirls everywhere!

As a leader, you don't need to be completely tech savvy to run these activities, but rather a willing facilitator. Practicing the activities in this book before sharing them with your girls will help you understand the struggles they may face and gain confidence as a guide. In the end, your girls will have fun expanding their programming know-how and opening up their digital futures. SciGirls get tech!

Table of Contents

Think, Plan, Build!
Engineering Design Process

Here is the **SciGirls**' engineering design process, the same steps every problem solver goes through when tackling a new challenge. Encourage your girls to follow these steps as they approach each **SciGirls Challenge** in this activity booklet.



Identify Problem In our activities, the **SciGirls Challenge** lays out the goal, but girls should also discuss constraints they may have (e.g., supplies, time, and tools).

Brainstorm Girls can generate ideas by looking at other comparable designs or models, consulting experts, researching in books or on the Internet, or talking with one another.

Plan Each group must reach a consensus and choose one idea. Then they can use their math and science know-how to make a plan of attack, sketch a design, and identify the appropriate materials.

Build Girls should always start small by making a model or prototype and building one piece of the design before tackling the whole project.

Test After each test, girls need to evaluate their results. A failed test can still be a great test! There is something to learn from every experiment.

Redesign The design process is circular. After one cycle, girls may need to modify their original idea, revise their plan, and build and test again until they are ready to share their work.

Share Girls can learn from others by sharing their observations and results with each other, their parents, or on the **SciGirls** website. Learning is not a competition; it's a collaboration.

Throughout this guide, the projector points you to videos on the companion DVD. Or you can watch online at pbs.org/teachers/scigirls.

tpt NATIONAL PRODUCTIONS
NSF
ExxonMobil

The SciGirls Seven

Strategies for Engaging Girls in STEM

The **SciGirls** approach is rooted in research on how to engage girls in STEM. A quarter of a century of studies have converged on a set of common strategies that work, and these have become **SciGirls**' foundation—aka the **SciGirls Seven.** All the activities in this booklet were created with the **SciGirls Seven** in mind and incorporate as many strategies as possible. We even mark the use of select strategies within each activity. (Look for superscript numbers and refer back to this page.) For additional information, please see our introductory booklet, *SciGirls Seven: How to Engage Girls in STEM,* which includes tips for implementing these strategies. You can download it for free at pbs.org/teachers/scigirls.

1. **Girls benefit from collaboration, especially when they can participate and communicate fairly.**

2. **Girls are motivated by projects they find personally relevant and meaningful.**

3. **Girls enjoy hands-on, open-ended projects and investigations.**

4. **Girls are motivated when they can approach projects in their own way, applying their creativity, unique talents, and preferred learning styles.**

5. **Girls' confidence and performance improves in response to specific, positive feedback on things they can control—such as effort, strategies, and behaviors.**

6. **Girls gain confidence and trust in their own reasoning when encouraged to think critically.**

7. **Girls benefit from relationships with role models and mentors.**

Activity 1

Robot Body Language

CAN YOU CONVEY AN EMOTION WHILE YOUR FACE IS HIDDEN?

These days social robots designed to interact with people are sold in stores as pets, house cleaners, and even healthcare assistants! To make these robots seem more humanlike, designers give them personalities using sounds, digital displays, and gestures.

You'll Need (per small group):

- paper and pencil
- large paper grocery bag
- optional: digital camera or video recorder

1 hour

Here's how:

1. **Introduce the challenge.** Ask girls to think of ways they can tell when someone is happy. (People can convey emotions using tone of voice, facial expressions, and body language.) Then ask them to consider how a robot might convey emotion. Introduce the **SciGirls Challenge:** Find ways to express emotions and feelings using only body movements.

2. **Brainstorm.** Divide girls into small groups [1] and ask them to brainstorm different emotions and feelings. (happiness, impatience, dejection, concern, friendliness) Then, have girls list body movements that could convey them. [3] (shoulder shrugging, head nodding, arm crossing, finger pointing, foot tapping) Remind girls that facial expressions and/or voice should not be included.

Watch girls brainstorm personalities and movements for their robots on the *SciGirls Get Tech* DVD. (Select Robots to the Rescue!: Brainstorm & Prototype.)

3. **Test.** Have one girl from each group cover her face with a large paper bag and act out the movements for one emotion from their list to see if the others can determine which is being conveyed. (Alternatively, have another girl take pictures or shoot video of the actions and then present them to the other teams.)

POINTER: Some girls may be shy about acting in front of the group. Encourage the timid to watch first before taking the stage, and have all girls practice being supportive. [5]

4. **Discuss.** Ask girls to talk about which emotions were easiest to convey. Most difficult? Which might be expressed more easily with tone of voice or facial expressions? Why?

Mentor Moment Dr. Robin Murphy is a computer scientist and engineer who designs rescue robots to help victims of disasters. She thinks about not only how the robot functions, but also its personality. Robin is a professor at Texas A&M University and works with teams of other scientists, including psychologists, to design the most "friendly" robots possible.

Watch Robin and the girls test rescue robots in Disaster City on the *SciGirls Get Tech* DVD. (Select Robots to the Rescue!: Mentor Moment). [7]

tpt NATIONAL PRODUCTIONS NSF ExxonMobil

[1-7] See **SciGirls Seven** strategies on page 3.

Activity 2

Passion for Pixels

SEND DIGITAL SIGNALS TO A FRIEND!

Did you know when you look at a photo of a planet in space, you're really looking at a set of numbers? Remote-sensing satellites take pictures and gather data that is transmitted to the ground as digital signals, or sets of numbers. Then computer software converts the numbers into color images.

You'll Need (per small group):

- pencils
- 2 pieces of grid paper
- optional: computer image to illustrate the concept of pixels

1 hour

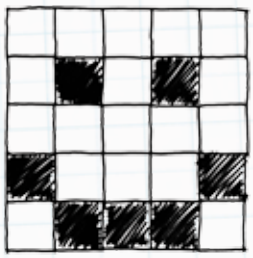
Here's how:

1. **Discuss digital images.** Explain that digital images are made up of hundreds of small squares called picture elements, or pixels. If you have a computer available, zoom in on an image to reveal the pixels.

POINTER: The more pixels per inch the higher the resolution and the better the image quality. Printed materials usually require 300 dpi (dots per inch), while online images are 72 dpi.

2. **Deliver the challenge.** Divide your group into pairs [1] and hand out the supplies. Introduce the **SciGirls Challenge:** "Transmit" an image digitally to your partner. Explain that they will create an image on the grid paper, and then use a code of zeroes and ones to transmit the image digitally, similar to the way satellites transfer images.

3. **Plan.** Ask each group to select one person to be the sender and the other to be the receiver. (The roles will be reversed later.) Have the girls decide on the size of their grid [3] (e.g., 5 squares x 5 squares or 6 squares x 8 squares), then have each girl draw an outline of the area on her paper. Next, have the sender draw a simple illustration on the grid by blacking out individual squares. (See below.) There should be no shaded or partially filled-in squares. And most important, the receiver should not see what the sender has drawn.



4. **Transmit data.** Direct the sender to "send" her picture to the receiver by reading her picture, square by square, as a digital code: 0 for a white (unfilled) square, 1 for a black (filled) square. As the sender reads the code, the receiver colors in the squares on her own grid. Be sure to have the girls agree upon a convention for the order of transmission (e.g., left to right, top to bottom).

5. **Compare the images.** Then have girls switch roles and do the activity again.

6. **Analyze.** How accurate were their image transfers? How could they send more complex images, such as images with color? How could they speed up the process of transmitting information? [6]

Activity 3

Dough Creatures

LIGHT UP A ROOM WITH ELECTRIFYING PLAY DOUGH CREATIONS.

You can use anything that conducts electricity to make an electrical circuit—copper, pencil lead, fruit, even play dough! Adding salt to the dough helps electricity move through the material. With enough power, the electrical current can light LEDs and sound a buzzer!

SMART START: Prepare the conductive and insulating dough beforehand, as described below.

Conductive dough

Mix all ingredients except ½ cup flour in a pot and cook over medium heat, stirring continuously. Add food coloring. (This will differentiate the two types of dough.) The mixture will begin to boil and get chunky. Keep stirring until a ball forms in the center of the pot, then remove the saucepan from the heat. CAUTION: The dough will be very hot! Allow it to cool before handling. Once cooled, mix flour into the dough until it is firm, but moldable.

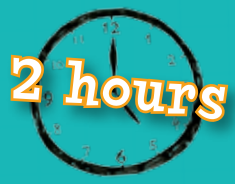
Insulating dough

Mix the oil and solid ingredients (setting aside ½ cup flour) in a bowl. Mix in 1 tbsp. deionized water and stir. Continue to add deionized water 1 tbsp. at a time until the mixture becomes moist and dough-like. Remove it from the bowl and slowly knead in flour until the desired consistency is reached.

Store the dough in an airtight container until needed. It will keep for 3 weeks.

You'll Need (per small group):

- conductive and insulating dough (See Smart Start for directions.)
- 4 AA batteries (or one, 9 V)
- battery holder or connector
- 4-8 LEDs, 1.9–2.4 V / 20 mA–40 mA (from RadioShack or digikey.com)
- paper and pencil
- optional: electric buzzers (2 V), aluminum foil, switch, wire terminals, soldering iron, assorted craft supplies (straws, sticks, etc.)



For dough preparation:

- mixing bowl
- wooden mixing spoon
- saucepan
- hot plate or stove
- 2 airtight containers
- measuring cups/spoons

For conductive dough (makes enough for 3-4 girls):

- 1½ cups flour
- 1 cup water
- ¼ cup salt
- 3 tbsp. cream of tartar
- 1 tbsp. vegetable oil
- food coloring

For insulating dough (makes enough for 3-4 girls):

- 1½ cups flour
- ½ cup sugar
- 1 tsp. granulated alum
- 3 tbsp. vegetable oil
- ½ cup deionized or distilled water
- optional: food coloring

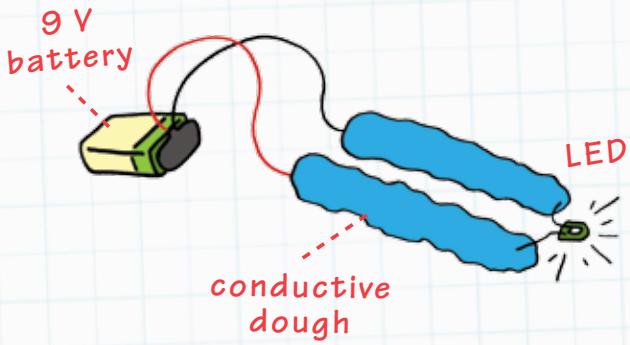
Dough Creatures continued

Here's how:

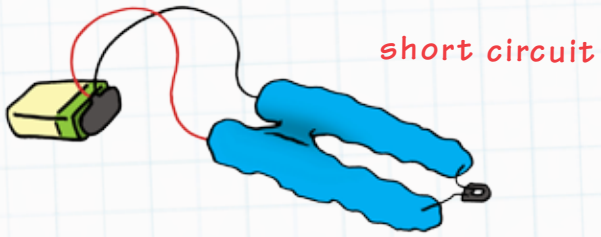
1. **Introduce insulators and conductors.** Ask girls if they know what a conductor is. (A material that allows energy, such as heat, electricity, light or sound, to pass easily through it.) What types of materials make good electrical conductors? (salt water, metals such as copper, gold, aluminum) What is an insulator? (A material that does not allow energy to pass through it easily.) What types of materials make good electrical insulators? (glass, rubber, plastic, cotton) Why might electric circuits include insulating materials? (Insulation protects us from electrical wires that might give us a shock and helps direct the flow of electricity.)

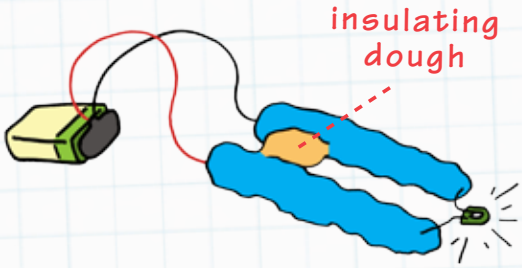
POINTER: If the girls have never worked with LEDs before, see the Smart Start on page 9.

2. **Build a simple circuit.** Break into small groups [1] and pass out some conductive dough, batteries, battery holders, and LEDs. Have girls brainstorm and sketch how to make a simple circuit using the materials provided. (A circuit is a closed loop, allowing electricity to flow in a complete circle.) Insert the two terminals from a battery holder or connector into two pieces of conductive dough. Insert an LED into both pieces of dough, so the positive lead (longer leg) is in the dough attached to the positive terminal of the battery and the negative lead (shorter leg) is in the dough attached to the negative terminal of the battery. (See above, right.) Have girls discuss why the LED lights up. [6] (For current to flow, there must be a complete path from one pole of the battery, through the wire, to the light, and back to the other pole of the battery.)



3. **Experiment.** What happens if two pieces of conductive dough touch? Have girls test this by connecting them with a third piece of conductive dough. (The bulb will not light because you created a short circuit.) What happens if insulating dough is placed between the two pieces of conductive dough? (See below.)





Dough Creatures continued

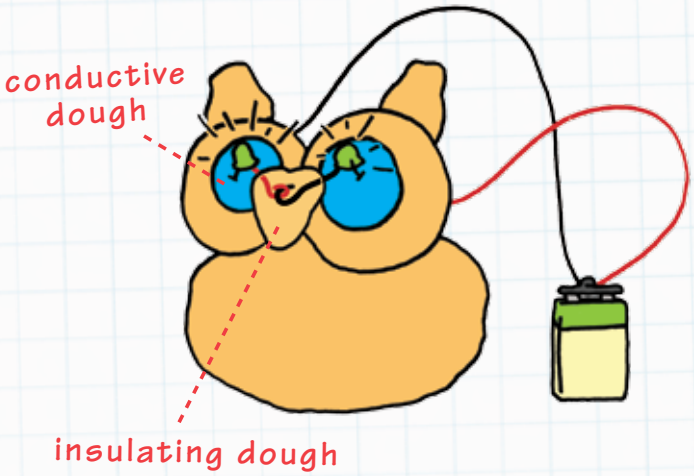
4. **Brainstorm.** Introduce the **SciGirls Challenge:** Use conductive and insulating dough to make battery-powered creatures that light up and/or buzz. Ask each group to brainstorm possible creature designs. What do they want the creature to do? [4] (have glowing eyes, make a noise when pressed) They should consider using sticks, straws, or other materials as supporting structures.

5. **Sketch and build.** Have groups draw sketches and then agree on one design to build. [3]

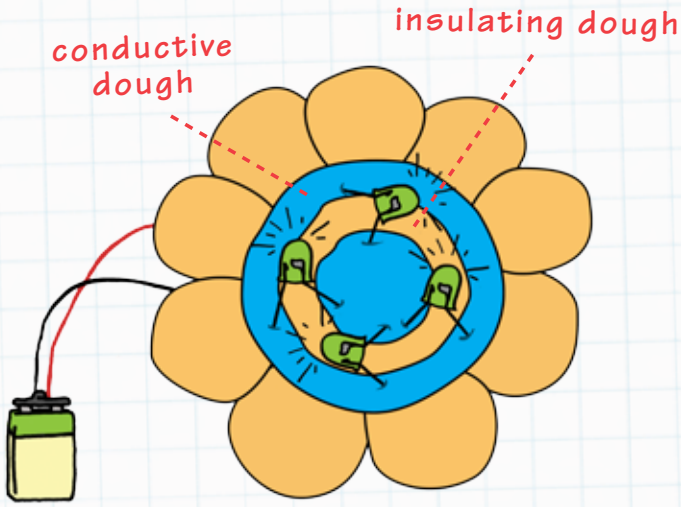
6. **Test.** If girls are having problems getting the creature to perform a complicated task, encourage them to start small. [5] Suggest they first try to achieve a simpler function, such as getting one eye to light up, and then, once they have accomplished this, move on to a more complicated task, such as getting two eyes to light. (See right for examples.)

POINTER: Remind girls that dough does not conduct as well as metal. They may find it helpful to use short thick chunks of the dough (to reduce resistance) or to increase the surface area of the electrical contacts by wrapping the ends of the battery wire in aluminum foil or crimping or soldering on wire terminals.

7. **Share.** When everyone is done, have groups demonstrate their creations and discuss. Talk about possible real world uses for the creatures. [2] If they could design an enhanced creature, what would they have it do?



Special thanks to AnnMarie Thomas, an engineering professor at the University of St. Thomas in Minnesota, for contributing her ideas and expertise. Dr. Thomas is co-director of the Center for Pre-Collegiate Engineering Education. She worked with engineering student Samuel Johnson to develop this activity.



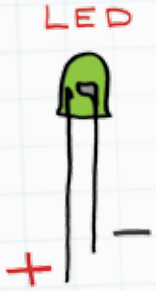
Activity 4

High Tech Fashion

MAKE A FASHION TECH ACCESSORY!

What do you get when you combine fashion and electronics? Fun and functional clothing and accessories! Soft circuits are electronic circuits that use conductive thread instead of wire. With these circuits, you can make wearable designs that light up the runway.

SMART START: If girls are unfamiliar with LEDs (light emitting diodes), start with a brief introduction. LEDs are a bright, energy-efficient, long-lasting, and generally unbreakable light source made from semiconductors. Point out that each LED has two legs, or leads, one slightly longer than the other. The longer lead is the positive side, the shorter lead, the negative side. Ask girls if they can think of any places they have seen LEDs. (bike lights, camping flashlights, light-up sneakers) [2]



You'll Need:

per girl

- paper and pencil
- 1 piece of felt
- 1 sewing needle
- conductive thread (members.shaw.ca/ubik/thread)
- 2 or 3 LEDs, 1.9 V - 2.4 V / 20 mA - 40 mA*
- 1 metal snap or magnetic purse snap (from a craft store)
- 1 CR2032 (coin cell) battery (e.g., 3 V watch battery)*
- 1 CR2032 battery holder*

  * from RadioShack or digikey.com

2 hours

per small group

- ruler
- scissors
- fabric pen or chalk (to sketch circuit on fabric)
- needle-nose pliers
- wire with alligator clips or wire stripper
- permanent black and red markers or nail polish
- optional: needle threader, regular thread, decorative fabric, lace, and beads

Part 1
Build Simple Circuits

Here's how:

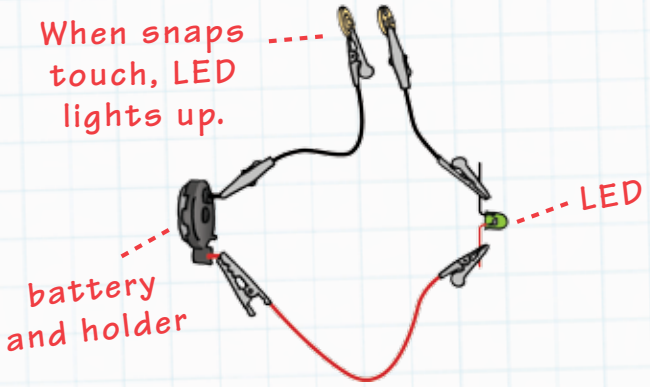
1. **Introduce fashion technology.** Ask girls if they have seen any clothing or fashion accessories that incorporate technology. [2] After a brief discussion, present the **SciGirls Challenge:** Make a fashion accessory with LEDs that lights up when you wear it.

2. **Prepare the battery and holder.** Divide girls into small groups [1] and pass out the coin cell batteries, holders and LEDs. Point out that one side of the battery is positive and the other negative. Now, place the battery in the holder and use black and red markers or nail polish to mark the positive and negative terminals. To determine which is which, test it with an LED. (The long lead of the LED must be attached to the positive terminal of the battery for it to light.)

High Tech Fashion continued

3. **Make a simple circuit.** Pass out the LEDs and wires with alligator clips and have girls make a simple circuit. Ask: How did you make the LED light up? (For their LED to light, electricity must travel from one terminal of the battery, through the wire to the LED, and back through another wire to the *other* terminal of the battery.)

4. **Add a switch.** Pass out the metal snaps and have girls think of a way to add them as a switch to turn the LEDs on and off. (A switch is used to open and close the circuit. When the switch is open, no current flows, and when the switch is closed, current flows.)

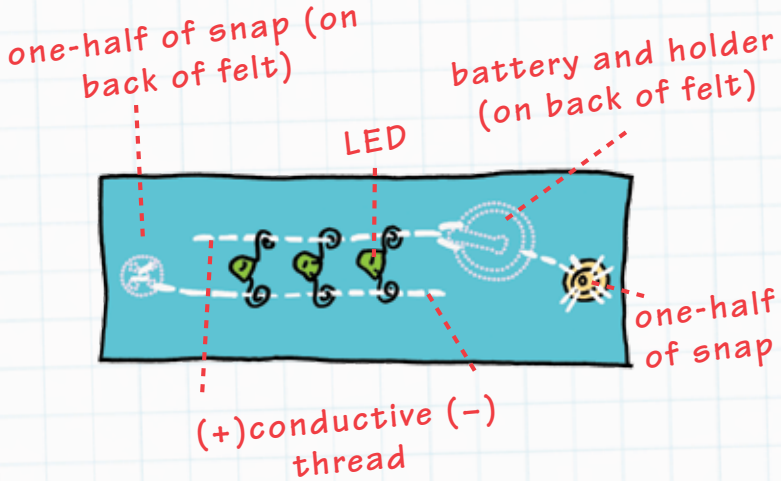


5. **Introduce conductive thread.** Explain to the girls they will be creating a fashion accessory that lights up by sewing a circuit made of conductive thread. The thread will replace the wire from the simple circuit. Ask: How can thread conduct electricity? (The thread itself is made of cotton or polyester, but is coated with metals, such as silver, copper, tin, and nickel, which are conductive.) Have girls try adding the conductive thread to the simple circuit from Steps 3 and 4 to see if the LED lights up.

Part 2
Prototype a Soft Circuit

6. **Brainstorm.** Explain to the girls they will be creating a circuit for an accessory that will only light up when a person snaps the two metal snaps together. (The snap will act as a switch that turns the LEDs on when it's closed and off when it's open.) Have girls brainstorm and sketch some ideas. [3]

7. **Plan circuit design.** Let each girl choose an accessory she wants to make (bracelet, choker, belt, headband). [4] Have girls decide where they want to place the LEDs on the accessory. Explain that the LEDs should span the two lines of conductive thread (one postive and one negative—see final design below). In this design, the LEDs are necessary for completing the circuit. When the snap is closed, current flows from the battery, through the conductive thread to the LEDs, and back to the battery.



High Tech Fashion continued

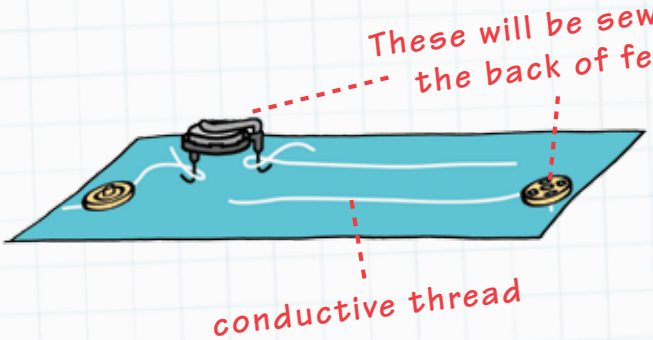
POINTER: The LEDs in this circuit are connected in parallel, meaning the electrical current splits and flows through all LEDs simultaneously.

To see girls use parallel circuits in their fashion design, watch the *SciGirls Get Tech* DVD. (Select High Tech Fashion: Design.) [7]

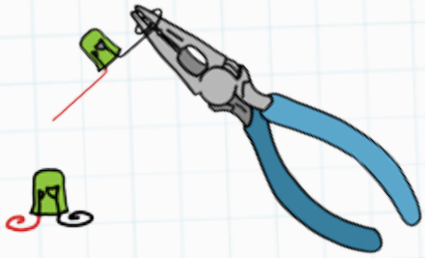
8. **Prepare battery holder.** Have girls bend the two terminals so the battery holder sits flat. Attach the conductive thread to the negative terminal of the battery holder (without the battery inside). Next, have them use another piece of conductive thread and attach it to the positive terminal of the battery holder.

9. **Prepare snap.** Have girls attach the conductive thread from the negative terminal of the battery to one half of the metal snap. Next, have them take a *separate* piece of conductive thread and attach it to the other half of the metal snap.

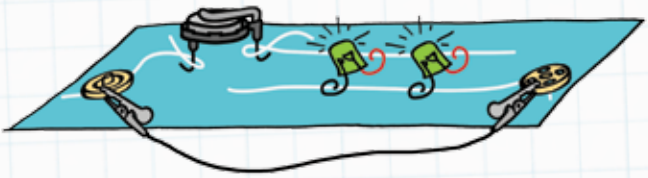
10. **Lay out the design.** Have each girl measure and cut a piece of felt of the appropriate size for her accessory. Lay each part of the circuit onto the felt as shown below.



11. **Prepare LEDs.** Girls should mark the long lead (positive side) of the LED with a red marker (or nail polish). Then have girls bend up the leads so the LED will lie flat, using needle-nose pliers to curve the leads into a loop.



12. **Test circuit design.** Have girls add a battery to the battery holder and place the LEDs on the conductive thread. Then, have them use a wire with alligator clips to make a connection between the two snaps to see if the LEDs will light up.



High Tech Fashion continued

Part 3
Sew a Switch-Activated Circuit

13. **Transfer design to the felt.** After they have shown their circuits work, have girls transfer the circuit pattern and placement of each piece onto the felt using a fabric pen or chalk. This is the "road map" they will follow as they sew. (Make sure to mark whether the piece is being sewn onto the front or back of the felt.)

14. **Stitch battery and snaps in place.** Use a new piece of conductive thread for each item.

15. **Stitch the circuit.** Now girls should stitch the conductive thread along their pattern using a simple stitch, such as a running stitch. Make sure the stitching shows on both sides of the felt. Have girls use a needle threader to make threading the needle less frustrating.

16. **Sew the LEDs.** Have girls stitch both looped leads of each LED to the conductive thread. Make sure the orientation is correct and the connections are good. Girls should trim the thread ends as close to the knots as possible. Warn them not to let any thread cross between the two LED loops—this could create a short circuit!

17. **Test.** Have girls test their design by connecting the snaps.

POINTER: If girls have problems, suggest they check all their connections. Then, have them test if the battery and individual LEDs are working. They should also check that the battery is properly inserted into the holder and the LED ends are oriented correctly. Girls may have to cut the stitch and redo that section, but in technology, that's just fixing a bug! Don't let girls get discouraged. [5]

18. **Get Creative.** Once the LEDs are working, have the girls sew lace, beads, and felt onto their accessories, using regular thread. [4]

19. **Debrief.** Let girls model their finished accessories for the group. Discuss which parts of the project were most challenging. Why? If they were going to do the project again, what would they do differently? [6]

See Diana mentor girls as they prototype LEDs on a breadboard on the *SciGirls Get Tech DVD*. (Select High Tech Fashion: Mentor Moment.) [7]

Mentor Moment Diana Eng is a fashion designer who displayed her love of technology on Season 2 of *Project Runway*. She is also the author of *Fashion Geek*, a how-to book for designing tech-savvy fashion projects. Since the age of 12, Diana has loved computer programming and showed off her skills each year at her school's science fairs!

Activity 5

Keep Out!

BUILD AN ALARMING DOORMAT TO KEEP SIBLINGS OUT OF YOUR ROOM.

BRAYNK! BRAYNK! BRAYNK! Most alarm systems are nothing more than a sensor or two connected to a siren or buzzer. Simple alarms consist of a sensor that doubles as a switch. When activated, the sensor completes an electric circuit and electricity flows to the siren, sounding the alarm!

You'll Need (per small group):

- small electric buzzer (2V)
- materials (e.g., insulated wire, metal paper clips, or aluminum foil)
- 9 V alkaline battery with snap connector
- tape
- switch materials (e.g., large plastic drinking straws, kitchen sponges, or other compressible, nonconductive materials)
- scissors
- mat (e.g., doormat, bath mat, or large towel)
- optional: wire cutter/stripper

Here's how:

1. **Introduce circuits.** Ask your girls: What is electric current? A circuit? What are batteries used for in a circuit? (In a circuit, current flows in a complete loop, for instance from a battery, along one wire, through a device such as a buzzer or light bulb, then along another wire and back to the battery.)

2. **Identify the problem.** Ask girls if they have ever wanted to keep a sibling out of their rooms. [2] Then introduce the **SciGirls Challenge:** Create a room alarm that sounds when someone steps on it.

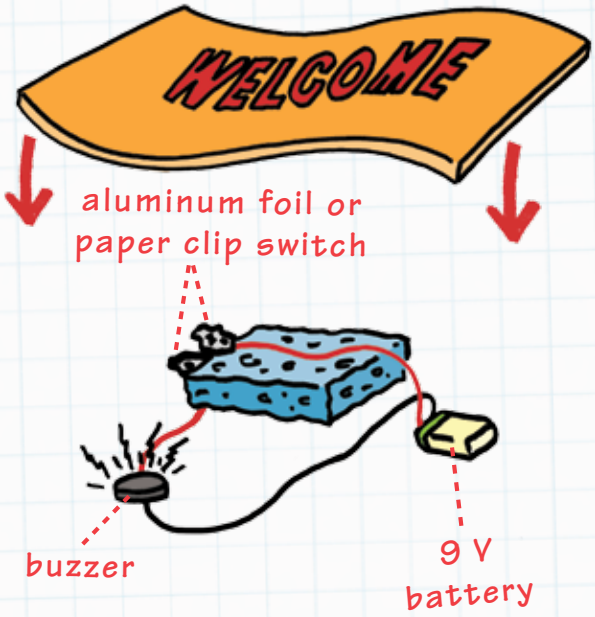
3. **Start small.** Divide the girls into small groups [1] and hand out the buzzer, conductive materials, and battery. Guide girls to use the materials provided to design and build a circuit that will sound the buzzer. Have them discuss first before digging in.

4. **Brainstorm.** Once they accomplish completing a circuit, ask each group to brainstorm ways to build a new circuit. This one should have a switch that closes the circuit when someone steps on it. Think about different ways to design the two parts of the circuit so they touch when the alarm is stepped on, but stay separate when there's no pressure. [3] Keep in mind that the circuit will ultimately be used as a room alarm, so it should be long enough to place in front of a door opening, and flat enough so it can be hidden under a mat or rug.

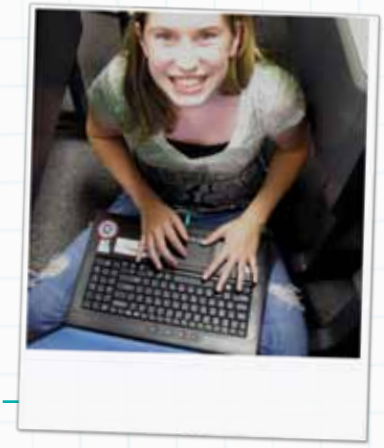
5. **Test and redesign.** Have girls test their designs by placing the alarm system under a mat or folded towel. If the alarm doesn't work, encourage girls to redesign and make changes.

Keep Out! continued

POINTER: If girls are having problems getting their circuits to work, find something positive about their current design and compliment their efforts before troubleshooting. [5] Have girls check the connections between the different parts to ensure there is a complete circuit. Also check that the insulation from the ends of the wire (if used) has been stripped where it is attached to the battery poles and buzzer, and that there is no extra wire or other conducting material causing a short circuit.



6. Discuss results. Once all the teams have created a working alarm, discuss the designs. What are the basic parts of the circuit? How does the electrical current flow through it? Did they first try a design that didn't work? What did they do to make it work better?



Standards Correlation

The activities in this book align to national education standards including: Standards for Technological Literacy and the National Science Education Standards. To download the complete and most current alignments, please visit pbs.org/teachers/scigirls.

Join the SciGirls Revolution at pbskidsgo.org/scigirls

PBS KIDS GO!

SciGirls®

Be a SciGirl!

Create a profile and make new friends!

Share cool science projects and learn what other girls are doing.

Watch real SciGirls go on STEM-ventures online and on PBS stations!

High Tech Fashion

Robots to the Rescue

Digging Archaeology

Collect all the SciGirls Educator Resources.

SciGirls is produced for PBS by ***tpt*** National Productions and is made possible by the National Science Foundation. Additional support by ExxonMobil.

tpt NATIONAL PRODUCTIONS

NSF

ExxonMobil