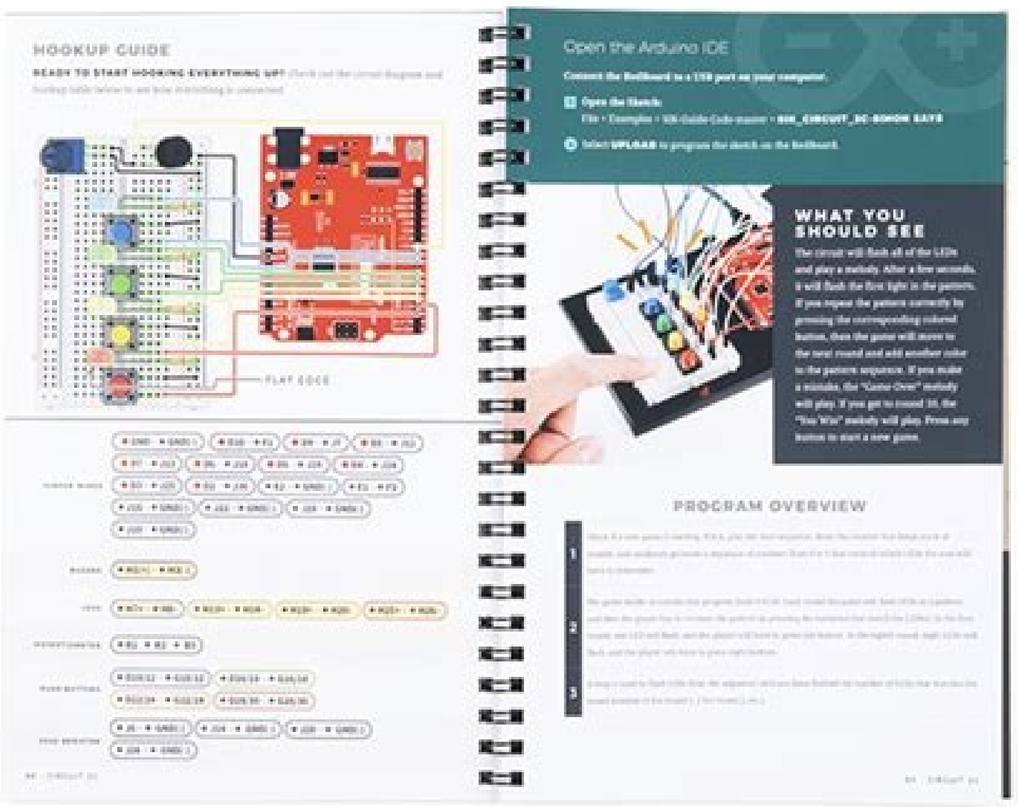
I'm not robot!



Sparkfun inventor's kit - v4.1.

BOK-14326 The Arduino microcontroller makes it easy to learn about electronics, but it can be hard to know where to start. The 10 proje… Contributors: Joel_E_B Favorited Favorite 8 Please note that this tutorial is for the SparkFun Inventor's Kit version 4.0 using the RedBoard with FTDI. If you are using version 4.1, please refer to the tutorial using the RedBoard Qwiic and CH340. The overall functionality of the circuits used in the kits are the same between v4.0 and v4.1. If you have SIK v3.3 or are using parts from the add-on pack, please refer to this tutorial. The SparkFun Inventor's Kit (SIK) is your map for navigating the waters of beginning embedded electronics. This guide contains all the information you will need to build five projects encompassing the 16 circuits of the SIK. At the center of this guide is one core philosophy: that anyone can (and should) play around with electronics. When you're done with this guide, you will have built five projects and acquired the know-how to create countless more. Now enough talk — let's start something! The print version of this guide is available as a PDF as well. Click the following link to download it. Keep in mind that the original file size used for the printed guidebook was reduced for the web. While the file size was reduced, it is still about a 26MB download. Notice: This online guide is kept up to date with all the most recent improvements and corrections. For users following along with the printed version of this guide, please visit sparkfun.com/SIKerrata for any and all changes that may affect your experience while using the printed guide. Choosing a Kit You should have one of the two following versions of the SIK. If you need a overview of the parts included in your kit, please click on the product link below. KIT-14265 The fourth edition of our popular SIK, fully reworked from the ground up for a better learning experience! 20 Retired Favorited Favorite 46 KIT-14418 The 4th edition of our popular SIK for Arduino Uno, fully reworked from the ground up for a better learning experience! Perfe… 3 Retired Favorited Favorite 12 The primary difference between the two kits is the microcontroller included in the kit. The SparkFun Inventor's Kit includes a SparkFun RedBoard, while the SparkFun Inventor's Kit for Arduino Uno includes an Arduino Uno R3. At the heart of each is the ATmega328p microcontroller, giving both the same functionality underneath the hood. Both development boards are capable of taking inputs (such as the push of a button or a reading from a light sensor) and interpreting that information to control various outputs (like a blinking LED light or an electric motor). And much, much more! Note: The Arduino Uno version of the kit does not include a carrying case or printed copy of this manual to decrease weight and cost for international shipping. Note: You can complete all 16 experiments in this guide with either kit. If you need more information to determine which microcontroller is right for you, please check out the following tutorials. What is this 'Arduino' thing anyway? This tutorials dives into what an Arduino is and along with Arduino projects and widgets. Favorited Favorite 46 How to get your RedBoard up-and-blinking! Favorited Favorite 5 Open Source! At SparkFun, our engineers and educators have been improving this kit and coming up with new experiments for a long time now. We would like to give attribution to Oomlout, since we originally started working off their Arduino Kit material many years ago. The Oomlut version is licensed under the Creative Commons Attribution Share-Alike 3.0 Unported License. The SparkFun Inventor's Kit V4.0 is licensed under the Creative Commons Attribution Share-Alike 4.0 International License. View as a single page Next Page → Baseplate Assembly KIT-16468 The SparkFun Inventor's Kit Parts Refill Pack provides, you with a way not to buy a whole new SIK if you lose a few of the sm… $4.95 The Guidebook You've Been Looking For The full-color SparkFun Inventor's Kit Guidebook V4 is a great way to introduce students to programming and electronics. Step-by-step instructions walk users through 16 different circuits. Full example code and circuit diagrams as well as troubleshooting tips offer assistance along the way. As students work their way through the circuits presented in the Guidebook, they will be introduced to new components, buildign a solid foundation for programming electronics. The final project of the guidebook incorporates all of the components and concepts introduced throughout the book. Note: This is just the manual for the SparkFun Inventor's Kit - v4.0. The kit itself or the individual parts used in this book will need to be purchased separately. Contributors: Joel_E_B Favorited Favorite 2 The SparkFun Inventor's Kit (SIK) is your map for navigating the waters of beginning embedded electronics. This guide contains all the information you will need to build five projects encompassing the 16 circuits of the SIK. At the center of this guide is one core philosophy: that anyone can (and should) play around with electronics. When you're done with this guide, you will have built five projects and acquired the know-how to create countless more. Now enough talk — let's start something! The print version of this guide is available as a PDF as well. Click the following link to view it. SparkFun Inventor's Kit - v4.0 You should have one of the two following versions of the SIK. If you need a overview of the parts included in your kit, please click on the product link below. 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The SparkFun Inventor's Kit V4.0 is licensed under the Creative Commons Attribution Share-Alike 4.0 International License. View as a single page Next Page → Baseplate Assembly Reviews (0) Continue shopping View cart & checkout Contributors: Joel_E_B Favorited Favorite 8 Please note that this tutorial is for the SparkFun Inventor's Kit version 4.0 using the RedBoard with FTDI. If you are using version 4.1, please refer to the tutorial using the RedBoard Qwiic and CH340. The overall functionality of the circuits used in the kits are the same between v4.0 and v4.1. If you have SIK v3.3 or are using parts from the add-on pack, please refer to this tutorial. The SparkFun Inventor's Kit (SIK) is your map for navigating the waters of beginning embedded electronics. This guide contains all the information you will need to build five projects encompassing the 16 circuits of the SIK. At the center of this guide is one core philosophy: that anyone can (and should) play around with electronics. 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The SparkFun Inventor's Kit V4.0 is licensed under the Creative Commons Attribution Share-Alike 4.0 International License. Before you can build circuits, you'll want to first assemble the breadboard baseplate. This apparatus makes circuit building easier by keeping the breadboard and the RedBoard microcontroller connected together without the worry of disconnecting or damaging your circuit. The larger the circuit, the more wires needed to build it. The more wires there are, the easier it is for one of those wires to come undone. To begin, grab all the parts: the RedBoard, the breadboard, the included screwdriver, the baseplate and the two baseplate screws. If the screwdriver end is a flathead screwdriver, pull the shaft out, rotate it around to the Phillips head screwdriver side, and reinsert the shaft. Next, peel the adhesive backing off the breadboard. Carefully align the breadboard over its spot on the baseplate. The text on the breadboard should face the same direction as the text on the baseplate. Firmly press the breadboard to the baseplate to adhere it. Align the RedBoard with its spot on the baseplate. The text on it should face the same direction as the text on the breadboard and the baseplate. Grab on of the two included screws, and firmly screw it into one of the four stand-off holes found on the RedBoard. The plastic holes are not threaded, so you will need to apply pressure as you twist the screwdriver. Screw the second screw in the stand-off hole diagonally across from the first. With that, your baseplate is now assembled. Arduino Uno Baseplate Assembly Newer versions of the Arduino Uno come with a clear, plastic baseplate of their own. It will need to be removed before the Uno can be attached to the breadboard baseplate. To remove it, pull it from the Uno. You may now attach the Uno to the baseplate as shown in the instructions above. Please Note: The Arduino Uno and the SparkFun RedBoard are pin-for-pin identical. Though the circuits in this guide show the SparkFun RedBoard, the Arduino Uno can be interchanged and used with all the same circuit diagrams and hookup tables. All the pin names and locations are the same on both development platforms. The SparkFun RedBoard is your development platform. At its roots, the RedBoard is essentially a small, portable computer, also known as a microcontroller. It is capable of taking inputs (such as the push of a button or a reading from a light sensor) and interpreting that information to control various outputs (like blinking an LED light or spinning an electric motor). That's where the term "physical computing" comes in; this board is capable of taking the world of electronics and relating it to the physical world in a real and tangible way. The SparkFun RedBoard is one of a multitude of development boards based on the ATmega328 microprocessor. It has 14 digital input/output pins (six of which can be PWM outputs), six analog inputs, a 16MHz crystal oscillator, a USB connection, a power jack, and a reset button. You'll learn more about each of the RedBoard's features as you progress through this guide. Check out the guide below to learn more about the SparkFun RedBoard. How to get your RedBoard up-and-blinking! Favorited Favorite 5 A breadboard is a circuit-building platform that allows you to connect multiple components without using a soldering iron. If you have never seen or used a breadboard before, it is highly recommended you read the following guide that explains the breadboards anatomy and how to use one. Welcome to the wonderful world of breadboards. Here we will learn what a breadboard is and how to use one to build your very first circuit. Favorited Favorite 73 The following steps are a basic overview of getting started with the Arduino IDE. For more detailed, step-by-step instructions for setting up the Arduino IDE on your computer, please check out the following tutorial. A step-by-step guide to installing and testing the Arduino software on Windows, Mac, and Linux. Favorited Favorite 16 In order to get your microcontroller up and running, you'll need to download the newest version of the Arduino software first (it's free and open source!). This software, known as the Arduino IDE, will allow you to program the board to do exactly what you want. It's like a word processor for writing code. Download Arduino Code You are so close to to being done with setup! Download the SIK Guide Code. You can also download the code from GitHub or click the following link to download the code: Place the SIK-Guide-Code folder in the Arduino IDE examples directory: Windows: drag the SIK-Guide-Code-V4.0a folder into C:\Program Files\Arduino-x\examples Note: For those that automatically installed the Arduino IDE on a Windows 64-bit computer, the Arduino program folder may be located in the "C:\Program Files (x86)..." folder. MacOS: Right-click on the Arduino IDE app and click "Show Package Contents...". Drag the SIK-Guide-Code-V4.0a folder into Contents/Resources/Java Linux: see Connect the Microcontroller to your Computer Use the USB cable provided in the SIK kit to connect the included microcontroller (RedBoard or Arduino Uno) to one of your computer's USB inputs. Install FTDI Drivers Depending on your computer's operating system, you will need to follow specific instructions. Please go to How to Install FTDI Drivers, for specific instructions on how to install the FTDI drivers onto your RedBoard. Select your Board: Arduino/Genuino Uno Before we can start jumping into the experiments, there are a couple adjustments we need to make. This step is required to tell the Arduino IDE which of the many Arduino boards we have. Go up to the Tools menu. Then hover over Board and make sure Arduino Uno is selected. Please note: Your SparkFun RedBoard and the Arduino UNO are interchangeable but you won't find the RedBoard listed in the Arduino Software. Select "Arduino/Genuino Uno" instead. Next up we need to tell the Arduino IDE which of our computer's serial ports the microcontroller is connected to. For this, again go up to Tools, then hover over Port (Serial Port in older Arduino versions) and select your RedBoard or Arduino's serial port. This will be the same serial port seen when installing FTDI drivers. With that, you're now ready to begin building your first circuit! Welcome to your first SparkFun Inventor's Kit project. Each project is broken up into several circuits, each designed to help you learn about new technologies and concepts. The knowledge gained from each circuit will play a part in building each

project. This first project will set the foundation for the rest of the projects in the guide and will aid in helping you understand the basic fundamentals of circuit building and electricity! In Project 1, you will learn about light-emitting diodes (LEDs), resistors, inputs and sensors --- using all of those technologies to build and program your own multicolored night-light! The night-light uses a sensor to turn on an RGB (Red, Green, Blue) LED when it gets dark, and you will be able to change the color using an input knob. New Components Introduced in This Project Each of the components listed below will be described in more detail as you progress through each project. LEDs Resistors Potentiometers Photoresistors New Concepts Introduced in This Project Each of the concepts listed below will be described in more detail as you progress through each project. Polarity Ohm's Law Digital Output Analog vs. Digital Analog Input Analog to Digital Conversion Voltage Divider Pulse-width Modulation Functions You Will Learn How to upload a program to your RedBoard or Arduino Uno Circuit building basics How to control LEDs with digital outputs How to read sensors you analog inputs Light-Emitting Diodes, or LEDs (pronounced el-ee-dees), are small, powerful lights that are used in many different applications. You can find LEDs in just about any source of light nowadays, from the bulbs lighting your home to the tiny status lights flashing on your home electronics. Blinking an LED is the classic starting point for learning how to program embedded electronics. It's the "Hello, World!" of microcontrollers. In this circuit, you'll write code that makes an LED flash on and off. This will teach you how to build a circuit, write a short program and upload that program to your RedBoard. Parts Needed Grab the following quantities of each part listed to build this circuit: New Components and Concepts: Each circuit will introduce new components or parts that will be used in the circuit. Each circuit will also introduce a few new concepts that will help you understand what your circuit and code is doing and why. Light-Emitting Diodes (LEDs) are small lights made from a silicon diode. They come in different colors, brightnesses and sizes. LEDs have a positive (+) leg and a negative (-) leg, and they will only let electricity flow through them in one direction. LEDs can also burn out if too much electricity flows through them, so you should always use a resistor to limit the current when you wire an LED into a circuit. Resistors Resistors resist the flow of electricity. You can use them to protect sensitive components like LEDs. The strength of a resistor (measured in ohms) is marked on the body of the resistor using small colored bands. Each color stands for a number, which you can look up using a resistor chart. New Concepts Polarity Many electronics components have polarity, meaning electricity can only flow through them in one direction. Components like resistors do not have polarity; electricity can flow through them in either direction. However, components like an LED that do have polarity only work when electricity flows through them in one direction. Ohm's Law Ohm's law describes the relationship between the three fundamental elements of electricity: voltage, resistance and current. This relationship can be represented by the following equation: Where V = Voltage in volts I = Current in amps R = Resistance in ohms (Ω) This equation is used to calculate what resistor values are suitable to sufficiently limit the current flowing to the LED so that it does not get too hot and burn out. Digital Output When working with microcontrollers such as the RedBoard, there are a variety of pins to which you can connect electronic components. Knowing which pins perform which functions is important when building your circuit. In this circuit, we will be using what is known as a digital output. There are 14 of these pins found on the RedBoard and Arduino Uno. A digital output only has two states: ON or OFF. These two states can also be thought of as HIGH or LOW or TRUE or FALSE. When an LED is connected to one of these pins, the pin can only perform two jobs: turning the LED on and turning the LED off. We'll explore the other pins and their functions in later circuits. The 14 digital pins highlighted. Hardware Hookup We recommend familiarizing yourself with each of the components used in each circuit first. Polarized Components Pay special attention to the component's markings indicating how to place it on the breadboard. Polarized components can only be connected to a circuit in one direction. **Pay close attention to the LED. It is polarized. The negative side of the LED is the short leg, marked with a flat edge. ** Components like resistors need to have their legs bent into 90° angles in order to correctly fit the breadboard sockets. Ready to start hooking everything up? Check out the circuit diagram and hookup table below, to see how everything is connected. Circuit Diagram Having a hard time seeing the circuit? Click on the image for a closer look. Hookup Table Hookup Tables: Many electronics beginners find it helps to have a coordinate system when building their circuits. For each circuit, you'll find a hookup table that lists the coordinates of each component and where it connects to the RedBoard, the breadboard, or both. The breadboard has a letter/number coordinate system, just like the game Battleship. Component RedBoard Breadboard Breadboard LED A1 LED (-) A2 LED (+) 330Ω Resistor(orange, orange, brown) E2 F2 Jumper Wire GND E1 Jumper Wire Digital Pin 13 J2 In the table, polarized components are shown with a warning triangle and the whole row highlighted yellow. Open Your First Sketch Open the Arduino IDE software on your computer. Open the code for Circuit 1A by accessing the SIK Guide Code you downloaded and placed into your examples folder earlier. To open the code, go to: File > Examples > SIK_Guide_Code-V_4 > SIK_Circuit_1A-Blink You can also copy and paste the following code into the Arduino IDE. Hit upload, and see what happens! language:cpp /* SparkFun Inventor's Kit Circuit 1A-Blink Turns an LED connected to pin 13 on and off. Repeats forever. This sketch was written by SparkFun Electronics, with lots of help from the Arduino community. This code is completely free for any use. View circuit diagram and instructions at: Download code at: */ void setup() { pinMode(13, OUTPUT); // Set pin 13 to output } void loop() { digitalWrite(13, HIGH); // Turn on the LED delay(2000); // Wait for two seconds digitalWrite(13, LOW); // Turn off the LED delay(2000); // Wait for two seconds } What You Should See The LED will flash on for two seconds, off for two seconds, then repeat. If it doesn't, make sure you have assembled the circuit correctly and verified and uploaded the code to your board, or see the Troubleshooting section at the end of this section. Program Overview Turn the LED on by sending power to Pin 13. Wait 2 seconds (2000 milliseconds). Turn the LED off by cutting power to Pin 13. Wait 2 seconds (2000 milliseconds). Repeat. One of the best ways to understand the code you just uploaded is to change something and see how it affects the behavior of your circuit. For this first circuit, try changing the number found in these lines of code: delay(2000);. What happens if you change both to 100? What happens if you change both to 5000? What happens if you change just one delay and not the other? Onboard LED PIN 13: You may have noticed a second, smaller LED blinking in unison with the LED in your breadboard circuit. This is known as the onboard LED, and you can find one on almost any Arduino or Arduino-compatible board including the RedBoard. In most cases, this LED is connected to digital pin 13 (D13), which is the same pin used in this circuit. This LED is useful for troubleshooting, as you can always upload the Blink sketch to see if that LED lights up. If so, you know your board is functioning properly. If you do not want this LED to blink with other LEDs in your circuits, simply use any of the other 12 digital pins (D0-D12). Code to Note Code to Note: The sketches that accompany each circuit introduce new programming techniques and concepts as you progress through the guide. The Code to Note section highlights specific lines of code from the sketch and explains them in further detail. CodeDescription Setup and Loop:void setup(){code to run once} & void loop(){code to run forever}Every Arduino program needs these two functions. Code that goes in between the curly brackets of setup() runs once, then the code in between the loop() curly brackets runs over and over until the RedBoard is reset or powered off. Input or Output?:pinMode(13, OUTPUT);Before you can use one of the digital pins, you need to tell the RedBoard whether it is an INPUT or OUTPUT. We use a built-in "function" called pinMode() to make pin 13 a digital output. You'll learn more about digital inputs in Project 2. Digital Output:digitalWrite(13, HIGH);When you're using a pin as an OUTPUT, you can command it to be HIGH (output 5 volts) or LOW (output 0 volts). Delay:delay(time in milliseconds);Causes the program to wait on this line of code for the amount of time in between the brackets. After the time has passed, the program will continue to the next line of code. Comments://This is a commentComments are a great way to leave notes in your code explaining why you wrote it the way you did. You'll find many comments in the examples that further explain what the code is doing and why. Comments can be single line using //, or they can be multi-line using /* */. Coding Challenges: The Coding Challenges section is where you can find suggestions for changes to the circuit or code that will make the circuit more challenging. If you feel underwhelmed by the tasks in each circuit, visit the Coding Challenges section to push yourself to the next level. ChallengeDescription Persistence of VisionComputer screens, movies and the lights in your house all flicker so quickly that they appear to be on all of the time but are actually blinking faster than the human eye can detect. See how much you can decrease the delay time in your program before the light appears to be on all the time but is still blinking. Morse CodeTry changing the delays and adding more digitalWrite() commands to make your program blink a message in Morse code. Troubleshooting: Last, each circuit has a Troubleshooting section with helpful tips and tricks to aid you in any problems you encounter along the way. ProblemSolution I get an error when uploading my codeThe most likely cause is that you have the wrong board selected in the Arduino IDE. Make sure you have selected Tools > Board > Arduino/Genuino Uno. I still get an error when uploading my codeIf you're sure you have the correct Board selected but you still can't upload, check that you have selected the correct Serial Port. You can change this in Tools > Serial Port > your_serial_port. Which Serial Port is the right one?Depending on how many devices you have plugged into your computer, you may have several active Serial Ports. Make sure you are selecting the correct one. A simple way to determine this is to look at your list of Serial Ports. Unplug your RedBoard from your computer. Look at the list again. Whichever Serial Port has disappeared from the list is the one you want to select once you plug your board back in to your computer. My code uploads, but my LED won't turn onLEDs will only work in one direction. Try taking it out of your breadboard, turning it 180 degrees, and reinserting it. Still not working?Jumper wires unfortunately can go "bad" from getting bent too much. The copper wire inside can break, leaving an open connection in your circuit. If you are certain that your circuit is wired correctly and that your code is error-free and uploaded but you are still encountering issues, try replacing one or more of the jumper wires for the component that is not working. Potentiometers (also known as "pots" or "knobs") are one of the basic inputs for electronics devices. By tracking the position of the knob with your RedBoard, you can make volume controls, speed controls, angle sensors and a ton of other useful inputs for your projects. In this circuit, you'll use a potentiometer as an input device to control the speed at which your LED blinks. Parts Needed Grab the following quantities of each part listed to build this circuit: New Components Potentiometer A potentiometer (trimpot for short) is a variable resistor. When powered with 5V, the middle pin outputs a voltage between 0V and 5V, depending on the position of the knob on the potentiometer. Internal to the trimpot is a single resistor and a wiper, which cuts the resistor in two and moves to adjust the ratio between both halves. Externally, there are usually three pins: two pins connect to each end of the resistor, while the third connects to the pot's wiper. New Concepts Analog vs. Digital Understanding the difference between analog and digital is a fundamental concept in electronics. We live in an analog world. There is an infinite number of colors to paint an object (even if the difference is indiscernible to our eye), an infinite number of tones we can hear, and an infinite number of smells we can smell. The common theme among all of these analog signals is their infinite possibilities. Digital signals deal in the realm of the discrete or finite, meaning there is a limited set of values they can be. The LED from the previous circuit had only two states it could exist in, ON or OFF, when connected to a Digital Output. Analog Inputs So far, we've only dealt with outputs. The RedBoard also has inputs. Both inputs and outputs can be analog or digital. Based on our definition of analog and digital above, that means an analog input can sense a wide range of values versus a digital input, which can only sense two states. You may have noticed some pins labeled Digital and some labeled Analog In on your RedBoard. There are only six pins that function as analog inputs; they are labeled A0--A5. The six analog pins highlighted. Voltage Divider A voltage divider is a simple circuit that turns some voltage into a smaller voltage using two resistors. The following is a schematic of the voltage divider circuit. Schematics are a universally agreed upon set of symbols that engineers use to represent electric circuits. A potentiometer is a variable resistor that can be used to create an adjustable voltage divider. A potentiometer schematic symbol where pins 1 and 3 are the resistor ends, and pin 2 connects to the wiper If the outside pins connect to a voltage source (one to ground, the other to Vin), the output (Vout) at the middle pin will mimic a voltage divider. Turn the trimpot all the way in one direction, and the voltage may be zero; turned to the other side, the output voltage approaches the input. A wiper in the middle position means the output voltage will be half of the input. Voltage dividers will be covered in more detail in the next circuit. Hardware Hookup The potentiometer has three legs. Pay close attention into which pins you're inserting it on the breadboard, as they will be hard to see once inserted. Potentiometers are not polarized. You can attach either of the outside pins to 5V and the opposite to GND. However, the values you get out of the trimpot will change based on which pin is 5V and which is GND. Ready to start hooking everything up? Check out the circuit diagram and hookup table below to see how everything is connected. Circuit Diagram Having a hard time seeing the circuit? Click on the image for a closer look. Hookup Table Component RedBoard Breadboard Breadboard Breadboard Jumper Wire 5V 5V Rail (+) Jumper Wire GND GND Rail (-) LED A1 LED (-) A2 LED (+) 330Ω Resistor(orange, orange, brown) E2 F2 Jumper Wire E1 GND Rail (-) Jumper Wire Digital Pin 13 J2 Potentiometer B25 B26 B27 Jumper Wire Analog Pin 0 (A0) E26 Jumper Wire E25 5V Rail (+) Jumper Wire E27 GND Rail (-) In the table, polarized components are shown with a warning triangle and the whole row highlighted yellow. Open the Sketch To open the code, go to: File > Examples > SIK_Guide_Code-V_4 > SIK_Circuit_1B-Potentiometer You can also copy and paste the following code into the Arduino IDE. Hit upload, and see what happens! language:cpp /* SparkFun Inventor's Kit Circuit 1B-Potentiometer Changes how fast an LED connected to pin 13 blinks, based on a potentiometer connected to pin A0 This sketch was written by SparkFun Electronics, with lots of help from the Arduino community. This code is completely free for any use. View circuit diagram and instructions at: Download code at: */ int potPosition; //this variable will hold a value based on the position of the potentiometer void setup() { Serial.begin(9600); //start a serial connection with the computer pinMode(13, OUTPUT); //set pin 13 as an output that can be set to HIGH or LOW } void loop() { //read the position of the pot potPosition = analogRead(A0); //set potPosition to a number between 0 and 1023 based on how far the knob is turned Serial.println(potPosition); //print the value of potPosition in the serial monitor on the computer //change the LED blink speed based on the pot value digitalWrite(13, HIGH); // Turn on the LED delay(potPosition); // delay for as many milliseconds as potPosition (0-1023) digitalWrite(13, LOW); // Turn off the LED delay(potPosition); // delay for as many milliseconds as potPosition (0-1023) } What You Should See You should see the LED blink faster or slower in accordance with your potentiometer. The delay between each flash will change based on the position of the knob. If it isn't working, make sure you have assembled the circuit correctly and verified and uploaded the code to your board, or see the Troubleshooting section. Program Overview Read the position of the potentiometer (from 0 to 1023) and store it in the variable potPosition. Turn the LED on. Wait from 0 to 1023 milliseconds, based on the position of the knob and the value of potPosition. Turn the LED off. Wait from 0 to 1023 milliseconds, based on the position of the knob and the value of potPosition. Repeat. The Serial Monitor: The Serial Monitor is one of the Arduino IDE's many great built-in tools. It can help you understand the values that your program is trying to work with, and it can be a powerful debugging tool when you run into issues where your code is not behaving the way you expected it to. This circuit introduces you to the Serial Monitor by showing you how to print the values from your potentiometer to it. To see these values, click the Serial Monitor button, found in the upper-right corner of the IDE in most recent versions. You can also select Tools > Serial Monitor from the menu. You should then see numeric values print out on the monitor. Turn the potentiometer, and you should see the values change as well as the delay between each print. If you are having trouble seeing the values, ensure that you have selected 9600 baud in the dropdown menu and have auto scroll checked. Code to Note CodeDescription Integer Variables:int potPosition;A variable is a placeholder for values that may change in your code. You must introduce, or "declare" variables before you use them. Here we're declaring a variable called potPosition of type int (integer). We will cover more types of variables in later circuits. Don't forget that variable names are case-sensitive! Serial Begin:Serial.begin(9600);Serial commands can be used to send and receive data from your computer. This line of code tells the RedBoard that we want to "begin" that communication with the computer, the same way we would say "Hi" to initiate a conversation. Notice that the baud rate, 9600, is the same as the one we selected in the monitor. This is the speed at which the two devices communicate, and it must match on both sides. Analog Input:potPosition = analogRead(A0);We use the analogRead() function to read the value on an analog pin. analogRead() takes one parameter, the analog pin you want to use, A0 in this case, and returns a number between 0 (0 volts) and 1023 (5 volts), which is then assigned to the variable potPosition. Serial Print:Serial.println(potPosition);This is the line that actually prints the trimpot value to the monitor. It takes the variable potPosition and prints whatever value it equals at that moment in the loop(). The ln at the end of print tells the monitor to print a new line at the end of each value; otherwise the values would all run together on one line. Try removing the ln to see what happens. Coding Challenges ChallengeDescription Changing the RangeTry multiplying, dividing or adding to your sensor reading so that you can change the range of the delay in your code. For example, can you multiply the sensor reading so that the delay goes from 0–2046 instead of 0–1023? Adding More LEDsAdd more LEDs to your circuit. Don't forget the current limiting resistor for each one. Try making multiple LEDs blink at different rates by changing the range of each using multiplication or division. Troubleshooting ProblemSolution The potentiometer always reads as 0 or 1023Make sure that your 5V, A0 and GND pins are properly connected to the three pins on your potentiometer. It is easy to misalign a wire with the actual trimpot pin. No values in Serial MonitorMake sure that you have selected the correct baud rate, 9600. Also ensure that you are on the correct Serial Port. The same Serial Port you use when uploading code to your board is the same Serial Port you use to print values to the Serial Monitor. In circuit 1B, you got to use a potentiometer, which varies resistance based on the twisting of a knob. In this circuit you'll be using a photoresistor, which changes resistance based on how much light the sensor receives. Using this sensor you can make a simple night-light that turns on when the room gets dark and turns off when it is bright. Parts Needed Grab the following quantities of each part listed to build this circuit: New Components Photoresistor Photoresistors, or photocells, are light-sensitive, variable resistors. As more light shines on the sensor's head, the resistance between its two terminals decreases. They're an easy-to-use component in projects that require ambient-light sensing. New Concepts Analog to Digital Conversion The world we live in is analog, but the RedBoard lives in a digital world. In order to have the RedBoard sense analog signals, we must first pass them through an Analog to Digital Converter (or ADC). The six analog inputs (A0--A5) covered in the last circuit all use an ADC. These pins "sample" the analog signal and create a digital signal for the microcontroller to interpret. The "resolution" of this signal is based on the resolution of the ADC. In the case of the RedBoard, that resolution is 10-bit. With a 10-bit ADC, we get 2 ^ 10 = 1024 possible values, which is why the analog signal varies between 0 and 1023. Voltage Divider Continued Since the RedBoard can't directly interpret resistance (rather, it reads voltage), we need to use a voltage divider to use our photoresistor, a part that doesn't output voltage. The resistance of the photoresistor changes as it gets darker or lighter. That changes the amount of voltage that is read on the analog pin, which "divides" the voltage, 5V in this case. That divided voltage is then read on the analog to digital converter. Left: A regular voltage divider circuit. Vout will be a constant voltage. Right: A variable voltage divider circuit. Vout will fluctuate as the resistance of the photoresistor changes. The voltage divider equation assumes that you know three values of the above circuit: the input voltage (Vin), and both resistor values (R1 and R2). Given those values, we can use this equation to find the output voltage (Vout): If R1 is a constant value (the resistor) and R2 fluctuates (the photoresistor), the amount of voltage measured on the Vout pin will also fluctuate. Hardware Hookup Note that the photoresistor is not polarized. It can be inserted in either direction. Ready to start hooking everything up? Check out the circuit diagram and hookup table below to see how everything is connected. Circuit Diagram Having a hard time seeing the circuit? Click on the image for a closer look. Hookup Table Component RedBoard Breadboard Breadboard Jumper Wire 5V 5V Rail (+) Jumper Wire GND GND Rail (-) LED A1 LED (-) A2 LED (+) 330Ω Resistor(orange, orange, brown) E2 F2 Jumper Wire E1 GND Rail (-) Jumper Wire Digital Pin 13 J2 Photoresistor A26 B25 10kΩ Resistor(brown, black, orange) C26 D27 Jumper Wire Analog Pin 0 (A0) E26 Jumper Wire E25 5V Rail (+) Jumper Wire E27 GND Rail (-) In the table, polarized components are shown with a warning triangle and the whole row highlighted yellow. Open the Sketch To open the code, go to: File > Examples > SIK_Guide_Code-V_4 > SIK_Circuit_1C-Photoresistor You can also copy and paste the following code into the Arduino IDE. Hit upload, and see what happens! language:cpp /* SparkFun Inventor's Kit Circuit 1C-Photoresistor Use a photoresistor to monitor how bright a room is, and turn an LED on when it gets dark. This sketch was written by SparkFun Electronics, with lots of help from the Arduino community. This code is completely free for any use. View circuit diagram and instructions at: Download drawings and code at: */ int photoresistor = 0; //this variable will hold a value based on the brightness of the ambient light int threshold = 750; //if the photoresistor reading is below this value the the light will turn on void setup() { Serial.begin(9600); //start a serial connection with the computer pinMode(13, OUTPUT); //set pin 13 as an output that can be set to HIGH or LOW } void loop() { //read the brightness of the ambient light photoresistor = analogRead(A0); //set photoresistor to a number between 0 and 1023 based on how bright the ambient light is Serial.println(photoresistor); //print the value of photoresistor in the serial monitor on the computer //if the photoresistor value is below the threshold turn the light on, otherwise turn it off if (photoresistor < threshold) { digitalWrite(13, HIGH); // Turn on the LED } else { digitalWrite(13, LOW); // Turn off the LED } delay(100); //short delay to make the printout easier to read } What You Should See The program stores the light level in a variable, photoresistor. Then, using an if/else statement, the program checks to see what it should do with the LED. If the variable is above the threshold (it's bright), turn the LED off. If the variable is below the threshold (it's dark), turn the LED on. You now have just built your own night-light! Open the Serial Monitor in Arduino. The value of the photoresistor should be printed every so often. When the photoresistor value drops below the threshold value set in the code, the LED should turn on (you can cover the photoresistor with your finger to make the value drop). Note: If the room you are in is very bright or dark, you may have to change the value of the "threshold" variable in the code to make your night-light turn on and off. See the Troubleshooting section for instructions. Store the light level in the variable photoresistor. If the value of photoresistor is above the threshold (it's bright), turn the LED off. If the value of photoresistor is below the threshold (it's dark), turn the LED on. CodeDescription If/else Statements:if(logic statement) { code to be run if the logic statement is true} else {code to be run if the logic statement is false } The if/else statement lets your code react to the world by running one set of code when the logic statement in the round brackets is true and another set of code when the logic statement is false. For example, this sketch uses an if statement to turn the LED on when it is dark, and turn the LED off when it is light. Logical Operators:(photoresistor < threshold) Programmers use logic statements to translate things that happen in the real world into code. Logic statements use logical operators such as 'equal to' (==), 'greater than' (>), and 'less than' (Port, and make sure that you select the right port. In this circuit, you'll take the night-light concept to the next level by adding an RGB LED, which is three differently colored Light-Emitting Diodes (LEDs) built into one component. RGB stands for Red, Green and Blue, and these three colors can be combined to create any color of the rainbow! Parts Needed Grab the following quantities of each part listed to build this circuit: New Components RGB LED An RGB LED is actually three small LEDs --- one red, one green and one blue --- inside a normal LED housing. The RGB LED included in this kit has all the internal LEDs share the same ground wire, so there are four legs in total. To turn one color on, ensure ground is connected, then power one of the legs just as you would a regular LED. If you turn on more than one color at a time, you will see the colors start to blend together to form a new color. New Concepts Analog Output (Pulse-width Modulation) You can use the digitalWrite() command to turn pins on the RedBoard on (5V) or off (0V), but what if you want to output 2.5V? The RedBoard doesn't have an Analog Output, but it is really good at switching some digital pins on and off fast enough to simulate an analog output. analogWrite() can output 2.5 volts by quickly switching a pin on and off so that the pin is only on 50 percent of the time (50% of 5V is 2.5V). By changing the percent of time that a pin is on, from 0 percent (always off) to 100 percent (always on), analogWrite() can output any voltage between 0 and 5V. This is what is known as pulse-width modulation (or PWM). By using PWM, you can create many different colors with the RGB LED. Digital (PWM~): Only a few of the pins on the RedBoard have the circuitry needed to turn on and off fast enough for PWM. These are pins 3, 5, 6, 9, 10 and 11. Each PWM pin is marked with a ~ on the board. Remember, you can only use analogWrite() on these pins. Creating Your Own Simple Functions When programmers want to use a piece of code over and over again, they write a function. The simplest functions are just chunks of code that you give a name to. When you want to run that code, you can "call" the function by typing its name, instead of writing out all of the code. More complicated functions take and return pieces of information from the program (we call these pieces of information parameters). In this circuit, you'll write functions to turn the RGB LED different colors by just typing that color's name. Hardware Hookup Polarized Components Pay special attention to the component's markings indicating how to place it on the breadboard. Polarized components can only be connected to a circuit in one direction. Just like a regular LED, an RGB LED is polarized and only allows electricity to flow in one direction. Pay close attention to the flat edge and to the different length leads. Both are indicators to help orient the LED correctly. Ready to start hooking everything up? Check out the circuit diagram and hookup table below to see how everything is connected. Circuit Diagram Having a hard time seeing the circuit? Click on the image for a closer look. Hookup Table Component RedBoard Breadboard Breadboard Breadboard RGB LED A5 (RED) A4 (GND) A3 (GREEN) A2 (BLUE) 330Ω Resistor(orange, orange, brown) E2 F2 330Ω Resistor(orange, orange, brown) E3 F3 330Ω Resistor(orange, orange, brown) E5 F5 Jumper Wire E4 GND Rail (-) Jumper Wire Digital Pin 9 J5 Jumper Wire Digital Pin 10 J3 Jumper Wire Digital Pin 11 J2 Jumper Wire 5V 5V Rail (+) Jumper Wire GND GND Rail (-) Potentiometer B15 B16 B17 Jumper Wire Analog Pin 1 (A1) E16 Jumper Wire E15 5V Rail (+) Jumper Wire E17 GND Rail (-) Photoresistor A26 B25 10kΩ Resistor(brown, black, orange) C26 D27 Jumper Wire Analog Pin 0 (A0) E26 Jumper Wire E25 5V Rail (+) Jumper Wire E27 GND Rail (-) In the table, polarized components are shown with a warning triangle and the whole row highlighted yellow. Open the Sketch To open the code, go to: File > Examples > SIK_Guide_Code-V_4 > SIK_Circuit_1D-RGBNightlight You can also copy and paste the following code into the Arduino IDE. Hit upload, and see what happens! language:cpp /* SparkFun Inventor's Kit Circuit 1D-RGB Nightlight Turns an RGB LED on or off based on the light level read by a photoresistor. Change colors by turning the potentiometer. This sketch was written by SparkFun Electronics, with lots of help from the Arduino community. This code is completely free for any use. View circuit diagram and instructions at: Download drawings and code at: */ int photoresistor = A0; //variable for storing the photoresistor value int potentiometer = A1; //this variable will hold a value based on the position of the knob int threshold = 700; //if the photoresistor reading is lower than this value the light will turn on //LEDs are connected to these pins int RedPin = 9; int GreenPin = 10; int BluePin = 11; void setup() { Serial.begin(9600); //start a serial connection with the computer //set the LED pins to output pinMode(RedPin, OUTPUT); pinMode(GreenPin, OUTPUT); pinMode(BluePin, OUTPUT); } void loop() { photoresistor = analogRead(A0); //read the value of the photoresistor potentiometer = analogRead(A1); Serial.print("Photoresistor value:"); Serial.print(photoresistor); //print the photoresistor value to the serial monitor Serial.print(" Potentiometer value:"); Serial.println(potentiometer); //print the potentiometer value to the serial monitor if (photoresistor < threshold) { //if it's dark (the photoresistor value is below the threshold) turn the LED on //These nested if statements check for a variety of ranges and //call different functions based on the current potentiometer value. //Those functions are found at the bottom of the sketch. if (potentiometer > 0 && potentiometer 150 && potentiometer 300 && potentiometer 450 && potentiometer 600 && potentiometer 750 && potentiometer 900) magenta(); } else { //if it isn't dark turn the LED off turnOff(); //call the turn off function } delay(100); //short delay so that the printout is easier to read } void red () { //set the LED pins to values that make red analogWrite(RedPin, 100); analogWrite(GreenPin, 0); analogWrite(BluePin, 0); } void orange () { //set the LED pins to values that make orange analogWrite(RedPin, 100); analogWrite(GreenPin, 50); analogWrite(BluePin, 0); } void yellow () { //set the LED pins to values that make yellow analogWrite(RedPin, 100); analogWrite(GreenPin, 100); analogWrite(BluePin, 0); } void green () { //set the LED pins to values that make green analogWrite(RedPin, 0); analogWrite(GreenPin, 100); analogWrite(BluePin, 0); } void cyan () { //set the LED pins to values that make cyan analogWrite(RedPin, 0); analogWrite(GreenPin, 100); analogWrite(BluePin, 100); } void blue () { //set the LED pins to values that make blue analogWrite(RedPin, 0); analogWrite(GreenPin, 0); analogWrite(BluePin, 100); } void magenta () { //set the LED pins to values that make magenta analogWrite(RedPin, 100); analogWrite(GreenPin, 0); analogWrite(BluePin, 100); } void turnOff () { //set all three LED pins to 0 or OFF analogWrite(RedPin, 0); analogWrite(GreenPin, 0); analogWrite(BluePin, 0); } What You Should See This sketch is not dissimilar from the last. It reads the value from the photoresistor, compares it to a threshold value, and turns the RGB LED on or off accordingly. This time, however, we've added a potentiometer back into the circuit. When you twist the pot, you should see the color of the RGB LED change based on the pot's value. Open the Serial Monitor. The value being read by the light sensor should be printed several times a second. When you turn out the lights or cover the sensor, the LED will shine whatever color your programmed in your color function. Next to the light value, you'll see the potentiometer value print out as well. Note: If the room you are in is very bright or dark, you may have to change the value of the "threshold" variable in the code to make your night-light turn on and off. See the Troubleshooting section for instructions. Store the light level from pin A0 in the variable photoresistor. Store the potentiometer value from pin A1 in the variable potentiometer. If the light level variable is above the threshold, call the function that turns the RGB LED off. If the light level variable is below the threshold, call one of the color functions to turn the RGB LED on. If potentiometer is between 0 and 150, turn the RGB LED on red. If potentiometer is between 151 and 300, turn the RGB LED on orange. If potentiometer is between 301 and 450, turn the RGB LED on yellow. If potentiometer is between 451 and 600, turn the RGB LED on green. If potentiometer is between 601 and 750, turn the RGB LED on cyan. If potentiometer is between 751 and 900, turn the RGB LED on blue. If potentiometer is greater than 900, turn the RGB LED on magenta. CodeDescription Analog Output (PWM):analogWrite(RedPin, 100); The analogWrite() function outputs a voltage between 0 and 5V on a pin. The function breaks the range between 0 and 5V into 255 little steps. Note that we are not turning the LED on to full brightness (255) in this code so that the night-light is not too bright. Feel free to change these values and see what happens. Nested if Statements:if(logic statement) { if(logic statement) { code to be run if the logic statement is true} if(logic statement) { code to be run if the logic statement is true} } A nested if statement is one or more if statements "nested" inside of another if statement. If the parent if statement is true, then the code looks at each of the nested if statements and executes any that are true. If the parent if statement is false, then none of the nested statements will execute. More Logical Operators:if(potentiometer > 0 && potentiometer These if statements are checking for two conditions by using the AND (&&) operator. In this line, the if statement will only be true if the value of the variable potentiometer is greater than 0 AND if the value is less than or equal to 150. By using &&, the program allows the LED to have many color states. Defining a Function:void function_name () { code to run inside function } This simple version of a function executes the code inside the curly brackets whenever the name is written in the main program. Calling a Function:function_name(); Calls a function that you have created. In a later circuit, you will learn how to make more complicated functions that take data from the main program (these pieces of data are called parameters). ChallengeDescription Add more colorsYou can create many more colors with the RGB LED. Use the analogWrite() function to blend different values of red, green and blue together to make even more colors. You can divide the potentiometer value up more and make more nested if statements so that you can have more colors as you twist the knob. Multi color blinkTry using delays and multiple color functions to have your RGB LED change between multiple colors. Change the thresholdTry setting your threshold variable by reading the value of a potentiometer with analogRead(). By turning the potentiometer, you can then change the threshold level and adjust your night-light for different rooms. Fading the LEDTry using a loop with the analogWrite() to get your LED to pulse gently or smoothly transition between colors. ProblemSolution The LED never turns on or offOpen the Serial Monitor in Arduino and make sure that your photoresistor is returning values between 0 and 1023. Try covering the photoresistor; the values should change. If they do not change, check the wiring of the photoresistor. If your photoresistor is working correctly, make sure that your threshold variable sits in between the value that the photoresistor reads when it is bright and the value that the photoresistor reads when it is dark (e.g., bright = 850, dark = 600, threshold = 700). My LED doesn't show the colors that I expectMake sure that all three of the pins driving your RGB LED are set to OUTPUT, using the pinMode() command in the setup section of the code. Then make sure that each LED is wired properly. Nothing is printing in the Serial MonitorTry unplugging your USB cable and plugging it back in. In the Arduino IDE, go to Tools > Port, and make sure that you select the right port. In Project 2, you will venture into the world of buttons and buzzers while building your own Simon Says game! Simon Says is a game in which the LEDs flash a pattern of red, green, yellow and blue blinks, and the user must recreate the pattern using color-coded buttons before the timer runs out. New Components Introduced in This Project Each of the components listed below will be described in more detail as you progress through each circuit. New Concepts Introduced in This Project Each of the concepts listed below will be described in more detail as you progress through each circuit. Arrays Binary Digital Inputs Pull-up Resistors For Loops Measuring Elapsed Time You Will Learn How to make tones with a buzzer How to read a button using digital inputs How to program a game In this circuit, you'll use the RedBoard and a small buzzer to make music, and you'll learn how to program your own songs using arrays. Parts Needed Grab the following quantities of each part listed to build this circuit: New Components Buzzer The buzzer uses a small magnetic coil to vibrate a metal disc inside a plastic housing. By pulsing electricity through the coil at different rates, different frequencies (pitches) of sound can be produced. Attaching a potentiometer to the output allows you to limit the amount of current moving through the buzzer and lower its volume. New Concepts Reset Button The RedBoard has a built-in reset button. This button will reset the board and start the code over from the beginning, running what is in setup() and then loop(). Tone Function To control the buzzer, you will use the tone function. This function is similar to PWM in that it generates a wave that is of a certain frequency on the specified pin. The frequency and duration can both be passed to the tone() function when calling it. To turn the tone off, you need to call noTone() or pass a duration of time for it to play and then stop. Unlike PWM, tone() can be used on any digital pin. Arrays Arrays are used like variables, but they can store multiple values. The simplest array is just a list. Imagine that you want to store the frequency for each note of the C major scale. We could make seven variables and assign a frequency to each one, or we could use an array and store all seven in the same array, as shown below. To refer to a specific value in the array, an index number is used. Arrays are indexed from 0. For example, to call the first element in the array, use array_name[0];; to call the second element, use array_name[1]; and so on. Musical Note Frequency (Hz) Using Variables Using an Array A 220 aFrequency frequency[0] B 247 bFrequency frequency[1] C 261 cFrequency frequency[2] D 294 dFrequency frequency[3] E 330 eFrequency frequency[4] F 349 fFrequency frequency[5] G 392 gFrequency frequency[6] Hardware Hookup Polarized Components Pay special attention to the component's markings indicating how to place it on the breadboard. Polarized components can only be connected to a circuit in one direction. The buzzer is polarized. To see which leg is positive and which is negative, flip the buzzer over and look at the markings underneath. Keep track of which pin is where, as they will be hard to see once inserted into the breadboard. There is also text on the positive side of the buzzer, along with a tiny (+) symbol. Volume Knob All of the circuits in Project 2 make use of a potentiometer as a rudimentary volume knob. Notice that only two of the potentiometer's legs are used in these circuits. In these instances, the potentiometer is acting as a variable resistor, limiting the amount of current flowing to the speaker and thus affecting the volume as you turn the knob. This is similar to the current-limiting resistor used to limit current to the LED in circuit 1A --- only this time the resistance is variable. Ready to start hooking everything up? Check out the circuit diagram and hookup table below to see how everything is connected. Circuit Diagram Having a hard time seeing the circuit? Click on the image for a closer look. Hookup Table Component RedBoard Breadboard Breadboard Breadboard Buzzer J1 (Buzzer +) J3 (Buzzer -) Potentiometer B1 B2 B3 Jumper Wire GND GND Rail (-) Jumper Wire Digital Pin 10 F1 Jumper Wire E2 GND Rail (-) Jumper Wire E1 F3 In the table, polarized components are shown with a warning triangle and the whole row highlighted yellow. Open the Sketch To open the code, go to: File > Examples > SIK_Guide_Code-V_4 > SIK_Circuit_2A-Buzzer You can also copy and paste the following code into the Arduino IDE. Hit upload, and see what happens! language:cpp /* SparkFun Inventor's Kit Circuit 2A - Buzzer Play notes using a buzzer connected to pin 10 This sketch was written by SparkFun Electronics, with lots of help from the Arduino community. This code is completely free for any use. View circuit diagram and instructions at: Download drawings and code at: */ int speakerPin = 10; //the pin that buzzer is connected to void setup() { pinMode(speakerPin, OUTPUT); //set the output pin for the speaker } void loop() { play('g', 2); //ha play('g', 1); //ppy play('a', 4); //birth play('g', 4); //day play('C', 4); //to play('b', 4); //you play(' ', 2); //pause for 2 beats play('g', 2); //ha play('g', 1); //ppy play('a', 4); //birth play('g', 4); //day play('D', 4); //to play('C', 4); //you play(' ', 2); //pause for 2 beats play('g', 2); //ha play('g', 1); //ppy play('G', 4); //birth play('E', 4); //day play('C', 4); //dear play('b', 4); //your play('a', 6); //name play(' ', 2); //pause for 2 beats play('F', 2); //ha play('F', 1); //ppy play('E', 4); //birth play('C', 4); //day play('D', 4); //to play('C', 6); //you while (true) {} //get stuck in this loop forever so that the song only plays once } void play(char note, int beats) { int numNotes = 14; // number of notes in our note and frequency array (there are 15 values, but arrays start at 0) //Note: these notes are C major (there are no sharps or flats) //this array is used to look up the notes char notes[] = { 'c', 'd', 'e', 'f', 'g', 'a', 'b', 'C', 'D', 'E', 'F', 'G', 'A', 'B', ' '}; //this array matches frequencies with each letter (e.g. the 4th note is 'f', the 4th frequency is 175) int frequencies[] = {131, 147, 165, 175, 196, 220, 247, 262, 294, 330, 349, 392, 440, 494, 0}; int currentFrequency = 0; //the frequency that we find when we look up a frequency in the arrays int beatLength = 150; //the length of one beat (changing this will speed up or slow down the tempo of the song) //look up the frequency that corresponds to the note for (int i = 0; i < numNotes; i++) // check each value in notes from 0 to 14 { if (notes[i] == note) // does the letter passed to the play function match the letter in the array? { currentFrequency = frequencies[i]; // Yes! Set the current frequency to match that note } } //play the frequency that matched our letter for the number of beats passed to the play function tone(speakerPin, currentFrequency, beats * beatLength); delay(beats * beatLength); //wait for the length of the tone so that it has time to play delay(50); //a little delay between the notes makes the song sound more natural } /* CHART OF FREQUENCIES FOR NOTES IN C MAJOR Note Frequency (Hz) c 131 d 147 e 165 f 175 g 196 a 220 b 247 C 262 D 294 E 330 F 349 G 392 A 440 B 494 */ What You Should See When the program begins, a song will play from the buzzer once. To replay the song, press the reset button on the RedBoard. Use the potentiometer to adjust the volume. Program Overview Inside the main loop: Play the first note for x number of beats using the play function. a. (Inside the play function:) Take the note passed to the play function and compare it to each letter in the notes array. When you find a note that matches, remember the index position of that note (e.g., 6th entry in the notes array). b. Get a frequency from the frequency array that has the same index as the note that matched (e.g., the 6th frequency). c. Play that frequency for the number of beats passed to the play function. Play the second note using the play function ...and so on. Code to Note CodeDescription Character Variables:void play(char note, int beats)The char, or character, variable to store character values. For example, in this sketch, the play() function gets passed two variables, a character variable that represents the mucial note we want to play and an integer variable that represents how long to play that note. A second array takes the character variable and associates a frequency value to it. This makes programming a song easier as you can just reference the character and not the exact frequency. Tone Function:tone(pin, frequency, duration);The tone() function will pulse power to a pin at a specific frequency. The duration controls how long the sound will play. Tone can be used on any digital pin. Declaring an Array:arrray_name[array_size]; or arrray_name[] = {array elements};To declare an array, you must give it a name, then either tell Arduino how many positions the array will have or assign a list of values to the array. Calling an Array:array_name[index #];To call one of the values in an array, simply type the name of the array and the index of the value. You can use a variable instead of a number in between the square brackets. Don't forget the index starts at 0, not 1, so to call the first element, use array_name[0];. Coding Challenges ChallengeDescription Change the tempo of the songExperiment with the beatLength; variable to change the tempo of the song. Make your own songTry changing the notes to make a different song. Spaces " " can be used for rests in the song. Troubleshooting ProblemSolution The song is too quiet or too loudTurn the potentiometer to adjust the volume. No sound is playingTry pressing the reset button on the RedBoard. If that doesn't work, check your wiring of the buzzer. It's easy to misalign a pin with a jumper wire. Learn about digital inputs and buttons as you build your own digital trumpet! Parts Needed Grab the following quantities of each part listed to build this circuit: New Components Buttons Buttons, also known as momentary switches, are switches that only remain in their on state as long as they're being actuated, or pressed. Most often momentary switches are best used for intermittent user-input cases: reset button and keypad buttons. These switches have a nice, tactile, "clicky" feedback when you press them. Note that the different colors are just aesthetic. All of the buttons included behave the same no matter their color. New Concepts Binary Number System Number systems are the methods we use to represent numbers. We've all been mostly operating within the comfy confines of a base-10 number system, but there are many others. The base-2 system, otherwise known as binary, is common when dealing with computers and electronics. There are really only two ways to represent the state of anything: ON or OFF, HIGH or LOW, 1 or 0. And so, almost all electronics rely on a base-2 number system to store and manipulate numbers. The heavy reliance electronics places on binary numbers means it's important to know how the base-2 number system works. Digital Input In circuit 1A, you worked with digital outputs. This circuit focuses on digital inputs. Digital inputs only care if something is in one of two states: TRUE or FALSE, HIGH or LOW, ON or OFF. Digital inputs are great for determining if a button has been pressed or if a switch has been flipped. Pull-up Resistors A pull-up resistor is a small circuit that holds the voltage HIGH (5V) on a pin until a button is pressed, pulling the voltage LOW (0V). The most common place you will see a pull-up resistor is when working with buttons. A pull-up resistor keeps the button in one state until it is pressed. The RedBoard has built-in pull-up resistors, but they can also be added to a circuit externally. This circuit uses the internal pull-up resistors, covered in more detail in the Code to Note section. Hardware Hookup Buttons are not polarized. However, they do merit a closer look. Buttons make momentary contact from one connection to another, so why are there four legs on each button? The answer is to provide more stability and support to the buttons in your breadboard circuit. Each row of legs is connected internally. When the button is pressed, one row connects to the other, making a connection between all four pins. If the button's legs don't line up with the slots on the breadboard, rotate it 90 degrees. Ready to start hooking everything up? Check out the circuit diagram and hookup table below to see how everything is connected. Circuit Diagram Having a hard time seeing the circuit? Click on the image for a closer look. Hookup Table Component RedBoard Breadboard Breadboard Breadboard Buzzer J1 (Buzzer +) J3 (Buzzer -) Potentiometer B1 B2 B3 Jumper Wire GND GND Rail (-) Jumper Wire Digital Pin 10 F1 Jumper Wire E2 GND Rail (-) Jumper Wire E1 F3 Push Button D16/D18 G16/G18 Push Button D22/D24 G22/G24 Push Button D28/D30 G28/G30 Jumper Wire Digital Pin 4 J18 Jumper Wire Digital Pin 3 J24 Jumper Wire Digital Pin 2 J30 Jumper Wire J16 GND Rail (-) Jumper Wire J22 GND Rail (-) Jumper Wire J28 GND Rail (-) In the table, polarized components are shown with a warning triangle and the whole row highlighted yellow. Open the Sketch To open the code, go to: File > Examples > SIK_Guide_Code-V_4 > SIK_Circuit_2B-ButtonTrumpet You can also copy and paste the following code into the Arduino IDE. Hit upload, and see what happens! language:cpp /* SparkFun Inventor's Kit Circuit 2B-ButtonTrumpet Use 3 buttons plugged to play musical notes on a buzzer. This sketch was written by SparkFun Electronics, with lots of help from the Arduino community. This code is completely free for any use. View circuit diagram and instructions at: Download drawings and code at: */ //set the pins for the button and buzzer int firstKeyPin = 2; int secondKeyPin = 3; int thirdKeyPin = 4; int buzzerPin = 10; void setup() { //set the button pins as inputs pinMode(firstKeyPin, INPUT_PULLUP); pinMode(secondKeyPin, INPUT_PULLUP); pinMode(thirdKeyPin, INPUT_PULLUP); //set the buzzer pin as an output pinMode(buzzerPin, OUTPUT); } void loop() { if (digitalRead(firstKeyPin) == LOW) { //if the first key is pressed tone(buzzerPin, 262); //play the frequency for c } else if (digitalRead(secondKeyPin) == LOW) { //if the second key is pressed tone(buzzerPin, 330); //play the frequency for e } else if (digitalRead(thirdKeyPin) == LOW) { //if the third key is pressed tone(buzzerPin, 392); //play the frequency for g } else { noTone(buzzerPin); //if no key is pressed turn the buzzer off } } /* note frequency c 262 Hz d 294 Hz e 330 Hz f 349 Hz g 392 Hz a 440 Hz b 494 Hz C 523 Hz */ What You Should See Different tones will play when you press different keys. Turning the potentiometer will adjust the volume. Program Overview Check to see if the first button is pressed. a. If it is, play the frequency for c. b. If it isn't, skip to the next else if statement. Check to see if the second button is pressed. a. If it is, play the frequency for e. b. If it isn't, skip to the next else if statement. Check to see if the second button is pressed. a. If it is, play the frequency for g. b. If it isn't, skip to the next else if statement. If none of the if statements are true a. Turn the buzzer off. Code to Note CodeDescription Internal Pull-Up Resistor:pinMode(firstKeyPin, INPUT_PULLUP);To declare a standard input, use the line pinMode(pin_name, INPUT). If you would like to use one of the RedBoard's built-in pull-up 20kΩ resistors, it would look like this: pinMode(firstKeyPin, INPUT_PULLUP);. The advantage of external pull-ups is being able to choose a more exact value for the resistor. Digital Input:digitalRead(pin);Check to see if an input pin is reading HIGH (5V) or LOW (0V). Returns TRUE (1) or FALSE (0) depending on the reading. Is Equal to:if(digitalRead(firstKeyPin) == LOW)This is another logical operator. The 'is equal to' symbol (==) can be confusing. Two equals signs are equivalent to asking, "Are these two values equal to one another?" On the other hand, one equals sign in code is assigning a particular variable to a value. Don't forget to add the second equals sign if you are comparing two values. Coding Challenges ChallengeDescription Change the key of each buttonUse the frequency table in the comment section at the end of the code to change the notes that each button plays. Play more than three notes with if statementsBy using combinations of buttons, you can play up to seven notes of the scale. You can do this in a few ways. To get more practice with if statements, try adding seven if statements and using the Boolean AND (&&) operator to represent all of the combinations of keys. Play more than three notes with binary mathYou can use a clever math equation to play more than three notes with your three keys. By multiplying each key by a different number, then adding up all of these numbers, you can make a math equation that produces a different number for each combination of keys. Troubleshooting ProblemSolution The buzzer is too loud or too quietTurn the potentiometer to adjust the volume. The RedBoard thinks one key is always pressedCheck your wiring. You may have ground and 5V backward if one or more buttons behave as though they're pressed all the time. The buttons are not workingFirst, make sure that the wiring is correct. It is easy to misalign a wire with a button leg. Second, make sure that you have declared your buttons as inputs and have enabled the internal pull-up resistors with INPUT_PULLUP. The Simon Says game uses LEDs to flash a pattern, which the player must remember and repeat using four buttons. The classic Simon) game has been a hit since the 1980s. Now you can build your own! Parts Needed Grab the following quantities of each part listed to build this circuit: New Concepts For Loops For loops repeat a section of code a set number of times. The loop works by using a counter (usually programmers use the letter "i" for this variable) that increases each loop until it reaches a stop value. Here's an example of a simple for loop: language:c for (int i = 0; i < 5; i++){ Serial.print(i); } The for loop takes three parameters in the brackets, separated by semicolons. The first parameter is the start value. In this case, integer i starts at 0. The second value is the stop condition. In this case, we stop the loop when i is no longer less than 5 (i < 5 is no longer true). The final parameter is an increment value. i++ is shorthand for increase i by 1 each time, but you could also increase i by different amounts. This loop would repeat five times. Each time it would run the code in between the brackets, which prints the value of i to the serial monitor. Measuring Durations of Time With millis() The RedBoard has a built-in clock that keeps accurate time. You can use the millis() command to see how many milliseconds have passed since the RedBoard was last powered. By storing the time when an event happens and then subtracting the current time, you can measure the number of milliseconds (and thus seconds) that have passed. This sketch uses this function to set a time limit for repeating the pattern. Custom Functions This sketch uses several user-defined functions. These functions perform operations that are needed many times in the program (for example, reading which button is currently pressed or turning all of the LEDs off). Functions are essential to make more complex programs readable and compact. Hardware Hookup Ready to start hooking everything up? Check out the circuit diagram and hookup table below to see how everything is connected. Circuit Diagram Having a hard time seeing the circuit? Click on the image for a closer look. Hookup Table Component RedBoard Breadboard Breadboard Breadboard Buzzer J1 (Buzzer +) J3 (Buzzer -) Potentiometer B1 B2 B3 Jumper Wire GND GND Rail (-) Jumper Wire Digital Pin 10 F1 Jumper Wire E2 GND Rail (-) Jumper Wire E1 F3 Push Button D10/D12 G10/G12 Push Button D16/D18 G16/G18 Push Button D22/D24 G22/G24 Push Button D28/D30 G28/G30 Jumper Wire Digital Pin 8 J12 Jumper Wire Digital Pin 6 J18 Jumper Wire Digital Pin 4 J24 Jumper Wire Digital Pin 2 J30 Jumper Wire J10 GND Rail (-) Jumper Wire J16 GND Rail (-) Jumper Wire J22 GND Rail (-) Jumper Wire J28 GND Rail (-) Blue LED H7 LED (+) H8 LED (-) Green LED H13 LED (+) H14 LED (-) Yellow LED H19 LED (+) H20 LED (-) Red LED H25 LED (+) H26 LED (-) Jumper Wire Digital Pin 9 J7 Jumper Wire Digital Pin 7 J13 Jumper Wire Digital Pin 5 J19 Jumper Wire Digital Pin 3 J25 330Ω Resistor(orange, orange, brown) J8 GND Rail (-) 330Ω Resistor(orange, orange, brown) J14 GND Rail (-) 330Ω Resistor(orange, orange, brown) j20 GND Rail (-) 330Ω Resistor(orange, orange, brown) J26 GND Rail (-) In the table, polarized components are shown with a warning triangle and the whole row highlighted yellow. Open the Sketch To open the code, go to: File > Examples > SIK_Guide_Code-V_4 > SIK_Circuit_2C-SimonSays You can also copy and paste the following code into the Arduino IDE. Hit upload, and see what happens! language:cpp /* SparkFun Inventor's Kit Circuit 2C-Simon Says The Simon Says game flashes a pattern using LED lights, then the player must repeat the pattern. This sketch was written by SparkFun Electronics, with lots of help from the Arduino community. This code is completely free for any use. View circuit diagram and instructions at: Download drawings and code at: */ //set the pins where the buttons, LEDs and buzzer connect int button[] = {2, 4, 6, 8}; //red is button[0], yellow is button[1], green is button[2], blue is button[3] int led[] = {3, 5, 7, 9}; //red is led[0], yellow is led[1], green is led[2], blue is led[3] int tones[] = {262, 330, 392, 494}; //tones to play with each button (c, e, g, b) int roundsToWin = 10; //number of rounds the player has to play before they win the game (the array can only hold up to 16 rounds) int buttonSequence[16]; //make an array of numbers that will be the sequence that the player needs to remember int buzzerPin = 10; //pin that the buzzer is connected to int pressedButton = 4; //a variable to remember which button is being pressed. 4 is the value if no button is being pressed. int roundCounter = 1; //keeps track of what round the player is on long startTime = 0; //timer variable for time limit on button press long timeLimit = 2000; //time limit to hit a button boolean gameStarted = false; //variable to tell the game whether or not to play the start sequence void setup() { //set all of the button pins to input_pullup (use the built-in pull-up resistors) pinMode(button[0], INPUT_PULLUP); pinMode(button[1], INPUT_PULLUP); pinMode(button[2], INPUT_PULLUP); pinMode(button[3], INPUT_PULLUP); //set all of the LED pins to output pinMode(led[0], OUTPUT); pinMode(led[1], OUTPUT); pinMode(led[2], OUTPUT); pinMode(led[3], OUTPUT); pinMode(buzzerPin, OUTPUT); //set the buzzer pin to output } void loop() { if (gameStarted == false) { //if the game hasn't started yet startSequence(); //flash the start sequence roundCounter = 0; //reset the round counter delay(1500); //wait a second and a half gameStarted = true; //set gameStarted to true so that this sequence doesn't start again } //each round, start by flashing out the sequence to be repeated for (int i = 0; i Examples > SIK_Guide_Code-V_4 > SIK_Circuit_3B-DistanceSensor You can also copy and paste the following code into the Arduino IDE. Hit upload, and see what happens! language:cpp /* SparkFun Inventor's Kit Circuit 3B-Distance Sensor Control the color of an RGB LED using an ultrasonic distance sensor. This sketch was written by SparkFun Electronics, with lots of help from the Arduino community. This code is completely free for any use. View circuit diagram and instructions at: Download drawings and code at: */ const int trigPin = 11; //connects to the trigger pin on the distance sensor const int echoPin = 12; //connects to the echo pin on the distance sensor const int redPin = 3; //pin to control the red LED inside the RGB LED const int greenPin = 5; //pin to control the green LED inside the RGB LED const int bluePin = 6; //pin to control the blue LED inside the RGB LED float distance = 0; //stores the distance measured by the distance sensor void setup() { Serial.begin (9600); //set up a serial connection with the computer pinMode(trigPin, OUTPUT); //the trigger pin will output pulses of electricity pinMode(echoPin, INPUT); //the echo pin will measure the duration of pulses coming back from the distance sensor //set the RGB LED pins to output pinMode(redPin, OUTPUT); pinMode(greenPin, OUTPUT); pinMode(bluePin, OUTPUT); } void loop() { distance = getDistance(); //variable to store the distance measured by the sensor Serial.print(distance); //print the distance that was measured Serial.println(" in"); //print units after the distance if (distance Examples > SIK_Guide_Code-V_4 > SIK_Circuit_4A-LCDHelloWorld You can also copy and paste the following code into the Arduino IDE. Hit upload, and see what happens! language:cpp /* SparkFun Inventor's Kit Circuit 4A-HelloWorld The LCD will display the words "Hello World" and show how many seconds have passed since the RedBoard was last reset. This sketch was written by SparkFun Electronics, with lots of help from the Arduino community. This code is completely free for any use. View circuit diagram and instructions at: Download drawings and code at: */ #include //the liquid crystal library contains commands for printing to the display LiquidCrystal lcd(13, 12, 11, 10, 9, 8); // tell the RedBoard what pins are connected to the display void setup() { lcd.begin(16, 2); //tell the lcd library that we are using a display that is 16 characters wide and 2 characters high lcd.clear(); //clear the display } void loop() { lcd.setCursor(0, 0); //set the cursor to the 0,0 position (top left corner) lcd.print("Hello, world!"); //print hello, world! starting at that position lcd.setCursor(0, 1); //move the cursor to the first space of the bottom row lcd.print(millis() / 1000); //print the number of seconds that have passed since the last reset } What You Should See The LCD screen will show "Hello, world!" On the row below, a counter will count every second that passes. Contrast Adjust If you are not seeing any characters, are seeing barely visible characters, or see just white rectangles, then you need to adjust the contrast. Twist the potentiometer very slowly until you can clearly read the display. If you reach the end of the potentiometer's rotation, try twisting in the opposite direction. A display that needs the contrast adjusted. Note the white rectangles. Program Overview Import the LCD library. Make an LCD object called "lcd" that will be controlled using pins 8, 9, 10, 11, 12 and 13. "Begin" the LCD. This sets the dimensions of the LCD that you are working with (16 x 2). It needs to be called before any other commands from the LCD library are used. Clear the display. Set the cursor to the top left corner lcd.setCursor(0,0);, then print "Hello, world!" Move the cursor to the first space of the lower line lcd.setCursor(0,1);, then print the number of seconds that have passed since the RedBoard was last reset. Code to Note CodeDescription LCD Library:#include Includes the liquid crystal library into your program. LCD Library Instance:LiquidCrystal LCD_name(RS_pin, enable_pin, d4, d5, d6, d7);As with servos, you need to create an LCD object and give it a name (you can make more than one). The numbers in the brackets are pins on the RedBoard that connect to specific pins on the LCD. LCD Begin:lcd.begin(16, 2);This line initializes the LCD object and tells the program the LCD's dimensions. In this case it is 16 characters by 2 characters. LCD Clear:lcd.clear();This method clears the pixels on the display. LCD Cursor:lcd.setCursor(0,0);Move the cursor to a point on the 16x2 grid of characters. Text that you write to the LCD will start from the cursor. This line is starting back at position (0,0). LCD Print :lcd.print("Hello, world!");Prints a string of characters to the LCD starting at the cursor position. Coding Challenges ChallengeDescription Change the messageTry changing the code to display another message. Show hours, minutes and secondsTry adding some code so that the display shows the hours, minutes and seconds that have passed since the RedBoard was last reset. Count button pressesBy adding a button to the circuit, you can count the number of times the button was pressed or have the button change what the LCD is displaying. There could be many pages of information. Troubleshooting ProblemSolution The screen is blank or flickeringAdjust the contrast by twisting the potentiometer. If it's incorrectly adjusted, you won't be able to read the text. Also, check the potentiometer, and make sure it's connected correctly. Not working at allDouble check the circuit's wiring. There are a lot of wires in this circuit, and it's easy to mix up one or two. Rectangles in first rowIf you see 16 rectangles (like "█") on the first row, it may be due to the jumper wires being loose on the breadboard. This is normal and can happen with other LCDs wired in parallel with a microcontroller. Make sure that the wires are fully inserted into the breadboard, then try pressing the reset button and adjusting the contrast using the potentiometer. Still not working?Jumper wires unfortunately can go "bad" from getting bent too much. The copper wire inside can break, leaving an open connection in your circuit. If you are certain that your circuit is wired correctly and that your code is error-free and uploaded but you are still encountering issues, try replacing one or more of the jumper wires for the component that is not working. Want to create a DIY environmental monitor or weather station? You can use a small, low-cost sensor like the TMP36 to make devices that track and respond to temperature. In this activity you will also use the LCD screen to display sensor readings, a common use for LCDs in electronics projects. Parts Needed Grab the following quantities of each part listed to build this circuit: New Components TMP36 Temperature Sensor This temperature sensor has three legs. One connects to 5V, one to ground, and the voltage output from the third leg varies proportionally to changes in temperature. By doing some simple math with this voltage we can measure temperature in degrees Celsius or Fahrenheit. New Concepts Algorithms An algorithm is a process used in order to achieve a desired result. Often, the information needed to create an algorithm lives in the part's datasheet. This sketch uses a few formulas to turn a voltage value into a temperature value, making them all part of the larger temperature-retrieving algorithm. The first formula takes the voltage read on analog pin 0 and multiplies it to get a voltage value from 0V--5V: language:c voltage = analogRead(A0) * 0.004882813; The number we are multiplying by comes from dividing 5V by the number of samples the analog pin can read (1024), so we get: 5 / 1024 = 0.004882813. The second formula takes that 0--5V value and calculates degrees Centigrade: language:c degreesC = (voltage - 0.5) * 100.0; The reason 0.5V is subtracted from the calculated voltage is because there is a 0.5V offset, mentioned on page 8 of the TMP36 datasheet. It's then multiplied by 100 to get a value that matches temperature. The last formula takes the Centigrade temperature and converts it to a Fahrenheit temperature using the standard conversion formula: language:c degreesF = degreesC * (9.0/5.0) + 32.0; Together, these three formulas make up the algorithm that converts voltage to degrees Fahrenheit. Hardware Hookup Polarized Components Pay special attention to the component's markings indicating how to place it on the breadboard. Polarized components can only be connected to a circuit in one direction. The temperature sensor is polarized and can only be inserted in one direction. See below for the pin outs of the temperature sensor. Pay very close attention to the markings on each side as you insert it into your circuit. Heads up! Double check the polarity of the TMP36 temperature sensor before powering the RedBoard. It can become very hot if it is inserted backward! Ready to start hooking everything up? Check out the circuit diagram and hookup table below to see how everything is connected. Circuit Diagram Having a hard time seeing the circuit? Click on the image for a closer look. Hookup Table Component RedBoard Breadboard Breadboard Breadboard Jumper Wire 5V 5V Rail (+) Jumper Wire GND GND Rail (-) LCD A15-A30 (Pin 1 on A15) Jumper Wire E30 GND Rail (-) Jumper Wire E29 5V Rail (+) Jumper Wire Digital Pin 8 E28 Jumper Wire Digital Pin 9 E27 Jumper Wire Digital Pin 10 E26 Jumper Wire Digital Pin 11 E25 Jumper Wire Digital Pin 12 E20 Jumper Wire Digital Pin 13 E18 Jumper Wire E16 5V Rail (+) Jumper Wire E15 GND Rail (-) Potentiometer A8 A9 A10 Jumper Wire E9 E17 Jumper Wire E8 GND Rail (-) Jumper Wire E10 5V Rail (+) TMP36 Temperature Sensor A1 (GND) A2 (Signal) A3 (V+) Jumper Wire E1 GND Rail (-) Jumper Wire Analog Pin 0 (A0) E2 Jumper Wire E3 5V Rail (+) In the table, polarized components are shown with a warning triangle and the whole row highlighted yellow. Open the Sketch To open the code, go to: File > Examples > SIK_Guide_Code-V_4 > SIK_Circuit_4B-TemperatureSensor You can also copy and paste the following code into the Arduino IDE. Hit upload, and see what happens! language:cpp /* SparkFun Inventor's Kit Circuit 4B - Temperature Sensor The LCD will display readings from a temperature sensor in degrees Celsius and Fahrenheit. This sketch was written by SparkFun Electronics, with lots of help from the Arduino community. This code is completely free for any use. View circuit diagram and instructions at: Download drawings and code at: */ #include //the liquid crystal library contains commands for printing to the display LiquidCrystal lcd(13, 12, 11, 10, 9, 8); // tell the RedBoard what pins

are connected to the display float voltage = 0; //the voltage measured from the TMP36 float degreesC = 0; //the temperature in Celsius, calculated from the voltage float degreesF = 0; //the temperature in Fahrenheit, calculated from the voltage void setup() { lcd.begin(16, 2); //tell the lcd library that we are using a display that is 16 characters wide and 2 characters high lcd.clear(); //clear the display } void loop() { voltage = analogRead(A0) * 0.004882813; //convert the analog reading, which varies from 0 to 1023, back to a voltage value from 0-5 volts degreesC = (voltage - 0.5) * 100.0; //convert the voltage to a temperature in degrees Celsius degreesF = degreesC * (9.0 / 5.0) + 32.0; //convert the voltage to a temperature in degrees Fahrenheit lcd.clear(); //clear the LCD lcd.setCursor(0, 0); //set the cursor to the top left position lcd.print("Degrees C: "); //print a label for the data lcd.print(degreesC); //print the degrees Celsius lcd.setCursor(0, 1); //set the cursor to the lower left position lcd.print("Degrees F: "); //Print a label for the data lcd.print(degreesF); //print the degrees Fahrenheit delay(1000); //delay for 1 second between each reading (this makes the display less noisy) } What You Should See The LCD will show the temperature in Celsius and Fahrenheit. The temperature readings will update every second. An easy way to see the temperature change is to press your finger to the sensor. Program Overview Get the analog value from the TMP36 and convert it back to a voltage between 0 and 5V. Calculate the degrees Celsius from this voltage. Calculate the degrees Fahrenheit from this voltage. Clear the LCD. Print the Degrees C with a label on the first row. Print the Degrees F with a label on the second row. Wait for a second before taking the next reading. Code to Note CodeDescription Voltage Conversion Algorithms Many of the sensors that you will use with your microcontroller work by changing a voltage in some predictable way in response to a property of the world (like temperature, light or magnetic fields). Often, you will need to build an algorithm that converts these voltages to the desired value and units. The temperature sensor is a great example of this code. We use three equations to convert a voltage value into degrees in C and F. voltage = analogRead(A0) * 0.004882813; degreesC = (voltage - 0.5) * 100.0; degreesF = degreesC * (9.0/5.0) + 32.0; Coding Challenges ChallengeDescription Display the temperature in degrees KelvinTry adding an equation so that the temperature is displayed in degrees Kelvin (you will have to look up the formula for converting from degrees Celsius or Fahrenheit to Kelvin) Display a bar graphBy changing the code you can display the temperature as a bar graph instead of a number. Display values from another sensorYou can swap out the TMP36 for a potentiometer, photoresistor or other sensor and display the new set of values. Add an RGB LEDAdd an RGB LED that changes color based on the temperature. Troubleshooting ProblemSolution Sensor is warm or hot to the touchMake sure that you wired the temperature sensor correctly. The temperature sensor can get warm to the touch if it is wired incorrectly. Disconnect your microcontroller, rewire the circuit, and connect it back to your computer. Temperature value is unchangingTry pinching the sensor with your fingers to heat it up or pressing a bag of ice against it to cool it down. Also, make sure that the wires are connected properly to the temperature sensor. Values not printing to screenIf you see text but no temperature values, there could be an error in your code. If you see no text at all, adjust the LCD contrast. "DIY Who Am I?" is based on the popular Hedbanz game or HeadsUp! app. It's a fun party game in which a player holds an LCD screen to his/her forehead so that the player can't see the word(s) that appear on the screen. Other players have to give hints, act out charades or make noises that will make the player with the LCD guess the word(s). Parts Needed Grab the following quantities of each part listed to build this circuit: New Components 4xAA Battery Holder Included in your kit is a 4-cell AA battery holder. The 5-inch cable is terminated with a standard barrel jack connector. The connector mates with the barrel jack on the RedBoard, allowing you to easily make your project battery powered. New Concepts Button Debounce When working with momentary buttons, it is usually necessary to add button debouncing to your code. This is because the code that is meant to execute when the button is pressed may execute faster than you can press and release the button (microcontrollers are fast!). The simplest way to debounce a button is to add a small delay to the end of your code. This sketch adds a 500 millisecond delay at the end of loop() to account for this. This simple addition will prevent a word from getting skipped when you press the button for the game. For a more complex example of button debouncing, in the Arduino IDE click File > Examples > 02.Digital > Debounce. Strings Strings are used to print words and even sentences to an LCD or the Serial Monitor. Strings are actually just an array of characters with a null character at the end to let the program know where the end of the string is. Arrays of Strings In circuit 2A you used an array of characters to represent musical notes. In this program, you'll want to make an array of strings. Strings use multiple characters to make words, so you'll need to use a little trick to put them in an array. The trick is to use a pointer. When you declare your array, you'll use an asterisk after the char data type, as follows: language:c const char* arrayOfStrings = {"Feynman" "Sagan", "Tyson", "Nye"}; Pointers Pointers are an advanced programming topic. They can be difficult to understand the first time you're introduced to them. For now, think of pointers as a variable that "points" to the value contained in a certain address in memory. In this sketch, the char* variable points to arrayOfStrings address and returns the character values to create a list of strings. Hardware Hookup Polarized Components Pay special attention to the component's markings indicating how to place it on the breadboard. Polarized components can only be connected to a circuit in one direction. Batteries are polarized. They have a positive end and a negative end. The battery holder has images indicating which end goes in which orientation for each cell. Ensure all the batteries are inserted correctly before plugging the battery holder into the RedBoard. Battery Holder Attachment To attach the battery holder to the breadboard baseplate, first cut two strips of Dual Lock that are roughly 1 inch x 1 inch each, or 2.5cm x 2.5cm. Remove the adhesive backing and attach one piece to the back of the battery holder. Adhere the second piece to the bottom of the breadboard baseplate (directly in the middle is recommended, as this will come into play in Project 5). Last, press the battery holder to the baseplate so that the two pieces of Dual Lock snap together. Insert the batteries into the holder if you have not done so already. Remember that batteries are polarized and can only go in one way. Remove the battery pack while building your circuit. Ready to start hooking everything up? Check out the circuit diagram and hookup table below to see how everything is connected. Circuit Diagram Having a hard time seeing the circuit? Click on the image for a closer look. Hookup Table Component RedBoard Breadboard Breadboard Breadboard Jumper Wire 5V 5V Rail (+) Jumper Wire GND GND Rail (-) LCD A15-A30 (Pin 1 on A15) Jumper Wire E30 GND Rail (-) Jumper Wire E29 5V Rail (+) Jumper Wire Digital Pin 8 E28 Jumper Wire Digital Pin 9 E27 Jumper Wire Digital Pin 10 E26 Jumper Wire Digital Pin 11 E25 Jumper Wire Digital Pin 12 E20 Jumper Wire E19 GND Rail (-) Jumper Wire Digital Pin 13 E18 Jumper Wire E16 5V Rail (+) Jumper Wire E15 GND Rail (-) Potentiometer A8 A9 A10 Jumper Wire E9 E17 Jumper Wire E8 GND Rail (-) Jumper Wire E10 5V Rail (+) Buzzer G6 (Buzzer +) G8 (Buzzer -) Jumper Wire Digital Pin 6 J6 Jumper Wire J8 GND Rail (-) Push Button D1/D3 G1/G3 Jumper Wire Digital Pin 2 J1 Jumper Wire J3 GND Rail (-) In the table, polarized components are shown with a warning triangle and the whole row highlighted yellow. Open the Sketch To open the code, go to: File > Examples > SIK_Guide_Code-V_4 > SIK_Circuit_4C-DIYWhoAmI You can also copy and paste the following code into the Arduino IDE. Hit upload, and see what happens! language:cpp /* SparkFun Inventor's Kit Circuit 4C - Heads Up Game This is a DIY version of the popular Heads Up party game. To play, one person resets the RedBoard and holds the LCD facing away from them so that they cannot see it (usually on their forehead). The display will show a short countdown then display random words. The other player(s) who can see the screen must yell out clues until time runs out or the player guesses what word is on the screen. If they guess correctly, they can press the button on the breadboard and another word will be displayed. This sketch was written by SparkFun Electronics, with lots of help from the Arduino community. This code is completely free for any use. View circuit diagram and instructions at: Download drawings and code at: */ #include //the liquid crystal library contains commands for printing to the display LiquidCrystal lcd(13, 12, 11, 10, 9, 8); // tell the RedBoard what pins are connected to the display int buttonPin = 2; //pin that the button is connected to int buzzerPin = 6; //pin for driving the buzzer int buttonPressTime = 0; //variable to show how much time the player has left to guess the word (and press the button) long timeLimit = 15000; //time limit for the player to guess each word long startTime = 0; //used to measure time that has passed for each word int roundNumber = 0; //keeps track of the roundNumber so that it can be displayed at the end of the game const int arraySize = 25; const char* words[arraySize] = {"moose", "beaver", "bear", "goose", "dog", "cat", "squirrel", "bird", "elephant", "horse", "bull", "giraffe", "seal", "bat", "skunk", "turtle", "whale", "rhino", "lion", "monkey", "frog", "alligator", "kangaroo", "hippo", "rabbit" }; // the start value in the sequence array must have a value that could never be an index of an array // or at least a value outside the range of 0 to the size of the words array - 1; in this case, it can't be between 0 to 24 int sequence[] = { -1, -1, -1, -1, -1, -1, -1, -1, -1, -1, -1, -1, -1, -1, -1, -1, -1, -1, -1, -1, -1, -1, -1, -1, -1, -1, -1, -1, -1}; //start with an array full of -1's void setup() { pinMode(buttonPin, INPUT_PULLUP); //set the button pin as an input lcd.begin(16, 2); //tell the LCD library the size of the screen generateRandomOrder(); //generate an array of random numbers from 0 to 24 that will determine which order the words are shown in showStartSequence(); //print the start sequence text } void loop() { for (int i = 0; i < arraySize; i++) { //for each of the 25 words in the sequence lcd.clear(); //clear off the array roundNumber = i + 1; //the array starts at 0, but the roundNumber will start counting from 1 lcd.print(roundNumber); //print the roundNumber (this is the current round number) lcd.print(": "); //spacer between the number and the word lcd.print(words[sequence[i]]); //print a random word from the word array startTime = millis(); //record the time that this round started while (digitalRead(buttonPin) == HIGH) { //do this until the button is pressed... int roundedTime = round((timeLimit - (millis() - startTime)) / 1000); //calculate the time left in the round (dividing by 1000 converts the number to seconds lcd.setCursor(14, 1); //set the cursor in the lower right corner of the screen lcd.print(" "); lcd.setCursor(14, 1); //set the cursor in the lower right corner of the screen lcd.print(roundedTime); //print the time left in the time limit delay(15); if (millis() - startTime > timeLimit) { //if the time limit is up before the button is pressed gameOver(); //end the game } if (digitalRead(buttonPin) == LOW) { tone(buzzerPin, 272, 10); //emit a short beep when the button is pressed } } //exit this loop when the button is pressed delay(500); //delay for a moment before going onto the next round, so that the button press doesn't get registered twice } //if you finish all 25 words winner(); //show the you win message } //----------FUNCTIONS---------- //DISPLAYS A COUNTDOWN TO START THE GAME void showStartSequence() { lcd.clear(); //clear the screen lcd.setCursor(0, 0); //move the cursor to the top left corner lcd.print("Category:"); //print "Category:" lcd.setCursor(0, 1); //move the cursor to the bottom left corner lcd.print("Animals"); //print "Animals:" delay(2000); //Wait 2 seconds lcd.clear(); //clear the screen lcd.print("Get ready!"); //print "Get ready!" delay(1000); //wait 1 second lcd.clear(); //clear the screen lcd.print("3"); //print "3" delay(1000); //wait 1 second lcd.clear(); //clear the screen lcd.print("2"); //print "3" delay(1000); //wait 1 second lcd.clear(); //clear the screen lcd.print("1"); //print "3" delay(1000); //wait 1 second } //GENERATES A RANDOM ORDER FOR THE WORDS TO BE DISPLAYED void generateRandomOrder() { randomSeed(analogRead(0)); //reset the random seed (Arduino needs this to generate truly random numbers for (int i = 0; i < arraySize; i++) { //do this until all 25 positions are filled int currentNumber = 0; //variable to hold the current number boolean match = false; //does the currentNumber match any of the previous numbers? //generate random numbers until you've generated one that doesn't match any of the other numbers in the array do { currentNumber = random(0, arraySize); //generate a random number from 0 to 24 match = false; //we haven't checked for matches yet, so start by assuming that it doesn't match for (int i = 0; i < arraySize; i++) { //for all 25 numbers in the array if (currentNumber == sequence[i]) { //does the currentNumber match any of the numbers? match = true; //if so, set the match variable to true } } } while (match == true); //if the match variable is true, generate another random number and try again sequence[i] = currentNumber; //if the match variable is false (the new number is unique) then add it to the sequence } } //GAME OVER void gameOver() { lcd.clear(); //clear the screen lcd.setCursor(0, 0); //move the cursor the top left corner lcd.print("Game Over"); //print "Game Over" lcd.setCursor(0, 1); //move to the bottom row lcd.print("Score: "); //print a label for the score lcd.print(roundNumber); //print the score (the round number is the same as the score) //play the losing fog horn tone(buzzerPin, 130, 250); //E6 delay(275); tone(buzzerPin, 73, 250); //G6 delay(275); tone(buzzerPin, 65, 150); //E7 delay(175); tone(buzzerPin, 98, 500); //C7 delay(500); while (true) {} //get stuck in this loop forever } //WINNER void winner() { lcd.clear(); //clear the screen lcd.setCursor(7, 0); //move the cursor to the top center of the screen lcd.print("YOU"); //print "You" lcd.setCursor(7, 1); //move the cursor to the bottom center of the screen lcd.print("WIN!"); //print "WIN!" //play the 1Up noise tone(buzzerPin, 1318, 150); //E6 delay(175); tone(buzzerPin, 1567, 150); //G6 delay(175); tone(buzzerPin, 2637, 150); //E7 delay(175); tone(buzzerPin, 2093, 150); //C7 delay(175); tone(buzzerPin, 2349, 150); //D7 delay(175); tone(buzzerPin, 3135, 500); //G7 delay(500); while (true) {} //get stuck in this loop forever } What You Should See The game will begin with a prompt telling you the category of words. Then it will run through a short countdown. When the first round starts, the word to be guessed will be displayed in the top left, and a countdown will be displayed in the bottom right of the LCD screen. Each time the button is pressed (before the timer expires) a new word will be displayed. If you win or lose, a short song will play and text will be displayed. Program Overview Generate a random order for the words to be displayed. Show the starting countdown on the LCD. Start a loop that will run 25 times (there are 25 words total). For each round: a. Print the round number and the word to be guessed. b. Display a countdown timer in the lower right-hand corner of the screen that counts down the time limit for each round. c. If the time limit runs out, play the losing song, print "Game Over" and show the player's final score. d. If the player presses the button before the time limit is up, advance to the next word. If the player gets through all 25 words, play the winning song and print "YOU WIN!" Code to Note CodeDescription Array of Strings:const char* array_name [array_length] = {"string1", "string2"...}Makes an array of strings. The strings are stored as constants, so they can't be changed once the program starts. Rounding function:round(value_to_round);This math function rounds a number up or down to the nearest whole number. Random Function:random(min, max);The random function takes a set of numbers and generates a pseudo-random number from that set. Button Debounce:delay(500);This 500 millisecond delay at the end of the loop adds button debounce so that erroneous button presses are not detected by the RedBoard. User Functions Description generateRandomOrder();Makes an array that is a random ordering of the numbers from 1-25. This is used to display words for the game in a random order. showStartSequence();Shows the category of words on the LCD, then displays a countdown before the game starts. gameOver();Plays a sound and shows the text "Game Over" along with the player's final score. winner();Shows the text "YOU WIN!" and plays a winning sound. Coding Challenges ChallengeDescription Change the time limitChanging the time limit variable will change the difficulty of the game. Change the words in the word listTry changing the categories and words. The number of words in your words array must match the value of the variable "arraySize". Change the winning and losing songsBy changing the tones in the winner() and gameover() functions you can change which song plays at the end of the game. Troubleshooting ProblemSolution The screen is blank or flickeringAdjust the contrast by twisting the potentiometer. If it's incorrectly adjusted, you won't be able to read the text. Also, check the potentiometer to make sure it's connected correctly. No sound is coming from the buzzerCheck the wiring from the buzzer. Make sure you are using the correct pin as defined in your code. You may add a potentiometer volume knob if you desire. The button doesn't work or words are getting skipped before they are guessedIf the button isn't working, check your wiring. If words are being skipped when the button is pressed, increase the debounce delay found at the end of the loop. It should be 500 milliseconds by default. Increasing this number by tiny increments will help with this problem. Ah, robots. One of the most iconic and exciting electronics applications. In this project you will learn all about DC motors and motor drivers by building your own robot! You'll learn how to control a tethered robot first by sending it commands over serial. Then you will unleash your robot by removing the tether and making it autonomous. New Components Introduced in This Project Each of the components listed below will be described in more detail as you progress through each circuit. TB6612FNG Motor Driver Switch DC Gearmotor Wheel New Concepts Introduced in This Project Each of the concepts listed below will be described in more detail as you progress through each circuit. Input Voltage Integrated Circuits H-Bridge Motor Driver ASCII Characters Converting Strings Autonomous Vehicles You Will Learn How to control two motors using a motor driver How to send serial commands to create a remote-controlled robot How to build a robot that uses sensors to react to its environment In this circuit you will learn the basic concepts behind motor control. Motors require a lot of current, so you can't drive them directly from a digital pin on the RedBoard. Instead, you'll use what is known as a motor controller or motor driver board to power and spin the motor accordingly. Parts Needed Grab the following quantities of each part listed to build this circuit: Additional Materials New Components Switch A switch is a component that controls the open-ness or closed-ness of an electric circuit. Just like the momentary buttons used in earlier circuits, a switch can only exist in one of two states: open or closed. However, a switch is different in that it will stay in the position it was last in until it is switched again. DC Gearmotors The motors in your Inventor's Kit have two main parts: a small DC motor that spins quickly and a plastic gearbox that gears down that output from the hobby motor so that it is slower but stronger, allowing it to move your robot. The motors have a clever design so that you can attach things that you want to spin fast (like a small fan or flag) to the hobby motor, and things that you want to be strong (like a wheel) to the plastic axle sticking out the side of the motor. The included wheels just so happen to fit on the plastic axles. Inside the hobby motor are coils of wire that generate magnetic fields when electricity flows through them. When power is supplied to these electromagnets, they spin the drive shaft of the motor. TB6612FNG Motor Driver If you switch the direction of current through a motor by swapping the positive and negative leads, the motor will spin in the opposite direction. Motor controllers contain a set of switches (called an H-bridge) that let you easily control the direction of one or more motors. The TB6612FNG Motor Driver takes commands for each motor over three wires (two wires control direction, and one controls speed), then uses these signals to control the current through two wires attached to your motor. New Concepts Voltage In (VIN) This circuit utilizes the VIN pin found with the other power pins. The VIN pin outputs a voltage that varies based on whatever voltage the RedBoard is powered with. If the RedBoard is powered through the USB port, then the voltage on VIN will be about 4.6--5V. However, if you power the RedBoard through the barrel jack (highlighted in the picture below), the VIN pin will reflect that voltage. For example, if you were to power the barrel jack with 9V, the voltage out on VIN would also be 9V. Integrated Circuits (ICs) and Breakout Boards An Integrated Circuit (IC) is a collection of electronic components --- resistors, transistors, capacitors, etc. --- all stuffed into a tiny chip and connected together to achieve a common goal. They come in all sorts of flavors, shapes and sizes. The chip that powers the RedBoard, the ATMega328, is an IC. The chip on the motor driver, the TB6612FNG, is another IC, one designed to control motors, referred to as an H-bridge. The guts of an integrated circuit, visible after removing the top. Integrated circuits are often too small to work with by hand. To make working with ICs easier and to make them breadboard-compatible, they are often added to a breakout board, which is a printed circuit board that connects all the IC's tiny legs to larger ones that fit in a breadboard. The motor driver board in your kit is an example of a breakout board. Hardware Hookup Polarized Components Pay special attention to the component's markings indicating how to place it on the breadboard. Polarized components can only be connected to a circuit in one direction. Most ICs have polarity and usually have a polarity marking in one of the corners. The motor driver is no exception. Be sure to insert the motor driver as indicated in the circuit diagrams. The motor driver pins are shown in the image below. Each pin and its function is covered in the table below. Pin LabelFunctionPower/Input/OutputNotes VMMotor VoltagePowerThis is where you provide power for the motors (2.2V to 13.5V) VCCLogic VoltagePowerThis is the voltage to power the chip and talk to the microcontroller (2.7V to 5.5V) GNDGroundPowerCommon Ground for both motor voltage and logic voltage (all GND pins are connected) STBYStandbyInputAllows the H-bridges to work when high (has a pulldown resistor so it must actively be pulled high) AIN1/BIN1Input 1 for channels A/BInputOne of the two inputs that determines the direction AIN2/BIN2Input 2 for channels A/BInputOne of the two inputs that determines the direction PWMA/PWMBPWM input for channels A/BInputPWM input that controls the speed A01/B01Output 1 for channels A/BOutputOne of the two outputs to connect the motor A02/B02Output 2 for channels A/BOutputOne of the two outputs to connect the motor When you're finished with Project 5, removing the motor driver from the breadboard can be difficult due to its numerous legs. To make this easier, use the included screwdriver as a lever to gently pry it out. Be careful not to bend the legs as you remove it. The motors are also polarized. However, motors are unique in that they will still work when the two connections are reversed. They will just spin in the opposite direction when hooked up backward. To keep things simple, always think of the red wire as positive (+) and the black wire as negative (-). Last, the switch is not polarized. It works the same no matter its orientation. Ready to start hooking everything up? Check out the circuit diagram and hookup table below to see how everything is connected. Circuit Diagram Having a hard time seeing the circuit? Click on the image for a closer look. Hookup Table Component RedBoard Breadboard Breadboard Breadboard Jumper Wire 5V 5V Rail (+) Jumper Wire GND GND Rail (-) Jumper Wire 5V Rail (+) 5V Rail (+) Jumper Wire GND Rail (-) GND Rail (-) Jumper Wire VIN A1 Motor Driver C1-C8 (VM on C1) G1-G8 (PWMA on G1) Jumper Wire A2 5V Rail (+) Jumper Wire A3 GND Rail (-) Jumper Wire Digital Pin 8 J5 Jumper Wire Digital Pin 9 J6 Jumper Wire Digital Pin 10 J7 Jumper Wire J4 5V Rail (+) Jumper Wire Digital Pin 11 J1 Jumper Wire Digital Pin 12 J2 Jumper Wire Digital Pin 13 J3 Motor A4 (Red +) A5 (Black -) Switch F25 F26 F27 Jumper Wire I26 GND Rail (-) Jumper Wire Digital Pin 7 I27 In the table, polarized components are shown with a warning triangle and the whole row highlighted yellow. Open the Sketch To open the code, go to: File > Examples > SIK_Guide_Code-V_4 > SIK_Circuit_5A-MotorBasics. You can also copy and paste the following code into the Arduino IDE. Hit upload, and see what happens! language:cpp /* SparkFun Inventor's Kit Circuit 5A - Motor Basics Learn how to control one motor with the motor driver. This sketch was written by SparkFun Electronics, with lots of help from the Arduino community. This code is completely free for any use. View circuit diagram and instructions at: Download drawings and code at: */ //PIN VARIABLES //the motor will be controlled by the motor A pins on the motor driver const int AIN1 = 13; //control pin 1 on the motor driver for the right motor const int AIN2 = 12; //control pin 2 on the motor driver for the right motor const int PWMA = 11; //speed control pin on the motor driver for the right motor int switchPin = 7; //switch to turn the robot on and off //VARIABLES int motorSpeed = 0; //starting speed for the motor void setup() { pinMode(switchPin, INPUT_PULLUP); //set this as a pullup to sense whether the switch is flipped //set the motor control pins as outputs pinMode(AIN1, OUTPUT); pinMode(AIN2, OUTPUT); pinMode(PWMA, OUTPUT); Serial.begin(9600); //begin serial communication with the computer Serial.println("Enter motor speed (0-255)... "); //Prompt to get input in the serial monitor. } void loop() { if (Serial.available() > 0) { //if the user has entered something in the serial monitor motorSpeed = Serial.parseInt(); //set the motor speed equal to the number in the serial message Serial.print("Motor Speed: "); //print the speed that the motor is set to run at Serial.println(motorSpeed); } if (digitalRead(7) == LOW) { //if the switch is on... spinMotor(motorSpeed); } else { //if the switch is off... spinMotor(0); //turn the motor off } } /********** void spinMotor(int motorSpeed) //function for driving the right motor { if (motorSpeed > 0) //if the motor should drive forward (positive speed) { digitalWrite(AIN1, HIGH); //set pin 1 to high digitalWrite(AIN2, LOW); //set pin 2 to low } else if (motorSpeed < 0) //if the motor should drive backward (negative speed) { digitalWrite(AIN1, LOW); //set pin 1 to low digitalWrite(AIN2, HIGH); //set pin 2 to high } else //if the motor should stop { digitalWrite(AIN1, LOW); //set pin 1 to low digitalWrite(AIN2, LOW); //set pin 2 to low } analogWrite(PWMA, abs(motorSpeed)); //now that the motor direction is set, drive it at the entered speed } What You Should See When you flip the switch, the motor will turn on and spin at the speed set by the motor speed variable (default is 0). By opening the serial monitor and sending numbers, you can change the speed of the motor. Any number from about 130 to 255 or -130 to -255 will work, though changes in the speed will be hard to notice. Send the number 0 to stop the motor. Adding a piece of tape to the motor shaft makes it easier to see it spinning. Program Overview Check to see if a command has been sent, then set the motor speed to the number that was sent over the Serial Monitor. Check to see if the switch is ON or OFF. a. If the switch is ON, drive the motor at the motor speed. b. If the switch is OFF, stop the motor. Code to Note CodeDescription Parsing Integers:Serial.parseInt();parseInt() receives integer numbers from the serial monitor. It returns the value of the number that it receives, so you can use it like a variable. Serial Available:Serial.available();Serial.available() checks how many bytes of data are being sent to the RedBoard. If it is greater than 0, then a message has been sent. It can be used in an if statement to run code only when a command has been received. Coding Challenges ChallengeDescription Make the switch change directionsChange the code so that the position of the switch changes the direction of the motor instead of turning it on and off. Replace the switch with a buttonTry wiring a button into the circuit instead of the sliding switch. Now the motor only turns on when you push the button. Replace the switch with a sensorTry changing the code so that the motor is activated by another sensor, like the photoresistor. Troubleshooting ProblemSolution Motor not spinningCheck the wiring to the motor driver. There are a lot of connections, and it's easy to mix one of them up with another. If it is still not working, you can test the B channel by moving you motor. (Black wire to A6, Red wire to A7). You'll need to change the code as well. Motor spins but then stopsIn the Serial Monitor, make sure you have No line ending selected in the drop down menu next to the Baud Rate drop down menu. Switch not workingMake sure that you are hooked up to the middle pin and one side pin on the switch. Still not working?Jumper wires unfortunately can go "bad" from getting bent too much. The copper wire inside can break, leaving an open connection in your circuit. If you are certain that your circuit is wired correctly and that your code is error-free and uploaded but you are still encountering issues, try replacing one or more of the jumper wires for the component that is not working. It's remote control time! In this circuit, you'll use a motor driver to control the speed and direction of two motors. You will also learn how to read multiple pieces of information from one serial command so that you can use the Serial Monitor to tell the robot what direction to move in and how far to move. Parts Needed Grab the following quantities of each part listed to build this circuit: Additional Materials New Concepts ASCII Characters ASCII is a standard formalized in the 1960s that assigns numbers to characters. This is a method of character encoding. When typing on a computer keyboard, each character you type has a number associated with it. This is what allows computers to know whether you are typing a lowercase "a," an uppercase "A" or a random character such as ampersand (&). In this experiment, you will be sending characters to the Serial Monitor to move your remote control robot. When you send a character, the microcontroller is actually interpreting that as a specific number. There are tons of ASCII tables available online. These tables make it easier to know which character is represented by which number. Converting Strings to Integers String variables hold words like "dog" or "Robert Smith" that are made up of multiple characters. Arduino has a set of special built-in methods for string variables that you can call by putting a period after the variable name, as follows: string_variable_name. toInt(); The .toInt() method converts the string to a number, and there are a dozen other methods that can do things like tell you the length of a word or change all of the characters in a string to uppercase or lowercase. Hardware Hookup Polarized Components Pay special attention to the component's markings indicating how to place it on the breadboard. Polarized components can only be connected to a circuit in one direction. Before you build this circuit, you'll need to make a few modifications to the breadboard baseplate to make it more robot-like! Assembling the Robot Using scissors, cut two strips of Dual Lock that are 1.25 inches (3.175cm) long and 1 inch (2.5cm) wide. Remove the adhesive backing, and attach the two pieces to the very corners of the baseplate on the side located under the breadboard. Note: You will likely have a piece of Dual Lock in the center of your baseplate from Project 4. Leave it if so. It will be used in the next circuit. Cut two more strips that are 1.25 inches (3.175cm) long and 3/4 inch (1.9cm) wide. Remove the adhesive backing, and attach the strips to the two motors. Be sure that your motors are mirror images of each other when you attach the Dual Lock. Press the motors to the baseplate, connecting the two Dual Lock surfaces. Try to get the motors as straight as possible so your robot will drive straight. The bottom of your baseplate should look like the image below. Remember that the two motors should be mirror images of each other. Note: The direction in which the motor wires face is arbitrary. Having them face out makes the circuit easier to build. Having them face in makes the circuit more robust against wires getting ripped out. Attach the wheels by sliding them onto the plastic shafts on the gearmotor. The shaft is flat on one side, as is the wheel coupler. Align the two, and then press to fit the wheel onto the shaft. Last, clip the binder clip onto the back end of the robot. This will act as a caster as the robot drives around. Once you're finished, it's time to build the circuit. You may choose to remove the motors or leave them on while you build the circuit. Ready to start hooking everything up? Check out the circuit diagram and hookup table below to see how everything is connected. Circuit Diagram Having a hard time seeing the circuit? Click on the image for a closer look. Hookup Table Component RedBoard Breadboard Breadboard Breadboard Jumper Wire 5V 5V Rail (+) Jumper Wire GND GND Rail (-) Jumper Wire 5V Rail (+) 5V Rail (+) Jumper Wire GND Rail (-) GND Rail (-) Jumper Wire VIN A1 Motor Driver C1-C8 (VM on C1) G1-G8 (PWMA on G1) Jumper Wire A2 5V Rail (+) Jumper Wire A3 GND Rail (-) Jumper Wire Digital Pin 8 J5 Jumper Wire Digital Pin 9 J6 Jumper Wire Digital Pin 10 J7 Jumper Wire J4 5V Rail (+) Jumper Wire Digital Pin 11 J1 Jumper Wire Digital Pin 12 J2 Jumper Wire Digital Pin 13 J3 Motor 1 (Right) A4 (Red +) A5 (Black -) Motor 2 (Left) A6 (Black -) A7 (Red +) Switch F25 F26 F27 Jumper Wire I26 GND Rail (-) Jumper Wire Digital Pin 7 I27 In the table, polarized components are shown with a warning triangle and the whole row highlighted yellow. Open the Sketch To open the code, go to: File > Examples > SIK_Guide_Code-V_4 > SIK_Circuit_5B-RemoteControlRobot You can also copy and paste the following code into the Arduino IDE. Hit upload, and see what happens! language:cpp /* SparkFun Inventor's Kit Circuit 5B - Remote Control Robot Control a two wheeled robot by sending direction commands through the serial monitor. This sketch was adapted from one of the activities in the SparkFun Guide to Arduino. Check out the rest of the book at This sketch was written by SparkFun Electronics, with lots of help from the Arduino community. This code is completely free for any use. View circuit diagram and instructions at: Download drawings and code at: */ //the right motor will be controlled by the motor A pins on the motor driver const int AIN1 = 13; //control pin 1 on the motor driver for the right motor const int AIN2 = 12; //control pin 2 on the motor driver for the right motor const int PWMA = 11; //speed control pin on the motor driver for the right motor //the left motor will be controlled by the motor B pins on the motor driver const int PWMB = 10; //speed control pin on the motor driver for the left motor const int BIN2 = 9; //control pin 2 on the motor driver for the left motor const int BIN1 = 8; //control pin 1 on the motor driver for the left motor int switchPin = 7; //switch to turn the robot on and off const int driveTime = 20; //this is the number of milliseconds that it takes the robot to drive 1 inch //it is set so that if you tell the robot to drive forward 25 units, the robot drives about 25 inches const int turnTime = 8; //this is the number of milliseconds that it takes to turn the robot 1 degree //it is set so that if you tell the robot to turn right 90 units, the robot turns about 90 degrees //Note: these numbers will vary a little bit based on how you mount your motors, the friction of the //surface that your driving on, and fluctuations in the power to the motors. //You can change the driveTime and turnTime to make them more accurate String botDirection; //the direction that the robot will drive in (this change which direction the two motors spin in) String distance; //the distance to travel in each direction /********** void setup() { pinMode(switchPin, INPUT_PULLUP); //set this as a pullup to sense whether the switch is flipped //set the motor control pins as outputs pinMode(AIN1, OUTPUT); pinMode(AIN2, OUTPUT); pinMode(PWMA, OUTPUT); pinMode(BIN1, OUTPUT); pinMode(BIN2, OUTPUT); pinMode(PWMB, OUTPUT); Serial.begin(9600); //begin serial communication with the computer //prompt the user to enter a command Serial.println("Enter a direction followed by a distance."); Serial.println("f = forward, b = backward, r = turn right, l = turn left"); Serial.println("Example command: f 50"); } /********** void loop() { if (digitalRead(7) == LOW) { //if the switch is in the ON position if (Serial.available() > 0) //if the user has sent a command to the RedBoard { botDirection = Serial.readStringUntil(' '); //read the characters in the command until you reach the first space distance = Serial.readStringUntil(' '); //read the characters in the command until you reach the second space //print the command that was just received in the serial monitor Serial.print(botDirection); Serial.print(" "); Serial.println(distance.toInt()); if (botDirection == "f") //if the entered direction is forward { rightMotor(200); //drive the right wheel forward leftMotor(200); //drive the left wheel forward delay(driveTime * distance.toInt()); //drive the motors long enough travel the entered distance rightMotor(0); //turn the right motor off leftMotor(0); //turn the left motor off } else if (botDirection == "b") //if the entered direction is backward { rightMotor(-200); //drive the right wheel forward leftMotor(-200); //drive the left wheel forward delay(driveTime * distance.toInt()); //drive the motors long enough travel the entered distance rightMotor(0); //turn the right motor off leftMotor(0); //turn the left motor off } else if (botDirection == "r") //if the entered direction is right { rightMotor(-200); //drive the right wheel forward leftMotor(255); //drive the left wheel forward delay(turnTime * distance.toInt()); //drive the motors long enough turn the entered distance rightMotor(0); //turn the right motor off leftMotor(0); //turn the left motor off } else if (botDirection == "l") //if the entered direction is left { rightMotor(255); //drive the right wheel forward leftMotor(-200); //drive the left wheel forward delay(turnTime * distance.toInt()); //drive the motors long enough turn the entered distance rightMotor(0); //turn the right motor off leftMotor(0); //turn the left motor off } } } else { rightMotor(0); //turn the right motor off leftMotor(0); //turn the left motor off } } /********** void rightMotor(int motorSpeed) //function for driving the right motor { if (motorSpeed > 0) //if the motor should drive forward (positive speed) { digitalWrite(AIN1, HIGH); //set pin 1 to high digitalWrite(AIN2, LOW); //set pin 2 to low } else if (motorSpeed < 0) //if the motor should drive backward (negative speed) { digitalWrite(AIN1, LOW); //set pin 1 to low digitalWrite(AIN2, HIGH); //set pin 2 to high } else //if the motor should stop { digitalWrite(AIN1, LOW); //set pin 1 to low digitalWrite(AIN2, LOW); //set pin 2 to low } analogWrite(PWMA, abs(motorSpeed)); //now that the motor direction is set, drive it at the entered speed } /********** void leftMotor(int motorSpeed) //function for driving the left motor { if (motorSpeed > 0) //if the motor should drive forward (positive speed) { digitalWrite(BIN1, HIGH); //set pin 1 to high digitalWrite(BIN2, LOW); //set pin 2 to low } else if (motorSpeed < 0) //if the motor should drive backward (negative speed) { digitalWrite(BIN1, LOW); //set pin 1 to low digitalWrite(BIN2, HIGH); //set pin 2 to high } else //if the motor should stop { digitalWrite(BIN1, LOW); //set pin 1 to low digitalWrite(BIN2, LOW); //set pin 2 to low } analogWrite(PWMB, abs(motorSpeed)); //now that the motor direction is set, drive it at the entered speed } What You Should See Open the Serial Monitor. It should prompt you to enter a command that contains a direction and distance. When you type a direction and distance into the serial monitor the robot will move or turn. Program Overview Prompt the user to enter a command and list the shortcuts for the directions. Wait for a serial command. Read the first part of the serial command and set that as the direction. Then read the second part of the command and set it as the distance: a. If the direction is "f", drive both motors forward for the distance. b. If the direction is "b", drive both motors backward for the distance. c. If the direction is "r", drive the right motor backward and the left motor forward. d. If the direction is "l", drive the left motor backward and the right motor forward. Code to Note CodeDescription Parsing Strings:Serial.readStringUntil(' ');Reads a serial message until the first space and saves it as a string. String to Int:string_name.toInt();If a number is stored in a string variable, this will convert it to an integer, which can be used in math equations. User Functions Description rightMotor(motor_distance);Drive the right motor long enough to travel the specified distance. leftMotor(motor_distance);Drive the left motor long enough to travel the specified distance. Coding Challenges ChallengeDescription Replace the switch with a buttonTry wiring a button into the circuit instead of the sliding switch. Now the motor only turns on when you push the button! Replace the switch with a sensorTry changing the code so that the motor is activated by another sensor, like the photoresistor. Troubleshooting ProblemSolution Motor not spinningCheck the wiring to the motor driver. There are a lot of connections, and it's easy to mix one of them up with another. If only one motor is working, check the wires coming from the non-working motor. Make sure they have not come loose from the motor. Switch not workingMake sure that you are hooked up to the middle pin and one side pin on the switch. Still not working?Jumper wires unfortunately can go "bad" from getting bent too much. The copper wire inside can break, le

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