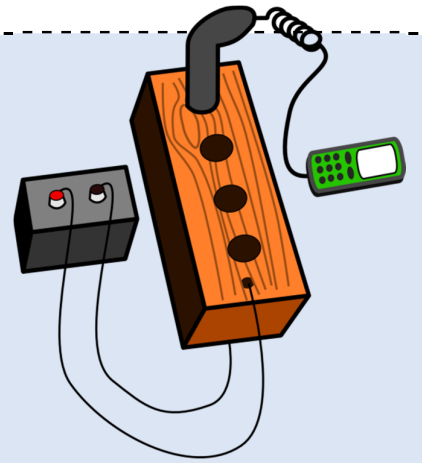
IDIN Build-it: Battery-powered wood block phone charger



GOALS:

- Participants know how to build a cell phone charger powered by a car/motorcycle battery
- Participants feel more comfortable with sawing, nailing, making hol es in wood; cutting sheet metal; wiring up a basic circuit.

TIME:

3.25 hours (for groups of 2-3)

PREPARATION:

- ☐ Collect materials and tools
- ☐ Charge the car or motorcycle battery
- ☐ Make a battery charger yourself to discover what participants might find difficult
- ☐ Review and/or print Build-It: Battery-powered phone charger instructions
- ☐ Test the battery and travel charger
- ☐ Make sure to have a piece of wood, the exposed battery charger, battery, sheet metal, multimeter, and, if there are enough, a set of tools for your demonstration
- ☐ Organize the tools into sets to be distributed during the introduction
- ☐ (optional) Pre-cut the wire to 1.5' lengths to facilitate distribution

ROOM SET-UP:

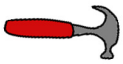
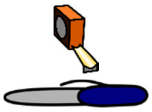
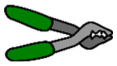
Sitting on a tarp on the ground worked well – it was clean and had a lot of space free for people to walk, sit, and observe. However, be careful to not damage the tarp with the sharp tools!

MATERIALS NEEDED FOR ONE CHARGER:

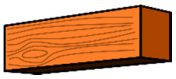
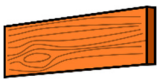
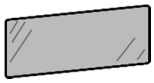
- ☐ Wood - 3"-4" wide, 8"-10" long, 1.5"-2"-thick (Get from 2x4 wood plank)
- ☐ Plywood of the same width and length as the wood (Get from plywood sheet)
- ☐ Sheet metal – 4" wide, 10" long, any thickness that is easy to cut (Get from corrugated roofing sheet)
- ☐ ~25 small nails
- ☐ Wire – 3' (1 m) total length
- ☐ 1 Fuse – rated between 5A and 13A
- ☐ Electrical tape (very little)
- ☐ 1 phone and cell phone travel charger which fits the phone
- ☐ 12V car or motorcycle battery (for testing during a training, one battery can be shared with all chargers)

However, **do not cut the wood, plywood, or metal** to the lengths indicated above, but leave them in their raw form and allow the participants to prepare the materials. The wire can be pre-cut, but not stripped, in order to economize wire usage.

TOOLS

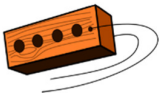
	Wood saw
	Hammer
	Metal snips
	Needle-nose pliers
	Tape measure
	Brace and bits (7/8” and 3/8”)
	Wire strippers

MATERIALS*

Item		Amount	Cost
	1.5” x 3” wood block	~10” long	$0.20
	Plywood	Same size as wood block	$0.10
	Sheet metal	~10” x 4”	$0.20
	Wire	3’ total (about 1 m)	$0.50
	Fuse	1 (between 5A-13A)	$1
	Electrical tape	1’ (about ¼ m)	minimal
	½” Nails	~30	minimal

Total cost = $2

ALL ITEMS NEEDED FOR THE CHARGER

	Wood block charger	$2
	Phone cord	$4
	12V motorcycle battery	$12

System cost = $18

1. *What is a Build-It?* (5 minutes)

A Build-It is a lesson where people make a small technology and learn some workshop skills. Everyone will build together, step by step. As you build the technology, you will learn good techniques for handling metal and wood. Each member will have an opportunity to learn these hands-on skills by using some tools and materials. At the end of the Build-It, you will have had some practice using tools and also have a technology for you to take home.

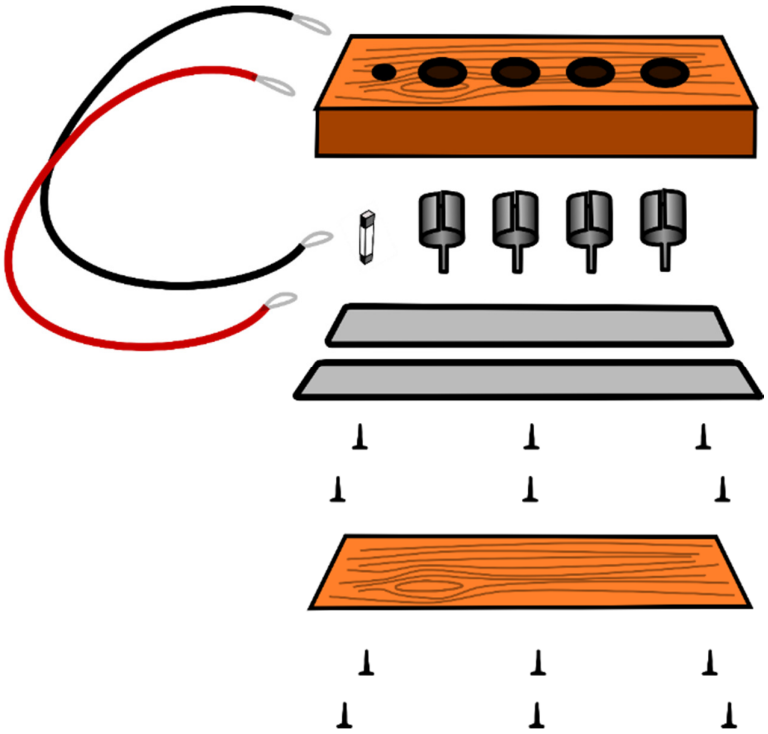
2. *What is a wood block phone charger?* (5 minutes)

DISCUSS THE CURRENT PROCESS OF CHARGING PHONES

- How do people charge their phone now? (possible answers: friend in town, local generator, D-cell batteries in series)
- How much does it cost to charge a phone?
- Where do people go to charge their phones?
- How long does it take someone to charge their phone?

INTRODUCE EACH MAJOR PART: BATTERY, WOOD BLOCK, PLUG-IN CHARGER, AND PHONE.

Identify the main components of the wood block charger (wires, wood, sheet metal, fuse) and inform participants they will be building the wooden section first, then attaching the metal portions of the insides in the second half.



INTRODUCE THE IDEA OF USING A CAR/MOTORCYCLE BATTERY TO CHARGE A CELL PHONE

- The business owner owns a battery and swaps it out with a local motorcycle- or car-owner when the charge gets low.
- In return, the motorcycle- or car-owner could get free phone-charging.
- This is good because it saves people transportation time and costs, creates a local business which keeps money from flowing outside of the community, but instead brings in money from outside of the community.
- The idea came from building on the ideas from villagers in Asampu (central Ghana)

3. Setting up the Build-It (5 minutes)

ENCOURAGE PARTICIPANTS TO:

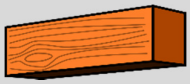
- Ask, "Why?" "Where?" "What?" "How?" at any time during the session
- Share building so that each person in the group can both observe and participate in all activities
- Single-gender groups often work best for allowing all members of the group to participate evenly.
- If there are not enough tools for each team to always have a full set, outline the fact that the tools will be shared. People should let the group know when they are done with the tools in demand.

DIVIDE INTO GROUPS OF 2 OR 3.

4. Preparing the wooden block (45 minutes)

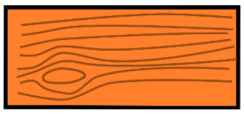
Tools

Materials



Steps

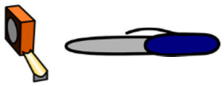
1. Cut a 10” long piece of wood

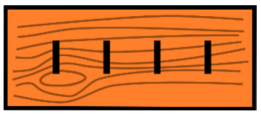


SHOW THE PARTICIPANTS HOW TO PROPERLY MEASURE AND CUT THE 2X4 WOOD PLANK TO 10”.

- Begin by explaining the details of the measuring tape. If there are both imperial and metric units, clarify which you are using and what the different-sized lines mean (1”, ½”, etc.) Then, mark the plank.
- Situate yourself to begin cutting and explain how to use a backwards stroke on the first cut of the saw. You can use your thumb to help guide and steady the saw.
- It may be necessary to have teams share planks of wood and/or saws.
- Walk around to ensure each participant has used the saw.

2. Mark at every 2”

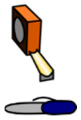


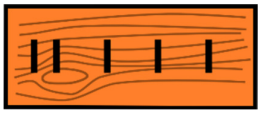


SHOW THE PARTICIPANTS HOW TO MARK THE HOLES FOR THE CHARGERS.

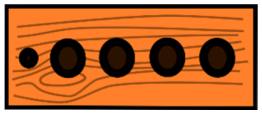
- Mark every 2” and at the first inch (1”, 2”, 4”, 6”, 8” marks) for the charging ports and fuse holder and tell them the dimensions several times.
- Reiterate the dimensions by using the measuring tape as a reference. Continue to demonstrate how to use the measuring tape with precision as you explain the dimensions.
- As you walk around, make sure everyone is using the correct units and marking their wood relatively precisely. The markers are thick and the dimensions for this particular technology are not critical to its functionality, so some error is not detrimental.

3. Mark 1” away from the left edge





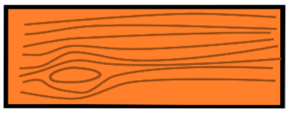
4. Drill the marks from step 2 with 7/8” drill and drill the mark from step 3 with 3/8” drill



SHOW THE PARTICIPANTS HOW TO CUT THE HOLES FOR THE CHARGERS USING THE HAND DRILL.

- The charging ports will be at every 2”, made with the 7/8” bit.
- The fuse holder will be at the first 1” mark.
- Line up the point on the bit with the mark on the wood.
- The hand on top does not move, but should stay directly above where you want the hole – this keeps the hole vertical and smooth.
- The hand drill needs to be pressed, but not very hard – if it is pressed too hard, it will make it more difficult

5. Cut a plywood cover the same size as the wood block



EXPLAIN THAT THEY WILL NEED A PLYWOOD COVER FOR THE BOTTOM OF THE CHARGER.

- The plywood is the same dimensions as the 2x4 wood, so people can simply trace the shape of the block onto the plywood. People who are waiting for the hand drill and bits can make their plywood bottom while they wait for other teams to finish up with the bits.
- The charging ports will be at every 2”, made with the 7/8” bit.

5. *Understanding the basic circuit* *(15 minutes)*

Once everyone is done preparing the block of wood and plywood cover, gather people close so they can see and hear the explanation of how the circuit works.

EXPLAIN THE BASIC CIRCUIT

- People will build more carefully when they understand how the circuit works and why short circuits should be avoided
- Electricity must travel in a circle.
- The electricity begins its journey at the positive end of the battery. It flows through the wire and arrives at the fuse. The fuse has a small wire inside and the electricity flows through it and onto the first metal strip. The electricity then makes its way through the tip of the charger and into the phone. It charges the phone.
- Now, the electricity must return to the battery. It travels to the metal strips on the side of the car charger. These strips touch the metal cylinders inside of the charger holes. These metal cylinders are attached to the second metal strip. The electricity moves through the metal strip and into the wire. It travels through the wire and into the negative terminal of the battery, finishing its circular journey!

FUSE DETAILS

- The fuse is there to protect the phone. If too much electricity goes through the phone, it will damage it.
- The wire in the fuse is very thin. If there is an accident and a lot of electricity escapes from the battery, the thin wire in the fuse will break. This will break the path the electricity goes on and stop the large amount of electricity from getting to the phone and damaging it.

A MAJOR SOURCE OF ERROR

- The two strips must not touch, or even be close to touching.
- The place where the two strips lay side-by-side and connect to the cylinders which connect to the charger is most often done incorrectly
- The tab should only touch the strip it goes under, but must not touch or be close to touching the other strip.
- The cylinders must not touch, or even be close to touching the other strip.

POTENTIAL WAYS FOR THE CIRCUIT/CIRCLE TO BREAK

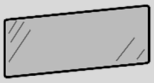
- (These details are not necessary to share, but for your reference)
- Short circuit – the circuit is closed before it is supposed to be. This could damage the battery and will destroy the fuse.
- Loose connection – the circuit has simply been broken. The most likely places of failure are at both ends of the fuse.
- Broken charger – check against this by checking for a complete circuit with the multimeter.
- Dead battery – check the voltage of the battery to ensure it is charged
  ** Above 12.7 V = 100% charged*
  ** 12.4 V = 75% charged*
  ** 12.2 V = 50% charged*
  ** 12.0 V = 25% charged*
  ** Below 11.9 V = fully discharged battery, and the battery may be damage*
  ** Below 10.5 V = battery is severely damaged and needs to be replaced*

6. *Preparing the metal strips* (45 minutes)

There are two components to the electric circuit: sheet metal and wiring. You will start with the sheet metal first.

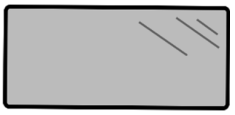
Tools

Materials



Steps:

1. Cut a 4" x 10" piece of sheet metal and pound out any bends

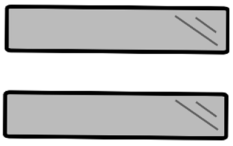


EACH GROUP WILL CUT THEIR PIECE OF SHEET METAL FROM THE LARGE ROOFING SHEET.

- Have people cut a piece of 4" x 10" corrugated roofing sheet. It is easier to cut the piece so that there are many, short corrugations rather than a couple long corrugations.
- Pound out the corrugations. The piece will grow about 10% along the corrugations when flattened; a bit of extra sheet metal is fine.

2. Cut it in half (along the length)

   You will have two 2" x 10" pieces

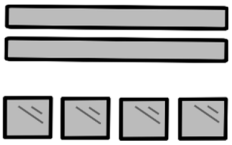


DEMONSTRATE HOW TO CUT THE LONG STRIPS

- Measure and cut two 2" x 10" strips from the sheet in order to show good measuring technique as well as proper handling of the snips.
- Many people find snips to be cumbersome, so explain that pushing the material all the way back into the mouth of the snips when you have them open all the way will allow you to put more force into cutting the metal and make the cutting easier to control. Many people try to cut using the tips of the snips only, which makes cutting very difficult

3. Cut one strip in half lengthwise again. Cut the other half in quarters

   You will have two 1" x 10" pieces and four 2" x 2.5" pieces



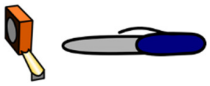
CUT ONE OF THE STRIPS IN HALF, INTO TWO 1" STRIPS.

- Strips should be as straight as possible, though typically people do a good job ensuring it is straight.

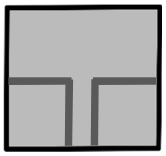
CUT THE OTHER STRIP INTO SMALL RECTANGLES TO BE MADE INTO CYLINDRICAL INSERTS

- There is a 2" x 10" strip left. With a marker, make a line across the top of the strip to indicate this is the top. This will help people distinguish between the 2" and 2-½" sides, which are difficult to keep track of otherwise. **(2½" edges will be the ones left with the line)**
- Beginning from one side, measure 2-½" and mark and cut until you have four pieces.

4. Mark a 1" square in each of two corners which share a side on the 2" x 2.5" piece



2" side



2.5" side

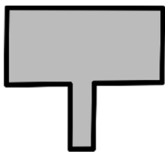
TAKE ONE OF THE CYLINDRICAL INSERT RECTANGLES AND MAKE IT A TABBED AND BENT INSERT.

If the explanation above doesn't make sense, try this one:

- With the marked 2-½" side on the top, measure 1" down the 2" side (which are on the right and left sides).
- Make a horizontal line between these dots, leaving a ¼" gap (or smaller) in the middle of the line. This is where the tab will stem from. We found that, oftentimes, a person will cut wherever there is a line; even if it doesn't make sense to cut the tab off, they may do so if the line is there.
- Mark where the tab should be cut out with two vertical lines which start where the horizontal lines end at the gap.
- Cut on these lines to get the T-shaped piece.

5. Cut out the piece

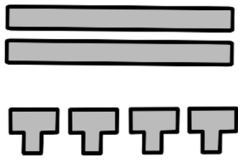
   Repeat step 4 for all four 2" x 2.5" pieces



6. Trim 1″ off both of the 1″ x 10″ strips

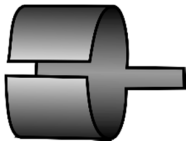
The strips should be 1” shorter than the plank so that the strips are within the edges of the wood (½” on each side). Typically, this means having a 1” x 9” strip. This is to safe-guard against the edges of the terminal being exposed, putting it at risk for short-circuit.

7. You will have two 1″ x 9″ pieces and four cut 2″ x 2.5″ pieces



8. Bend the tabs of each of the 2″ x 2.5″ pieces to be very smooth and round

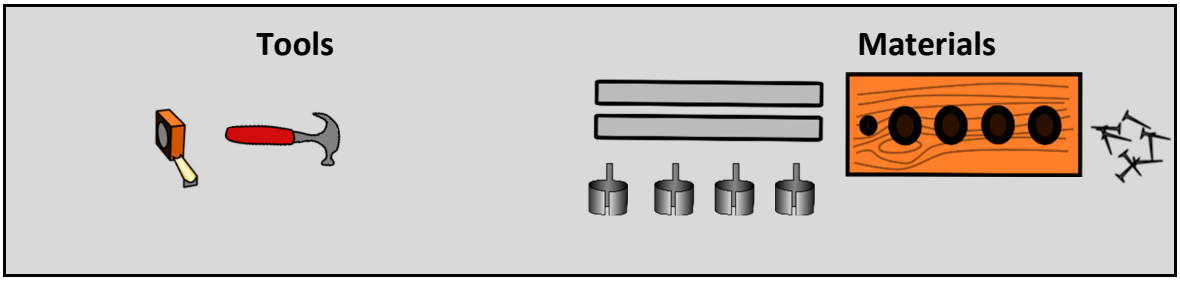
   It is best to be patient and bend a little bit at a time with needle-nose pliers



- Using needle-nose pliers, begin to gently bend the cylinder into shape. If done aggressively, the bends will be too sharp and will not allow the charger to be inserted smoothly.
- Reiterate that it is important to be patient and go slowly to get it smooth!!
- The cylinders should be as smooth as possible and be slightly larger than the charging port hole. The springy nature of the cylinder will allow them to press tight against the sides of the hole.

7. *Attaching the metal pieces* (20 minutes)

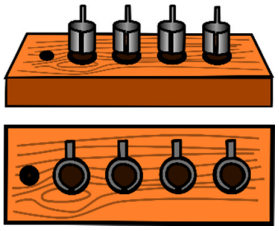
Remember that **these two 1" strips should never touch**; one strip is the positive terminal (attaching to the fuse) and the other is the negative (attaching to the tabbed cylindrical inserts). If they touch, the system will be short circuited, the battery could be damaged, and the charger will not work.



Steps

1. Insert all cylindrical inserts into the block

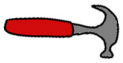
   All tabs should be on the same side. Make sure the cylindrical inserts wrap most of the way around the hole

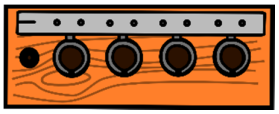


- About a third of the way up away from the main cylinder body, bend the tab.
- Insert the cylinder into the charging port hole until the tab is flat against the wood.
- The pre-bent tab ensures the bottom of the cylinder body is kept safely away from the opposite terminal.

2. Nail the negative terminal to secure the cylindrical inserts

   Don't nail through the tabs – the thin nails will bend! Instead, secure the negative terminal by nailing on either side of the tabs



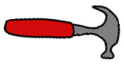


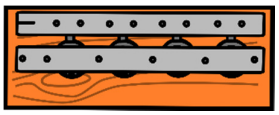
ATTACH THE 1" STRIP - NEGATIVE TERMINAL

- Lay the 1" strip on top of the cylinder's tabs.
- The strip should not be flush with or overhanging the edge. It also should not be too close to the large hole where the tabbed cylinder is. Otherwise, the metal is exposed and could create a short circuit.
- Secure the strip by nailing it to the wood on either side of the tab that lies underneath. **Do not nail through the strip and tab together** (2 pieces of sheet metal) – nail on the immediate left and right side of the tabs so you are only nailing through the strip (1 piece of sheet metal). Do **not** nail down the ends of the terminal close to the short edges of the wood block. This part will eventually be connected to the wire.

3. Nail on the positive terminal to cover the holes

   Don't nail through the holes!





ATTACH THE 1" STRIP - POSITIVE TERMINAL

- Arrange and trim the strip so that **1)** the strip covers over half of the large holes (the charger tip must contact this terminal) **2)** the strip completely covers the small hole (the fuse must be securely held in place) **3)** the strip does not come close to touching the other terminal (this would cause a short circuit and a non-functioning device)
- Nail the strip in place (3-5 nails will be enough) – but be careful not to nail above a hole!

PREPARE TO ATTACH THE WIRES TO THE TERMINALS

- On the end of the negative terminal (which is connected to the cylindrical tabs), you will attach a wire. On the end that is closer to the fuse, snip a 1" slot into the strip, at about halfway in the middle.

There are a couple of different ways the wires will come in.

- **Single wire**. If you have single wire, give each participant a 3' piece to cut into two 1.5' lengths.
- **Double- or triple-core wire**. This means that there are two or three individual wires in the same length of wire. These wires are very common for doing homes' electric wiring. If you have double- or triple-core wire, cut into 3' pieces and pull all of the wires apart. **Make sure the wires are individually insulated** and can easily be separated from each other. Some may have the wires' insulation directly attached next to each other; starting at one end, carefully pull them apart so as to not damage the insulation protecting the wire inside. Some may be inside an additional insulation which holds all three wires loose inside; remove the additional insulation which holds all the wires together and you will be left with the individual wires.

8. *Wiring the circuit* *(30 minutes)*

Tools

Materials

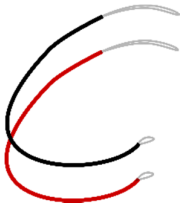
Steps

1. Cut the wire in half with the wire strippers (or if it is a dual-core wire, pull the wire apart)

   The goal is to have two pieces of wire, each about 1½' long

2. Strip about 4" off one end of each wire. Strip 1" off the other end.

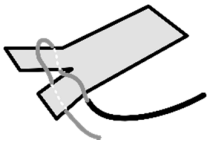
   You should have a little more than 1' left not stripped



Each wire should have one side that is stripped 4" and the other side with 1" stripped.

3. Wrap the stripped end of one wire around the slit cut in the negative terminal

   Repeat the wrapping shown in the picture 3 more times. Nail the tabs down onto the board

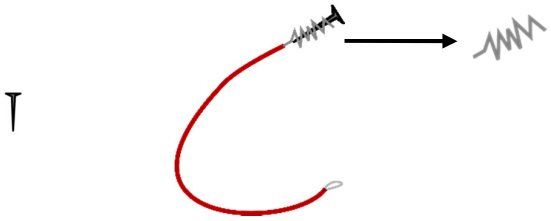


ATTACH THE WIRE - NEGATIVE TERMINAL

- With the first wire, wrap the 4” stripped end through the slit and around the tabs of the positive terminal (attached to the cylinders) in a figure eight pattern several times. Nail the tabs down to secure the figure eight wrapping. This helps ensure the wire does not slip off the negative terminal

4. Wrap the stripped end of the other wire around a nail to create a sort of spring out of the wire

   Cut the spring off of the end and put it into the small hole for the fuse



5. Strip the wire 1” more and attach it to the fuse

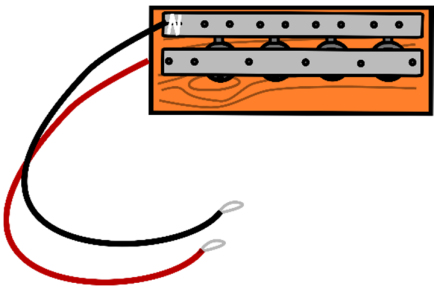
   Tape the wire onto the fuse cap with electrical tape.

ATTACH THE WIRE AND THE FUSE - POSITIVE TERMINAL

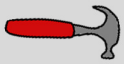
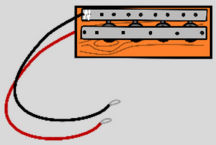
- With the second wire, wrap the stripped end around a medium-to-large nail to create a “spring” out of the wire. The “spring” should fit inside of the fuse hole. Cut the “spring” off with wire strippers. Strip 1” of the insulation off the end of this wire again.
- Put the “spring” into the hole where the fuse will go.
- Wrap the 1” end of the wire around the metal top of the fuse and use electrical tape to securely attach the fuse to the wire. It is helpful to wrap the electrical tape in the same direction around the fuse that you wrapped the wire around the fuse.
- Plug the wire-and-fuse group into the fuse hole.

6. Insert the fuse into the small fuse hole.

   Add layers of tape around the wire-fuse connection to make sure the fuse sits snugly, but not too much to keep it from sliding fully into the hole



9. Finishing and checking the charger (15 minutes)

Tools	Materials
 (if possible, multimeter)	

Steps

1. Ensure the charger is a complete circuit but ensure it does not have short circuits

CHECK FOR A COMPLETE CIRCUIT

- Turn the multimeter to "circuit" mode, where the multimeter beeps if it is connected to a closed circuit.
- Attach the wires coming from each side to each other; touch the multimeter on the cylinder (negative terminal) and on the metal at the bottom of the hole (positive terminal). If the multimeter beeps, there is a complete circuit (see "Troubleshoot for short circuits" below). If the multimeter does NOT beep, the circuit is not complete and something is disconnected (see "Troubleshoot for disconnected circuits")

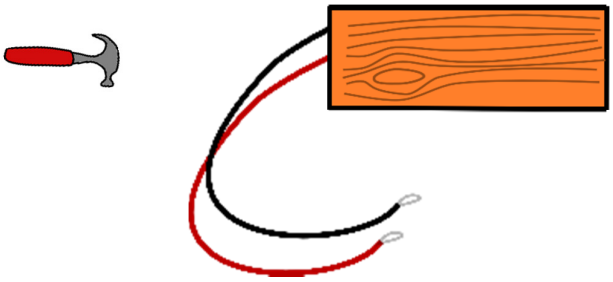
TROUBLESHOOT FOR SHORT CIRCUITS (THESE ARE BAD!)

- Disconnect the wires which connect to the battery separate while checking for short circuits. At this point, the positive terminal and the negative terminal should be completely separate. Touch the positive terminal and the negative terminal with the multimeter; if it beeps, there is a short circuit! Try to find where the two terminals touch by touching different parts of each terminal.
- The most common mistake is when the cylinders from the negative terminal touch the positive terminal.

TROUBLESHOOT FOR DISCONNECTED CIRCUITS (THESE ARE BAD!)

- Touch the multimeter across each connection to ensure the connection is secure
- The most common mistake is a misconnection at each end of the fuse (The taping at one end may have moved the wire off of the metal tip of the fuse OR the tape around the fuse is too fat and is preventing the bottom of the fuse from touching the metal spring which is touching the positive terminal strip.

2. Nail on the plywood cover



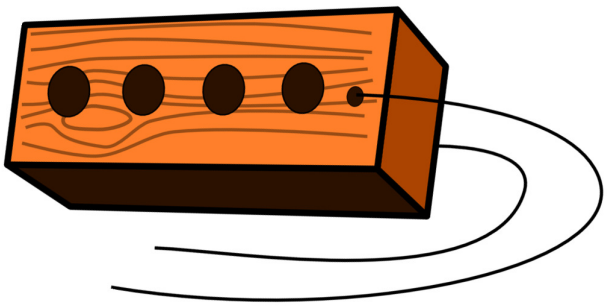
ATTACH THE PLYWOOD COVER

- Once the circuitry is checked to be correct, attach the plywood cover to protect the electrical work. Be careful when you are nailing the plywood to not nail onto another nail on the layer below.

10. Wrap up (10 minutes)

Congratulate them on a job well-done!

Ask if there are any questions about the technology.



Appendix:
How to choose the right battery and a good car plugin

Choose a 12V battery

This charger design uses a 12V battery because the car plugin charger's circuitry is designed to use the 12V coming from a car battery.

Car/motorcycle batteries come in different voltages – 6V and 12V are the most common. If 6V was used, it would not provide enough voltage to work; if something more than 12V was used, it would provide too much power and damage the charger and possibly damage the phone.

Choose a "solar battery" (also called "deep cycle battery")

Deep cycle batteries are designed to provide less power over a long period of time; this allows the battery to be used for a longer time between charges.

Solar batteries look very similar to car batteries and use the same chemicals, but there is one difference; the plates inside of the battery are solid and thicker. Typical solar batteries can be safely discharged to 50% capacity, then need to be recharged (discharging the battery to 20% is acceptable, but slightly reduces the life of the battery). Discharging to 40%-80% capacity is best. If this battery were used heavily for phone charging, it is estimated it would last about 6 years.

Most batteries will be labelled deep cycle battery or solar battery, but you can check the "Depth of Discharge" rating on the battery (DOD). A DOD of 80% means that the battery can be discharged down to 20% of its original charge; this would be a deep cycle battery.

Standard lead-acid car batteries are designed to provide a lot of power very quickly and to be *immediately* recharged; if the battery is used for a long time between charges, the battery will be damaged.

Holes in the metal plates inside the battery help create a sharp spike of power used for starting a car; once the car is started, the alternator immediately recharges the battery to full capacity. Sometimes these batteries are called "Starting batteries." Typical car batteries can be safely discharged to 80% of its capacity, then need to be recharged (20% depth of discharge (DOD)). If this battery were used heavily for phone charging, it is estimated it would last about 6 months.

Both of these batteries will charge phones, but the solar battery will be able to be discharged more before it needs to be recharged. This means more phones can be charged before the battery needs recharging.

Choose a battery with enough storage capacity

The storage capacity of the battery is measured in *Ah* (Amp-Hours). A 36-Ah battery has half the capacity, so lasts half as long, at a 72-Ah battery. The physical size of the battery is often related to its storage capacity.

Choose a good charger with a microchip

Check with a voltmeter: a good charger will briefly show a resistance reading, then revert back to a blank screen.

Phone chargers have to control the amount of current that gets delivered to the phone battery.

Good chargers control the power delivered to the phone with a **microchip** (and it saves energy!). The microchip is smart, so does some switching to avoid wasting electricity.

> *With a voltmeter, measure the resistance between the side metal piece and the metal tip of the car charger; it will show a resistance reading, then go to zero or a blank screen. When you attach the voltmeter to a good charger, it initially has a resistance to measure but somehow triggers the switching circuit, and the resistance reading disappears.*

Cheap chargers control the amount of current delivered to the phone with a large **resistor**; power is drawn and the resistor wastes the excess energy into heat.

> *With a voltmeter, measure the resistance between the side metal piece and the metal tip of the car charger; it will show a constant resistance or none at all.*

Of course, when in doubt, you could buy a charger and carefully split it open to check before you buy more.

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The battery powered wood block charger featured here was designed by participants of the International Development Design Summit, and has been adapted by IDIN contributors. The document was created by Benji Moncivaiz in collaboration with IDIN representatives at UC-Davis and Olin College.