You do (and a little thing called a microprocessor). Each Smart Circuits module contains an electronic component that can take orders from a tiny—but powerful—computer in your microprocessor module.

Written by Ben Gould, Betsy Henry Pringle, and Jim Becker
Your Kit Includes:

**6 Boards**
Connect boards to construct flat and three-dimensional surfaces for your games and gadgets. The Build illustration for each activity will show you the suggested board assembly. As you get more advanced, you can create your own board configurations.

**Assemble**
On each board, two sides have narrow tabs and two sides have wide tabs.

- **Wide Tabs**
  - Once assembled, do not try to bend your boards from flat to angled or from angled to flat.
  - When assembling a flat build, wide tabs slide **down** into wide grooves; narrow tabs slide **up** into narrow grooves.

- **Narrow Tabs**
  - Wide tabs at the bottom slide **down** into wide grooves.
  - Narrow tabs at the bottom slide **across** into narrow grooves.

**Modules**
Each module has multiple ports, and each port has three pinholes you can use.

**Wires**
Your Kit comes with four lengths of hookup wires. The diagrams will indicate the color of the suggested wire length. As you get more advanced, you can choose the wire length that works best for your board configuration.

- **10 White**
- **10 Gray**
- **10 Black**
- **1 Green Wire**
- **1 Red Wire**

**Tips for Parents**
Please read over the activities prior to your child’s experimentation. Because children’s abilities vary so much, supervising adults should exercise discretion as to which activities are suitable for their child. Make sure your child understands the following:
- Connect the wires only as directed in the instructions.
- Not all wires will be used in every activity.
- Not all component ports will be filled in every activity.
- Do not short circuit the battery.
- NEVER stick the wires into any electrical outlet or socket.

**50 Builds—Unlimited Projects!**
This book shows 50 builds, but many of them can be expanded into multiple projects—sometimes just by moving a single wire! Look for this symbol throughout the book:

When you see this icon, go to the Operate and What’s Going On sections for multiple projects in the same build.

**MP**
Do not disassemble or alter any electronic part. Alteration could cause the toy to stop functioning permanently or overheat. Battery leakage could occur.

**Seek The Help Of The SmartLab**
Something missing or broken? Call SmartLab Customer Service at 1-866-319-5900. We will happily resolve your concerns.
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**READ THIS FIRST**

*Use these best practices to build each of your circuits.*

**Connect**

1. **Press the modules into the holes on the boards, as shown in the Build Illustration.**

2. **Use the Wire diagram as your guide for each port-to-port hookup.** The Wire diagram also indicates the wire color you’ll use for each port hook up.

3. **Starting at the top left of the Wire diagram, press the metal end of the wire firmly into a pinhole of the port indicated.** The first wire you plug in will ALWAYs be to the negative (–) side of the battery (BAT–).

4. **Press the other end of the wire into the port indicated in the diagram.**

**Check**

6. **Before you hook up the last wire, STOP and check to make sure you’ve wired each connection correctly.** We’ve included a handy check-off box for you!

**Power**

7. **Connect the last wire to the power source, which is the positive side of the battery (BAT+).**

- On some builds, the action starts as soon as the last hookup is made.
- Other projects have an Operate section with numbered instructions.
- Games feature a Gameplay section.

Always remove all the wires from the modules before building a new circuit.

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**Troubleshooting Power Check**

Anytime you want to test your batteries, build the simple circuit described in **Build 1**. If the LED lights up, the batteries are good. If not, it’s time to replace them.
Electricity

Electricity is the invisible energy you use every day. It’s all around you, but where does electricity come from?

Everything is made of tiny parts called atoms. Inside atoms are smaller particles called electrons. Electrons can jump from one atom to another. The movement of electrons is electricity. When a bunch of electrons are moving in the same direction, you have an electric current.

Electric Current

When electric current flows, amazing things can happen—you can use it to cook a pizza, light up your bedroom, or power a computer. But electric current can’t just flow into your devices and stop. For electricity to work, the current of electrons has to keep moving in a circle or an electric circuit.

In the circuit you just built, the component was a light-emitting diode and it used the electrical energy to light up!

Electric Circuits

In an electric circuit, electrons start their journey by flowing from the battery. They travel through a loop of conductive material (usually metal wires), giving up energy along the way.

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What’s Going On?

This loop of electricity flowing from the battery, through the wire, through the LED, and through the wire back to the battery is an electric circuit. In order to understand what’s going on, you first need to know a bit about electricity.

Build a Glowing Circuit

Make electricity flow through a simple circuit to light up an LED.

For this first build, you’ll wire up a basic circuit.

1. Plug one end of a gray wire into the port on the negative side of the battery (BAT–).
2. Plug the other end of the wire into the LED 7 port. This is the negative side of the LED module.
3. Plug one end of another gray wire into the LED 1 port.
4. Plug the other end of the wire into the port on the positive side of the battery (BAT+).

Is the LED glowing? If so, you’ve built your first circuit! If it’s not, check all your wire connections and make sure the batteries are installed correctly.

What are those two wires? Every project will have at least two wires—one coming out of the negative side of the battery and one going into the positive side. Why? It all has to do with how circuits are built. Keep reading to find out more.

Wire

1. BAT– 2. BAT+
2. LED 7 3. LED 1
3. BAT– 4. BAT+

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Light

When the electricity flows through the wires from the terminal of the battery, around the loop, and back to the battery, it is called a complete circuit.

Because it flows, people often compare electricity to water. Water flowing can also be used to do things.

Electronic Components

Throughout a circuit, different parts or components can be added. Some components—like an on/off switch—regulate the flow of energy. Some components turn the electrical energy into other forms of useful energy, like light or sound.

In the circuit you just built, the component was a light-emitting diode and it used the electrical energy to light up!
**Make It Two!**

Light up two LEDs at the same time by building a parallel circuit.

2. Use another wire to connect LED 1 to BAT+. LED 1 should light up.
3. Plug a third wire into LED 2 and connect it to another pinhole of BAT+. LEDs 1 and 2 should light up.

Another way to make this parallel circuit is to connect the two LEDs with a wire, and then connect this LED module to the battery.

---

**Conductance Detector**

Use the green and red wires to test how well certain materials conduct electricity.

2. Connect the green wire to LED 1.
3. Connect the red wire to BAT+.

Operate

1. Touch the end of the green wire to the end of the red wire. You should see LED 1 light up.
2. Now touch both of the loose ends to a coin. Did the LED light up?
3. Touch the ends to other objects to see what makes a good conductor, and what might make a good insulator. Try fruit, a glass of salt water, a glass of tap water, juice, and wood!

---

**What’s Going On?**

In a simple circuit like the one in Build 1, the electric current has one path (wire) to travel as it flows through the circuit.

In a parallel circuit, the current has more than one path to travel. The current will continue to flow through one LED if the wire leading to the other is broken or disconnected.

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The word parallel refers to lines that are side by side. In a parallel circuit, the electric current divides into two or more paths before coming back together to complete the circuit.

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**Electric current travels through some materials quite easily. These materials are called conductors.** Metals like copper, silver, aluminum, and gold are good conductors. A material that does not transmit electricity is called an insulator. Plastic, rubber, and glass are good insulators. That’s why the metal wires (conductors) in your kit are wrapped in plastic (insulator)—to keep the electricity inside the wire.

---

A material’s ability to transmit electricity is called conductance. Some materials, such as metals, allow electricity to flow easily.

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Some materials resist the flow of electricity. The greater the resistance, the more difficult it is for electrons to flow.

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**WARNING!**

NEVER STICK THE WIRES INTO ANY OUTLET!

You can also daisy-chain the LEDs together by connecting one to the next all the way from LED 1 to LED 6.
Wires can conduct electricity back and forth, but some electronic components can move electricity in only one direction. Components that conduct one way only are called semi-conductors. LEDs are a type of semi-conductor.

In this build, you’ll connect the wires as you did in Project #1 to make the LED light up. Then you’ll reverse the wires. Does anything happen?

What’s Going On?
LEDs are diodes, components that allow current to flow in only one direction. Current flows from the positive terminal of the diode to the negative terminal. LEDs give off light when electricity passes through them. Unlike regular light bulbs, LEDs use very little electricity.

Current can’t flow in this direction.
A push button is a simple way of connecting and disconnecting wires.

What's Going On?
Inside the button is a tiny piece of metal. When the button is pressed, the metal touches the two wires that go into it. This completes the circuit by making a bridge for electricity to flow to the LED. When the button isn’t being pressed, the metal doesn’t touch the wires and the electricity can’t flow through. This is the same as turning the power on and off.

Our everyday lives are full of buttons just like this: doorbells, keyboards, and TV remotes all have buttons.
**Resistors** are components that resist the electricity that flows through them. That means they reduce the flow of electricity in a circuit. You can change the brightness of the LED by controlling the amount of electricity that goes through it.

Resistors are usually made out of carbon, which is not a particularly good conductor. The more carbon the electricity has to flow through, the more the current is reduced.

**Operate**
1. Turn the knob on the variable resistor. What happens to the LED?

**What’s Going On?**
A variable resistor has a knob that lets you adjust the amount of electricity moving through the circuit. In this build, the variable resistor is placed between the battery and the LED module. Turning the knob changes the amount of electricity that is lighting up the bulb.

**Build 10**

**Tilt Switch**

**Operate**
1. Pick up the board and tip it from side to side to turn the tricolor LED on and off.

**What’s Going On?**
When the metal ball rolls to the end, it closes the gap in the circuit, and the tricolor LED lights up.

The tilt switch is built with a tiny metal ball bearing that rolls from side to side along a track when tilted. Give the tilt switch a shake and you’ll hear the ball bearing inside. Whenever the ball touches one end of its track, a connection is made and the circuit is completed, just like pressing the push button.

**Build 9**

**Varying Light Levels**

**Operate**
1. Turn the knob on the variable resistor. What happens to the LED?

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It's called a "chip" because it's made from a tiny piece of silicon (the stuff sand is made of) etched with microscopic wires.

Congratulations! You’ve completed your first 10 circuits! Now it’s time to start playing with the microprocessor! A microprocessor is a tiny but powerful computer. It has electrical connection points where it can receive information (INPUT), and transmit information (OUTPUT). Information comes to and leaves the microprocessor in the form of electrical pulses and signals.

This tiny microprocessor (makes sense: micro = tiny, processor = computer) has all the same building blocks of even the biggest computers. Here’s what virtually EVERY computer has, including your microprocessor:

- **Inputs**: How the microprocessor receives information from the outside world. Inputs tell the computer what to do.
- **Outputs**: Allows the microprocessor to turn things on.
- **Central Processing Unit (CPU)**: The brains of the computer. Does all the calculating and makes all the decisions.
- **Random-Access Memory (RAM)**: Temporary memory your microprocessor uses to remember things that you input into the microprocessor, such as which program to run.
- **Read-Only Memory (ROM)**: Built-in memory installed at the factory. Your ROM stores the information needed for each project, as well as the sound effects.
- **System Clock**: Sends the microprocessor pulses of electricity at regular intervals so everything happens at the correct time.

As soon as you complete the circuit (connect M+ to BAT+), you should hear the speaker make a sound. Disconnect the BAT+ wire when you want the sound to stop.

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What’s Going On Inside the Microprocessor Module?

Inside the module, a computer chip holds the electronic circuitry. The chip is only about this big: All the computing power you need to create 40 different electronics builds is crammed into that tiny chip.

Inputs: How the microprocessor receives information from the outside world. Inputs tell the computer what to do.

Outputs: Allows the microprocessor to turn things on.

Central Processing Unit (CPU): The brains of the computer. Does all the calculating and makes all the decisions.

System Clock: Sends the microprocessor pulses of electricity at regular intervals so everything happens at the correct time.

At the factory where it was manufactured, your microprocessor was programmed to perform certain tasks.

What’s Going On?

Let’s use the example of Build 11 to see how it all works. When you hook up all the wires, here’s what happens:

1. The wires going to and from the battery provide electricity for the circuit.
2. The microprocessor senses the wire in PROG A and PROG B as INPUTS. It sends a signal to the ROM to remember that wires A and B are connected together.
3. The CPU goes to the ROM and looks up what it should do when PROG A and PROG B are connected.
4. ROM tells the CPU to play a tone.
5. The tone is directed to the speaker OUTPUTS and you hear a sound! So even this simple project of playing the tone used the CPU, INPUTS, RAM, ROM, and OUTPUTS, just like every other computer!

A speaker is a transducer—a component that converts, or changes, electricity into something else, like light or sound. A speaker converts electricity into sound.

A speaker has a paper cone, a magnetic field, and a moving magnet (a magnet that only works with electricity). When electrical pulses flow through the circuit, the electrical field pushes and pulls against the regular magnet. This shakes the paper cone so fast it makes a sound you can hear!
Microprocessors are great at multitasking—doing more than one thing at a time. They can send multiple signals in many different directions while receiving and processing information.

In this build, the microprocessor will make tones and flash lights at the same time.

**What’s Going On?**

When you connect a wire between PROG A and PROG C, your microprocessor recognizes this as the program you want it to run. This particular program sends electrical pulses through two of the microprocessor’s outputs, so the speaker and tricolor LED are energized at the same time.

**What's Going On?**

The amount of electric current running through the variable resistor will change depending on how you rotate the knob. The microprocessor interprets the amount of electricity it is receiving through its input to determine the sound it is sending through the output.

**What's Going On?**

Most electronic screens are made up of many millions of tiny red, green, and blue lights. All of the colors on the screen are made by mixing the three light colors.

**What’s Going On?**

Build 13

**Varying Tone and Beeping**

Adjust the frequency of a tone pulse by turning the knob on the variable resistor.

Pulses of electricity through a speaker cause vibrations that produce a tone. The high or low pitch of the tone is based on how many times the electromagnet pulses per second. This rate of vibration is also known as frequency.

**What’s Going On?**

Turning the knob changes the electrical current going to the microprocessor. The program responds to the change by varying the output of the three colors of the tricolor LED.
If a light flashes on and off fast enough, it looks like the light is always on—even though it is still flashing! Did you know that fluorescent light bulbs are actually flashing all the time, and are not constantly lit? In fact, half the time they appear to be on, they are actually off and conserving energy.

### Persistence of Vision

#### Change the frequency to make a flashing light look like it’s always on.

1. Turn the knob on the variable resistor to change the frequency of electricity going to the tricolor LED.
2. Raise the frequency to the point where you can no longer see the flashes.
3. Pick up the boards and wave the LED in front of you.

**What’s Going On?**

For a split second after the flash has disappeared, your eyes are still sending the light signal to your brain. This effect is called persistence of vision. When the intervals between flashing lights are extremely small, the flickers appear to fuse into a continuous light.

### Sound Box

**Explore your sound effects program!**

Your microprocessor is programmed to play a whole bunch of recorded sounds. Here’s how to hear them!

#### Operate

1. Push the button to hear the sound effect.
2. Move the wire in MI 1 to MI 2.
3. Move the wire in MI 2 to MI 3.
4. Repeat for MI 4, MI 5, and MI 6.

**What’s Going On?**

As you know, sound is created by vibrations. In your microprocessor, prerecorded sound vibrations are stored as complex pulse sequences. When you select a sound to play, the microprocessor quickly sends the pulse sequence of that sound to your speaker. The pulses cause the speaker to vibrate, which emits vibrations—sound waves—into the air.

### Wired Sound Box

**Use the microprocessor port as a connection point to your sound effects inputs.**

In this experiment, you’ll connect a wire from MI+ to five inputs: MI 2 to MI 6. Each input will select a different sound.

#### Operate

1. Push the button.
2. Move the wire from MI 2 to MI 3 and push the button.
3. Repeat for MI 4, MI 5, and MI 6.

**What’s Going On?**

When you connect the positive terminal of the battery to the microprocessor (BAT+ to M+), M+ can then be used just like BAT+. The gray wire tells the microprocessor to play a sound. The wire connected to inputs MI 2 to MI 6 tells the microprocessor which sound to play.

---

Wire connections

- MI 2
- MI 3
- MI 4
- MI 5
- MI 6
- BAT+
- M+
- BAT—
- M—
- VR1
- VR2
- TC 1
- TC 2
- MO 7
- PB 1
- PB 2

- MS 13
- MS 14

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Lights Out!

Every great DJ uses a complex computer to manipulate and distort recorded sounds. Then they play back the sounds as music. In this build, you’ll adjust the speed and frequency of the recorded sounds on the microprocessor. Plus, if you hold down your push button, the selected sound will play in a continuous loop until the button is released!

DJ Playback
Adjust the variable resistor to change the speed and frequency of recorded sounds, just like a real DJ!

What’s Going On?
You will notice that the sounds sound “higher” when they are played back faster. A faster sound is higher frequency, so it sounds “higher pitched” to us. To test this, try placing your fingers on your throat, and hum a low note. Then hum a high one. You should feel the difference in your fingertips between the two; the low note has a slower vibration frequency than the high note.

Motorcycle Engine Sounds
Get your motor runnin’ and rev up the engine by adjusting the variable resistor!

Motorcycle engines are powered by controlled explosions. Every time one of these explosions occurs, the exhaust gases exit the tailpipe as a pop sound. These rapid pop-pop-pops are what give motorcycle engines their distinctive sound. In this circuit, when you rotate your variable resistor knob, you’ll hear the motorcycle go from a gentle idling sound up to a roaring speedster!

What’s Going On?
The microprocessor is programmed to create electrical impulses at the same frequency as a motorcycle engine. When those impulses go to the speaker and are converted into sound, it sounds like a real motorcycle!

Strobe Light
Stop motion!

As soon as you plug the wire into BAT+, the tricolor LED will start flashing. Turn the knob on the variable resistor to make it flash faster or slower.

What’s Going On?
A strobe light makes things that are moving look like they are standing still. Strobe lights flash a very bright light, but for only a very brief moment. When a strobe light is used in a dark room, moving objects appear to freeze and rapidly unfreeze as they move through space.

What’s Going On?
Normally, when something is moving, you see it as moving because over time you watch it change position. With a strobe light in a dark room, you see the object for only a split second, so there isn’t enough time for you to see it move to a new position. The falling-upward effect can be explained easily: If the flash is timed just right, then you might see a drop when it is 5 inches (13 cm) below the faucet on the first flash, and then see another drop when it is 4 (10 cm) inches below the faucet on the next flash, and so on. The drops would appear to be moving up, but they aren’t.

Connections

Connections

Connections
If you’ve ever spent the night on a farm, you might have heard a rooster crow at the first sign of the sunrise. We like roosters so much that we’ve put one inside your microprocessor. Just kidding! But we have programmed a rooster recording that will play when your light sensor detects light.

**Electronic Rooster**

Build a circuit that makes a rooster sound when light shines on the light sensor.

Operate
1. Place your Electronic Rooster in a dark room, then turn on the lights.
2. Did your rooster crow?
3. Want to have some fun? Put it in the drawer that your little brother keeps getting into. Or set it up in a dark bathroom and wait for someone to turn on the light!

**What’s Going On?**
A light sensor is a transducer that converts light into an electrical signal. When the light sensor is in the dark, it blocks the flow of electric current to an input on the microprocessor. When light hits the sensor, current flows to the input on the microprocessor and it plays the rooster sound.

**Shadow Composer**

Use your light sensor to make music.

Can you make music with light? You can in this build! Here, your light sensor will adjust the frequency of the sound depending on how much light it detects. More light will make a lower sound, and less light will make it higher.

**What’s Going On?**
Your light sensor can detect varying degrees of light. The electrical current is controlled by the amount of light the light sensor is exposed to. If there isn’t much light, there isn’t much electricity (high resistance), and a high tone is produced. If there is a lot of light, there is a lot of electricity (low resistance), and you get a low tone.

**Smart-Light**

Build a night-light that turns itself on when the lights go out.

Have you ever had a night-light in your bedroom? Many night-lights have a switch you turn on and off. The night-light you’re going to make in this build is smarter than that—it turns itself on when the lights go out!

**What’s Going On?**
Think of the light sensor as an on/off switch that’s controlled by light. In this circuit, your microprocessor is programmed to turn on the LEDs when the light sensor detects no light. This is the way streetlights work: when the light is too low, the sensor tells the circuit in the streetlight to activate the flow of electricity.
Your eyes can’t see infrared light waves, but your light sensor can! So can your television. When you press a button on your TV remote, an infrared LED sends a signal to your TV. A sensor in your TV detects the signal as some sort of command for your TV’s microprocessor. Now, you’re going to use your TV’s remote control to turn on an LED!

**Invisible-Light Detector**

Make an infrared light detector like the one on your TV.

1. Turn out the lights. The LED should turn off.
2. Point a TV remote directly at the light sensor and press a button on the remote. The LED will light up to show you that it detected the infrared light that you didn’t see!
3. Release the button on the remote. Now push it again. The LED color should change. Keep pressing!

### Television

Test your ability to see rapidly flashing LEDs.

1. Turn the knob on the variable resistor from low to high to increase the speed of the flashing LEDs. How fast can you flash the LEDs before they seem to be constantly lit?
2. Adjust the light so you can see the flashes, then wave the module in the air and watch the light patterns.

What’s Going On?

As you know, white light is a combination of many colors and it travels in waves. Each color of light has a different wavelength, the distance between the peaks of the waves. Infrared light has such a long wavelength that it is invisible to humans, but not to your light sensor!

### Dance Party Light Show!

Create and control a light show!

1. Turn the knob on the variable resistor to speed up and slow down the flashes.
2. Practice with a piece of music until you can get the LEDs to sync up with the musical beats.
3. Turn off the overhead lights, start the tunes, and put on a show!

What’s Going On?

For a split second after the flash has disappeared, your eyes are still sending the light signal to your brain. When the intervals between flashing lights are extremely small, the flickers appear to fuse into a continuous light. On your TV or computer screen, the flashing lights are red, green, and blue, so you see everything in full color.

### What’s Going On?

For a split second after the flash has disappeared, your eyes are still sending the light signal to your brain. When the intervals between flashing lights are extremely small, the flickers appear to fuse into a continuous light. On your TV or computer screen, the flashing lights are red, green, and blue, so you see everything in full color.

What’s Going On?

The variable resistor is sending a signal to the microprocessor to change the speed of the red, green, and blue LED elements flash. Sometimes you see other colors like purple and orange, because these are mixtures of the red, green, and blue LEDs.
Drag Race Game
Test your reaction time—
like a real drag racer!

Ready, Set, RACE!
At the starting line of every racetrack is a set of lights on a pole called the Christmas tree. The lights tell the drivers when to step on the gas and GO! Races are won—and lost—by fractions of a second, so a winning drag racer must have excellent reaction timing, beginning with how he or she begins the race at the starting line.

Gameplay
Number of players: 2
Overview: Be the first to push your button when LED 1 lights up.
• Each player has a push button.
• When the circuit is connected, LED 6 will light up, then LED 5, and so on.
• As soon as LED 1 lights up, each player pushes his or her button.
• The player who presses first while LED 1 is lit is the winner!

Scoring
After 10 races, LED 1 will flash the number of points scored by Player 1, then LED 6 will flash the number of points scored by Player 2.

Racers ready?
ACTION SOUND SCORE
Player 1 wins 1 beep Player 1 scores 1 point
Player 2 wins 2 beeps Player 2 scores 1 point
No winner 3 low tones Neither player scores a point

Color Trap It!
Trap the blue light!

Gameplay
Number of players: 1
Overview: Whenever you see the blue light, press your push button.
• Press the button to start the game. The tricolor LED will blink three times, then you will hear a tone play three times. After that, the LED will flash randomly.
• Push the button every time the blue LED lights up. If your trap is successful, you will hear a tone.
• After four successful traps, the game will move to the next level and the speed will increase.
• The game is over when a buzzer sounds and the blue LED lights up for three seconds.

Scoring
If you miss pressing your button or wait too long, the game is over. After you hear the buzzer and see the blue light, the level you achieved will be displayed by green LED flashes.

Operate
1. Hold the baton in your hand and tilt it back and forth or side to side. Each tilt plays the next note in a song.

Music is made up of many notes played in the right sequence, and in the right timing. Each note is a different frequency. This program features a sequence of frequencies (notes) that you will play by moving the tilt switch back and forth.

What’s Going On?
Every time the tilt switch is activated, the program tells the microprocessor to play the next note in the song.
**Electronic Drum Kit**

**Play four different drum tones!**

Are you ready to rock? Many musical artists use electronic drum sounds in their songs. Electronic beats allow artists to manipulate the sound and timing with much greater precision than live acoustic instruments. Each of these modules, when played correctly, will trigger a different drum sound through the speaker:

- **Hi-hat cymbals**
- **Snare drum**
- **Bass drum**
- **Cymbal crash**

**What’s Going On?**

By waving and pushing and shading, you’re starting and stopping the current flowing through the different modules (completing and breaking the circuit). The microprocessor has been programmed to make a specific drum sound when the current flows or stops at each module.

---

**Build 30**

Are you ready to rock? Many musical artists use electronic drum sounds in their songs. Electronic beats allow artists to manipulate the sound and timing with much greater precision than live acoustic instruments. Each of these modules, when played correctly, will trigger a different drum sound through the speaker:

- **Hi-hat cymbals**
- **Snare drum**
- **Bass drum**
- **Cymbal crash**

**What’s Going On?**

By waving and pushing and shading, you’re starting and stopping the current flowing through the different modules (completing and breaking the circuit). The microprocessor has been programmed to make a specific drum sound when the current flows or stops at each module.

---

**Build 31**

**Scary, Funny, or Smelly Game**

Follow the colors for hilarious results!

Players follow the changing light colors, pressing the buttons to make different sounds. Pay attention and press quickly, or the game is over! Challenge a friend to beat your high score!

**Gameplay**

**Number of players:** 1 or 2

**Overview:** Press the buttons according to the light colors.

- Press push button A to start the game.
- The tricolor LED will start cycling. When you see those lights, press these buttons:

<table>
<thead>
<tr>
<th>COLOR</th>
<th>BUTTON TO PRESS</th>
<th>YOU’LL HEAR</th>
</tr>
</thead>
<tbody>
<tr>
<td>RED</td>
<td>A</td>
<td>Scream</td>
</tr>
<tr>
<td>GREEN</td>
<td>B</td>
<td>Laughter</td>
</tr>
<tr>
<td>BLUE</td>
<td>A and B at same time</td>
<td>Fart</td>
</tr>
</tbody>
</table>

**Scoring**

At the end of the time limit, the player’s score will be shown by light flashes:

- 1 red flash = 10 points
- 1 green flash = 1 point
- For example, five red flashes and seven green flashes = 57 points.

Use a paper and pencil to keep track of each player’s score. After scoring, the game restarts when button A is pushed.

---

**Build 32**

**Motion-Sensing Room Alarm**

Create your very own light-sensing security system.

Want to stop intruders in their tracks? In this program, your light sensor is like a watchdog that never sleeps.

**Operate**

Works best in direct light!

1. Place the circuit in a location where an intruder (like your little brother) will cast a shadow over the light sensor.
2. Once you’ve found your location, try walking naturally past the sensor to see if you trigger the alarm. If not, move the circuit or provide more light, and retest.

**Scoring**

The sensor is continually checking light levels and sending signals to the microprocessor to report changes. This same sort of sensor is used in some of the most advanced security systems today.

---

**What’s Going On?**

The sensor is continually checking light levels and sending signals to the microprocessor to report changes. This same sort of sensor is used in some of the most advanced security systems today.
Coin Flip
Build an electronic decision maker!

Do you ever just need to flip a coin to make a decision—like who’s going to take out the garbage? This circuit will help you out of those tough situations. Red is heads. Green is tails. Decision made!

This program also works great for playing Truth or Dare.

What’s Going On?
Once you build the circuit, pressing the push button will cause the microprocessor to randomly choose either the red or the green LEDs in the tricolor LED to illuminate.

Conductance Meter
How many LEDs can you light up?

Compare the conductivity of different materials on a scale from 1 to 6. This circuit will take analog (continuous) input in the form of conducted electricity and convert it into digital (on or off) output using your LED module.

What’s Going On?
You’ve probably seen two kinds of car speedometers: one is mechanical and has a needle that moves across a dial (analog), the other displays numbers on a screen (digital). The analog speedometer allows you to watch the needle move between numbers on the dial as you speed up and slow down. The digital readout shows you your speed at any given moment.

When you touch the green and red wires to a conductive object, electric current flows through the object and to the microprocessor. The computer measures the amount of returning electricity and lights up LEDs corresponding to the amount of electric current. The strength of the electric current (analog input) is shown as the number of glowing LEDs (digital output). A highly conductive object will light up all six LEDs.

Conductance
Meter
What’s Going On?
When you close the refrigerator door, does the light stay on? Build a circuit to find out!

Fridge Fright
Solve a mystery—and give someone a surprise!

What’s Going On?
If no light is detected by the light sensor, no action. But when light shines on the light sensor, electric current flows to the microprocessor and a prerecorded alarm will sound for 5 seconds.

Operate
1. Cover the light sensor module.

What happens when you remove your hand? You’d hope the sound goes off. It’s time to set up the loop, or the experiment. Here’s how:
1. Clear room on the top refrigerator shelf (if the shelf is sticky, wipe it off and dry it first).
2. Place your circuit on the shelf. Now close the door and wait for someone to open the fridge!

Build 33
Coin Flip
Build an electronic decision maker!

Operate
1. Push the button. The tricolor LEDs will blink rapidly and you’ll hear a clicking sound. Then they’ll slow down. When the decision is made, you’ll hear a tone and either the red light or the green light will be on. The light will stay on until the button is pushed again.

What’s Going On?
Operate
1. Gather small items and place them where the ends of the green and red wires can touch them. Examples of items to test: penny, plastic toy, fruit, potato, metal toy car, pencil, eraser, soda can, salt water, and tap water.

Operate
1. Touch the ends of the green and red wires to either side of an object to see how many LEDs light up. A very conductive object should illuminate all 6. Can you find objects that light up only 3? Or even 1?

Operate
1. Clear room on the top refrigerator shelf (if the shelf is sticky, wipe it off and dry it first).

Operate
1. Place your circuit on the shelf. Now close the door and wait for someone to open the fridge!

Operate
1. Choose and change sound effects by moving the wire coming from M+ to MI 2, MI 3, and so on. The program restarts when no light is detected again.

Choose and change sound effects by moving the wire coming from M+ to MI 2, MI 3, and so on. The program restarts when no light is detected again.

Operate
1. What’s Going On?

What’s Going On?
When you close the refrigerator door, does the light stay on?

What’s Going On?

Build 34
Conductance Meter
How many LEDs can you light up?

Build 35
Fridge Fright
Solve a mystery—and give someone a surprise!

What’s Going On?
If no light is detected by the light sensor, no action. But when light shines on the light sensor, electric current flows to the microprocessor and a prerecorded alarm will sound for 5 seconds.

What’s Going On?

What’s Going On?

What’s Going On?
Quiz Show Game

Play an electronic trivia game! Questions and answers are on the back cover of this book.

Gameplay

Number of players: 3
(1 game show host and 2 contestants)

Overview: Contestants compete to see who can buzz in first and answer the question correctly.

• Contestant 1 stands in front of push button A.
• Contestant 2 stands in front of push button B.
• The Host will read a trivia question aloud (see back cover for questions and answers).
• The two contestants will compete to buzz in and answer the question correctly.
• If Contestant 1 buzzes first, LED 1 will light up.
• If Contestant 2 buzzes first, LED 6 will light up.
• The light will go dark after 5 seconds so you can go to the next question.

If you want to keep score, use a piece of paper and give each contestant 1 point for each correct answer. The first contestant to get 10 points wins the game. The next time you play, try writing your own trivia questions!

In this two-player game, each player attempts to "trap" his or her LED while it's lit. The lights flash progressively faster with each trap.

Gameplay

Number of players: 2

Overview: "Trap" your light when it flashes.

• Player 1 controls push button A.
• Player 2 controls push button B.
• The game starts as soon as the BAT+ wire is hooked up to M+.
• The LED module will randomly flash.
• When your LED is lit on D1, quickly press your button to "trap" it. If the trap is successful, you’ll hear a high-pitched tone. If the trap missed, the tone is low.
• Each successful trap speeds up the game. The game is over when one player has trapped five LEDs.

Scoring

After one player has trapped five LEDs, LED 1 flashes the number of points scored by Player 1, and LED 6 flashes the number of points for Player 2. Scoring example: If Player 1 scored three points and Player 2 scored five points, LED 1 will flash three times, pause, and then LED 6 will flash five times.

Wire

[Diagram of wire connections]

If you want to keep score, use a piece of paper and give each contestant 1 point for each correct answer. The first contestant to get 10 points wins the game. The next time you play, try writing your own trivia questions!
Pong Game

Play electronic ping-pong!

In this version of a classic video game, a push button takes the place of a paddle. The game starts slowly, but it speeds up quickly.

Gameplay

Number of players: 2

Overview: Push your button while the LED at your end of the module is still glowing.

- Player 1 stands in front of push button A.
- Player 2 stands in front of push button B.
- When BAT+ is plugged into M+, you’ll hear three tones announcing the start of the game. Then, LEDs 1-6 will light up in sequence (1, 2, 3, 4, 5, 6).
- Player 1 presses his button when LED 1 lights up.
- Player 2 presses hers when LED 6 lights up.
- The lights will move faster and faster until a player misses hitting the button.
- If a player fails to press the button in time, you’ll hear a funny tone and all the lights will flash. Then, the game starts over.

Wire

[Diagram of connections]

Grab a paper and pencil if you want to keep score.

Magic Message Wand

Make a secret message appear in the air!

In this version of a classic video game, a push button takes the place of a paddle. The game starts slowly, but it speeds up quickly.

Your microprocessor has been programmed with a secret message.

What’s Going On?

The lights from the quickly moving LEDs hit different parts of your retina as they move. Your eyes don’t refresh immediately after each flash, so your eyes retain an afterimage—an image that continues to appear in your vision after the original object is no longer there. If you wave the wand really fast, you’ll see the lights coming from their first position as they move into their final position. Your brain puts it all together and sees the whole picture.
Knock, knock!
Who’s there?
How come.
How come who?
How come I’m knocking on your door when you’ve got this sweet doorbell?!

This circuit lets you make your very own doorbell—which should ensure that guests don’t show up with any more rotten knock-knock jokes!

What’s Going On?
You can find doorbells on nearly every house, but did you know that they are essentially the same as your push button? Doorbells send an electrical signal to a nearby microprocessor, which sends its signal to a speaker to make a sound.

Actions

**Knock, knock!**
- **Who’s there?**
- **How come?**
- **How come who?**
- **How come I’m knocking on your door when you’ve got this sweet doorbell?!**

**Make your very own doorbell**—which should ensure that guests don’t show up with any more rotten knock-knock jokes!

Ding-Dong!
Make a doorbell for your room!

**Knock, knock!**
- **Who’s there?**
- **How come?**
- **How come who?**
- **How come I’m knocking on your door when you’ve got this sweet doorbell?!**

This circuit lets you make your very own doorbell—which should ensure that guests don’t show up with any more rotten knock-knock jokes!

**What’s Going On?**
You can find doorbells on nearly every house, but did you know that they are essentially the same as your push button? Doorbells send an electrical signal to a nearby microprocessor, which sends its signal to a speaker to make a sound.

**Authorized Entry Only!**
Push the button for permission.

**Make sure bright, direct light is shining on the Light Sensor.**

**Action Sounds Game**
Beat the computer!

**This one- or two-player game requires lightning-fast reflexes.**
When you hear a sound, you must quickly perform the correct task. If you perform the wrong task—game over. If you take too long—GAME OVER!

**Gameplay**
Number of players: 1–2

**Overview:** When you hear the sound, perform the task!

- **Press button A to start the game.**
- **The speaker will play one of four randomly selected sounds: ROOSTER, EVIL LAUGH, FART, or SCREAM. You have 2 seconds to activate the assigned trigger:**
  - **If no trigger is activated within 2 seconds, a buzzer sounds and the game is over.**
  - **If you activate the wrong trigger, a buzzer sounds and the game is over.**
  - **If the correct trigger is activated within 2 seconds, the next sound is played, and so on until an error is made.**
  - **Each “level” is four completed sounds.**

**Scoring**
After a miss, the DOORBELL sound announces the number of levels completed (2 DOORBELLS = Level 2).
Do you love playing board games? Wiring together an electronic circuit might be more complex than rolling a pair of dice, but you'll look a whole lot cooler at your next Monopoly tournament!

Electronic Dice
Generate a random number from 1 to 6 through chance—just like a pair of dice!

**Connections**

**Wire**

1. Push the button, and the LED module will display a number between 1 and 6.
2. Push the button twice if you're playing a game that requires two dice.

**What's Going On?**

In this circuit, the push button tells the microprocessor to select a number from 1 to 6, and then display the selection on one of the six LEDs.

**Light Meter**
Measure the brightness of light!

This build works best at night in a dark room. It's also fun to use with a flashlight and a dimmer switch on a lamp. This circuit converts continuous analog input (light) into digital output—a display on your LED module.

**Connections**

**Wire**

1. When you hook up the light meter, the LEDs will light up. Take the meter into a dark room or closet. Are the LEDs still shining?
2. While in the dark, shine a flashlight onto the light sensor module. What happens?
3. If you have a dimmer switch, slowly turn up the brightness of the light and watch the LEDs.
4. Take the circuit outside at night and then bring it back into the house. How quickly does it respond?

**What's Going On?**

The microprocessor measures the current moving through the light sensor and lights up LEDs corresponding to the amount of current. Bright lights allow more current to flow, so more LEDs light up. The light meters built into digital cameras work this way—they detect the amount of light reflecting off the subject so the camera can make adjustments to the settings.

**Indoor Rainbow**
Paint a rainbow in the air!

This works best in the dark!

1. When the lights start flashing, wave the module back and forth quickly in front of your eyes.

**What's Going On?**

As you saw in Make a Rainbow, all the colors of the rainbow can be made with red, green, and blue light (the RGB colors of your tricolored LEDs). And as you observed in Magic Message Wand, when you wave a flashing LED in front of your eyes, the afterimages can “paint” a picture in the air. In this activity, when you wave the flashing tricolor LED, the lights make RGB dashes in space when the wand is waved—and your eyes and brain hold on to the flashes just long enough to blend them together into a rainbow.
TV Buddy

Use your TV remote to make funny sounds!

Operate

1. After you build the circuit, place it as near to your TV as possible, facing toward you just like the TV screen.
2. Turn out the lights in the room, aim the remote at the TV, and push a button. Did your circuit make the sound you selected?

What’s Going On?
The invisible infrared light from your TV remote is received by the light sensor, which sends a signal to the microprocessor to play the sound you selected.

Wire

An infrared detector can detect invisible light coming from your TV remote. Let’s build a circuit that makes funny sounds every time you use the remote!

Light Beam Alarm

Be the spy!

Operate

Once you’ve constructed this circuit, the LED will light up, telling the light sensor that it has a clear path across the U to the light sensor. If you place your hand in the space between the sensor and the light, an alarm will sound.

1. Set a small toy or a piece of candy inside the U before you connect M+ to BAT+. Can you remove the item without setting off the alarm? You had better have a good escape plan!

What’s Going On?
The tricolor LED is acting as a transmitter (like your TV remote) and the light sensor is a receiver (like your TV). When the light pulses from the transmitter are blocked and can’t reach the receiver, the circuit is broken and the alarm goes off.
Full-Tilt Baseball

Play ball!

The first rule of baseball is: keep your eye on the ball! In this version of baseball, you’ll keep your eye on the LED!

Gameplay

Number of players: 1

Overview: When LED 1 lights up, swing the tilt switch “Bat” to score a hit!

• When you make the final hookup, the LED module will light up one LED at a time, starting at LED 6 and moving down to LED 1.
• While LED 1 is lit, swing your bat to make a hit. If you swing too soon—or too late—you’ll miss hitting the ball.
• The sound of the crowd will tell you whether you knocked it out of the park, or swung and missed.

Pencil Musical Organ

Use a pencil to draw music you can hear!

What’s Going On?

As you move your second wire to the different lengths of graphite, you’re sending different amounts of electricity back to the microprocessor. The program produces a different tone based on the amount of electric current it detects. Longer lines have more resistance, which creates a lower tone. Try drawing other images and see how else you can move your wires across the page to create cool sounds and even beats!

Did you know that the graphite in your pencil is a great conductor? In fact, if you draw lines on a sheet of paper with a pencil, you can conduct electricity across the page!

Operate

1. Use a pencil to draw a straight line on a piece of paper. Press down hard on your line to make it thick and dark—your want a lot of graphite on the page.
2. Touch the green wire to one end of the line, and then touch the tip of the red wire to the opposite end.
3. Move the wire tips nearer and farther along the line to change the pitch.

Build 47

Wire

Build 48

Wire

The first rule of baseball is: keep your eye on the ball! In this version of baseball, you’ll keep your eye on the LED!

Gameplay

Number of players: 1

Overview: When LED 1 lights up, swing the tilt switch “Bat” to score a hit!

• When you make the final hookup, the LED module will light up one LED at a time, starting at LED 6 and moving down to LED 1.
• While LED 1 is lit, swing your bat to make a hit. If you swing too soon—or too late—you’ll miss hitting the ball.
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1. Use a pencil to draw a straight line on a piece of paper. Press down hard on your line to make it thick and dark—your want a lot of graphite on the page.
2. Touch the green wire to one end of the line, and then touch the tip of the red wire to the opposite end.
3. Move the wire tips nearer and farther along the line to change the pitch.
Microprocessors love to count, and they are capable of counting multiple things at a time. In this single- or multi-player game, see how many times you can shake the tilt switch back and forth while the microprocessor counts to 10 seconds.

**Gameplay**
- **Number of players:** 1 or more
- **Overview:** Shake the tilt sensor as fast as possible during a 10-second period.
  - The game starts as soon as you connect M+ to BAT+.
  - You’ll hear a 3-second countdown. Start shaking as soon as the countdown is over.
  - The microprocessor will record the number of times the tilt switch is activated. The speaker will count down with tones when you have 5 seconds left.
  - A 2-second tone will play when the time is up.

**Scoring**
At the end of the time limit, the number of shakes will be displayed on the tricolor LED.

- 1 red flash = 10 points.
- 1 green flash = 1 point

For example, three red flashes and no green flashes = 30 points.
Two red flashes and two green flashes = 22 points.
Use a paper and pencil to keep track of each player’s score.

---

**Fart-Sound Frenzy Game**

How quickly can you recognize and respond to sounds? This game will have you rolling with laughter.

**Gameplay**
- **Number of players:** 1 or more
- **Overview:** Press the button every time the speaker plays a FART sound!
  - When you push the button, the speaker will begin playing random sounds.
  - As soon as the FART sound plays, you have 1 second to press the button again.
  - After each successful “hit,” the sounds will play faster.
  - If you don’t press the button within the 1-second window, the game is over, and the buzzer will sound.
  - You can start a new game 2 seconds after the buzzer.

**Scoring**
The number of points achieved will play as FART sounds once the game is over.
Battery Installation

Install batteries into the battery pack.

1. Use a Phillips screwdriver to unscrew the battery compartment door.
2. Insert three new 1.5V AAA (LR03) batteries in the battery compartment. Make sure the polarities match the diagram inside the battery compartment.
3. Replace the battery compartment door and screw it on.

Battery Cautions

- To ensure proper safety and operation, an adult must carry out the battery replacement.
- Never let a child use this product unless the battery door is secure.
- Keep all batteries away from small children, and immediately dispose of any batteries safely.
- Batteries are small objects and could be ingested.
- Do not recharge non-rechargeable batteries.
- Remove rechargeable batteries from the toy before charging them.
- Rechargeable batteries are only to be charged under adult supervision.
- Different types of batteries or new and used batteries are not to be mixed.
- Do not mix old and new batteries.
- Only use batteries of the same or equivalent types as recommended.
- Do not mix alkaline, standard (carbon-zinc), or rechargeable batteries.
- Insert batteries with the correct polarity.
- Remove exhausted batteries from the toy.
- Do not short-circuit the supply terminals.
- Dispose of used batteries in accordance with all local, state, and federal laws.
- This toy is not to be connected to more than recommended number of power supplies.

Quiz Show Game

Sample questions

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>What is the fastest land animal in the world?</td>
<td>Cheetah</td>
</tr>
<tr>
<td>What galaxy is Earth located in?</td>
<td>Milky Way</td>
</tr>
<tr>
<td>How many sides does a triangle have?</td>
<td>3</td>
</tr>
<tr>
<td>Who was the first person to walk on the moon?</td>
<td>Neil Armstrong</td>
</tr>
<tr>
<td>What is the skin?</td>
<td>The skin</td>
</tr>
<tr>
<td>What is the largest animal on earth?</td>
<td>Blue whale</td>
</tr>
<tr>
<td>Is the sun a star or a planet?</td>
<td>Star</td>
</tr>
<tr>
<td>What is the sum of 6 plus 7?</td>
<td>13</td>
</tr>
<tr>
<td>What is the largest land dinosaur?</td>
<td>False</td>
</tr>
<tr>
<td>How many legs does a tarantula have?</td>
<td>8</td>
</tr>
<tr>
<td>True or false: The sun orbits the Earth</td>
<td>True</td>
</tr>
<tr>
<td>How many horns did Triceratops have?</td>
<td>3</td>
</tr>
<tr>
<td>True or false: Venus is a planet</td>
<td>False</td>
</tr>
<tr>
<td>How many days are in the month of March?</td>
<td>31</td>
</tr>
<tr>
<td>True or false: Africa is a country</td>
<td>False</td>
</tr>
</tbody>
</table>

Smart Circuits Electronics Lab
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