

The Role of  
Electronics Shops

Blaise Thompson

Research Shops

Custom Research  
Electronics

Appliance  
Maintenance

Safety

Electrocution  
Fire

Conclusion

# The Role of Electronics Shops In a Research Environment

Blaise Thompson

University of Wisconsin–Madison

2024-04-10



# What is a research electronics shop?



## The Role of Electronics Shops

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Electronics

Appliance  
Maintenance

Safety

Electrocution  
Fire

Conclusion



# UW-Madison Department of Chemistry



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Custom Research  
Electronics

Appliance  
Maintenance

Safety  
Electrocution  
Fire

Conclusion

three shops:

- ▶ machine
  - ▶ three full time staff
  - ▶ specialty focus on pump repair
- ▶ glass
  - ▶ two full time staff
- ▶ electronics
  - ▶ two full time staff
  - ▶ four student workers



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Custom Research  
Electronics

Appliance  
Maintenance

Safety  
Electrocution  
Fire

Conclusion

## Electronics at UW-Madison Chemistry

- ▶ here for as long as anyone can remember
  - ▶ at least 50 years
- ▶ historically much larger group
  - ▶ more than seven full time staff, at peak
- ▶ construct, repair, assist





## Department of Physics

Research, teaching and outreach in Physics at UW-Madison

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## Electronics Shop

The Physics Electronics Shop does not sell parts to the public. We don't do repairs for the public.

[3336 Chamberlin Hall](#)

1150 University Ave.

Madison, WI 53706

Phone: (608) 262-0527



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of  
Electronics Shops

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Research Shops

Custom Research  
Electronics

Appliance  
Maintenance

Safety

Electrocution  
Fire

Conclusion

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Department of Chemistry

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[Home](#)

> [Jonathan Amy Facility for Chemical Instrumentation](#)

> Jonathan Amy Facility for Chemical Instrumentation

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Projects ▾

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Research Facilities ▾

## Jonathan Amy Facility for Chemical Instrumentation

The Amy Instrumentation Facility (JAFCI) is dedicated to the fusion of engineering expertise with the quest for scientific knowledge to further research and instructional efforts in the Department of Chemistry and School of Chemical Engineering at Purdue University. Our team of scientists and engineers provide assistance in the design / construction of specialized instrumentation not commercially available along with repair / modification of commercial systems.





# DEPARTMENT OF CHEMISTRY

MENU A standard three-line menu icon.



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## Electronics Shop

The Electronics Shop ([Bagley Hall](#) room 74) supports graduate teaching activities and research.



All staff are skilled in design, development, construction, repair and maintenance of scientific apparatus and



## Chemical and Biological Engineering

COLLEGE OF ENGINEERING AND APPLIED SCIENCE



### Instrument Shop

For over 16 years the professional research Instrument Shop at the Department of Chemical and Biological Engineering has provided mechanical and electrical design and fabrication services at CU Boulder. The experienced staff provides solutions for instructional and research needs for any department or college at highly competitive rates. The Instrument Shop is collectively comprised of a machine shop and electronics shop, both of which are located in the basement level of the Jennie Smoly Caruthers Biotechnology Building.

In short, the shop's primary mission is to help the labs and researchers get the custom tools and instruments they need to successfully complete their projects, from problem to solution. Contact the shop staff with the details of your project.

 Tools, components, and instruments

Instrument Shop Equipment and Products

#### Instrument Shop Staff

Dragan Mejic  
Shop Manager, Instrument Maker /  
Fabricator  
[dragan.mejic@colorado.edu](mailto:dragan.mejic@colorado.edu)  
(303) 735-5901

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The Role  
of  
Electronics Shops

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Research Shops

Custom Research  
Electronics

Appliance  
Maintenance

Safety

Electrocution  
Fire

Conclusion



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David Emala



THE COLLEGE OF ARTS + SCIENCES

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## Electronics



## Location

Room C249, Kenan Laboratories, second floor.

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Research Shops

Custom Research  
Electronics

Appliance  
Maintenance

Safety

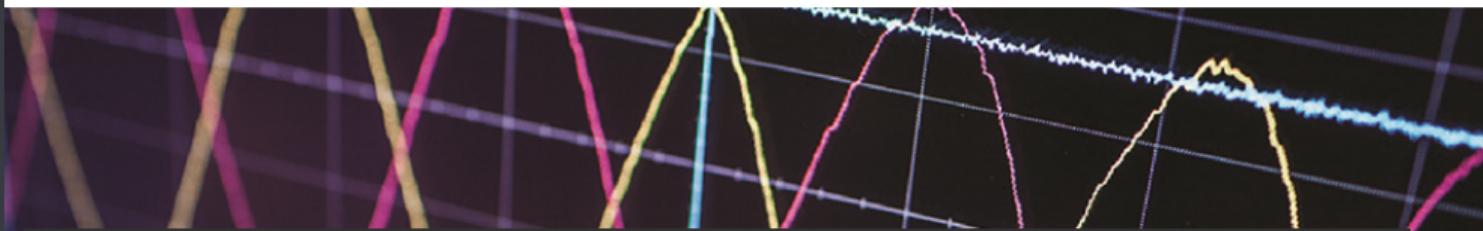
Electrocution

Fire

Conclusion



Core Facilities



## Instrument Design and Fabrication

ASU Core Research Facilities

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Research Shops

Custom Research  
Electronics

Appliance  
Maintenance

Safety

Electrocution

Fire

Conclusion

Stanford University

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☰  
Menu



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Research Shops

Custom Research  
Electronics

Appliance  
Maintenance

Safety

Electrocution

Fire

Conclusion



BROWN

Department of Chemistry



IN THIS SECTION

## Electronics Shop

The Electronics Shop has a variety of equipment available for use in research and for teaching.

The Role of  
Electronics Shops

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Research Shops

Custom Research  
Electronics

Appliance  
Maintenance

Safety  
Electrocution  
Fire

Conclusion

# Custom electronics for research?



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Research Shops

Custom Research  
Electronics

Appliance  
Maintenance

Safety  
Electrocution  
Fire

Conclusion

Electronics development has a key role to play in higher education & cutting-edge research.

- ▶ lowered cost
- ▶ greater reproducibility
- ▶ automation, high throughput
- ▶ creativity and niche application



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Custom Research  
Electronics

Appliance  
Maintenance

Safety

Electrocution

Fire

Conclusion



ORIGINAL RESEARCH  
published: 10 July 2020  
doi: 10.3389/fpls.2020.01015



# The XyloTron: Flexible, Open-Source, Image-Based Macroscopic Field Identification of Wood Products

Prabu Ravindran <sup>1,2\*</sup>, Blaise J. Thompson <sup>3</sup>, Richard K. Soares <sup>1,2</sup>  
and Alex C. Wiedenhoef <sup>1,2,4,5</sup>

<sup>1</sup> Center for Wood Anatomy Research, USDA Forest Products Laboratory, Madison, WI, United States, <sup>2</sup> Department of Botany, University of Wisconsin, Madison, WI, United States, <sup>3</sup> Department of Chemistry, University of Wisconsin, Madison, WI, United States, <sup>4</sup> Department of Forestry and Natural Resources, Purdue University, West Lafayette, IN, United States, <sup>5</sup> Departamento de Ciências Biológicas (Botânica), Universidade Estadual Paulista, Botucatu, Brazil



Forests, estimated to contain two thirds of the world's biodiversity, face existential threats due to illegal logging and land conversion. Efforts to combat illegal logging and to support sustainable value chains are hampered by a critical lack of affordable and scalable

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Custom Research  
Electronics

Appliance  
Maintenance

Safety

Electrocution

Fire

Conclusion

xylotron picture here please





## Review of Scientific Instruments

ARTICLE

[scitation.org/journal/rsi](https://scitation.org/journal/rsi)

# Multichannel gas-uptake/evolution reactor for monitoring liquid-phase chemical reactions

Cite as: Rev. Sci. Instrum. 92, 044103 (2021); doi: [10.1063/5.0043007](https://doi.org/10.1063/5.0043007)

Submitted: 5 January 2021 • Accepted: 28 March 2021 •

Published Online: 15 April 2021



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Chase A. Salazar, Blaise J. Thompson, Spring M. M. Knapp, Steven R. Myers, and Shannon S. Stahl<sup>a</sup>

## AFFILIATIONS

Department of Chemistry, University of Wisconsin-Madison, Madison, Wisconsin 53719, USA

<sup>a</sup>Author to whom correspondence should be addressed: [stahl@chem.wisc.edu](mailto:stahl@chem.wisc.edu)

## ABSTRACT

gas uptake picture here please





April 1, 2024 at 20:33:38 (UTC).  
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Letter

## Versatile Open-Source Photoreactor Architecture for Photocatalysis Across the Visible Spectrum

Philip P. Lampkin, Blaise J. Thompson, and Samuel H. Gellman\*



Cite This: *Org. Lett.* 2021, 23, 5277–5281



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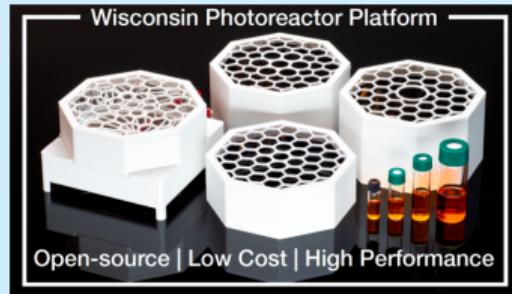
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Supporting Information

**ABSTRACT:** Adoption of commercial photoreactors as standards for photocatalysis research could be limited by high cost. We report the development of the Wisconsin Photoreactor Platform (WPP), an open-source photoreactor architecture potentially suitable for general adoption. The WPP integrates inexpensive commercial components and common high-intensity LEDs in a 3D-printed enclosure. Dimensions and features of WPP reactors can be readily varied and configurations easily reproduced. WPP performance is evaluated using literature transformations driven by light of disparate wavelengths.



photoreactor picture here please



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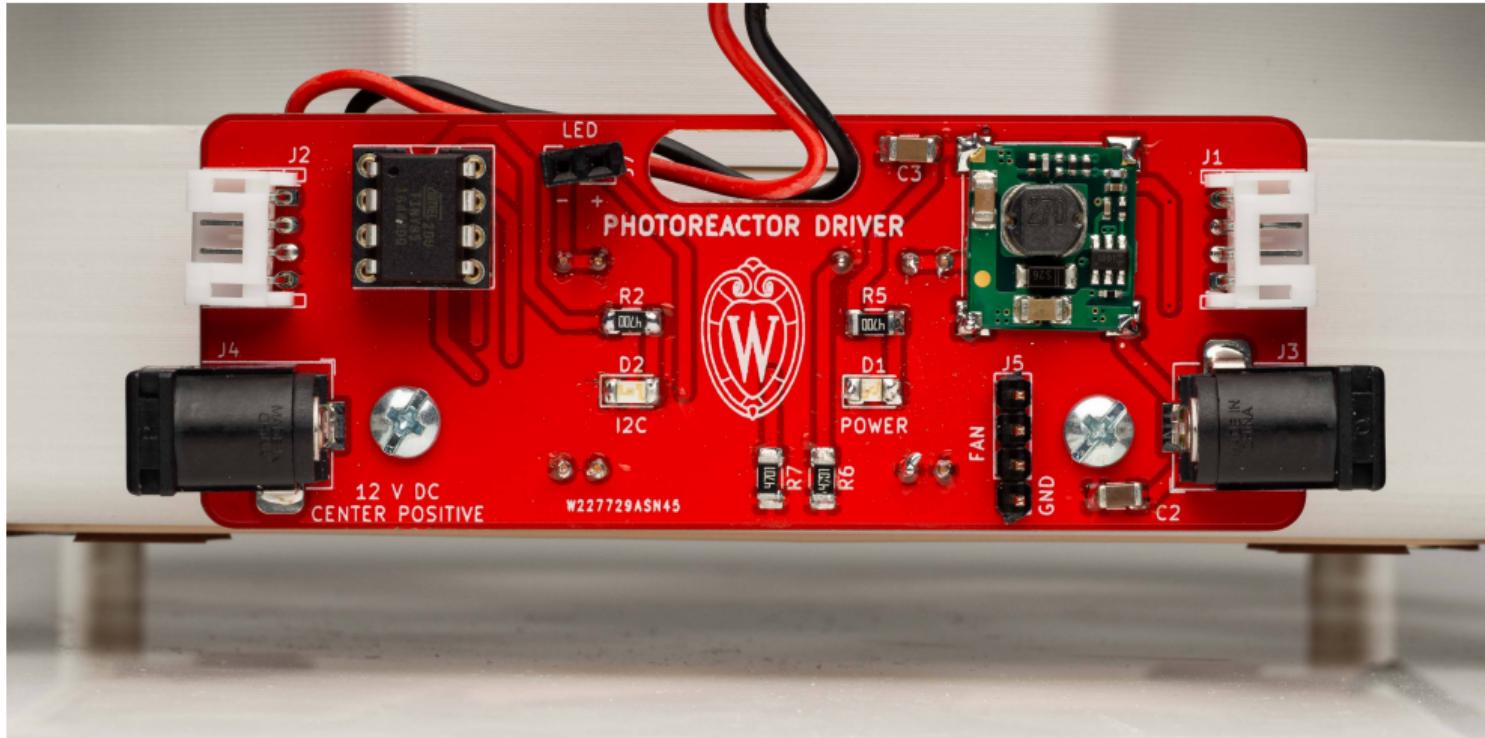
Custom Research  
Electronics

Appliance  
Maintenance

Safety

Electrocution  
Fire

Conclusion



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Custom Research  
Electronics

Appliance  
Maintenance

Safety

Electrocution

Fire

Conclusion



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Research Article

## The Wisconsin Oscillator: A Low-Cost Circuit for Powering Ion Guides, Funnels, and Traps

Steven J. Kregel,\* Blaise J. Thompson, Gilbert M. Nathanson, and Timothy H. Bertram



Cite This: *J. Am. Soc. Mass Spectrom.* 2021, 32, 2821–2826



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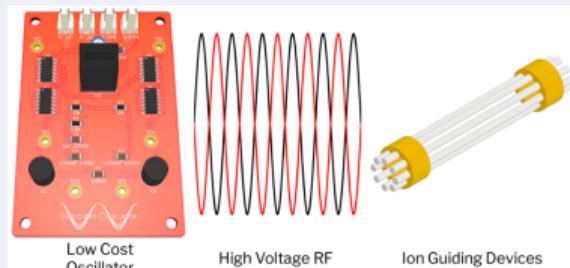


Article Recommendations



Supporting Information

**ABSTRACT:** In this work, we present the Wisconsin Oscillator, a small, inexpensive, low-power circuit for powering ion-guiding devices such as multipole ion guides, ion funnels, active ion-mobility devices, and non-mass-selective ion traps. The circuit can be constructed for under \$30 and produces two antiphase RF waveforms of up to 250 V<sub>P-P</sub> in the high kilohertz to low megahertz range while drawing less than 1 W of power. The output amplitude is determined by a 0–6.5 VDC drive voltage, and voltage amplification is achieved using a resonant LC circuit, negating the need for a large RF transformer. The Wisconsin Oscillator automatically oscillates with maximum amplitude at the resonant frequency defined by the onboard capacitors, inductors,



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Custom Research  
Electronics

Appliance  
Maintenance

Safety

Electrocution

Fire

Conclusion

oscillator picture here please



# Teaching

The Role of  
Electronics Shops

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Research Shops

Custom Research  
Electronics

Appliance  
Maintenance

Safety

Electrocution

Fire

Conclusion



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Custom Research  
Electronics

Appliance  
Maintenance

Safety

Electrocution

Fire

Conclusion

# Workspace

workspace



# Electronics: More Accessible than Ever

arduino rpi oshpark kicad adafruit, sparkfun kits





## PLOS BIOLOGY

ESSAY

### Open hardware: From DIY trend to global transformation in access to laboratory equipment

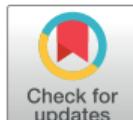
Tobias Wenzel  \*

Institute for Biological and Medical Engineering, Schools of Engineering, Medicine and Biological Sciences, Pontificia Universidad Católica de Chile, Macul, Región Metropolitana, Chile

\* [tobias.wenzel@uc.cl](mailto:tobias.wenzel@uc.cl)

#### Abstract

Open hardware solutions are increasingly being chosen by researchers as a strategy to improve access to technology for cutting-edge biology research. The use of DIY technology is already widespread, particularly in countries with limited access to science funding, and is catalyzing the development of open-source technologies. Beyond financial accessibility, open hardware can be transformational for the access of laboratories to equipment by



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Research Shops

Custom Research Electronics

Appliance Maintenance

Safety

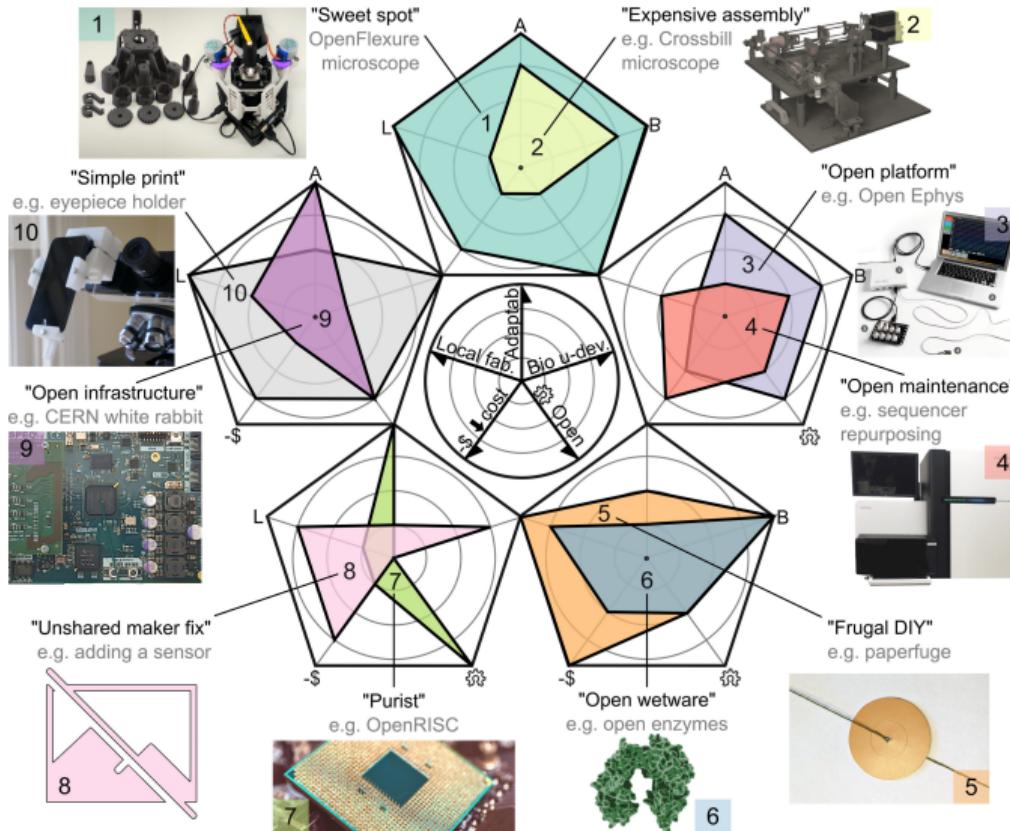
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Fire

Conclusion



# Open Source Hardware



# Repair and maintenance of research equipment.



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Electronics

Appliance  
Maintenance

Safety

Electrocution

Fire

Conclusion



Amber Bartz  
Chemistry Electronics Shop  
[afbartz@wisc.edu](mailto:afbartz@wisc.edu)

Check out Amber's poster presentation:  
*What Researchers Should Know When Powering Lab Equipment*



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Custom Research  
Electronics

Appliance  
Maintenance

Safety

Electrocution  
Fire

Conclusion

# Electrical Safety as Viewed from the Shop



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Custom Research  
Electronics

Appliance  
Maintenance

Safety

Electrocution  
Fire

Conclusion

Researchers utilize advanced electronics.

Researchers design and build custom instruments.

Researchers rely on in-house repair.

Let's think about safety implications!



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Custom Research  
Electronics

Appliance  
Maintenance

Safety

Electrocution  
Fire

Conclusion

I'm not a safety expert... talking at CSHEMA is a bit intimidating.

I'm glad you are dedicating a symposium to electrical safety.

I have no idea how to think about certification...

I hope we can work together.



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Custom Research  
Electronics

Appliance  
Maintenance

Safety

Electrocution  
Fire

Conclusion

Cutting-edge researchers will inevitably customize/create electronic circuits.

Hopefully, the electronics shop can be a place to do this work under professional supervision!

We don't have the time or the staff to look over every shoulder... ...instead, we try to convince researchers that they have a professional responsibility to care about electrical safety.



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Electronics

Appliance  
Maintenance

Safety

Electrocution

Fire

Conclusion

Two categories of electrical hazard:

- ▶ electrocution
- ▶ fire



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Custom Research  
Electronics

Appliance  
Maintenance

Safety  
Electrocution

Fire

Conclusion

Electrical hazards represent a serious, widespread occupational danger; practically all members of the workforce are exposed to electrical energy during the performance of their daily duties, and electrocutions occur to workers in various job categories. Many workers are **unaware** of the potential electrical hazards present in their work environment, which makes them more vulnerable to the danger of electrocution.

WORKER DEATHS BY ELECTROCUTION  
A Summary of NIOSH Surveillance and Investigative Findings  
May 1998



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Custom Research  
Electronics

Appliance  
Maintenance

Safety  
Electrocution

Fire

Conclusion

Relatively small amounts of current can be very dangerous!

- ▶ 1 mA - barely perceptible
- ▶ 16 mA - maximum current an average person can grasp and “let go”
- ▶ 20 mA - paralysis of respiratory muscles
- ▶ 100 mA - ventricular fibrillation threshold
- ▶ 2000 mA - cardiac standstill and internal organ damage
- ▶ 15000 mA - fuse / breaker opens circuit

A typical LED draws 20 mA.

Fuses and breakers will NOT protect you from death by electrocution!

WORKER DEATHS BY ELECTROCUTION  
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May 1998



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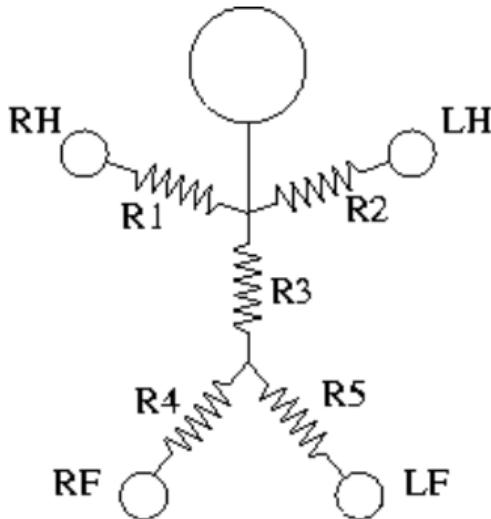
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Custom Research  
Electronics

Appliance  
Maintenance

Safety  
Electrocution  
Fire

Conclusion



Current and voltage are related by Ohm's Law.

$$V = IR$$

Larger voltages drive more current through your body.



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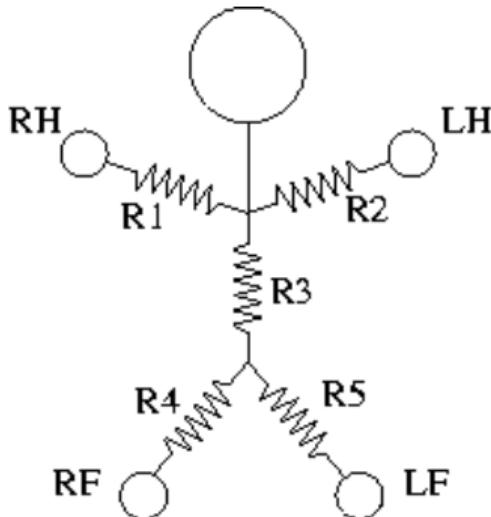
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Custom Research  
Electronics

Appliance  
Maintenance

Safety  
Electrocution  
Fire

Conclusion



“Typical” resistance across the human body:  
as low as  $10\text{k}\Omega$ . Solve for voltage driving 10 mA

$$V = 10\text{mA} \times 10\text{k}\Omega$$

$$V = 100\text{V}$$

Every device plugged into the wall is at least **120V**.



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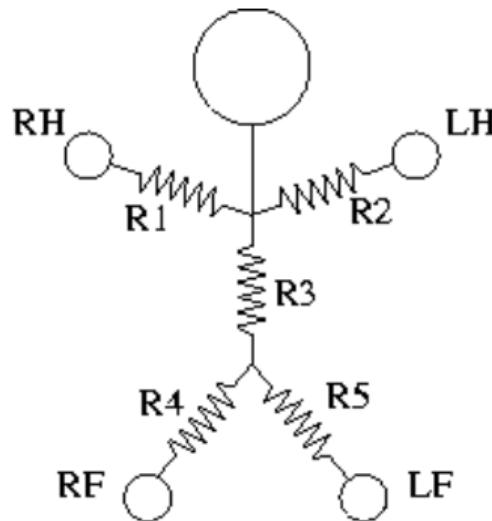
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Custom Research  
Electronics

Appliance  
Maintenance

Safety  
Electrocution  
Fire

Conclusion



Most resistance is at the skin.

Resistance **decreases** significantly if your skin is **wet**.



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Custom Research  
Electronics

Appliance  
Maintenance

Safety  
Electrocution

Fire

Conclusion

Treat anything above 30 V as an electrocution hazard.

- ▶ 5 V - USB power supply
- ▶ 120 V - typical lab appliance
- ▶ 120 V - typical vacuum roughing pump
- ▶ 1000 V - piezoelectric actuators
- ▶ 1000 V - photomultiplier tubes
- ▶ 3000 V - electron / ion multipliers
- ▶ 15000 V - X-Ray sources
- ▶ TODO: GEL ELECTROPHORESIS



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Electronics

Appliance  
Maintenance

Safety

Electrocution

Fire

Conclusion



Voltage is not necessarily dangerous,

Know the current rating!

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Custom Research  
Electronics

Appliance  
Maintenance

Safety

Electrocution

Fire

Conclusion



Designed specifically for shock protection.

Ensure that no current is leaking out of circuit.  
Sensitive to a few mA.

Will trip if used with large inductive loads (motors).

Prone to weaken over time—replaced every ten years.



# Recommendations for Avoiding Shock

Avoid contact with energized electrical circuits.

- ▶ NEVER work behind the outlet or in the walls.
- ▶ If it is safe to do so, work with only one hand. This precaution reduces the likelihood of accidents that result in current passing through the chest cavity.
- ▶ When it is necessary to handle equipment that is plugged in, be sure hands are dry and, when possible, wear nonconductive gloves and shoes with insulated soles.
- ▶ If an individual comes in contact with a live electrical conductor, do not touch the equipment, cord or person. Disconnect the power source from the circuit breaker or pull out the plug using a leather belt.



# Recommendations for Avoiding Shock

Research Shops

Custom Research  
Electronics

Appliance  
Maintenance

Safety  
Electrocution

Fire

Conclusion

Avoid mixing water and electricity.

- ▶ Minimize the use of electrical equipment in cold rooms or other areas where condensation is likely. If equipment must be used in such areas, mount the equipment on a wall or vertical panel.
- ▶ If water or a chemical is spilled onto equipment, shut off power at the main switch or circuit breaker and unplug the equipment.



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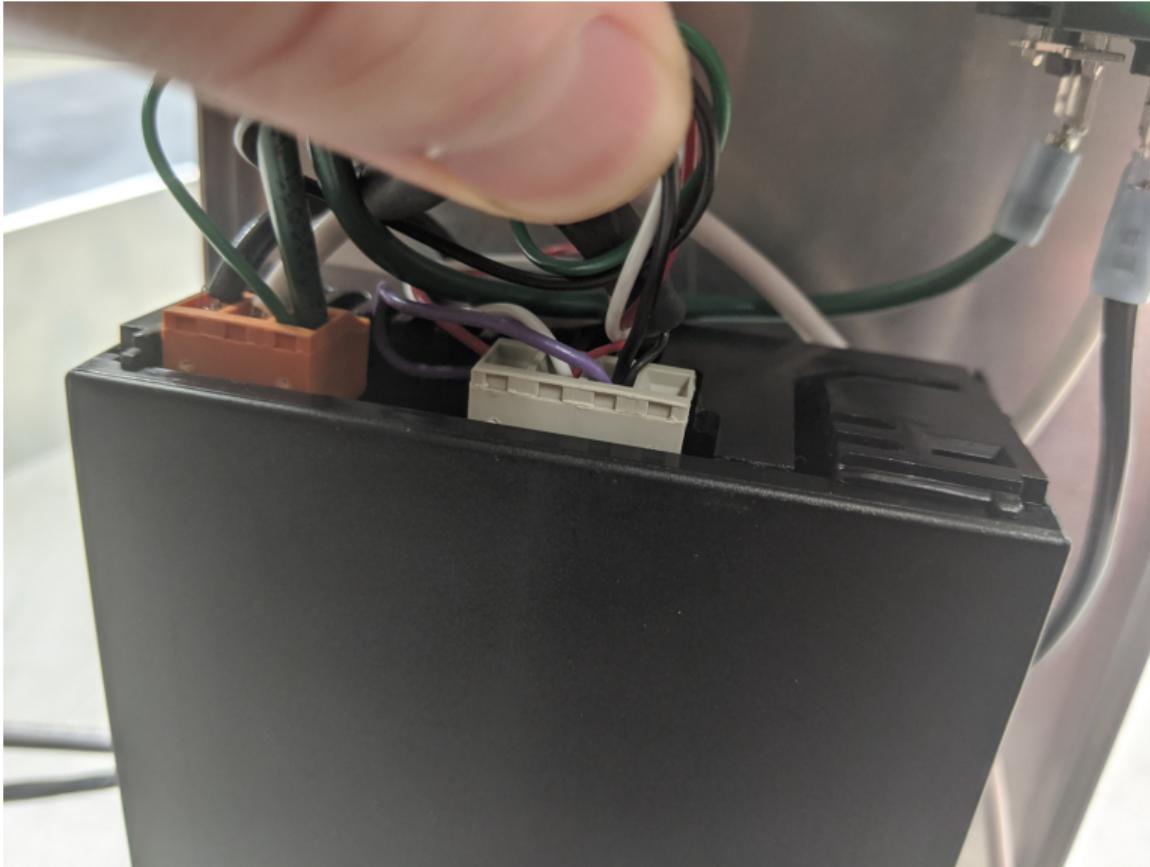
Appliance  
Maintenance

Safety

Electrocution

Fire

Conclusion



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Research Shops

Custom Research  
Electronics

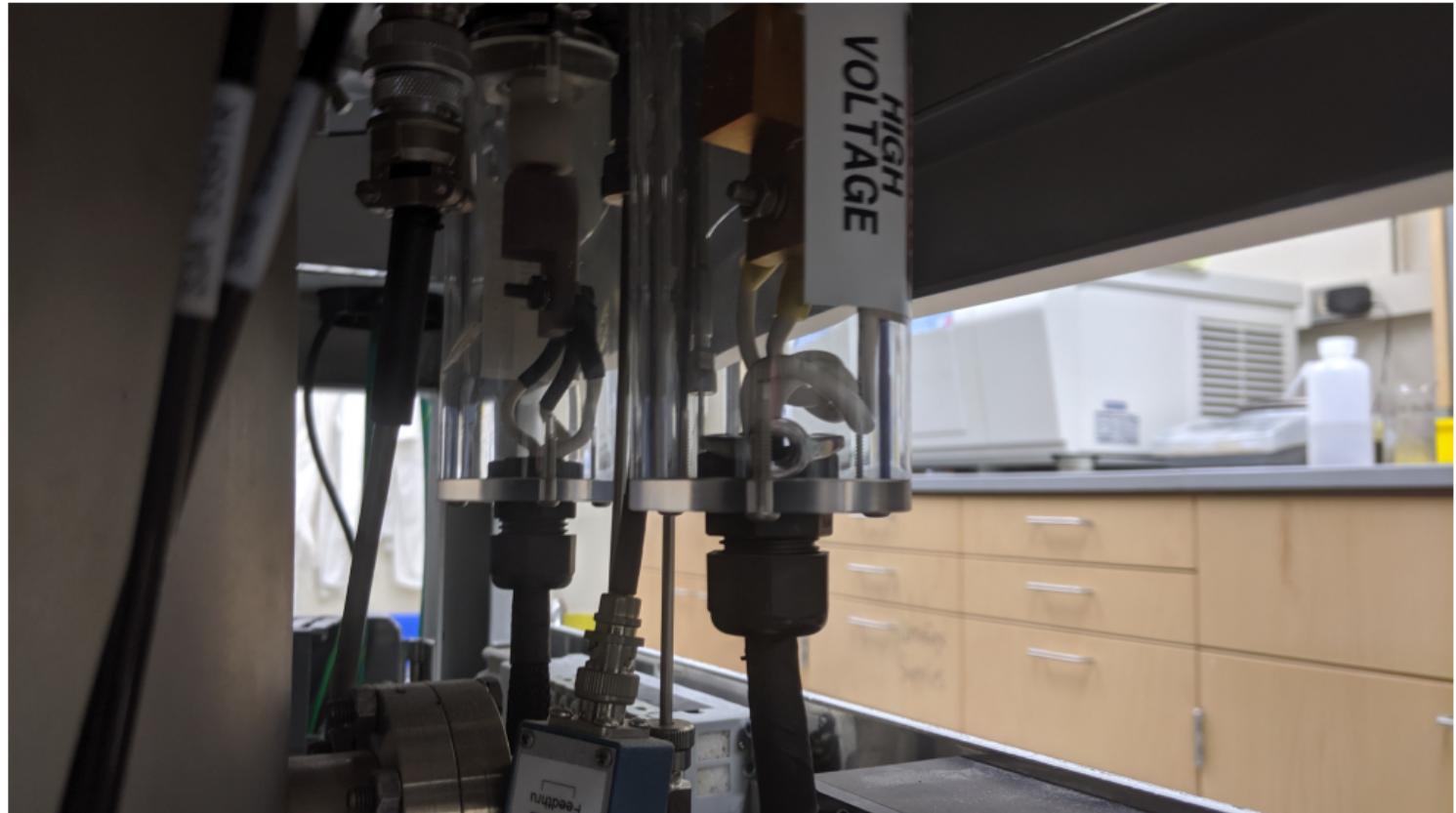
Appliance  
Maintenance

Safety

Electrocution

Fire

Conclusion



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Research Shops

Custom Research  
Electronics

Appliance  
Maintenance

Safety

Electrocution

Fire

Conclusion



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Research Shops

Custom Research  
Electronics

Appliance  
Maintenance

Safety

Electrocution

Fire

Conclusion

When an electrical circuit fails it can rapidly cause sparks and get very hot.

When combined with chemicals, this situation can become explosive.

Even low voltage circuits are capable of getting very hot.  
Power is product of voltage and current.



# Recommendations for Avoiding Electrical Fire

Ensure that circuits are not overloaded.

- ▶ Recognize which devices are drawing a lot of power.
  - ▶ Heaters, ovens
  - ▶ Pumps
  - ▶ Motors
- ▶ Be aware which devices share a circuit.
- ▶ Never use extension cords or power strips.
- ▶ When in doubt, ask! We can get new power outlets installed into your lab when necessary.



# Recommendations for Avoiding Electrical Fire

## Use good housekeeping.

- ▶ Do not crowd multiple appliances into small spaces.
- ▶ Regularly inspect power cords for damage.
- ▶ Keep appliances clean, free from chemical buildup.
- ▶ Dispose of broken appliances quickly.



# Recommendations for Avoiding Electrical Fire

Protect against catastrophic failure.

- ▶ Ensure that devices have fuses and/or breakers.
- ▶ When designing heating systems, consider incorporating thermal fuses.
- ▶ Ground exposed metal.



Research Shops

Custom Research  
Electronics

Appliance  
Maintenance

Safety

Electrocution

Fire

Conclusion



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Research Shops

Custom Research  
Electronics

Appliance  
Maintenance

Safety

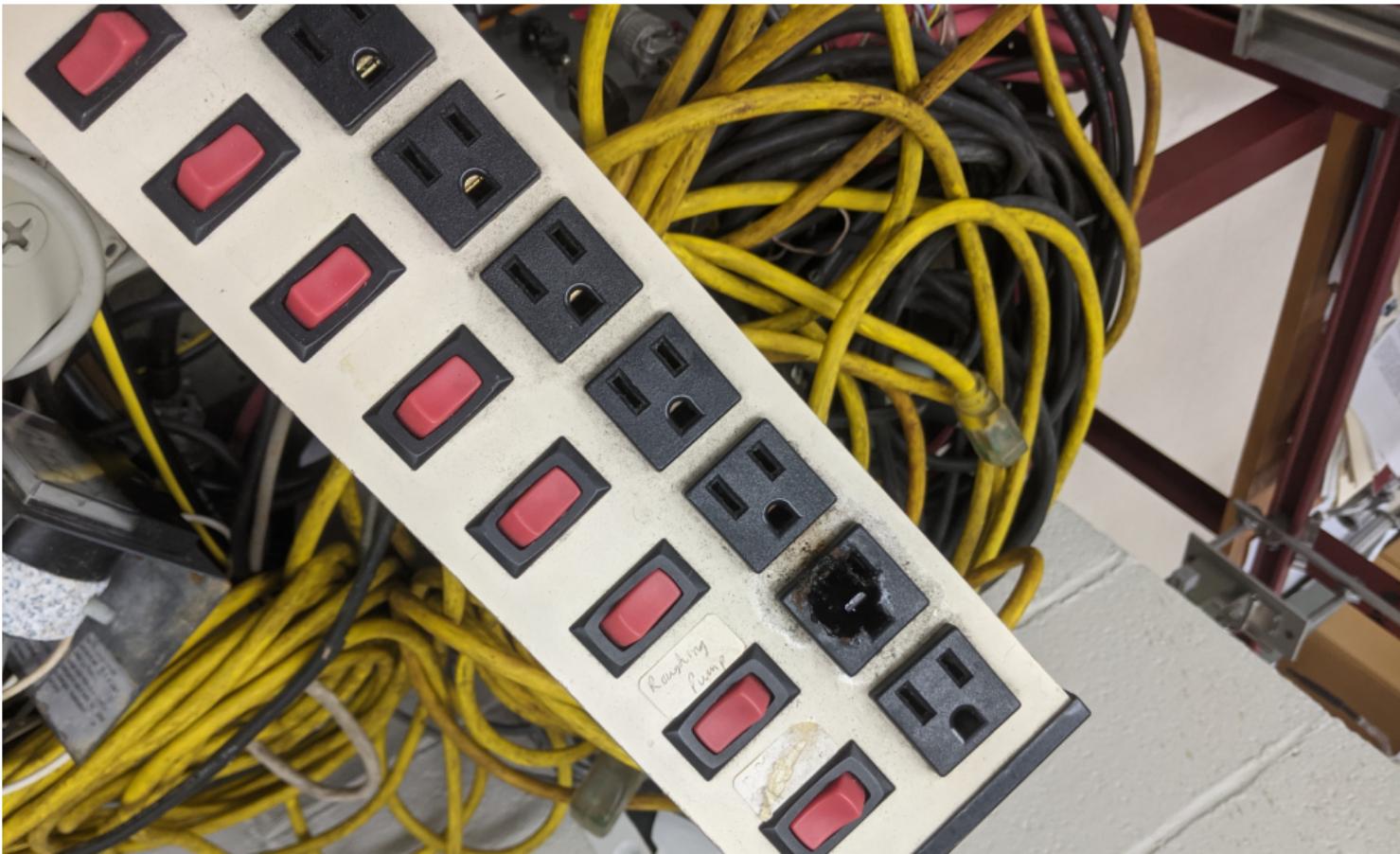
Electrocution

Fire

Conclusion



# Fire Hazard



Grounding, spark hazard.



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Custom Research  
Electronics

Appliance  
Maintenance

Safety

Electrocution

Fire

Conclusion



NEMA 5-15

120 V

Up to 15 amps, but many cables 10 amps!



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Custom Research  
Electronics

Appliance  
Maintenance

Safety

Electrocution

Fire

Conclusion



BNC

500 V

Typically 1 Amp

Use SHV connectors for high voltage (!!)



interlocks proper enclosures thermal fuse



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Electronics

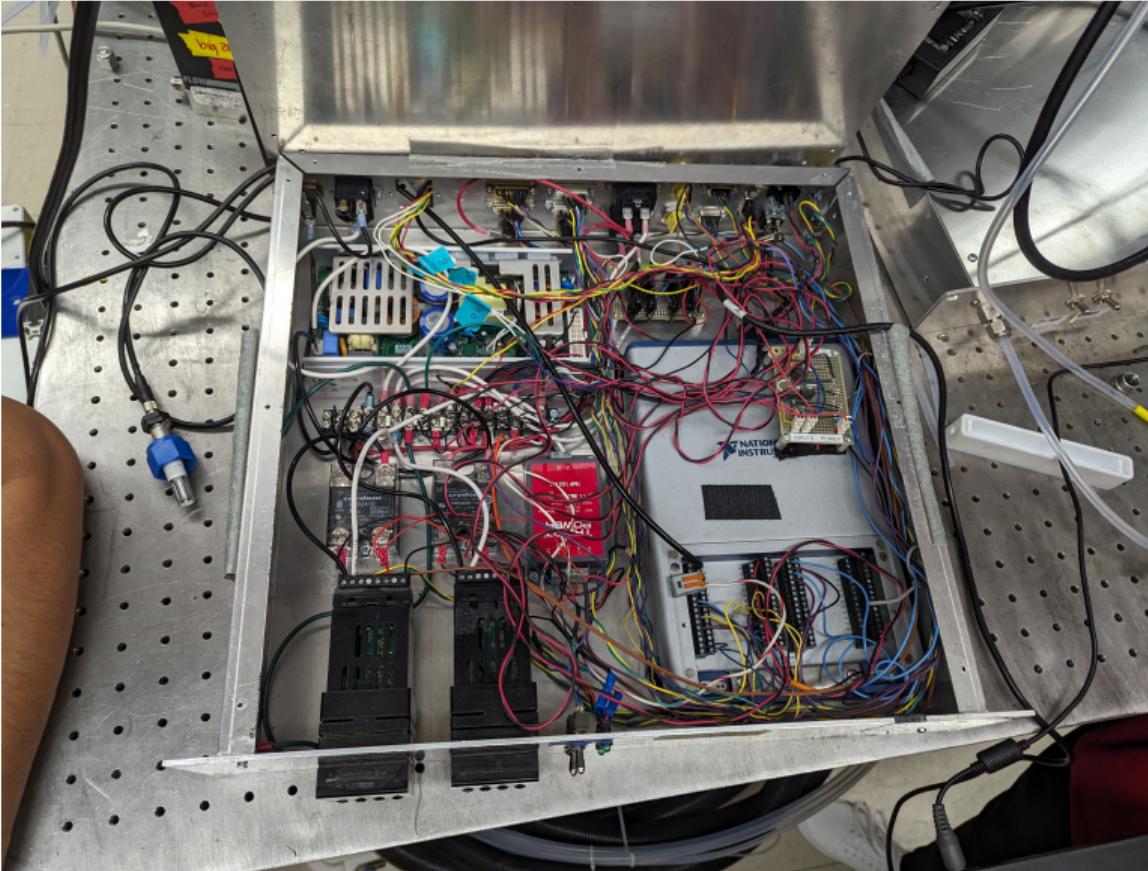
Appliance  
Maintenance

Safety

Electrocution

Fire

Conclusion



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Research Shops

Custom Research  
Electronics

Appliance  
Maintenance

Safety

Electrocution

Fire

Conclusion

Academic electronics shops contain staff working with researchers to best utilize electronic research equipment.

Shop staff are professionals who care about electrical safety.

Your institution might have a research electronics shop—consider reaching out!



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Research Shops

Custom Research  
Electronics

Appliance  
Maintenance

Safety

Electrocution

Fire

**Conclusion**



Blaise Thompson  
Chemistry Electronics Shop  
[blaise.thompson@wisc.edu](mailto:blaise.thompson@wisc.edu)

Love to learn about research & electronics.  
Let's chat!

Questions?

