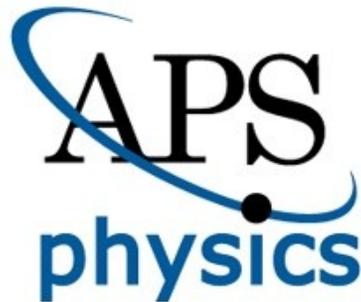


# The Badger Jets Solder Squad

**Mission: Teach middle school students to solder**

*Billy J. Gates, Jr., James C. Reardon  
University of Wisconsin—Madison*



**National Society of Black Physicists annual conference, Baltimore, MD, February 2015**

## **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**

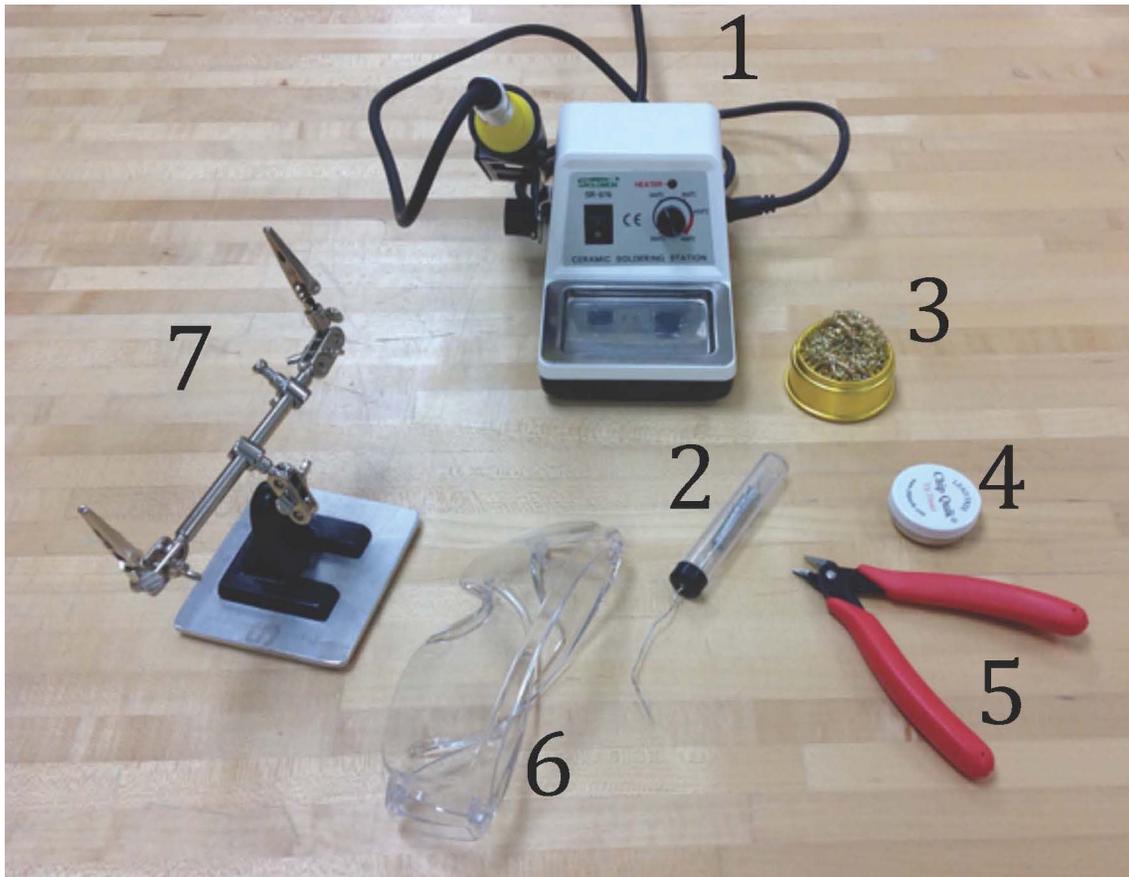
- 1. Soldering irons get hot!**
- 2. Wear safety glasses.**
- 3. Wash hands before you leave.**

# Badger Jets Solder Squad

**BADGER JETS**  
**SOLDER SQUAD**



## The Materials:



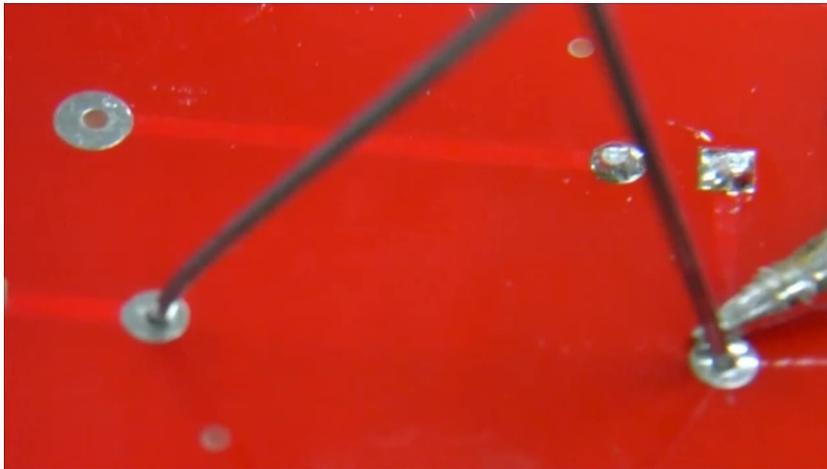
1. Variable-Temperature Soldering Iron
2. Lead-free solder
3. Tip cleaner (brass shavings)
4. Tip tinner (solder/flux)
5. Diagonal cutters
6. Safety glasses
7. "Third Hands"

# 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™ 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



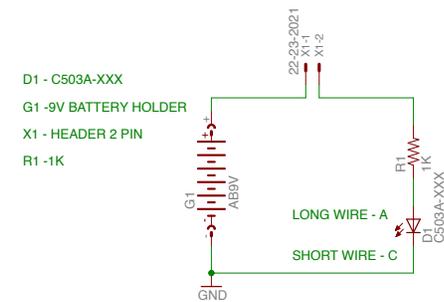
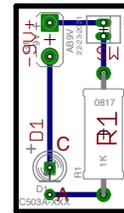
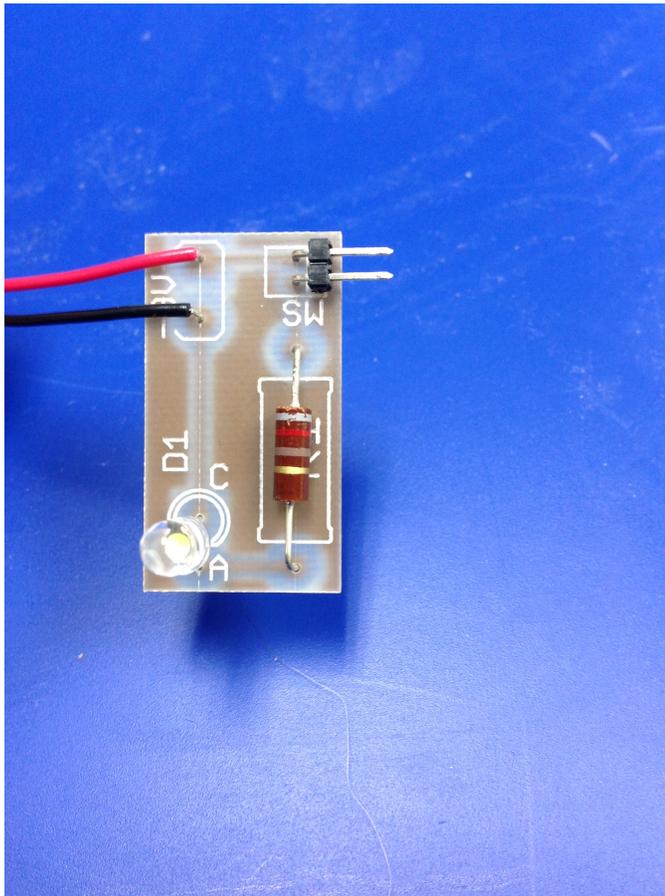
1. Place tip as close to pad and lead as possible.
2. Wait three to five seconds.
3. Add solder.

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

[https://mediaspace.wisc.edu/media/Badger+Jets+Soldering+Video/0\\_wd6lh87a](https://mediaspace.wisc.edu/media/Badger+Jets+Soldering+Video/0_wd6lh87a)

## Keep your tip shiny!

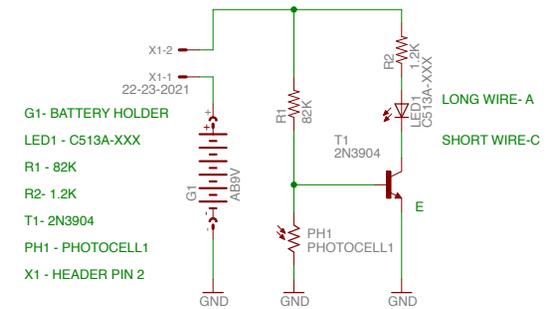
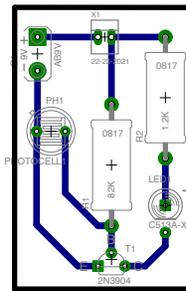
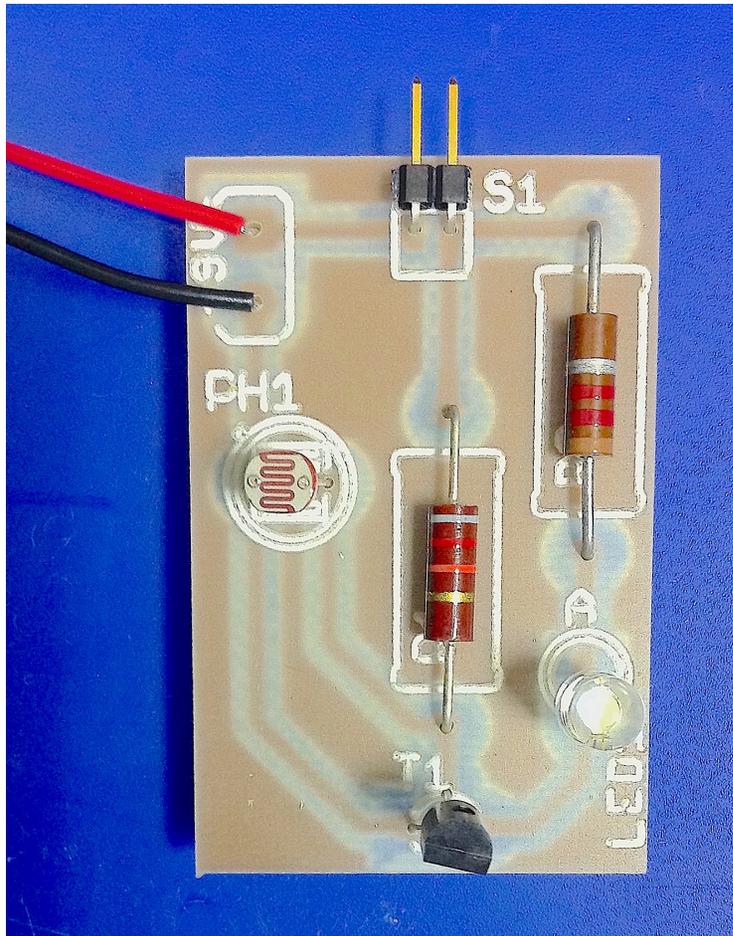
# Badger Jets: Circuit 1 "1-pixel LED TV"



Circuit 1: 1-pixel LED TV

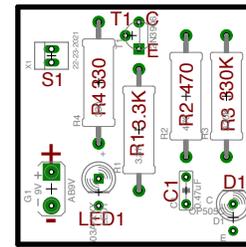
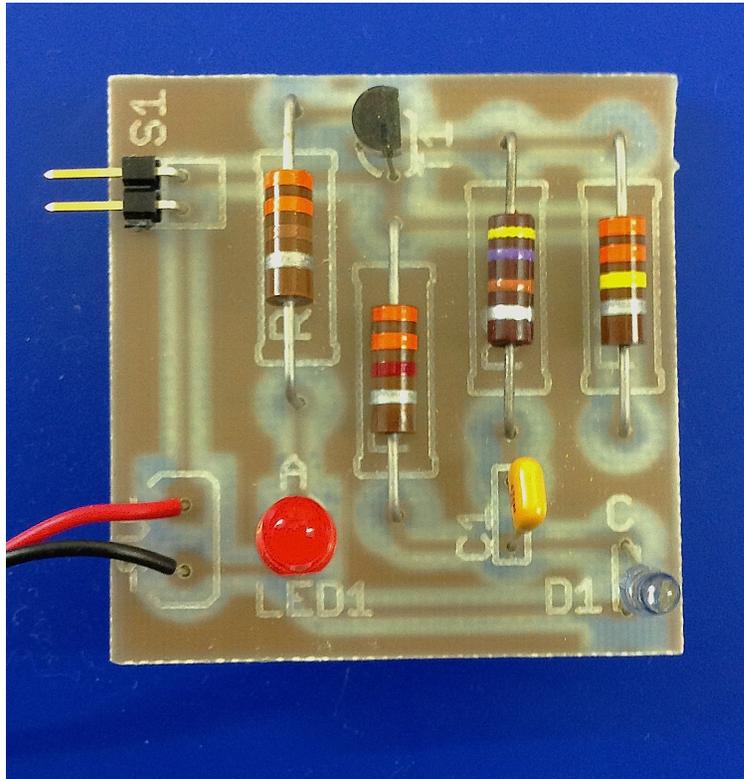
Quantity	Supplier	Part No.	Diagram	Description	Price/Each (USD \$)
1	Newark	22C4351	9V	Keystone 233 Battery Strap, 9V, Wire Lead	0.377
1	Newark	32M6606	SW	Molex 22-28-8020 Board-Board Connector Header, 2way, 1row	0.216
1	Newark	97F9685		FCI 71363-102 Jumper, 2way, 2.54 mm	0.203
1	Newark	04R6682	D1	CREE 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"

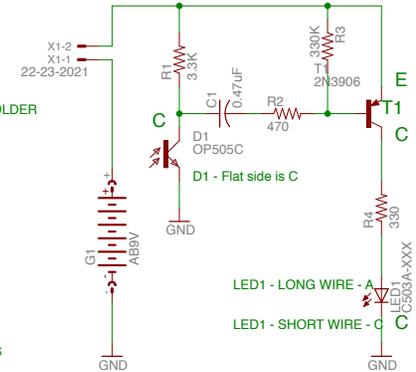


Quantity	Supplier	Part No.	Description	Price/Each (USD \$)
1	Newark	22C4351	Keystone 233 Battery Strap, 9V, Wire Lead	0.377
1	Newark	32M6606	Molex 22-28-8020 Board-Board Connector Header, 2way, 1row	0.216
1	Newark	97F9685	FCI 71363-102 Jumper, 2way, 2.54 mm	0.203
1	Newark	04R6682	CREE C513A-WSN-CV0Y0151 LED, COOL WHITE, T-1 3/4 (5MM), 4CD	0.236
1	Newark	08N8111	Multicomp 2N3904 Bipolar Transistor, NPN, 40V, TO-92	0.125
1	Newark	81F157	Alkaline ZN/MNO2 Battery, 9V	2.2
1	Digikey	0F823JE-ND	RES 82K Ohm 1/2W 5% Axial	0.652
1	Digikey	0F122JE-ND	RES 1.2K Ohm 1/2W 5% Axial	0.652
1	Digikey	PDV-P8103-ND	Photocell 16-33KOhm	0.65

# Badger Jets: Circuit 3 "Remote Checker"



- C1 - 0.47uF
- D1 - OP505C
- G1 - 9V BATTERY HOLDER
- LED1 - C503A-XXX
- R1 - 3.3K
- R2 - 470
- R3 - 330K
- R4 - 330
- T1 - 2N3906
- X1 - HEADER 2 PINS



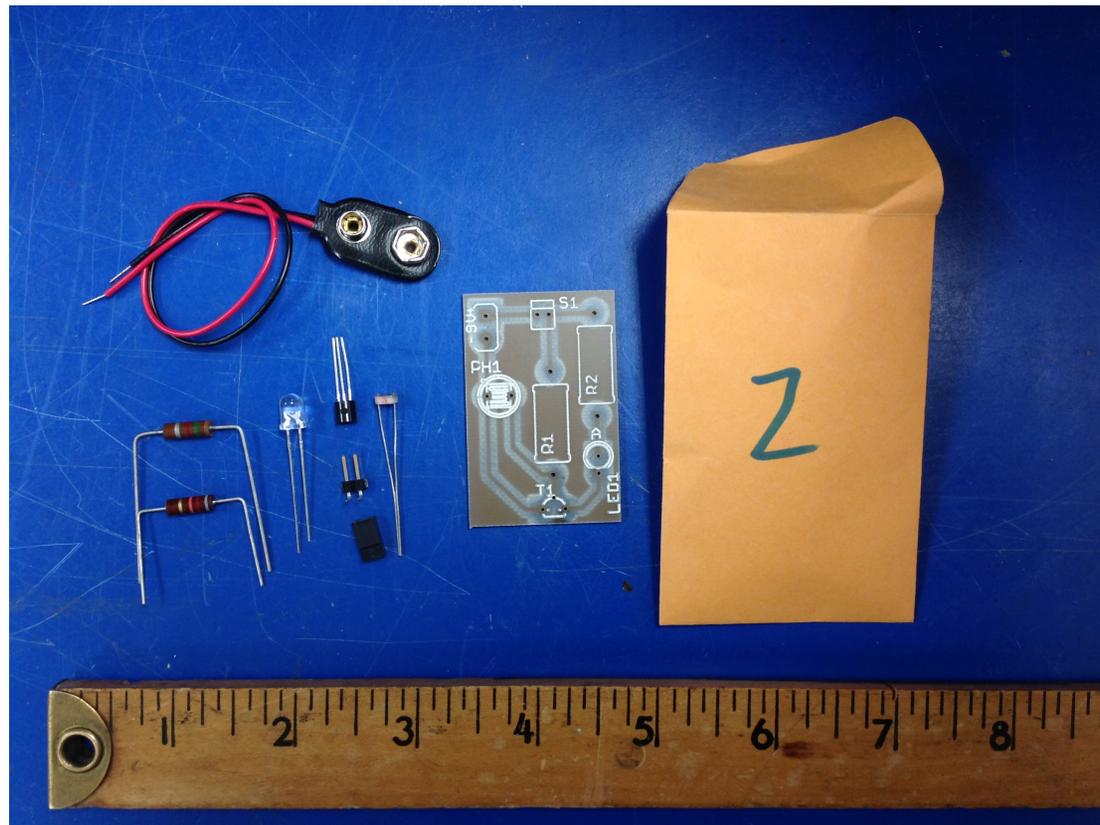
Circuit 3: remote checker

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 CS13A-WSN-CV0Y0151 LED, COOL WHITE, T-1 3/4 (5MM), 4CD	0.236
1	Newark	05R0383	T1 Fairchild Semiconductor 2N3906FTR 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

Total: 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.

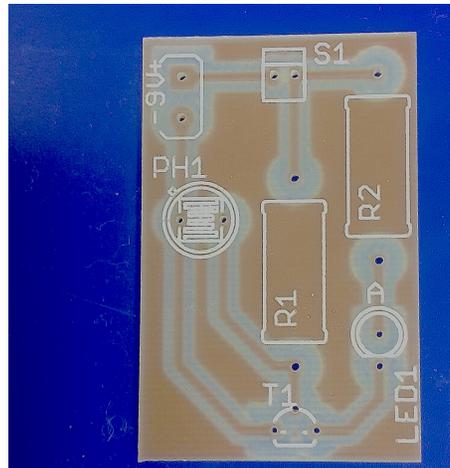


Left: Parts for circuit 2. Right: envelope in which parts are given to student.

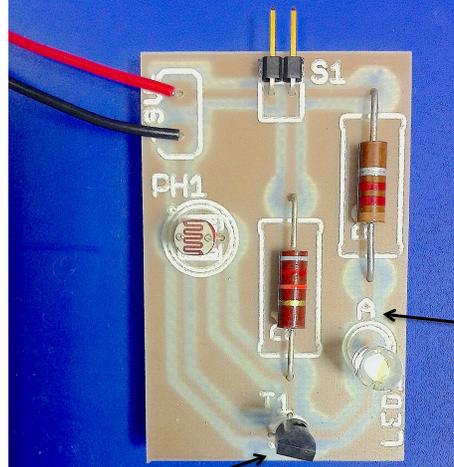
# Giving Instructions to Students: The Pictures

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



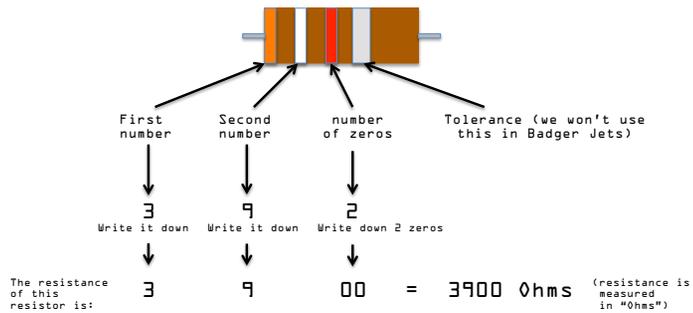
Resistor Color Codes



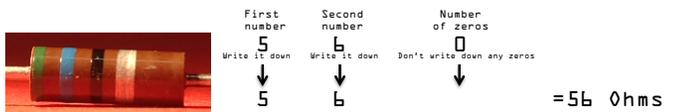
This is a resistor

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



### Example

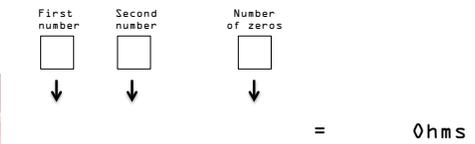
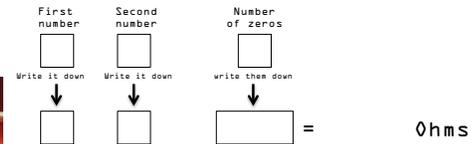


## Back side

Name \_\_\_\_\_

### Quiz

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



# 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**

