4-H NATIONAL YOUTH SCIENCE DAY

INCREDIBLE WEARABLES

FACILITATOR GUIDE

VERSION 2.0

TABLE OF CONTENTS

2017 NYSD FACILITATOR'S GUIDE

INTRODUCTION

The 4-H National Youth Science Day (NYSD) aims to bring youth together from around the world in an exciting, interactive learning experience that engages them in science, technology, engineering and math (STEM). The event brings together young people, volunteers and educators from the nation's 110 land-grant colleges and universities to simultaneously complete the National Science Challenge.

This year's exciting theme for NYSD is *Incredible Wearables.* From watches and eyewear to fashion and virtual reality headsets, wearable technologies are fast becoming the must-have accessory for forward-thinking people around the world. Wearable technologies didn't start out as trendy however – one of the world's first wearable technologies was the hearing aid! Wearable technologies are now used in industries around the globe, from education and sports, to health, fashion, entertainment, transportation and communication. Even agriculture is entering the wearable space with bio-metric ear tag sensors that can identify and signal illness in animals (http://quantifiedag.com/about/).

This year's challenge will see youth use the engineering design process to build a prototype wearable technology that will gather data to help solve a real-world problem. The Incredible Wearables challenge will take approximately 90 minutes, with the option of adding a pre-activity to help youth gain context for solving their problem. The challenge is suitable for youth in Grade 4 and above.

WEARABLE TECHNOLOGIES

In the broadest sense, electronic textiles (e-textiles) represent a field of engineering that combines electronics and computing with textiles and design. Wearable technology refers to electronic textiles or electronic accessories that can be worn, such as watches, eye glasses, or clothing like a shirt or jacket that contains electronics and a computing device. The field of wearable technologies continues to grow in both quantity and quality. New technologies are being developed and put on the market on a regular basis, including virtual reality and augmented reality devices, clothing and accessories, as well as health monitoring devices that monitor everything from breathing and heart rate to sleeping patterns and the amount of oxygen in the blood. The future of wearable technologies is limited only by the imaginations of those designing them. By studying STEM, youth could develop mechanisms such as exoskeletons, mind-controlled artificial limbs or jet packs! Use the "Jobs in Wearable Technology" section on page 27 in the Youth Guide to see the different careers that are available in these areas.

THE CHALLENGE

In this 2017 National Youth Science Day challenge, youth will design and build their own low-cost wearable health monitor following the engineering design process. The health monitor will consist of a small computer called the ESP8266 (or, colloquially, 'The THING'), a pulse oximeter, and a tilt sensor (which can be used as a pedometer). Details for each of the components will be provided in the challenge section of the guide. The challenge will touch on three important topics: engineering design, especially optimization of the design solution whereby solutions are systematically tested and refined (NGSS, 2013), wearable technologies, and health monitoring.

The problem that participants will attempt to solve is that youth and adults are not staying active enough to lead healthy lives. To help solve this problem, youth will learn to build a prototype fitness tracking device that could ultimately be marketed and sold to consumers to positively affect fitness behaviors. For this challenge, the central engineering problem is to: 'Design a functional wearable device that can record multiple biological signals such that the data can be used to make informed decisions about the wearer's health.'

In order to meet the objectives of the challenge, participants must:

1. Learn to follow the engineering design process such that they are able to create new technology; and
2. Learn enough about fitness and health data such that they can design, test and utilize a functional product.

The engineering design process is a series of steps that are used to solve a problem. It is important to remember that the process is iterative, which means that engineers can go back and repeat the steps as many times as necessary to solve the problem. The steps do not have to be followed in order; part of the engineering design process is teamwork and open-ended design.

GOALS, OBJECTIVES AND OUTCOMES

1. Design and build a functional fitness tracking prototype device.
2. Apply the engineering design process (design, build, test, refine) to technology product creation.
3. Learn about human health and how it can be tracked and improved using technology.
4. Understand the vast potential of wearable technology by learning how physiology and technology can work together.

CONSTRAINTS

During the Incredible Wearables challenge, youth must design a device to measure multiple biological signals and convert those signals to data that can then be analyzed. In order for the product to be viable, the device should be small, comfortable, unobtrusive to the wearer and, of course, aesthetically pleasing.

Size: The device should be small enough to be worn on the body.
Aesthetics: The device should be visually appealing.
Available components: Pulse oximeter, tilt sensor, 'The THING', power supply, alligator clips, jumper wires, felt, velcro strip, and AA batteries.
Time: 90 minutes to build and run the device.

KIT COMPONENTS

In the challenge, youth will use the kit components to build a wearable health monitor. If youth do the full challenge, it will help them to better understand why they are building the health monitor and how much easier it is to track their health data with a device. They will work in groups of up to 10 team members and will need a connected device (computer, smartphone, tablet) to view data from the health monitor.

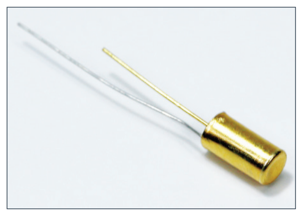
The components of the *Incredible Wearables* kit include three AA batteries, one piece of 12" x 9" felt and a velcro strip to create a wristband, screwdriver, plus the following:

MICROPROCESSOR ESP9266 ('The THING')

A small computer that also acts as a Wi-Fi router that will "push" sensor data to a website, which can then be viewed online.

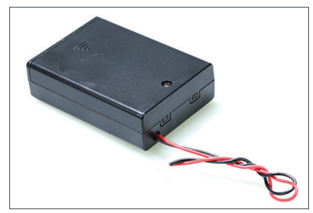
TILT SENSOR

A sensor that measures when something either tilts, speeds up, or slows down.



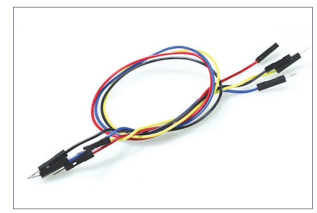
POWER SUPPLY

Batteries and holder to power the ESP8266/ The THING.



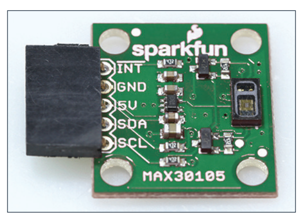
JUMPER WIRES

A short wire with a metal pin on each end used to complete an electrical circuit.



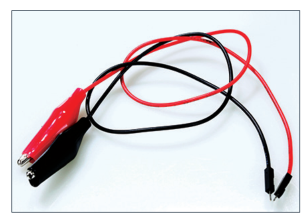
PULSE OXIMETER

A sensor that measure the amount of oxygen in the blood as well as temperature.



ALLIGATOR CLIPS

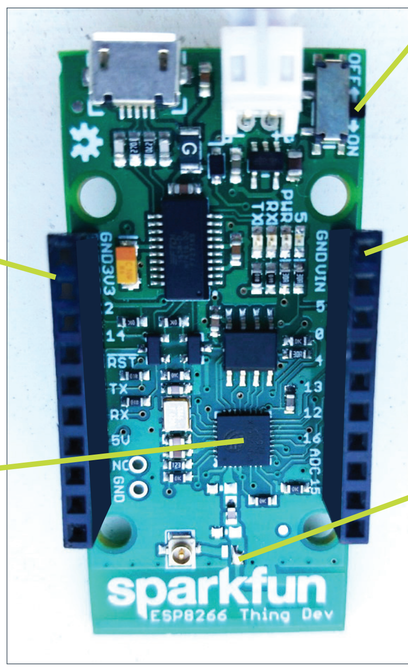
A metal clip with copper wires for making temporary electrical connections.



ABOUT THE THING

The diagram below shows the different components that make up The THING. The THING is a low cost computer, called a microprocessor. It works because the chip collects data and transmits instructions to other parts of the microprocessor. These parts include the female headers. They communicate with the chip through silver lines on The THING. These lines function like an electrical highway, sending information to and from the female headers to the chip.

Look closely on The THING and you will see some numbers or letters next to the female headers. These labels name each separate pin on the female header. In the challenge youth will connect the tilt sensor and the pulse oximeter to specific pins on the female headers. The chip knows how to make the sensors work because the pins that connect to the sensors know what each pin will do and communicate those instructions to the rest of the microprocessor.



On/Off Switch: This controls the power to and from The THING

Female Headers: These are the two black bars on The THING that are made up of pins.

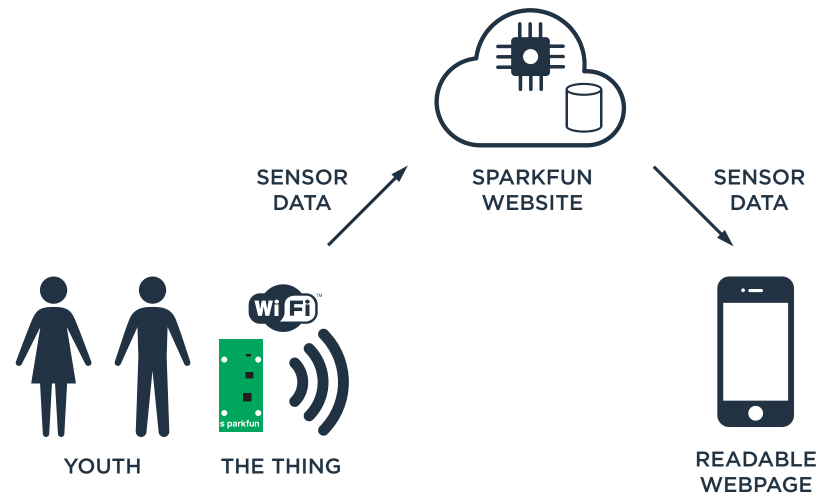
Pins: The small holes on the female headers. These can either input or output data to external hardware.

Chip: The brain of The THING, it executes the instructions written in its programming.

Printed Antenna: This transmits the network signal to your computer or other device.

HOW IT WORKS

The THING has built-in Wi-Fi and runs a web server to read data from the tilt sensor and pulse oximeter. The Thing then populates that data as a webpage, but it isn't connected to the web. This type of wireless service is known as a LAN, a Local Area Network.



FACILITATING YOUR GROUP

Below are different options for completing Full and Short versions of this challenge with youth in groups of 3-6 or 7-10. It would be good to prepare a space for youth to work that allows them to collaborate in groups, build their device, and have their connected computer, phone or tablet on a table so that it is easy to view their information.

NOTE: The internet site will be unique to each team's THING. Data will not be publicly accessible.

CHALLENGE VARIATION	HEALTH LEARNING	DEVICE LEARNING	BUILD	DATA COLLECTION	COOL DOWN
Full: 105 minutes	25 minutes	10 minutes	15 minutes	45 minutes	10 minutes
Short: 90 minutes	10 minutes	10 minutes	15 minutes	45 minutes	10 minutes

If you have 3-6 YOUTH

The roles for a group of 3-6 youth are listed below:

1. Project Managers: Coordinates work for the team, makes sure everyone is involved and keeps the group on task.
2. Lead Engineers: Documents the engineering design process in the group's Challenge Journal and keeps the engineers on task.
3. Data Analysts: Translates and communicates numbers into plain English for better decision-making.
4. Textile Designers: Creates a structure for the textile design.
5. Biomedical Engineers: Designs solutions to gather biological information through technology, including sensor calibration.
6. Marketing Specialists: Takes pictures and posts about progress in order to communicate about STEM to the public.

If you have 7-10 YOUTH

The roles for a group of 7-10 youth are listed below. The youth will be divided into groups of 3-4, with one person on each team doing each job. While the first group does their iteration, the second and third groups can watch and take notes so that when they test their design they can already have made some improvements.

1. Project Managers: Coordinates work for the team, makes sure everyone is involved and keeps the group on task.
2. Lead Engineers: Documents the engineering design process in the group's Challenge Journal and keeps the engineers on task.
3. Data Analysts: Translates and communicates numbers into plain English for better decision-making.
4. Textile Designer: Creates a structure for the textile design.

If time permits, all of the engineers will get together in one group, the managers will get together in another, and the data analysts will get together in a third group. This is explained further in the data part of the challenge. They will then compare their data and see if the entire team could come up with a new iteration that improves the group's design.

EVENT CHECKLIST

This checklist will help you prepare for your Incredible Wearables challenge. Additional resources are provided on **www.4-H.org/NYSD**, including the '4-H NYSD Toolkit' which provides information on community outreach and planning.

BEFORE YOUR EVENT

- [ ] IMPORTANT! - If you have more than one Incredible Wearables Kit, you need to pre-program your THINGS to have unique SSIDs by following instructions on pg. 18.
- [ ] Pick your devices (laptops, phones or tablets) and test them out with each fitness tracker (for connectivity troubleshooting see pg. 18).
- [ ] Prepare fun, active activities that engage all the youth. We recommend activities like group jump rope or hula hoop challenges. Activities that won't be hand held are less likely to interfere with the trackers.
- [ ] Have some additional craft supplies for youth to be creative with the design. This can include things like extra felt, scissors, tape, staplers, stickers, yarn, or anything else the kids can have fun with!
- [ ] We recommend one adult facilitator for every group with a tracker. This can help keep the activity moving.
- [ ] Leading up to the event you can show kids the NYSD How-to Video to help get them excited. This can be found at www.4-H.org/NYSD.

SETUP

- [ ] Mix younger and older youth together.
- [ ] Layout the kit components so youth can see all the parts and check them out before you begin.
- [ ] Divide up any extra materials ahead of time as groups sometimes move at different paces.

DURING THE CHALLENGE

- [ ] Make sure every youth in a group has a role as described on pg. 7. This helps keep everyone engaged!
- [ ] Have facilitators visit each group to make sure everyone has a turn seeing how all the components fit together and are able to test the tracker.

PART I

HEALTH LEARNING

CHALLENGE

LEARNING OBECTIVES

1. Framing the engineering design question.

2. Health concepts:
    a. Pulse (heart rate)
    b. Resting pulse
    c. Pulse points on the body

ENGINEERING PROBLEM STATEMENT

Start by explaining that the participants will tackle the challenge of increasing activity levels in youth and adults in order to help people live healthier lifestyles. In order to do this, they will need to design and build a functional, wearable health monitor.

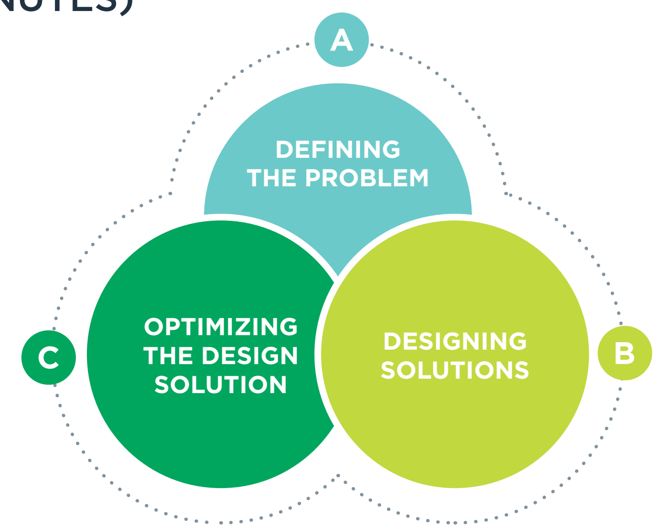
WHY WEARABLES?

It is helpful for youth to discover first-hand why a wearable device is so well suited to increasing activity levels. To do this, show them how difficult it is to monitor their pulse and the number of steps they are walking while doing an activity, by having them attempt to do this. (To manually take a pulse, place two fingers on the inside of the wrist and gently apply pressure until you feel your pulse.) Discuss how the youth could solve this problem, writing down ideas as they go. If needed, steer the conversation so that the youth begin to think about how technology could be a solution to the problem. In all likelihood, they will do this naturally.

STEP 1

The **constraints** and an engineering design flow chart are listed in the Youth Guide on page 9. Briefly go over the engineering design process and constraints. In the design notebook, youth should sketch how they might design a health monitor using the two sensors and small computer.

(15 MINUTES)



A **Defining engineering problems** involves stating the problem to be solved as clearly as possible in terms of criteria for success and constraints or limits.

B **Designing solutions for engineering problems** begins with generating a number of possible solutions, then evaluating those solutions to see which ones best meet the criteria and constraints of the problem.

C **Optimizing the design solution** involves a process in which solutions are systemically tested and refined, and the final design is improved by trading off less important features for those that are more important.

STEP 2

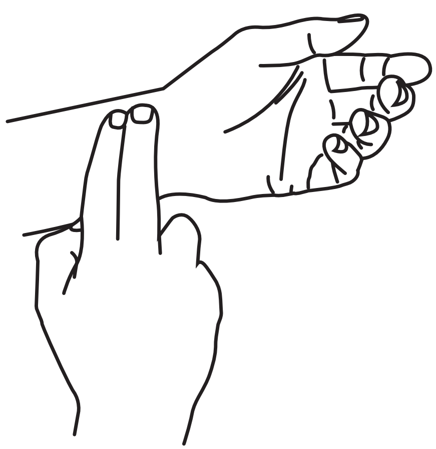
(Skips this step if completing the shorter challenge)

Explain to youth that your Pulse is the number of times the heart beats per minute, so this will give the heart rate. A resting heart rate is the lowest amount of blood the heart is pumping for a person not moving, and is usually between 60 and 100 beats per minute. Explain that the pulse oximeter sensor measures a pulse as a function of time.

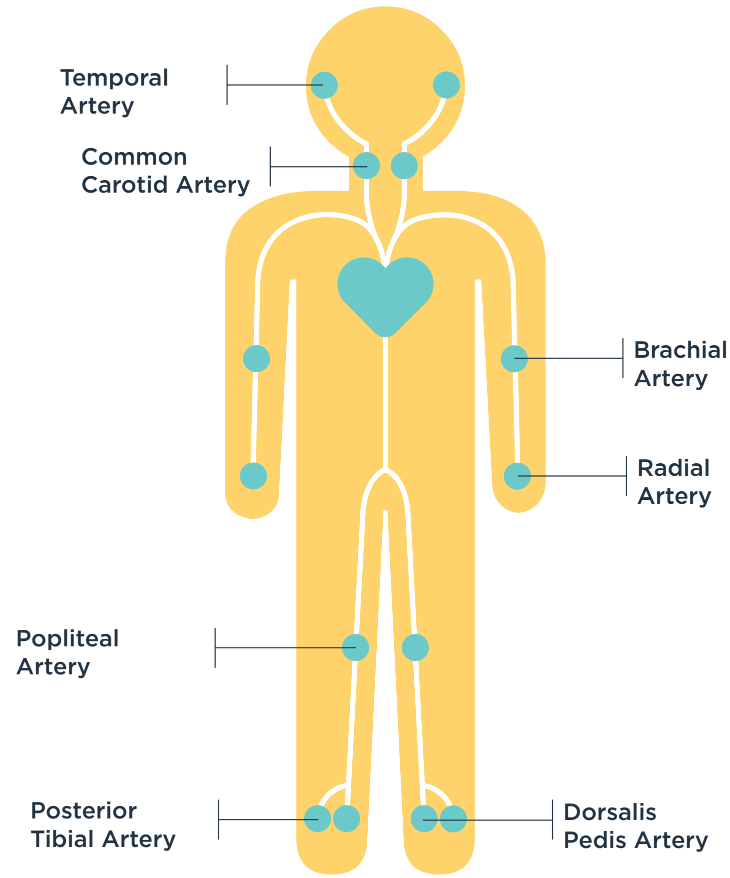
There are a number of areas on the body where pulse can be measured. Have youth measure and record their resting heart rate using their fingers for 30 seconds, and multiply the number by two.

When exercising, it's helpful to know your heart rate, number of calories you are burning and the distance you have traveled or the number of steps you have taken. Later in the challenge youth will compare their resting heart rate data taken here to their resting and active heart rates taken with the pulse oximeter.

(10 MINUTES)



PULSE POINTS



PART II

DEVICE LEARNING

CHALLENGE

(10 MINUTES)

LEARNING OBECTIVES

1. Understand how to create a basic circuit.
2. Understand how The THING interfaces with other wireless devices.

BASIC CIRCUIT

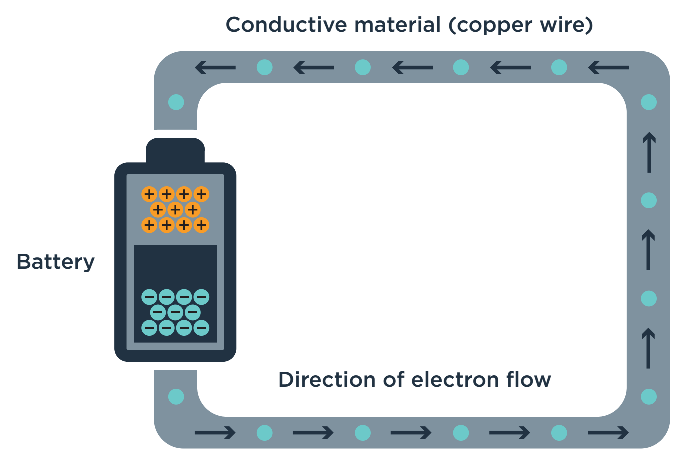
In order for electricity to do any work, it needs to be able to move. Ask the youth, 'What makes electricity move? After this question, please direct youth to the illustration on page 13 of the Youth Guide.

The following analogy can be given to youth to help them visualize this process (see illustration):

It's kind of like a blown-up balloon; if you pinch it off there is air in there that could do something if it's released, but it won't actually do anything until you let it out. Electricity wants to flow from a higher voltage to a lower voltage. This is exactly like the balloon: the pressurized air in the balloon wants to flow from inside the balloon (higher pressure) to outside the balloon (lower pressure). If you create a conductive path between a higher voltage and a lower voltage, electricity will flow along that path. If you insert something useful into that path like a Light Emitting Diode (LED), the flowing electricity will do some work for you, like lighting up that LED.

So, where do you find a higher voltage and a lower voltage in a battery? Why do batteries have a positive sign on one end and a negative sign on the other end? Here's something really useful to know: every source of electricity has two sides. You can see this on batteries, which have metal caps on both ends. In batteries, these sides, called terminals, are named positive (+) and negative (-).

We're finally ready to make electricity work for us! If we connect the positive side of a voltage source through something that does some work such as an LED, and back to the negative side of the voltage source, electricity, or current, will flow.



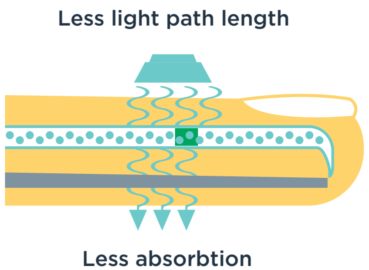
A simple circuit with electrons moving through the conductive material.

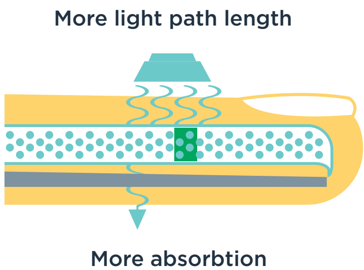
CAUTION – this will short circuit a battery causing heat and potentially a fire!

THE PULSE OXIMETER

Ask youth what a pulse oximeter measures. How does the pulse oximeter measure it?

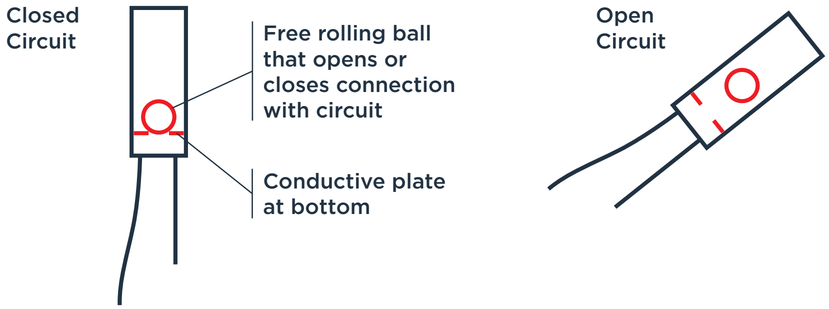
A pulse oximeter measures the amount of light that travels through an artery (tubes in the body that carry blood from the heart). The amount of light received by the light sensor depends on the amount of blood the light has to pass through, as well as the amount of oxygen in the blood. Since the artery expands each time the heart pumps, the light signal decreases and the pulse can be detected as a change in the sensor's signal.





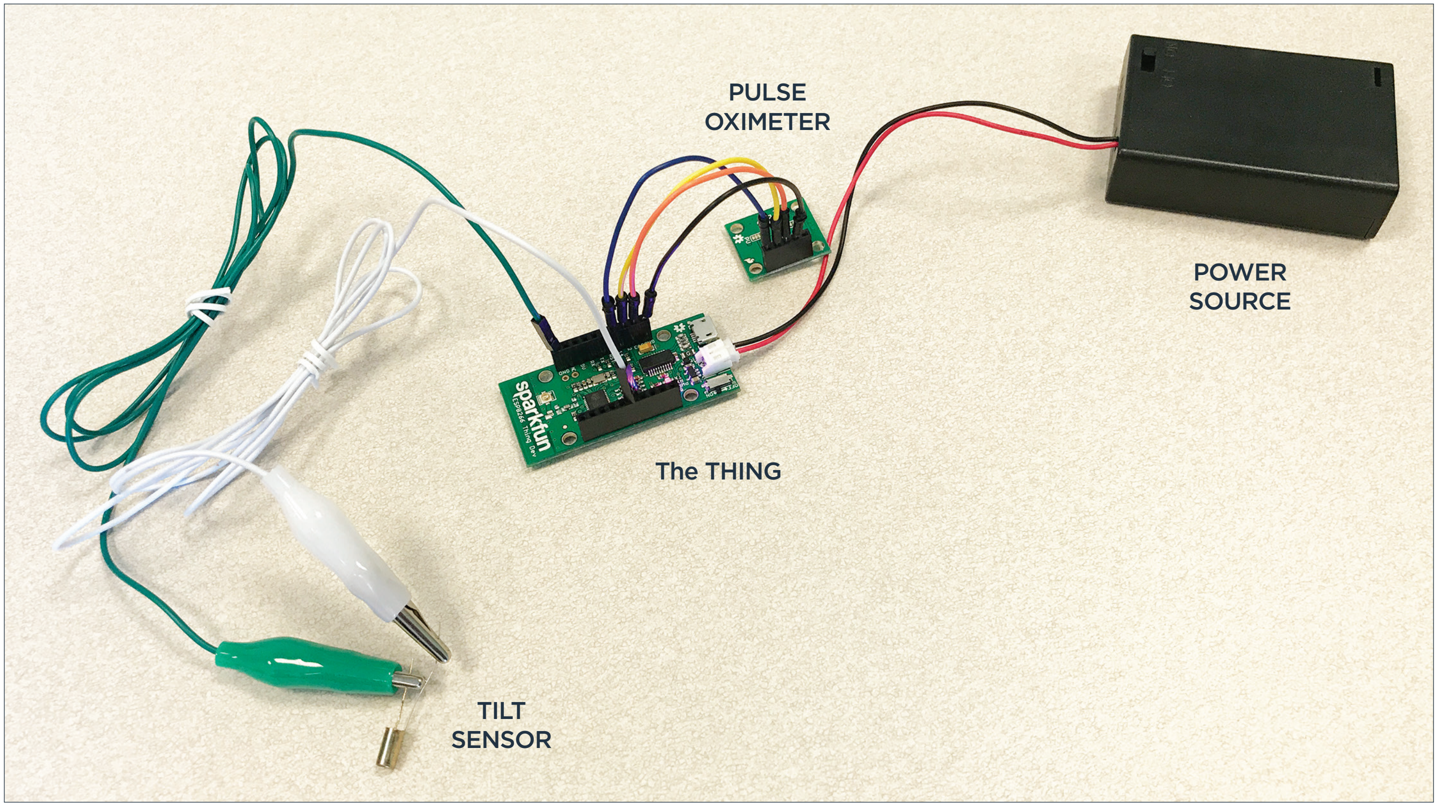
THE TILT SENSOR

The tilt sensor uses a small metal ball that moves when the sensor is tilted. There is a conductive plate at the bottom of the tilt sensor, so when the ball makes contact with the plate, it closes the circuit.



OVERVIEW OF THE ASSEMBLED COMPONENTS

The diagram below provides an overview of the connections between the sensors, the ESP8266 computer (The THING) and the power source. The components are connected using jumper wires and alligator clips as per the diagram below. You will find kit building instructions on page 17, and page 17 of the Youth Guide.



PART III

BUILD

CHALLENGE

(15 MINUTES)

Have youth follow along with the building instructions starting on page 17 of the Youth Guide.

LEARNING OBJECTIVE

Connect the sensors to the The THING.

STEP 1: CONNECT THE POWER

1. Check that the power switch on The THING is in the “off” position.

2. Open the power supply with the supplied screwdriver and insert three AA batteries.

3. Connect the power supply to The THING.

4. Turn on the power supply by sliding the power switch to the ‘On’ position.

5. Turn on The THING by sliding the small switch to the ‘On’ position. You will see a light appear on The THING.

*Note: Both the Power Supply and The THING must be turned on for the device to function.

STEP 2: GET CONNECTED

One of the great things about The THING is that it has the ability to act like a webserver, meaning that if you connect to it through a standard browser on your device (laptop or mobile device), it will display a webpage.

To connect one THING to one device:

1. On your device, open the Wi-Fi connections and select the ‘Incredible Wearables’ network. If your device does not connect the first time wait 30 seconds and try again Sometimes it may take multiple tries to connect.

2. Once connected, open an internet browser and enter 192.168.4.1 into the address search bar.

When running more than one THING at the same time, follow steps on page 18.

IMPORTANT!

If you are using five or more THINGs you must change each THING’s SSID (wireless network name).

- The estimated time it will take to change the SSID is 30-60 minutes depending on the number of devices.
- This process will require a USB-A to USB-B micro cable.
- For detailed instructions visit www.4-h.org/NYSD and click the “Guides & Resources” tab.

To connect 2-4 THINGs to multiple devices:

Each THING can broadcast its SSID (the name of its wireless network) as either Incredible Wearables, or Incredible Wearables 1-3. When operating more than one THING at the same time they must each have a unique SSID. In this step you will be using jumper wires to connect pins on each THING, so that each THING connects to a separate network.

Tip: Label each THING with its SSID so you can keep track of them.

1. Make sure all things are turned off.

2. Use the jumper wires to set each THING with a unique SSID. These wires will stay connected throughout the challenge. See images to the right for reference.

    THING 1: Connect pin 16 to pin 0 and connect pin 13 to pin GND. THING 1 will now connect to the network 'Incredible Wearables1'

    THING 2: Connect pin 16 to pin 0 and connect pin 12 to pin GND. THING 2 will now connect to the network "Incredible Wearables2'.

    THING 3: Connect pin 16 to pin GND. THING 3 will now connect to the network 'Incredible Wearables3'.

    THING 4: Connect pin 16 to pin 0. THING 4 will now connect to the network 'Incredible Wearables'.

3. Turn your THINGs on.

4. On your device, open the Wi-Fi connections and select one of your networks. If your device does not connect the first time wait 30 seconds and try again. Sometimes it may take multiple tries to connect.

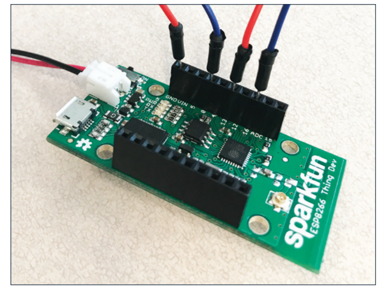
5. Once connected, open an internet browser and enter 192.168.4.1 into the address search bar.

6. Repeat steps 4 and 5 for each THING that had its network changed.

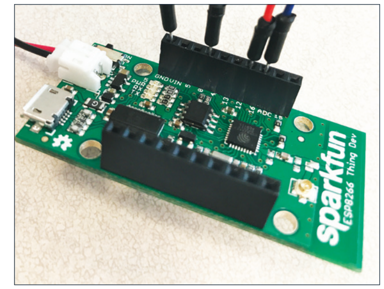
To connect 5+ THINGs to multiple devices:

Connecting more than 5 devices will require a USB-A to USB-B micro cable and will take 30-60 minutes. Make sure you do this before your planned 4-H NYSD event. For detailed instructions visit www.4-h.org/NYSD and click the "Guides & Resources" tab.

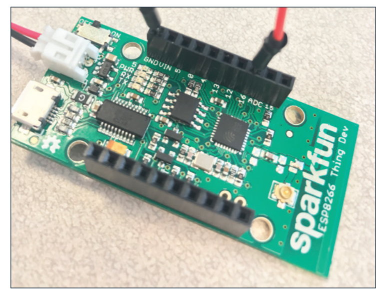
Images below reference connections for 2-4 THINGs



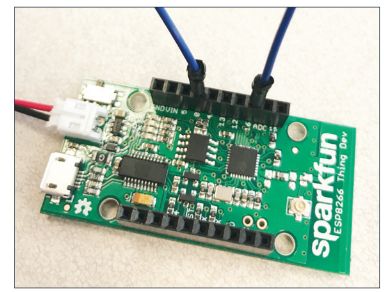
THING 1



THING 2



THING 3



THING 4

TROUBLESHOOTING

If you are experiencing trouble connecting to the Incredible Wearables Network. Please try:

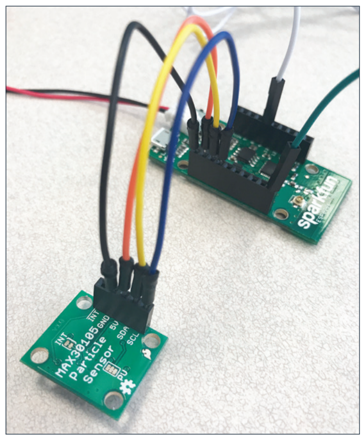
- Opening your device's network connections and disconnect from any other wireless networks by selecting 'forget network'.
- Find the on/off switch on The THING. When your device is trying to connect to the Incredible Wearables network turn The THING off and then immediately back on again.
- For detailed troubleshooting instructions visit **www.4-h.org/NYSD** and click the "Guides & Resources" tab.

STEP 3: CONNECT THE PULSE OXIMETER

In this step, you will use jumper wires to connect the pins on the pulse oximeter to The THING.

1. Turn off The THING
2. Use the chart below to make the proper connections between the pulse oximeter and The THING

Pulse Oximeter Pin	The THING Pin
5V	3v3
GND	GND
SDA	2
SCL	14



Pulse Oximeter connection to The THING

STEP 4: TILT SENSOR

In this step, you will connect the tilt sensor to The THING using alligator clips.

1. Connect the longer leg of the tilt sensor to pin 4 on The THING
2. Connect the shorter leg of the tilt sensor to GND on The THING.

STEP 5: TESTING

1. Power on The THING. A blue light on The THING indicates that the Tilt Sensor is working. As you move the tilt sensor a blue light will turn off and on as the sensor's circuit opens and closes. A red light will be lit on the pulse oximeter to indicate it is working.
2. Finally, place the pulse oximeter on one of your team member's index fingers. The side opposite the pins will be against your finger.
3. Refresh your browser displaying the incredible wearables data at 192.168.4.1. Scroll down to the bottom of the page to see your most recent data.

Have you done all of Part III? Check off each item when you have completed it.

- ☐ **1. Connected the power source to The THING.**
- ☐ **2. Connected The THING to the "Incredible Wearables" network**
- ☐ **3. Opened the webpage 192.168.4.1 in your internet browser and viewed the Incredible Wearables page.**
- ☐ **4. Connected the pulse oximeter to The THING using jumper wires.**
- ☐ **5. Connected the tilt sensor to The THING using alligator clips.**
- ☐ **6. Youth have placed the pulse oximeter on a team member's finger and made sure it is recording data.**
- ☐ **7. Moved the tilt sensor back and forth to make sure that the data are being displayed on the device.**

PART IV

DATA COLLECTION

CHALLENGE: OVERVIEW

SUMMARY

In this part of the challenge, youth will complete the build of their fitness tracker and then begin to collect data for the group for both their resting pulses and their active pulses. Have youth follow along with this activity starting on pg. 21 of the Youth Guides.

LEARNING OBECTIVES

1. Understand how to view and interpret data.

2. Understand what careers are related to the skills used in this challenge.

SETUP

The instructions for a group of 3-6 youth are listed first, followed by the instructions for a group of 7-10 youth using one kit. If you have multiple kits with youth divided into groups of 3-6, you should use the instructions for groups of 3-6 youth.

Tip: The pulse oximeter will work best when used on the index finger; however, the tilt sensor may be more efficient on the wrist, arm or leg.

WRISTBAND ASSEMBLY

Use the included rubber bands and velcro strips to turn the felt into a wristband. Other materials such as scissors, staplers, and sticker can help bring out youth's creativity.

3-6 YOUTH PER KIT
(45 MINUTES)

In the first part of the challenge the tilt sensor will be located on the wrist for all the teams. In the second part of the challenge, the youth will optimize their design to determine if there are better places on the body to place the tilt sensor. Each team member will collect information for each condition and then calculate an average for the entire team.

STEP 1

It's now time for the youth to design a way for their fitness tracker to be wearable. Using their notebooks, have them sketch their initial designs. Remind them that the final product should be wearable and aesthetically pleasing. In the notebook there is a place for them to define the problem and note the constraints of the project. Once they have a good idea of how they will build their project, have them use their drawings as a guide. It's OK to disconnect the alligator clips at this time, but they may want to record a connection diagram in their notebooks. At this stage, have the youth design the monitor so that the tilt sensor is located on the wearer's wrist. Please reference the directions on page 7 to assemble your wristband.

STEP 2

Once the fitness tracker has been built, it's time to collect data. In this step have each youth wear the pulse oximeter on their index finger. Ask them to open the web page (IP address 192.168.4.1) on their device and record their resting pulse rate and the number of steps taken for one minute; this information should be written down in their notebooks. Once all the data has been collected for each person, calculate an average resting heartbeat for the entire group (sum all scores/number of scores).

STEP 3

At this stage you will repeat step two, only this time the youth will jog in place while their pulse is measured for one minute. Again, have them record their answers in their workbooks.

STEP 4

Now it's time for the youth to optimize their design. First, have them modify the design if needed to place the tilt sensor on other parts of the body (for example the hand, elbow or upper arm). They should choose at least two additional points. Next, they should collect a resting average and a moderate movement average for the other two pulse points. Each youth will place the tilt sensor on other parts of the body.

STEP 5

Have the youth share their group (not individual) data regarding their average resting pulse, active pulse, and movement rates, and say what they thought was the most accurate place to put the tilt sensor.

7-10 YOUTH PER KIT
(45 MINUTES)

Each team will subdivide into groups of 3-4 youth. Each subgroup will have an opportunity to use the device they build to collect information for each condition and then calculate an average for the entire team. In the first part of the challenge the tilt sensor will be located on the wrist for all the teams.

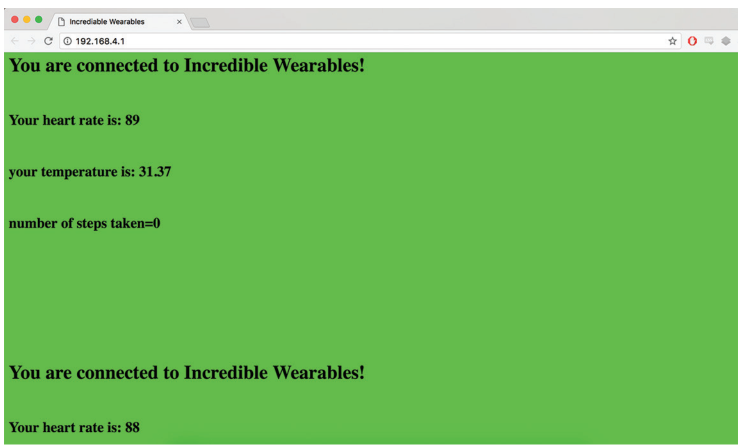
In the second part of the challenge, the youth will optimize their design to determine if there are better places on the body to place the tilt sensor.

STEP 1

It's now time for the youth to design a way for their fitness tracker to be wearable. Using their notebooks, have them sketch their initial designs. Remind them that the final product should be wearable and aesthetically pleasing. In the notebook there is a place for them to define the problem and note the constraints of the project. Once they have a good idea of how they will build their project, have them use their drawings as a guide. It's OK to disconnect the alligator clips at this time, but they may want to record a connection diagram in their notebooks. At this stage, have the youth design the monitor so that the tilt sensor is located on the wearer's wrist.

STEP 2

Once the fitness tracker has been built, it's time to collect data. In this step have one youth in each subgroup wear the pulse oximeter on their index finger. Ask them to open the web page (IP address 192.168.4.1) on their device and record their resting pulse rate and the number of steps taken for one minute. One youth can be the data analyst who records that information for analysis, one youth will provide the data by using the pulse oximeter, and one youth will make sure the device is functioning properly and gathering data. Have the youth enter the number in their notebooks. Once all the data has been collected for each subgroup, ask the whole group to come back together and obtain an average resting heartbeat for the entire group (sum all scores/number of scores).



STEP 3

In this step you will repeat step two, only this time the measurement will have the youth jog in place while their pulse is measured for one minute. Again, have them record their answers in their workbook.

STEP 4

Now it's time for the youth to optimize their design. First, have them modify their design if needed to place the tilt sensor on other parts of the body (e.g. hand, elbow or upper arm). They should choose at least two additional points. Next they should collect a resting average and a moderate movement average for the other two pulse points.

The group will decide which additional points on the body they would like to test and then assign one point to each group. They will again divide into subgroups and each subgroup will test one point on one member in the subgroup. While one group is working with the device, the rest of the group should be discussing how they are going to place the tilt sensor and how their proposed placement of the sensor fits into their wearable design. For example, how will they hook up the tilt sensor if they want to put it on their lower leg or arm? How far from The THING can they place the sensor with the alligator clips/wires they were given? The member of the group who is the marketing specialist could also be gathering information or pictures for social media (with adult permission).

STEP 5

Have youth share their group (not individual) data regarding their average resting pulse, active pulse, movement rates and what they thought was the most accurate place to put the tilt sensor.

PART V

COOL DOWN

CHALLENGE

(10 MINUTES)

In this part, the youth follow the steps of the engineering design process to build and optimize a wearable health monitor. The monitor provides time-series data concerning pulse rates which can be used to determine the relative level of activity of the wearer.

Help guide the youth to reflect and share their learning experiences through the Incredible Wearables challenge. They can record their reflections in their notebooks before sharing with the group. The most important question for each part is listed first. If you still have time there are additional questions for youth to answer related to each part of the activity listed below.

STEP 1

SHARE WHAT YOU DID. WHAT DID YOU LEARN?

- How could youth and adults use the information your device gathers to make decisions that could improve their health?
- What could you improve about your device to help youth and adults be more active?

STEP 2

PROCESS WHAT'S IMPORTANT. WHAT WAS IMPORTANT TO LEARN?

- How did planning your design on paper prior to building the health monitor help you with design issues?

STEP 3

GENERALIZE TO YOUR LIFE. HOW WILL IT HELP YOU IN EVERYDAY LIFE?

- What is the benefit of knowing your pulse rate and monitoring your health?

STEP 4

APPLY WHAT YOU HAVE LEARNED. HOW WILL IT APPLY TO OTHER SITUATIONS?

- What careers would be related to this challenge? Talk about careers that would use the skills the youth learned in this activity. Use the remaining three steps of the 4-H career pathways and provide a list of opportunities/activities where they could learn, practice and/or experience these skills.

CLOSING STATEMENT

The youth have now had the experience of using the engineering design process to build a device to help them monitor their health so they can gather data to make decisions. They now know more about how wearable technologies like FitBits are made, but health monitoring is only one part of wearable technologies; there are many other industries such as agriculture and fashion that are working with technology like this to improve lives.

GOING FURTHER

The health monitor is a great stepping stone to other DIY electronic projects. The youth may also choose to continue to optimize their health monitors, either aesthetically or by investigating other sensors that could be added to The THING. Additional resources are available at **Sparkfun.com/ NYSD2017**.

LEARN MORE

To learn more, please visit **learn.sparkfun.com**:

Micro controllers - Arduino, ESP8266
The THING is a small Wi-Fi enabled web server that can do many things as you have already seen. Youth can learn more about the capabilities of The THING by visiting learn.sparkfun.com.

Programming - Processing, HTML, JavaScript
One of the interesting capabilities of The THING is that it can act as a webserver by answering web requests using HTML (Hypertext Markup Language) and JavaScript. These can be modified using the Arduino programming language (https://processing. org/).

Servers - PHP, NodeJS, LAMP
A webserver has the capability to answer web requests from client browsers. Using scripting languages like PHP, NodeJS, and LAMP, it is possible to build dynamic web sites and web applications.

Sensors - sparkfun.com, BMP280, ADXL345, MAG3110
Sensors allow The THING to collect external environmental data. These include the BMP280 pressure sensor, ADXL345 triple axis accelerometer, and the MAG3110 magnetometer that can be used like a compass to determine direction.

Data - SQL, JSON, CSV
Data can be gathered, stored and retrieved in common formats. SQL and JSON are electronic ways to manage data and CSV is a way to save data in plain text (human readable).

BioMed - pulse oximetry, respiration, temp
Pulse oximetry, respiration and temperature are ways to evaluate the health of an individual and can be monitored to look for potential changes in health.

THANK YOU!

Special thanks to **SparkFun Electronics** for supporting the development of the *Incredible Wearables* challenge.

10

4-H
NATIONAL
YOUTH
SCIENCE DAY

10 Years of Growing Curious Minds

4-H leads the way with **STEM** projects for youth across aerospace engineering and robotics to veterinary science and hydroponics, empowering young people with the skills to lead for a lifetime.

Visit **4-H.org/NYSD** and explore now.

2017 - INCREDIBLE WEARABLES

2016 - DRONE DISCOVERY

2015 - MOTION COMMOTION

2014 - ROCKETS TO THE RESCUE

2013 - MAPS & APPS

2012 - ECO BOT CHALLENGE

2011 - WIRED FOR WIND

2010 - 4-H_2O

2009 - BIOFUEL BLAST

2008 - HELPFUL HYDROGELS

INCREDIBLE WEARABLES

www.4-H.org/NYSD

University of Nebraska Lincoln

USDA United States Department of Agriculture | National Institute of Food and Agriculture

NATIONAL PARTNERS

HughesNet. LOCKHEED MARTIN U.S. Cellular

SIGNATURE PARTNER

DuPont Pioneer

4-H GROWS HERE

In 4-H, we believe in the power of young people. We see that every child has valuable strengths and real influence to improve the world around us. We are America's largest youth development organization—empowering nearly six million young people across the U.S. with the skills to lead for a lifetime.

Learn more online at: **www.4-H.org** | #4HNYSD