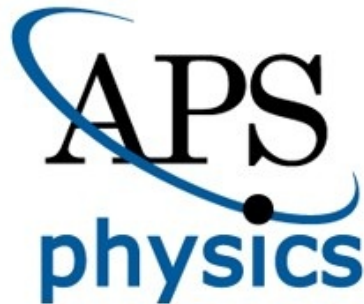


The Badger Jets Solder Squad

Mission: Teach middle school students to solder

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University of Wisconsin—Madison*



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Why middle school?

Students are young enough to explore (haven't decided "science is not for me") but old enough to be able to stay on task.

Why soldering?

"Gateway" skill for scientists, engineers, technicians.

The Method

Each student solders three simple circuits* (described below), completes a quiz, and receives a Certificate of Completion.

*** Students take home the circuits they have made.**

The Safety Instructions

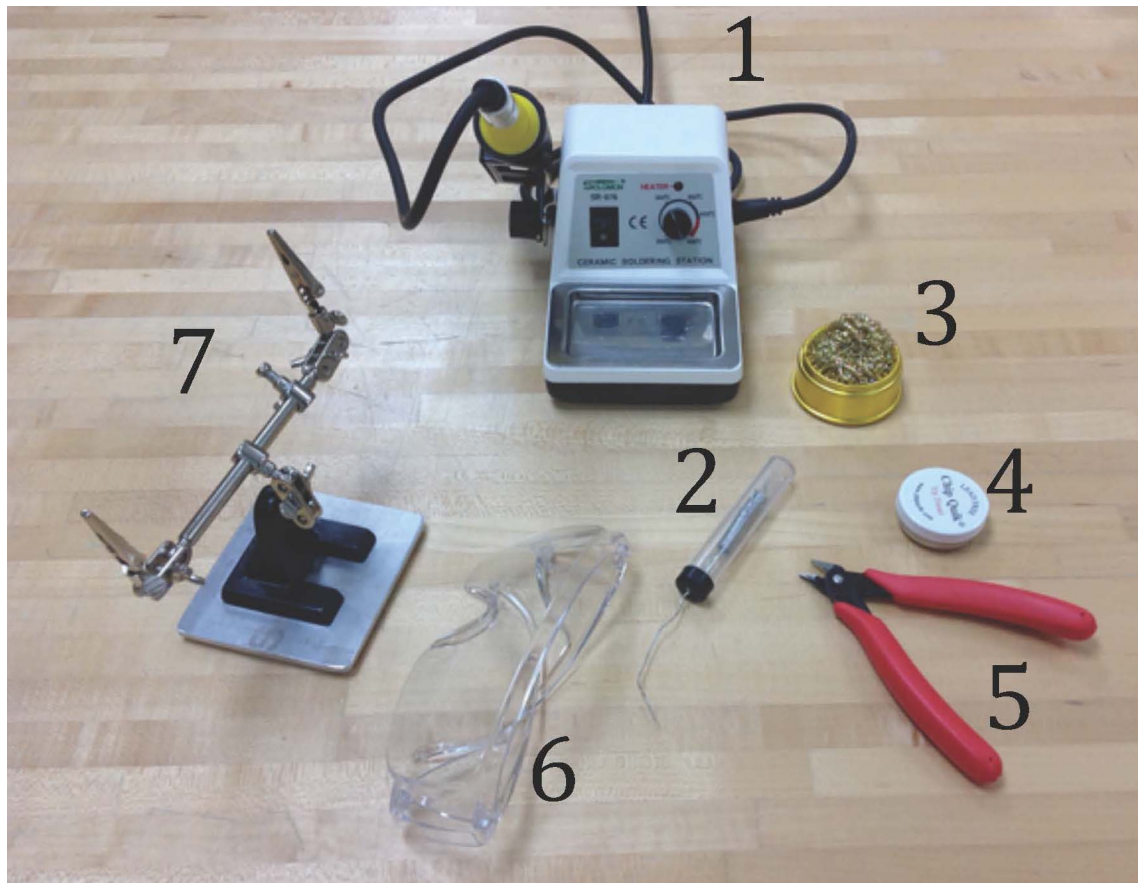
- 1. Soldering irons get hot!**
- 2. Wear safety glasses.**
- 3. Wash hands before you leave.**

Badger Jets Solder Squad

BADGER JETS
SOLDER SQUAD



The Materials:



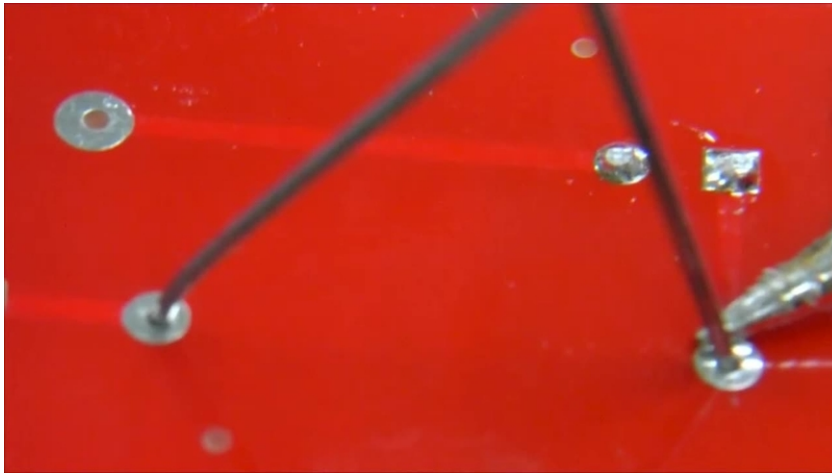
1. Variable-Temperature Soldering Iron
2. Lead-free solder
3. Tip cleaner (brass shavings)
4. Tip tinner (solder/flux)
5. Diagonal cutters
6. Safety glasses
7. "Third Hands"

The Materials: Details

1. **Choice of soldering iron: Avoid cheap "pencil" soldering irons without regulated tip temperature. In the hands of beginners, the tips oxidize rapidly due to high temperatures.**
2. **Choice of solder:**
 - Avoid leaded solder due to negative associations of lead. We use 96.3% Sn/0.7% Cu/3% Ag solder.
 - Use solder with a comparatively large amount of flux. We have obtained good results with solder containing 2% IPC/J-STD-004 ROM1 flux (We use Multicore TM 733001 solder which we buy from Digikey).
3. **Tip cleaner: Brass shavings for regular mechanical cleaning of tip.**
4. **Tin tinner: "Chip-Quik Lead-free Tip Tinner"=mixture of Tin/Copper/Ammonium Phosphate Monobasic, for regular tinning of tip.**
5. **Diagonal cutters: for trimming component leads.**
6. **Safety glasses: Mandatory for all students.**
7. **"Third-hands": Mounted by us on metal base to improve stability.**

Not shown: we keep a bottle of Nokorode (contains zinc chloride and ammonium chloride) on hand so we can rapidly clean soldering iron tips that get oxidized. We don't let the students use it. We also keep some desoldering braid handy, so that we can desolder parts for students.

The Technical Instructions



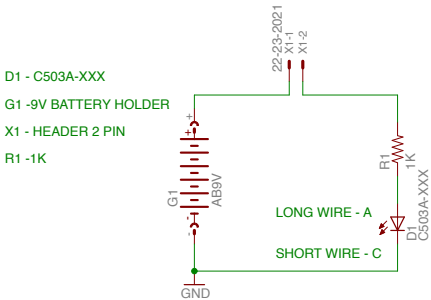
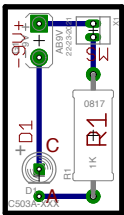
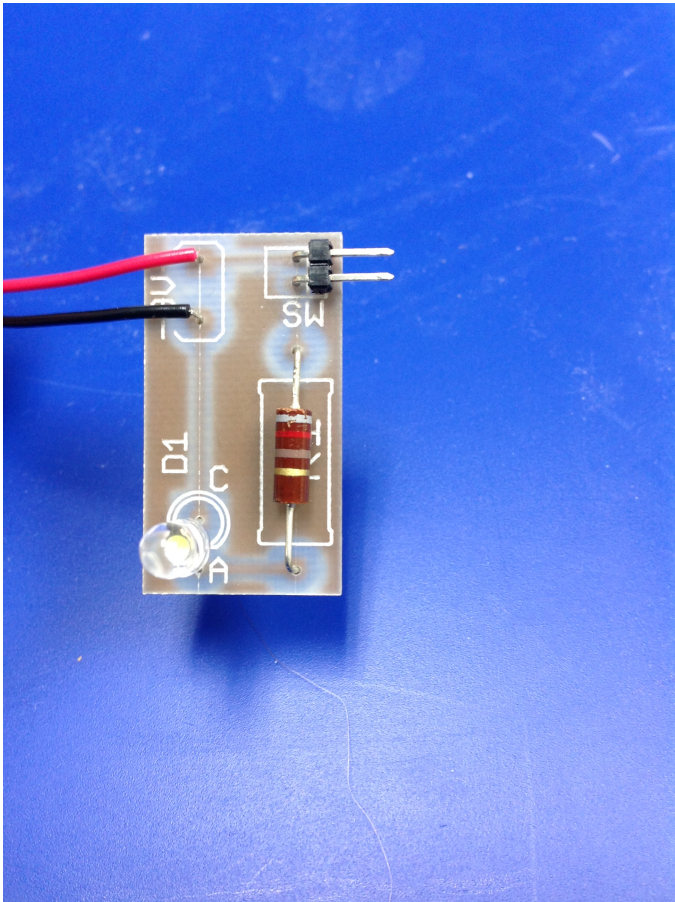
1. Place tip as close to pad and lead as possible.
2. Wait three to five seconds.
3. Add solder.

The solder joint you have just made should look like a Hershey's TM Kiss.

https://mediaspace.wisc.edu/media/Badger+Jets+Soldering+Video/0_wd6lh87a

Keep your tip shiny!

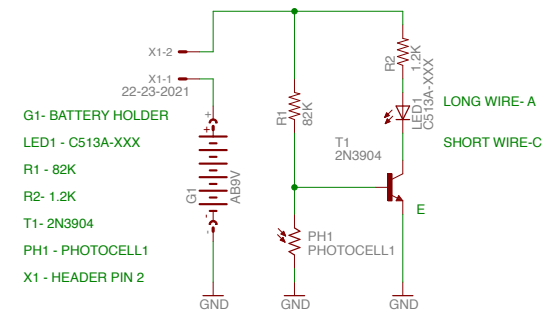
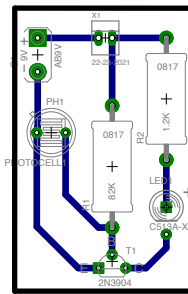
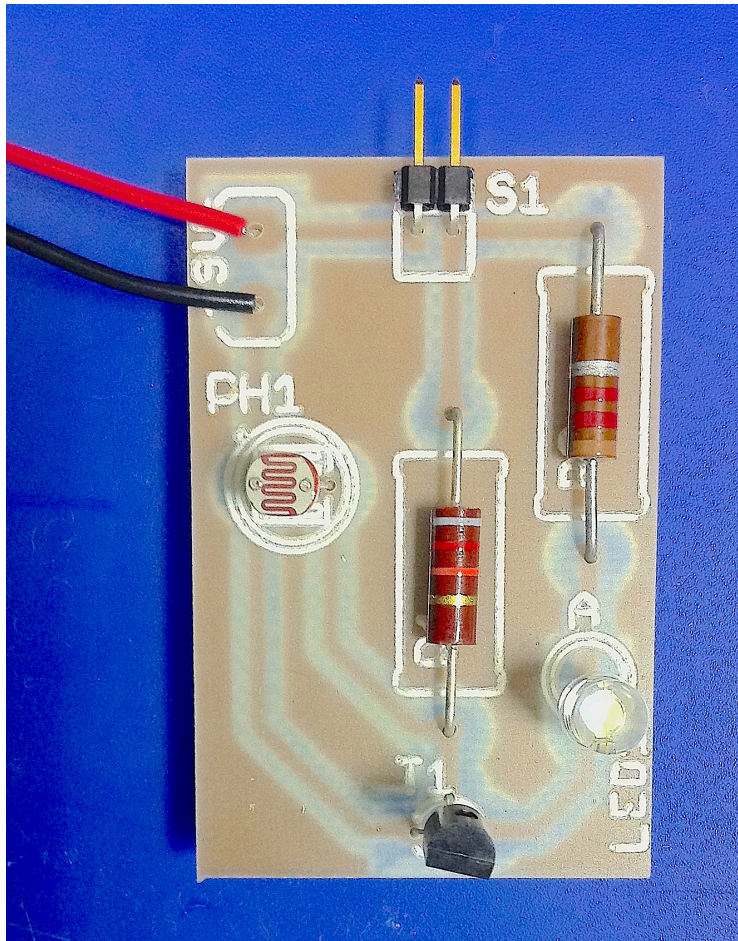
Badger Jets: Circuit 1 "1-pixel LED TV"



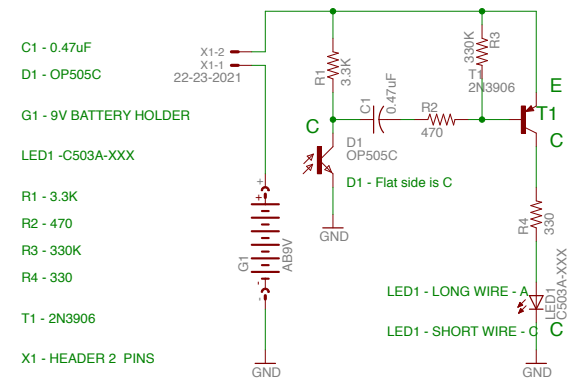
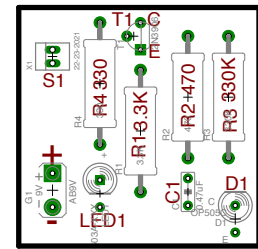
Circuit 1: 1-pixel LED TV

Quantity	Supplier	Part No.	Diagram	Description	Price/Each (USD \$)
1	Newark	22C4351	9V	Keystone 233 Battery Strap, 9V, Wire Lead	0.377
1	Newark	32M6606	SW	Molex 22-28-8020 Board-Board Connector Header, 2way, 1row	0.216
1	Newark	97F9685		FCI 71363-102 Jumper, 2way, 2.54 mm	0.203
1	Newark	04R6682	D1	CREE C513A-WSN-CV0Y0151 LED, COOL WHITE, T-1 3/4 (5MM), 4CD	0.236
1	Newark	81F157		Alkaline ZN/MNO2 Battery, 9V	2.2
1	Digikey	OF821JE-ND	R1	RES 820 Ohm 1/2W 5% Axial	0.652

Badger Jets: Circuit 2 "Night-light"



Quantity	Supplier	Part No.	Description	Price/Each (USD \$)
1	Newark	22C4351	9V	0.377
1	Newark	32M6606	X1	0.216
1	Newark	97F9685	FCI 71363-102 Jumper, 2way, 2.54 mm	0.203
1	Newark	04R6682	LED1	0.236
1	Newark	08N8111	T1	0.125
1	Newark	81F157	Alkaline ZN/MNO2 Battery, 9V	2.2
1	Digikey	OF823JE-ND	R1	0.652
1	Digikey	OF122JE-ND	R2	0.652
1	Digikey	PDV-P8103-ND	PH1	0.65

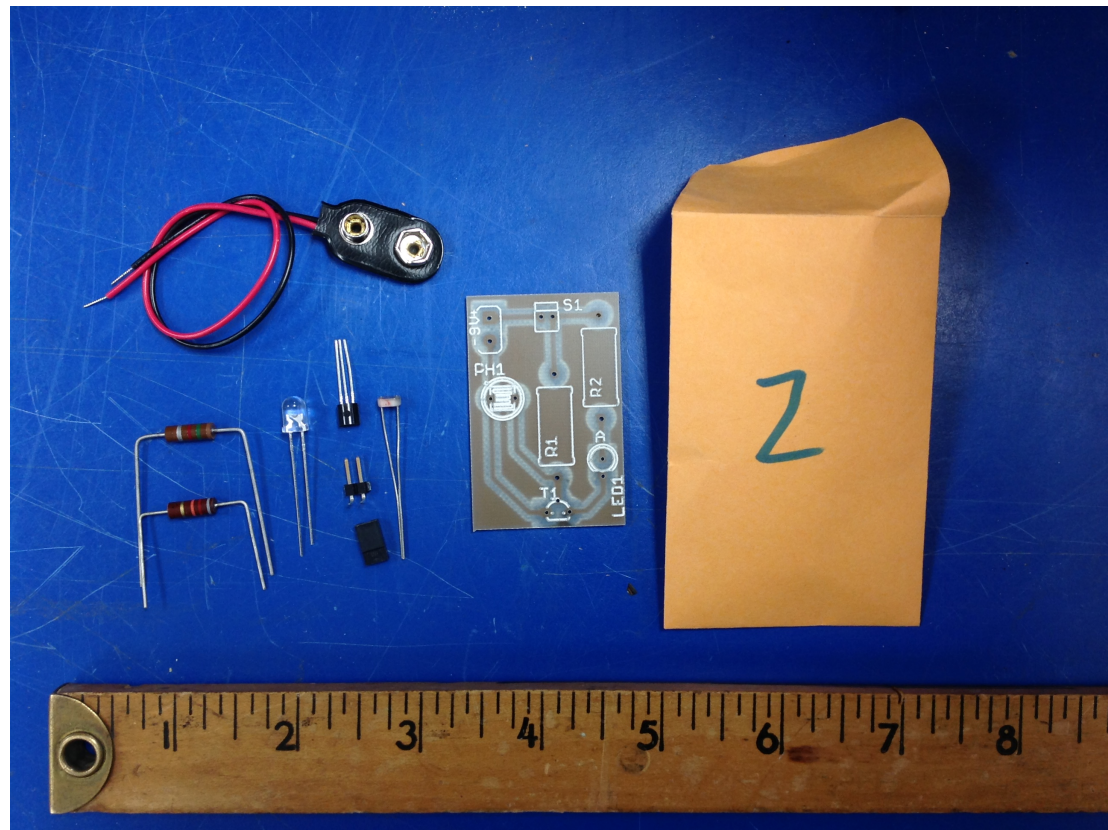


Quantity	Supplier	Part No.	Description	Price/Each (USD \$)
1	Newark	22C4351	9V Keystone 233 Battery Strap, 9V, Wire Lead	0.377
1	Newark	32M6606	S1 Molex 22-28-8020 Board-Board Connector Header, 2way, 1row	0.216
1	Newark	97F9685	FCI 71363-102 Jumper, 2way, 2.54 mm	0.203
1	Newark	04R6682	LED1 CREE C513A-WSN-CV0Y0151 LED, COOL WHITE, T-1 3/4 (5MM), 4CD	0.236
1	Newark	05R0383	T1 Fairchild Semiconductor 2N3906TFR Transistor, PNP, -40V, TO-92	0.169
1	Newark	32R8868	C1 PANASONIC ECQ-V1H474JL CAPACITOR POLY FILM, 0.47UF, 50V, 5%, RADIAL	0.235
1	Newark	08F3008	D1 OPTEK TECHNOLOGY OP505C OPTICAL SENSOR PHOTOTRANSISTOR	0.443
1	Newark	81F157	Alkaline ZN/MNO2 Battery, 9V	2.2
1	Digikey	OF332JE-ND	R1 RES 3.3K Ohm 1/2W 5% Axial	0.652
1	Digikey	OF471JE-ND	R2 RES 470 Ohm 1/2W 5% Axial	0.652
1	Digikey	OF334JE-ND	R3 RES 330K Ohm 1/2W 5% Axial	0.652
1	Digikey	OF331JE-ND	R4 RES 330 Ohm 1/2W 5% Axial	0.652

15.882

Giving Parts to Students: The Envelopes

In order to handle large student-to-teacher ratios: when a student is ready to start a circuit, we give the student all the necessary parts in an envelope. This seems to maximize the likelihood the student completes the circuit without help.

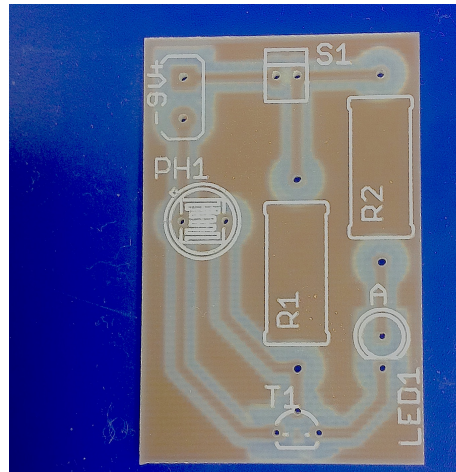


Left: Parts for circuit 2. Right: envelope in which parts are given to student.

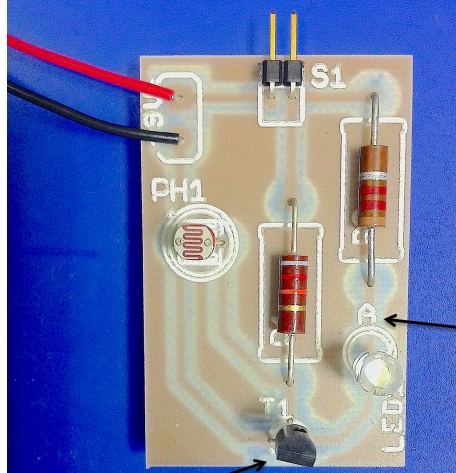
Giving Instructions to Students: The Pictures

Circuit 2

Before:



After:



LED1
long
lead
goes
in A

Flat side of T1 faces down

Each student is given a one-page laminated handout showing "before" and "after" pictures of the circuit board (right: handout for circuit 2).

The handout seems to prevent the most common problems that arise (for circuit 2, putting in LED backwards, or putting in transistor upside down).

Students learn to distinguish between 2 resistors based on the pattern of colored bands.

Keeping Track of Students: The Name Cards



We make a name card for each student. It sits on the table next to the work. We check them off when they complete a circuit or the quiz.

Badger Jets: The Quiz

one sheet of paper, double-sided

Front side

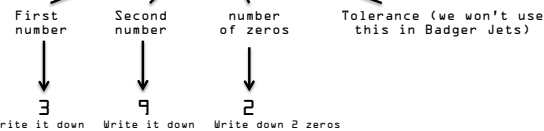
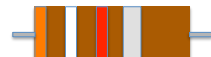


Resistor Color Codes



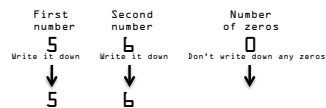
The colored bands tell you what its resistance is:

black	brown	red	orange	yellow	green	blue	violet	gray	white
0	1	2	3	4	5	6	7	8	9



The resistance of this resistor is: 3 9 00 = 3900 Ohms (resistance is measured in "Ohms")

Example



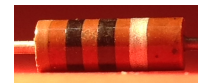
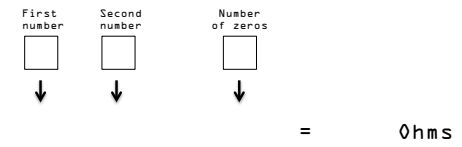
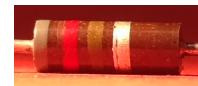
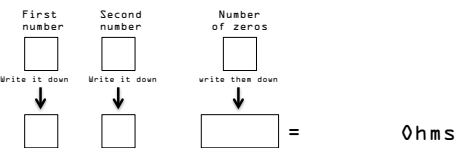
= 56 0hms

Back side

Name _____

Quiz

black	brown	red	orange	yellow	green	blue	violet	gray	white
0	1	2	3	4	5	6	7	8	9



= Ohms

The Certificate

**Given to students who make three (functioning) circuits, and complete quiz.
Printed on the fanciest paper available.**



The Meeting Places

We have done six iterations of BJSS, in six different meeting places:

- **Church basement**
- **Science classroom in local middle school**
- **Art classroom in local middle school**
- **All-purpose room in community center**
- **Table in hallway at science fair**
- **Lab room in UW physics building**

The lesson:

Pack everything you'll need, and always look for ways to decrease setup time.

Thanks to:

Ozanne Anderson, Nehemiah/Fountain of Life Ministry

Shawn Avery, UW—Madison PEOPLE Program

Kia Hunter, UW—Madison PEOPLE Program

Shelton Kingcade, Wright Middle School

Jaimie Schlicher, Kennedy Heights Community Center

Kabao Vang, UW Morgridge Institute for Research

UW—Madison Department of Physics

American Physical Society

**Thanks for your interest in the Badger Jets Solder Squad.
Good luck with your own STEM outreach/pipeline program!**

BADGER JETS
SOLDER SQUAD

