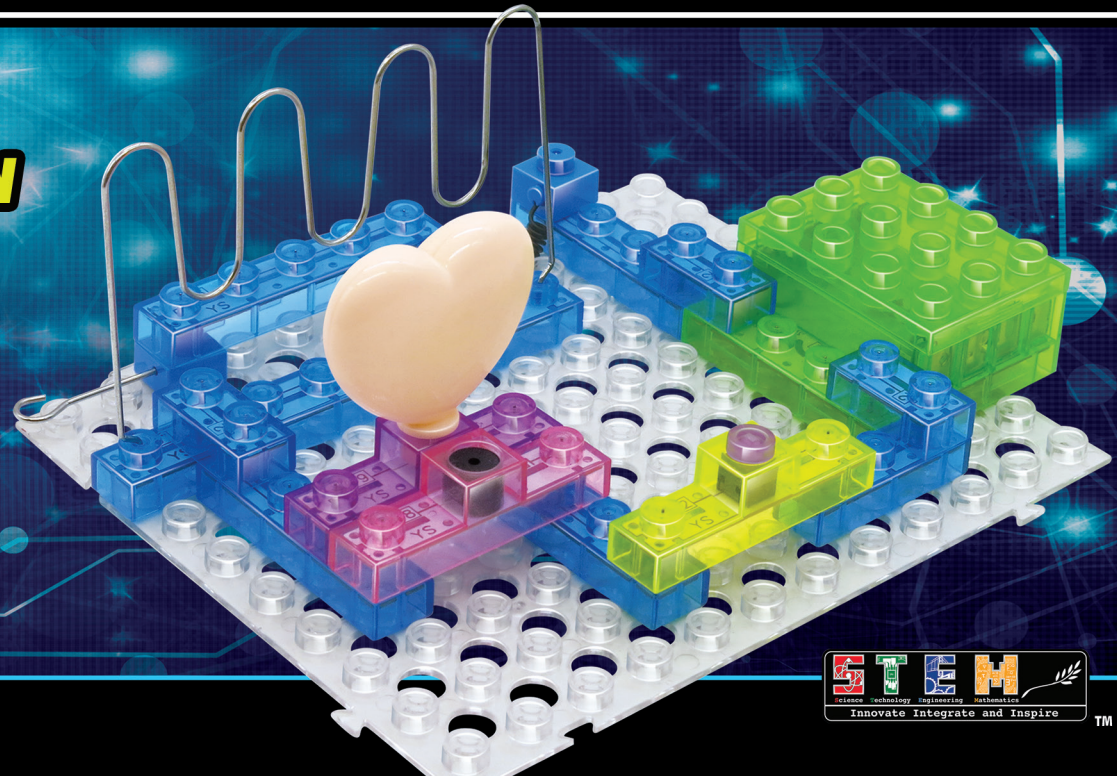
E-Blox®

CIRCUIT BLOX™

USE YOUR EXISTING BUILDING BRICKS TO CREATE ENDLESS POSSIBILITIES!

INSTRUCTION MANUAL



72 PROJECTS

STEM Science Technology Engineering Mathematics
Innovate Integrate and Inspire™

CIRCUIT BLOX™ 72

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.

FCC Notice: Please note that changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

NOTE: This equipment 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. This equipment 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 this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures: • Reorient or relocate the receiving antenna. • Increase the separation between the equipment and receiver. • Connect the equipment into an outlet on a circuit different from that to which the receiver is connected. • Consult the dealer or an experienced radio/TV technician for help.

WARNING: SHOCK HAZARD

Never connect E-Blox® Circuit Blox™ to the electrical outlets in your home in any way!

WARNING:

Only use the battery holder with the cover securely in place.

WARNING: CHOKING HAZARD

Small parts. Not for children under 3 years.

WARNING: MOVING PARTS

Do not touch the fan while it is spinning.

Batteries:

- Use only 1.5V "AA" type, alkaline batteries (not included).
- Insert batteries with correct polarity.
- 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 mix old and new batteries.
- Do not mix alkaline, standard (carbon-zinc), or rechargeable (nickel-cadmium) batteries.
- Remove batteries when they are used up.
- Do not short circuit the battery terminals.
- Never throw batteries in a fire or attempt to open its outer casing.
- Batteries are harmful if swallowed, so keep away from small children.

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 made.
4. Try replacing the batteries. Note: Rechargeable batteries do not work as well as alkaline batteries.

E-Blox® is not responsible for parts damaged due to incorrect wiring.

Note: If you suspect you have damaged parts, you can follow the Advanced Troubleshooting procedure on page 14 to help determine which ones need replacing.

About Electricity (Science)

1. What is Science?

Q: What do we mean when we say "Science"?

A: Science is defined as the intellectual and practical activity encompassing the systematic study of the structure and behavior of the physical and natural world through observation and experiment.

Early scientists were curious people that wondered what made lightning. They decided to experiment to see if they could understand lightning and even make their own somehow.

2. Who Discovered Electricity?

Q: Who was the first scientist to study electricity?

A: In ancient Greece, it was found that rubbing fur on amber produced an attraction between the two. This discovery is credited to the philosopher Thales of Miletus. One day, when he was polishing his amber at home, he found that a piece of fur was attracted by the amber after he put it on the desk. Then he split them, but it happened again. So he made a record about the phenomenon. It took many centuries before anyone was able to connect this phenomenon with electricity and a century before electrical current was put to practical use.

3. What Other Ways Does Science Help Us?

Q: What are some areas of Science?

A: A few major Sciences are Biology, Chemistry, Astronomy, and Physics.

Biology is the study of living things like plants & animals.
Chemistry is the study of substances & how they react when you combine them. Things like the plastic in your remote and the batteries that make it work.
Astronomy is the study of the universe.
Physics is the study of matter, energy, and forces that are on structures like a tall tower.
The science of **Electronics** is considered a branch of Physics.

4. Can Science Help Predict the Weather?

Q: What Sciences were used to help weather prediction?

A: Putting a satellite into orbit that could monitor the weather required the use of almost all the Sciences. **Astronomy** and **Physics** were needed to understand the forces of gravity and how objects stay in orbit. **Chemistry** was needed to make materials that could withstand the heat and cold and to make fuels to get the satellite into orbit. **Electronics** was used to study the weather and transmit it back to earth. **Biology** was needed to study how repair people could work in orbit.

About Electricity (Technology)

5. What is Technology?

Q: What is technology and who used technology in the past?

A: Technology is the application of scientific knowledge for practical purposes. Dating back to the 18th century, Benjamin Franklin (a famous American) proved that lightning was caused by electricity by performing an experiment in which an electrical conductor would be used to extract power from a thundercloud. In the experiment, he flew a kite with a metal key attached to it into a suitable cloud. The precise historical details are unclear, but he may have then retrieved the key and discharged electricity from it. He later, in 1799, invented the lightning rod, a device that served a practical purpose.

6. Technical Terms

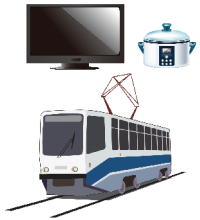
Q: What terms do electrical technicians need to know?

A: When technicians work on circuits and appliances there are some terms they need to know. Current is the movement of electrons and is measured in Amperes (Amps), which is named in honor of André-Marie Ampère. Resistance is the opposition of the flow of electric current and is measured in Ohms, which is named after George Ohm. Electro-Motive Force EMF that pushes the electrons through the resistance is measured in Volts, named after Alessandro Volta. Electrical Power is the rate, per unit time, at which electrical energy is transferrred by an elctric circuit and is measured in Watts, named after the famous technical inventor James Watt.

7. Technology in Everyday Life

Q: Where do we see Technology?

A: Since Technology is the application of scientific knowledge, we see it every day when we watch television, cook in an electric pot, ride on a train that is powered by electricity, and more. Repairmen that fix our furnaces or our air-conditioning units are technicians because knowledge of how the science was used to make things hot and cold helps us repair a broken device.



8. Is There an Age Requirement to be a Technician?

Q: How old do you have to be to become a Technician?

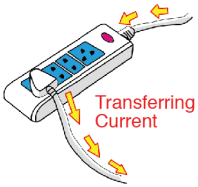
A: Let me tell you a story about a girl named Becky. She was only 10 years old when she was attempting to do her homework in her mom's car. As it got darker outside, she had the idea that there should be a way to make her paper easier to see in the dark. She began playing around with phosphorescent materials, which exhibited light without heat. She then used phosphorescent paint to cover an acrylic board and The Glo-Sheet was created. At the ripe old age of 12, Becky became the youngest woman to be approved for a U.S. patent for her Glo-Sheet invention.

About Electricity (Engineering)

9. What is Engineering?

Q: What is Engineering? What do engineers do?

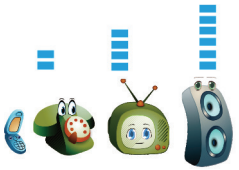
A: Engineering is the application of Science, Technology, and Mathematics to make products that are useful to people. Engineers are skillful in using their knowledge to make products. For example, surge protectors transfer current from the electrical wall outlet to the electrical appliances plugged into it while protecting the appliances from large spikes of electricity which could damage them. Some surge protectors have many sockets to plug computers and TVs into them, while others only have two. The design is an engineer's job.



10. Is Engineering only about Electronics?

Q: Besides Electronics what else do Engineers do?

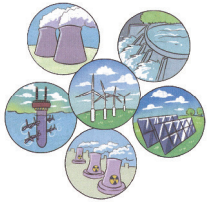
A: Engineers must design the products to be the most appealing at the best price. Product appearance helps marketing sell the product. Product performance is also important and engineers are given specifications by marketing to meet their requirements. Safety is always very important. An audio device should only be loud enough to serve the specifications. Production Engineers use electronic and magnetic sensors to automate production. Civil engineers design roads and bridges that are safe for everyone to use.



11. Engineering and Electricity Generation

Q: Do engineers help make electricity for daily use?

A: Yes! So far they have designed systems that use the seven fundamental methods of directly transforming other forms of energy into electrical energy: Fossil-fuel, biomass, hydro/tidal, wind, nuclear, mechanical power generation, and solar thermal energy. Certainly there will be more methods for electricity generation to be found, since the engineers, like artists, are always creating.



12. Environmental Engineering - Battery Recycling

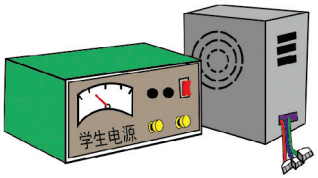
Q: How do Engineers help protect our environment?

A: Batteries contain a number of toxic chemicals and their improper disposal may cause soil contamination and water pollution. Engineers know that most typical kinds of batteries can be recycled, especially lead-acid automotive batteries which are nearly 90% recycled today. Nickel-cadmium (Ni-Cd), nickel metal hydride (Ni-MH), lithium-ion (Li-ion) and nickel zinc (Ni-Zn) can also be recycled. Engineers are always looking for ways to make products safe like integrating fuses into their designs to prevent overheating and fires.

About Electricity (Mathematics)

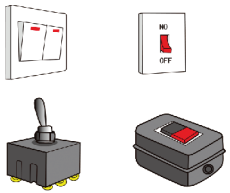
13. Ohm's Law

Ohms Law states that Voltage equals Current multiplied by Resistance. If V = Voltage, I = Current, and R = Resistance, then mathematically Ohms Law is V = I x R where "x" stands for "multiplied by". Since the law starts with Voltage, we need a voltage source or a Power Supply. There are both DC (direct current) and AC (alternating current) power supplies. Batteries are also a source of DC voltage. Using Algebra, any one unknown can be calculated if the other two variables are known. For example, if V=9 Volts and R=1000 Ohms, then I=0.009 Amp or 9 milliamps.



14. Switches and Power

A switch is a device that may control other components in the circuit. It is used for power connection and disconnection. A switch is a device that is either ON or OFF and used often in digital electronics. Power is the product of the current in a device multiplied by the voltage across it. Electronic Power is expressed in Watts. Mathematically this is expressed as W = V x I. If you have a 60 Watt light that is on a voltage of 120 Volts, then the current can be calculated to be 60 Watts divided by 120 Volts, which equals 1/2 Amp. Some switches are controlled by magnets and others by temperature.

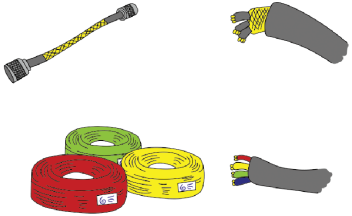


15. Using Mathematics to Calculate Fuses

Many different appliances can be connected to draw current from the outlets in your homes. If these outlets are all connected to one fuse, then the fuse must be able to handle the sum of all the currents being drawn. Fuses are used in the battery holder that comes with this product. Each current drawn from any outlet in your home will add up as the appliances are turned ON because they are all connected in parallel.

16. Calculating Resistance

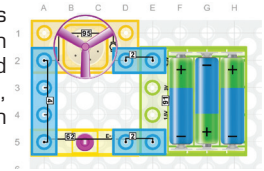
Conductive paths are used to connect circuits and transfer electricity. If the voltage on one end of the conductor is lower than on the other end when current is flowing, then the conductor has resistance. The voltage drop on the conductor divided by the current in the conductor is the Resistance of the conductor or wire. In Mathematical terms and from Ohms law, this would be stated as R = V ÷ I. If the voltage drop is 2 Volts when 4 Amps is flowing, then the resistance of the conductor is 1/2 Ohm.



About Electricity (STEM)

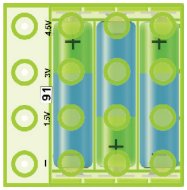
17. Circuit Blox™

For Circuit Blox™, the definition of an electrical circuit is: The complete path for an electric current flow, usually including the source of electric energy. The path shown in the circuit below is from the battery, through the blue 2-wire, through the motor under the fan, through the blue 4-wire, through the switch, through the blue 2-wire, and then back to the battery. If the switch in this circuit is closed, then current will flow from the battery through all the components and back to the battery. If enough current flows, the motor will spin and launch the fan. If the switch is open, nothing will happen since it is an open circuit with no current.



18. Short Circuits in Circuit Blox™

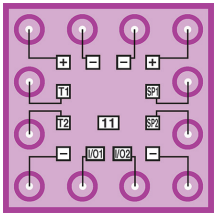
The battery holder that comes with your Circuit Blox™ Kit is fully protected. A short circuit indicator LED lights and a beeper sounds if any of the outputs are shorted or under a high current draw. It is important that you always use this battery holder in the circuits you build to protect the batteries and prevent damage to parts. Even shorts from one voltage output to another is protected by a patented circuit and will indicate an excessive current. This circuit uses resettable Positive Temperature Fuses (PTCs). Circuit Blox™ kits are always approved by independent safety laboratories to insure all users will be able to experiment without worry of harm to parts or themselves.



19. Sound and Light

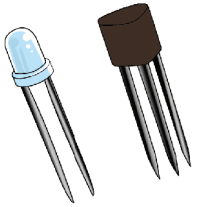
There are many modules in Circuit Blox™ that will produce different sounds and different light effects.

The Three-in-One module, for example, has two control inputs (T1, T2), a speaker connection (SP1, SP2), and music & space sound selects (I/01, I/02). By proper connection of parts with the Three-in-one module many special effects can be generated and triggered in different ways. This module will be used to simulate many of the different interesting problems in the fields of Sound Technicians, Medical Engineering, Communication Engineers, Home Security, and much more.



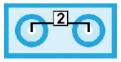
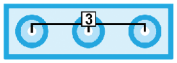
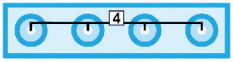
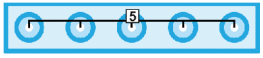
20. Semiconductors

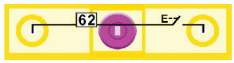
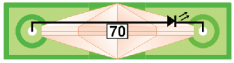
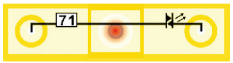
Semiconductors have properties that can control current flowing through a conductor similar to a faucet controlling the flow of water in a pipe. A diode acts like a check valve in a water pipe by only letting current flow in one direction. A Light Emitting Diode (LED) produces light when very little current flows. Different colored LEDs are made and some LEDs can even produce Laser light similar to handheld pointers or gun scopes. Transistors have three leads and one is used to control the current between the other two.

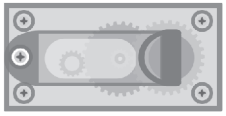
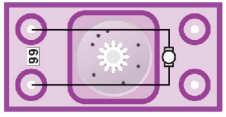


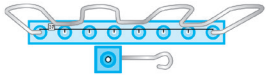
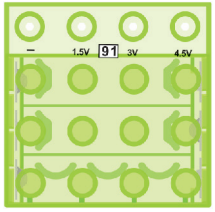
Parts List (colors and styles may vary) Symbols and Numbers

Important: If any parts are missing or damaged, **DO NOT RETURN TO RETAILER.** Call toll-free (855) MY EBLOX (693-2569) or e-mail us at: help@myeblox.com. Customer Service: 880 Asbury Dr., Buffalo Grove, IL 60089 U.S.A.

Qty.	Name	Symbol	Part #
2	1-wire Block		6EB2X01
8	2-wire Block		6EB2X02
2	3-wire Block		6EB2X03
3	4-wire Block		6EB2X04
1	5-wire Block		6EB2X05
2	Level 1-Block		6EB2X100
2	Level 2-Block		6EB2X200
1	Spring Wire		6EB2X09

Qty.	Name	Symbol	Part #
1	Reed Switch		6EB2X83
1	Press Switch		6EB2X61
1	Switch		6EB2X62
1	LED		6EB2X69
1	LED		6EB2X70
1	Bi-color LED		6EB2X71
1	Lamp		6EB2X76
1	Alarm		6EB2X78

Qty.	Name	Symbol	Part #
1	Magnet		6EB2X07
1	Hand Crank		6EB2X94
1	Generator		6EB2X99

Qty.	Name	Symbol	Part #
1	Base Grid		6EB2X101
1	Maze		6EB2X37
1 1	Battery Holder Battery Cover		6EB2X91 6EB2X91C

How to Use Your E-Blox® Circuit Blox™ Set

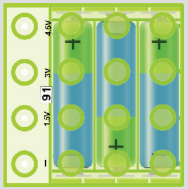
E-Blox® Circuit Blox™ parts contain a PC board with connectors so you can build the different electrical and electronic circuits in the projects. Each block has a function: there are switch blocks, a light block, battery block, wire blocks, etc. These blocks are different colors and have numbers on them so that you can easily identify them.

For Example:
This is the press switch, it is green and has the marking 61 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 comes in 5 different lengths. The part has the number 1, 2, 3, 4, or 5 on it depending on the length of the wire connection required.

There are also 1-post and 2-post blocks that are used as a spacer or for interconnection between different layers.

You need a power source to build each circuit. The part is marked 91 and requires three (3) 1.5V "AA" batteries (not included). The four connections are marked –, 1.5V, 3V, and 4.5V.

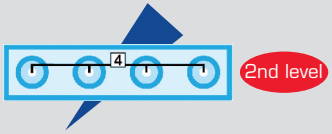


A short circuit indicator LED lights and beeper sounds if any of the outputs are shorted or under a high current draw.

Only use the battery holder when the cover is securely in place.

A large 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 plug into.

Next to the circuit diagram may be a part with an arrow and red circle as shown below. This indicates that the part is installed below other parts and which level it is on.



About Your E-Blox® Circuit Blox™ Parts

(Part designs are subject to change without notice).

The **base grid (39)** functions like the printed circuit boards found in most electronic products. It is a platform for mounting parts and wire blocks (though the wires are usually "printed" on the board).

The **blue wire blocks** are just wires used to connect other 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 **spring wire (9)** is two single blocks connected by a wire used to make unusual connections.

The **batteries (91)** produce an electrical voltage using a chemical reaction. This "voltage" can be thought of as electrical pressure, pushing electrical "current" through a circuit. This voltage is much lower and much safer than that used in your house wiring. Using more batteries increases the "pressure" and so more electricity flows.

The **switch (62)** connects (ON) or disconnects (OFF) the wires in a circuit.

The **press switch (61)** connects (pressed) or disconnects (not pressed) the wires in a circuit, just like the switch does.

A **reed switch (83)** is an electrical switch operated by an applied magnetic field. When exposed to a magnetic field, the switch closes (ON). When the magnetic field is removed the switch opens (OFF).

The blue **level blocks (100 & 200)** are non-conductive and just used as building blocks.

The **LEDs (69 & 70)** are light emitting diodes inside the heart & star, 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 (between 1.8V to 3.3V typically); brightness then increases. A high current will burn out the LED, so the current must be limited by other components in the circuit. LEDs block electricity in the "reverse" direction.

The **4.5V lamp (76)** contains a special wire (filament) that glows bright when a large electric current passes through it. Voltages above the bulb's rating can burn out the wire.

The **alarm (78)** converts electricity into sound by making mechanical vibrations. These vibrations create variations in air pressure which travel across the room. You "hear" sound when your ears feel these air pressure variations.

The **maze (37)** provides a challenge to test the steadiness of your hands. See if you can move the hook through the maze without touching it.

The **generator (99)** converts mechanical energy into electrical energy.

The **hand crank (94)** is used to provide mechanical energy to the generator by turning the crank.

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 batteries), a resistance (which might be an LED, lamp, motor, integrated circuit, etc.), and wiring paths between them and back. **You must be careful not to create "short circuits" (very low-resistance paths across the batteries, see examples below) as this will damage components and/or quickly drain your batteries.** Only connect the parts using configurations given in the projects, incorrectly doing so may damage them. **E-Blox® is not responsible for parts damaged due to incorrect wiring.**

Here are some important guidelines:

DO **USE EYE PROTECTION WHEN EXPERIMENTING ON YOUR OWN.**

DO include at least one component that will limit the current through a circuit, such as the speaker, lamp, LED, integrated circuit (IC, which must be connected properly), or generator.

DO disconnect your batteries immediately and check your wiring if something appears to be getting hot.

DO check your wiring before turning on a circuit.

DO connect the IC using configurations given in the projects or as per the connection descriptions for the part.

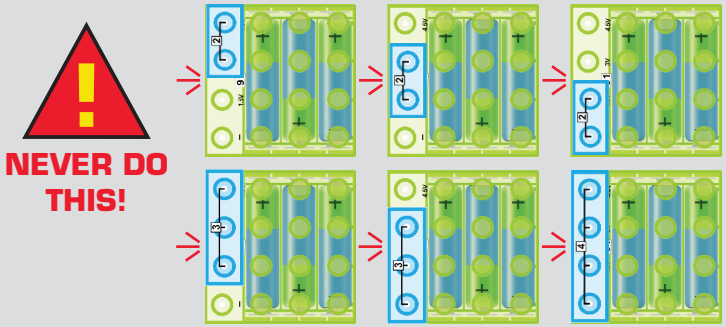
DON'T connect to an electrical outlet in your home in any way.

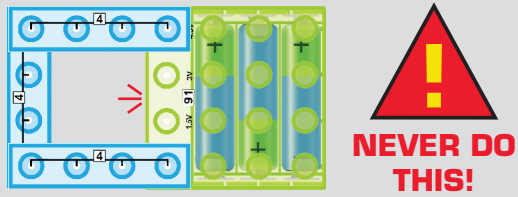
DON'T leave a circuit unattended when it is turned on.

DON'T touch the motor when it is spinning at high speed.

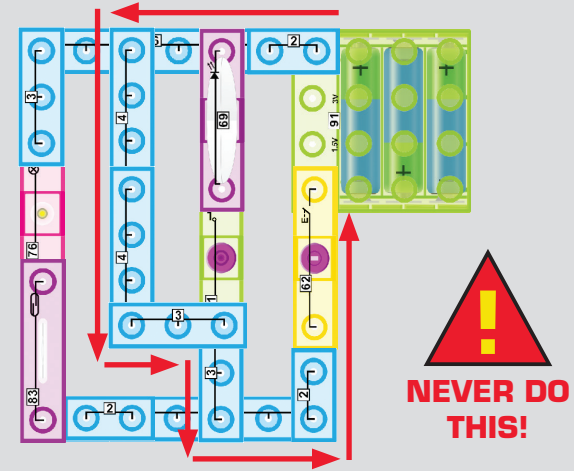
Examples of SHORT CIRCUITS – NEVER DO THIS!

Placing a wire block directly across the battery holder is a SHORT CIRCUIT, indicated by a flashing LED in the battery holder.





When the switch (S1) is turned on, 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.



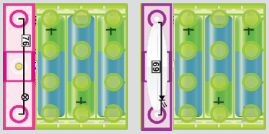
WARNING: SHOCK HAZARD! Never connect E-Blox® Circuit Blox™ to the electrical outlets in your home in any way!

Advanced Troubleshooting (adult supervision recommended)

E-Blox® is not responsible for parts damaged due to incorrect wiring.

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

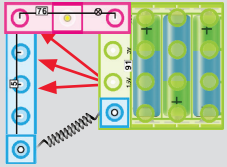
1. **Lamp (76), LEDs (69, 70, 71), Battery Holder (91):** Place part directly across the battery holder as shown, it should light. If none work, then replace your batteries and repeat, if still bad then the battery holder is damaged. Make sure the LEDs are installed in the correct direction.



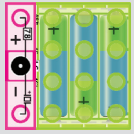
2. **Wire Blocks (1-5), Spring Wire (9), and Speaker (95):** Use this mini-circuit to test each of the Wire Blocks and Speaker (95), one at a time. The lamp (76) should light if the part is functioning properly. Follow the steps below:

   Spring Wire test - Build the circuit shown below. The lamp (76) should light.

   Wire Block tests - Insert the Wire Blocks between the spring wire to lamp connection shown in the figure. The lamp should light.



   Speaker test - Insert the speaker (95) between the spring wire to lamp connection shown in the figure. The speaker will not sound, but the lamp will light.



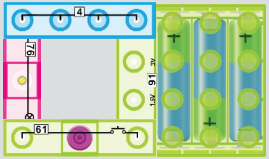
3. **Alarm (78):** Place the alarm across the battery holder as shown. The alarm should sound.

4. **Switch (62), Press switch (61), Reed Switch (83):** Use this circuit to test each switch. The lamp (76) should light. If the lamp doesn't light, then the switch is bad.

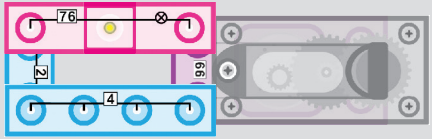
   Switch - Up position the lamp off, Down position lamp on.

   Press - Light when switch is pressed.

   Reed - When you place the magnet on the switch the lamp should light.



5. **Generator (99) & Hand Crank (94):** Build the circuit shown below. The lamp (76) should light when the hand crank is turned.



E-Blox®

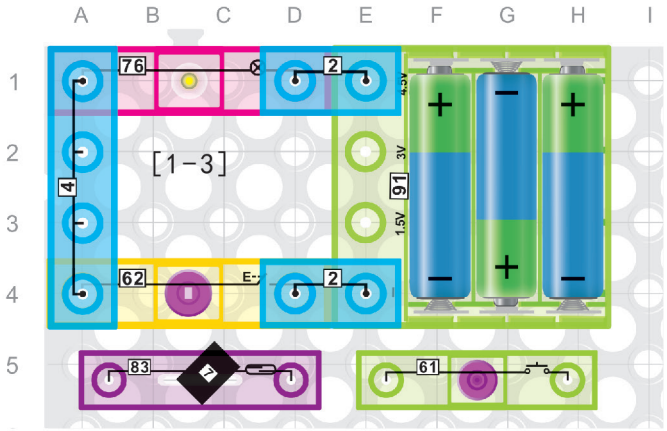
880 Asbury Dr., Buffalo Grove, IL 60089 U.S.A.

Phone / Fax: (855) MY EBLOX (693-2569)

e-mail: help@myeblox.com ● Website: www.myeblox.com

You may order additional / replacement parts at: www.pickabrick.com

Project Listings



1. Closed Circuit

E-Blox® Circuit Blox™ uses electronic blocks that plug into a clear plastic grid to build different circuits. These blocks have different colors and numbers on them so that you can easily identify them.

Build the circuit shown on the left by placing all the parts that plug into the first layer base. Then, assemble the parts that connect to the secondary layer. Install three (3) "AA" batteries (not included) into the battery holder (91). **Secure the battery cover before using it.**

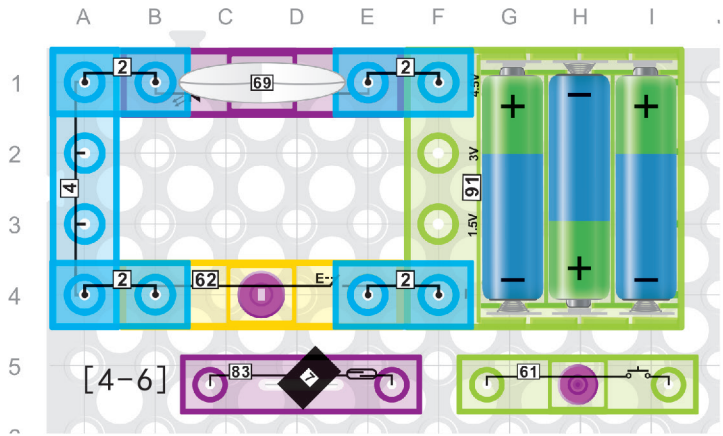
Pressing the switch (62) creates a closed circuit; the lamp (76) will turn on. Press it again to open the circuit and the lamp (76) will turn off.

2. Magnetic Switch

Replace the switch (62) with the reed switch (83). If you touch the reed switch (83) with magnet (7), you will light up the lamp (76). If you move the magnet (7) away from the reed switch (83), the lamp (76) will be turned off. This is a "no touch" switch!

3. The 'Momentary' Switch

Replace the switch (62) with the press switch (61), then press the press switch (61). The lamp (76) will be turned on. Release the press switch (61) and the lamp (76) will be turned off. This type of switch is called a 'momentary' switch since it is only on when pressed.



4. LED, the Check Valve Light

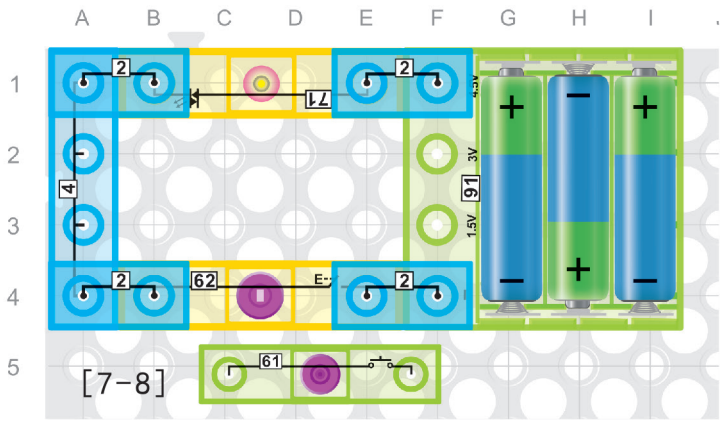
Replace the lamp (76) with the LED (69), making sure it's in the correct direction. Press the switch (62) to turn it ON and OFF. Reverse the LED (69) and repeat. Notice that the LED does not light when in the circuit in the reverse direction, demonstrating how LEDs only allow current to flow in one direction.

5. Magnetically-controlled LED & Motion Sensing

Replace the switch (62) with the reed switch (83). If you touch the reed switch (83) with the magnet (7), you will light up the LED (69). If you move the magnet (7) away from the reed switch, the LED (69) will be turned off. This simulates a motion detector that turn on the lights when you enter the room.

6. Press Switch-controlled LED

Replace the switch (62) with the press switch (61), then press the press switch (61). You will light up the LED (69). Release the press switch (61) and the LED (69) will be turned off.

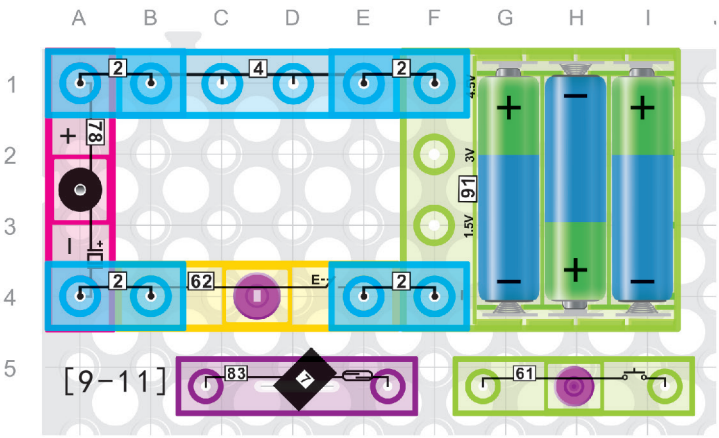


7. Bi-directional LED

Build the circuit to the left and turn on the switch (62). You will see the bi-directional LED (71) is on with red light. Disconnect the switch (62) and the bi-directional LED (71) will be turned off. Reverse the direction of the bi-directional LED (71) and you will see the bi- directional LED (71) is turned on with blue light. Bi-directional LEDs actually have two diodes in them in opposite directions so current can flow in both directions. But current is only flowing through one diode at a time, which determines which color LED lights.

8. Bi-directional LED Sensor

Replace the switch (62) with the press switch (61), then press the press switch (61) and you will see the bi-directional LED (71) in on with red light. Release the press switch (61) and the bi-directional LED (71) will be off. Reverse the direction of the bi-directional LED (71) and it will turn on blue when you press the press switch (61). Bi-directional LEDs can be used as sensors that indicate which direction current is flowing.



Morse Code

A ●–	J ●–––	S ●●●
B –●●●	K –●–	T –
C –●–●	L ●–●●	U ●●–
D –●●	M ––	V ●●●–
E ●	N –●	W ●––
F ●●–●	O –––	X –●●–
G ––●	P ●––●	Y –●––
H ●●●●	Q ––●–	Z ––●●
I ●●	R ●–●	

9. Warning Alarm

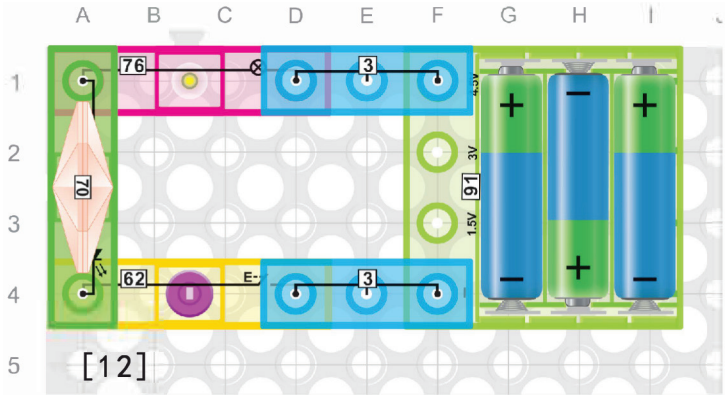
Build the circuit to the left and turn on the switch (62). You will hear an alarm sound from the alarm (78). This type of device could be used to create an audio signal if you need help.

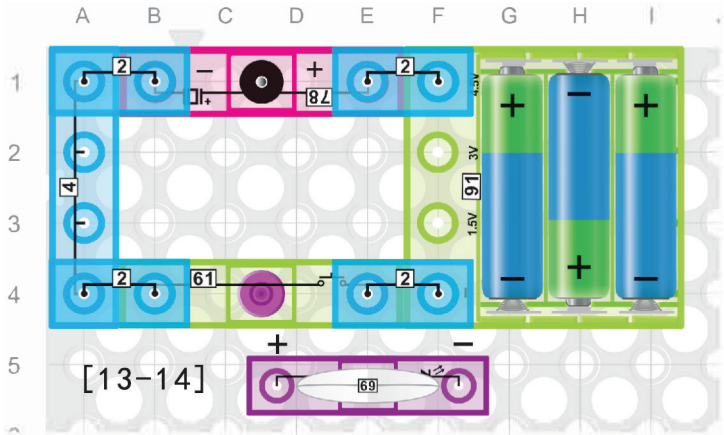
10. House Alarm

Replace the switch (62) with the reed switch (83), then touch the reed switch (83) with the magnet (7); you will hear the alarm (78) sound. This simulates a house alarm triggered by motion sensing.

11. Morse Code

Replace the switch (62) with the press switch (61), then press the press switch (61). You will hear the sound from the alarm (78) whenever you press the press switch (61). This can be used as a Morse code typing simulator. Morse code uses various sequences of long and short on-off tones, lights or clicks to represent letters, numbers, and text. Since World War II, the process for sending messages using signal lamps has barely changed. It requires someone trained in Morse code to operate the lamp's shutter by hand, receiving, decoding, and replying to messages.





12. Electronic Efficiency

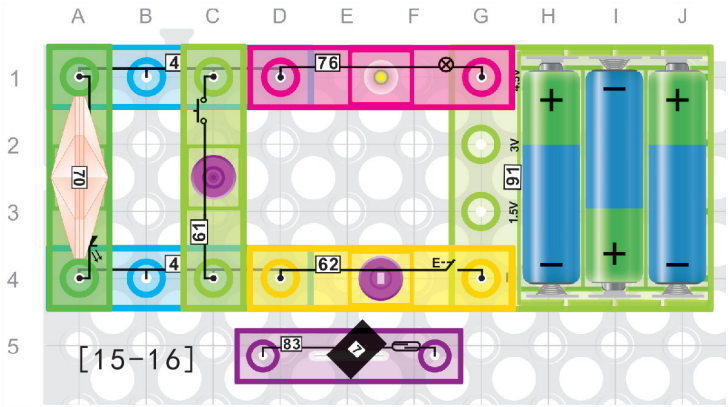
Electronic Efficiency is defined as the Useful Power Output divided by the Total Power Input. Build the circuit to the left and press the switch (62). The LED (70) will light, but the lamp (76) will not light or will be very dim. There is resistance built into the LED (70) to protect it (too much current could damage an LED), and this resistance is limiting the current in the circuit, preventing the lamp (76) from lighting. Yet this circuit shows that the LED (70) is more efficient than the lamp (76) because it still produces light (useful output power) even at the lower current.

13. Morse Code Revisited

Build the circuit, press the press switch (61) at a certain pace and you will hear the Morse code sounds from the alarm (78). The International Morse Code is shown below where a dot represents a quick push of the press switch (61) and a dash represents holding the press switch (61) for a second. Try sending letters or a code to a friend and see if they can decode it by listening to how the sequence of tones you send.

14. Digital Transmission

Replace the alarm (78) with the heart LED (69), then press the press switch (61) at a certain pace and you will see the heart LED (69) flashing. This circuit can be used for sending digital information, such as using a fiber to carry the light sequences from LEDs.

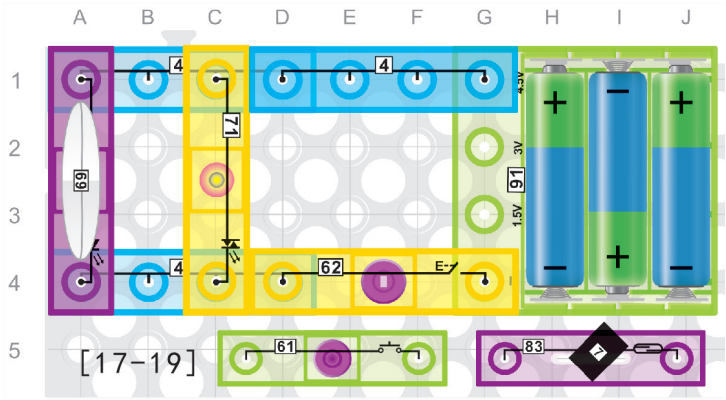


15. Ohm's Law

Using Ohm's Law the resistance of each part could be calculated. Build the circuit to the left and turn on the switch (62). In this circuit the lamp (76) and the star LED (70) are in series so they all see the same current. If you had a voltmeter and measured the voltage drop across each component, you would see that the voltage drop across the star LED (70) is much greater than the voltage drop across the lamp (76). According to Ohm's Law, R = V÷I which means the internal resistance of the star LED (70) is much greater than the internal resistance of the lamp (76). The high internal resistance of the star LED (70) is limiting the current in this circuit, which is why the lamp (76) does not light. Each part is designed using Ohm's Law to perform best when they have full battery voltage. Press the press switch (61) to remove the resistance in the star LED (70) from the circuit and now the lamp (76) lights.

16. Reed Switch Technology

Replace the press switch (61) with the reed switch (83), turn ON the switch (62) and the star LED (70) will light. Touching the reed switch (83) with the magnet (7) eliminates the star LED (70) from the circuit (all the current flows through the reed switch and not the star LED (70) and makes the lamp (76) light. A reed switch is typically made from two or more ferrous reeds (thin strips) encased within a small glass tube-like envelope, which become magnetized and move together or separate when a magnetic field is moved towards the switch.



17. Parts Connected in Parallel

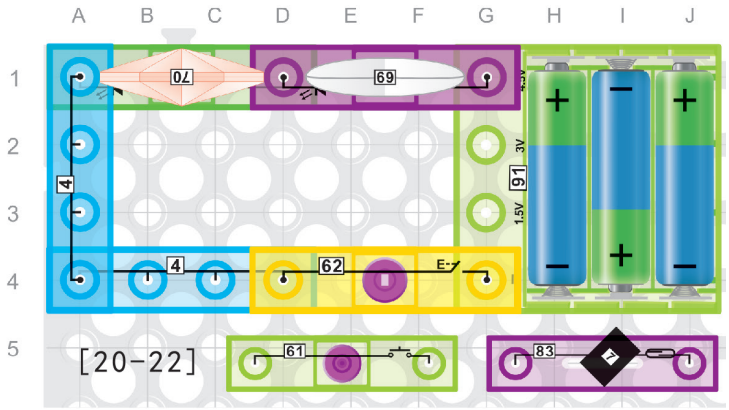
Build the circuit on the left and turn the switch (62) ON. The heart LED (69) and the bi-directional LED (71) will both be on. Notice that both the heart LED (69) and bi-directional LED (71) are bright. This is because the heart LED (69) and bi-directional LED (71) in this circuit are in parallel, allowing each to have separate paths for current flow.

18. Press Lights

Replace the switch (62) with the press switch (61), then press the press switch (61) and you will see the two LEDs are shining with red light. Release the press switch (61) and the LEDs will turn off. Circuits like this are used in many infant toys where kids push a buttons that make lights turn on.

19. Blind Spot Simulator

Replace the switch (62) with the reed switch (83), then touch the reed switch (83) with magnet (7) and you will see both LEDs are shining with red light. If you move away the magnet (7), they will be turned off. This circuit simulates the way blind spot sensors in cars work. As you move the magnet towards the reed switch (83) you are simulating a car entering your blind spot that makes a red light in your car come on.



20. Parts Connected in Series

Build the circuit, turn on the switch (62) and you will light up two LEDs at the same time. Notice that both LED components are dim. This is because they are in series in this circuit and each LED has an internal resistance that is adding up together to limit the current through each LED.

21. Kirchhoff's First Law

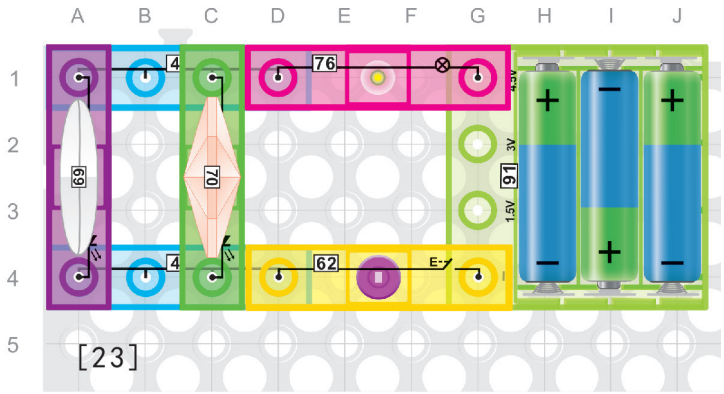
Replace the switch (62) with the press switch (61), then press the press switch (61) and you will light up the two LEDs at the same time. Release the press switch (61) and they will both turn off. Kirchhoff's first law states: At any node (junction) in an electrical circuit, the sum of currents flowing into that node is equal to the sum of currents flowing out of that node. Location D1 represents a node. If a positive current is coming into a node and a negative current is leaving a node, and we use the letter I to represent current, then:

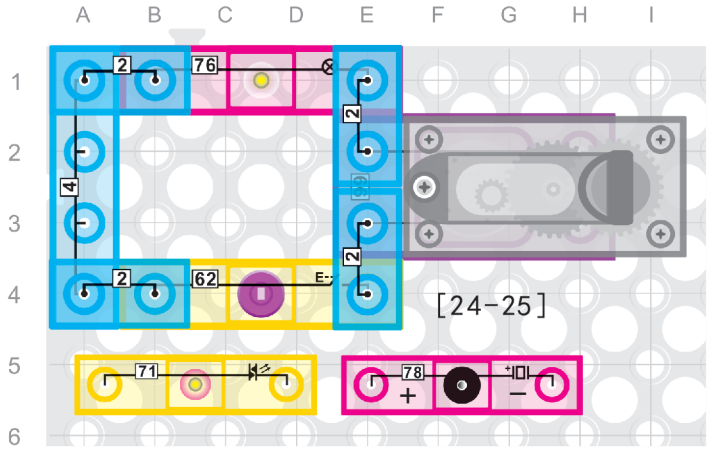
$$I_{heart} + I_{star} = 0$$

This shows that the current coming into node D1 from the heart LED (69) (positive current) is the same as the current leaving node D1 towards the star LED (70) (negative current).

22. Reed Switch vs. Mechanical Switch

Replace the switch (62) with the reed switch (83), then touch the reed switch (83) with the magnet (7) and you will light up the two LEDs at the same time. Move away the magnet (7) and they will both turn off. One of the benefits of reed switches over mechanical switches like the press switch (61) is reliability/lifetime. Mechanical switches can wear out more quickly as you use them, and some studies show that reed switches can be used 10,000 times more often than mechanical switches before they wear out.





23. Parts Connected in Series and Parallel

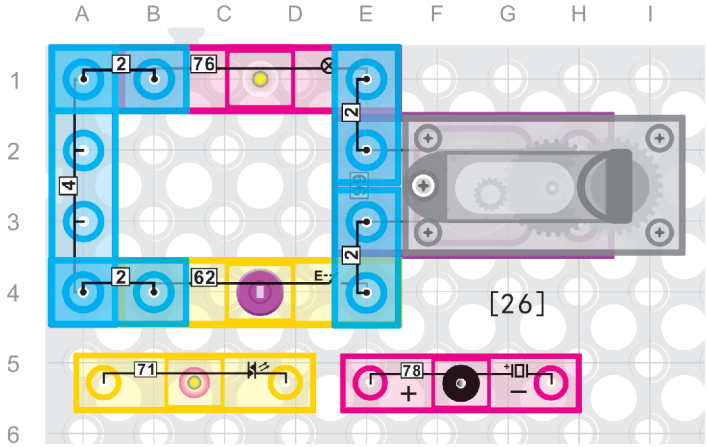
Build the circuit to the left, turn on the switch (62) and you will light up the two LEDs and the lamp (76) at the same time, but the lamp (76) is dim. Notice that the lamp (76) isn't as dim as it was in project 12. This is because having two LEDs in parallel with each other reduces the total resistance in the circuit since there are two ways for current to flow, and thus more current is now flowing through the lamp (76).

24. Hand Crank Generator

Build the circuit, turn on the switch (62) and then turn the hand crank generator (94 & 99) and you will light up the lamp (76). A hand crank generator (94) is a machine that turns mechanical energy (turning the crank) into electrical energy (the lamp (76) lighting). Make sure the hand crank (94) is connected to the generator (99) properly (the end of the generator that is labeled '99' and has pin connections on the bottom should be open and connected to the rest of the circuit).

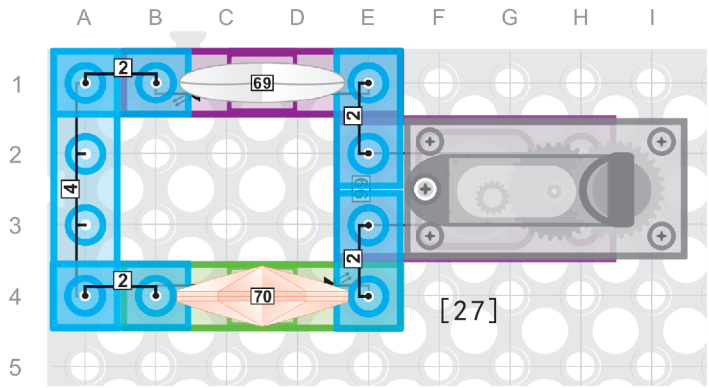
25. Reversing Current

Replace the lamp (76) with the bi-directional LED (71), then turn on the switch (62) and turn the hand-crank generator (94 & 99) clockwise and you will light up the bi-directional LED (71) in red light. Turn the hand crank generator (94 & 99) counter-clockwise and you will light up the bi-directional LED (71) in blue light. This shows that by turning the hand crank generator (94 & 99) in opposite directions you are reversing the current.



26. Mechanical to Electrical to Mechanical Energy

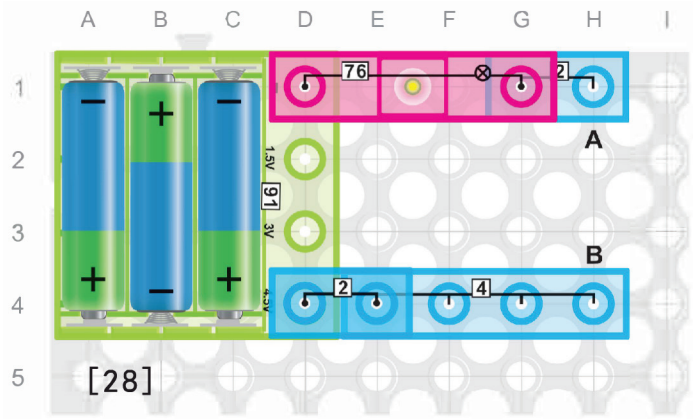
Replace the lamp (76) with the alarm (78), then turn on the switch (62). If you turn the hand crank generator (94 & 99), you will hear sound from the alarm (78). If you hear no sound, then try turning the hand crank (94) in the reverse direction. The alarm (78) makes sound by creating vibrations in the speaker that your ear can hear. So this circuit is an example of mechanical energy (hand crank generator (94 & 99)) being converted to electrical energy (current through the alarm (78)) being converted back to mechanical energy (alarm (78) making vibrations to create sound).



27. Hand Crank Generator-controlled Heart & Star LED

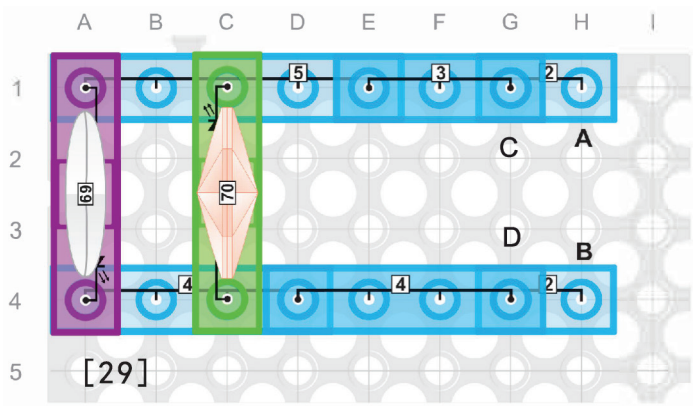
Build the circuit, turn the hand crank generator (94 & 99) and you will light up the heart LED (69) and the star LED (70) at the same time. If the LEDs do not light, then try reversing the direction you turn the hank crank (94).

A dynamo is a type of generator. It rotates coils of metal wire (the mechanical energy) within a magnetic field to force the field to push on the electrons in the metal and vary its flux (amount of field passing through the coils).



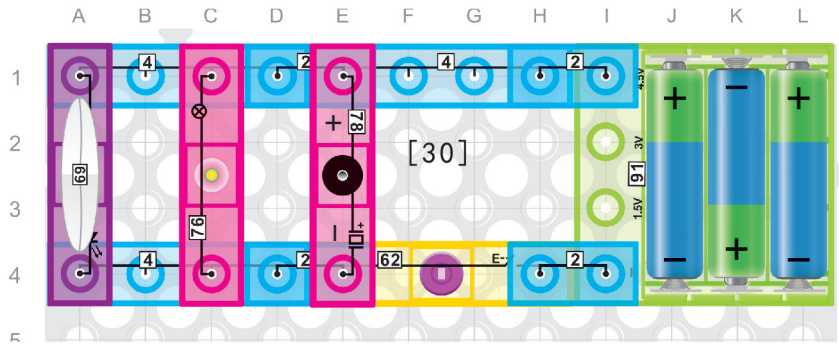
28. Conductivity Tester

By using this circuit, we can identify which materials in our daily life are conductors, and which are insulators. Connect the testing item across points A (using the hook from the maze (37)) and B (using the pin on the bottom of the spring wire (9)). If you see the lamp (76) on, the tested item can be considered a conductor. Otherwise, it can be considered an insulator.



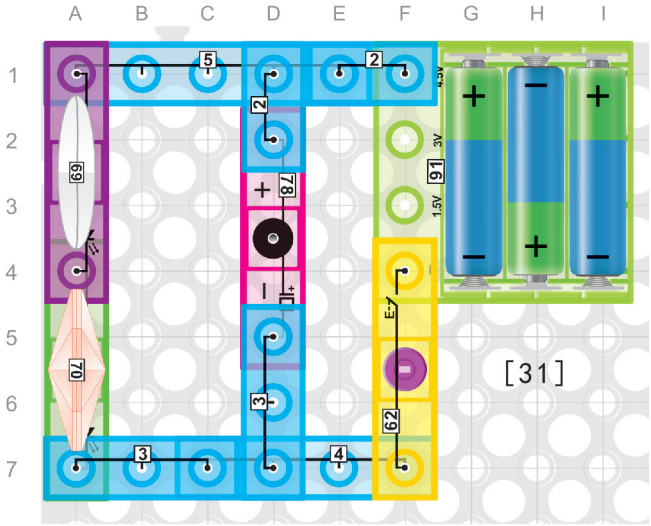
29. Identification of Polarity of the Power

Build the circuit and connect the battery module (91) across points A and B. You will only light up the Heart LED (69). But if you install the battery reversely across points C and D, you will light up the star LED (70). This circuit could be used to test the polarity of a battery. If the heart LED (69) comes on, it can be concluded that point A is the anode (+ side of the battery) and point B is cathode (– side of the battery). If the star LED (69) comes on, it can be concluded that point D is the anode (+ side of the battery) and point C is cathode (– side of the battery).



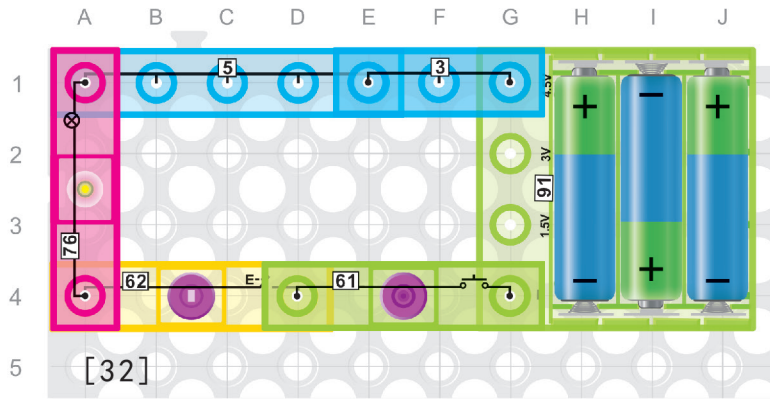
30. Pros and Cons of Parallel Circuits

Build the circuit, turn on the switch (62) and you will light up the heart LED (69), the lamp (76) and the alarm (78) at the same time. The LED (69) and lamp (76) are bright and the alarm (78) is loud. This demonstrates the benefit of putting all three of these components in parallel because they all have their own current paths and thus all operate well. The down side of parallel circuits is that more current is being drawn from the batteries with each component you place in parallel, so you drain your batteries more quickly with parallel circuits.



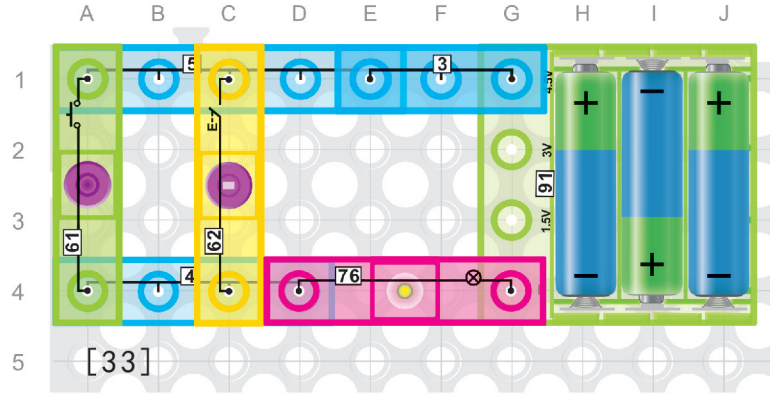
31. Pros and Cons of Series Circuits

Build the circuit, turn on the switch (62) and you will hear the alarm (78) loudly, but the heart LED (69) and the star LED (70) will light dimly. Because the heart LED (69) and star LED (70) are in series, their internal resistance adds up to limit the current through each of them. This demonstrates the benefits of series circuits (less current drawn from the battery means longer battery life) and the downside of series circuits (less current means that the components may not operate well as they are dim).



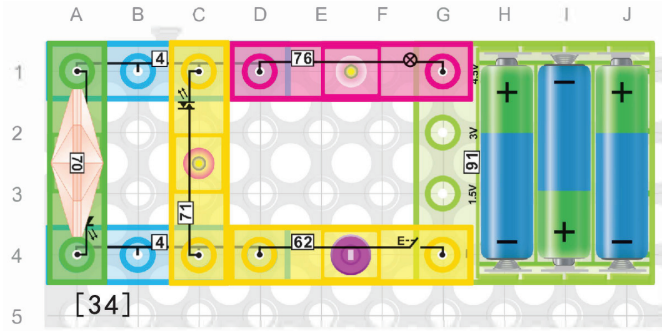
32. Electronic 'AND' Gate

Build the circuit, turn on the switch (62) and the press switch[61] and you will light up the lamp (76). In digital electronics there are seven logic gates: AND, OR, XOR, NOT, NAND, NOR, and XNOR. This circuit represents an AND gate. If ON = True and OFF = False then an AND gate is best defined as: The output is TRUE only when both inputs are True. Therefore, the two inputs represented by the press switch (61) and the switch (62) must both be ON (TRUE) in order for the output represented by the lamp (76) to be ON (TRUE).



33. Electronic 'OR' Gate

Build the circuit, turn on the switch (62) or press the press switch (61) and you will light up the lamp (76). If you want to turn off the lamp (76), you have to disconnect both the switch (62) and the press switch (61). This circuit represents an OR gate. If ON = True and OFF = False, then an OR gate is best defined as: The output is TRUE when any input is True and False only when all the inputs are False. In this circuit the output represented by the lamp (76) is ON (True) if either input represented by the press switch (61) or the switch (62) or both is ON (TRUE). The lamp (76) is OFF (False) only when both switches are OFF (False).



34. Calculating Equivalent Resistance

Build the circuit, turn on the switch (62) and you will light up the lamp (76), the star LED (70), and the bi-directional LED (71) at the same time. Notice that the lamp (76) is dim, but not as dim as it was in project 12. This is because the equivalent resistance of the parallel connection of the star LED (70) and bi-directional LED (71) is less than the resistance of the star LED (70) alone. To prove this, assume the star LED (70) resistance is R_{star} and the bi-directional LED resistance is R_{bdled}. Then Ohm's Law states that:

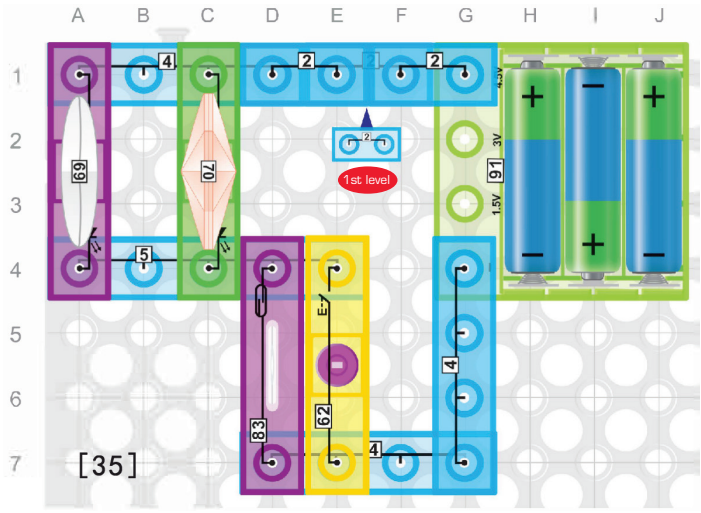
$$I_{star} = V/R_{star} \quad \text{AND} \quad I_{bdled} = V/R_{bdled}$$

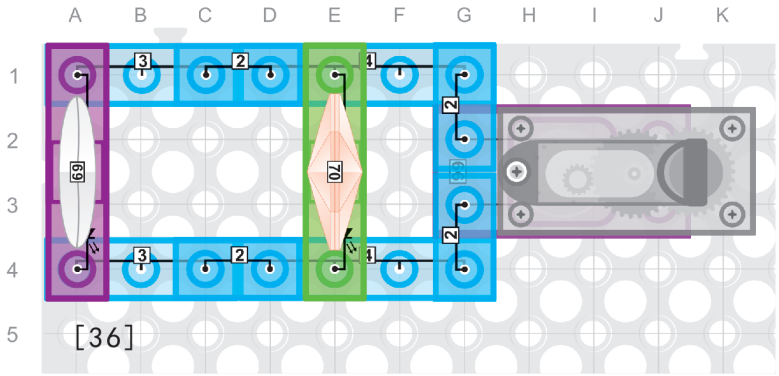
where V is the voltage across both the star LED (70) and bi-directional LED (71), which is the same since they are connected in parallel. Thus, the total current can be written as:

$$\begin{aligned} I_{total} = I_{star} + I_{bdled} &= V/R_{star} + V/R_{bdled} \\ &= (V*R_{bdled} + V*R_{star}) / R_{star}*R_{bdled} \\ &= V*(R_{bdled} + R_{star}) / R_{star}*R_{bdled} \end{aligned}$$

Solving for V yields: $V = I_{total}*R_{star}*R_{bdled} / (R_{bdled} + R_{star})$

This shows that the equivalent resistance through the parallel connection of the star LED (70) and bi-directional LED (71) is $R_{star}*R_{bdled}/(R_{bdled} + R_{star})$. If for simplicity we were to assume that the internal resistance of the star LED (70) is the same as the internal resistance of the bi-directional LED (71), and thus $R_{star} = R_{bdled} = R$, then the equivalent resistance of the parallel connection is $R*R/(R+R) = R/2$. Thus the equivalent resistance of the parallel connection is half that compared to having the resistance from just the star LED (70) in the circuit (like in project 12), which is why the lamp (78) is not as dim in this project.



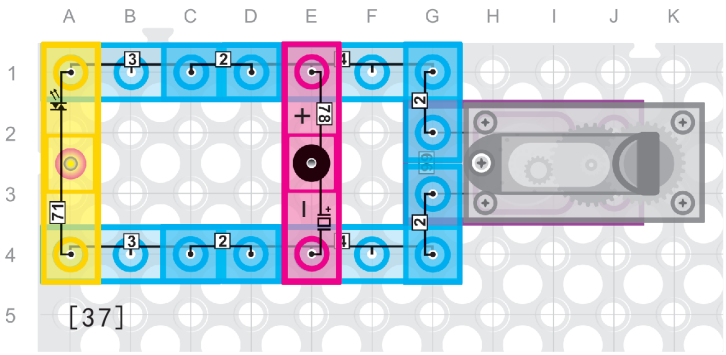


35. Switches in Your House

Build the circuit, turn on the switch (62) or touch the reed switch (83) with magnet (7), you will light two LED at the same time. If you want to turn off them, you should disconnect both these two switches. You might think this type of circuit could be used to have multiple switches in a room in your house control the same device(s). However, this type of circuit is not ideal because the switches do not toggle with each other. In your house, if you pushed the switch (62) ON to turn on your lights, then if you moved the magnet (7) near the reed switch (83) you would want your lights to go OFF. Your house uses three-way switches to do this, not the circuit here.

36. Hand Crank Generator Used as Backup Power Source

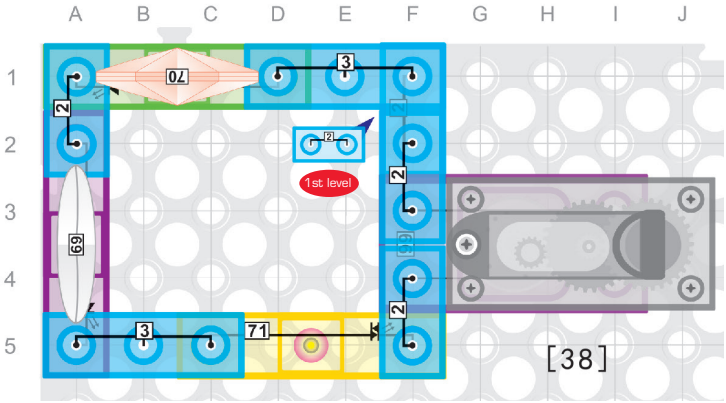
Build the circuit, turn on the switch (62) or press the press switch (61) and you will light up the lamp (76). If you want to turn off the lamp (76), you have to disconnect both the switch (62) and the press switch (61). This circuit represents an OR gate. If ON = True and OFF = False, then an OR gate is best defined as: The output is TRUE when any input is True and False only when all the inputs are False. In this circuit the output represented by the lamp (76) is ON (True) if either input represented by the press switch (61) or the switch (62) or both is ON (TRUE). The lamp (76) is OFF (False) only when both switches are OFF (False).



37. Hand Crank Generator-controlled Parallel Siren & Bi-directional LED

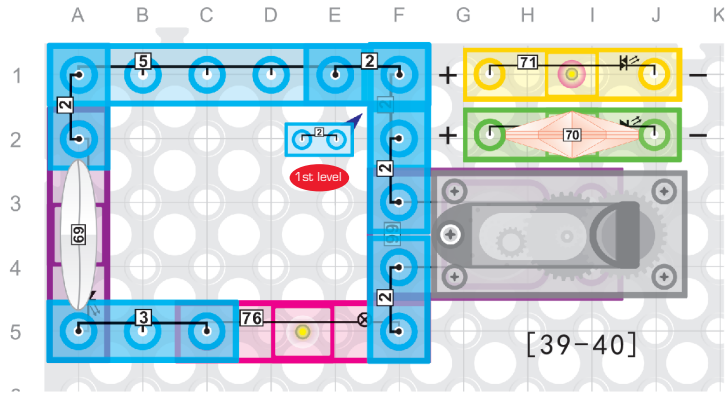
Build the circuit, turn the hand crank generator (94 & 99) clockwise and blue light will emit from the bi-directional LED (71) and the alarm (78) will sound too. Turn the hand crank generator (94 & 99) counter-clockwise and the alarm (78) will turn off while red light emits from the bi-directional LED (71).

Generators usually output direct current (DC) power like in this circuit, but some generators have internal power inverters that convert this to alternating current (AC) power. DC power provides a steady voltage, like your "AA" batteries that each provide about 1.5V. AC power provides a voltage that changes like a sine wave and alternates the polarity of the voltage.



38. Hand Crank Generator for Cellphones

Build the circuit, turn the hand crank generator (94 & 99) and all three LEDs will be turned on. One practical use for hand crank generators today is to charge your cellphone when low on battery power (you can purchase such devices online or in some stores today).



39. History of Hand Crank Generators

Build the circuit, then turn the hand crank generator (94 & 99) and you will light up the heart LED (69) initially. If you turn the hand crank generator (94 & 99) faster, you will see the lamp (76) light and get brighter the faster you turn.

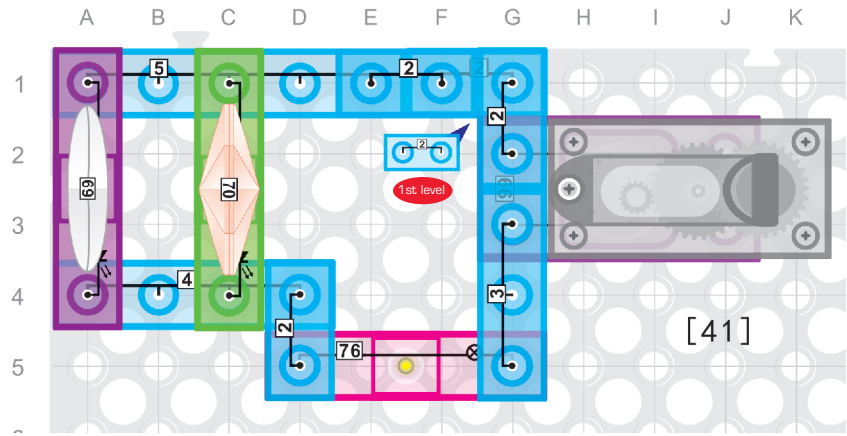
Did you know that hand crank generators date back at least to the 1960s? Military units used special hand generators that could fold up into a backpack. With a soldier turning the crank, the generator could be used to power electronic equipment while in the field, far from any available power source.

40. Kirchhoff's Second Law

Replace the lamp (76) with the bi-directional LED (71) and replace the heart LED (69) with the star LED (70). If you turn the hand crank generator (94 & 99), you will light up both LEDs at the same time. However, you might have noticed that you have to turn the hand crank (94) faster to make the bi-directional LED (71) light up as bright as it did in project 24. Kirchhoff's second law states: The sum of the voltages around a closed network is zero. If a drop in voltage is considered as a negative voltage and a rise in voltage a positive voltage, then the following equation is a mathematical representation of Kirchhoff's second law:

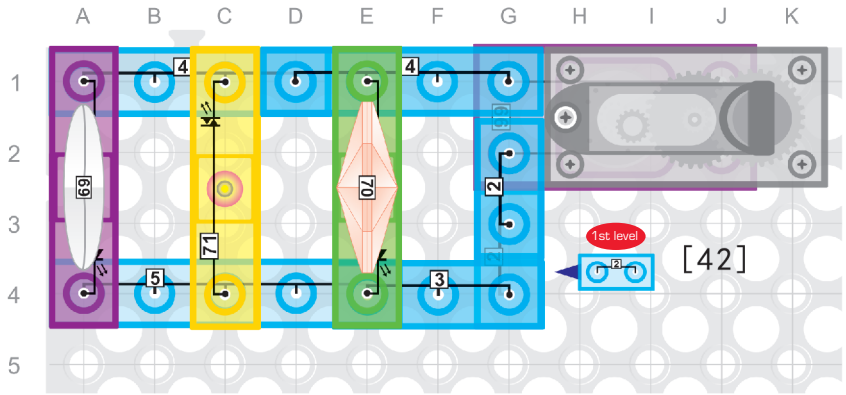
$$V_{star} + V_{bdled} + V_{hcg} = 0$$

This shows that the voltage drop across the hand crank generator (94 & 99) must equal the voltage drop across the star LED (70) plus the voltage drop across the bi-directional LED (71). Since the voltage being generated by the hand crank generator (94 & 99) is split across the star LED (70) and bi-directional LED (71), you need to turn the hand-crank (94) faster than in project 24 to get the same voltage across the bi-directional LED (71).



41. LED Colors

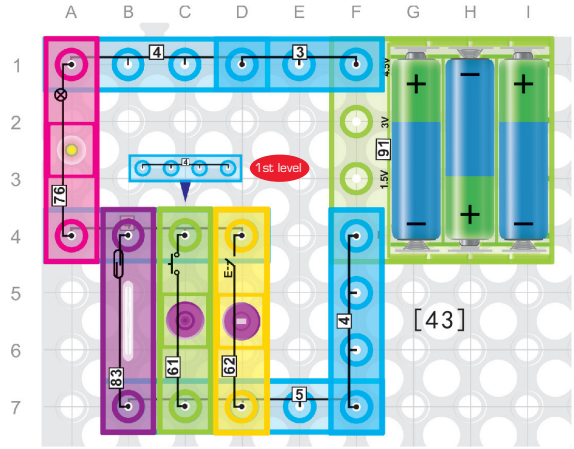
Build the circuit, turn the hand crank generator (94 & 99) and you will light up the heart LED (69) and the star LED (70) at the same time. If you turn the hand crank (94) faster, you will see the lamp (76) will light and be brighter the faster you turn.



42. Hand Crank Generator-controlled Three LEDs in Parallel

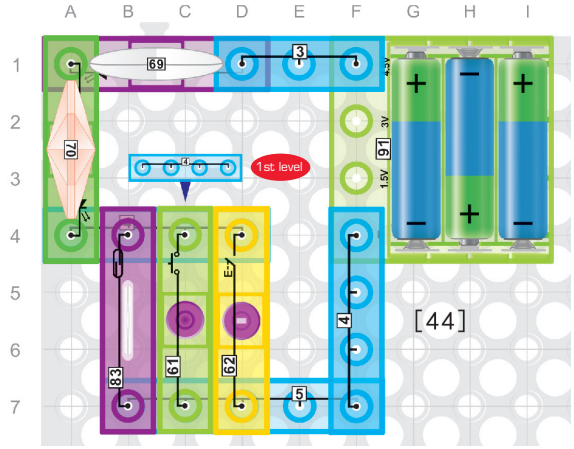
Build the circuit, turn the hand crank generator (94 & 99) and you will light up three LEDs at the same time. If you turn the hand crank generator (94 & 99) in the opposite direction, you will only light up the bi-directional LED (71).

LEDs produce different colors by transmitting light waves with different wavelengths. Light waves cycle up and down and a wavelength is the distance between successive crests of the wave. Red light has a wavelength of around 665 nanometers, while blue light has a wavelength of around 470 nanometers.



43. Triple Input 'OR' Gate

Build the circuit as shown on the left. If you turn on any one of the switches, you will light up the lamp (76). If you want to turn off the lamp (76), you must turn off all the switches. Electronic OR Gates can have two or more inputs but the function is still the same. All inputs must be False (OFF) for output to be False (OFF).

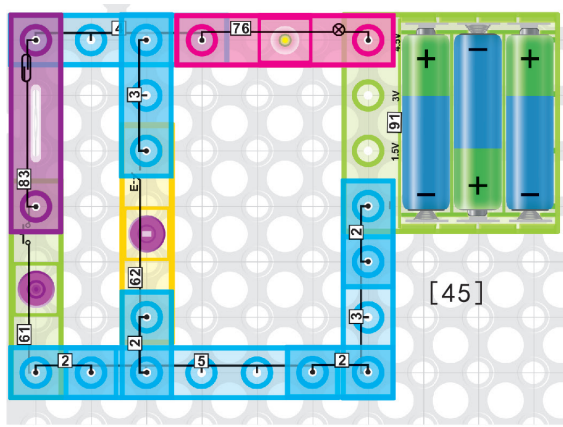


44. The Resettable Fuse

Build the circuit as shown on the left. If you turn on any one of the switches, you will light up the two LEDs at the same time. If you want to turn them off, you must turn off all the switches.

Positive-Temperature-Coefficient, or PTC, thermistors – also known as resettable fuses are devices that have very low resistance until a current is reached, then they get warm and the resistance changes limit the current.

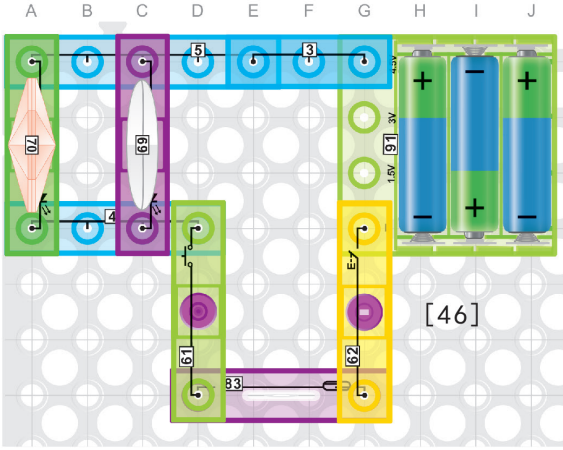
Pretend the reed switch (83) and LEDs are a PTC fuse and pretend the magnet (7) is a piece of ice. Place the magnet (7) near the reed switch (83) to cool down the PTC fuse, allowing current to flow and the LEDs to light. Move the magnet (7) away from the reed switch (83) and the PTC fuse gets warm, trips and prevents current from flowing through the LEDs and thus they do not light.



45. Switches in Series and Parallel

In this circuit, if you want to light up the lamp (76), you can turn on the switch (62), or you can place the magnet (7) near the reed switch (83) and press the press switch (61) at the same time.

Using a hotel analogy, the reed switch (83) could represent a key card holder and the press switch (61) could be a light in the room. In order for lights to turn on in the room, the key card holder must put the key in the slot near the door entrance AND must flip the switch on the lights. However, employees (e.g. maids) at the hotel may have a master key card (the switch (62)) that turns on all the lights in the room regardless of which switches are turned on or off in the room.

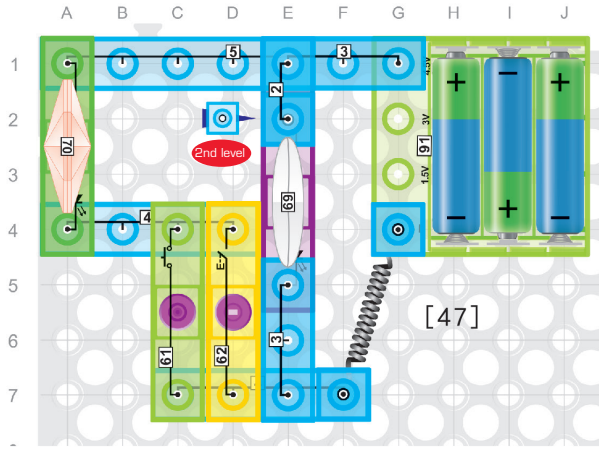


46. Three-person Rocket Launch

Build the circuit as shown on the left. If you want to turn on the two LEDs, you need to turn ON all three switches at the same time.

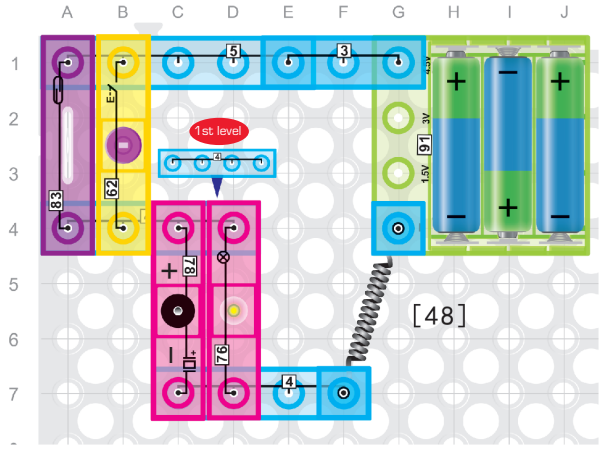
In this circuit, pretend the two LEDs are a rocket. To launch the rocket the switch (62) must be ON, AND the press switch (61) must be ON, AND the reed switch (83) must be turned ON with the magnet (7).

Systems like this are used to prevent accidental rocket launching by having the switches placed far enough apart that it requires three people to turn them on simultaneously.



47. Electrical Current Detector

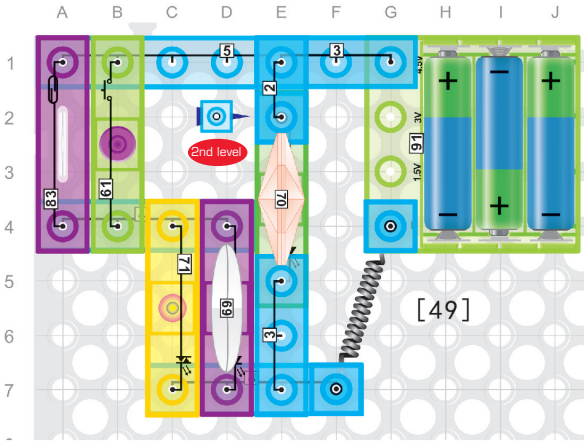
Build the circuit as shown on the left. You will light up the heart LED (69) at once. If you want to turn on the star LED (70), you should turn on the switch (62) or the press switch (61). The star LED (70) in this circuit is a very simple device that can be used to detect current flow. A more advanced device, called an ammeter, is used to measure the amount of electrical current flowing in a circuit.



48. House Alarm

Build the circuit as shown on the left. Turn on the switch (62) or touch the reed switch (83) with magnet (7) and you will light up the lamp (76) and you will hear the alarming sounds from the alarm (78).

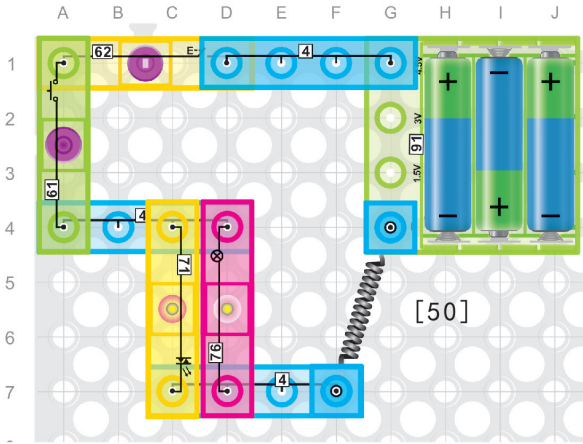
This simulates a house alarm system where the reed switch (83) acts like a motion sensor and sets off an alarm when the magnet (7) is moved near it (simulating motion in the house). The switch (62) acts like a test button where you can test that the alarm system is working by pressing the switch (62).



49. History of LEDs

Build the circuit as shown on the left and you will light up the star LED (70). If you want to turn on the heart LED (69) and the bi-directional LED (71), you must press the press switch (61) or touch the reed switch (83) with the magnet (7).

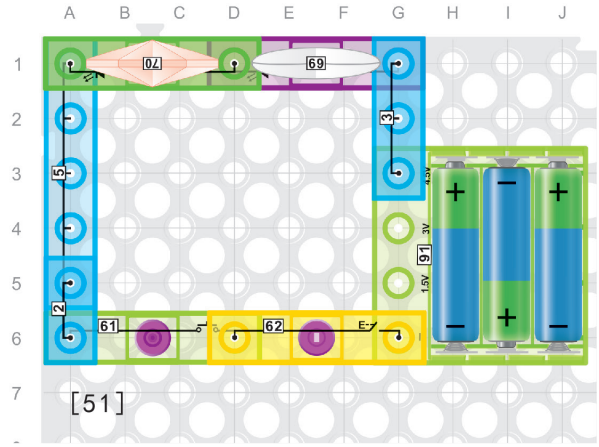
The lighting industries as a whole are pushing LEDs to replace incandescent sources in a variety of applications, but the first time that LEDs actually did displace incandescent lamps was in vehicle brake lights, signal lights, and traffic lights back in 1987.



50. Master Switch

Build the circuit as shown on the left. Turn on the switch (61), then press the press switch (61) and you will light up the lamp (76) and the bi-directional LED (71) at the same time.

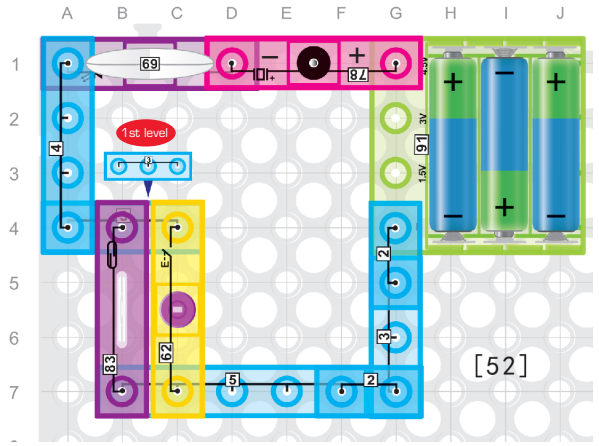
This type of circuit simulates a house with a master switch that you need to turn on first (the switch (62)) before you can turn on any light in the house with the press switch (61).



51. Power Outage

Build the circuit as shown on the left and turn on the switch (62). Press the press switch (61) and you will light up the heart LED (69) and the star LED (70) at the same time.

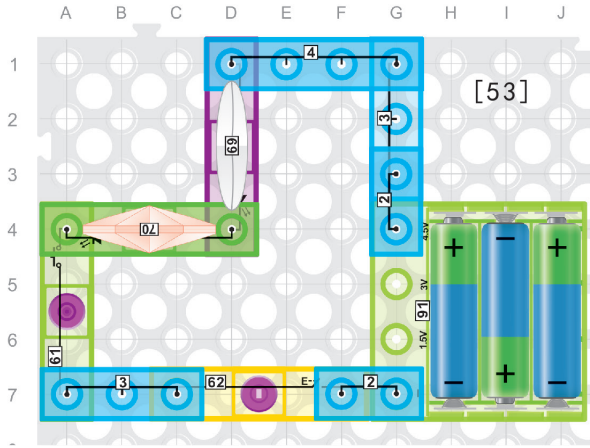
You could use this circuit to simulate a power outage in your neighborhood. Pretend the switch (62) is the power plant in your neighborhood and the press switch (61) represents switches in your house. The press switches (61) in your house will work as long as the power plant is up and working (the switch (62) is ON), but none of the switches in your house will turn on a light is the power plant goes down (the switch (62) is OFF).



52. Visual Alarm

Build the circuit as shown on the left and turn on the switch (62) or touch the reed switch (83) with the magnet (7). This will light up the heart LED (69) and the alarm (78) will sound too. But the sound from the alarm (78) is faint in this circuit since the alarm (78) is in series with the heart LED (69).

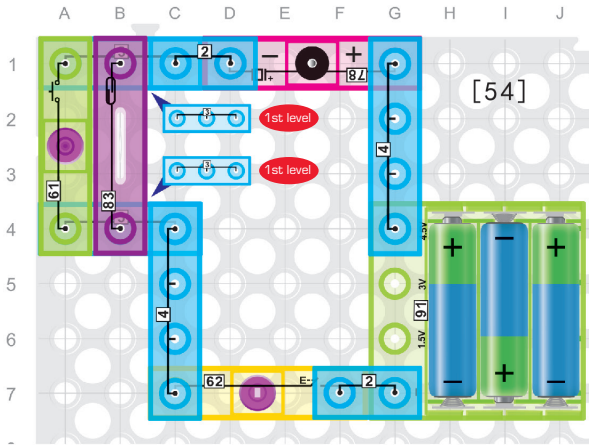
The heart LED (69) in this circuit is useful as a visual alarm in case the audio alarm (78) cannot be heard (e.g. it's loud in the room).



53. LED Light Bulbs

Build the circuit as shown on the left and turn on the switch (62). Press the press switch (61) and you will light up the heart LED (69) and the star LED (70) at the same time.

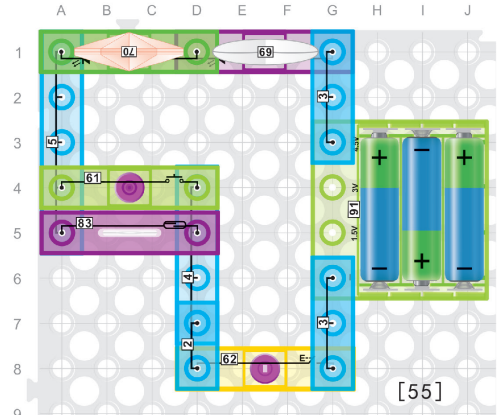
LED-based light bulbs are increasingly being used instead of traditional light bulbs these days. One reason is because good-quality LED bulbs can have a useful life of 25,000 hours or more. This means they can last more than 25 times longer than traditional light bulbs. That is a life of more than three years if run 24 hours a day, seven days a week.



54. Hearing Range

Build the circuit as shown on the left and turn on the switch (62). Press the press switch (61) or touch the reed switch (83) with the magnet (7) and you will hear the alarm (78) sound.

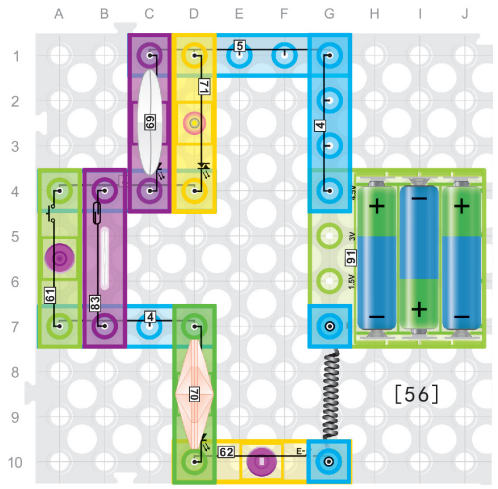
The alarm (78) is producing a tone somewhere in the range of 20Hz to 20kHz, which is the typical range of hearing for human beings, though specific individual hearing may vary. Hertz (Hz) is a unit of measurement for frequency. One Hz represents one cycle per second.



55. Backup Switch

Build the circuit as shown on the left and turn on the switch (62). Press the press switch (61) or touch the reed switch (83) with the magnet (7) and you will light up the heart LED (69) and the star LED (70) at the same time.

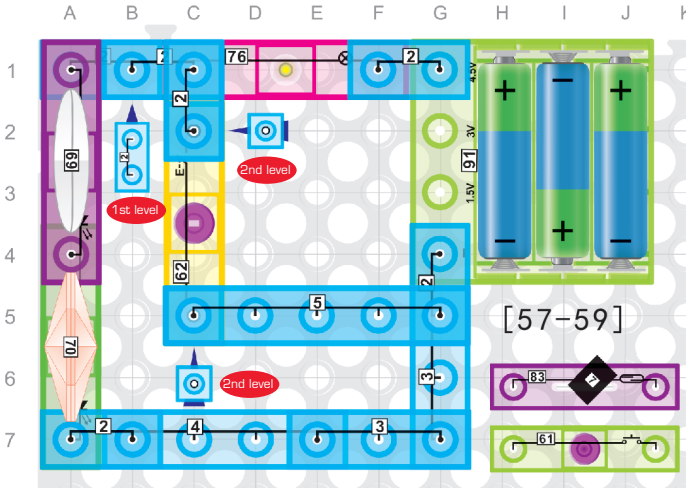
This circuit could simulate having a backup switch, where if for whatever reason reed switch (83) stopped working, you could still use the press switch (61) to turn on the LEDs.



56. Fluid Level Detector

Build the circuit as shown on the left and turn on the switch (62). Press the press switch (61) or touch the reed switch (83) with the magnet (7) and the heart LED (69) and the bi-directional LED (71) will be turned on with red light, while the star LED (70) is also on.

Reed switch circuits can be used to detect fluid levels for coffee makers, dishwashers, washing machines, and water heaters. By putting a magnet on a float, which rises and falls with the liquid in the container, the magnet can trigger a reed switch circuit that turns on a warning light whenever the liquid, and by extension, the magnet, reaches a certain level.



57. Light Power

Build the circuit as shown on the left and you will light up the two LEDs at the same time. If you turn on the switch (62) now, the two LEDs will be turned off, while the lamp (76) will still be on and will be brighter.

Light power can be measured in Watts or Lumens. Watts refer to how much energy the bulb uses while Lumens are a measure of the bulb's light output intensity.

58. Visual Effects

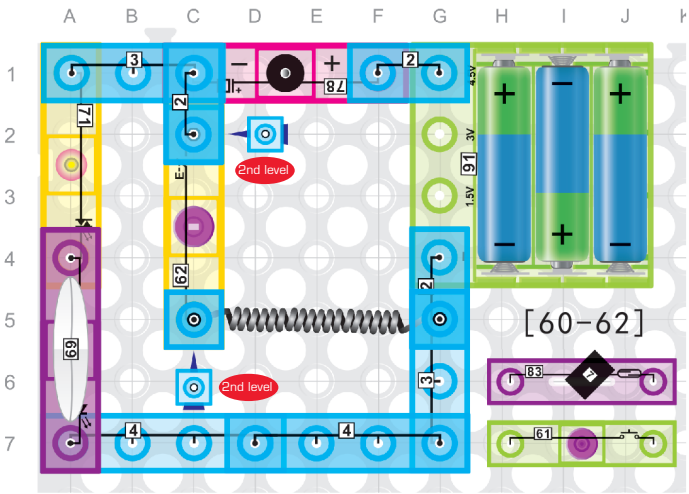
Replace the switch (62) with the press switch (61). The two LEDs will still be on. If you press the press switch (61), you will light up the lamp (76) while turning off the LEDs.

Circuits like this could be used in toys where you can get cool visual effects where certain lights come on while other lights go off when you press a button.

59. Earth is a Magnet

Replace the switch (62) with the reed switch (83). The two LEDs will still be on at the same time. Now touch the reed switch (83) with the magnet (7) and you will light up the lamp (76) and the two LEDs will be turned off.

Did you know that the Earth is like one big bar magnet? It has a magnetic north and a magnetic south, which is what enables a compass to point in the direction of the north pole.



60. Tornado Drill

Build the circuit as shown on the left and you will light up the two LEDs at the same time. If you turn on the switch (62), the two LEDs will be turned off and the alarm (78) will sound.

This circuit could simulate a tornado drill in your school where they intentionally turn off the lights while activating a tornado alarm and have you practice where to go and what to do during a tornado.

61. Help!

Replace the switch (62) with the press switch (61). The two LEDs will still be on at the same time. If you press the press switch (61), the two LEDs will be turned off and the alarm (78) will sound.

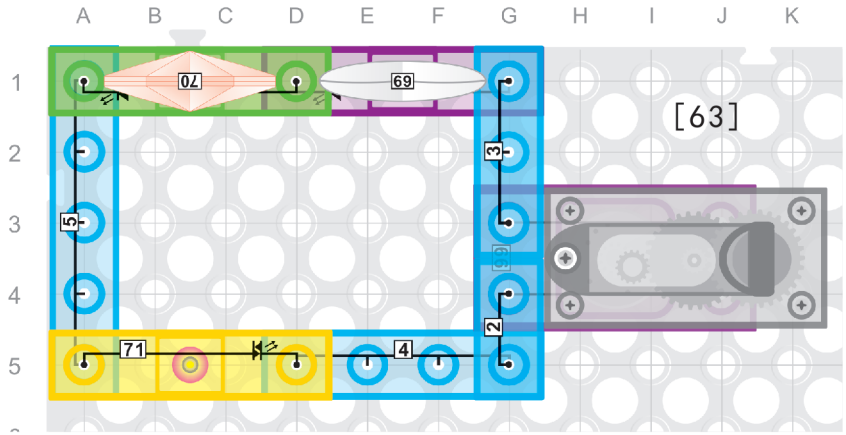
Try using this circuit as a Morse code generator and tap in the code below. This stands for S.O.S, or Save Our Souls. If you ever hear this sound, then it means someone is in danger and calling for help.

●●● – – – ●●●
S O S

62. Angular Light Intensity

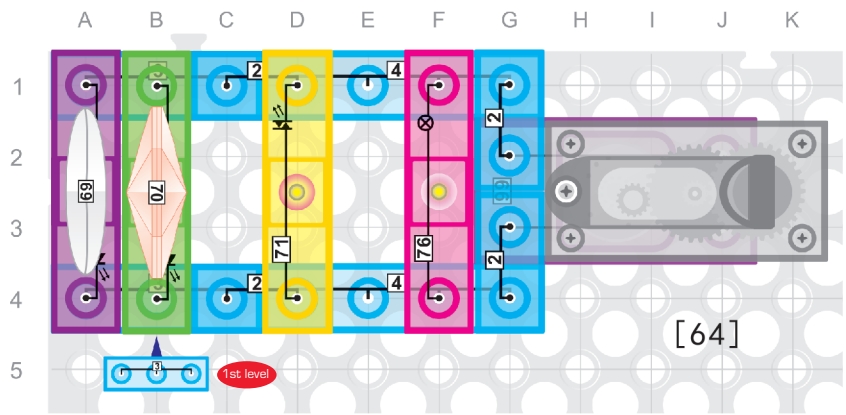
Replace the switch (62) with the reed switch (83) and you will light up the two LEDs at the same time. If you touch the reed switch (83) with the magnet (7), the two LEDs will be turned off and the alarm (78) will sound.

While it may appear that the bi-directional LED (71) is brighter than the heart LED (69), this is because most LEDs have angular light intensity profiles such that a majority of the light emits straight out of the top of the LED. If you look from the side at the bi-directional LED (71) you will see it looks very dim, just like looking at the side of the heart LED (69).



63. Failures in Series Circuits

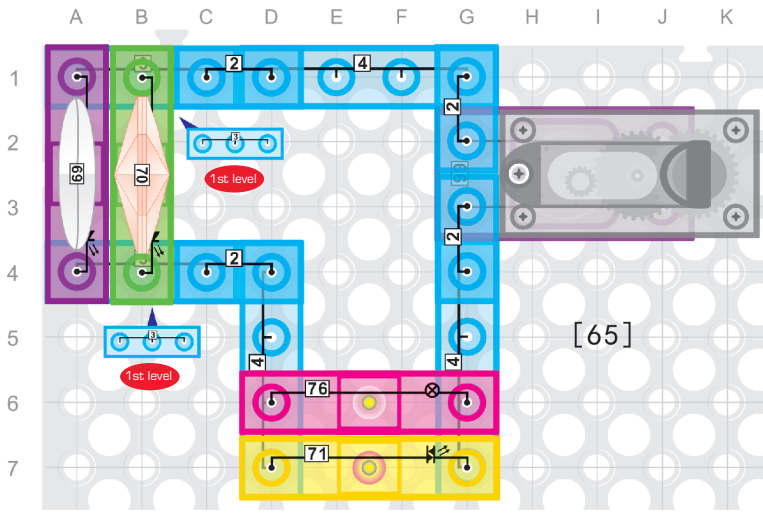
Build the circuit as shown on the left, turn the hand crank generator (94 & 99) clockwise and you will light up all the LEDs at the same time. Note that if you were to remove any one of the LEDs from the circuit (e.g. remove the star LED (70)), this opens the circuit and both of the other LEDs turn off. This is a disadvantage of series circuits: if one light goes out then they all go out (remember those old Christmas tree lights?).

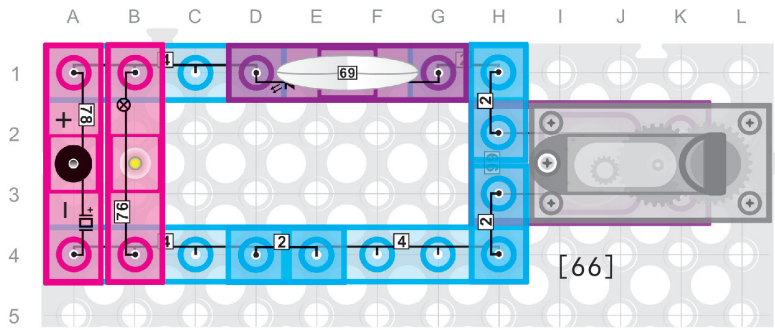


64. Failures in Parallel Circuits

Build the circuit as shown on the left, turn the hand crank generator (94 & 99) clockwise and you will light up all the LEDs and the lamp (76) at the same time. If you turn the hand crank generator (94 & 99) counter-clockwise, then only the bi-directional LED (71) and the lamp (76)will light.

Note that if you were to remove any one of the LEDs or lamp (76) from the circuit (e.g. remove the star LED (70)), this does not affect the rest of the circuit and both of the other LEDs and lamp (76) stay on. This is an advantage of parallel circuits: if one light goes out, it doesn't affect the rest of the lights.





65. Gears

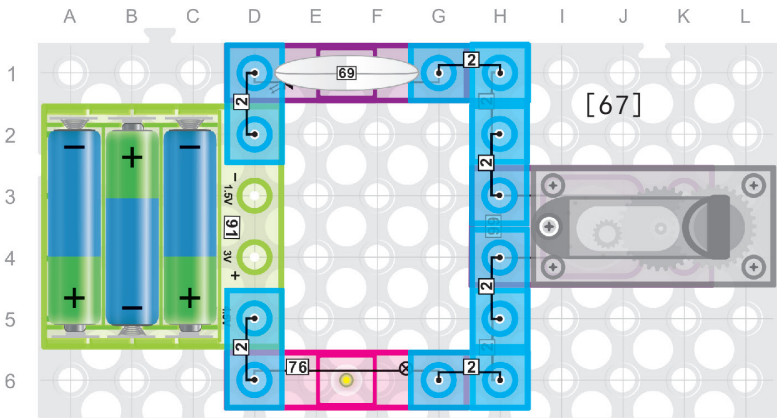
Build the circuit as shown on the left, turn the hand crank generator (94 & 99) clockwise, and you will light up three LEDs and the lamp (76) at the same time.

If you look inside the hand crank, you will see several toothed wheels called gears. Gears are used to alter the relation between the speed of the driving mechanism (the hank crank) and the speed of the driven part (the shaft from the generator (99)). In this case the gears are setup so that the shaft from the generator (99) spins much faster than the speed at which you turn the hand crank (94).

66. Usage of Gears

Build the circuit as shown on the left, turn the hand crank generator (94 & 99) clockwise, and you will light up the LED (69) and lamp (76) and hear the alarm (78) sound.

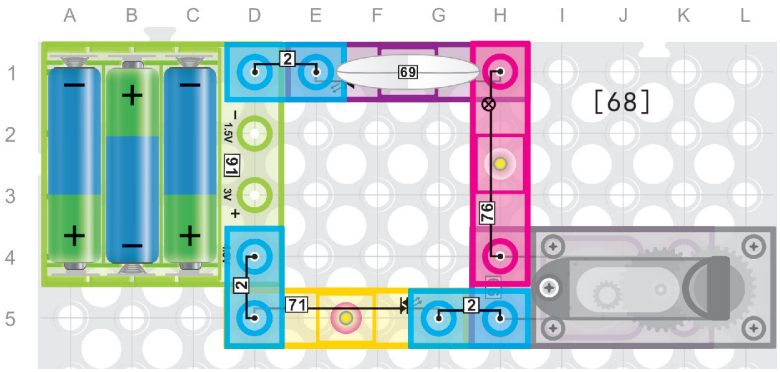
The gears in the hank crank (94) are designed to make the shaft of the generator (99) spin faster than you spin the hand crank (94). Gears are everywhere where there are engines and motors producing rotational motion. For example, car engines and transmissions contain lots of gears. In addition to increasing or decreasing rotational speed, gears can also reverse the direction of rotational motion, move rotational motion to a different axis, and keep rotation of two axis synchronized.



67. Electrical to Mechanical Energy

Build the circuit as shown on the left and you will light up the heart LED (69) at once. If you turn the hand crank generator (94 & 99) clockwise, you will see the heart LED (69) become brighter and the lamp (76) will be turned on.

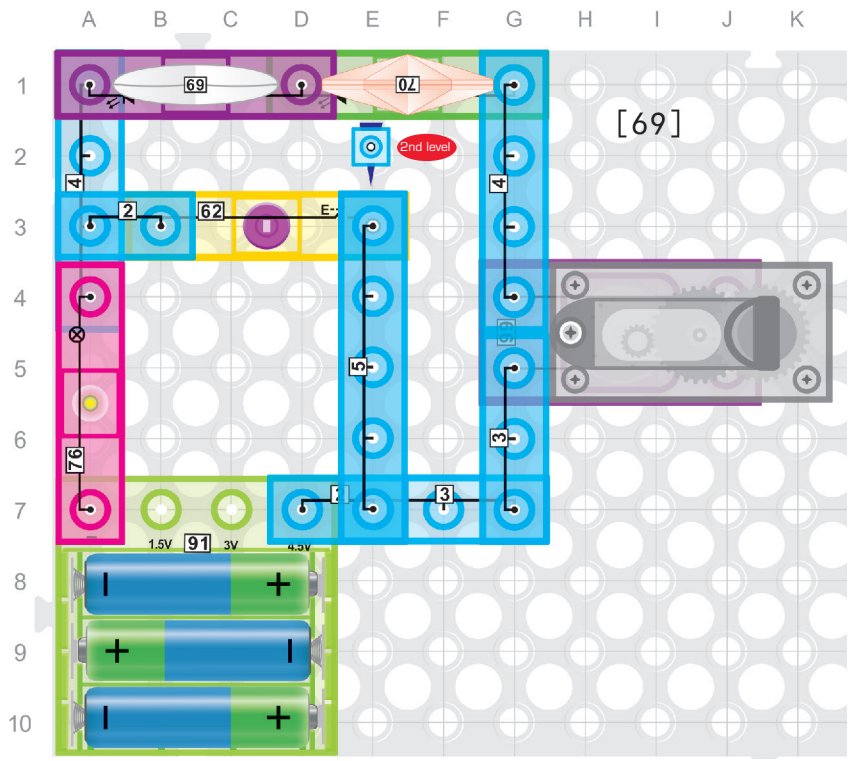
Try removing the hand crank (94) from the generator (99). Notice that the shaft on the generator (99) may be spinning (if not you might need to start it spinning with your finger). The electrical power from the batteries is being converted to mechanical power in the generator (99) to spin the shaft.



68. Generators and Magnetic Fields

Build the circuit as shown on the left and you will light up the heart LED (69) and the bi-directional LED (71) at the same time. If you turn the hand crank generator (99), you will see the heart LED (69) and the bi-directional LED (71) become brighter and the lamp (76) will be turned on.

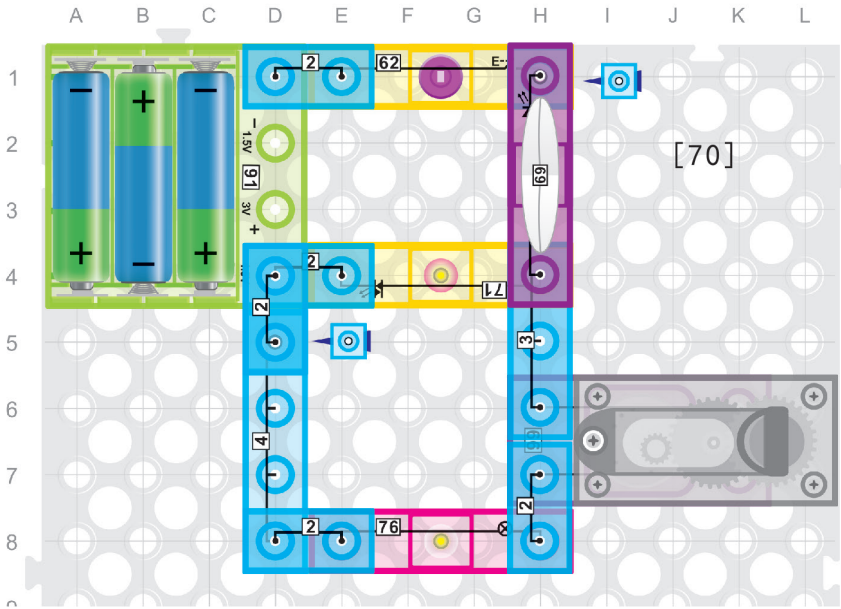
Now put the magnet (7) near the generator (99). Note that the magnet (7) is attracted to the generator (99) at certain locations. This is because generators have magnets inside them that create a magnetic field. When a current flows through this magnetic field (from the batteries in this circuit), it creates a force (look up Fleming's rule) that spins the motor shaft.



69. Newton's First Law of Motion

Build the circuit as shown on the left and you will light up the heart and star LED. Turn the hand crank generator (94 & 99) and you will see the two LEDs become brighter. The faster you turn, the brighter they will be. If you turn on the switch (62), the LEDs will turn off and the lamp (76) will be turned on. Now you can turn the hand crank generator (94 & 99) and the heart and star LEDs will be turned on again.

Now try removing the hand crank (94) from the generator (99). Notice that unlike in project 67, the shaft on the generator (99) does not spin. Newton's first law of motion states: An object either remains at rest or continues to move at a constant velocity, unless acted upon by a force. Due to the higher resistance in this circuit compared to project 67 (two LEDs and a lamp here vs. one LED and a lamp in project 67), current through the generator (99) is not quite enough to create a force inside the generator (99) to spin the shaft, and thus the shaft remains at rest.

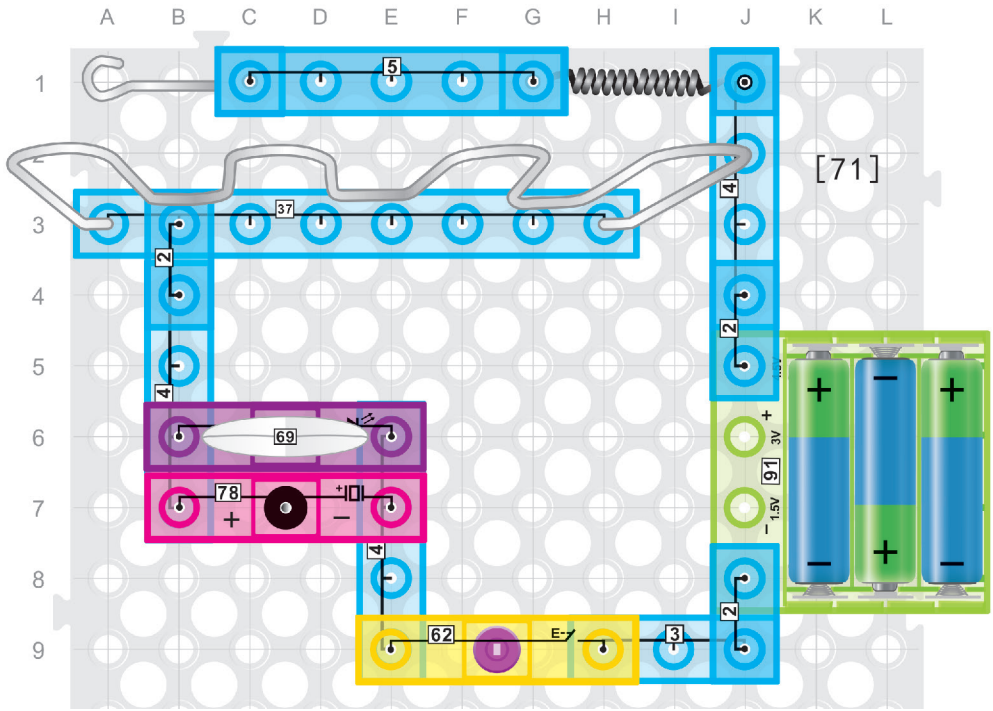


70. Inertia

Build the circuit as shown on the left. If you turn the hand crank generator (94 & 99), you will light up the lamp (76) and the bi-directional LED (71) at the same time. If you turn on the switch (62), you will light up the heart LED (69).

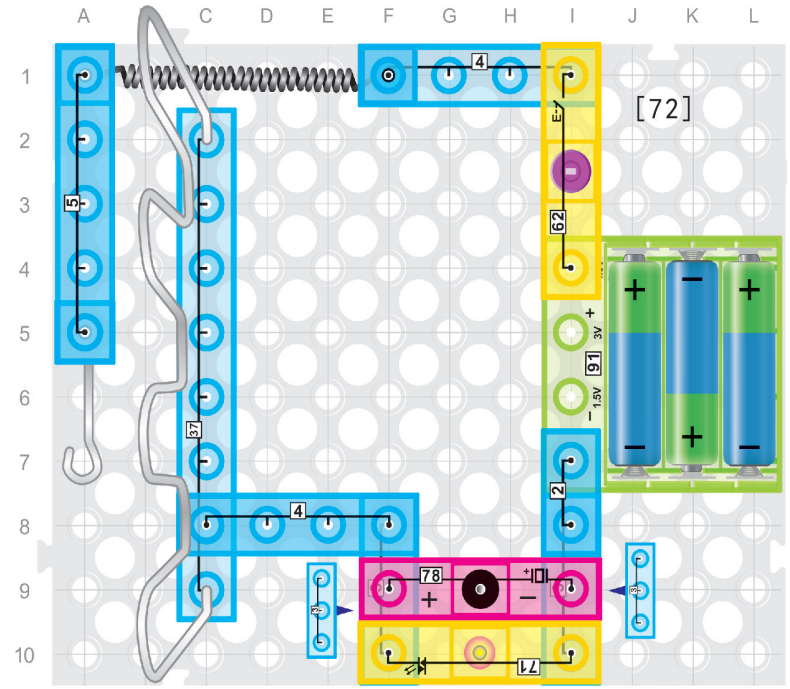
Try removing the hand crank (94) from the generator (99). Note that when you turn the switch (62) on, the generator (99) shaft may start spinning, but sometimes you need to start it spinning with your finger and then it continues spinning. This demonstrates the concept of Inertia: a property of matter by which it continues in its existing state of rest or uniform motion in a straight line, unless that state is changed by an external force.

The generator has inertia because when it's at rest, it tends to stay at rest (the current running through the magnetic field inside the generator (99) does not create quite enough force to spin the shaft), but once enough force is applied to the shaft when your finger starts it spinning, then the shaft tends to stay spinning (the current running through the magnetic field inside the generator (99) does create enough force to keep the shaft spinning).



71. Test Your Hand Steadiness

Build the circuit as shown above and turn on the switch (62). Then move the hook that is connected to the 5-wire (5) through the metal of the maze (37). When the metal of the maze (37) is touched by the hook, you will light up the heart LED (69) and the alarm (78) will sound. Test how steady your hand is. Can you make it through the maze (37) without lighting the heart LED (69) and making the alarm (78) sound?



72. Nerves & Muscles

Build the circuit as shown above and turn on the switch (62). Then move the hook that is connected in the 5-wire (5) through the metal of the maze (37). When the metal of the maze (37) is touched by the hook, you will light up the bi-directional LED (71) and the alarm (78) will sound. It's not as easy as it looks! It is actually normal for your hands to shake slightly as the nerves and muscles switch continuously between states of relaxation and contraction, so keeping your hands in a relaxed state all the way through the maze (37) is challenging. Especially when you know the alarm (78) will sound if you slip!

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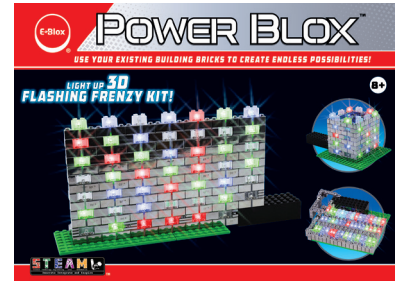

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