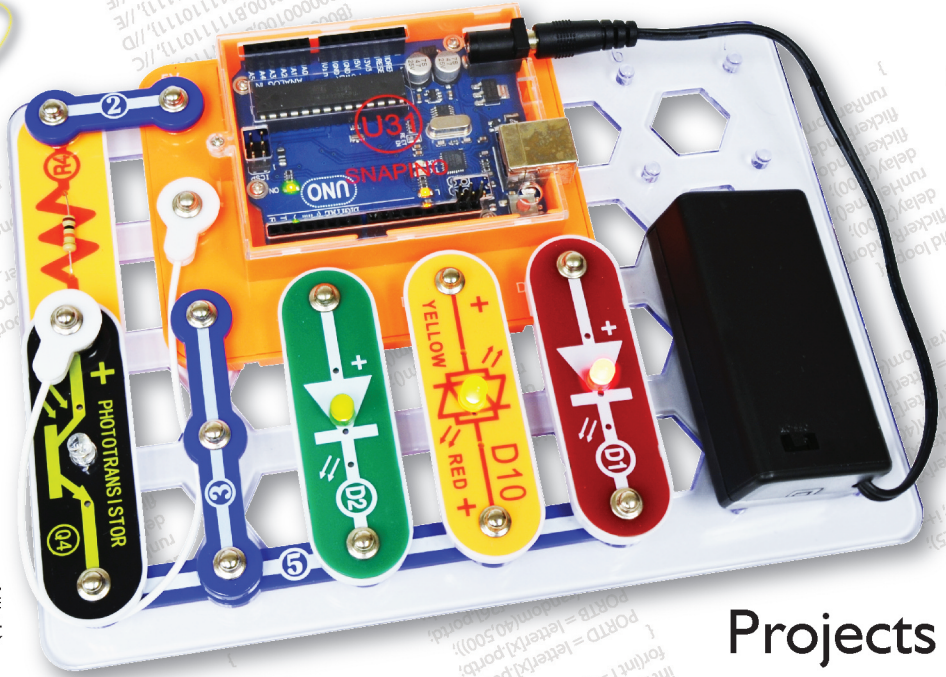
Snapino™

MAKING CODING A SNAP

ELENCO®

SNAP CIRCUITS®

Instruction Manual



AGES 12-112

Project 12

ARDUINO™ IS THE TRADEMARK OF ARDUINO, LLC AND IS USED HERE IN FULL COMPLIANCE WITH ARDUINO, LLC'S OPEN SOURCE POLICY. THE SNAPINO™ PC BOARD ASSEMBLY IS FULLY ARDUINO™ COMPATIBLE.

Projects 1-20

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U.S. Patents: 7,144,255; 7,273,377; & patents pending

A NOTE ABOUT THE FCC

The Federal Communications Commission (FCC) regulates use of the radio frequency spectrum in the United States to prevent products from interfering with each other.

Snapino™ has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. Snapino™ generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If Snapino™ does cause harmful interference to radio or television reception, which can be determined by turning Snapino™ off and on, try to correct the interference by:

1. Moving Snapino™ away from the receiver.
2. Contacting Elenco® for help by calling (800) 533-2441, or e-mail us at help@elenco.com.

FCC regulations for your Snapino™ require you to accept any interference from authorized sources and that you shut down if you are causing interference with other authorized products.

You should never modify the electrical circuit components inside your Snapino™ module (U31) as this may cause malfunctions or violate FCC regulations for this product.

FC Snapino™
Model 6SCU31

WARNING: This product should ONLY be powered using a USB cable, the 9V battery holder included in the set, or an AC adapter with 9V output (not included)! **It should NEVER be used with Snap Circuits® battery holders or other power sources!**

WARNING: SHOCK HAZARD
Never connect Snapino™ to the electrical outlets in your home in any way!

WARNING: CHOKING HAZARD
Small parts. Not for children under 3 years.

Conforms to all applicable U.S. government requirements and CAN ICES-3 (B)/NMB-3 (B).

WARNING: Always check your wiring before turning on a circuit. Never leave a circuit unattended while the batteries are installed. Never connect additional batteries or any other power sources to your circuits. Discard any cracked or broken parts.

Adult Supervision: Because children's abilities vary so much, even with age groups, adults should exercise discretion as to which experiments are suitable and safe (the instructions should enable supervising adults to establish the experiment's suitability for the child). Make sure your child reads and follows all of the relevant instructions and safety procedures, and keeps them at hand for reference.

This product is intended for use by adults and children who have attained sufficient maturity to read and follow directions and warnings.

Never modify your parts, as doing so may disable important safety features in them, and could put your child at risk of injury.

Batteries:

- **Use only 9V type, alkaline battery (not included).**
- **Insert batteries with correct polarity.**
- **Remove batteries when they are used up.**
- **Never throw batteries in a fire or attempt to open its outer casing.**
- **Non-rechargeable batteries should not be recharged. Rechargeable batteries should only be charged under adult supervision, and should not be recharged while in the product.**
- **Do not short circuit the battery terminals.**
- **Batteries are harmful if swallowed, so keep away from small children.**

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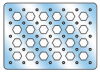
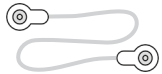
Parts List

Important: If any parts are missing or damaged, **DO NOT RETURN TO RETAILER**. Call toll-free (800) 533-2441 or e-mail us at: help@elenco.com. Customer Service • 150 Carpenter Ave. • Wheeling, IL 60090 U.S.A.

Qty.	ID	Name	Symbol	Part #
❒ 1	2	2-Snap Wire		6SC02
❒ 1	3	3-Snap Wire		6SC03
❒ 1	5	5-Snap Wire		6SC05
❒ 1		9V Battery Holder and Switch		6SCB9
❒ 1		Base Grid Mini (7.7" x 5.5")		6SCBGM
❒ 1	D1	Red LED		6SCD1
❒ 1	D2	Green LED		6SCD2
❒ 1	D10	Red/Yellow Bi-color LED		6SCD10

Qty.	ID	Name	Symbol	Part #
❒ 1		White Jumper Wire		SCJ3F
❒ 1		Red Snap-to-pin Wire		6SCJ5RED
❒ 1	Q4	Phototransistor		6SCQ4
❒ 1	R4	Resistor 10kΩ		6SCR4
❒ 1	S2	Press Switch		6SCS2
❒ 1	U31	Snapino™ Module		6SCU31
❒ 1		USB Cable (A-male to B-male)		9TLSCUSBAB

You may order additional / replacement parts at our website: www.snapcircuits.net

How to Use Snapino™

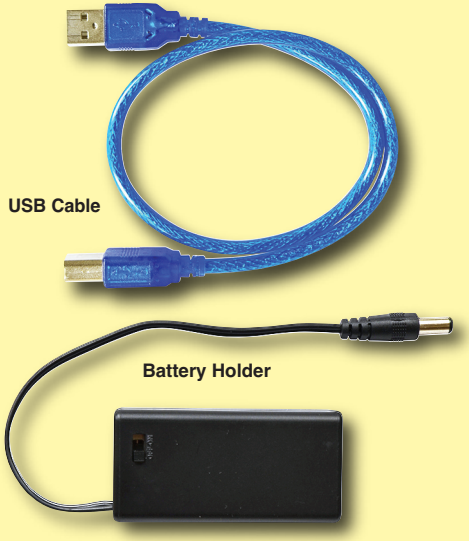
Snap Circuits® uses building blocks with snaps to build the different electrical and electronic circuits in the projects. Each block has a function: there are switch blocks, light blocks, battery blocks, different length wire blocks, etc. These blocks are different colors and have numbers on them so that you can easily identify them. The blocks you will be using are shown as color symbols with level numbers next to them, allowing you to easily snap them together to form a circuit.

For Example:

This is the press switch block which is green and has the marking (S2) on it. The part symbols in this booklet may not exactly match the appearance of the actual parts, but will clearly identify them.

This is a wire block which is blue and comes in different wire lengths. This one has the number (2), (3), or (5) on it depending on the length of the wire connection required.

You need a power source to run your circuits. You can use your USB cable or your 9V battery holder (9V battery not included).



A clear plastic base grid is included with this kit to help keep the circuit blocks properly spaced. You will see evenly spaced posts that the different blocks snap into. The base has rows labeled A-E and columns labeled 1-7.

Next to each part in every circuit drawing is a small number in black. This tells you which level the component is placed at. Place all parts on level 1 first, then all of the parts on level 2, then all of the parts on level 3, etc.

Some circuits use jumper wires to make unusual connections. Just clip them to the metal snaps or as indicated.

There is a snap-to-pin wire that allows you to make connections directly to the Arduino UNO circuit board on the Snapino™ module (U31).

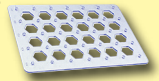
Note: While building the projects, be careful not to accidentally make a direct connection across the battery holder (a "short circuit"), as this may damage and/or quickly drain the batteries.

About Your Snapino™ Parts

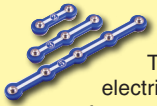
(Part designs are subject to change without notice).

BASE GRID

The **base grid** is a platform for mounting parts and wires. It functions like the printed circuit boards used in most electronic products, or like how the walls are used for mounting the electrical wiring in your home.



SNAP WIRES & JUMPER WIRES



The blue **snap wires** are wires used to connect components. They are used to transport electricity and do not affect circuit performance. They come in different lengths to allow orderly arrangement of connections on the base grid.

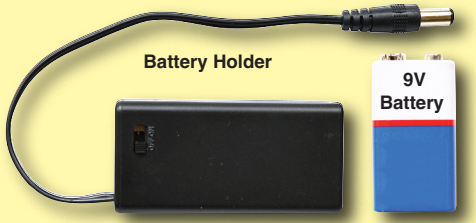
The white **jumper wire** makes flexible connections for times when using the snap wires would be difficult.

The red **snap-to-pin wire** allows for direct connection to the Arduino UNO circuit board.

Wires transport electricity just like pipes are used to transport water. The colorful plastic coating protects them and prevents electricity from getting in or out.

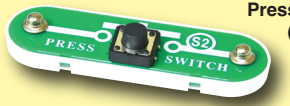
BATTERY HOLDER

Batteries, like that in your 9V battery connector, produce an electrical voltage using a chemical reaction. This "voltage" can be thought of as electrical pressure pushing electricity through a circuit just like a pump pushes water through pipes. This voltage is much lower and much safer than that used in your house wiring. Using more batteries increases the "pressure", therefore, more electricity flows. Snapino™ circuits can also be powered through the USB.



SWITCHES

The **press switch (S2)** and the switch in the 9V battery holder connect (pressed or "ON") or disconnect (not pressed or "OFF") the wires in a circuit. When ON they have no effect on circuit performance. Switches turn on electricity just like a faucet turns on water from a pipe.



Press Switch (S2)

LEDs

The **red & green LEDs (D1 & D2)** are light emitting diodes, and may be thought of as a special one-way light bulb. In the "forward" direction, (indicated by the "arrow" in the symbol) electricity flows if the voltage exceeds a turn-on threshold (about 1.5V for red and yellow, about 2.0V for green, and about 3.0V for blue; brightness then increases. A high current will burn out an LED, so your Snap Circuits® LEDs have internal resistors to protect them. LEDs block electricity in the "reverse" direction.

Red & green LEDs (D1 & D2)

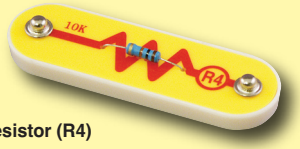
The **red/yellow LED (D10)** is like the others but has red and yellow LEDs connected in opposite directions.

Red / yellow LED (D10)

About Your Snapino™ Parts

RESISTORS

Resistors "resist" the flow of electricity and are used to control or limit the current in a circuit. This set includes a **10kΩ resistor (R4)** ("k" symbolizes 1,000, so R4 is really 10,000Ω). Materials like metal have very low resistance (<1Ω), while materials like paper, plastic, and air have near-infinite resistance. Increasing circuit resistance reduces the flow of electricity.



10kΩ Resistor (R4)

PHOTOTRANSISTOR

The **phototransistor (Q4)** is a transistor that uses light to control electric current.

Phototransistor (Q4)

CABLE

The **USB cable** is used to program and communicate with the Snapino™ module (U31).

USB Cable

SNAPINO™ MODULE

The Snapino™ module (U31) includes an Arduino UNO circuit board. This is a mini computer which can be programmed to perform different tasks, including monitoring things and making things happen.

Snapino™ module (U31)

U31 Snapino™ module snap connections:
(+) - power
(–) - power
A0 - Analog input
D9-D11 - Digital inputs/outputs

Note: Snapino™ does not have an on/off switch when powered using the USB cable. To turn it off, disconnect the USB cable from your computer.

Note: There is additional Arduino information at www.arduino.cc, including a schematic for the Arduino UNO.

Notes for using the SNAPINO™ module in other applications:

Power source:
Snapino™ should ONLY be powered using a USB cable, the 9V battery holder included in the set, or an AC adapter with 9V output (not included). Snapino™ should NEVER be used with Snap Circuits® battery holders from other sets or other power sources.

Analog inputs (snap A0, or pins A0-A5 on the circuit board):
These can measure voltage with 10-bit accuracy (1024 levels). They can also be configured to act as additional digital inputs/outputs.

Digital inputs/outputs (snaps D9-D11, or pins 0-13 on the circuit board):
When configured as inputs the voltages should be above 80% of the power source voltage to be high, or below 20% of the power source voltage to be low. When configured as outputs each can supply or receive up to 20 mA; this is enough to light an LED, but an interface transistor may be needed when controlling a motor or speaker. Some of these (3, 5, 6, 9, 10, and 11) can be configured to simulate analog outputs using Pulse Width Modulation (PWM).

Other pins on the circuit board can be accessed using snap-to-pin wires; see the Arduino website (www.arduino.cc) for more information.

Introduction to Electricity

What is electricity? Nobody really knows. We only know how to produce it, understand its properties, and how to control it. Electricity is the movement of sub-atomic charged particles (called **electrons**) through a material due to electrical pressure across the material, such as from a battery.

Power sources, such as batteries, push electricity through a circuit, like a pump pushes water through pipes. Wires carry electricity, like pipes carry water. Devices like LEDs, motors, and speakers use the energy in electricity to do things. Switches and transistors control the flow of electricity like valves and faucets control water. Resistors limit the flow of electricity.

The electrical pressure exerted by a battery or other power source is called **voltage** and is measured in **volts** (V). Notice the "+" and "–" signs on the battery; these indicate which direction the battery will "pump" the electricity.

The **electric current** is a measure of how fast electricity is flowing in a wire, just as the water current describes how fast water is flowing in a pipe. It is expressed in **amperes** (A) or **milliamps** (mA, 1/1000 of an ampere).

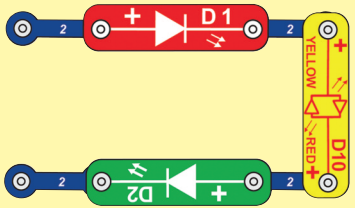
The "**power**" of electricity is a measure of how fast energy is moving through a wire. It is a combination of the voltage and current (Power = Voltage x Current). It is expressed in **watts** (W).

The **resistance** of a component or circuit represents how much it resists the electrical pressure (voltage) and limits the flow of electric current. The relationship is Voltage = Current x Resistance. When the resistance increases, less current flows. Resistance is measured in **ohms** (Ω), or **kilo ohms** (kΩ, 1000 ohms).

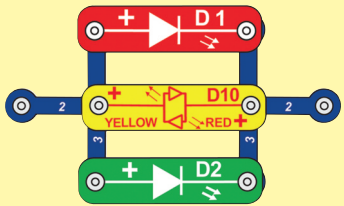
Nearly all of the electricity used in our world is produced at enormous generators driven by steam or water pressure. Wires are used to efficiently transport this energy to homes and businesses where it is used. Motors convert the electricity back into mechanical form to drive machinery and appliances. The most important aspect of electricity in our society is that it allows energy to be easily transported over distances.

Note that "distances" includes not just large distances but also tiny distances. Try to imagine a plumbing structure of the same complexity as the circuitry inside a portable radio - it would have to be large because we can't make water pipes so small. Electricity allows complex designs to be made very small.

There are two ways of arranging parts in a circuit, in series or in parallel. Here are examples:



Series Circuit



Parallel Circuit

Placing components in series increases the resistance; highest value dominates. Placing components in parallel decreases the resistance; lowest value dominates.

The parts within these series and parallel sub-circuits may be arranged in different ways without changing what the circuit does. Large circuits are made of combinations of smaller series and parallel circuits.

DOs and DON'Ts of Building Circuits

After building the circuits given in this booklet, you may wish to experiment on your own. Use the projects in this booklet as a guide, as many important design concepts are introduced throughout them. Every circuit will include a power source (the 9V battery holder or USB cable), a resistance (which might be a resistor, LED (which has an internal protection resistor), etc.), and wiring paths between them and back. You must be careful not to create "short circuits" (very low-resistance paths across the power source, see examples below) as this will damage components and/or quickly drain your batteries. **ELENCO® is not responsible for parts damaged due to incorrect wiring.**

Here are some important guidelines:

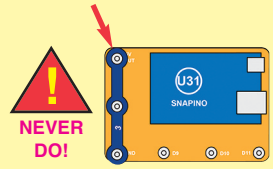
- ***ALWAYS*** **USE EYE PROTECTION WHEN EXPERIMENTING ON YOUR OWN.**
- ***ALWAYS*** include at least one component that will limit the current through a circuit, such as a resistor, an LED (which has an internal protection resistor), etc.
- ***ALWAYS*** use switches in conjunction with other components that will limit the current through them. Failure to do so will create a short circuit and/or damage those parts.
- ***ALWAYS*** disconnect your power source immediately and check your wiring if something appears to be getting hot.
- ***ALWAYS*** check your wiring before turning on a circuit.
- ***ALWAYS*** connect the Snapino™ module (U31) using configurations given in the projects, as per the About Your Parts section, or as per the Arduino website.
- ***NEVER*** connect to an electrical outlet in your home in any way.
- ***NEVER*** leave a circuit unattended when it is turned on.
- ***NEVER*** connect battery holders from other Snap Circuits® sets to the Snapino™ (U31) module.

Warning about power sources:

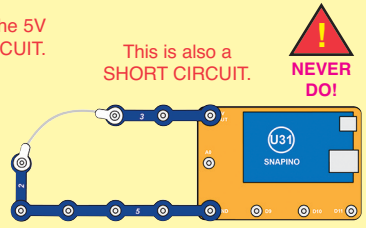
Snapino™ should ONLY be powered using a USB cable, the 9V battery holder included in the set, or an AC adapter with 9V output (not included). **Snapino™ should NEVER be used with Snap Circuits® battery holders from other sets or other power sources.**

Examples of SHORT CIRCUITS - NEVER DO THESE!!!

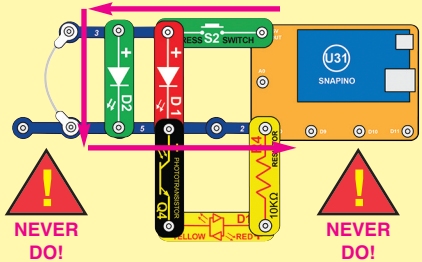
Placing a 3-snap wire directly across the 5V OUT and GND snaps is a SHORT CIRCUIT.



This is also a SHORT CIRCUIT.



When the press switch (S2) is pushed, this large circuit has a SHORT CIRCUIT path (as shown by the arrows). The short circuit prevents any other portions of the circuit from ever working.



You are encouraged to tell us about new programs and circuits you create. If they are unique, we will post them with your name and state on our website at:
www.snapcircuits.net/learning_center/kids_creation
Send your suggestions to ELENCO®: **elenco@elenco.com**.

ELENCO® provides a circuit designer so that you can make your own Snap Circuits® drawings. This Microsoft® Word document can be downloaded from:
www.snapcircuits.net/learning_center/kids_creation
or through the **www.snapcircuits.net** website.

WARNING: SHOCK HAZARD - Never connect Snap Circuits® to the electrical outlets in your home in any way!

Troubleshooting (Adult supervision recommended)

Elenco® is not responsible for parts damaged due to incorrect wiring.

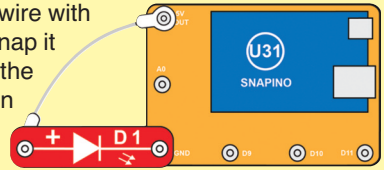
Basic Troubleshooting

1. Most circuit problems are due to incorrect assembly, always double-check that your circuit exactly matches the drawing for it.
2. Be sure that parts with positive/negative markings are positioned as per the drawing.
3. Be sure that all connections are securely snapped.
4. Try replacing the batteries.

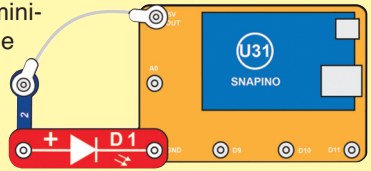
Advanced Troubleshooting

If you suspect you have damaged parts, you can follow this procedure to systematically determine which ones need replacing:

1. **Snapino™ module (U31 - partial test, see step 6 for full test), 9V battery holder, and USB cable:** Install a 9V battery into the battery holder, turn on its switch, and plug the holder into the Snapino™ module; a green "ON" light and another light on the Snapino™ module should be on. Remove the 9V battery holder and connect the USB cable; the same lights on the Snapino™ module should be on. If the Snapino™ lights do not come on in either case then Snapino™ is damaged, if they only come on for one power source then the other power source is damaged.
2. **Red LED (D1), green LED (D2), and red/yellow LED (D10):** Place the red LED across the "5V OUT" and "GND" snaps on the Snapino™ module (U31), with LED "+" to 5V OUT; the red LED should light. Repeat for the green LED. Repeat for the red/yellow LED but test it in both directions. If some LEDs work but others do not then the ones that did not work are damaged. If no LEDs work then the Snapino™ module is damaged.
3. **White jumper wire and red snap-to-pin wire:** Use this mini-circuit to test the white jumper wire, the LED should light. Replace the white jumper wire with the red snap-to-pin wire (snap it on the LED, then touch the pin end to the GND snap on the Snapino™ module (U31)) to test it.



4. **Snap wires:** Use this mini-circuit to test each of the snap wires, one at a time. The LED should light.



5. **Press switch (S2), 10kΩ resistor (R4), and phototransistor (Q4):** Build project #1 and push the press switch, if the red LED (D1) doesn't light then the press switch is bad. Replace the press switch with the 10kΩ resistor; the LED should be much dimmer now but still light. Replace the 10kΩ resistor with the phototransistor ("+" on right) and vary the amount of light shining on it; more light should make the LED brighter.
6. **Snapino™ module (U31 - full test):** Use project 15 to test it.

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You may order additional / replacement parts at: www.snapcircuits.net

Project Listings

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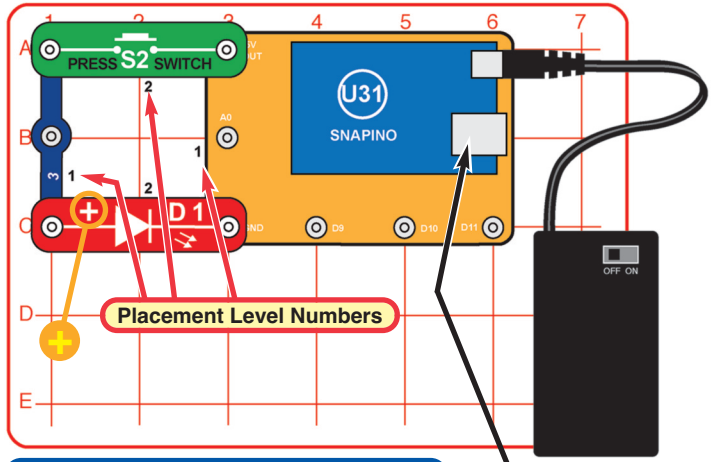
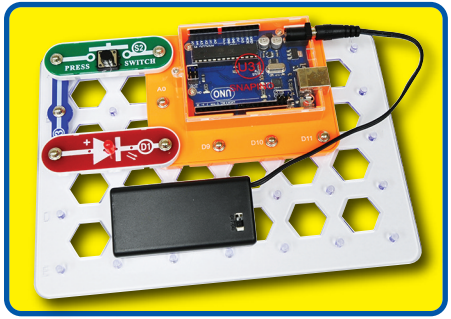
Project 1
Red Light





Optional: USB cable to USB device may be used as alternate power source in place of 9V battery.

A. Snap Circuits® uses electronic blocks that snap onto a clear plastic grid to build different circuits. These blocks have different colors and numbers on them so you can easily identify them.

Build the circuit shown by placing all the parts with a black **1** next to them on the board first. Then, assemble parts marked with a **2**. Install a 9V battery into the 9V battery holder, plug it into the connector on the Snapino™ module (U31), and turn on the switch on the battery holder. A small green light (usually labeled "ON") on the Snapino™ module should be on, indicating that it has power. Alternately you may power the circuit using the USB cable instead of the 9V battery.

Push the press switch (S2), and the red LED (D1) lights.

Educational Note:
When you press the press switch, electricity flows from the Snapino™ module, through the switch and back to the Snapino™ module through the red LED. If the switch is not pressed, the flow of electricity is blocked, and the red LED won't light.

For this and the next few circuits, the Snapino™ module is used only to provide power to the rest of the circuit. Snapino™ is powered using a 9V battery or through the USB, and produces a 5V output to operate other Snap Circuits® components.

NOTE: This circuit (and many others in this book) have an LED being used without a resistor or other component to limit the electric current through it. Normally this could damage an LED, but your Snap Circuits® LEDs include internal protection resistors and will not be damaged. Be careful if you later use other electrical sets with unprotected LEDs.

B. Use the preceding circuit but replace the 3-snap wire with the red/yellow LED (D10, in either orientation). The red LED is a little dimmer now.

Educational Note: The voltage from the Snapino™ module (U31) is now split between the two LEDs, making the red one dimmer.

C. Use the preceding circuit but replace the red/yellow LED (D10) with the 10kΩ resistor (R4). The red LED (D1) is much dimmer now.

Educational Note: Resistors "resist" the flow of electricity, so the LED is much dimmer now.

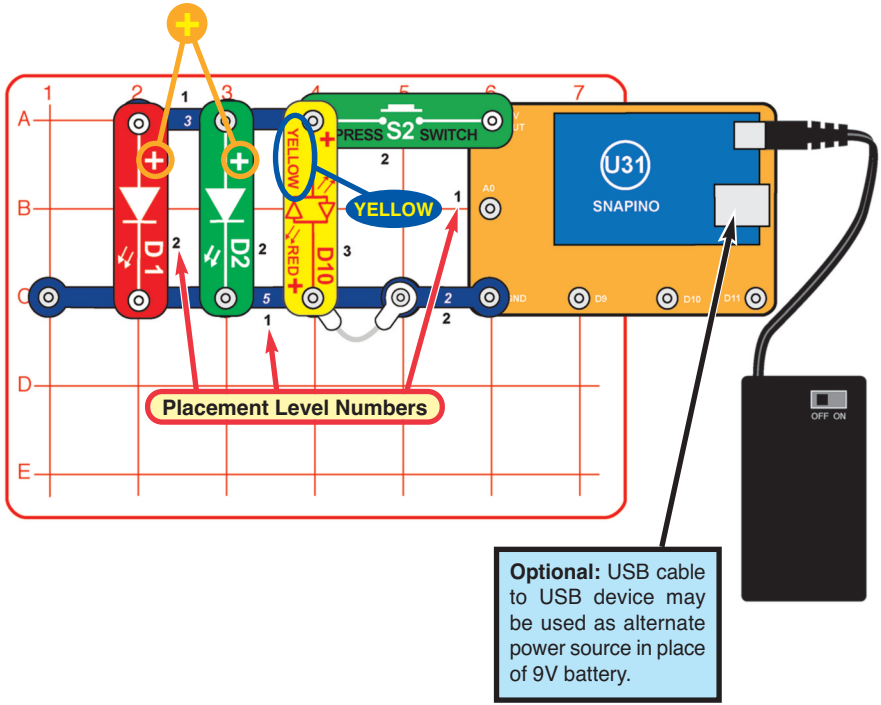
D. Use the preceding circuit but replace the 10kΩ resistor (R4) with the phototransistor (Q4, "+" towards S2). Vary the brightness of light on the phototransistor to change the red LED brightness.

Educational Note: The resistance of the photo-transistor varies depending on how much light is shining on it.

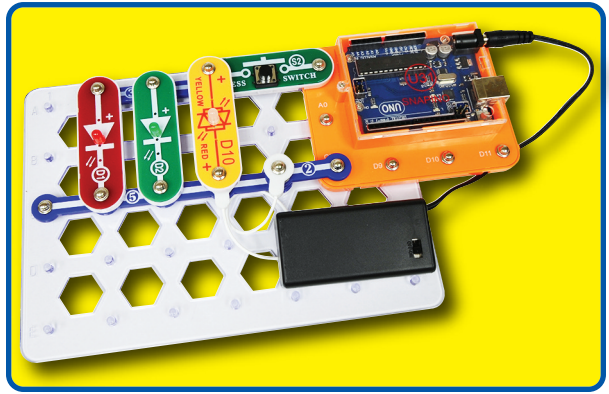
E. Replace the red LED (D1) with the green LED (D2) in any of the preceding four circuits.

Educational Note: The green LED needs a little more voltage to turn on than the red LED, so it will be a little dimmer.

Project 2 Lights



Optional: USB cable to USB device may be used as alternate power source in place of 9V battery.



A. Build the circuit, turn on the switch in the 9V battery holder, and push the press switch (S2). The red, green, and yellow LEDs (D1, D2, & D10) light.

Note: The white jumper wire is used only as a spacer (so both snaps on the yellow LED are on level 3); its right snap need not be connected.

Educational Note:
LEDs are light emitting diodes, which convert electrical energy into light. The color of the light depends on the characteristics of the material used in them.

B. Use the preceding circuit but reverse the position of the press switch (S2), 3-snap wire, 5-snap wire, and each of the LEDs (D1, D2, & D10), separately.

Educational Note: Reversing the switch and snap wires has no effect. LEDs only work in one direction, so the red & green LEDs do not work in reverse, but the yellow LED (D10) is a bi-color LED, with separate red & yellow LEDs in opposite directions, as shown in its symbol.

C. Use the project 2A circuit but replace the press switch (S2) with the phototransistor (Q4, "+" on right). Vary the brightness of light shining on the phototransistor and see how it changes the brightness of the LEDs.

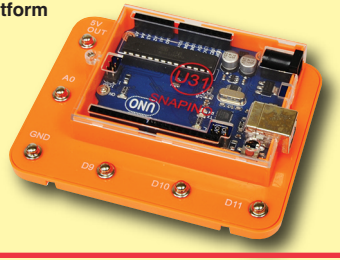
Educational Note: The resistance of the phototransistor varies depending on how much light is shining on it, brighter light lowers its resistance. In this circuit the phototransistor restricts the flow of electricity to all three LEDs at once, so it takes very bright light to make all three LEDs light. Some LEDs need less electricity to turn on than others, so they may turn on sooner.

D. Use the project 2A circuit but remove the press switch (S2) and move one of the LEDs (D1, D2, or D10) to where the switch was (place the LED "+" on the right). The LEDs may be a little dimmer now.

Educational Note: All the electricity flows through the LED that replaced the switch, then divides between the remaining two LEDs. The LEDs are a little dimmer because the battery voltage is split between them now.

Introduction to Microcontrollers

Arduino UNO circuit board on Snap Circuits® platform



The Snapino™ module (U31) is an Arduino UNO microcontroller mounted on a Snap Circuits® base. Arduino is an electronics platform for prototyping with easy-to-use hardware and software. Usually Arduino is used with a prototyping breadboard, but combining with it with Snap Circuits® - which has electronic parts and modules mounted on snaps - makes an even better prototyping platform.

This set is only intended as an introduction to Arduino. Users who want to learn more about it should visit the Arduino website (www.arduino.cc) after finishing the projects in this set.

WHAT IS A MICROCONTROLLER?

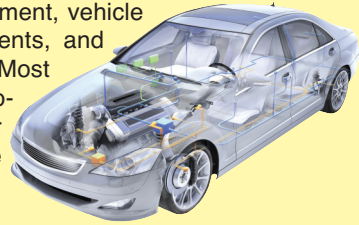
A microcontroller is a mini computer. It's a miniaturized circuit that contains memory, logic, processing, and input/output circuitry. Microcontrollers are programmed with specific instructions to control many different devices. Once programmed the microcontroller is built into a product to make the product more intelligent and easier to use.

A microcontroller receives input (such sources such as a switch, phototransistor, or computer keyboard), processes it and makes decisions, then controls outputs (such as an LED, speaker, motor, or computer display) based on the decisions.

For example, a microwave oven uses a single microcontroller to process information from the keypad, display user information on a display, and control the turntable motor, light, bell and cooking time.

One microcontroller can often replace a number of separate parts, or even a number of complete electronic circuits.

Microcontrollers are used in household appliances, alarm systems, medical equipment, vehicle subsystems, musical instruments, and electronic instrumentation. Most cars contain many micro-controllers, using them for engine management, remote locking, and other functions.



Programs are stored in memory as a series of numbers. A program is executed by moving information (stored as numbers) between places, such as activity registers, input/output ports, and memory. Computers cannot do complex mathematics, but they can perform simple math very quickly, and programming tricks allow complex calculations to be performed as a series of simple ones.

☐ Project 3 Blinking Light (Programming Snapino™)

This project explains the procedure for programming the Snapino™ module (U31). The microcontroller can be re-programmed in ANY circuit that uses it, by attaching the programming cable to it. When you initiate a new program download, any program currently running in the microcontroller is interrupted. When a new program download is complete, the new program will begin running.

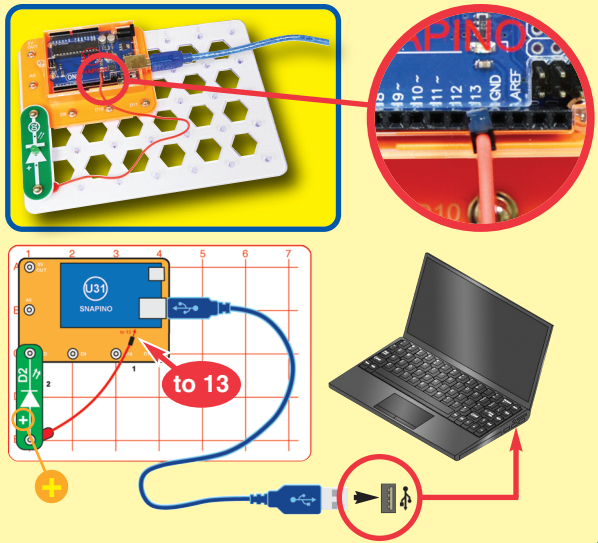
The USB cable is needed to download new programs to the microcontroller, and to allow some programs to transfer information to/from the computer's display. The USB also provides power to your circuits, so the 9V battery connector is ignored while you are connected to a USB device. Once Snapino™ has been programmed, you may disconnect the USB cable and run the circuit using the 9V battery connector.

Installing Software and Programming Cable

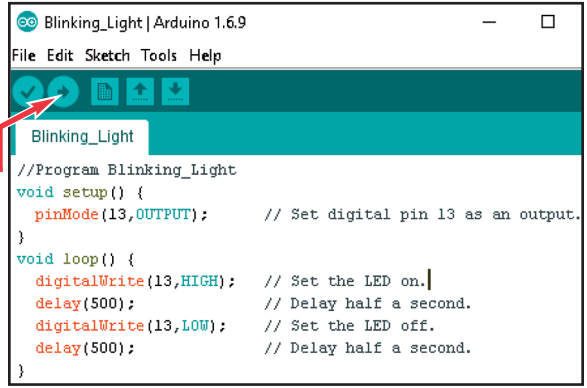
Install the Arduino software - called the Integrated Development Environment (IDE) from the Arduino website (www.arduino.cc/en/main/software). Choose the appropriate version for your computer's operating system (most users will pick "Windows installer" or "Mac OS X"), then follow the installation instructions there. Depending on your operating system, you may be asked to agree to a license agreement, or to give permission to install drivers.

When the IDE installation is complete, build the circuit shown here (which includes the red snap-to-pin wire, which is plugged into slot 13 of the black connector on the circuit board on the Snapino™ module (U31)), connect the USB cable to your computer. The green LED (marked ON) on the circuit board should be on, and other lights may be on if the board had previously been programmed. Your computer should automatically find the drivers it needs. Run the Arduino IDE.

Now select the port for communicating with Snapino™. In the Tools menu in the Arduino IDE, select Port, then pick the one that shows an Arduino UNO (Windows users) or either of the following:
/dev/tty/usbmodem or */dev/cu.usbmodem5dll* (Mac users).

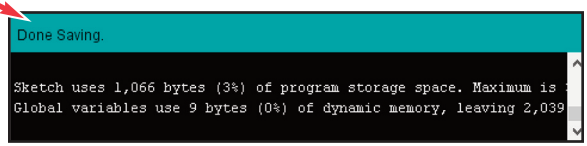


Go to the Snapino™ product page (www.snapcircuits.net/scsnapino) and download the Snapino™ program files from our website to your computer. In the File menu in the Arduino IDE, pick Open, then go to where you downloaded the Snapino™ program files to, and pick the Blinking_Light program or "sketch" (Arduino users refer to a program as a sketch). The sketch should appear in the IDE window, as shown below.



Now download the program into the Snapino™ module. Click on the Upload button in the IDE.

The blue status bar near the bottom should indicate that the upload is occurring, and when it is done. Two LEDs should now be blinking - a small yellow LED on the UNO board (usually marked "L") and the green LED (D2) in Snap Circuits®.



You can now disconnect the USB cable and connect the 9V battery holder. Turn on the switch on the 9V battery holder, and the sketch will begin running.

Note: Snapino™ does not have an on/off switch when powered using the USB cable. To turn it off, disconnect the USB cable from your computer.

Troubleshooting:
If there was a problem with the upload, then the status bar would be orange, indicating a problem.

If you had unplugged the USB cable and it does not recognize the module when USB is connected again, then you may need to re-select the port. In Tools, select Port, then pick the one that shows an Arduino UNO (Windows users) or either of the following: */dev/tty/usbmodem* or */dev/cu.usbmodem5dll* (Mac users).

Educational Note: Any time a task needs to be performed over and over again, a microcontroller should be considered to help perform the task.

Learn About Programming

Here is how the sketch works:

void - this sets up a function.

setup - this is a function that initializes variables, pin modes, etc.

pinMode(13, OUTPUT) - this configures digital pin 13 to act as an output.

loop - this is a function for executing the following commands in a continuous loop.

digitalWrite(13, HIGH) - this tells Snapino™ to put an electrical voltage at digital pin 13 (where the Snap Circuits® green LED (D2) is connected). This voltage will light the LED. A small yellow LED on the UNO circuit board also lights; this LED is permanently connected to digital pin 13.

delay(500) - this tells Snapino™ to pause for 500 milliseconds, or 0.5 second, before performing the next instruction.

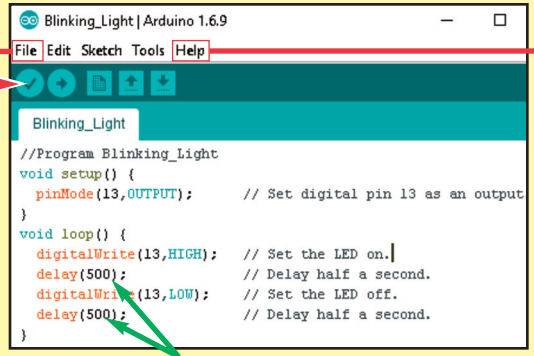
digitalWrite(13, LOW) - this tells Snapino™ to turn off or remove any voltage at digital pin 13. This will turn off the green LED (and the yellow LED on the UNO board).

Comments: All information after **//** is Comments. Comments are a description of what the sketch is doing, to help you understand and remember it. Comments are automatically removed before the sketch is downloaded to Snapino™.

You can edit the sketch to change parameters or commands if desired. The editing procedure is similar to other word processors. You may also type in a completely new sketch. To save sketches you have created or modified, use **Save As** under **File** menu.

Only valid sketches (without errors) may be downloaded, or a downloading error will result. You can check for errors by clicking the **Verify** box. **Verify** also tells you how much memory the sketch uses.

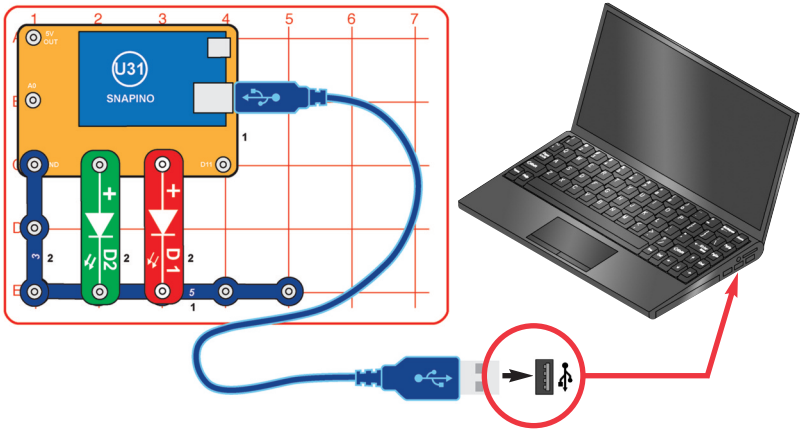
Explanations for all Arduino commands, and some basic information about programming, can be found under the **Help** menu or on the Arduino website (www.arduino.cc).



You can change the blink rate by changing the delay value from 500 to something else. Try 200 (faster blinking) or 2000 (slower blinking). Change the value at both locations in the sketch, then upload the sketch into Snapino™.

Project 4

Alternating Lights



Build this circuit. Load sketch Alternating_Lights into Snapino™ using the programming instructions in project 3. Arduino controls the two Snap Circuits® LEDs (red and green), and alternates turning them on and off.

Alternating_Lights | Arduino 1.6.9

File Edit Sketch Tools Help

Save

Alternating_Lights

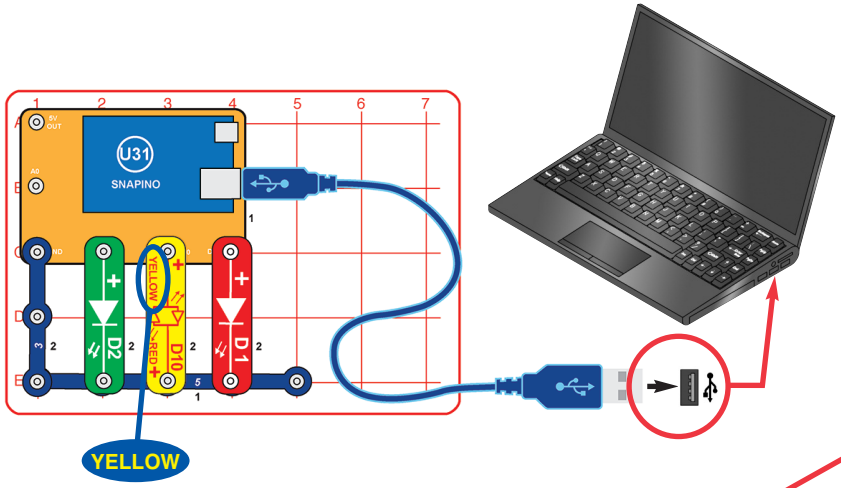
```
//Alternating_Lights

int delay1 = 250;          //Set delay value.

void setup()
{
  pinMode(9, OUTPUT);      //Set digital pin 9 as an output.
  pinMode(10, OUTPUT);     //Set digital pin 10 as an output.
}
```

Programming Note:
This sketch uses the **int** command (int is short for integer) to assign a constant value that will be used within the sketch. You can change the blink rate by editing the delay value, then reloading it into Snapino™.

The microcontroller on the Arduino UNO board lets you control the LEDs in ways that would be difficult to do using switches or other devices.

Project 5

Stoplight



Build this circuit. Load sketch Stoplight into Snapino™ using the programming instructions in project 3. Snapino™ controls the three Snap Circuits® LEDs (green, yellow, and red), and turns them on and off like a stoplight. The yellow light is only on for half as long, just like a normal stoplight.

Stoplight | Arduino 1.6.9

File Edit Sketch Tools Help

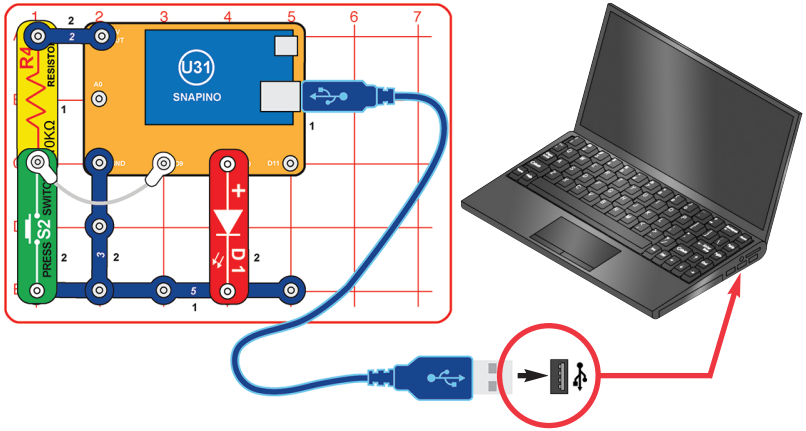
Stoplight §

```
//Stoplight

int delay1 = 1000;           //Set delay value
int red = 11;                //Set up red as a constant
int yellow = 10;             //Set up yellow as a constant
int green = 9;               //Set up green as a constant

void setup() {
pinMode(red, OUTPUT);        //Set digital pin red as an output
pinMode(green, OUTPUT);      //Set digital pin green as an output
pinMode(yellow, OUTPUT);     //Set digital pin yellow as an output
}

void loop() {

digitalWrite(green, HIGH);   //Turn the green light on
delay(delay1);               //Wait 1000 ms

digitalWrite(green, LOW);    //Turn the green light off
digitalWrite(yellow, HIGH); //Turn the yellow light on
delay(delay1 / 2);           //Wait 500 ms

digitalWrite(yellow, LOW);   //Turn the yellow light off
digitalWrite(red, HIGH);     //Turn the red light on
delay(delay1);               //Wait 1000 ms

digitalWrite(red, LOW);      //Turn the red light off
}
```

Programming Note: This sketch uses the **int** command to assign constant values for the delay and LED connection pins. Doing this makes them easy to change later, because you would only need to change them in one place, instead of throughout the sketch. You can change the blink rate by editing the delay value, then reloading it into Snapino™.

Project 6

Button



Build this circuit. Load sketch Button into Snapino™ using the programming instructions in project 3. The red LED (D1) should be on; push the press switch (S2) to turn it off.

Swap the locations of the press switch and 10KΩ resistor (R4). Now the red LED turns on when the press switch is pushed.

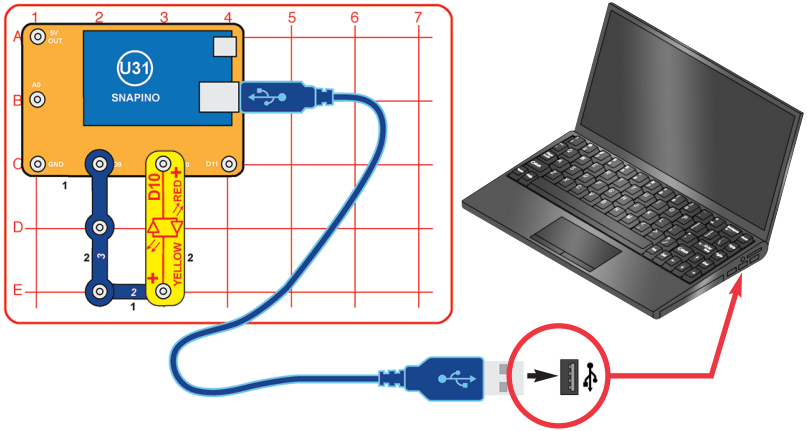
```
Button | Arduino 1.6.9
File  Edit  Sketch  Tools  Help
Button §
//Button

const int ledPin =  10;
const int button = 9;
int buttonState = 0;

void setup() {
  pinMode(ledPin, OUTPUT);
  pinMode(button, INPUT);
}

void loop(){
   buttonState = digitalRead(button);  //Read the value from the button

  if (buttonState == HIGH) {
    digitalWrite(ledPin, HIGH);          //If the value is high (button
  }
  else {
    digitalWrite(ledPin, LOW);           //If anything else happens turn
  }
}
```

Programming Note:
This sketch monitors the voltage between the 10KΩ resistor and press switch; normally the resistor pulls the voltage high, but pushing the switch pulls it low. Snapino™ monitors the voltage and turns off the red LED when it receives a low signal from the button. If the button is released, then the monitored voltage will go back to high, and Snapino™ turns on the red LED.

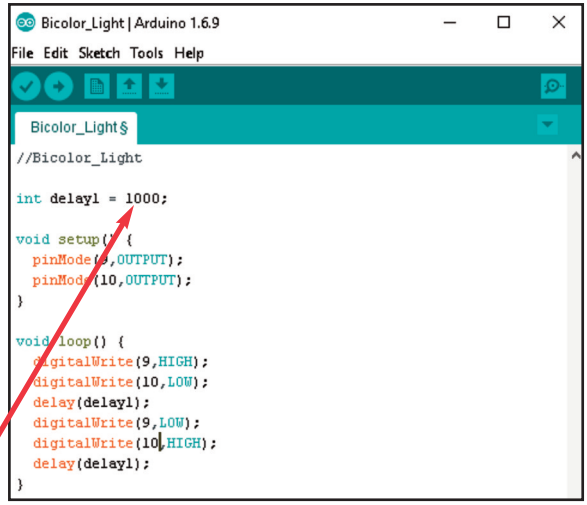
digitalRead(button) - this command tells Snapino™ to read the voltage at button (which had been assigned as digital pin 9), and assign it to variable buttonState.

Project 7

Bicolor Light



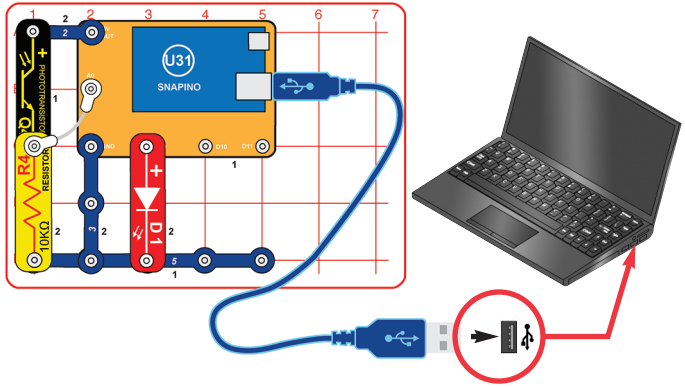
Build the circuit and load sketch Bicolor_Light into Snapino™ using the programming instructions in project 3. The red/yellow bicolor LED (D10) alternates between red and yellow.



Programming Note:
The red/yellow bicolor LED (D10) has red and yellow LEDs connected in opposite directions. The sketch instructions alternate between turning digital pins 9 and 10 HIGH or LOW, so that electricity flows out of one and into the other.

Try reducing the delay to 100 to make it change colors faster. Next, reduce the delay to 10 to make it change colors really fast - so fast that red and yellow blend into orange.

Project 8 Night Light



Build this circuit. Load sketch Night_Light into Snapino using the programming instructions in project 3. Cover the phototransistor (Q4) to turn on the red LED (D1).

Once programmed, you can use the 9V battery connector to power the circuit instead of the USB cable, then take the circuit with you into a dark room.

Programming Note: **analogRead(0)** - this command measures the voltage at analog pin A0 using a 10-bit analog-to-digital converter, and outputs a value from 0 to 1023 (representing a voltage of 0V to 5V).

You can adjust the sensitivity by changing 200 to be higher or lower.

```
//Night_Light

const int LED = 9;
int val = 0;

void setup(){
  pinMode(LED, OUTPUT);
}

void loop(){
  val = analogRead(0);      //Read the value of analog pin 2, and
  if(val < 200){
    digitalWrite(LED, HIGH); //If the value is less than 200, turn
  }
    else
    digitalWrite(LED, LOW);  //If anything else happens, turn the LE
  }
```

Project 9 Blink Rate

Use the preceding circuit, but load sketch Blink_Rate into Snapino™. The red LED (D1) will be blinking; the darker the room, the faster it blinks. If the room is very dark then the red LED may appear to be on continuously.

Swap the locations of the 10KΩ (R4) resistor and phototransistor (Q4). Now brighter light makes the LED blink faster and darkness makes it slower.

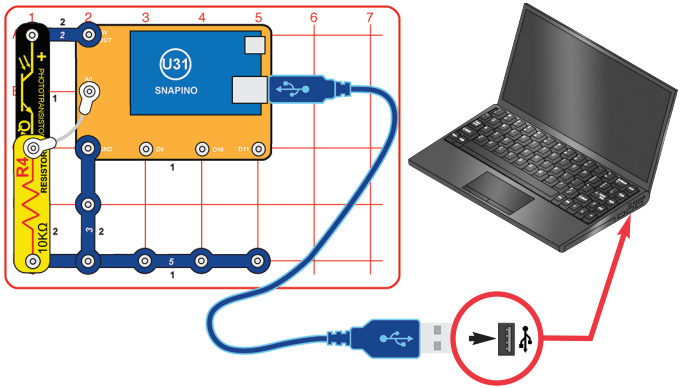
Project 10 Copy Cat Light

Programming Note: This program uses a counter to keep track of how long you cover the phototransistor. The longer you cover it, the higher the counter gets. Once the phototransistor is uncovered, the LED will turn on, and the program will start subtracting from the counter. This can count backwards until the counter is equal to zero, where it would then turn the LED off.

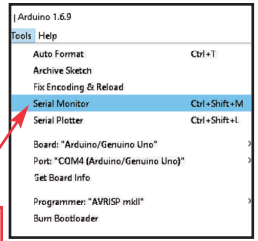
Use the preceding circuit, with the R4 and Q4 locations swapped (so Q4 connects to the 5-snap wire). Load sketch Copy_Cat_Light into Snapino™. Place the circuit in a bright room, so there is light on the phototransistor (Q4). Block the light to the phototransistor with your hand; when you uncover it then the red LED (D1) will be on for as long as the phototransistor was covered. Try this several times.

Project 11

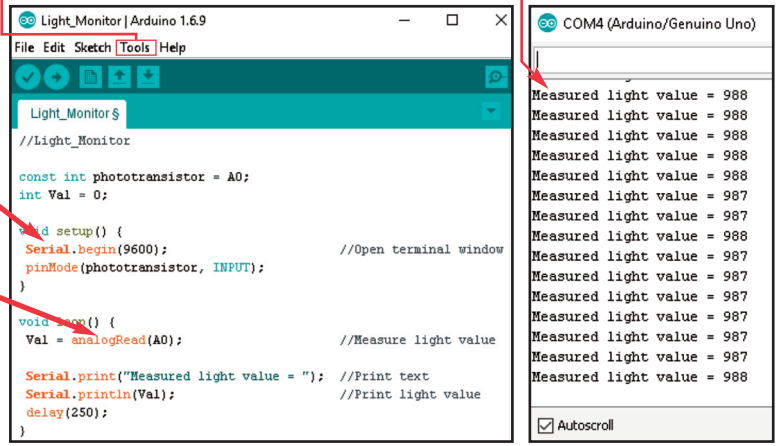
Light Monitor



This project opens a window on your computer to display measured data in real time. Build the circuit shown. Load sketch Light_Monitor into Snapino™ using the programming instructions in project 3. When the upload is finished, click on the **Tools** menu, then pick **Serial Monitor** from the list. A window opens on your computer screen, displaying the measured light value. Vary the amount of light shining on the phototransistor (Q4) and see how the number displayed changes.



Serial monitor window:



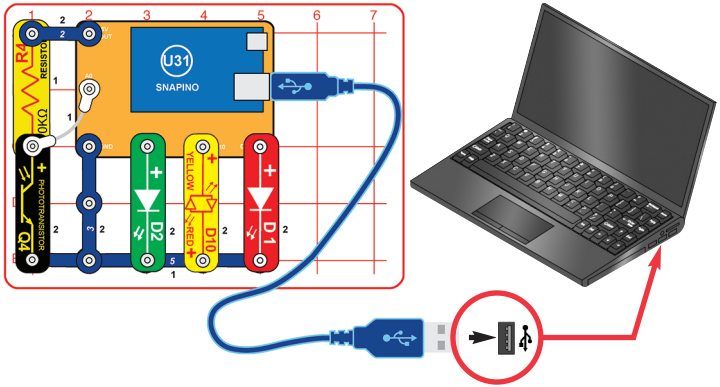
Programming Note:

The **Serial** commands open the window, then display some text with the light measurement.

Changing the amount of light shining on the phototransistor changes its resistance, and so changes the voltage measured at the A0 input. The **analogRead** command has 10-bit accuracy, so the measured number will be from 0 (darkest) to 1023 (brightest).

The 10KΩ resistor (R4) allows the voltage at the A0 input to fall when it is dark and rise when there is light on the phototransistor. The voltage measured depends on the ratio of the phototransistor resistance to the 10KΩ resistor (R4). The measured value will be about 512 when the phototransistor resistance equals R4. Replacing R4 with another resistor would shift the measured light value.

Project 12 Distance Sensor



This sketch changes which LED is on depending on the amount of light the phototransistor is getting. Build the circuit and load sketch Distance_Sensor into Snapino™ using the programming instructions in project 3.

Vary the amount of light shining on the phototransistor (Q4) - if the light is bright then the green LED (D2) will be on, if there is less light then the yellow LED (D10) will be on, and if there is low light or no light then the red LED (D1) will be on. This can be used to determine the distance something is above it, since the object will slowly block out more light the closer it gets to the phototransistor.

Once programmed, you can use the 9V battery connector to power the circuit instead of the USB cable, then walk around with it.

```
Distance_Sensor§
//Distance Sensor

const int redLED = 11;
const int yellowLED = 10;
const int greenLED = 9;
const int phototransistor = A0;
int Val = 0;

void setup() {                          //Declare which variables are outputs or
    pinMode(redLED,OUTPUT);
    pinMode(yellowLED,OUTPUT);
    pinMode(greenLED,OUTPUT);
    pinMode(phototransistor,INPUT);
}

void loop() {
  Val = analogRead(phototransistor); //Read the value of the A2 pin and assi

  delay(50);

      if (Val >= 750){
      digitalWrite(redLED,HIGH);
      digitalWrite(yellowLED,LOW);  //If the value is very high, just turn o
      digitalWrite(greenLED,LOW);

      if ((Val < 750) && (Val > 150)){
      digitalWrite(redLED,LOW);
      digitalWrite(yellowLED,HIGH); //If the value is not high or low, just
      digitalWrite(greenLED,LOW);

      if (Val <= 150){
      digitalWrite(redLED,LOW);
      digitalWrite(yellowLED,LOW);  //If the value is low, just turn on the
      digitalWrite(greenLED,HIGH);
```

Project 13 Photo Stop

Use the preceding circuit, but load sketch Photo_Stop into Snapino™. The LEDs change colors in a stoplight pattern, with the rate of change controlled by the phototransistor (Q4). Vary the amount of light shining on the phototransistor; the brighter the light, the faster the LEDs change.

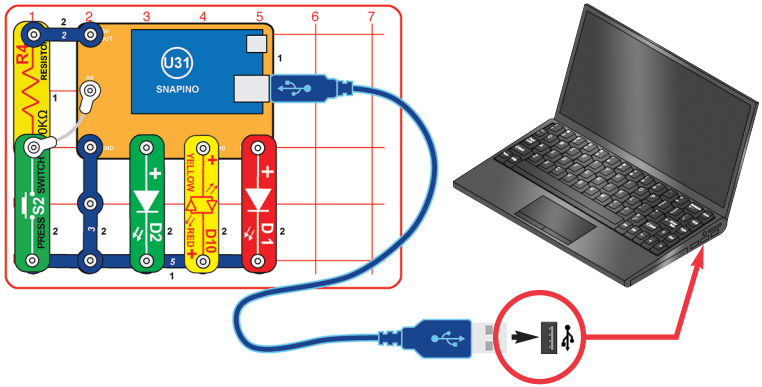
Programming Note: This sketch reads the value from the phototransistor, and uses that value to change the time delay, causing the stoplight to switch the LEDs faster or slower.

Programming Note:
This sketch works by measuring how much light the phototransistor is getting, and assigning that value to a variable, in this case the variable is "Val". The Arduino then uses this value to determine which light to turn on. If the variable is above a certain value, the Arduino switches the LED from green to yellow, and if the value still gets too high, the Arduino switches the yellow LED to the red LED.

You can adjust the sensitivity by changing values 750 and 150 to be higher or lower.

Project 14

Button Stoplight



Build this circuit. Load sketch Button_Stoplight into Snapino™ using the programming instructions in project 3. The red LED (D1) should be on; push the press switch (S2) to change which LED is on, order is red-yellow-green like a stoplight.

Button_Stoplight | Arduino 1.6.9

File Edit Sketch Tools Help

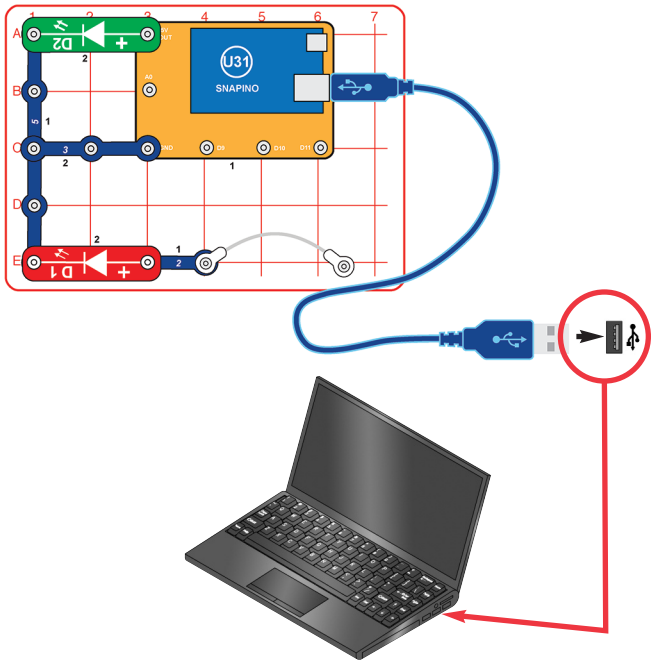
Button_Stoplight

```
//Button_Stoplight

const int redLED = 11;
const int yellowLED = 10;
const int greenLED = 9;
const int button = A0;
int Val;
int oldVal;
int counter = 3;

void setup() {
  pinMode(redLED,OUTPUT);
  pinMode(yellowLED,OUTPUT);
  pinMode(greenLED,OUTPUT);
  pinMode(button,INPUT);
}

void loop() {
  Val = digitalRead(button);              //Read the value from the button
  if((Val == HIGH) && (oldVal == LOW)){   //If Val is HIGH and oldVal is LOW then
    ++counter;                            //Add to the counter when the button is pressed
  }
  oldVal = Val;
  delay(10);
                                          //When the counter variable = 1, turn on the red LED
      if (counter == 1){
      digitalWrite(redLED,HIGH);
      digitalWrite(yellowLED,LOW);
      digitalWrite(greenLED,LOW);
                                          //When the counter variable = 2, turn on the yellow LED
      }if (counter == 2){
      digitalWrite(redLED,LOW);
      digitalWrite(yellowLED,HIGH);
```

Programming Note: This sketch uses a counter to switch between different LEDs. When the button is pressed, it increases the counter by 1. Each LED is activated when the counter reaches a certain number. When the counter reaches 4 it is reset to back 1.

Project 15

Snapino™ Test



This circuit tests the snap connections on the Snapino™ module (U31), and is referenced by the Advanced Troubleshooting procedure on page 8. Build the circuit as shown, leaving one end of the white jumper wire unconnected for now. Load sketch Snapino_Test into Snapino™ using the programming instructions in project 3.

The green LED (D2) should be on. Connect the loose end of the white jumper wire to each of the unused snaps on the Snapino™ module (U31), one at a time; the red LED (D1) should be blinking each time. Remove the USB cable, then connect the 9V battery holder and turn on its switch; the circuit should work the same as with the USB cable.

Snapino_Test | Arduino 1.6.9

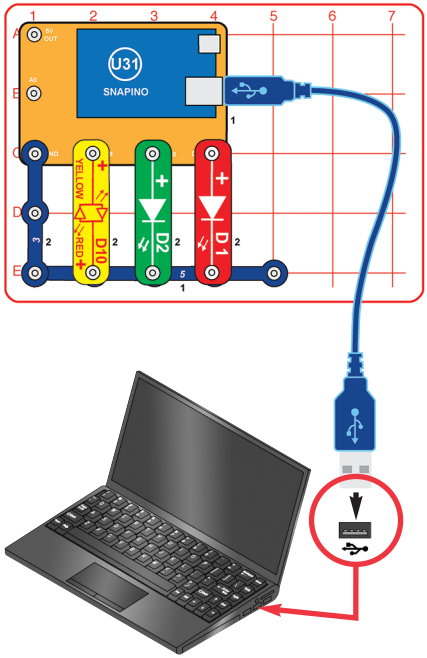
File Edit Sketch Tools Help

Snapino_Test§

```
//Snapino_Test

void setup() {
   pinMode(9,OUTPUT);
  pinMode(10,OUTPUT);
  pinMode(11,OUTPUT);
  pinMode(12,OUTPUT);
  pinMode(A0,OUTPUT);
  pinMode(A1,OUTPUT);
  pinMode(A2,OUTPUT);
}

void loop() {
digitalWrite(9,HIGH);
digitalWrite(10,HIGH);
digitalWrite(11,HIGH);
digitalWrite(12,HIGH);
digitalWrite(A0,HIGH);
digitalWrite(A1,HIGH);
digitalWrite(A2,HIGH);
delay(250);
digitalWrite(9,LOW);
digitalWrite(10,LOW);
digitalWrite(11,LOW);
digitalWrite(12,LOW);
digitalWrite(A0,LOW);
digitalWrite(A1,LOW);
digitalWrite(A2,LOW);
delay(250);
}
```

Programming Note: This sketch sets each connection on Snapino™ to be an output, then toggles each on and off.

Project 16 Varying LED Brightness



Programming Note:
This sketch uses a counter to increase the brightness of the LEDs. Once the LED nears full brightness then the counter decreases to make the LEDs dimmer.

Some of the digital pins (including D9, D10, and D11, which are connect to snaps and used here) may be controlled using the **analogWrite()** command. **analogWrite()** simulates an analog voltage using pulse width modulation, which varies the duration of a digital pulse. Here the LEDs are made brighter by increasing the duration of the pulse (making the LEDs on for a longer amount of time), or made dimmer by decreasing the duration of the pulse.

The value for **analogWrite()** can be from 0 (LED off) to 255 (LED always on). This sketch uses a maximum value of 30 for **analogWrite()**, because the LED brightness would change very slowly for higher values. Try increasing this value from 30 to 255, upload the sketch to Snapino™, and see how it affects the LED brightness. You can also adjust the **delay** value (currently 30) to make the LED brightness change faster or slower.

Why do **analogWrite()** values of 30 or more make the LEDs appear at full brightness? Because the light is changing faster than your eyes can adjust, and your eyes continue seeing what they have just seen. This is often called "persistence of vision". This concept is used in movie theaters.

Build the circuit and load sketch Varying_LED_Brightness into Snapino™ using the programming instructions in project 3. The three LEDs (D1, D2, & D10) continuously vary in brightness.

Varying_LED_Brightness | Arduino 1.6.9

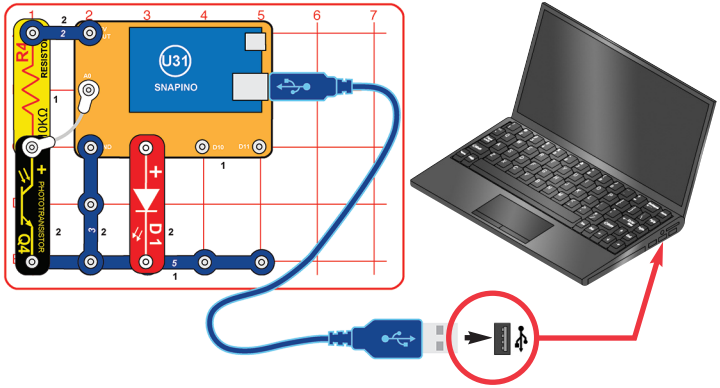
File Edit Sketch Tools Help

Varying_LED_Brightness

```
//Varying_LED_Brightness

int lightval = 0;
int counter = 1;

void setup() {
  pinMode(9,OUTPUT);
  pinMode(10,OUTPUT);       //Declare which variables are outputs.
  pinMode(11,OUTPUT);
}

void loop() {
  if(counter <= 0){         //Switch to add to counter.
    lightval = 1;
    }
  if(counter >= 30){        //Switch to subtract from counter.
    lightval = 0;
    }
  if(lightval == 1){        //Start adding to the counter.
    ++counter;
    }
  if(lightval == 0){        //Start subtracting from the counter.
    --counter;
    }
  analogWrite(9,counter);
  analogWrite(10,counter);  //Turn the LEDs on at the value of the
  analogWrite(11,counter);
  delay(30);                //Wait 30 milliseconds.
}
```

Project 17

Light Controlled LED



Build the circuit and load sketch Light_Controlled_LED into Snapino™ using the programming instructions in project 3. Vary the brightness of light on the phototransistor (Q4) to change the brightness of the red LED (D1). The red LED gets brighter as the phototransistor gets darker. The circuit acts as a night light, making the red LED brighter as the room gets darker.

Light_Controlled_LED | Arduino 1.6.9

File Edit Sketch Tools Help

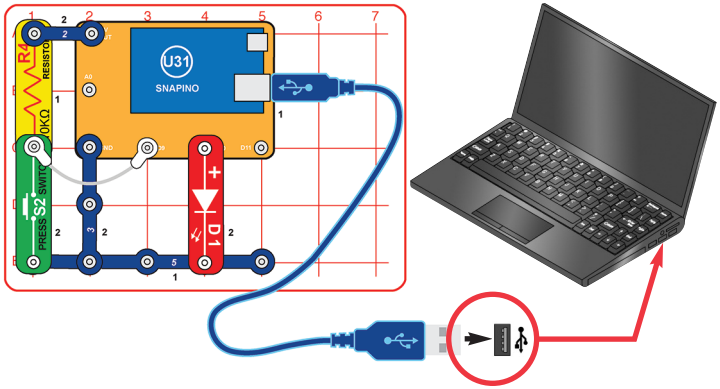
Light_Controlled_LED

```
//Light_Controlled_LED

const int phototransistor = A0;
int lightval;

void setup() {
  pinMode(9, OUTPUT);
}

void loop() {
  lightval = analogRead(phototransistor); //Read the value from the phototransistor
  analogWrite(9,lightval/16);             //Turn on the LED at a certain brightness
  delay(5);                               //Wait 5 milliseconds
}
```

Programming Note:
The light on the phototransistor is measured with the **analogRead()** command, then 1/16 of that value is used for the red LED brightness with the **analogWrite()** command. The value is divided by 16 because **analogRead()** returns a number between 0 and 1023 while the **analogWrite()** value must be between 0 and 255, and because the red LED will appear to be near full brightness for values >30.

Project 18

LED Brightness Button



Build the circuit and load sketch LED_Brightness_Button into Snapino™ using the programming instructions in project 3. Push the press switch (S2) repeatedly; the red LED (D1) gets brighter each time. After the red LED reaches full brightness then it resets and starts over.

LED_Brightness_Button | Arduino 1.6.9

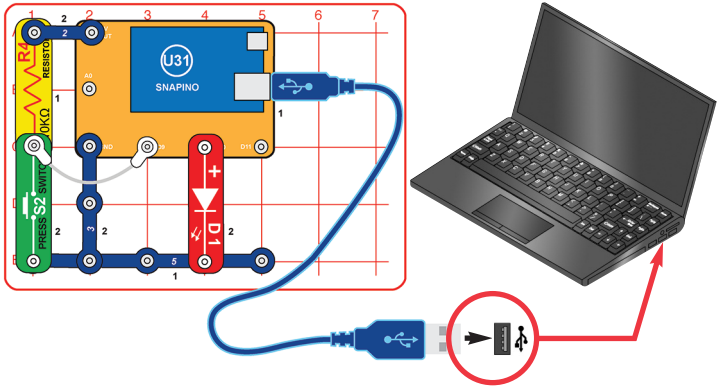
File Edit Sketch Tools Help

LED_Brightness_Button §

```
//LED_Brightness_Button

int LEDstate = 0;
int buttonval = 0;
int oldbuttonval = 0;
int level = 0;
int brightness [] = {1, 2, 4, 8, 16, 32, 64, 128, 255, 0};
                                        //Set up aray with LED brightness values
void setup() {
  pinMode(9,INPUT);
  pinMode(10,OUTPUT);
}

void loop() {
  buttonval = digitalRead(9);
  if((buttonval == LOW) && (oldbuttonval == HIGH)){
    LEDstate ++;
  }
  oldbuttonval = buttonval;
  if(LEDstate >= 1){
    LEDstate = 0;
    analogWrite(10,brightness[level]);  //Set LED brightness
    level ++;                           //Increment array to next value
    if (level >= 10) {                  //Reset array after last value is used
      level = 0;
    }
    }
    delay(10);
}
```

Programming Note:
The red LED brightness is set using the **analogWrite()** command, which uses values from 0 to 255, but incremental increases will be much more noticeable between low numbers than between high numbers. Because of this, this sketch uses an array to set the red LED brightness in multiples of 2, then resets back to minimum.

Project 19 Sloppy Switches



Build the circuit and load sketch Sloppy Switches into Snapino™ using the programming instructions in project 3. Slowly push the press switch (S2) many times, watching the red LED (D1) as you do. Usually the LED will turn on or off when you push the switch, but sometimes it will stay the same. Do you know why the LED sometimes stays the same?

Programming Note:
When you push the switch its contacts may bounce, sometimes making equipment monitoring the switch think it was pressed more than once. This effect is called "switch bounce". To prevent this a small delay is normally added to ensure the switch contacts have settled before the sketch checks the switch again.

In this sketch the delay(10); command has // in front of it, making it a comment that is ignored by the sketch. Remove the //, upload the revised sketch, and see if the red LED always changes when you push the switch.

Sloppy_Switches | Arduino 1.6.9

File Edit Sketch Tools Help

Sloppy_Switches

```
//Sloppy_Switches

int LEDstate = 0;
int buttonval;
int oldbuttonval;

void setup() {
  pinMode(9,INPUT);
  pinMode(10,OUTPUT);
}

void loop() {
  buttonval = digitalRead(9);
  if((buttonval == LOW) && (oldbuttonval == HIGH)){
    ++LEDstate;
    }
  oldbuttonval = buttonval;
  if(LEDstate >= 2){
    LEDstate = 0;
    }
  if(LEDstate == 1){
    digitalWrite(10,HIGH);
    }else{
      digitalWrite(10,LOW);
    }
  //delay(10);
}
```

Project 20 Click Counter

This project opens a window on your computer to display how many times you pressed a button. Use the preceding circuit but upload sketch Click_Counter into Snapino™. When the upload is finished, click on the **Tools** menu, then pick **Serial Monitor** from the list. A window opens on your computer screen. Push the press switch (S2) as many times as you like; the program displays the current count on your computer screen. The red LED (D1) is not used, and may be removed.

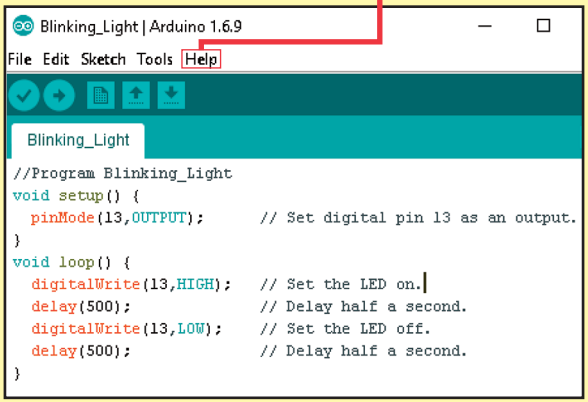
Programming Note:
Remove the delay(10); command from the sketch (or add // in front to make it a comment that is ignored), upload the revised sketch, and watch the display as you are pushing the press switch. Notice that sometimes the display will show you pushed the switch several times when you only pushed it once.

To Go Further

Snap Circuits® is an ideal environment for working with Arduino due to the ease of building circuits with it. The modules available in your Snapino™ set comprise only a small fraction of those available, for a full listing go to www.snapcircuits.net. **Additional Snapino™ sketches for use with other Snap Circuits® sets are available at the Snapino™ product page (www.snapcircuits.net/scsnapino).**

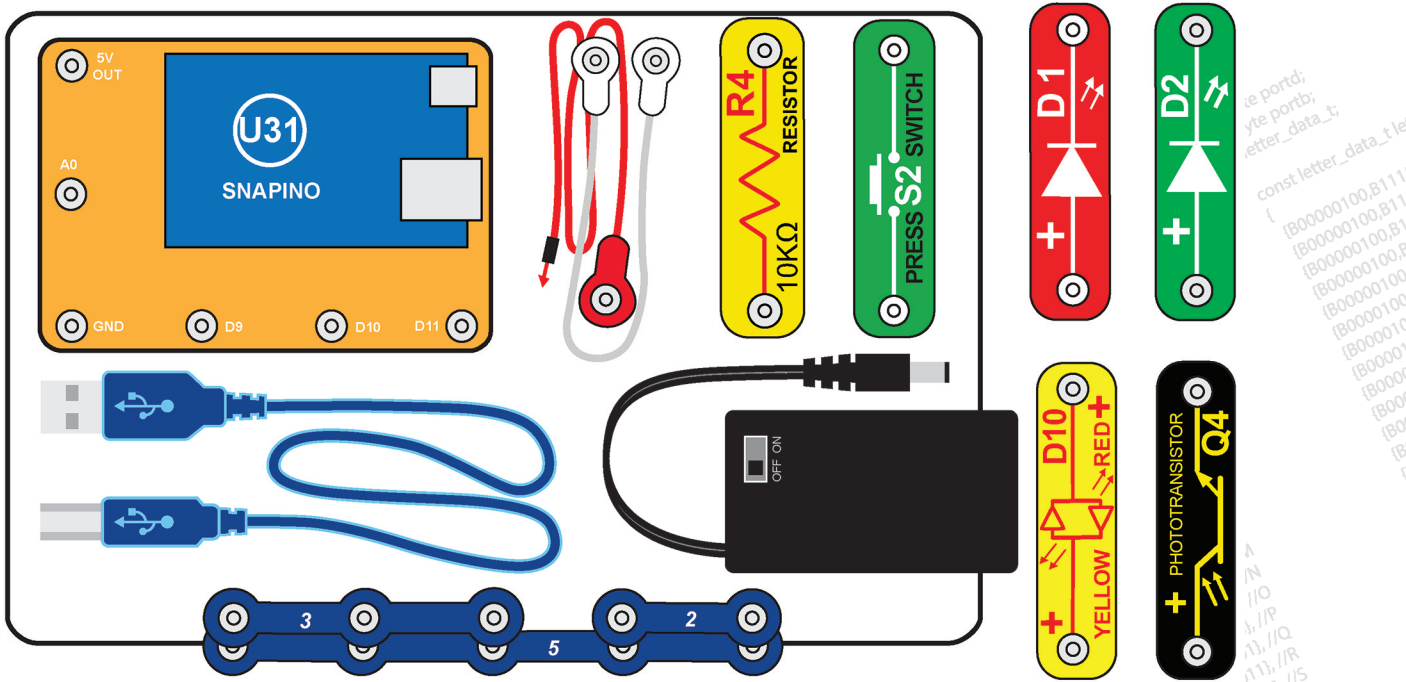
Only 9 of the Arduino UNO connection points are accessible by snaps on the Snapino™ module and some of those (A1 & A2) are not used in any Snapino™ projects; they are available for future experimenting on your own. The UNO connection points that are not accessible by snaps may be accessed using snap-to-pin wires, which may be purchased from Elenco® in 10-packs as SCJW-10.

This set is only intended as an introduction to Arduino. Users who want to learn more about it should visit the Arduino website (www.arduino.cc) after finishing the projects in this set. Explanations for all Arduino commands, and some basic information about programming, can be found under the **Help** menu in the Arduino software IDE, or on the Arduino website (www.arduino.cc).



WARNING: This product should ONLY be powered using a USB cable, the 9V battery holder included in the set, or an AC adapter with 9V output (not included). **It should NEVER be used with Snap Circuits® battery holders or other power sources!**

Some graphical programming languages have been developed to make Arduino programming easier by picking command blocks from a list instead of typing in a program; these may be helpful to new Arduino users. One is Ardublock, see www.ardublock.com to learn more about it.

SC-SNAPINO Block Layout

Important: If any parts are missing or damaged, **DO NOT RETURN TO RETAILER**.
Call toll-free (800) 533-2441 or e-mail us at: help@elenco.com. Customer Service • 150 Carpenter Ave.
Wheeling, IL 60090 U.S.A. **Note:** A complete parts list is on page 2 in this manual.