SNAP CIRCUITS®

ELENCO®

GREEN ENERGY

EXPLORATION IN ALTERNATIVE ENERGY

Simply Snap Together!

OVER 125 EXCITING PROJECTS

CONTAINS OVER 45+ PARTS

Project 38

STEM.ORG AUTHENTICATED™ EDUCATIONAL PRODUCT

Ages 8-108

Rechargable battery included

MADE WITH CIRCUITSAFE™ fuse technology

AWARD WINNING SNAP CIRCUITS GENUINE BRAND

PRINTED Projects 38

95 ONLINE Projects

Projects 39-133 See your printed manual for projects 1-38

ELENCO® Learn by doing.®

Copyright © 2022 by ELENCO® Electronics, LLC. All rights reserved. No part of this book shall be reproduced by any means; electronic, photocopying, or otherwise without written permission from the publisher. Source Code: SCG-225V1 Rev B 753170WEB

Project Listings

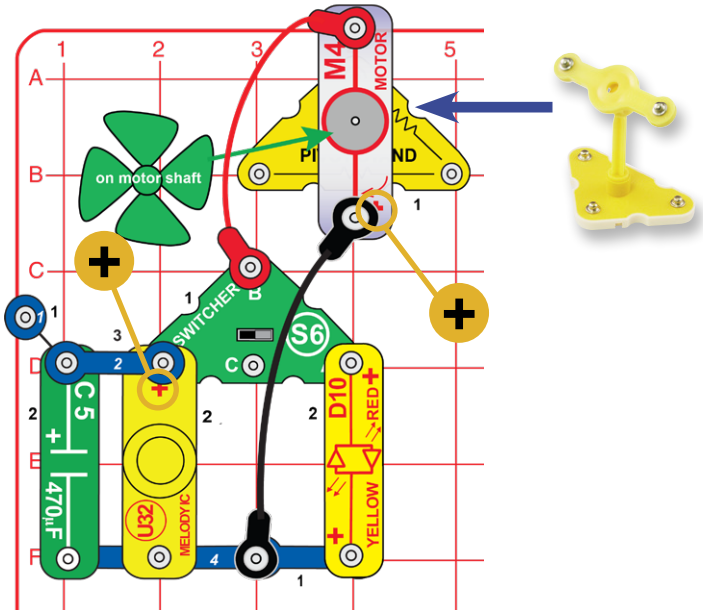
Project #	Description	Page #	Project #	Description	Page #
1	Hand Cranking	12	37	Yellow Cola	29
2	Crank Charger	12	38	Everything Circuit	30
3	Best Charging Circuits	13	39	Wind Warning	3
5	Solar Color Power	14	40	Light Charger	3
4	Solar Power	14	41	Mini Car with on-Board Sound	4
6	Solar Motor	14	42	Mini Car with Light & Sound	4
7	Solar Charger 5mA	15	43	Mini Car with Solar Charger	4
8	Long Light	15	44	Fan Car	5
9	Windmill	16	B1	Light Activated Car	5
10	Windy Lights	16	45	LED Currents	6
11	Multi Power	17	46	Battery Load	7
12	Battery Power	17	47	Battery Load Current	7
13	Electric Circuit	18	48	Make Your Own Parts	8
14	Close the Door	19	49	Liquid Resistors	8
15	Feeling Switchy	19	50	Liquid Lights	8
16	Reverser	20	51	Moving Voltage	9
17	Super Reverser	20	52	Moving More Voltage	9
18	Voltage	21	53	Power Sources	10
19	Resistors	21	54	Powering Clock	11
20	Light Emitting Diode	22	55	Powering Sound	11
21	Play a Tune	22	56	Powering LED	11
22	Clock	23	57	Powering Big Voltage	11
23	Capacitor	23	58	Powering Big Current	11
24	Motor	24	59	Splitting Current	12
25	Water Wheel	24	60	Splitting Current Differently	12
26	Motor Voltage	24	61	Wind Direction	12
27	Crank Motor	25	62	Voltage Order	13
28	Crank Motor Voltage	25	63	Current Order	14
29	Fade Out	26	64	Sources in Series	14
30	Mini Car with Wired Control	26	65	Sources in Parallel	15
31	Wired Control Car with Light/Sound	26	66	Two in Series	16
32	Mini Car with on-Board Control	27	67	Two in Parallel	16
33	Mini Car with on-Board Light	27	68	Two LEDs Series	17
34	Liquid Battery	28	69	Two LEDs in Series-Filtered	17
35	Juice Battery	28	70	Two LEDs in Parallel	17
36	Cola Light	29	71	Wind Sound	18

Note:Projects in dark green can be found in the printed manual.

Project Listings

Project #	Description	Page #	Project #	Description	Page #
72	Windy Time	18	101	Morse Light	32
73	Wind Charger with Light	19	102	Motor Status LEDs	33
74	Wind Charger with Sound	19	103	Energy Converter	33
75	Kick Start Motor	19	104	Energy Conversion	34
76	Electricity From Water	20	105	Small Energy	34
77	Water Light	20	106	Mechanical Energy Conversion	34
78	Cola Clock	21	107	Generator	35
79	Cola Clock with Memory	21	108	Clock with Memory	35
80	Changing Water Pressure	22	109	Saving Energy	36
81	Storing Energy in Water	22	110	Energy Transmission Loss	36
82	Hydro Lights	23	111	Water Timer	37
83	Directional Wind Lights	23	112	Sun & Wind Light	37
84	Emergency Transmission Loss	23	113	Hybrid	38
85	Using Stored Water	25	114	Hybrid Car Concept	38
86	Water Redirection	25	115	Solar Fun	39
81	Storing Energy in Water	22	116	Triple Current Meter	39
82	Hydro Lights	23	117	Hand Charger	40
83	Directional Wind Lights	23	118	Parallel Cranking	40
84	Emergency Transmission Loss	23	119	Hard to Crank	41
85	Using Stored Water	25	120	Slow In Flash Out	41
86	Water Redirection	25	121	Filling Station	42
87	One of the Most Powerful Forces in the world	25	122	Gas Petal	42
			123	Volt Meter	43
88	Electricity Against Water	25	124	Anemometer	43
89	Harnessing Static Electricity	26	125	Capacitor Charging	44
90	Solar Light Clock	27	126	Current Summer	44
91	Solar Light Charger	27	127	More Current Summing	44
92	Solar Light Row	28	128	Summing Voltage	45
93	Crank Support	28	129	Charging Currents	45
94	Hand Lights	29	130	Big Resistance	46
95	Hand Noise	29	131	Little Resistance	46
96	Heavy Fan	30	132	Slow Charge	47
97	Remote Header	30	133	Funky Beeper	47
98	Remote Water Heater	31			
99	Electrical Material Checker	31			
100	Morse Code	32			

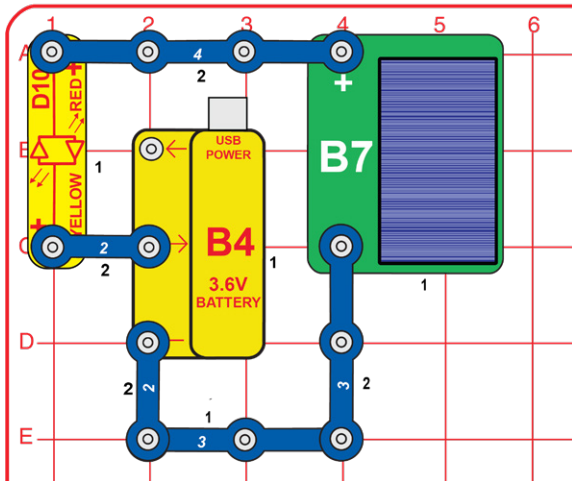
PROJECT 39 • **Wind Warning**



Build the circuit as shown, with the motor on the pivot stand. Set the switcher (**S6**) to the left for sound (in one wind direction) or to the right for light. Blow on the fan, place it in a strong wind, or give it a good spin with your fingers. The fan must spin very fast to produce sound.

This circuit can be used to warn you of dangerous winds.

PROJECT 40 • **Light Charger**

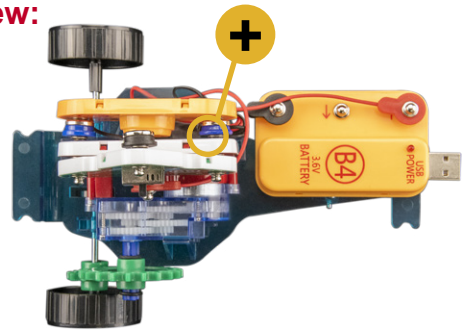


This circuit uses the solar cell (**B7**) to charge the rechargeable battery (**B4**). Place the solar cell in sunlight or near an incandescent light bulb. The red/yellow LED (**D10**) lights red when the battery is being charged. The brighter the LED, the faster it is charging.

PROJECT 41 • Mini Car with on-Board Sound

Side view:

Top view:

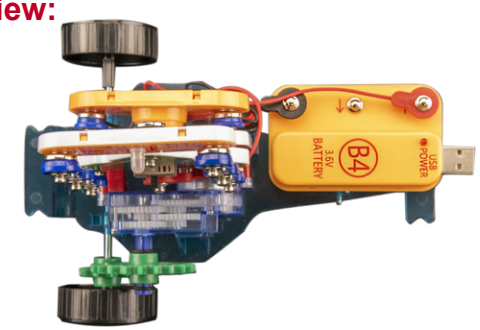


Use the project 34 (in the paper manual) circuit but add the melody IC (**U32**) using two 1-snap wires, as shown. A tune plays when the car moves backward. You can reverse the orientation of the melody IC to make the sound play when the car moves forward.

PROJECT 42 • Mini Car with Light & Sound

Side view:

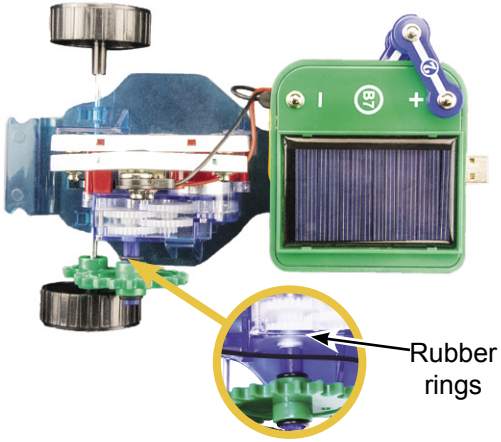
Top view:



Use the preceding circuit but add the red/yellow LED (**D10**) using two 3-snap wires, as shown.

PROJECT 43 • Mini Car with Solar Charger

Top view:

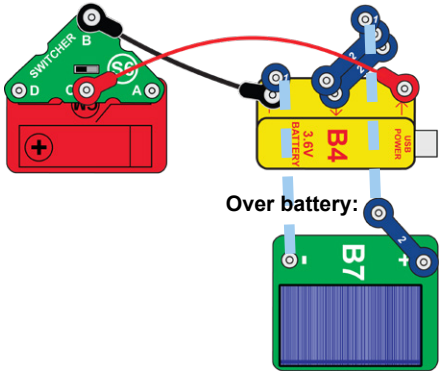


Front view:

Use the project 34 circuit but add the solar cell (**B7**) using two 1-snap wires and three 2-snap wires, as shown. Sunlight or incandescent lights can recharge the battery.

CIRCUIT DRAWING:

Side mounted: **On front of car:**



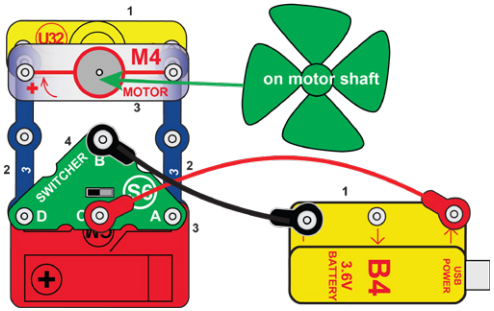
PROJECT 44 • **Fan Car**

Build the circuit as shown, initially setting the switcher (**S6**) to the middle setting. Mount the 1.75” gear on the geared motor (**GM**) with the rubber rings to keep it from sliding out of position, place it on the mini car frame, and connect the battery (**B4**) and other parts as shown. Use the switcher (**S6**) to make the mini car go forward, backward-turning, or stop. The fan spins when the car is moving.

See project 3 if you need to recharge the battery (**B4**).

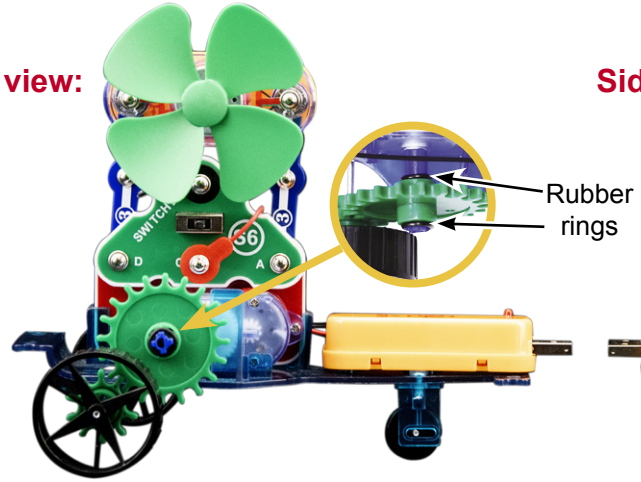
CIRCUIT DRAWING:

Side mounted:

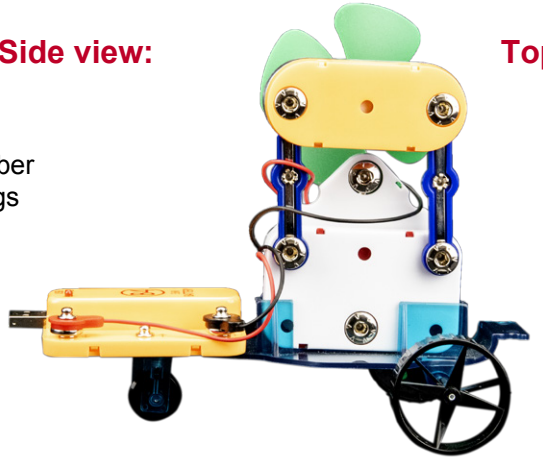


B4 on front of car.

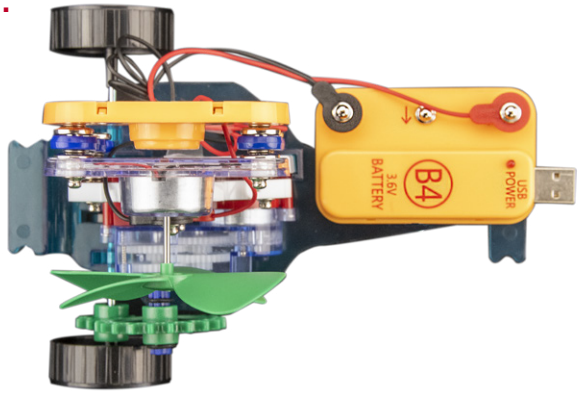
Side view:



Side view:



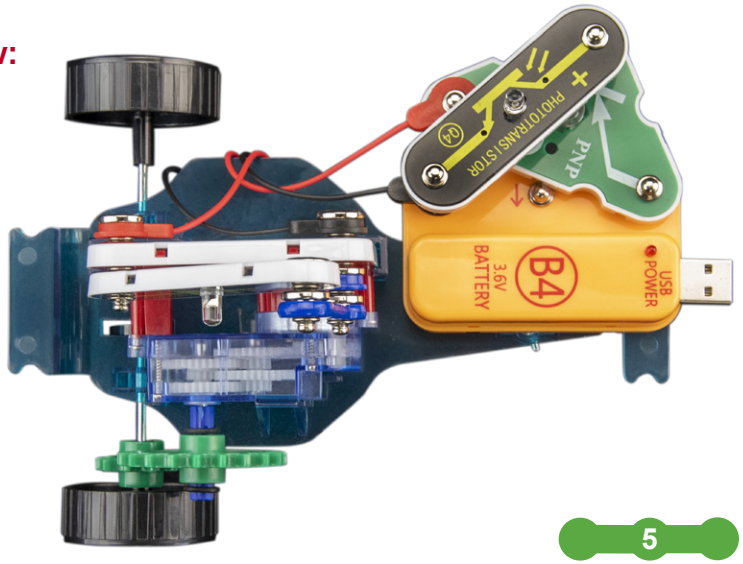
Top view:



PROJECT B1 • **BONUS: Light Activated Car**

Side view:

Top view:



This project requires some parts not included in this set, but which you may already have from other Snap Circuits® sets.. Mount the 1.75” gear on the geared motor (**GM**) with the rubber rings to keep it from sliding out of position, place it on the mini car frame, and connect the battery (**B4**), color LED (**D8**), two 1-snap wires, one 2-snap wire, a PNP transistor (**Q1**, not included), a phototransistor (**Q4**, not included; a photoresistor (**RP**) may be used instead), and red & black jumper wires as shown. Shine a bright light on the phototransistor (or photoresistor) to make the car go forward.

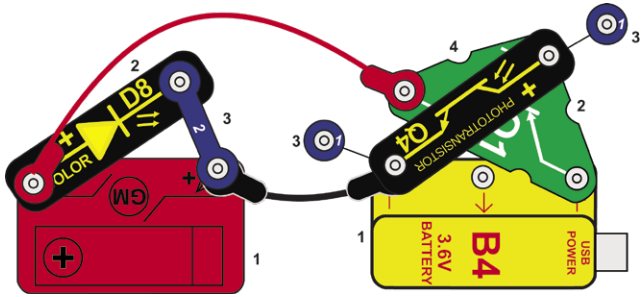
You can swap the red & black jumper wire connections to the geared motor (**GM**) to make the car go backward-turn instead of forward.

The battery may not be able to drive this mini car for long without recharging, so connect it to a USB port to recharge it as needed (it can also be recharged using the solar cell as shown in project 3).

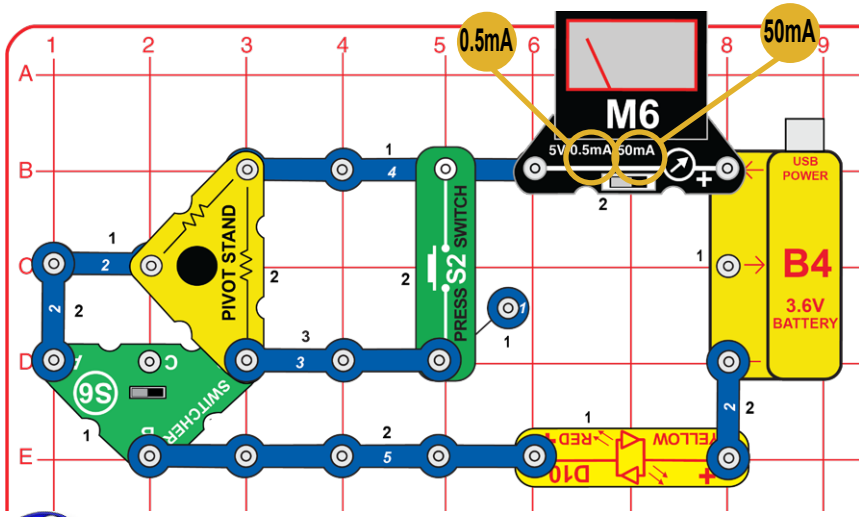
Parts required from other Snap Circuits® sets:
PNP transistor (**Q1**)
phototransistor (**Q4**) or photoresistor (**RP**)

CIRCUIT DRAWING:

Side mounted: **On front of car:**



PROJECT 45 • LED Currents



Adding resistors to a circuit is like partially blocking a water pipe, reducing the flow of water.

High currents can damage LEDs, so resistors are usually used with them to limit the current. Your **D8** and **D10** LEDs have internal resistors of around 330Ω to protect them.

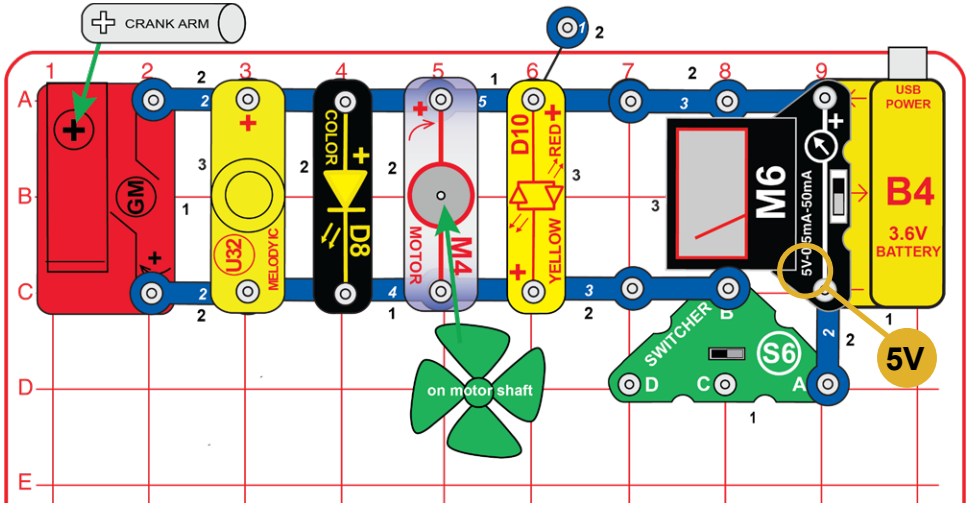
Build the circuit, set the switcher (**S6**) to the left position, and set the meter (**M6**) to the **0.5mA** setting. This circuit has the red/yellow LED (**D10**) in series with a 10KΩ resistor in the pivot stand. 10KΩ is a high resistance, so the meter measures a small current and the LED is dimly lit. It is easier to see the LED if you take the circuit into a dark room. If the LED does not light at all then the battery needs to be recharged.

Switch the meter to the **50mA** setting. Now set the switcher to the right position, replacing the 10KΩ resistor with a smaller 47Ω resistor in the pivot stand. The LED is brighter now and the current is higher. The current is not as high as you might have expected with only a 47Ω resistor in series with the LED, because the LED has a 330Ω resistor hidden inside to protect it from possible overloading, so the total resistance in series with the LED is actually 47Ω + 330Ω = 377Ω.

Now push the press switch to bypass the 47Ω resistor in the pivot stand. The current and LED brightness are slightly higher now since only the LED’s 330Ω internal resistor remains in the circuit.

Flip the red/yellow LED around to its yellow side or replace it with the color LED (**D8**, “**+**” on left) and see how the brightness and current change.

PROJECT 46 • Battery Load



Build the circuit and set the meter (**M6**) to the **5V** setting. Set the switcher (**S6**) to the left or middle position (off) and read the battery (**B4**) voltage when it is not running anything.

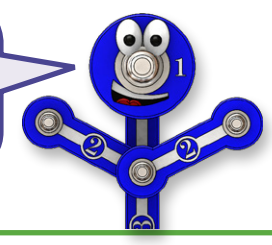
Now set the switcher to the right position and see what happens to the voltage when everything turns on. If the battery is already weak, some modules may not start. If you watch the voltage for a while, you will see it slowly drop as the battery is discharged. If the battery was already weak, the voltage will drop faster.

If you remove some of the devices the battery is running (the LEDs, melody IC, motor, and geared motor), then the voltage will not drop as much when the switcher is turned on.

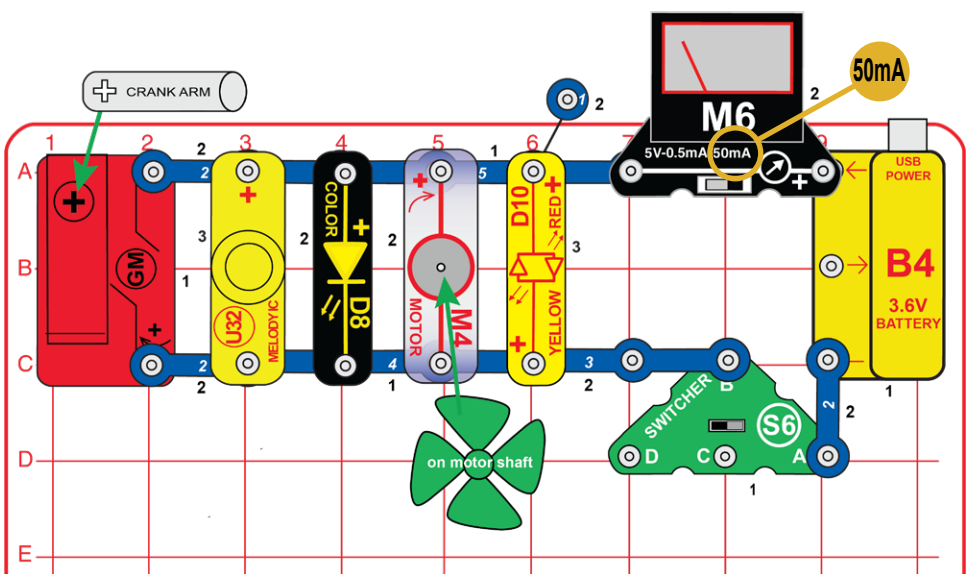
See project 3 if you need to recharge the battery (**B4**).

The battery makes electricity using a chemical reaction, but has a limited amount of chemicals and not all of it can react at the same time. When a battery cannot supply as much current as a circuit needs, the voltage (electrical pressure) drops. That is why the voltage drops when the switch connects the battery to the rest of this circuit.

Engineers refer to all the devices a power source is running as the load, because they are the burden the power source is carrying.



PROJECT 47 • Battery Load Current

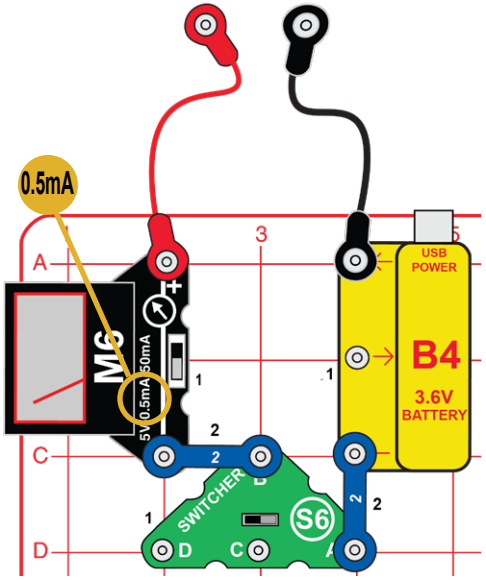


Move the meter to the new location shown and set the meter (**M6**) to the **50mA** setting. Set the switcher (**S6**) to the right position and see how high the current is when the battery is running all these devices.

You may see that the current is very high, which explains why the battery voltage dropped in the preceding project. Do you know which devices need most of the current? Remove some and see how the current changes to see if you were right.

Your **M6** meter is a simple meter, don't expect it to be as accurate as normal electronic test instruments.

PROJECT 48 • Make Your Own Parts



Build the circuit, set the meter (**M6**) to the **0.5mA** setting & set the switcher (**S6**) to the right position.

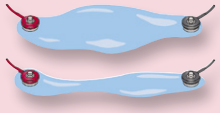
Make your parts using either the water puddles method (**A**), the drawn parts method (**B**), or the pencil parts method (**C**). Touch the metal in the jumper wires to your parts and read the current.

See project 3 if you need to recharge the battery (**B4**).

Resistance = Voltage / Current, so you can use the battery voltage (3.6V) and the current you measure to find the resistance of your puddles and drawings.

Long narrow shapes have more resistance than short wide ones. The black core of pencils is graphite, the same material used in the resistors in the pivot stand.

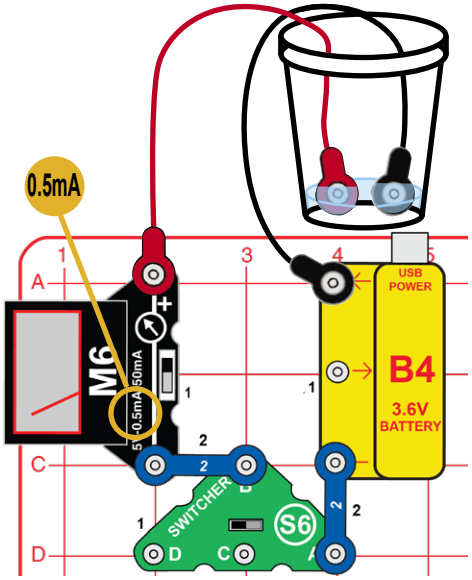
Method A (easy): Spread some water on the table into puddles of different shapes, perhaps like the ones shown here. Touch the jumper wires to points at the ends of the puddles.



Method B (challenging): Use a SHA**RP** pencil (No. 2 lead is best) and draw shapes, such as the ones here. Draw them on a hard, flat surface. Press hard and fill in several times until you have a thick, even layer of pencil lead. Touch the jumper wires to points at the ends of the drawings. You may get better electrical contact if you wet the metal with a few drops of water. Wash your hands when finished.

Method C (adult supervision and permission required): Change the setting on the meter to the **50mA** scale. Use some double-sided pencils if available, or VERY CAREFULLY break a pencil in half. Touch the jumper wires to the black core of the pencil at both ends.

PROJECT 49 • Liquid Resistors



Build the circuit, set the meter (**M6**) to the **0.5mA** setting, and set the switcher (**S6**) to he right position. Add about 1/4 inch of water to a cup or bowl. Connect the jumper wires to the circuit as shown and place the loose ends in the water, make sure the metal parts aren't touching each other. Measure the current through the water.

Add salt to the water and stir to dissolve it. The current should be higher now, since salt water has less resistance than plain water. If the current is too high to measure on the **0.5mA** scale, switch to the **50mA** scale.

Now add more water to the cup and watch the current.

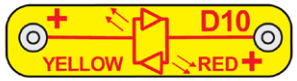
If you have some distilled water, place the jumper wires in it and measure the current. You should measure close to zero current, since distilled (pure) water has very high resistance. Normal water has impurities, which lower its resistance. Now add salt to the distilled water and watch the current increase as the salt dissolves!

You can also measure the current through other liquids. ***Don't drink any water or liquids used here.***

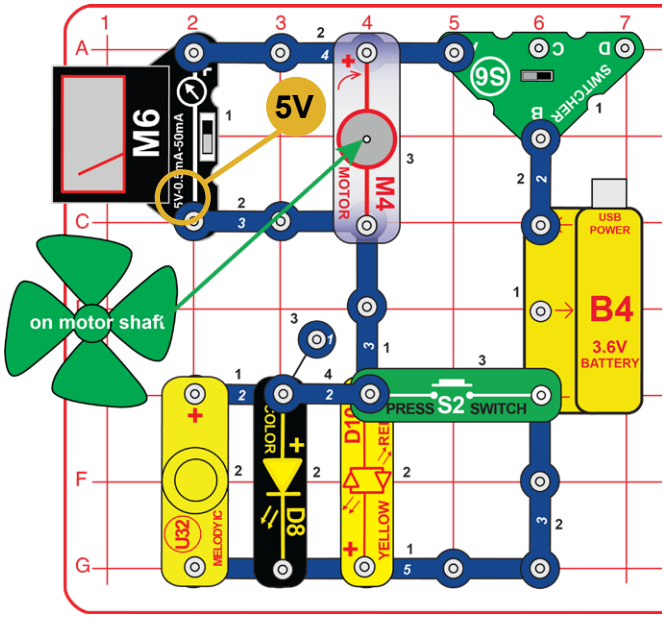
Pure water has very high resistance because its electrons are tightly held in place. Impurities (such as dissolved dirt, minerals, or salt) decrease the resistance because they have loose electrons, which disrupt the structure and make it easier for other electrons to move through.

PROJECT 50
Liquid Lights

Replace the meter with the red/yellowLED (**D10**, positioned in either direction). Place the jumper wires back into water, into salt water, or on the shapes you drew.



PROJECT 51 • Moving Voltage



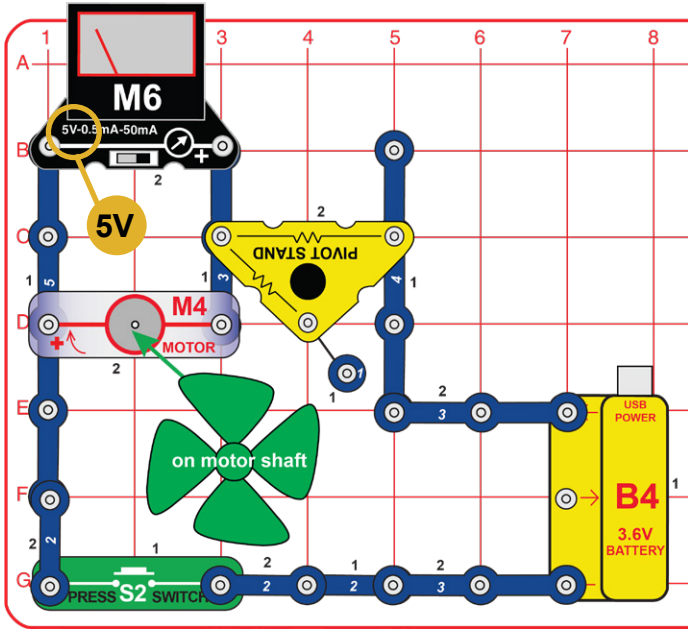
Build the circuit and set the meter (**M6**) to the **5V** setting. Place the wind fan on the motor (**M4**). Set the switcher (**S6**) to the left position. The LEDs (**D8** & **D10**) light, the melody IC (**U32**) makes sound, the fan spins, and the meter shows the voltage across the motor. You may need to give the fan a push to get it started. The voltage produced by the battery is split between the motor and the LEDs and melody IC.

Push the press switch (**S2**). The LEDs and melody IC turn off, the motor speeds up, and the meter shows a higher voltage across the motor. With the press switch on, the full voltage from the battery is available at the motor because the LEDs and melody IC are bypassed.

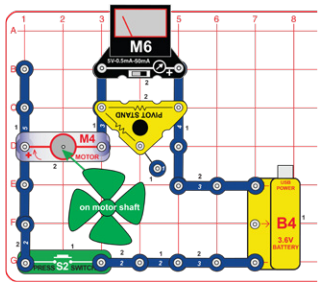
See project 3 if you need to recharge the battery (**B4**).

Switches are used to move voltage around a circuit.

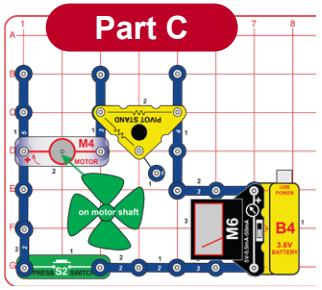
PROJECT 52 • Moving More Voltage



Part B



Part C

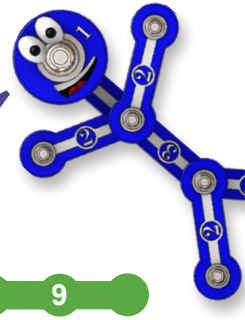


Build the circuit and set the meter (**M6**) to the **5V** setting. Push the switch (**S2**); the meter measures the voltage across the motor. The voltage increases as the motor speeds up.

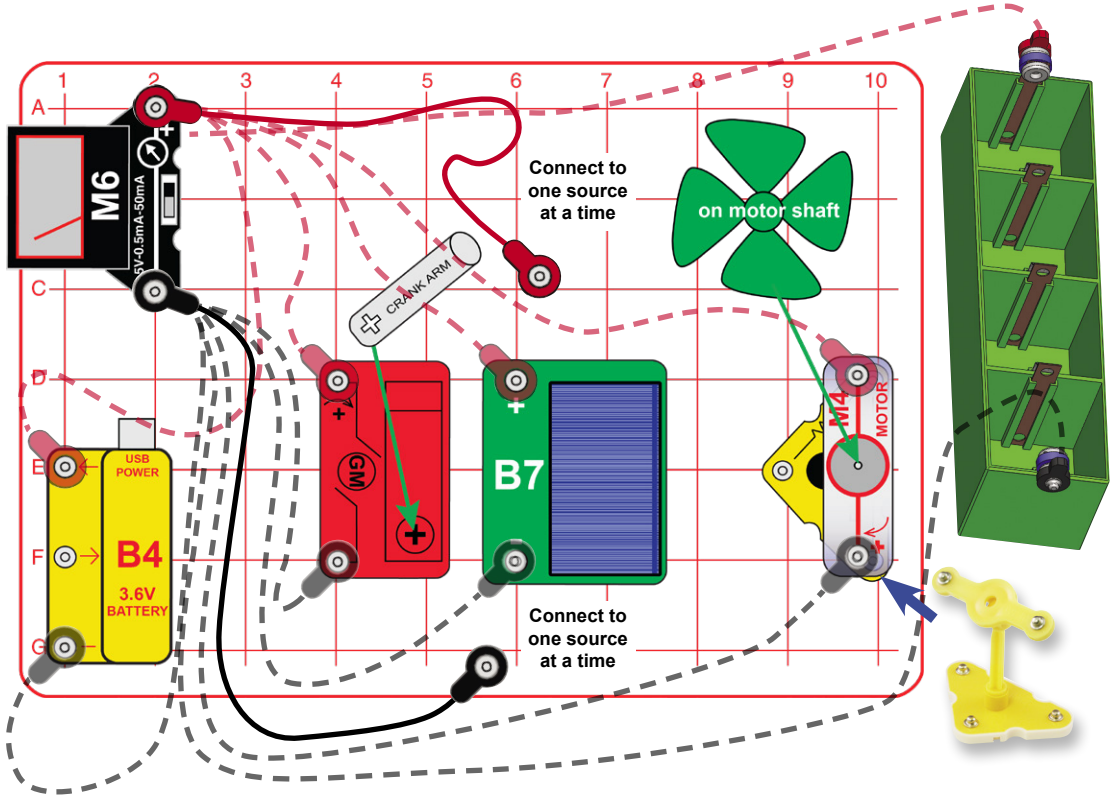
Part B: Move the meter so it is across the pivot stand. The pivot stand has a 47Ω resistor inside. Push the switch to measure the voltage across the pivot stand resistor.

Part C: Move the meter so it is directly across the battery (**B4**). Push the switch to measure the voltage produced by the battery.

The motor voltage plus the picot stand voltage should about equal the battery voltage. It may be a little different, because the **M6** meter has limited accuracy. The voltage across the switch will be very low when it is pressed.



PROJECT 53 • Power Sources



Snap Circuits® Green has 6 electrical power sources: battery, hand crank, solar cell, windmill, watermill, and liquid holder. Let's compare them. The watermill is similar to the windmill and its messy, so we'll skip it.

Connect the red & black jumper wires to the meter and to one of the power sources at a time, as shown. Measure the voltage produced using the **5V** meter setting; then look at the current produced using either the **0.5mA** or the **50mA** meter settings. Some times the meter reading will be more than the **5V** or **50mA** scales. Take some notes in the table below.

A. Battery.

B. Hand Crank: Turn it clockwise at different speeds.

C. Solar cell: Place it in sunlight or near an incandescent lamp.

D. Windmill: Mount the motor on the pivot stand, place the wind fan on it, and blow on it or place it in a strong wind. You may need to give it a push to get it started.

E. Liquid energy source: Assemble it using the instructions on page 4 of the paper manual. Fill the compartments with cola or juice.

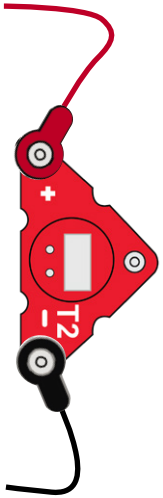
See project 3 if you need to recharge the battery (**B4**).

Power Source	Highest Meter Voltage	Highest Meter Current	Clock (Project 49)	Melody IC (Project 50)	LED (Project 51)	Big Voltage (Project 52)	Big Current (Project 53)
Battery							
Hand Crank							
Solar Cell							
Windmill							
Liquid							

The most powerful power source is the one which produces the best balance of voltage and current. Different types of circuits need different levels of voltage and current.

For each power source, the balance between voltage and current produced can be adjusted by changing its construction or with how groups of them are arranged.

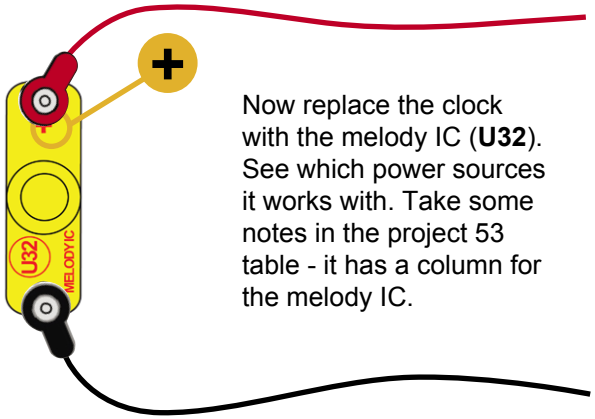
PROJECT 54
Powering Clock



Use the 5 power sources you have set up in project 53 but replace the meter with the clock (**T2**) as shown. See if it works with each power source (it should). Take some notes in the project 53 table - it has a column for the clock.

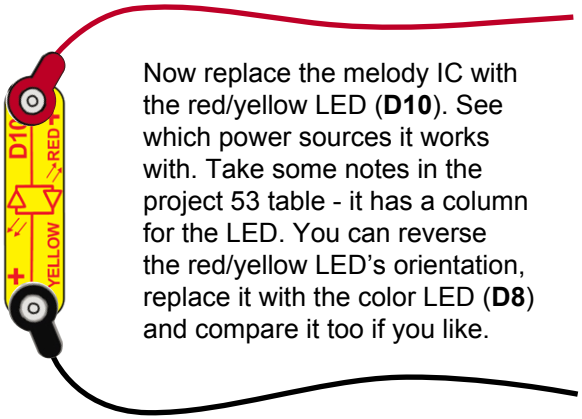
You are not using the clock with a separate energy storage device, so notice how continuous power is from each source (for example, the clock stops when you stop turning the hand crank).

PROJECT 55
Powering Sound



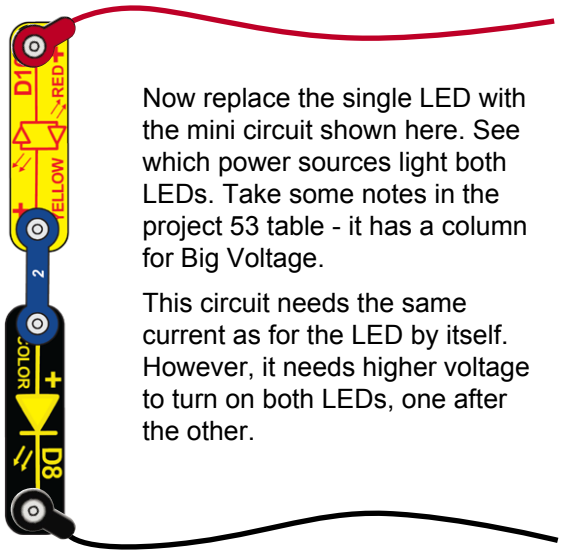
Now replace the clock with the melody IC (**U32**). See which power sources it works with. Take some notes in the project 53 table - it has a column for the melody IC.

PROJECT 56
Powering LED



Now replace the melody IC with the red/yellow LED (**D10**). See which power sources it works with. Take some notes in the project 53 table - it has a column for the LED. You can reverse the red/yellow LED's orientation, replace it with the color LED (**D8**) and compare it too if you like.

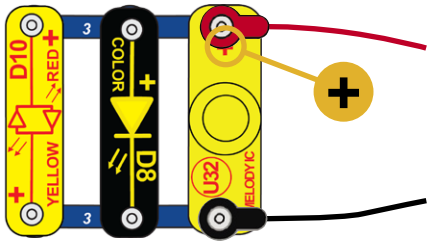
PROJECT 57
Powering Big Voltage



Now replace the single LED with the mini circuit shown here. See which power sources light both LEDs. Take some notes in the project 53 table - it has a column for Big Voltage.

This circuit needs the same current as for the LED by itself. However, it needs higher voltage to turn on both LEDs, one after the other.

PROJECT 58
Powering Big Current



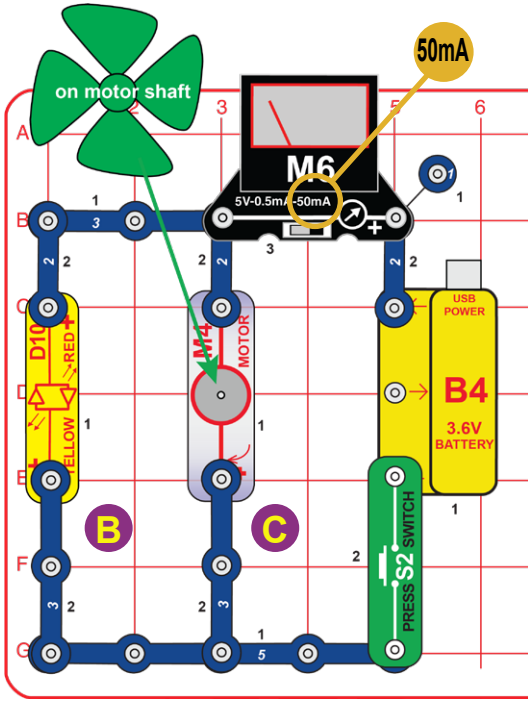
Now change to this mini circuit instead. Find out which power sources can run both LEDs and the melody IC. Take some notes in the project 53 table - it has a column for Big Current.

This circuit needs about the same voltage as for each device by itself, but it needs higher current to turn on all of them at the same time.

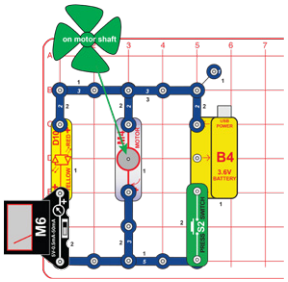
Each power source has advantages and limitations:

A. Batteries have lots of power but they only store energy, they don't actually produce it.
B. The hand crank has lots of power but only while you are turning the crank.
C. The solar cell has limited power, and only while it has light.
D. The windmill makes good power but only in a strong wind.
E. The liquid energy source has very little power.

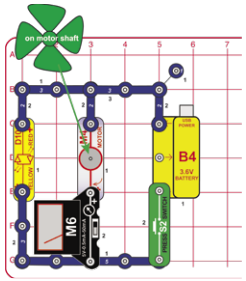
PROJECT 59 • Splitting Current



Part B



Part C



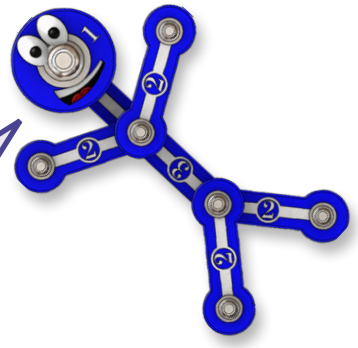
Build the circuit and set the meter (**M6**) to the **50mA** setting. Push the switch (**S2**); the meter measures the current from the battery (**B4**). let the fan get to full speed.

Part B: swap the location of the meter with the 3-snap wire marked “B” (“**+**” side towards the red/yellow LED (**D10**)). Push the switch to measure the current through the LED (**D10**).

Part C: swap the “B” location of the meter with the “C” 3-snap. Push the switch to measure the current through the motor (**M4**).

See project 3 if you need to recharge the battery (**B4**).

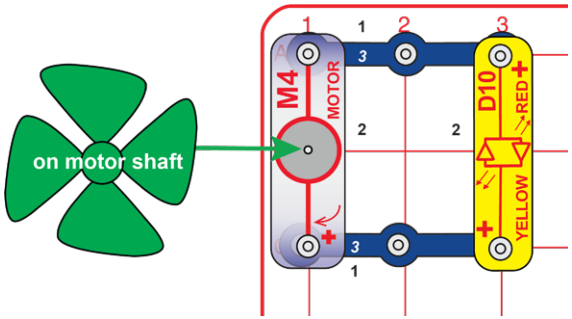
The current from the battery splits up between the LED and the motor. If you add up the current you measured through the LED and motor (Parts B & C), it should be the same as the current you measured from the battery. (Your result may be a little different, because **M6** is a simple meter with low accuracy.)



PROJECT 60 • Splitting Current Differently

Replace the red/yellow LED or motor with the color LED (**D8**, “**+**” on top”) or melody IC (**U32**, “**+**” on top). Try different combinations and see how the current changes.

PROJECT 61 • Wind Direction

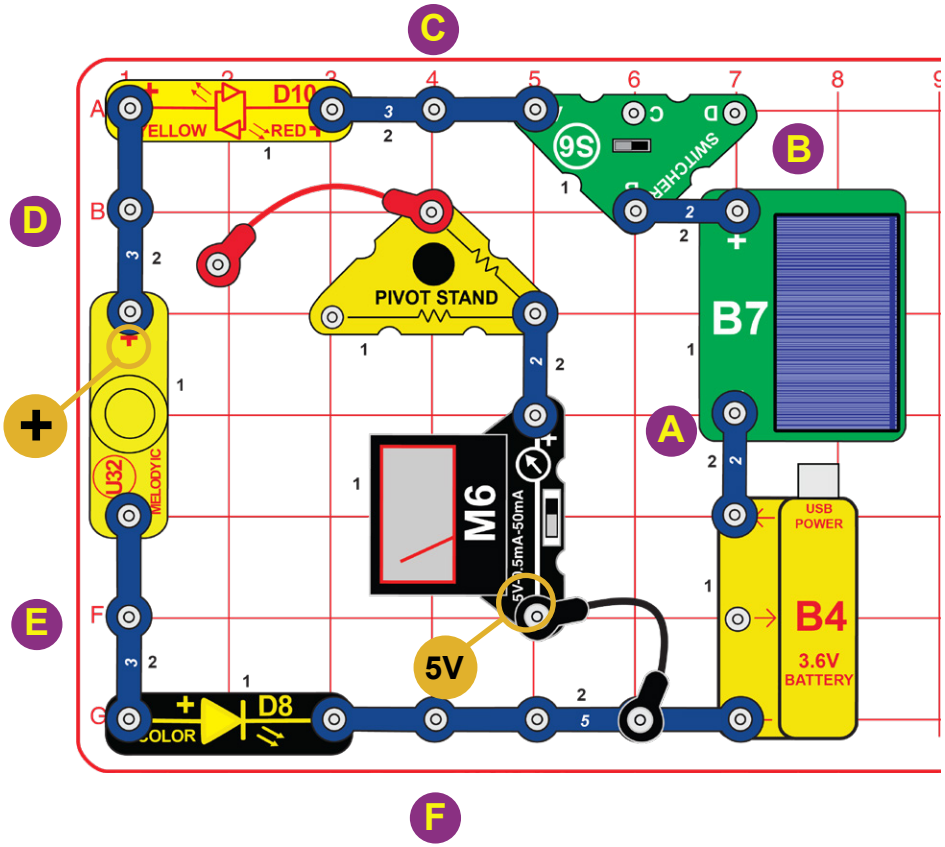


Blow on the fan or spin it with your fingers. The rotating shaft on the motor (**M4**) generates a current and the LED (**D10**) lights.

Spin the fan in the other direction (or reverse the position of the motor and blow on it), so it generates a current in the opposite direction. The LED (which is bi-color) now lights in a different color than before.

As the fan spins faster, the LED lights brighter. You can use this circuit as a wind direction and speed indicator.

PROJECT 62 • Voltage Order



Build the circuit and set the meter (**M6**) to the **5V** setting. Connect the black jumper wire between the meter and 5-snap wire. Connect one end of the red jumper wire to the pivot stand; leave the other end loose. Set the switcher (**S6**) to the left position. Place the solar cell (**B7**) in bright sunlight or near an incandescent lamp. If the light is bright enough, the LEDs (**D8** & **D10**) will light and the melody IC will make a little noise.

See project 3 if you need to recharge the battery (**B4**).

This circuit has the battery (**B4**) and solar cell producing voltage to push electric current through the LEDs and melody IC. Although the meter is set to the **5V** scale, a resistor in the pivot stand changes the voltage scale to **10V**, so double the voltage you read on the meter.

A. Connect the loose end of the red jumper wire to the snap marked A to measure the voltage between there and the black jumper wire's location. It is just the voltage across the battery.

B. Move the end of the red jumper from point A to point B, to see how much the voltage is increased by the solar cell.

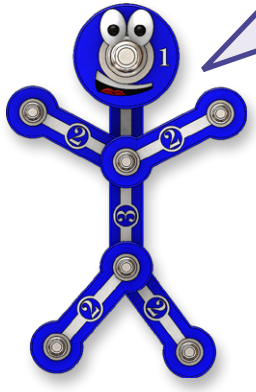
C. Move the end of the red jumper from point B to point C, to see how much the voltage changed across the switch.

D. Move the end of the red jumper from point C to point D, to see how much the voltage was reduced as it pushed current through the red/yellow LED.

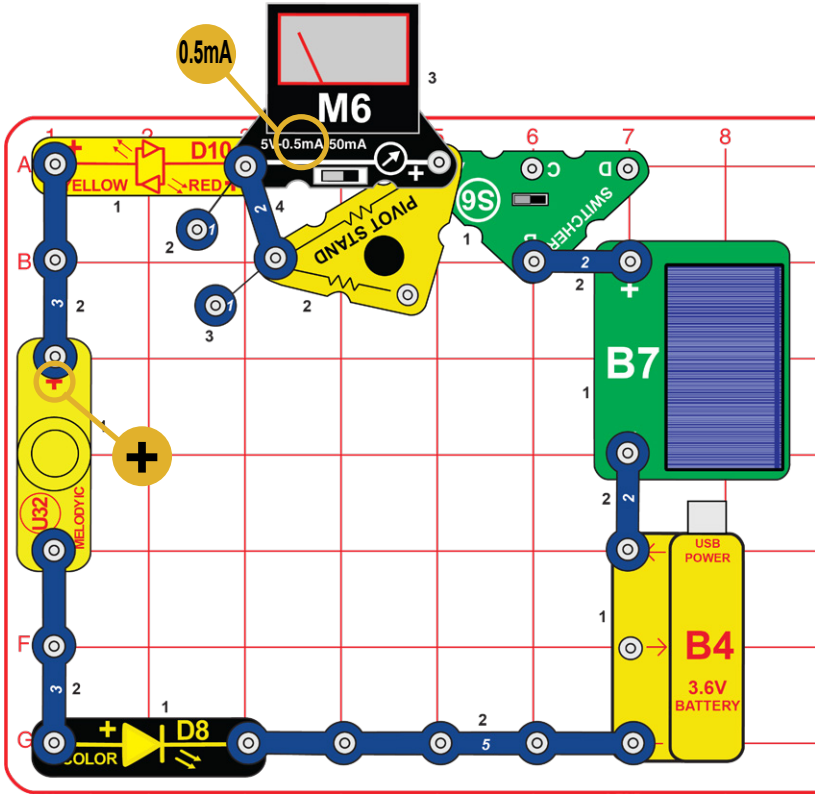
E. Move the end of the red jumper from point D to point E, to see how much the voltage was reduced as it pushed current through the melody IC.

F. Finally, move the end of the red jumper from point E to point F, to see how much the voltage was reduced as it pushed current through the color LED.

Part 2: Take the end of the black jumper wire off the 5-snap wire. Place the loose ends of the red and black jumper wires across any two points in the circuit to measure the voltage change between them (remember that the meter only measures positive voltages).



PROJECT 63 • Current Order



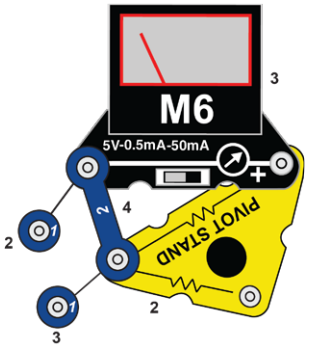
Build the circuit; it has the parts arranged in a loop. Set the meter (**M6**) to the **0.5mA** setting. Set the switcher (**S6**) to the left position. Place the solar cell (**B7**) in bright sunlight or near an incandescent lamp. If the light is bright enough, the meter will show a current, the LEDs (**D8** & **D10**) will light, and the melody IC (**U32**) will make a little noise.

Note: The **0.5mA** meter scale is actually a 5mA scale due to a resistor in the pivot stand being used to scale the current. When re-arranging the parts in Part B, treat the "5mA meter group" as a single module.

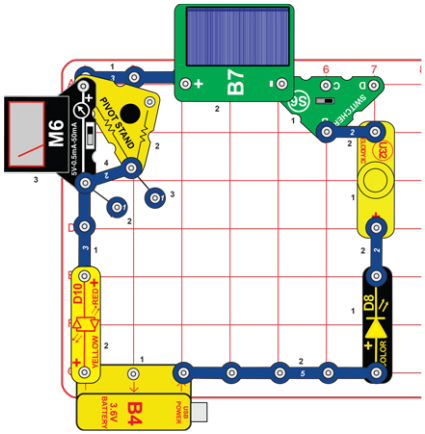
Part B: Rearrange the parts around the loop into the order shown, or any similar order you like. Keep the "**+**" side of the parts in the same direction as you move parts around the loop, and keep the light on the solar cell the same as before. The LED brightness, melody IC sound, and current shown on the meter should be the same no matter how you order the parts.

See project 3 if you need to recharge the battery (**B4**).

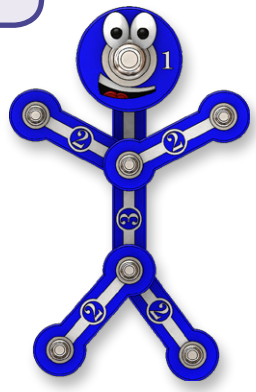
5mA meter group



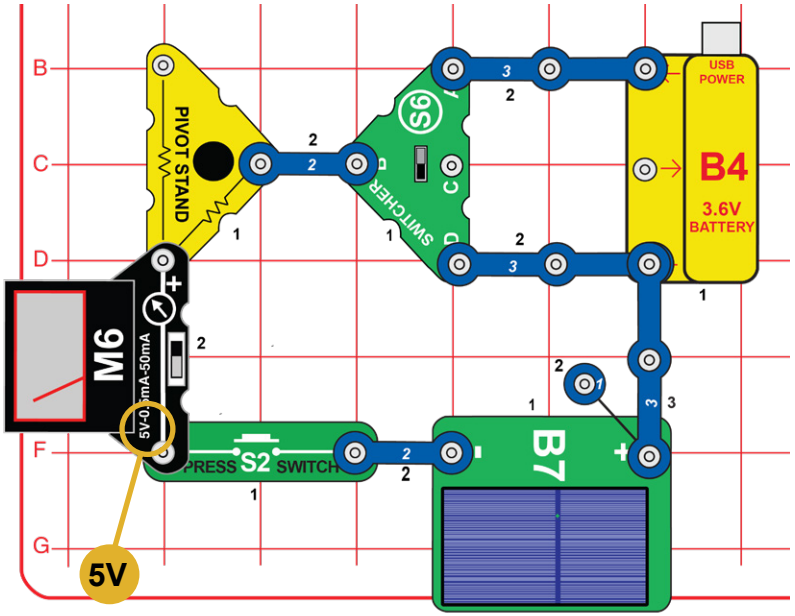
Part B



This circuit has the battery (**B4**) and solar cell producing voltage to push electric current through the LEDs and melody IC The current is flowing counter-clockwise around the loop, and is the same through all parts. If you rearrange the parts in the loop, without changing their "**+**" orientation to the flow of current, then you have exactly the same circuit.



PROJECT 64 • Sources in Series



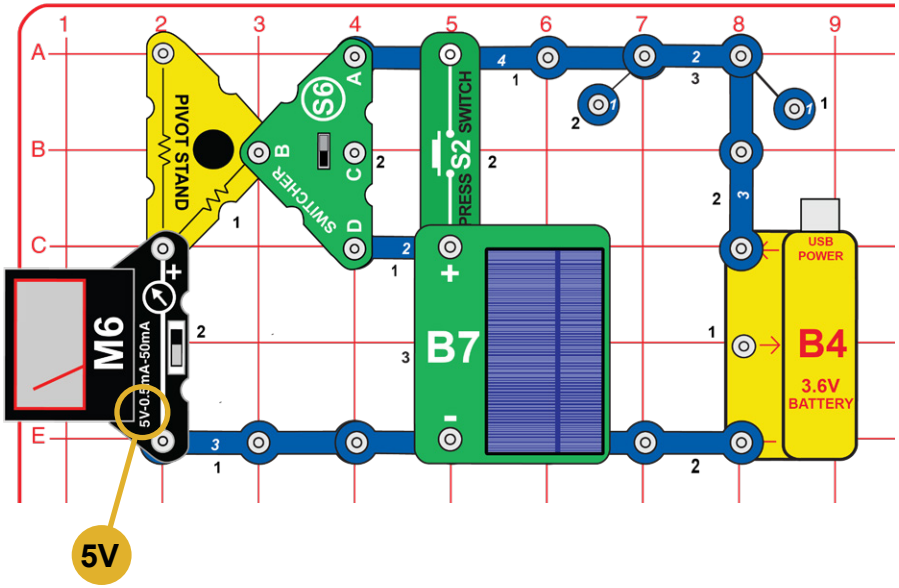
Build the circuit shown. Place the solar cell (**B7**) in sunlight or close to an incandescent lamp. Set the meter to the **5V** setting, but double the reading it shows, since a resistor in the pivot stand converts the scale to **10V**. Push the press switch (**S2**). If the switcher (**S6**) is set to the upper position, then the meter shows the combined battery (**B4**) and solar cell (**B7**) voltage. If it is set to the lower position, then the meter shows only the solar cell voltage.

Vary the light on the solar cell and see how the voltage changes.

See project 3 if you need to recharge the battery (**B4**).

The voltage produced will be lower when these sources are running something that needs lots of current, because the solar cell can only produce a small amount of current.

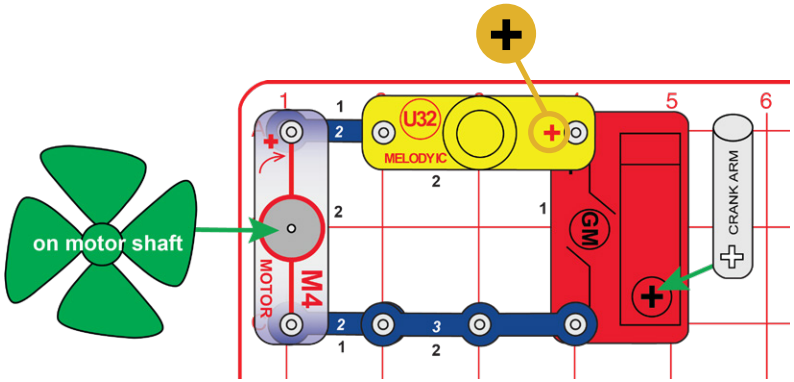
PROJECT 65 • Sources in Parallel



Build the circuit shown. Place the solar cell (**B7**) in sunlight or close to an incandescent lamp. Set the meter to the **5V** setting, but double the reading it shows, since a resistor in the pivot stand converts the scale to **10V**. If the switcher (**S6**) is set to the upper position, then the meter shows the battery (**B4**) voltage. If it is set to the lower position, then the meter shows the solar cell (**B7**) voltage.

If you push the press switch (**S2**), then the battery and solar cell are connected in parallel with each other, and the meter shows the resulting voltage. Vary the light on the solar cell and see how the total voltage changes.

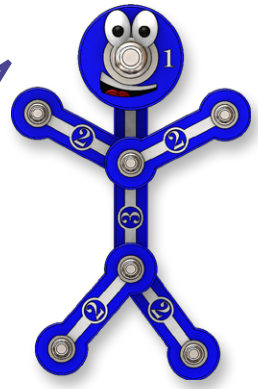
PROJECT 66 • Two in Series



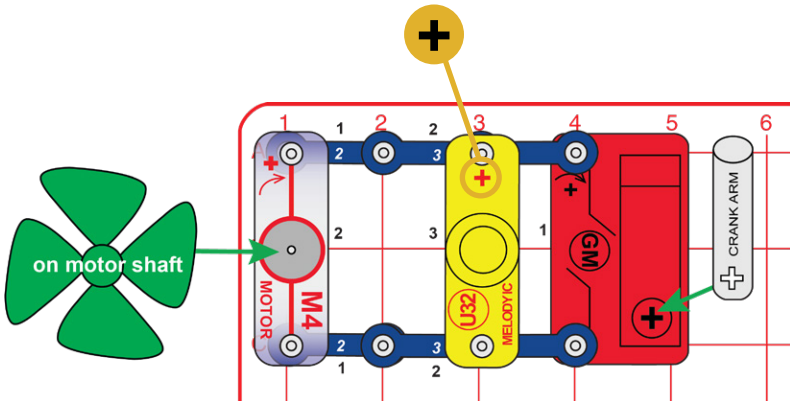
Turn the crank arm clockwise to run the fan and melody IC (**U32**).

Current flows from the geared motor (**GM**), through the melody IC, then through the motor/fan, and then back to the geared motor. If you remove the melody IC or motor (**M4**) from the circuit then the other will not work, because they are connected in series.

Connecting components in series makes wiring easier, and allows one to control others (like having a switch control a lamp in your home).

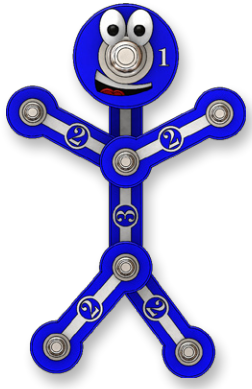


PROJECT 67 • Two in Parallel



Turn the crank arm clockwise to run the fan and melody IC (**U32**).

Compare how hard it is to turn the crank arm in this circuit and the preceding one.

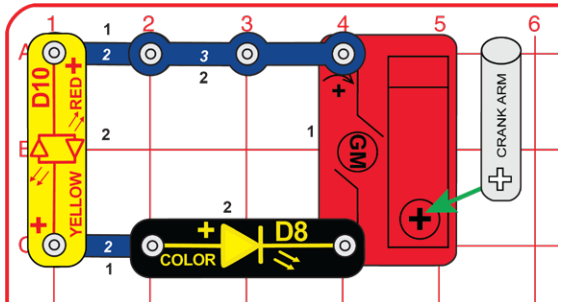


Current flows from the geared motor (**GM**), then splits up so some goes through the melody IC and some goes through the motor/fan, and then it all comes back to the geared motor. If you remove the melody IC or motor (**M4**) from the circuit then the other will still work, because they are connected in parallel.

Notice that the crank arm is harder to turn in this circuit (with **U32** and **M4** in parallel) than in the preceding one (where **U32** and **M4** were in series). This is because more power is used by components connected in parallel.

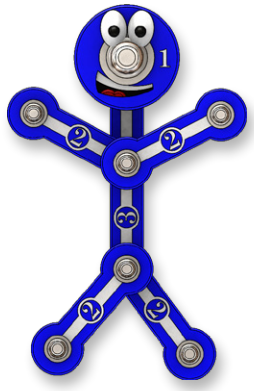
The lights in your home are wired in parallel so if one burns out, the others stay on.

PROJECT 68 • Two LEDs Series

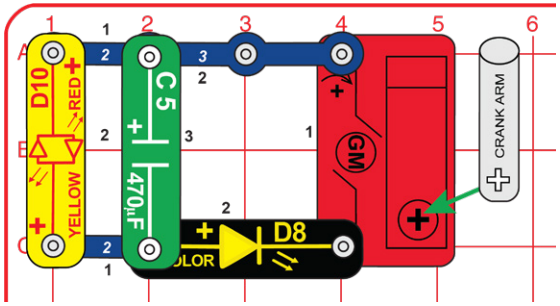


Turn the crank arm clockwise to light the LEDs (**D8** & **D10**). Turn the crank at a constant speed so both LEDs light, and notice how both are flashing.

The color LED briefly turns off as it changes colors, causing the red/yellow LED to flash at the same time, because both LEDs are connected in series.



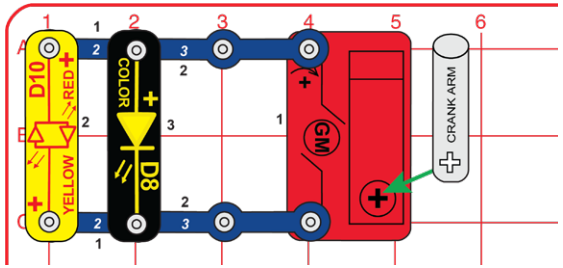
PROJECT 69 • Two LEDs in Series-Filtered



Turn the crank arm clockwise to light the LEDs (**D8** & **D10**). Turn the crank at a constant speed so both LEDs light, and notice how now the red/yellow LED brightness does not vary as much.

The 470µF capacitor (**C5**) filters out most of the voltage disturbance that occurs when the color LED changes colors, so the brightness of the red/yellow LED is not affected as much as in the preceding circuit.

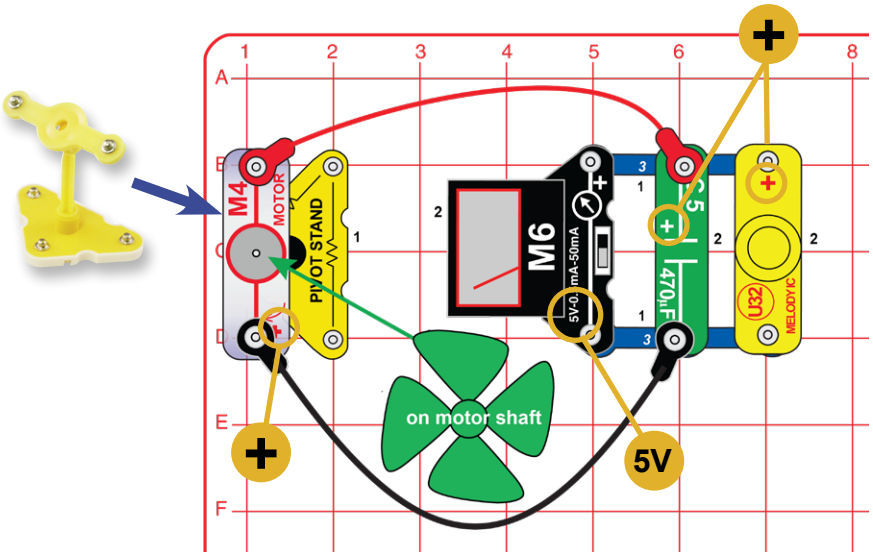
PROJECT 70 • Two LEDs in Parallel



Turn the crank arm clockwise to light the LEDs (**D8** & **D10**). Turn the crank at a constant speed so both LEDs light, and notice how only the color LED is flashing now.

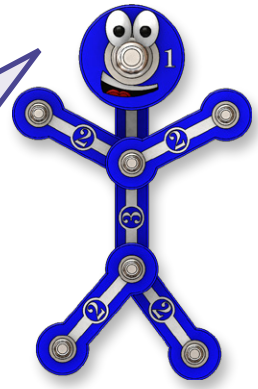
In this circuit the red/yellow LED is not flashing. The color-changing of the color LED does not affect the red/yellow LED because they are connected in parallel, so they do not affect each other.

PROJECT 71 • Wind Sound

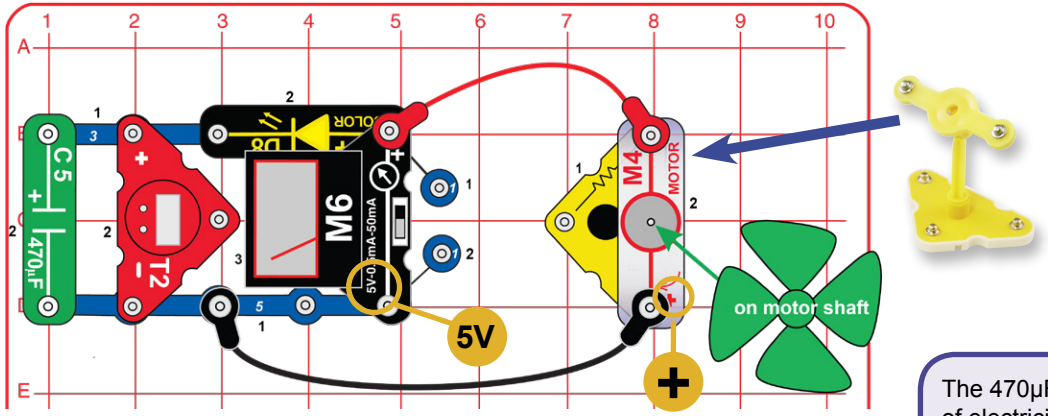


Build the circuit shown. Set the meter (**M6**) to the **5V** setting. Blow on the fan or place it in a strong wind (either outside or near an electric fan). The meter measures how much voltage your "windmill" produces, and the melody IC (**U32**) makes sound from the voltage. The sound will be brief and not very loud.

The electricity produced by the windmill motor is constantly changing, due to the mechanical design of the motor and variations in wind speed. The horn needs a steady voltage to work properly, so the 470µF capacitor (**C5**) is used. The capacitor stores a small amount of electricity and then releases it as needed to steady the voltage.



PROJECT 72 • Windy Time



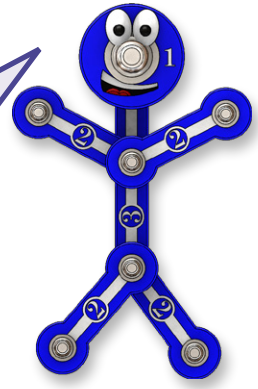
Build the circuit shown. Set the meter to the **5V** setting. Blow on the fan or place it in a strong wind (either outside or near an electric fan). The meter (**M6**) measures how much voltage your "windmill" produces. You may need to give the fan a push to get it started.

The clock display (**T2**) should be on, and stay on for a while when the wind is not blowing. Together the "windmill" and capacitor (**C5**) can run the clock using free, clean wind power. The color LED (**D8**) will not light.

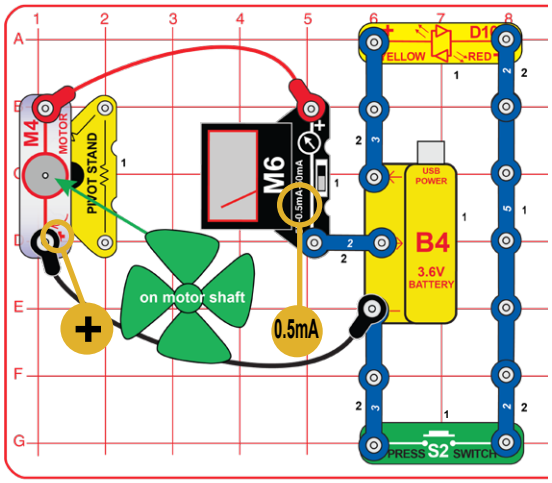
If you would like to set the time on the clock, see page 4.

The 470µF capacitor (**C5**) can store a small amount of electricity. The clock needs very little electricity to operate, so the capacitor can run it for a while when the wind is not blowing.

The color LED is like a one-way light, only allowing electricity to flow in one direction. Here it is used to prevent electricity stored in the capacitor from discharging through the motor when the wind is not blowing.

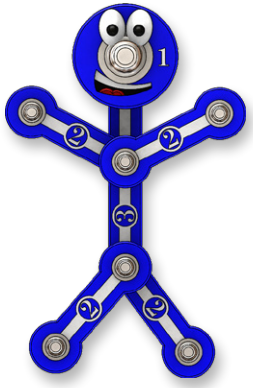


PROJECT 73 • Wind Charger with Light



Build the circuit shown. Set the meter (**M6**) to the **0.5mA** setting. Blow hard on the fan or place it in a very strong wind (either outside or near an electric fan). The "windmill" charges the battery (**B4**) when the wind is blowing hard, and the meter measures the charging current. Push the press switch (**S2**) to turn on the LED (**D10**).

A problem with using wind to power a light is that the wind isn't always blowing when you need the light on. On the other hand, the wind is often blowing when you don't need the light on. So here you use the battery to store energy from the windmill when the wind is blowing, and then run the LED when you need the light on. This way light is always available from clean, free wind power.

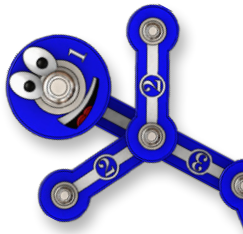


PROJECT 74 • Wind Charger with Sound

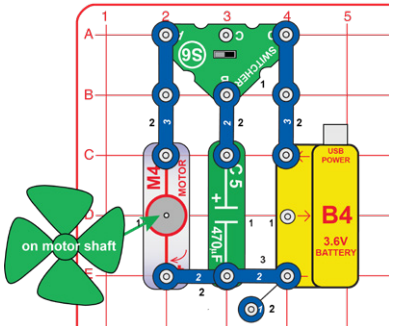
Replace the red/yellow LED (**D10**) with the melody IC (**U32**, "**+**" on left). The circuit works the same except pressing the switch makes sound.

Here the melody IC is run using wind power, by using the battery for storage.

Ice Storage units utilize a conventional air conditioner to make ice at off hours using off-peak electricity that is often sold at lower rates. The ice is stored in a large, well-insulated tank. When there is demand for air conditioning, refrigerant is circulated through coils in the ice. The chilled refrigerant then flows through the building's air-conditioning system inside the home or business to provide cooling.

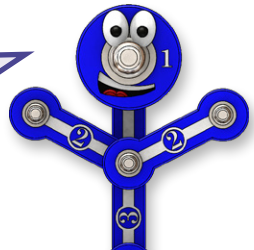


PROJECT 75 • Kick Start Motor

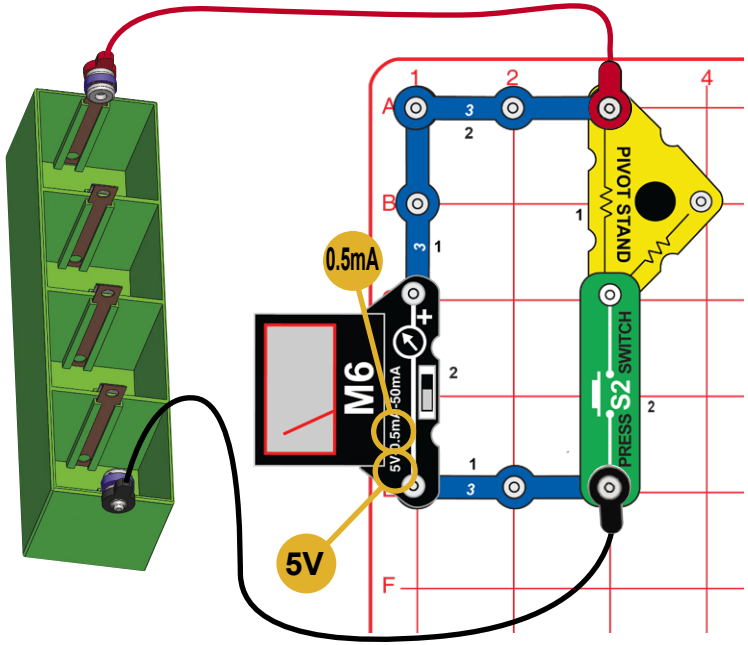


Sometimes motors under a load are difficult to get started. A capacitor can be used to give the motor a little kick. In this project setting the switcher (**S6**) to the right will charge the 470µF capacitor (**C5**), then moving it to the left will give the motor a little kick. Since no other power is applied, the motor will not go very far on the small amount of power stored in the capacitor. This is still a good way to get a motor started as power is supplied.

When this technique is used, they call the capacitor a "Starting Capacitor". A capacitor start motor is a split-phase induction motor with a starting capacitor inserted in series with the startup winding, creating a much greater starting torque.



PROJECT 76 • Electricity From Water



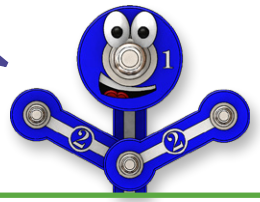
Assemble the liquid energy source using the instructions on page 4 of the paper manual. Build the circuit and connect the red & black jumper wires; the red wire goes to the copper electrode. Set the meter (**M6**) to the **5V** setting. Fill the compartments with water. The meter shows the voltage produced, if any.

Set the meter to the **0.5mA** setting to see how much current your water can supply, if any. If the reading is higher than **0.5mA**, push the press switch to change the current scale to 5mA. (The switch adds a 47Ω resistor in the pivot stand to the circuit, changing the current scale on the meter. It should not be used with the **5V** setting.)

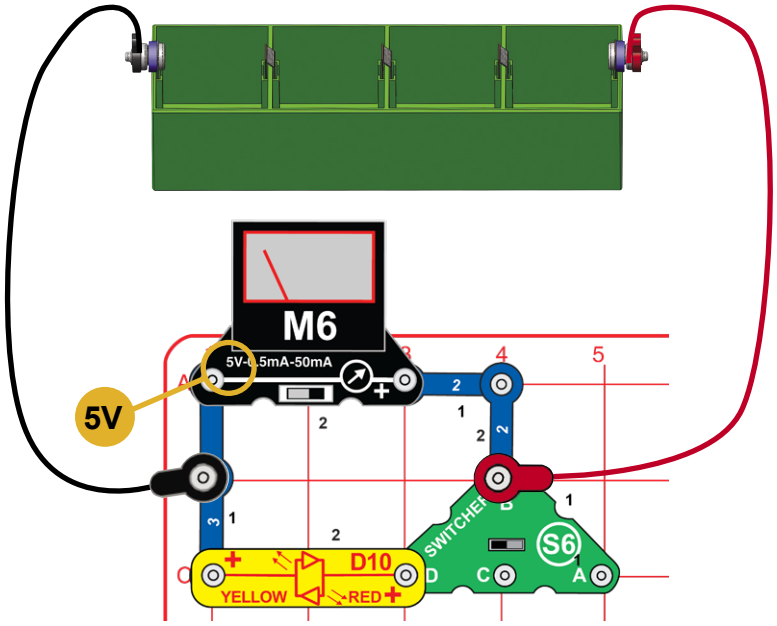
Try dissolving some salt in the water in all four compartments. The voltage and current should be higher now. If you have some distilled water, test it too (rinse out the salt water first). The voltage and current produced should be zero now.

Don't drink any water used in this project. Wash the electrodes and liquid holder.

The water in some areas is slightly acidic due to impurities in it. This may be strong enough to produce electricity by reacting with the electrodes, similar to how a battery works. These impurities should be safe to drink. Distilled water has almost no impurities.



PROJECT 77 • Water Light

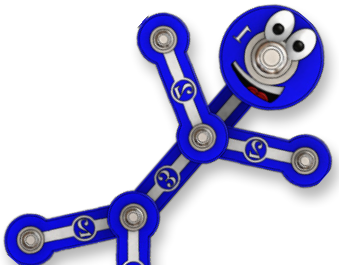


Connect the liquid energy source to the circuit shown here. Fill the compartments with water. Set the switcher (**S6**) to the left position. Set the meter (**M6**) to the **5V** setting to see the voltage produced. The red/yellow LED (**D10**) may be dimly lit, depending on your local water supply. If you set the switcher to the right position, the voltage may be higher since the water is not trying to light the LED.

Dissolve some salt in the water in all four compartments. The voltage will be higher and the LED should light now. See how long it lights the LED for.

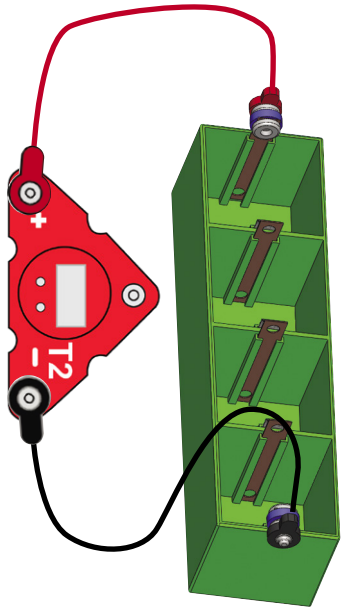
Try replacing the red/yellow LED with the color LED (**D8**) or the clock (**T2**). See how long the water can run the clock. If you would like to set the time, see page 4 of the paper manual.

Don't drink any water used in this project. Wash the electrodes and liquid holder.



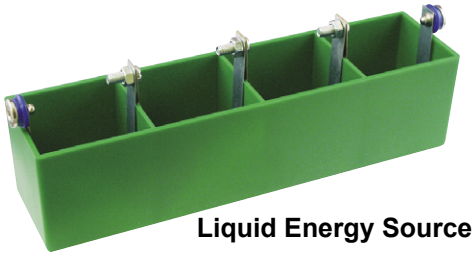
Salt and other impurities in the water react with the electrodes to produce electricity like the cola does in project 73. The voltage produced by the water is usually lower and water will not run the LED or clock as long.

PROJECT 78 • Cola Clock



Setting the time on the clock (T2):

- Press the left button to select what to change (month, date, hour, or minutes).
- Press the right button until it is correct.
- Press the left button until the time is showing, then press the right button once to start.
- The colon (“:”) will be flashing when the clock is running.
- Press the right button to display the date.



Liquid Energy Source

Assemble the liquid energy source using the instructions on page 4 of the paper manual. Connect it to the clock (**T2**) with the red & black jumper wires, the red wire goes to the copper electrode. Fill the compartments with cola soda (other soda flavors and lemon, tomato, or grapefruit juice also work). The clock should be running. Set the time if you like.

With cola, the clock will typically run for a week. When the display gets dim, replace the cola.

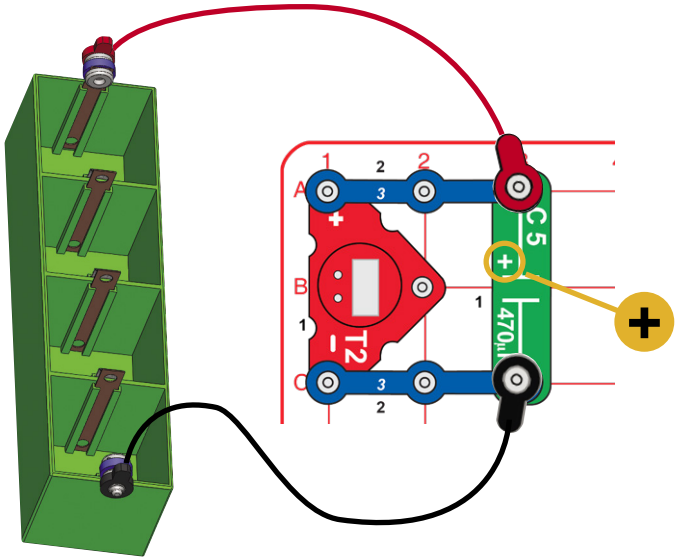
You can move the copper electrode with the snap on it over to the next compartment, as shown in the Liquid Battery project. The clock display will not be as bright now.

If the copper and zinc electrodes get corroded through use, use sandpaper, steel wool, or a scraper to remove the corrosion and improve performance.

Don’t drink any soda or juice used in this project. Wash the electrodes and liquid holder.

The clock needs very little electric current to operate (much less than 1mA). The liquid power source does not produce much electricity, but it can supply enough for the clock. Slowly, the chemical energy in the cola is used up, and the voltage drops enough for the clock to stop working.

PROJECT 79 • Cola Clock with Memory



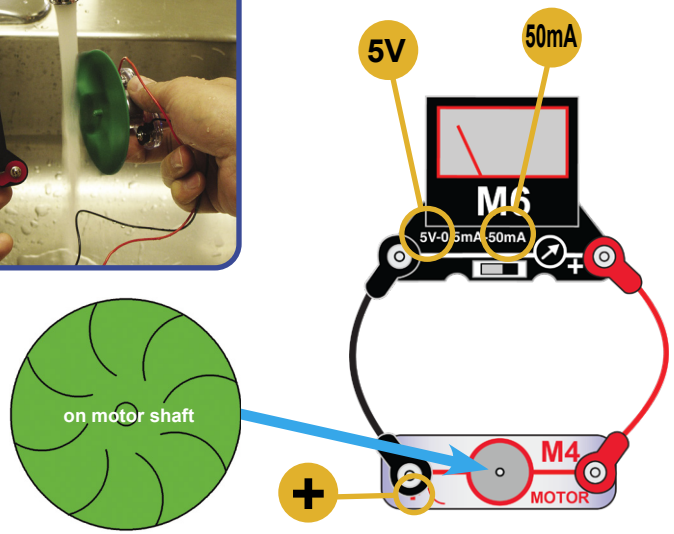
In the preceding Cola Clock project, when you disconnect the liquid energy source to replace the cola, the time is lost. Wouldn’t it be nice if the clock remembered the time long enough for you to replace the cola?

Add the 470µF capacitor to the clock as shown here. The capacitor stores enough electricity to run the clock for a while if you disconnect the liquid energy source.

Don’t drink any soda or juice used in this project. Wash the electrodes and liquid holder.

You could also use a battery for electricity storage instead of the capacitor. A battery stores much more electricity than a capacitor but you don’t need much storage here. Batteries are much more expensive than capacitors and contain chemicals that can harm the environment when you throw them away.

PROJECT 80 • Changing Water Pressure to Electrical Pressure

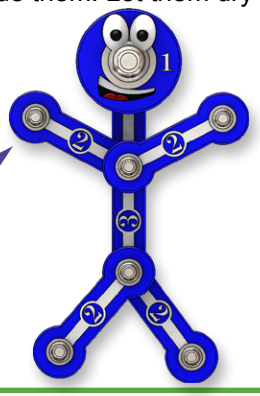


Place the water wheel on the motor (**M4**) and connect it to the meter (**M6**), as shown. Set the meter to the **5V** or **50mA** setting. Hold the motor under a water faucet so the water wheel will "catch" the water as it falls. See how much voltage and current you can produce.

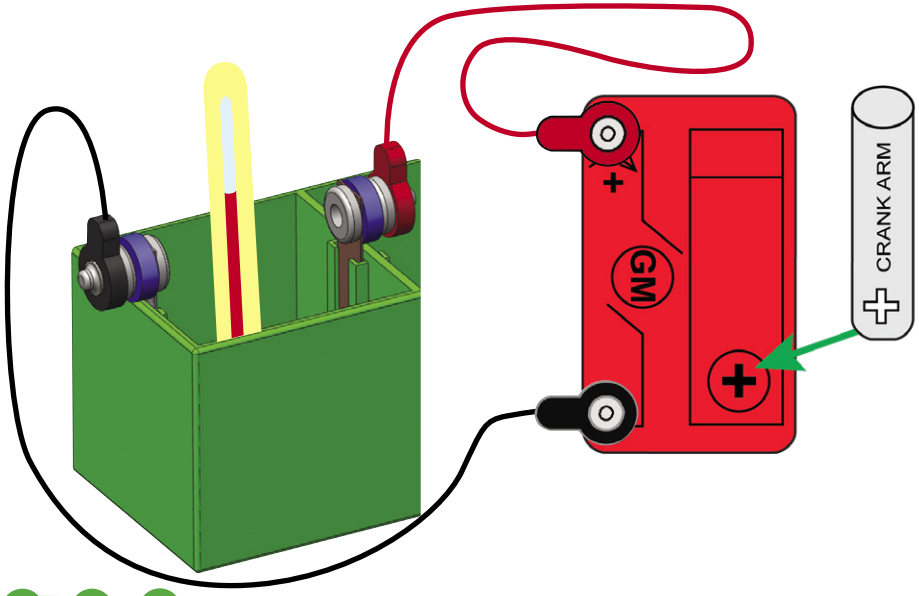
Using the water pressure from your faucet to make electricity using the motor (used as a generator here) is just like using water pressure from a lake to run an electric generator in a dam.

Your parts might stop working if water gets inside them. Let them dry out and they should be fine.

Hoover Dam has a lake that is 500 feet deep on one side to provide great pressure to turn the generators that make our electricity.



PROJECT 81 • Storing Energy in Water



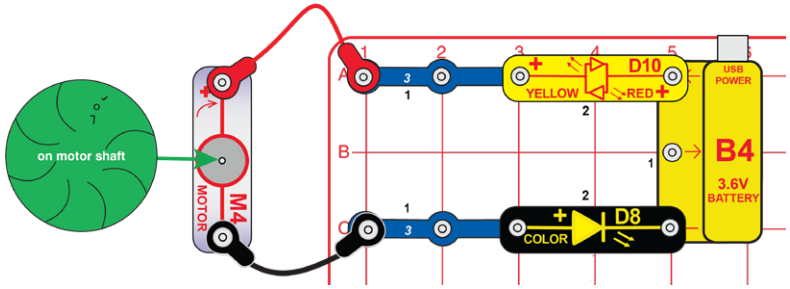
Place ½ teaspoon of salt into a small amount of water and stir until it dissolves. You can use a compartment on the liquid power source for this, but don't use a metal container. If available, use a thermometer from your home to measure the water temperature. If no thermometer is available, test the water temperature by touching it with your finger. Connect the red & black jumper wires to the geared motor (**GM**) and place the loose ends in the water so they aren't touching. Place the crank arm on the geared motor

Turn the crank to heat the water. You should see the temperature rise on the thermometer or feel the difference with your finger. You may have to crank for a minute or two before the water gets warmer.

Don't drink any water or liquids used in this project.

Solar or wind power may be used to heat water during the day, then use the hot water to keep homes warm at night.

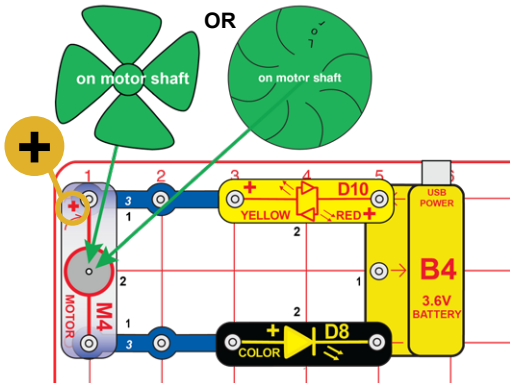
PROJECT 82 • Hydro Lights



Place the water wheel on the motor (**M4**) and connect it to the circuit as shown. Hold the motor under a water faucet so the water wheel will "catch" the water as it falls. The LEDs (**D8** & **D10**) should light.

Your parts might stop working if water gets inside them. Let them dry out and they should be fine.

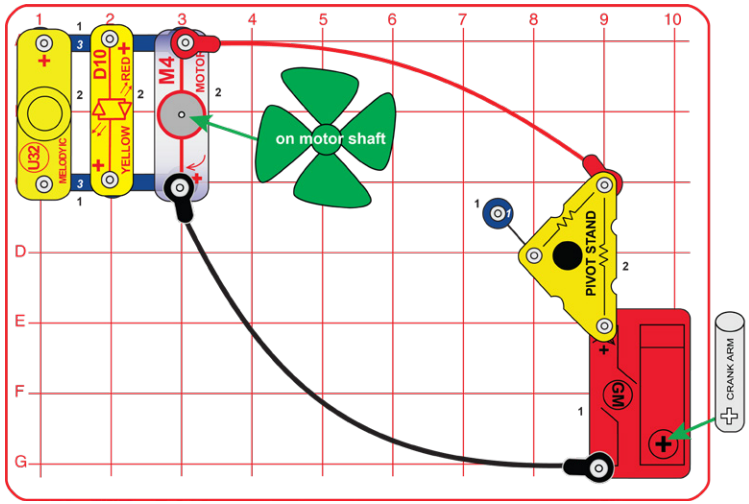
PROJECT 83 • Directional Wind Lights



Build the circuit, and place either the wind fan or the water wheel on the motor (**M4**). To make the LEDs (**D8** & **D10**) bright, blow on the wind fan from above, or blow into the "curves" of the water wheel.

See project 3 if you need to recharge the battery (**B4**).

PROJECT 84 • Emergency Transmission Loss

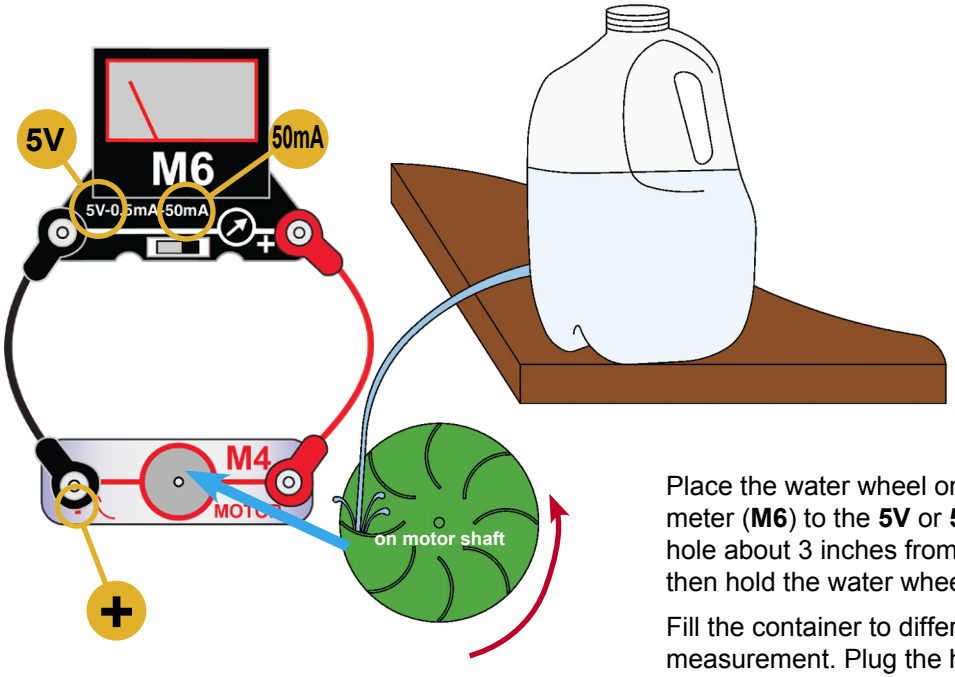


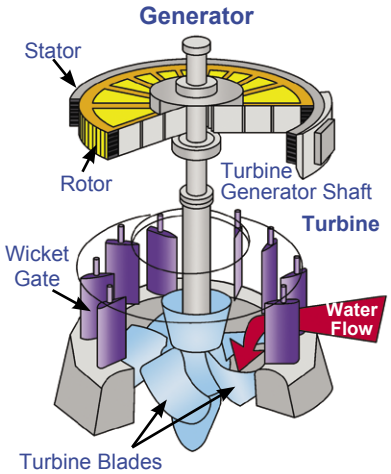
Turn the crank arm on the geared motor (**GM**) clockwise to run the motor (**M4**) and fan, red/yellow LED (**D10**), and melody IC (**U32**) or turn it backwards to run just the motor and LED.

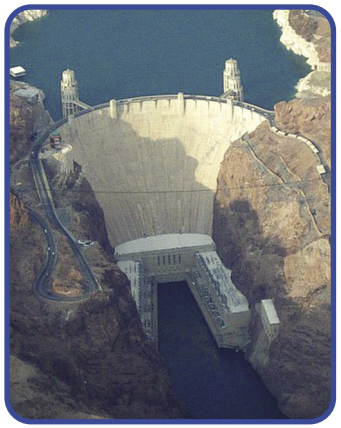
If you remove the pivot stand base and connect the red jumper wire directly to the geared motor then there will be a little more light, sound, and motion.

Think of this circuit as an electricity distribution system, like the one powering your home. The geared motor and crank represent a big electric generator driven by steam or water pressure at an electric power plant. The red & black jumper wires represent the power lines distributing electricity from the power plant to homes. A resistor in the pivot stand base represents the electricity lost in distributing electricity across long distances. The fan, LED, and melody IC represent appliances, lights, and music devices using electricity in homes.

PROJECT 85 • Using Stored Water





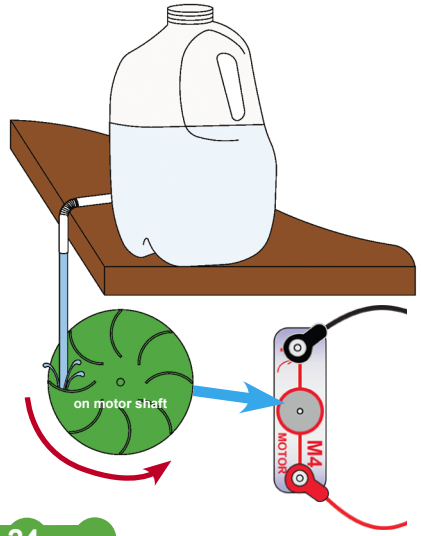


Place the water wheel on the motor (**M4**) and connect it to the meter (**M6**), as shown. Set the meter (**M6**) to the **5V** or **50mA** setting. Take an empty plastic water or milk container, make a hole about 3 inches from the bottom, place the bottle in a sink or bathtub, fill it with water, and then hold the water wheel next to it and measure the voltage or current produced.

Fill the container to different heights and see how the water pressure affects the meter measurement. Plug the hole with your finger while you fill the container, and try to keep the water wheel in the same position each time.

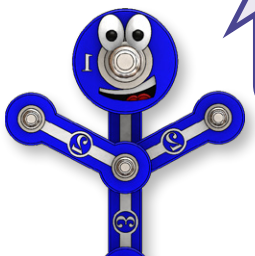
Your parts might stop working if water gets inside them. Let them dry out and they should be fine.

PROJECT 86 • Water Redirection



In dam generators, the water to the turbine blades is directed by a series of wicket gates.

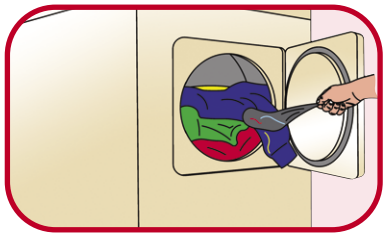
Attach a straw (flexible ones work best) from your home to redirect the flow to the Water fan. Try and seal the area around the straw with putty, play dough, scotch tape or other such material. Repeat the meter readings from the previous project and see how much the power has increased.



Raising the water level in the container is just like storing water in a lake next to a dam. A higher water level means more water pressure, which spins the shaft faster, which produces more electricity.

A dam converts the potential energy of the high water into kinetic energy of fast moving water, which is reduced when the water is used to spin the turbine in a generator. The water in Hoover Dam is 500 feet deep at its base and reaches speeds of 85 mph going into the turbine.

PROJECT 87 • One of the Most Powerful Forces in the Universe



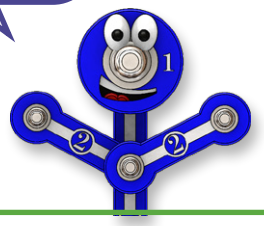
Find some clothes that cling together in the dryer, and try to uncling them.

The crackling noise you hear when taking off a sweater is static electricity. You may see sparks when taking one off in a dark room.

Rub a sweater (wool is best) and see how it clings to other clothes.

Note: This project works best on a cold dry day. If the weather is humid, the water vapor in the air allows the static electric charge to dissipate, and this project may not work.

The static electricity around us is extremely powerful. If we could learn to move and control it, we might have all the energy we need. Maybe someday you will find a way.



These effects are caused by electricity. We call this static electricity because the electrical charges are not moving, although pulling clothes apart sounds like static on a radio. When electricity is moving (usually through wires) to do something in another place, we call it an electric current.

Electricity exists everywhere but is so well balanced that you seldom notice it. But sometimes, electrical charges get separated and build up a difference between materials, and sparks can fly. Lightning is the same effect as the sparks between clothes, but on a much greater scale. A cloud holds static electricity just like a sweater.

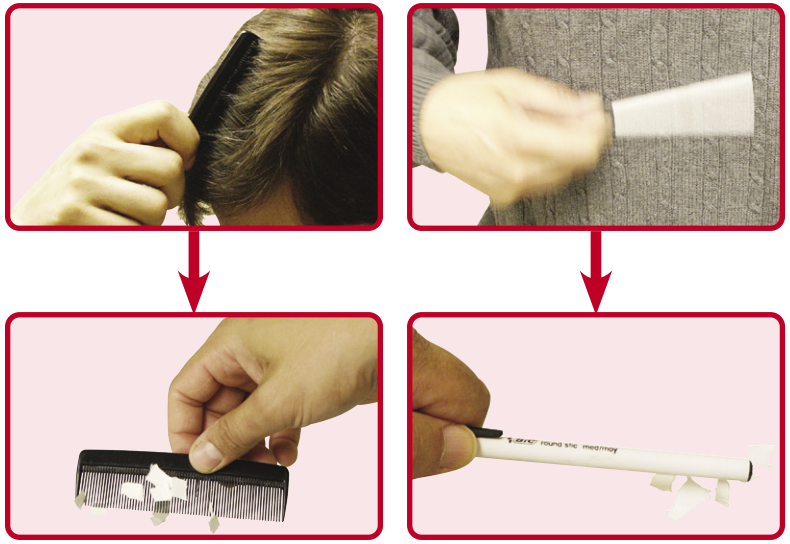
PROJECT 88 • Electricity Against Water

Note: This project works best on a cold dry day. If the weather is humid, the water vapor in the air allows the static electric charge to dissipate, and this project may not work.

You need a comb (or plastic ruler) and a water faucet for this project. Run the comb through your hair several times then hold it next to a slow, thin stream of water from a faucet; the water will bend towards it. You can also use a plastic ruler. Rub it on your clothes (wool works best).

Rubbing the comb through your hair builds up a static electrical charge on it, which attracts the water.

PROJECT 89 • Harnessing Static Electricity



You need a comb (or a plastic ruler) and some paper for this project. Rip up the paper into small pieces. Run the comb through your hair several times then hold it near the paper pieces to pick them up. You can also use a plastic ruler, rub it on your clothes (wool works best).

Rubbing the comb through your hair pulls extremely tiny charged particles from your hair onto the comb. These give the comb a static electrical charge, which attracts the paper pieces.

Electricity is immensely more powerful than gravity (gravity is what causes things to fall to the ground when you drop them). However electrical attraction is so completely balanced out that you don't notice it, while gravity effects are always apparent because they are not balanced out.

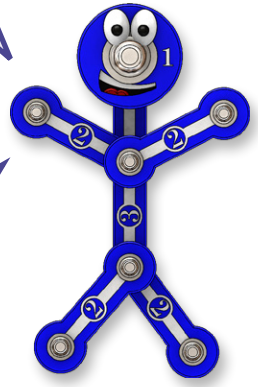
Gravity is actually the attraction between objects due to their weight (or technically, their mass). This effect is extremely small and can be ignored unless one of the objects is as big as a planet (like the earth). Gravity attraction never goes away and is seen every time you drop something. Electrical charge, though usually balanced out perfectly, can move around and change quickly.

For example, you have seen how clothes can cling together in the dryer due to static electricity. There is also a gravity attraction between the sweaters, but it is always extremely small.

Some electricity is produced in dams, by harnessing the power of gravity to move water to spin a generator. If instead we could harness the static electricity contained in the water, we would have all the electricity we need.

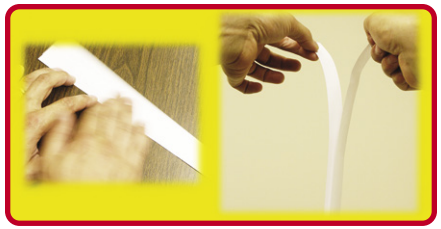
Note: This project works best on a cold dry day. If the weather is humid, the water vapor in the air allows the static electric charge to dissipate, and this project may not work.

Snappy says to notice how your hair can "stand up" or be attracted to the comb when the air is dry. Wetting your hair dissipates the static charge.



If you have two balloons, rub them to a sweater and then hang the rubbed sides next to each other. They repel away. You could also use the balloons to pick up tiny pieces of paper.

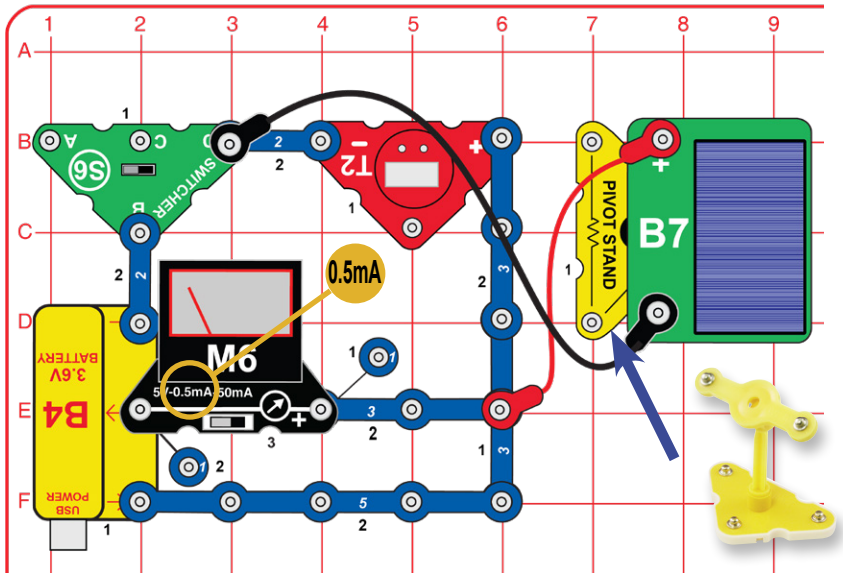
Take a piece of newspaper or other thin paper and rub it vigorously with a sweater or pencil. It will stick to a wall.



Cut the paper into two long strips, rub them, then hang them next to each other. See if they attract or repel each other.

Get a roll of plastic tape. Make some strips about a foot long. Hold their ends so they hang downwards, and slowly bring them close together. See if you can make them touch each other.

PROJECT 90 • Solar Light Clock



Assemble the pivot, mount the solar cell (**B7**) on it, and place it next to the circuit as shown. Connect the solar cell to the circuit using the red and black jumper wires. Set the meter to the **0.5mA** setting. Set the Switcher switcher (**S6**) to the left position. Place the circuit so the solar cell is in bright sunlight or close to an incandescent light bulb. The display on the clock (**T2**) should be on.

Now set the slide switcher to the right position, to add the rechargeable battery to the circuit. See if you can adjust the position of the solar cell on the pivot to make the meter (**M6**) measure a current.

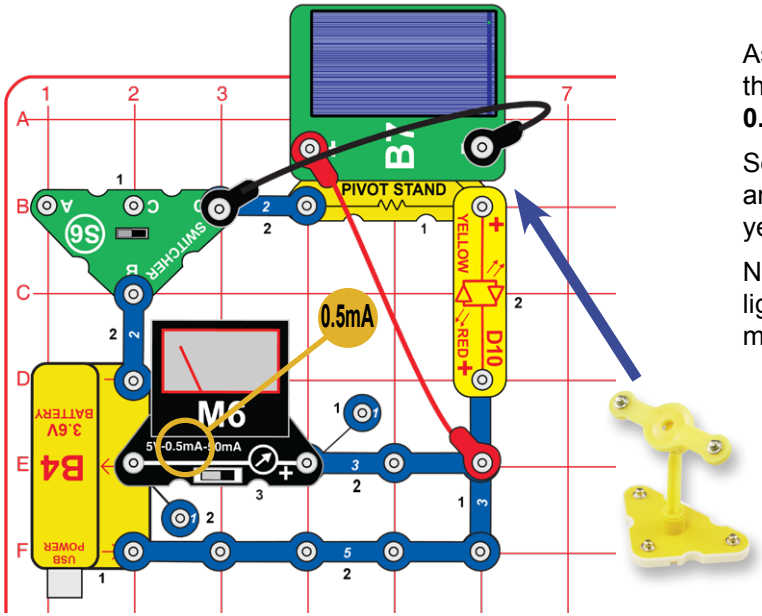
If your light source is strong enough then the solar cell will charge the battery while running the clock. If your light source is weak then the battery will run the clock.

If you would like to set the time on the clock, see page 4 in your printed manual.

See project 3 if you need to recharge the battery (**B4**).

Solar cells are often used with rechargeable batteries, since the sun isn't always shining. Used together, the solar cell and battery can run the clock for a very long time.

PROJECT 91 • Solar Light Charger

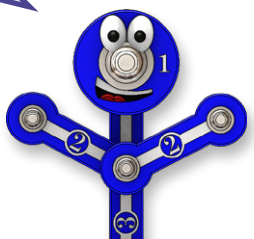


Assemble the pivot, mount the solar cell (**B7**) on it, and place it in the circuit as shown. Connect the solar cell to the circuit using the red and black jumper wires. Set the meter (**M6**) to the **0.5mA** setting.

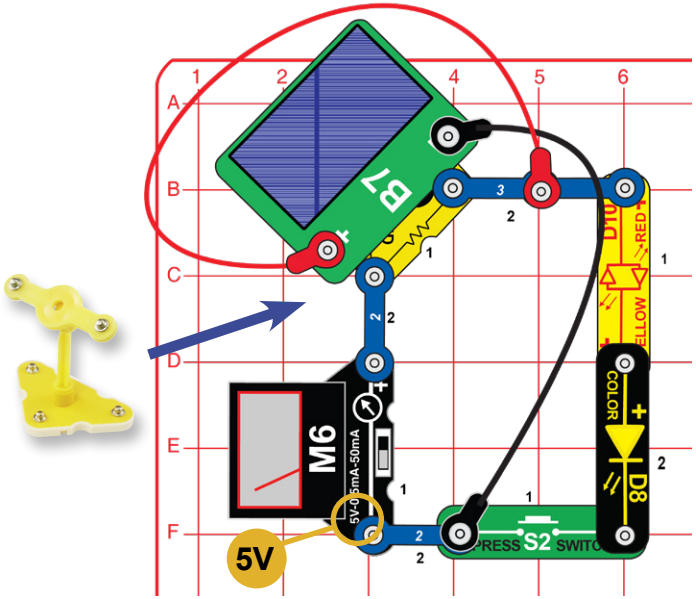
Set the switcher (**S6**) to the left position. Place the circuit in bright sunlight or 3-6 inches from an incandescent light bulb. Adjust the position of the solar cell on the pivot to make the red/yellow LED (**D10**) brightest.

Now set the switcher to the right position, to add the rechargeable battery to the circuit. If your light source is strong enough then the solar cell will charge the battery, and the meter will measure the charging current. If your light source is weak then the battery will light the LED.

The solar cell only produces a small amount of electricity. The red/yellow LED needs a lot more electricity than the clock, so the solar cell can only run the LED and charge the battery if the light source is very strong.



PROJECT 92 • Solar Light Row

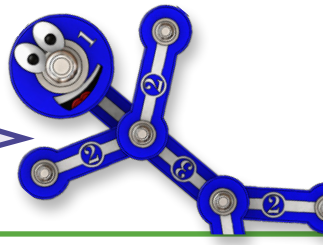


Assemble the pivot, mount the solar cell (**B7**) on it, and place it in the circuit as shown. Connect the solar cell to the circuit using the red and black jumper wires. Place the circuit so the solar cell is in bright sunlight or close to an incandescent light bulb. Set the meter (**M6**) to the **5V** setting.

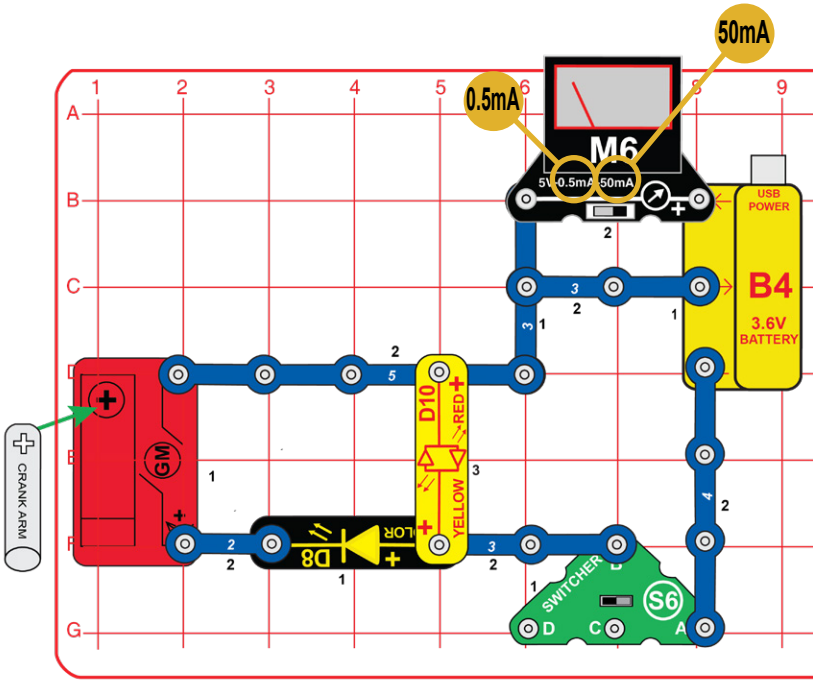
The meter is measuring the voltage produced by the solar cell. Adjust the position of the solar cell to make the highest voltage you can. Now push the press switch to run the yellow/red and color LEDs (**D10**, **D8**) with the solar cell. Notice how the voltage produced drops a little when the LEDs are connected, but not as much as when only the yellow/red LED was in the circuit (the Solar Power project).

Note: The voltage produced is actually twice that shown on the meter (so a 3V reading is really 6V), because a resistor in the pivot stand is changing the scale.

Having both LEDs in series resists the flow of electric current more than just one, making it easier for the solar cell to run them.



PROJECT 93 • Crank Support



Build the circuit by setting up the parts as shown. Set the meter (**M6**) to the **0.5mA** or **50mA** setting. Set the switcher switch (**S6**) to the right position to connect the rechargeable battery (**B4**) to the red/yellow LED (**D10**). If the battery is charged, the LED will light and the meter will show that an electric current is flowing out of the battery. The **0.5mA** meter scale will show a high current while the **50mA** scale may show little or no current.

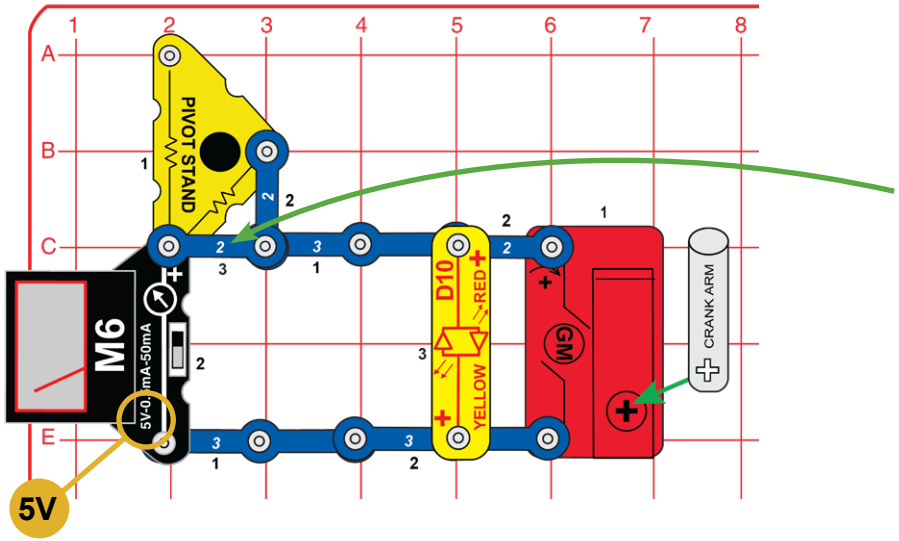
Turn the handle on the crank arm on the geared motor (**GM**) counter-clockwise (opposite to the direction a clock turns) to have it take over powering the red/yellow LED. When you crank fast enough, the color LED (**D8**) will turn on (indicating that current is flowing through the geared motor) and the meter will no longer show any current flowing from the battery.

Warning: the hand crank is sturdy but not indestructible. If you push hard on it or crank it really fast you may break it.

See project 3 if you need to recharge the battery (**B4**).

Think of the red/yellow LED as an emergency light in your home. When the main power goes out, it can run for a while on battery backup or a hand crank generator.

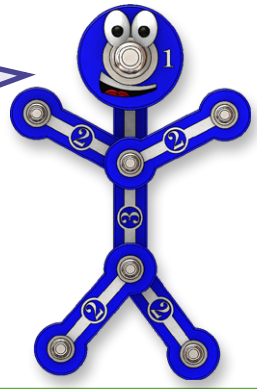
PROJECT 94 • Hand Lights



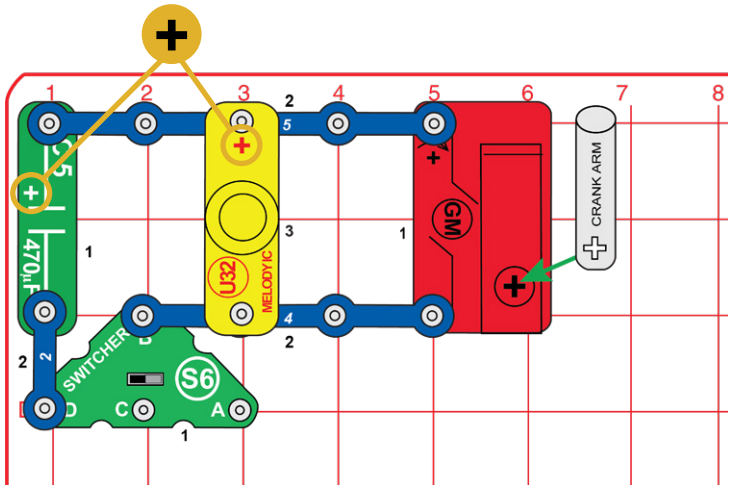
Set the meter (**M6**) to the **5V** setting and turn the crank arm on the geared motor (**GM**). Turning clockwise will light the red/yellow LED (**D10**) red while the meter shows the voltage produced. Turning counter-clockwise produces electricity flow in the opposite direction, so the LED lights yellow.

You can probably turn the crank fast enough to measure more than **5V** on the meter. Remove the 2-snap wire across base grid locations C2-C3 on level 3. This puts a 10KΩ resistor in the pivot stand in series with the meter, changing its voltage scale. Now turn the crank but double the voltage shown on the meter (so 4V is really 8V).

The hand crank has a gearbox, which allows a motor in it to spin faster and with less force than you turn the crank. The faster the motor spins, the more electricity is produced.



PROJECT 95 • Hand Noise

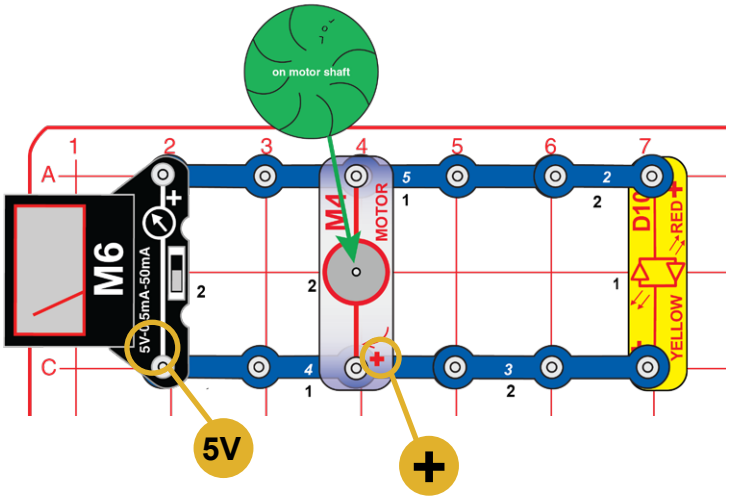


Turn the crank arm on the geared motor (**GM**) clockwise. The melody IC (**U32**) makes noise. Set the switcher (**S6**) to the left position to make the sound a little louder.

If you are out in the wilderness, you can use a hand crank and horn to sound an alarm.

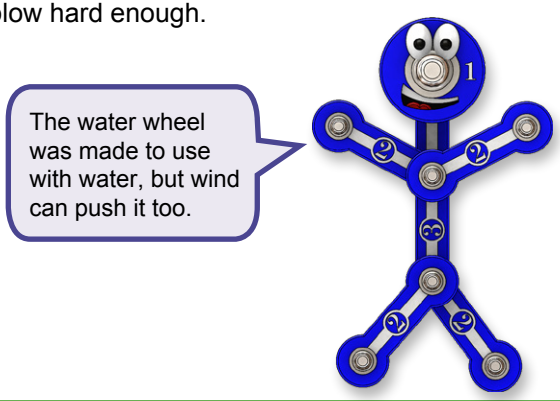
The electricity produced by the hand crank is unstable, due to the design of the motor inside it and because you can't turn the crank in a steady manner. The 470µF capacitor (**C5**) acts like a filter to stabilize the electricity, which makes the melody IC work better.

PROJECT 96 • **Heavy Fan**

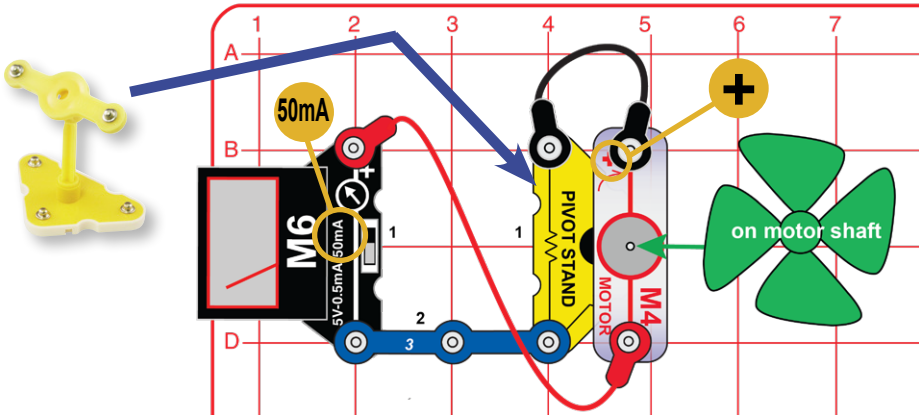


Build the circuit as shown, with the water wheel on the motor. Set the meter (**M6**) to the **5V** setting. Blow on the water wheel, aiming the air into the "curves" on the fan. Watch the meter to see the voltage produced, and the red/yellow LED (**D10**) will light red.

If you blow on the opposite side of the fan curves, the fan will not spin as easily. The LED will light yellow if you blow hard enough.



PROJECT 97 • **Remote Header**



Build the circuit as shown, with the motor (**M6**) on the pivot and the wind fan on the motor. Set the meter (**M6**) to the **50mA** setting. Blow on the fan or place it in a strong wind.

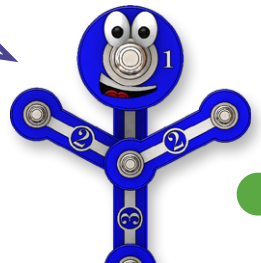
This circuit uses wind power to heat a 47Ω resistor in the pivot stand. The resistor is getter warmer, but you will not notice it through the plastic case. The meter measures the current.

You can replace the motor with the solar cell (**B7**, red wire to "**+**" side) to heat the resistor using sunlight.

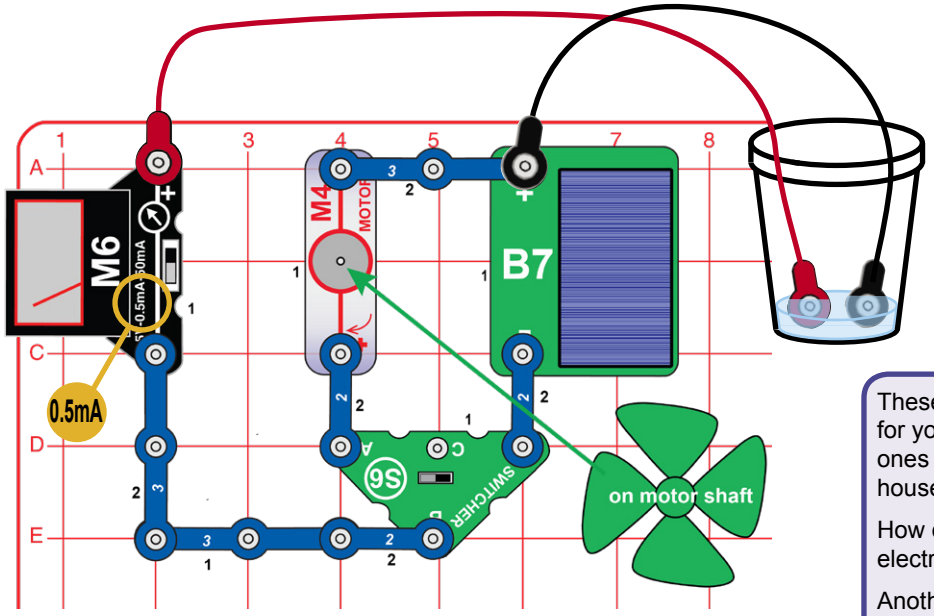
Most of the energy used to make electricity eventually becomes heat. Many computers and TVs have fans to circulate the air to prevent components from overheating. LEDs convert some of the electricity to light, and the rest becomes heat. The radio and horn convert some electricity to sound waves, and the rest becomes heat.

You can help to heat your home by putting a windmill on your roof and using it to heat a resistor in your living room.

Electricity is great for transporting energy. Here electricity is used to move energy harnessed from the wind to the resistor where it is used. The electrical transmission lines in your neighborhood transport the electricity from a power plant to your home.



PROJECT 98 • Remote Water Heater



Build the circuit, place the wind fan on the motor (**M4**), and set the meter (**M6**) to the **0.5mA** scale. Place the circuit so wind is blowing on the fan or sunlight is shining on the solar cell (**B7**). Set the switcher (**S6**) to the left position if you have wind or to the right position if you have sunlight. Connect the jumper wires to the circuit and place the other ends in a cup of water, make sure the metal parts aren't touching each other.

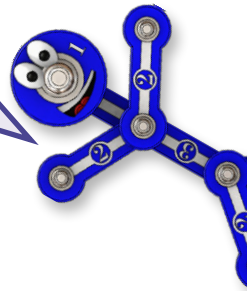
Your power source (wind or sun) is making an electric current flow through the water, and the meter measures the current. As the current flows through the water, the water is warmed.

Don't drink any water or liquids used in this project.

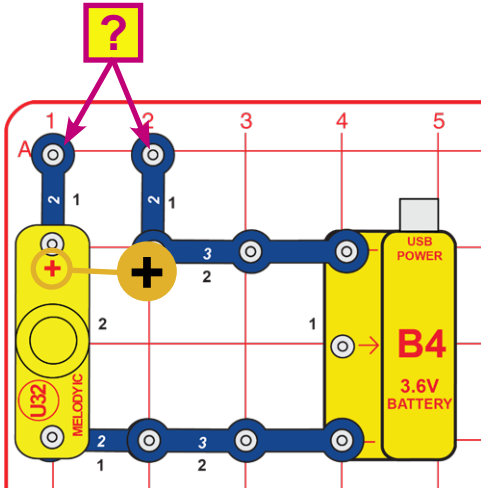
These small wind and solar power sources may not produce enough heat for you to notice the water getting warmer, but you could use more powerful ones to heat up a lot of water. You could then pump the water around your house in pipes to use the wind or solar heated water to warm up your house.

How do you harness the wind to heat your house? It is easy when you use electricity to help.

Another way to harness sunlight to heat homes is by using sunlight to heat water, then pumping the water around the house.



PROJECT 99 • Electrical Material Checker



See project 3 if you need to recharge the battery (**B4**).

Build the circuit shown, and touch various materials between the snaps marked with ?.

The melody IC (**U32**) will signal for materials that are good at transporting electricity. Try string, the electrodes, a shirt, plastic, paper, wood, or anything in your home.

Many electronic test instruments test wires and connections using probes and a sound device like you did here. A sound device is used so the user can focus his attention on where he puts the probes without looking at a display.

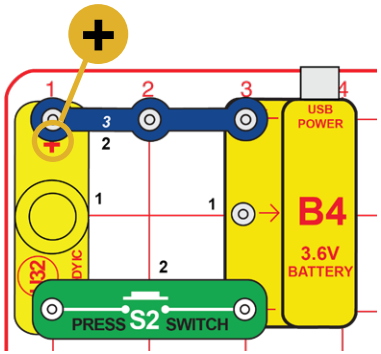
You can replace the melody IC with the meter (**0.5mA** setting) or one of the LEDs (**D8** & **D10**) to make a visual continuity checker.

Some materials, such as metals, have very low resistance to electricity and will turn on the horn. These materials are called **conductors**.

Other materials, such as paper, air, and plastic, have very high resistance to electricity. These will not turn on the horn. These materials are called **insulators**.

Copper is one of the best conductors ever found so it is used for most electrical wires. Plastic is a very good insulator so it is used around copper wires to prevent electricity from getting in or out of the wire.

PROJECT 100 • Morse Code



Build the circuit and push the switch (**S2**) several times to send secret messages to your friends using Morse Code.

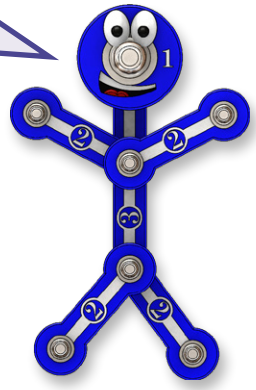
If the melody IC (**U32**) was located 10 miles away and connected to the switch and battery (**B4**) using really long wires, then you could still use it to send messages.

See project 3 if you need to recharge the battery (**B4**).

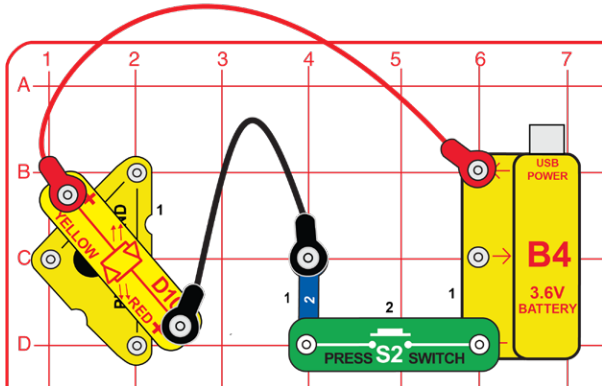
Morse Code: The forerunner of today's telephone system was the telegraph, which was widely used in the latter half of the 19th century. It only had two states - on or off (that is, transmitting or not transmitting), and could not send the range of frequencies contained in human voices or music. A code was developed to send information over long distances using this system and a sequence of dots and dashes (short or long transmit bursts). It was named Morse Code after its inventor. It was also used extensively in the early days of radio communications, though it isn't in wide use today. It is sometimes referred to in Hollywood movies, especially Westerns.

MORSE CODE

A	. _	N	_ .	Period	. _ . _ . _
B	_ . . .	O	_ _ _	Comma	_ _ . . _ _
C	_ . _ .	P	. _ _ .	Question	. . _ _ . .
D	_ . .	Q	_ _ . _	1	. _ _ _ _
E	.	R	. _ .	2	. . _ _ _
F	. . _ .	S	. . .	3	. . . _ _
G	_ _ .	T	_	4	. . . . _
H	. . . .	U	. . _	5	. . . . .
I	. .	V	. . . _	6	_ . . . .
J	. _ _ _	W	. _ _	7	_ _ . . .
K	_ . _	X	_ . . _	8	_ _ _ . .
L	. _ . .	Y	_ . _ _	9	_ _ _ _ .
M	_ _	Z	_ _ . .	0	_ _ _ _ _

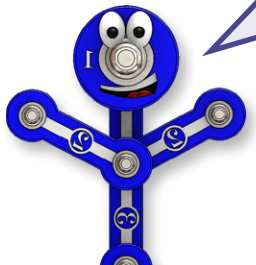


PROJECT 101 • Morse Light



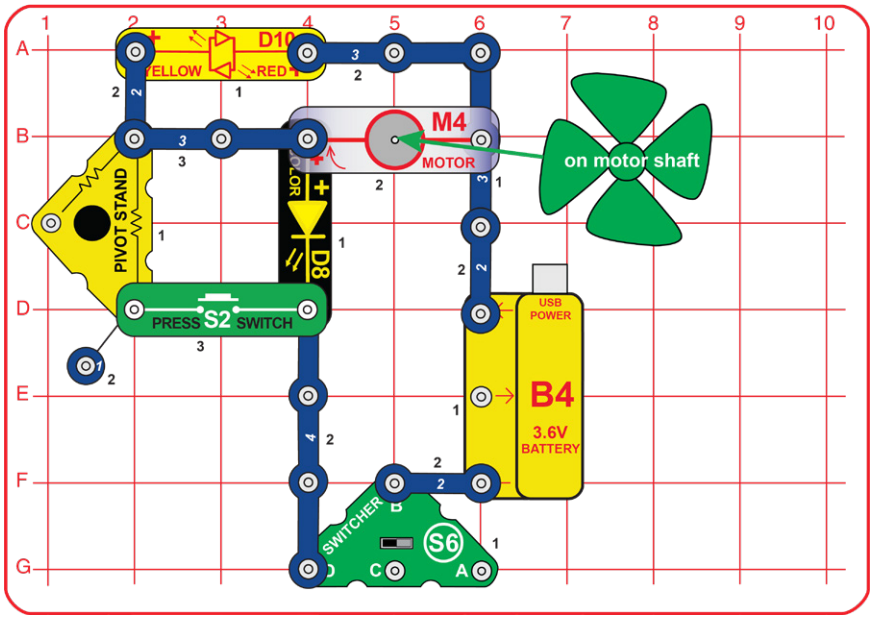
Build the circuit as shown, with the red/yellow LED (**D10**) on the pivot. Point the LED towards your friends and push the switch (**S2**) several times to send messages to your friends using Morse Code.

You could use this system to send messages during a noisy concert, or out in the wilderness where your cell phone won't work.



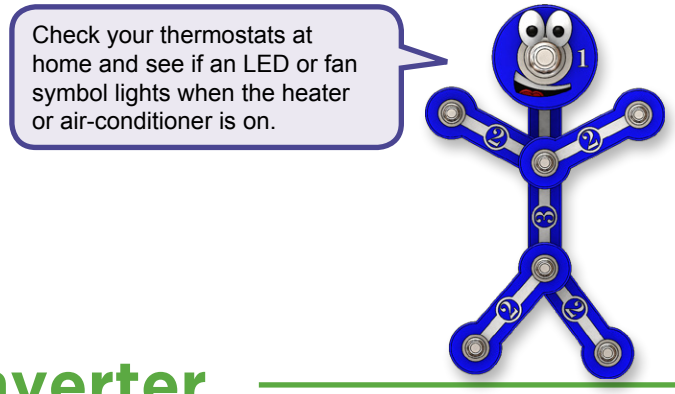
During World War II Navy ships sometimes communicated by flashing Morse Code messages between ships using searchlights (because radio transmissions might reveal their presence to the enemy). Years ago, Native Americans would send messages to other tribes using smoke signals and a special code.

PROJECT 102 • Motor Status LEDs

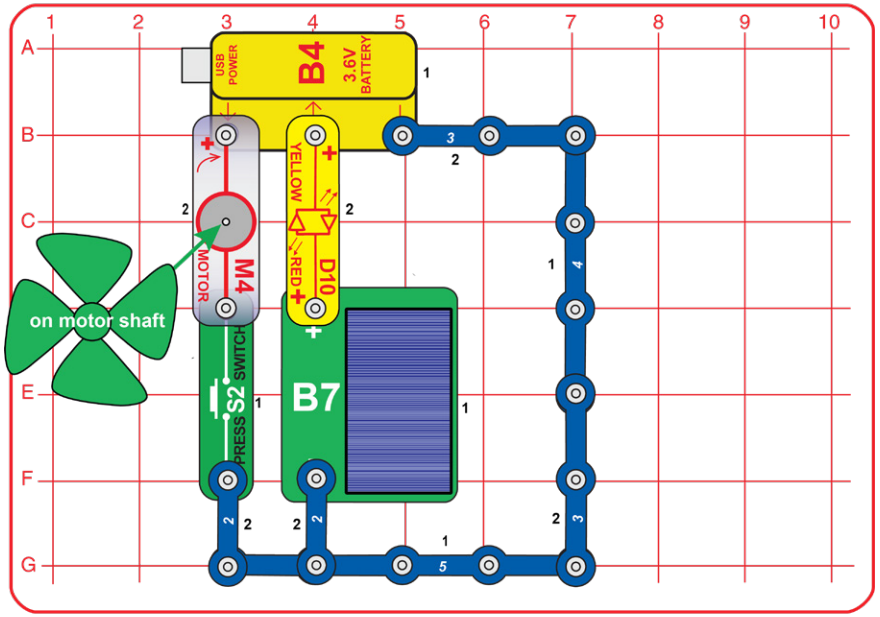


In this circuit we use the LED's (**D8** & **D10**) to indicate if the motor (**M4**) is spinning. Set the switcher (**S6**) to the left position, the color LED lights, indicating the motor is not spinning. Pushing the press switch (**S2**) bypasses the color LED, and it turns off. The voltage across the motor and red/yellow LED increases, so they turn on.

See project 3 if you need to recharge the battery (**B4**).



PROJECT 103 • Energy Converter

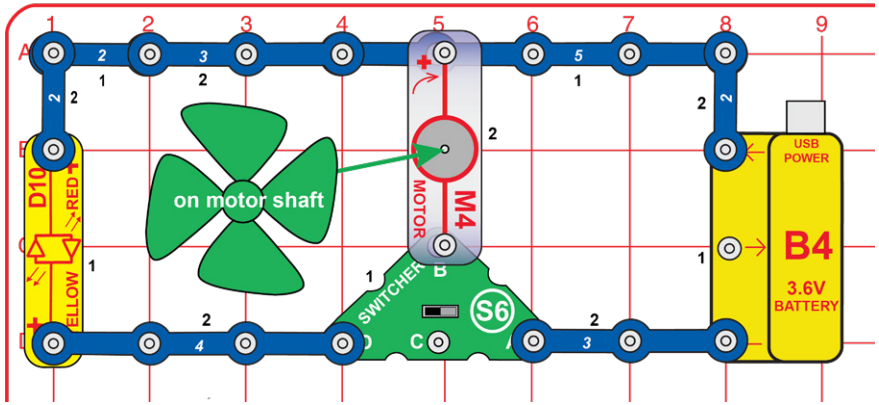


In this project you'll convert one form of energy to another. Place the solar cell in sunlight or about 12 inches from an incandescent light bulb of 60W or more. Adjust the light on the solar cell to make the red/yellow LED (**D10**) brightest. The solar cell converts light energy into electrical that lights the LED and charges the battery (**B4**).

The electrical energy charges the battery, converting it into a chemical form. When you press switch **S2**, chemical energy in the battery makes electrical energy, which runs the motor (**M4**) and fan. The spinning motor shaft and fan are another form of energy called motion.

If you prefer, you can mount the solar cell on the pivot stand, connect it to the circuit using the red & black jumper wires, and then adjust the pivot so the solar cell faces the light.

PROJECT 104 • Energy Conversion



Set the switcher (**S6**) to the right position. Some of the chemical energy in the battery becomes electricity, which is converted into mechanical energy of motion by the motor (**M4**).

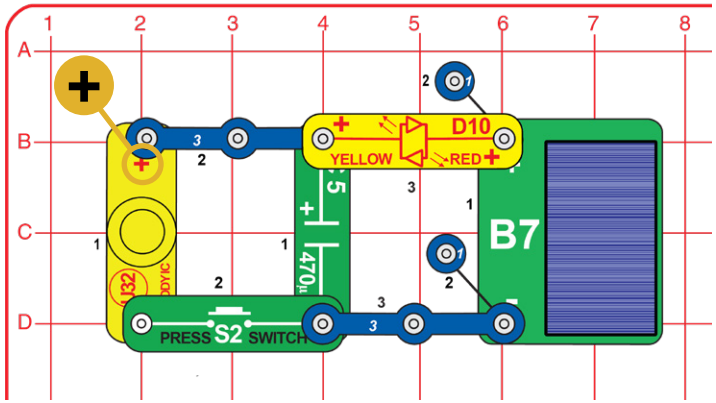
Now set the switcher to the left position. Some the mechanical energy in the spinning motor shaft and fan generates electricity, which travels to the LED (**D10**), where it becomes light. The LED will only light briefly.

Part B: Replace the motor with the color LED (**D8**) or the melody IC (**U32**). Set the switcher to the right position. Now the chemical energy in the battery becomes light energy or sound energy (air pressure variations).

Part C: Replace the battery with the geared motor (**GM**) and crank arm. Now you can convert mechanical energy of motion to chemical energy in the battery, then to motion, light, or sound.

See project 3 if you need to recharge the battery (**B4**).

PROJECT 105 • Small Energy Conversion



The capacitor stores energy as an electric field, similar to the magnetic field of a magnet. It can only store a small amount of energy in this way.

Build the circuit shown, and place the solar cell (**B7**) in sunlight or close to an incandescent lamp for a few seconds. The LED (**D10**) should light briefly. The solar cell converted some light energy into electrical energy, which was stored in the 470µF capacitor (**C5**).

Press the switch (**S2**). The melody IC (**U32**) makes a brief sound. The electrical energy in the capacitor was converted to sound waves (variations in air pressure) by a speaker in the melody IC.

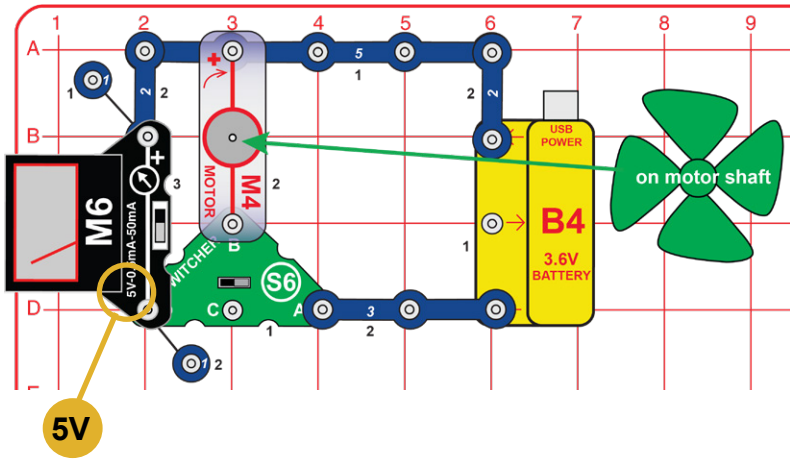
Part B: Replace the melody IC with the color LED (**D8**). Now the color LED converts the energy stored in the capacitor back to light.

Part C: Replace the color LED with the motor (**M4**) and wind fan. Now the energy stored in the capacitor is converted to mechanical motion by the motor. The fan will not move very much.

PROJECT 106 Mechanical Energy Conversion

Replace the solar cell with the geared motor and crank arm. Now you can convert mechanical energy to electrical energy in the capacitor, then to sound, light, or motion.

PROJECT 107 • Generator



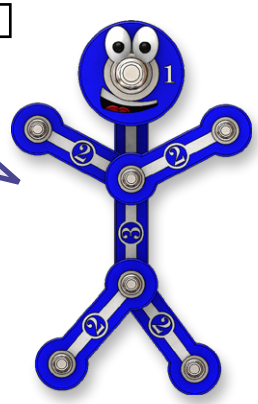
Set meter (**M6**) to the **5V** setting and set the switcher (**S6**) to the right position. Some of the chemical energy in the battery becomes electricity, which is converted into mechanical energy of motion by the motor (**M4**).

Now set the switcher to the left position. Some the mechanical energy in the spinning motor shaft and fan generates electricity, which is measured as voltage on the meter.

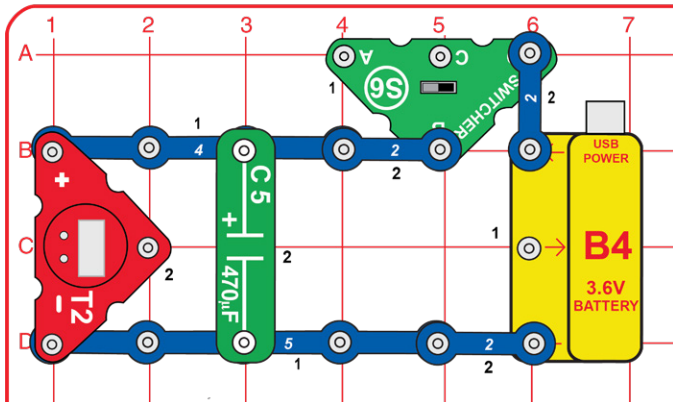
Keep the switcher in the left position and spin the fan clockwise with your finger. The meter measures the voltage produced.

See project 3 if you need to recharge the battery (**B4**).

A motor uses electricity to produce mechanical motion. A generator uses mechanical motion to produce electricity.



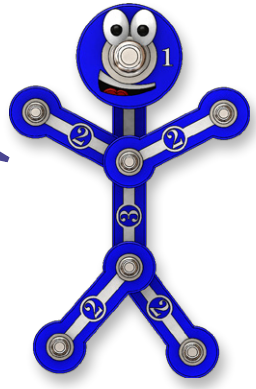
PROJECT 108 • Clock with Memory



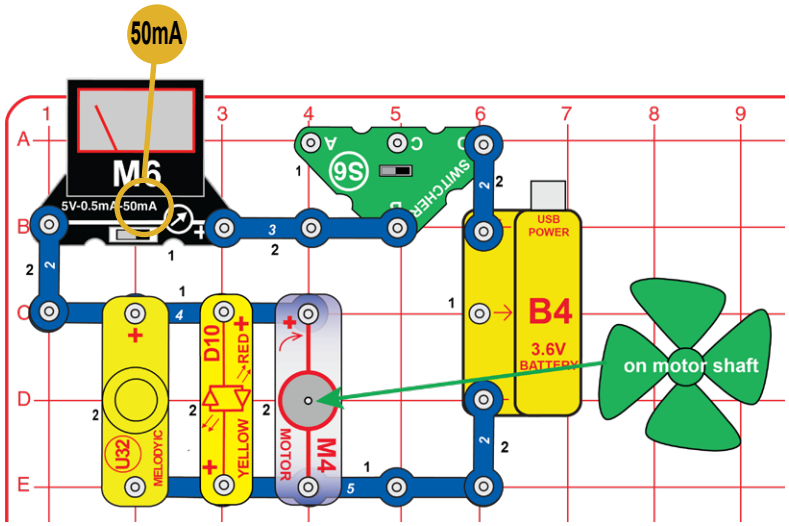
Build the circuit, and set the switcher (**S6**) to the right position to turn on the clock. If you turn off the switch or disconnect the power source (the **B4** battery), the clock will still work for a while. The 470µF capacitor (**C5**) stores enough electricity to run the clock for a while during power disruptions. If you remove the capacitor, the clock will turn off when you turn off the switch.

See page 4 if you would like to set the time.

Many clocks use capacitors or small batteries as backups in case the power goes out for short periods.



PROJECT 109 • Saving Energy



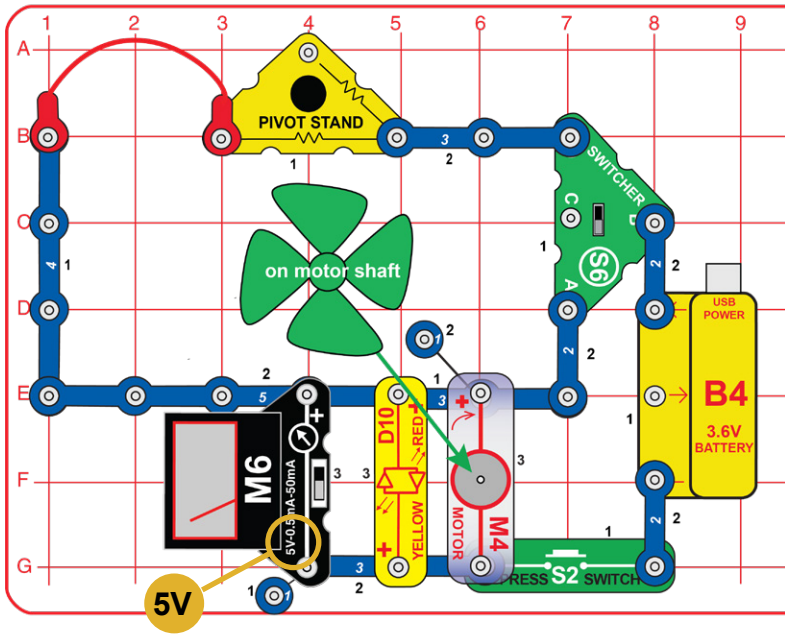
Build the circuit shown. Set the meter to the **50mA** setting. Set the switcher (**S6**) to the right position. The battery operates the melody IC (**U32**), LED (**D10**), and motor (**M4**), just like batteries operate stuff in your home. The meter shows how much current is used to operate them; the more current is used, the faster the battery will run out.

You can make the battery last longer if you turn off some things. Remove the melody IC, LED, or motor from the circuit, and see how much the current drops. Then remove another. Some devices use more current than others, so it helps most if you disconnect the highest current device - find out which one it is. You can also replace the motor with the geared motor (**GM**) or clock (**T2**) to see how their current compares to the other devices.

See project 3 if you need to recharge the battery (**B4**).

Reducing how much energy we use is just as important as finding new sources of clean energy.

PROJECT 110 • Energy Transmission Loss



Set the switcher (**S6**) to the top or bottom position and push the press switch (**S2**); the motor (**M4**) spins the fan, the LED (**D10**) lights, and the meter (**M6**) measures the voltage across them.

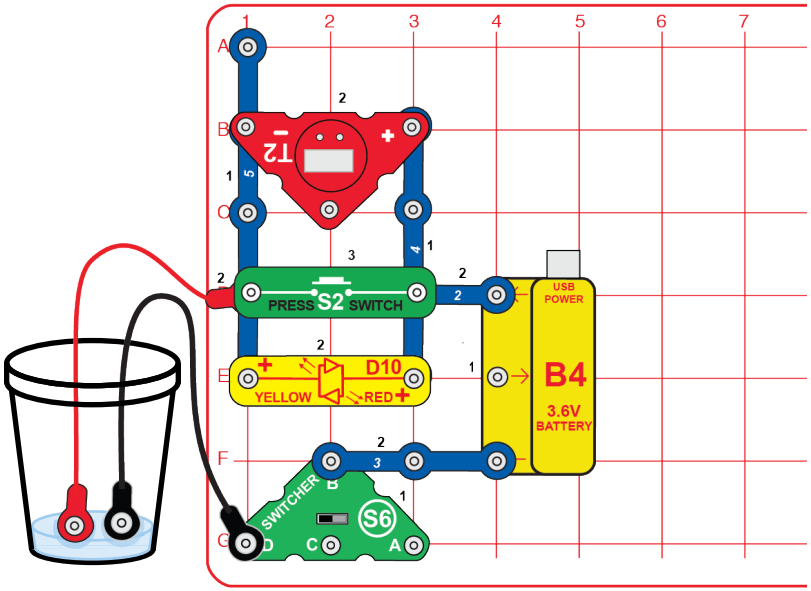
If the switcher is in the bottom position, the electric current takes the short path to the meter/LED/motor. If the switcher is in the top position, the current takes the longer path, and the voltage available at the meter/LED/motor is lower due to more resistance in the path.

Remove the LED or motor and see how the voltage changes. If less current is used, less voltage will be lost along the way.

Electrical wires have low resistance, but when you are transporting large amounts of electricity over large distances (such as between power plants and cities), even low resistance causes large power losses. In this circuit a resistor in the pivot stand simulates having a very long wire.

When electric power companies transport electricity long distances (like between power generating plants and cities), they use high voltages and low currents since this reduces power loss in the wires. Transformers convert this to 120V, which is supplied to homes and offices.

PROJECT 111 • Water Timer



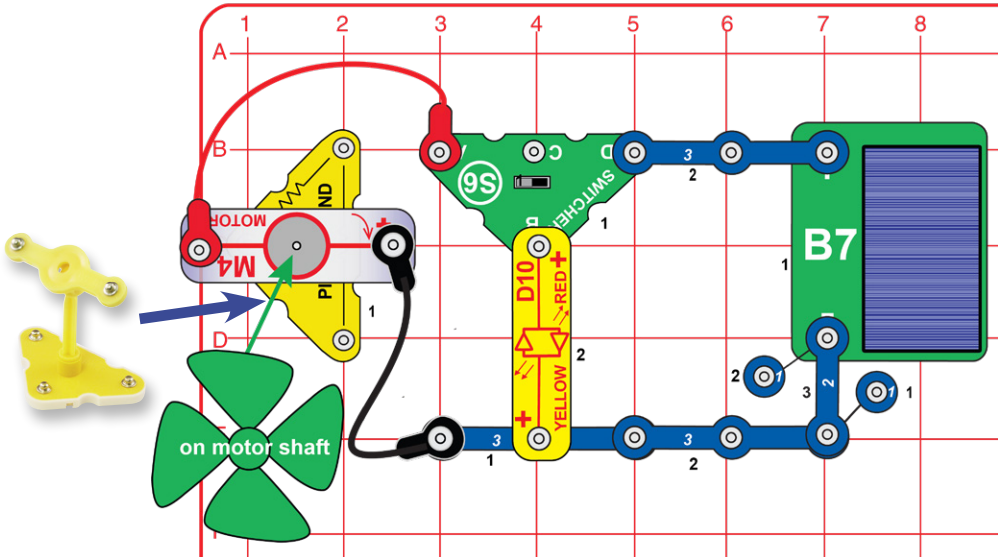
Set the switcher (**S6**) to the left position. Place the loose ends of the red & black jumper wires into a cup of water without the metal parts touching. The LED (**D10**) should light dimly and the clock (**T2**) should run, but it depends on your local water supply. Add salt to the water if they are off or dim to make them brighter.

Remove the water, and push the press switch (**S2**) to reset the clock. Place the empty cup under a faucet or a gutter drain. When water goes into the cup, the clock will start. If you go away and return, you can use this timer to see how long ago water entered the cup.

Don't drink any water or liquids used in this project.

See project 3 if you need to recharge the battery (**B4**).

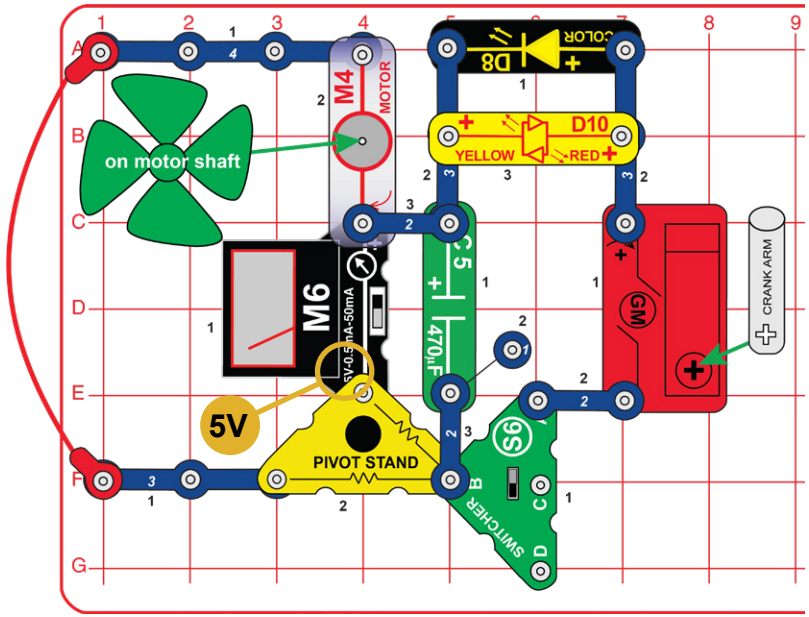
PROJECT 112 • Sun & Wind Light



Build the circuit shown, with the motor mounted on the pivot stand like a windmill. Use either sunlight or wind power to run the red/yellow LED (**D10**). Set the switcher (**S6**) to the left to use wind power, or to the right to use solar power.

During the day, the sun powers the LED using the solar cell. At night, the wind powers the LED. This circuit does not consume any fuel, and causes no pollution.

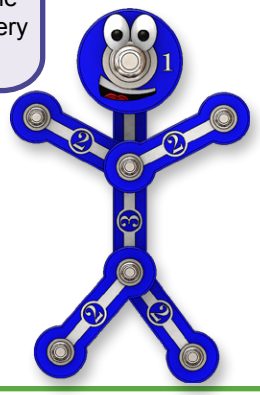
PROJECT 113 • **Hybrid**



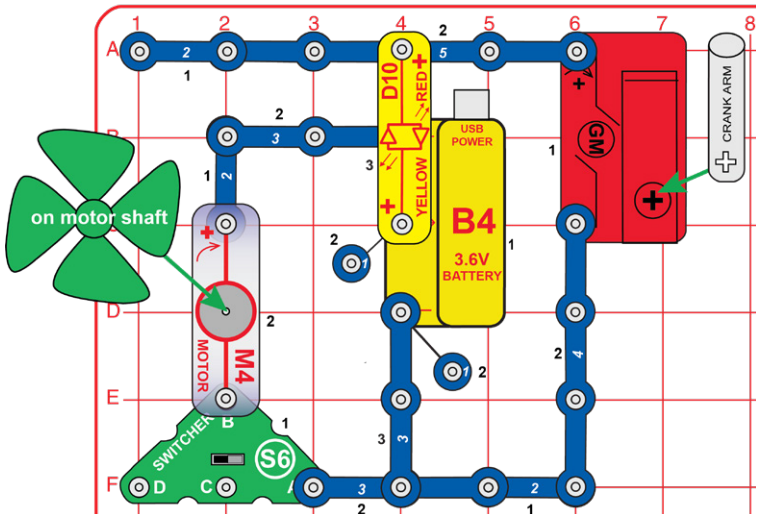
Set the switcher (**S6**) to the top position and turn the crank arm on the geared motor (**GM**). The LEDs (**D8** & **D10**) light, the meter measures the voltage, and the fan spins.

The meter scale is **10V** (not **5V**), due to a scaling resistor in the pivot stand.

The motor is powered by the hand crank or stored energy from the 470µF capacitor (**C5**). It might be called a hybrid, because it runs on power from either source. However, the capacitor does not store much energy, so it will run the motor for only a very short time. If the rechargeable battery were used here, the motor would run for much longer.



PROJECT 114 • **Hybrid Car Concept**

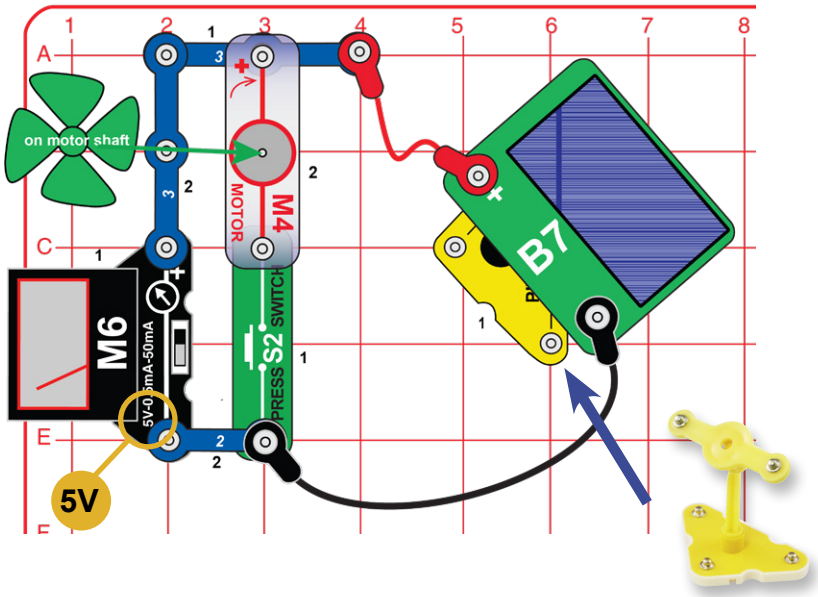


Set the switcher (**S6**) to the left position and turn the crank arm on the geared motor (**GM**). The LED (**D10**) lights when the crank is charging the battery (**B4**).

Set the switcher to the right position to run the motor (**M4**) using the battery. If you turn the crank now, it will both charge the battery and run the motor.

This circuit demonstrates the concept of hybrid cars. A power source (the hand crank is used here) charges a battery (**B4** here) in a car. The car has an electric motor (not a gasoline powered motor), which is powered by electricity from the battery. Some electric cars also have gasoline powered motors as backups, in case you are driving a long distance and your battery runs out of charge.

PROJECT 115 • Solar Fun

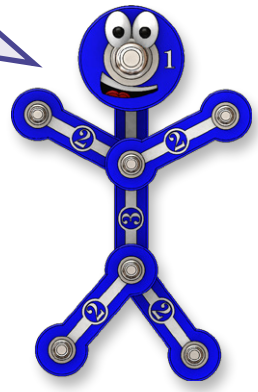


Mount the solar cell (**B7**) on the pivot stand as shown, and place it in sunlight or near an incandescent lamp. The meter (**M6**) measures the voltage produced.

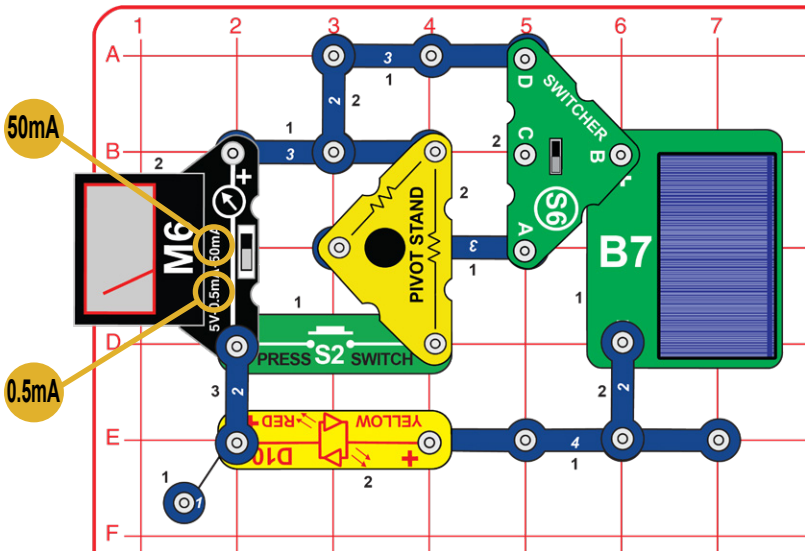
Press the switch (**S2**) to turn on the fan (the **M4** motor), you may need to give it a push to get it started. The meter shows the voltage is much lower now with the solar cell running the fan.

The solar cell cannot produce as much current as the fan needs, so the voltage drops.

The same thing happens with water. A pump might push water through a narrow pipe at high pressure, but if you connect the same pump to a much larger pipe, the pressure drops because the pump can only push so much water.



PROJECT 116 • Triple Current Meter

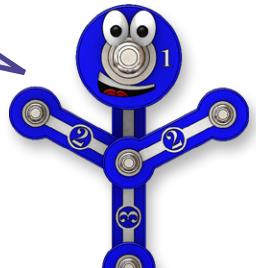


Build the circuit shown. This circuit measures current using several scales on the meter (**M6**). Set the switcher (**S6**) to the top position. Place the solar cell (**B7**) in sunlight or near an incandescent lamp, and vary the light on it. Use the **0.5mA** or **50mA** settings on the meter to measure the current through the LED (**D10**).

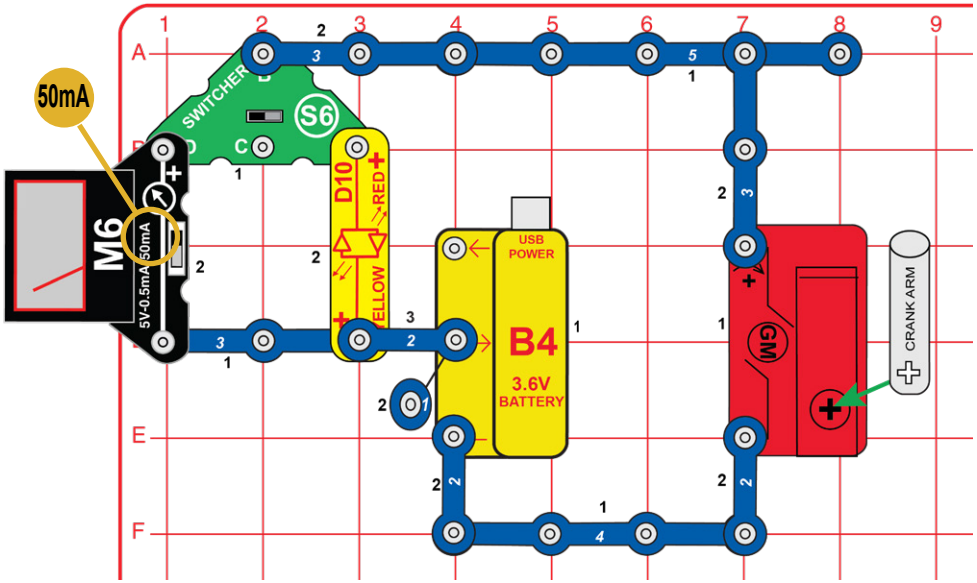
If the current is too high to measure on the **0.5mA** setting and too low to measure on the **50mA** setting, use the **0.5mA** and push the press switch (**S2**); this uses a resistor in the pivot stand to change the scale to 5mA.

Set the switcher to the bottom position. This places a high resistor (in the pivot stand) in series with the LED. Measure the current now.

If you don't have a suitable light source, you can use the battery (**B4**) in place of the solar cell.

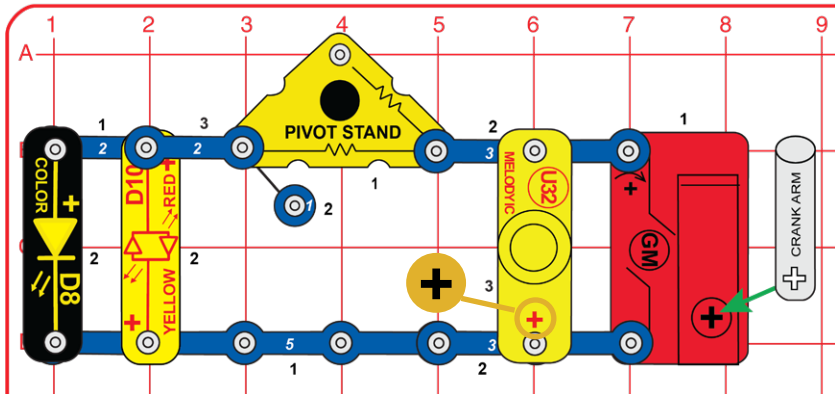


PROJECT 117 • Hand Charger



Use the crank arm to charge the battery (**B4**), the meter (**M6**) or LED (**D10**) show how fast you are charging it.

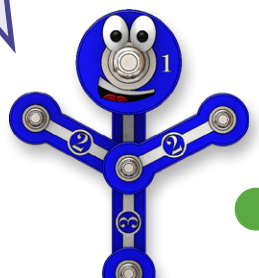
PROJECT 118 • Parallel Cranking



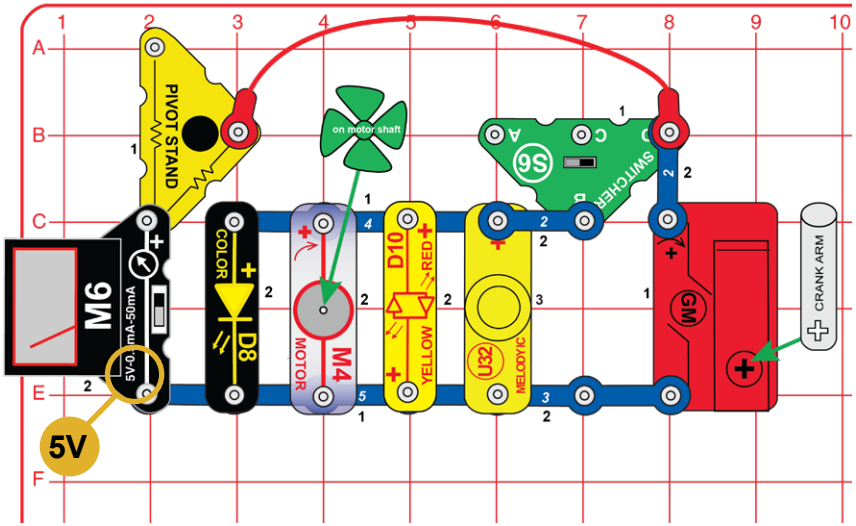
Turn the crank arm on the gearedmotor (**GM**) slowly clockwise, just enough to turn on the red/yellow LED (**D10**, which will be red) and make the color LED (**D8**) show red. Then crank faster, until the color LED also shows green and blue brightly.

If you turn the crank counter-clockwise the red/yellow LED is yellow and the melody IC (**U32**) plays a tune, but the color LED will not light.

The yellow LED needs a little more voltage to turn on, but can get much brighter. LEDs are manufactured with two regions of permanent electrical charge. Once the voltage exceeds a turn-on level, the resistance becomes very low in one direction, and some energy is emitted as light.



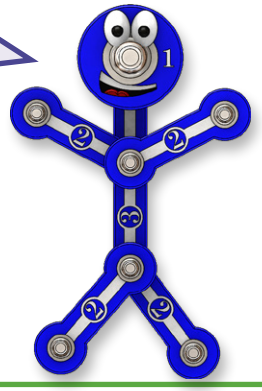
PROJECT 119 • Hard to Crank



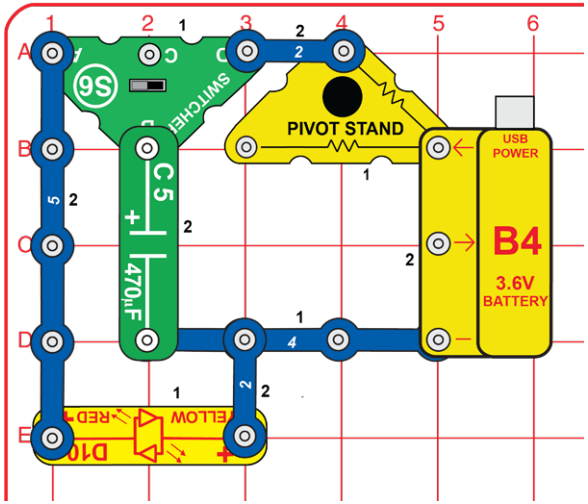
Set the switcher (**S6**) to the left position, and turn the crank arm. Notice how easy it is to turn the crank, and how high the voltage gets. A resistor in the pivot stand changes the scale to **10V**, so double the voltage shown on the meter.

Set the switcher to the right position and turn the crank clockwise. The crank runs the melody IC, two LEDs, and motor. Notice how much harder it is to turn the crank now, and how the voltage doesn't get as high.

The crank is easier to turn when devices that need lots of electric current do not load it down. It is like you trying to throw rocks - you can throw small rocks much farther than you can throw heavy ones.



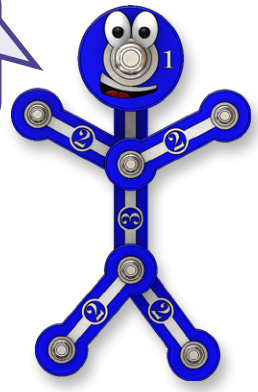
PROJECT 120 • Slow In Flash Out



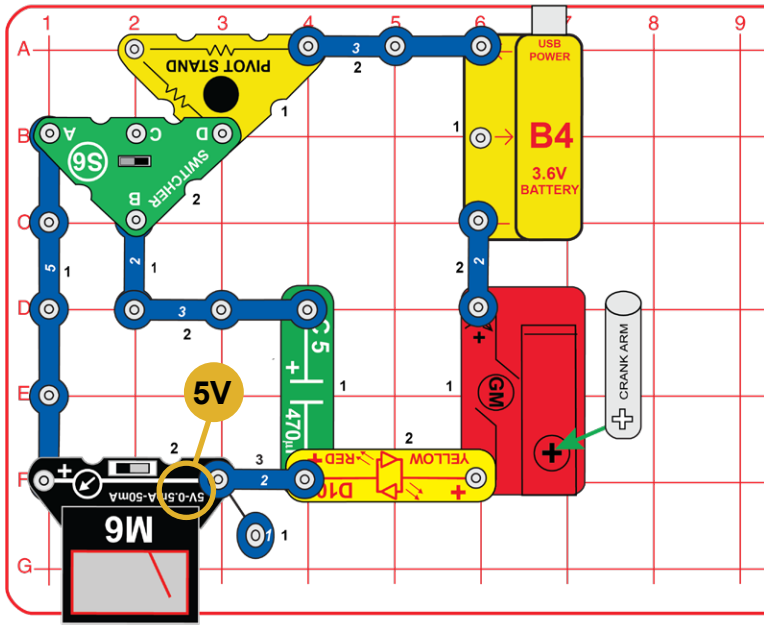
The electrons slowly trickle into the 470µF capacitor (**C5**) through a 10KΩ resistor (in the pivot stand) when the switcher (**S6**) is in the right position. If you wait and let the capacitor charge up it will flash nicely when you switch to the left. If you are not patient, and switch back too quickly your flash will be weak.

See project 3 if you need to recharge the battery (**B4**).

Patience is its own reward. If you just wait a little while, you get a brighter flash. If you rush your flash will be weak.



PROJECT 121 • Filling Station

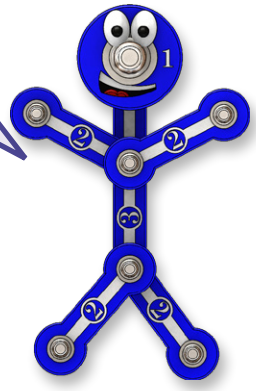


The 470µF capacitor (**C5**) is a storage device, so it would be nice to know when it is filled to capacity. With the switcher (**S6**) in the right position, turn the crank arm until the LED (**D10**) no longer produces light. When the capacitor is fully charged, the current is blocked and the light cannot turn on.

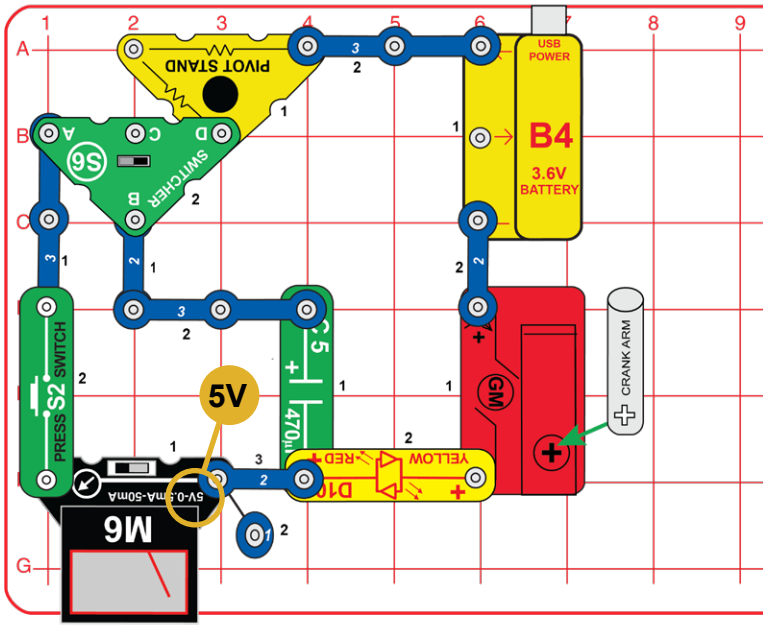
Flip the switcher to the left to show the voltage across the capacitor, but at the same time it will use current to move the meter and the charge will drop as you read it.

See project 3 if you need to recharge the battery (**B4**).

Did you ever wonder how long capacitor **C5** could hold its charge? Try filling it up and waiting a while before taking a reading.



PROJECT 122 • Gas Petal

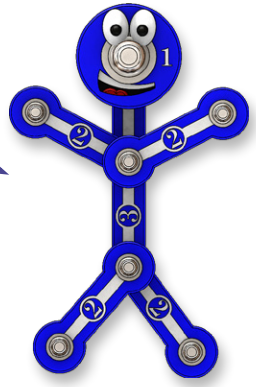


Modify the circuit to include the press switch (**S2**), as shown. With the switcher (**S6**) in the right position, turn the crank arm until the LED (**D10**) no longer produces light. When the capacitor is fully charged, the current is blocked and the light cannot turn on.

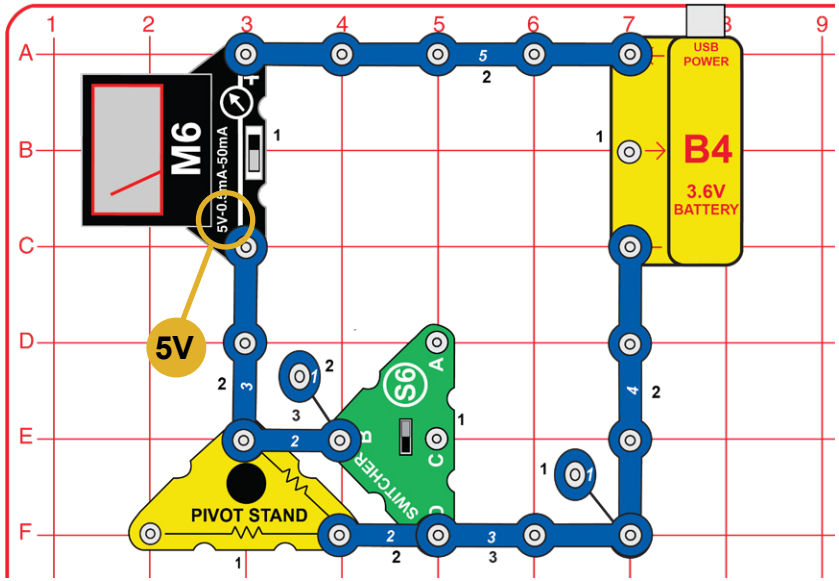
Flip the switcher to the left and notice that the meter does not move. The press switch is open and stops current from flowing until it is pressed, just like a gas pedal stops gasoline from flowing when the car is stopped.

Press **S2** on and off a few times to send current to the meter.

I sure would not get very far if my electric car used a capacitor to store energy. I guess this is why they all use batteries and carry a gas driven charger to charge the batteries up when they get low.



PROJECT 123 • Volt Meter



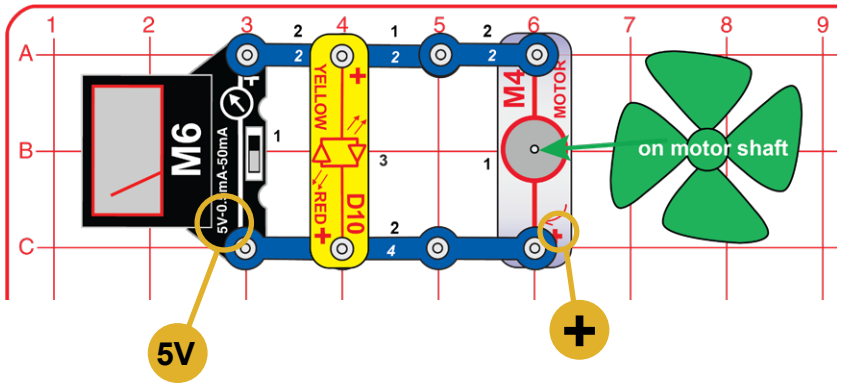
To make a voltage measurement, the meter (**M6**) is set to **5V** and connected in parallel between the two points where the measurement is to be made. Since the voltmeter is in parallel and has a high resistance, very low current flows through it.

To measure the voltage of the battery (**B4**), set the switcher (**S6**) to the bottom position. Look at the scale and read the voltage, it should be over 3 volts. If the voltage is less then 3 volts, you need to charge the battery.

You can change the meter scale from **5V** to **10V** by adding a 10KΩ resistor in the pivot stand in series with the meter. Set the switcher to the top or middle position. The meter pointer drops to a lower position since each segments now equal **2V**.

See project 3 if you need to recharge the battery (**B4**).

PROJECT 124 • Anemometer

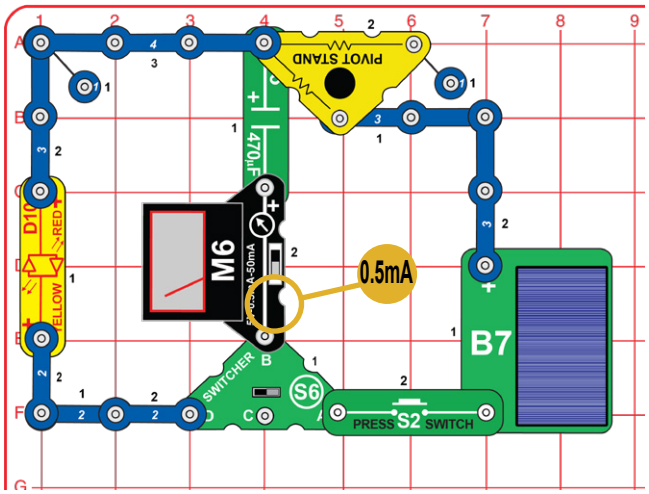


The energy in the moving wind can be used to generate electricity. An anemometer is a device used for measuring wind speed, and is one instrument used in a weather station. The term comes from the Greek word anemos, meaning wind. Leon Battista Alberti invented the anemometer.

Set the meter (**M6**) to the **5V** setting. Slowly blow on the fan and notice the reading on the meter. The meter measures the voltage generated by the spinning shaft on the motor. The faster the shaft spins, the greater voltage generated. See how fast the fan must spin to light the LED.

Wind speed is important for wind energy. Wind turbines need a constant, average wind speed of about 14 miles per hour before the wind turbines can generate electricity.

PROJECT 125 • Capacitor Charging



Build the circuit shown. Set the meter (**M6**) to the **0.5mA** setting. Set the switcher (**S6**) to the right position, place the solar cell (**B7**) in sunlight or near an incandescent lamp, and push the press switch (**S2**). The solar cell slowly charges up the 470µF capacitor (**C5**), and the meter shows the current.

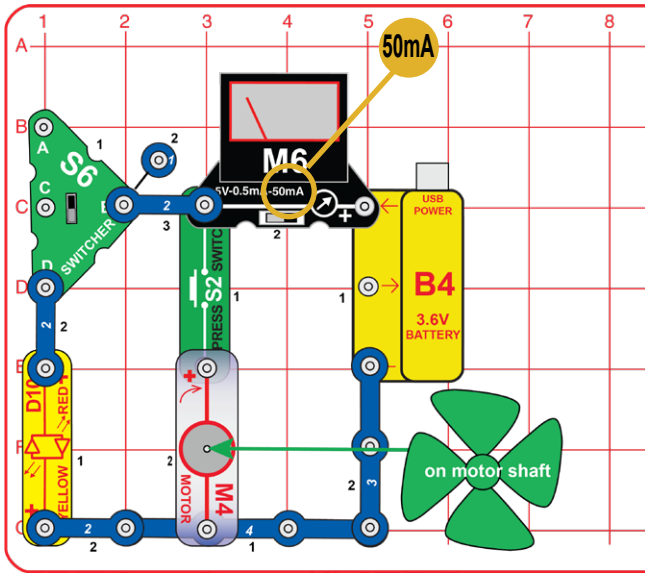
Set the switcher to the left position to discharge the capacitor, making the LED (**D10**) flash.

Set **S6** back to the right, push **S2** to see the current, and then set **S6** back to the left to see the flash.

See project 3 if you need to recharge the battery (**B4**).

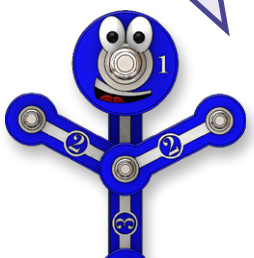
If you don't have a suitable light source, you can use the battery (**B4**) in place of the solar cell.

PROJECT 126 • Current Summer



Build the circuit and set the meter (**M6**) to the **50mA** setting and the switcher (**S6**) to the top position. Set the switcher to the bottom position to measure the current through the LED (**D10**), push the press switch (**S2**) to measure the current through the motor (**M4**), or do both to measure the combined current.

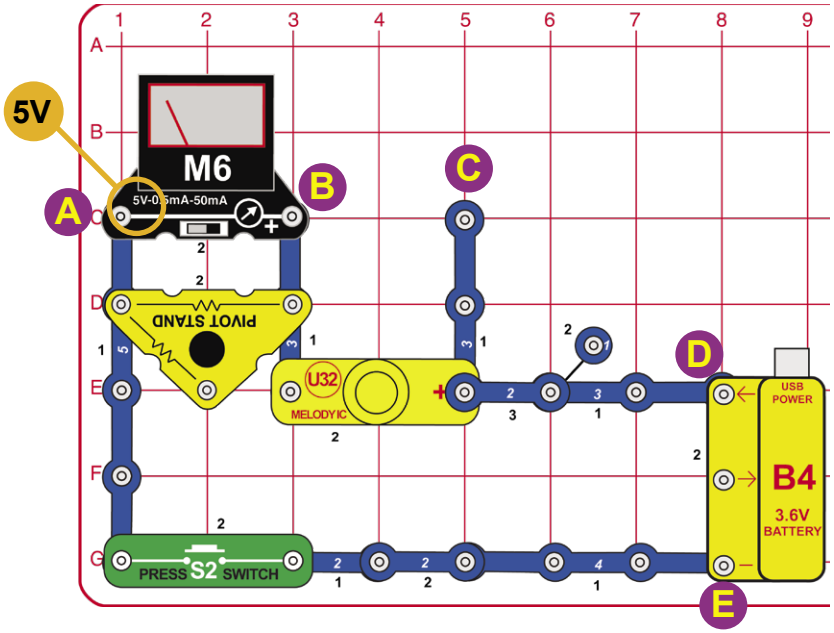
The current from the battery will go through the LED, the motor, or both, depending on which switches (**S2** and **S6**) are on. If you add up the individual currents you measured for the LED and motor, they should add up to the current you measured for both. (Your result may be a little different, because **M6** is a simple meter with low accuracy.)



PROJECT 127 More Current Summing

Replace the red/yellow LED (**D10**, "**+**" to top) with the color LED (**D8**) or the melody IC (**U32**, "**+**" to top), or place one of them directly over the red/yellow LED (on level 3). See how the current changes on the meter.

PROJECT 128 • Summing Voltage



Build the circuit and place the wind fan on the motor (**M4**). Set the meter (**M6**) to the **5V** setting. Push the press switch (**S2**); the meter measures the voltage across a resistor in the pivot stand. The measured voltage varies a little as the sound changes.

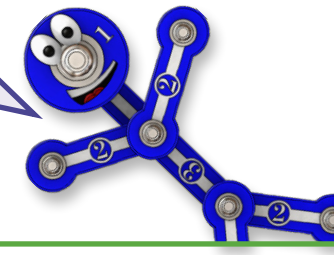
Now move the meter so it is across points B & C, so it measures the voltage across the melody IC (**U32**).

Now move the meter so it is across points D & E, so it measures the voltage from the battery (**B4**).

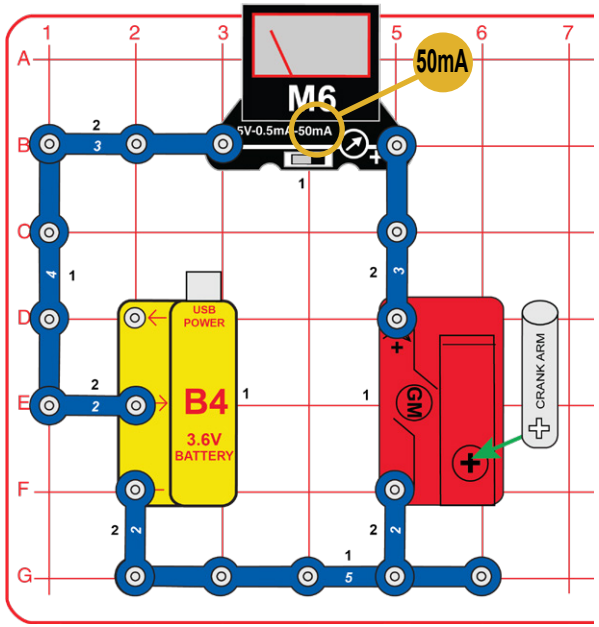
Compare the voltage across the battery to the sum of the voltages across the pivot stand and melody IC.

See project 3 if you need to recharge the battery (**B4**).

The voltage you measured across the battery should equal the sum of the voltages across the pivot stand and melody IC. (Your result may be a little different, because **M6** is a simple meter with low accuracy.) This is because the voltage produced by the battery is the same as the voltages across all of the devices using it. There are also voltage drops across the snap wires and the press switch, but those are tiny and can be ignored.



PROJECT 129 • Charging Currents

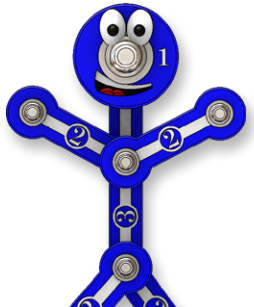


Build the circuit and set the meter (**M6**) to the **50mA** setting. Turn the crank arm on the geared motor (**GM**) clockwise to charge the battery (**B4**), the meter measures the current. The battery will be more difficult to charge when it is near full charge.

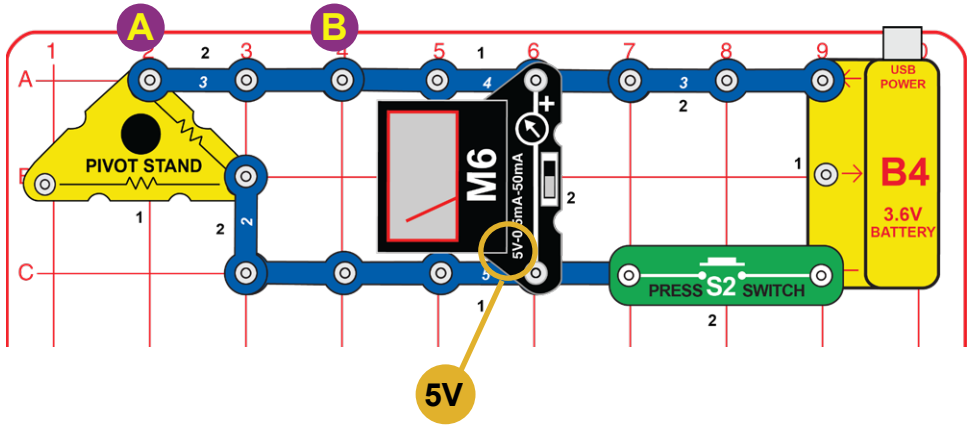
Replace the geared motor with the motor (**M4**, "**+**" on bottom) and wind fan. Blow hard on the fan to charge the battery, and compare the charge current to that from the hand crank. Use either the **0.5mA** or **50mA** setting on the meter.

Now replace the motor and fan with the solar cell (**B7**). Place the solar cell in sunlight or near an incandescent light bulb, and compare the charge current to that from the hand crank and fan. Use either the **0.5mA** or **50mA** setting on the meter.

The hand crank should charge the battery a lot faster than the fan or solar cell, as shown by the charging currents you measure on the meter. However turning the crank arm takes a lot of effort from you, so it is much easier to charge the battery using wind or solar power.



PROJECT 130 • Big Resistance



Set the meter (**M6**) to the **5V** setting and push the press switch (**S2**). Read the voltage on the meter.

Next, replace the 3-snap wire across points A & B with the meter ("**+**" on right), and set the meter to the **0.5mA** setting. Push the press switch and read the current on the meter.

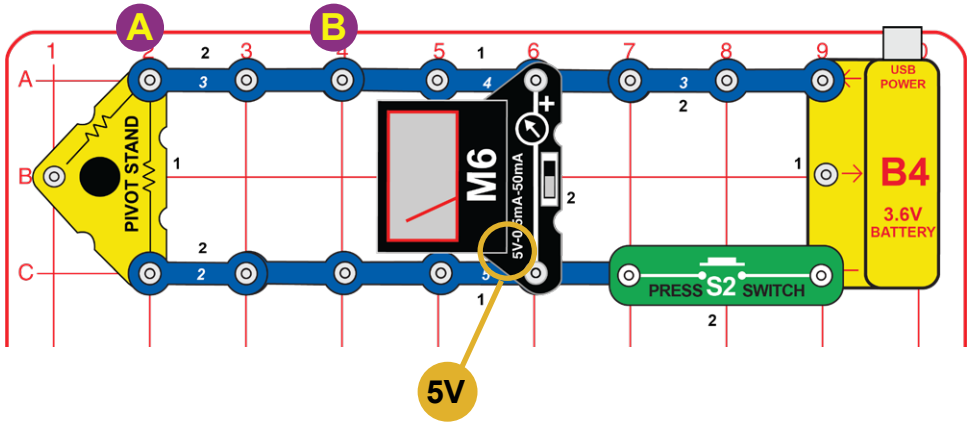
Calculate the resistance using Ohm's Law:

$$\text{Resistance} = \frac{\text{Voltage}}{\text{Current}}$$

See project 3 if you need to recharge the battery (**B4**).

These snaps on the pivot stand have an internal resistance of about 10,000 ohms, but your measurements will vary because the **M6** meter is a simple meter with limited accuracy.

PROJECT 131 • Little Resistance



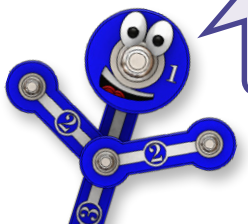
Modify the preceding circuit to be this one, which connects to a different resistor in the pivot stand. Set the meter (**M6**) to the **5V** setting and push the press switch (**S2**). Read the voltage on the meter.

Next, replace the 3-snap wire across points A & B with the meter ("**+**" on right), and set the meter to the **50mA** setting. Push the press switch and read the current on the meter.

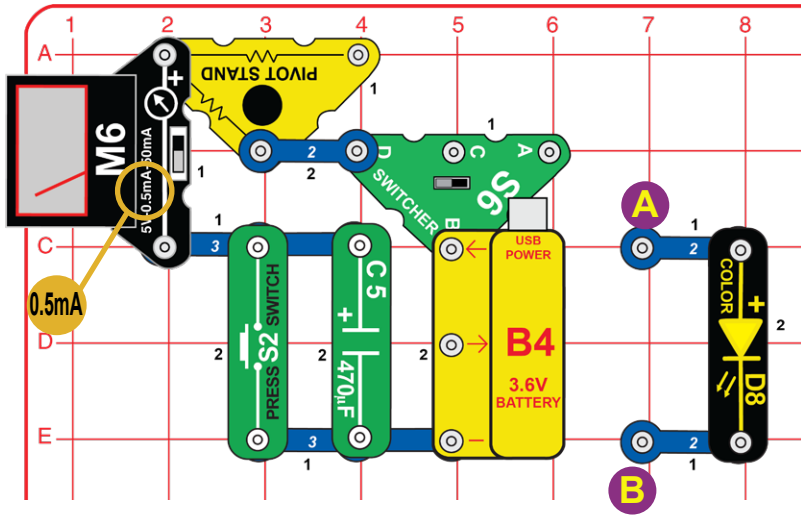
Calculate the resistance using Ohm's Law:

$$\text{Resistance} = \frac{\text{Voltage}}{\text{Current}}$$

These snaps on the pivot stand have an internal resistance of about 50 ohms, but your measurements will vary because the **M6** meter is a simple meter with limited accuracy.



PROJECT 132 • **Slow Charge**

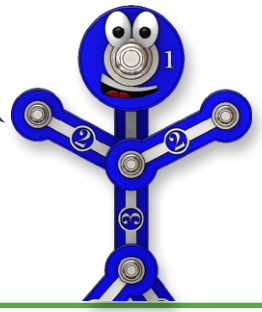


Set the meter (**M6**) to the **0.5mA** setting, and set the switcher (**S6**) to the left position. Watch the current on the meter as the 470µF capacitor (**C5**) slowly charges up. Once **C5** is near full charge you can push the press switch (**S2**) to instantly discharge the capacitor and restart the charging process.

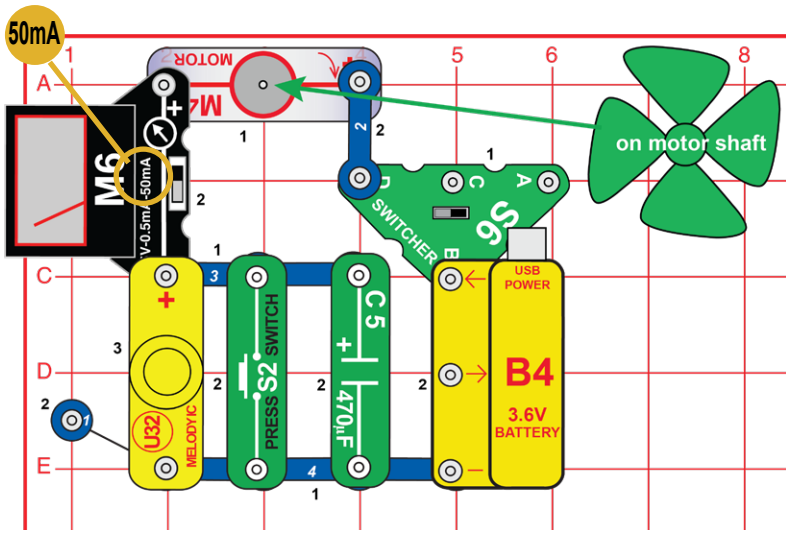
Once **C5** is near full charge remove it and connect it across points A & B. The color LED (**D8**) lights for a moment as **C5** discharges through it. Return **C5** to the main circuit to re-charge it.

See project 3 if you need to recharge the battery (**B4**).

A high resistance in the pivot stand is used here to charge the 470µF capacitor at a slow rate so you can watch it charge up. The capacitor is like a mini battery, which you can move to the LED and light it for a moment.



PROJECT 133 • **Funky Beeper**



Set the meter (**M6**) to the **50mA** setting, and set the switcher (**S6**) to the left position. You should hear a beeping sound from the melody IC (**U32**) as the meter measures the current. Spin the fan in either direction with your finger to change the sound. Push the press switch (**S2**) to spin the fan.

WELCOME TO THE WORLD OF SNAP CIRCUITS®

Build hundreds of exciting projects, or create your very own circuits! With over 30 kits there's hours of Learning Fun® guaranteed.

- SNAP CIRCUITS® makes learning electronics easy and fun!
- Build existing projects - flying saucers, radios, alarms & more!
- Great for schools, STEM programs, homeschool or everyday fun.
- Parts snap together with ease. Project guide with each kit.

#FUTUREENGINEER
DEVELOPING THE INNOVATORS OF THE FUTURE
#SNAPCIRCUITS

STEM AUTHENTICATED EDUCATIONAL PRODUCT

ELENCO® Learn by doing.

@snapcircuits | elenco.com