4H3010

WEAR TEC

BOOK 1 | CIRCUITRY

WHAT IS WEARTEC?

The Nebraska 4-H Wearable Technology (WearTec) is a National Science Foundation (NSF) funded project focused on activities related to wearable technologies. The goals of the project are to develop an intervention that focuses on solving real world problems and practicing the engineering design process while immersed in the innovative area of wearable technologies.

This curriculum was developed for youth in grades 4 to 6 to teach engineering design, computer programming, basic circuitry and sewing. The curriculum has been designed to encourage connections between in-school and out-of-school time instruction. Wearable technologies provide a powerful, personally expressive tool for use in both formal and informal learning environments.

These technologies bring together engineering and computing to make computers, which are “soft, colorful, approachable, and beautiful”. Wearables offer a window into the world of technology enabling students to develop technology literacy in a more inclusive manner than game development or educational robotics. The electrical components of wearable technologies expose the connections and circuitry that is normally hidden from students. Students can literally see the connections between the electrical and technical components when creating circuits with conductive thread or copper tape. This provides a tangible artifact that brings relevant theories from physics, engineering, and computing to life. Crafting and aesthetics are key components of designing wearable technologies further increasing the attractiveness and accessibility to students.

Creating wearable technologies provides an outlet for personal expression as the end product can be worn. This has particular power in attracting female students who tend to be more interested in aesthetics, textile design and social connections than their male counterparts.

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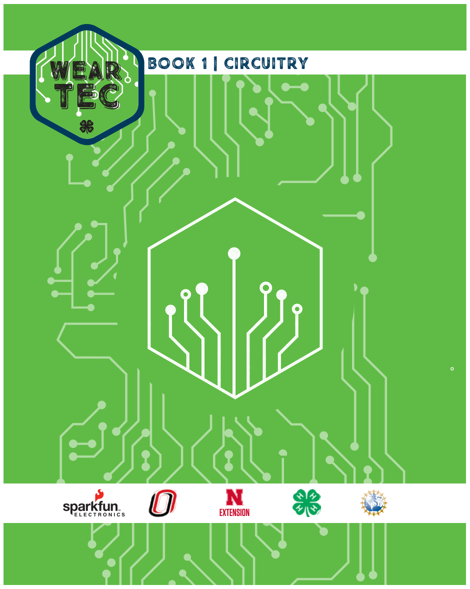
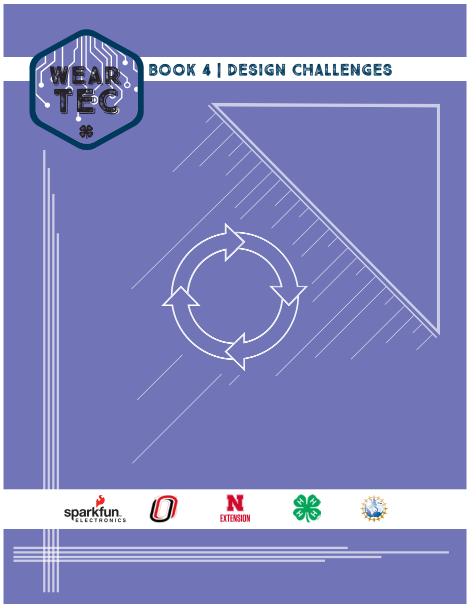
WEARTEC CURRICULUM



BOOK 1 | CIRCUITRY

BOOK 2 | SEWING & MICROCONTROLLERS

BOOK 3 | PROGRAMMING



BOOK 4 | DESIGN PROJECTS

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ENGINEERING DESIGN PROCESS

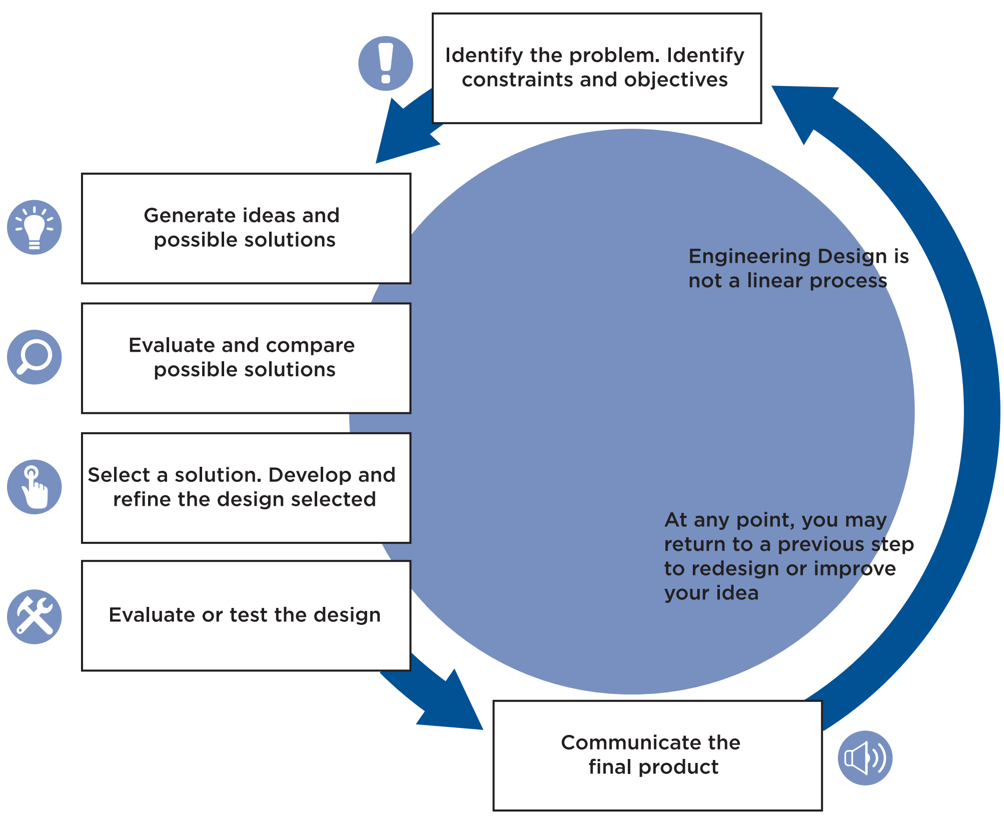
Engineering Design Process (EDP) Overview

The engineering design process is a series of steps that engineers follow to come up with a solution to a problem. Many times the solution involves designing a product that meets certain criteria and/or accomplishes a certain task. This process is different from the steps of the scientific method. While scientists study how nature works, engineers create new things, such as products, websites, environments, and experiences. Because engineers and scientists have different objectives, they follow different processes in their work. Scientists perform experiments using the scientific method; whereas, engineers follow the creativity-based engineering design process.

It's important to note that the EDP is flexible. There are as many variations of the model as there are engineers. With WearTec, students work through all six steps, but in real life, engineers often work on just one or two steps, then pass their work to another team.

Note that the EDP is non-linear. At any point, you may return to a previous step to redesign or improve your idea. **The EDP is reliant on the iterative process.** An iterative process is a process for reaching a desired result by means of a repeated cycle of operations (steps). The cycle should come closer to the desired result as the number of iterations increase. For example, after you improve your design once, you may want to begin all over again to refine your technology. You can use the EDP again and again!

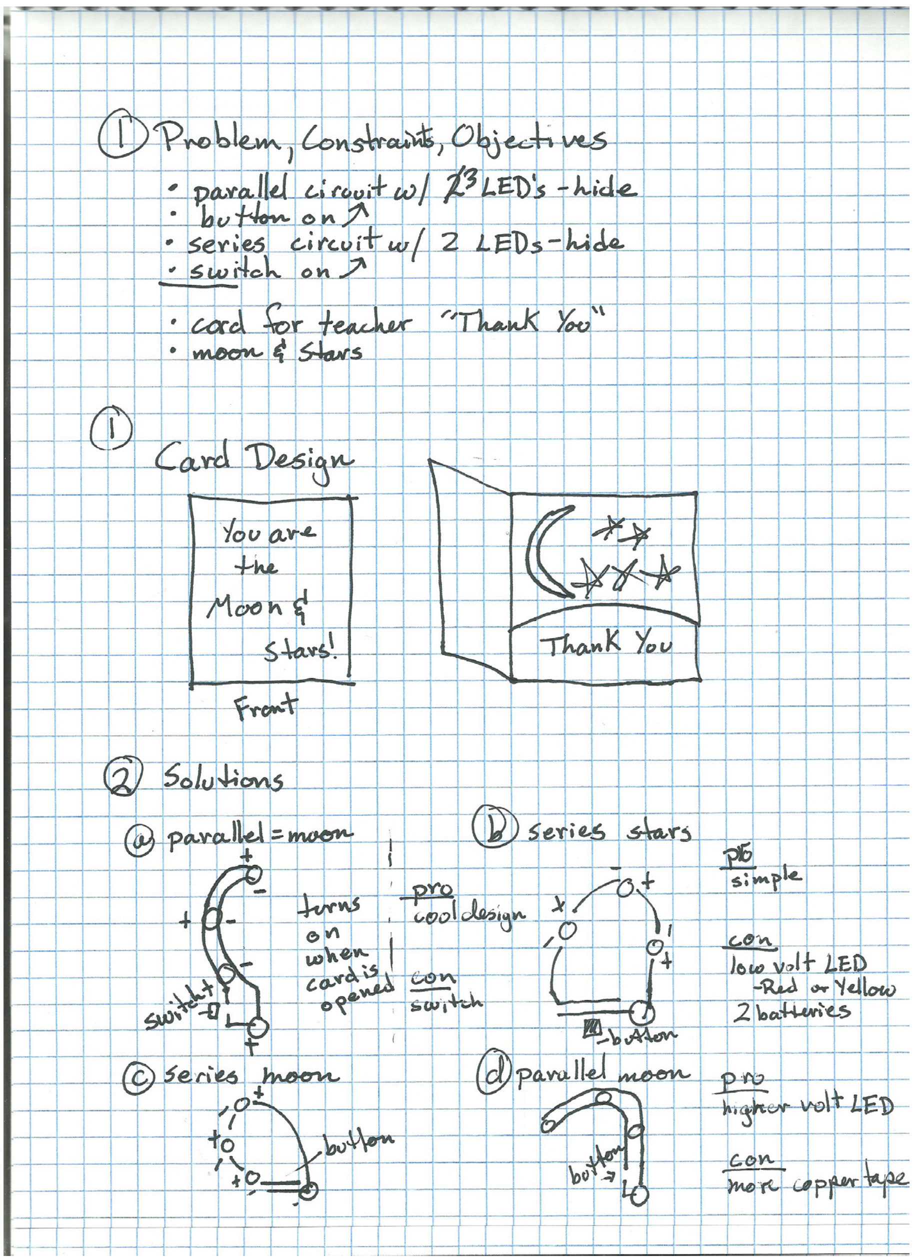
In the WearTec curriculum you will notice symbols to represent each step in the EDP. These symbols are intended to help you identify each steps of the EDP and bring about the thinking associated with that step. The symbols can be used for short-hand inclusion in the engineering journal. A one-page printable format of the EDP is found at Appendix A.



EDP Journal Explanation and Use Guidelines

An engineering design process (EDP) journal is a working document. It is where ideas, sketches, and student reflections are recorded. It is a journal the students will use to document their learning and discovery through drawings, data, and record keeping. The journals should show thought behind strategy, designs, innovations, and organization. The journals are evidence of how students have grown and overcome obstacles in their designs. Each step of the engineering design process should have a corresponding journal entry.

Professional engineers use design notebooks to record their thoughts and learn from their experiences. By using a design journal, students are engaging with real-life tools and experiences important for skill and interest development.



Key elements to incorporate in Engineering Journal

- Use dates
- Indicate step of engineering design process
- Write notes on inclusion or exclusion of ideas
- List pros and cons of solutions
- Describe reasoning for iterations

WHAT YOU'LL NEED

Electronic Components

* Components needed for each student/participant

Sparkfun supplies*	Bow	Badge	Card	Culminating	Total
LED 3 or 5mm	1	2	5	3	11
1220/1225 Battery	1	2	3	1	7
Copper tape	2in	4 feet	4 feet	3 feet	11ft 2in
Alligator clips (10 pack)	1	1	1	1	1

General Supplies

	Bow	Badge	Card	Culminating
Scotch tape	x	x	x	x
Card stock	x	x	x	x
Paper	x	x	x	x
Vellum paper			x	x
String/elastic				x
Drawing supplies			x	x
Other art supplies			x	x

BOW PROJECT

ACTIVITY OVERVIEW

The activities in this project establish the foundations of circuitry and engineering design process. The students will build a quick and simple paper-based electronic bow to kick off this project. Subsequent activities spring-board off of the simplicity of the bow to further the students' understanding of the concepts and materials used in this book.

Established Standards

Next Generation Science Standards (NGSS):

- 3-5-ETS1-1. Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
- 3-5-ETS1-2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
- 3-5-ETS1-3. Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.
- 4-PS3-4. Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.
- MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
- MS-ETS1-2. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
- MS-ETS1-3. Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.
- MS-ETS1-4. Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

Nebraska (NE) State Science Standards:

- SC5.1.1.g Share information, procedures, and results with peers and/or adults.
- SC5.1.3 Students will solve a simple design problem.
- SC5.1.3.a Identify a simple problem.
- SC5.1.3.b Propose a solution to a simple problem.
- SC5.1.3.c Implement the proposed solution.
- SC5.2.3.f Recognize that the transfer of electricity in an electrical circuit requires a closed loop.
- SC8.1.3.f Distinguish between scientific inquiry (asking questions about the natural world) and technological design (using science to solve practical problems).

Learning Objectives

Students will be able to:

- Build an electrical closed circuit using alligator clips, an LED, and power source.
- Recognize the steps of the engineering design process.
- Complete a working circuit using a battery and LED.
- Identify conductors and insulators.
- Identify the basic components needed for a simple circuit.

Supplies needed for each student:

- Bow template (Appendix B)
- 2 LEDs
- 2 (1220/1225) Coin cell battery
- 1 Set of 10 alligator clips
- Engineering journals

Before the project:

- Gather materials
- Prepare to hand out journals
- Cue video (link on page 12)
- Review how to make connectors on the battery (pg 13)

Project Outline	*Time*
Introduction: the "sew" what	5 min
Activity 1: Bow	20 min
Explanation of Simple Circuit	10 min
Activity 2: Explore Conductors & Insulators	15 min
Reflection/Closure/Journal	10 min
Review: Cont. Activity 2 - Conductors & Insulators	5 min
Reflection/Closure/Journal	10 min

Vocabulary

battery – stores electrical energy

circuit – a path for electrical current to flow through

conductive path - in a circuit, the path in which electric charge is carried

conductor – materials that electricity can flow through easily

constraints - conditions that we need to happen or would like to happen with a design

electrical load - an electrical component that consumes electric power

electricity – a form of energy that is produced by the flow of electrons

engineering design process - a series of steps that engineers use in creating functional products and processes. The process is iterative.

insulator – materials that electricity does not flow through easily

iteration (iterate v.) - the act of repeating a process with the aim of approaching a desired goal, target or result

LED – stands for light emitting diode, a component that produces light

power source - a source of energy

simple circuit - includes the **minimum** things needed to have a functioning circuit

solution – a way to solve a problem

wearable technology - clothing and accessories incorporating computer and electronic technologies

ACTIVITY INSTRUCTIONS & PICTURES

The hook: "sew" what?

1. Tell students they are going to watch a video that has components of wearable technologies. You want them to watch for:
   - *Elements that make the wearable technology work.*
   - *The problem that was solved with this wearable technology.*

2. Show students the video.
http://web.media.mit.edu/~leah/LilyPad/build/turn_signal_jacket.html

3. Discuss: The most important question to answer is:

"What problem do you think the wearable solved?"

This begins the foundation of the engineering design process: "**identifying a problem."** In addition to answering the question above discuss elements that make the turn signal jacket work.

- Describe to a partner the project you just saw.
- What elements/parts did the wearable use? (Power, button, switch lights, connections, thread, conductor, user input, etc.)
- What problem do you think the wearable solved?
- Explain to the participants that this video is the big idea. They will be learning what makes projects like these work. During WearTec they won't make this jacket, but will have the necessary skills to plan and build a similar jacket by the end of the program.

Activity 1: A bow

For this activity you (the instructor) will be guiding the students through the EDP steps. This is intended to be a guided example for the students. You will be doing a **guided think-aloud** to help students see the process of engineering design. You will also be encouraging students to reflect on this process at the end of the activity.

The students will record each step of the EDP.

Say: "We are going to use the engineer design process to solve a problem. We start by identifying the problem, constraints or goals of an issue."

The Problem
We've been invited to a party with Beyoncé and Lil' Wayne. The invitation says they are having a 'light-up bow' party. A light up bow is mandatory for admission. The party is tonight!!!

Identify problem, constraints and objectives
We need something:

- Simple (time constraint)
- Small (it's a bow)
- Can be worn: i.e. hair bow, bow-tie, accessory, shoes, etc

Generate ideas/possible solutions
Ask Students: "What could we use to make a bow?"

- Have students write down some ideas, or jot ideas on a display (board, presentation pad, etc.) light bulb, cloth bow tie, wires...

After exploring the house, you found 1) LED's, 2) card stock, 3) coin-cell batteries.

Back to Identify Problem: *We return to this step, because we now have constraints of materials that we have on hand.* This is important to tell students. By moving from back and forth between steps, you are illustrating the fluid nature of the engineering design process. This exemplifies '**iteration**.'

Solution 1: Cardstock		Solution 2: Papier mâché		Solution 3: Cloth	
Pro	**Con**	**Pro**	**Con**	**Pro**	**Con**
simple	not the fanciest	durable	too long to make	looks like an actual bow (cloth)	clothes cost more than paper
light-weight	not durable	can make fancy	have to build mold, no materials for it here	fabric designs	parents won't like cutting up clothes

Note: You are guiding students through the process, so the solution of cutting paper into a bow shape and connecting an LED is the option for this guided think-aloud. If you have time and materials, you could allow students to choose one of the above solutions and continue steps. The following are two examples of the EDP at work: First, a student chooses papier mache as a solution. Next, in the process of doing the papier mache the student determines that the solution may not serve his/her needs. Thus, encourage them to add evaluation of their generated ideas. To continue iterating, the student can choose a new solution to try and tinker with. Another example of the process: At this step, a student chooses to make a cloth bow as a solution. Next, they make a prototype. Finally, they share their final product with the other students, and reflect on the process they went through and what could be improved on their design.

Identify problem, constraints, and objectives
We need something:
- Simple (time constraint)
- Small (it's a bow)
- Can be worn: i.e. hair bow, bow-tie, accessory, shoes, etc
- Use LEDs
- Use card stock
- Use coin-cell batteries

Generate solutions
We return to step two because we now need to come up with solutions with our newly identified constraints.

Say: " Now I'm going to think aloud, generating some solutions. 'How can we use these three things to make a bow that meets our goal?''

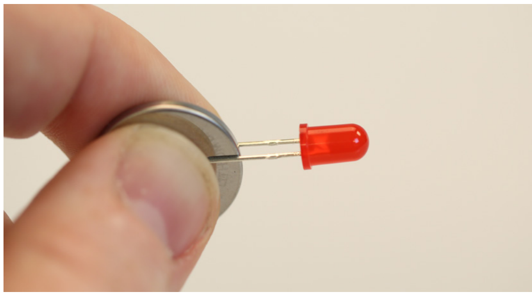
Write these so all can see.
- Solution 1: cut up the paper into a bow shape and connect the LED
- Solution 2: shred paper and make a paper mâché mold to make bow with LEDs built in mâché mold
- Solution 3: cut up our own clothes to make bow, then put in LEDs

Evaluate and compare possible solutions
Say: "All solutions have positive and negatives, or pros and cons; try to find at least 2 pros and 2 cons for each solution."

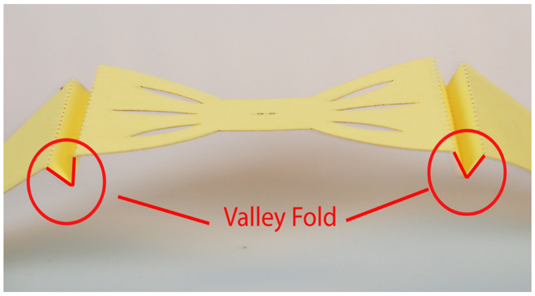
Encourage students to come up with their own pros and cons in discussion. The table above is provided as an example.

Select a solution: Develop (prototype) and refine the selected solutions.
Say: "Based on our analysis of the three solutions we will choose solution 1: Cut up the paper into a bow shape and connect the LED."

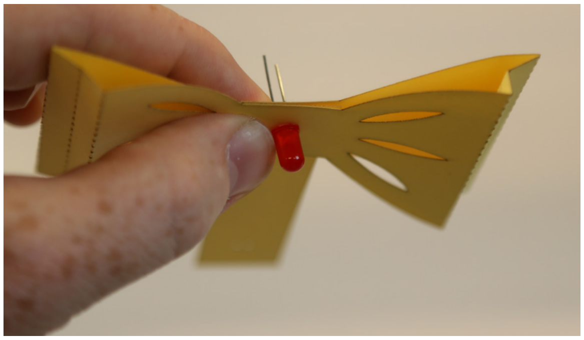
Make Bow Steps:
1. Test LED and battery then set them aside.



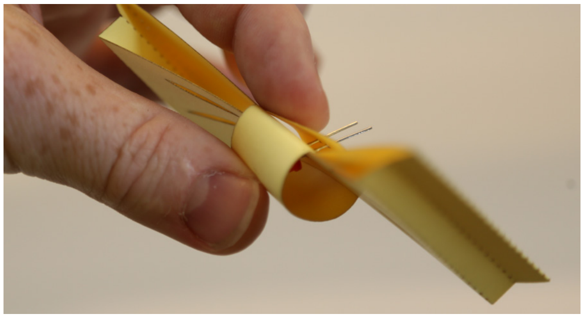
2. Fold bow according to picture.



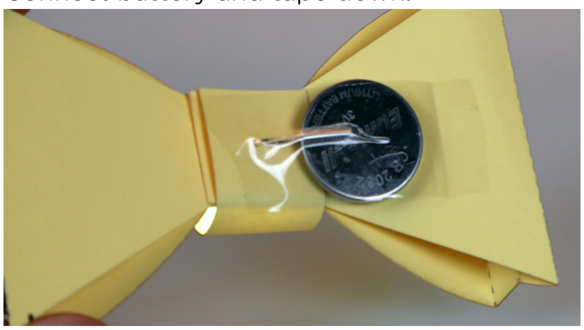
3. Insert LED into perforated holes.



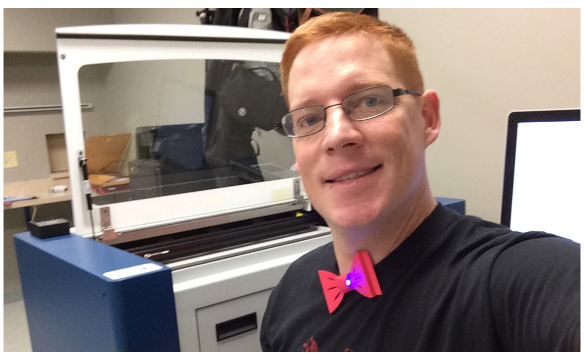
4. Bend front around LED & thread LED legs.



5. Connect battery and tape down.



6. *Wear the bow.*



Evaluate or test the design

With the students evaluate the design. Tell them to record their ideas in their journal.

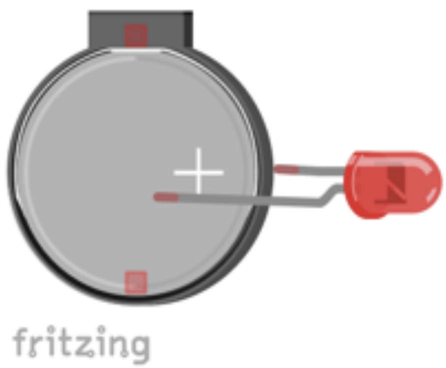
- *What works well/doesn't?*
- *What would you change if you built another bow?*
- *Does this first iteration meet constraints/ objectives and provide a solution to the problem?*

Explanation of simple circuit:

Tell students that they just made a “simple circuit” that includes the **minimum** things needed to have a functioning circuit:

- Source of power
- Conductive path
- Electrical load (LED, electric motor, speaker, etc.)

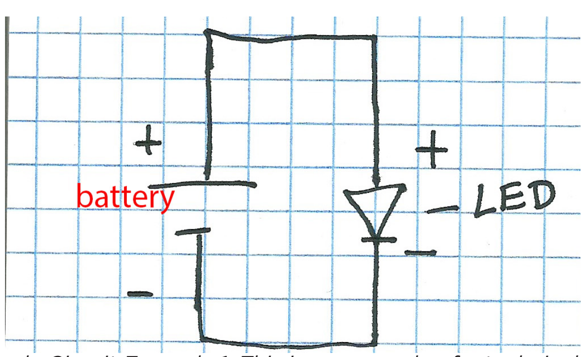
In the bow example, the battery is the **power source**. The legs of the LED are the **conductive paths**. The LED is the **electrical load**.



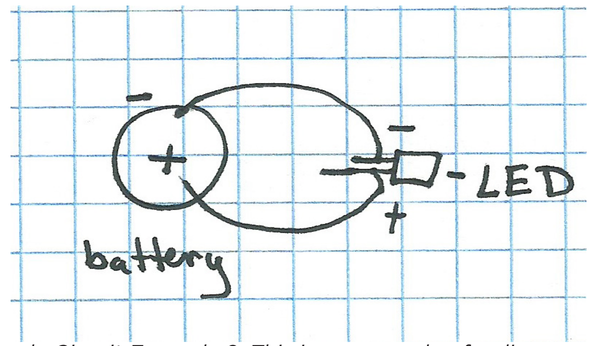
Fritzing is open-source software that supports designers to develop electronic projects. visit: www.fritzing.org

Have students draw a simple circuit in their journals. They can draw it using their own understanding. A more technical drawing (Example 1) could be used. Alternatively, a drawing can include the components they are familiar with (Example 2). However, the drawing must include:

- power source
- conductive path
- LED as load



Simple Circuit Example 1: This is an example of a technical diagram using the accepted symbols for a diode (LED) and power source (battery).



Simple Circuit Example 2: This is an example of a diagram using the drawings of components familiar to the students.