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Celebrating invention, inspiring youth

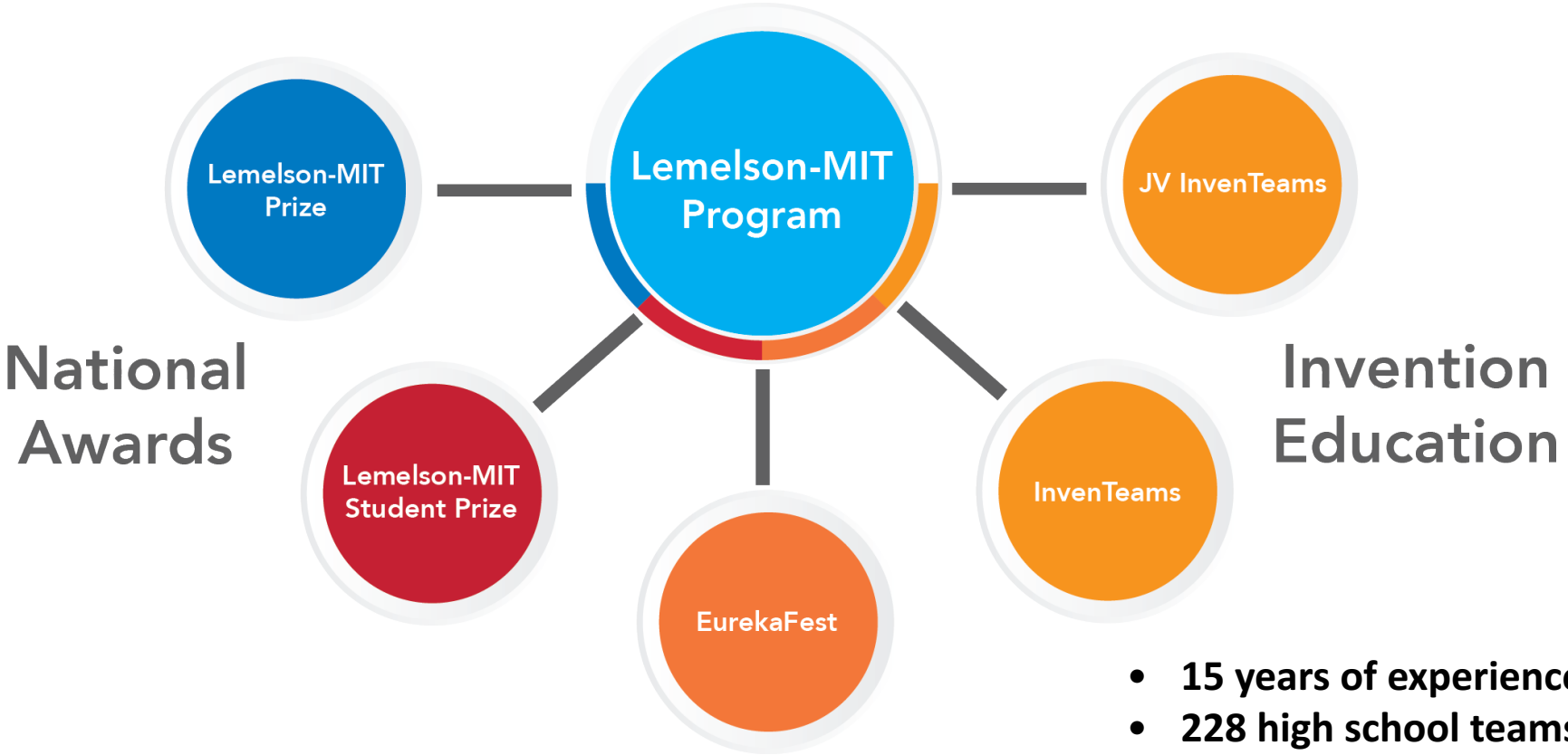
Batteries- A primer

Invention Education
Webinar Series

Thursday, February 22, 2018

6:30 – 7:00 p.m. ET

Lemelson-MIT Program Overview



- **15 years of experience**
- **228 high school teams**
- **7 U.S. patents**

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Presenter Don Domes

- Special Projects in STEAM and CTE for the Office of School Performance, Hillsboro Public School District, Oregon
- Member of the Board of Directors of Oregon Robotics Tournament & Outreach Program
- Retired high school CTE teacher

Lemelson-MIT Invention Education Experience

- Hillsboro High School InvenTeam (2007)
- Self-installed automotive heads-up display
- Master teacher with LMIT for 9 years

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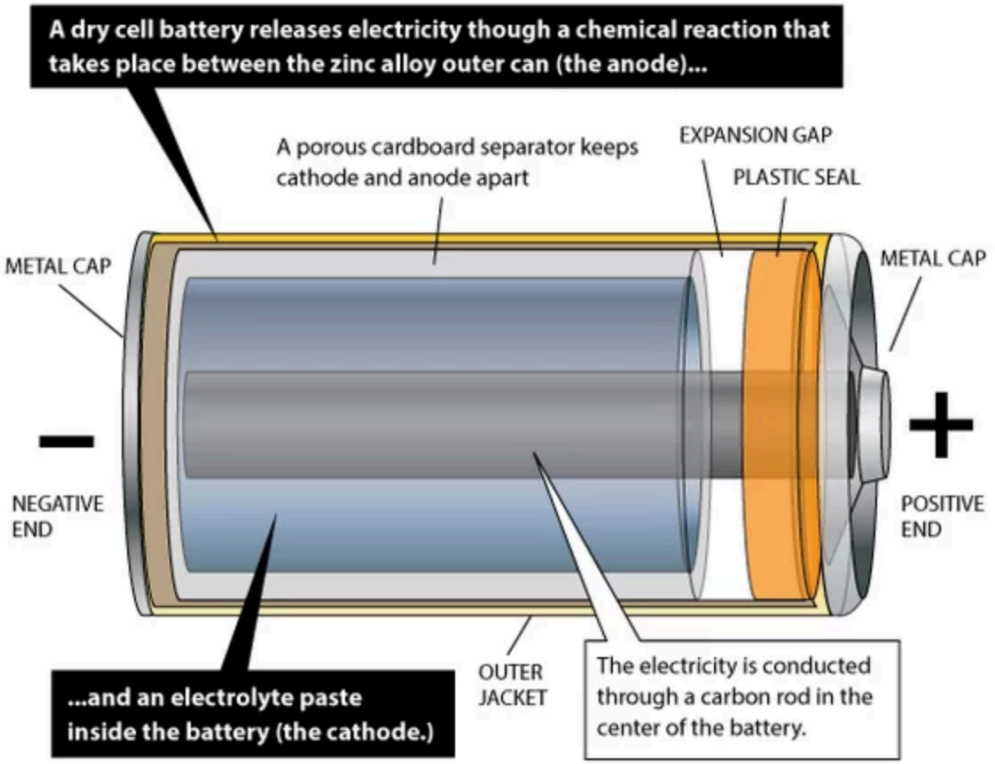
Batteries

- Three parts:
  cathode (+, the positive terminal), anode (-, the negative terminal), and the electrolyte.
- The chemical reactions in the battery causes a build up of electrons at the anode.
- But the separator keeps the electrons from going straight from the anode to the cathode within the battery.



Source: livescience.com

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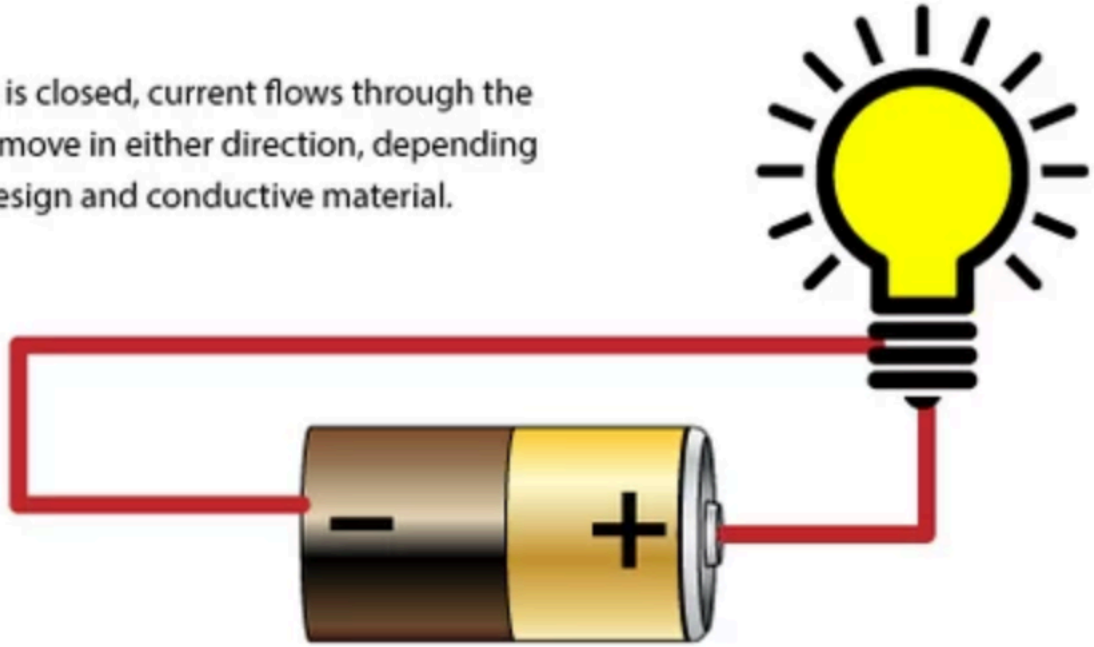
Batteries

When a circuit is closed, current flows through the battery. It can move in either direction, depending upon circuit design and conductive material.



COMMON TYPES:

- "Heavy-duty" zinc-carbon battery
- Alkaline battery

Both use zinc as the anode and manganese dioxide as the cathode.

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Different Types of Batteries

- Non-rechargeable Batteries

  The chemical reactions **are not** easily reversible.

Disposable non-rechargeable batteries

- Rechargeable Batteries

PHOTOS: WIKIMEDIA (PUBLIC DOMAIN), SHUTTERSTOCK

Powered by a **reversible** chemical reaction between the cathode and anode.

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Different Types of Batteries

- Different sizes (AAA, AA, A, C, D, 9V, coin batteries, etc.)

(from left to right) a 12.6-volt car battery, a 4.5-volt (3R12) battery, a *D Cell*, a *C cell*, an *AA cell*, an *AAA cell*, an *AAAA cell*, an *A23 battery*, a 9-volt *PP3 battery*, and a pair of button cells (CR2032 and LR44)

- Different electrolyte
  - Lead-acid (car battery)
  - Alkaline battery
  - ….

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Different Types of Batteries

- Why so many different types of cells?
  - In an electrical circuit or device, there are two really important things: **voltage** and **current**.

    The D size battery will deliver more current than the C, AA, and AAA size battery, even if they are both rated as having a voltage of 1.5.

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Basic Safety Rules for Tool Use

Wear safety glasses.

If you are in doubt about how to use a tool, ask!

Have a plan for what you are going to do with the tool.

Be mindful of others who might enter into your workspace accidentally.

Secure the workpiece.

Have a balanced stance while using a tool.

Remove all jewelry, watches, and loose clothing before working with machinery.

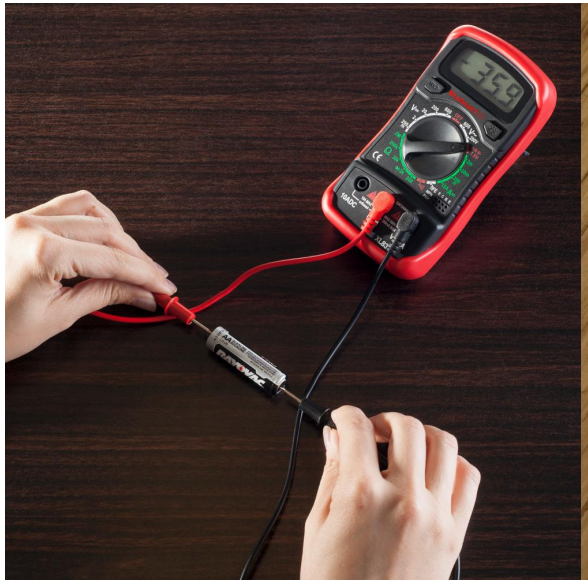
Pin up long hair and wear closed-toe footwear.

Never work when you are tired or unfocused.

Leave the workspace cleaner than you found it.

Tools working with Batteries

- Multimeter to troubleshoot circuit
- Battery tester
- Alligator clips



Testing batteries using a multimeter

https://vimeo.com/album/1897420/video/60032726

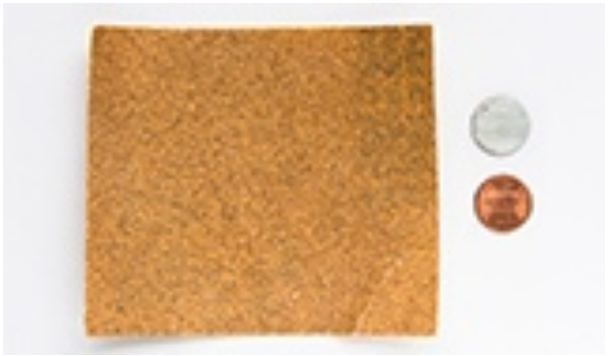
Do not tilt car batteries!

Do not allow young children to work with coin cells! They may swallow them!!

Building a five-cent Battery

- **Materials:**
  - 5 pennies from post 1982 (these have a zinc interior, which is important)
  - Piece of 100-grit sandpaper
  - 4 square cut-outs of paper towel (slightly smaller than the size of a penny)
  - White vinegar and salt
  - 5mm red LED
  - Tape

- **Steps:**
  1. Sand one side of four pennies until the outer (copper) layer is removed. Leave the 5th penny intact.



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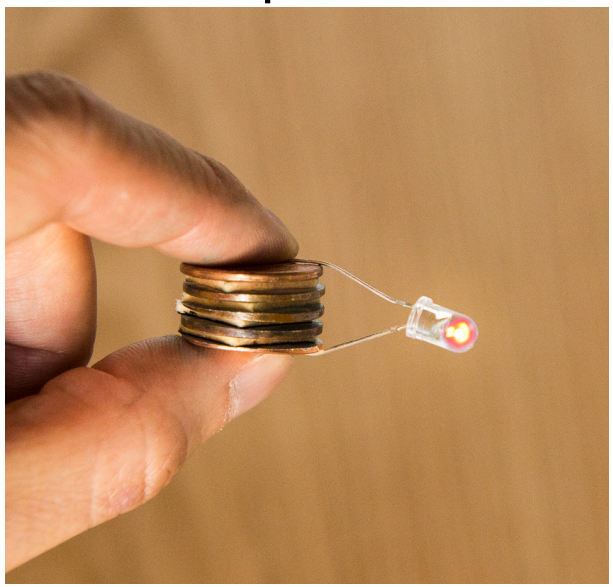
Building a five-cent Battery

2. Make a saturated salt solution by adding salt to water and stirring until it doesn't dissolve anymore. Add a splash of vinegar to this solution.
3. Dip the paper towel squares in solution until they are saturated.
4. Place a soaked square on top of the zinc (sanded) side of one penny, and then stack the other four pennies and squares on top in the same pattern.
5. Use some duct tape or rubber bands to secure the pennies in place.
6. Place the longer wire of the LED against the surface of the top penny and the other wire against the bottom.
7. The LED is on!



Recycling Batteries

- **Alkaline Batteries**

End products through mechanical separation processes:

  - zinc and manganese concentrate
  - steel
  - paper, plastic and brass fractions

- **Lead Acid Batteries**
  - Break apart the batteries in a hammer mill, a machine that hammers the battery into pieces.
  - Place the broken battery pieces into a vat, where the lead and heavy materials fall to the bottom and the plastic floats.
  - Melt the plastic floats into an almost liquid state and recycle.
  - Melt the lead parts for remanufacture.
  - Neutralize sulfuric acid or convert it to sodium sulfate.

Future Batteries

- **Better density:** storing more charge in the same physical size.

- **Improved longevity:** current rechargeable batteries can only be recharged so many times before they start to lose capacity.

- **Safety:** making batteries safer—solid-state batteries that contain a solid electrolyte, instead of a flammable liquid (to minimize problems similar as those in Samsung Note 7)

Potential future batteries: lithium-air (Li-air), lithium-sulphur (Li-S) battery, solid-state batteries, sodium batteries, etc.

Lemelson-MIT Resources

- Lemelson-MIT Program
http://lemelson.mit.edu/

- InvenTeams National Grants Initiative
http://lemelson.mit.edu/inventeams

- JV InvenTeams Curriculum Materials
http://lemelson.mit.edu/jv-inventeams

- Inventor Archive
http://lemelson.mit.edu/search-inventors

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Other Resources

How to Use a Multimeter from Sparkfun
https://learn.sparkfun.com/tutorials/how-to-use-a-multimeter

Make a penny battery
https://www.exploratorium.edu/snacks/penny-battery

How does a battery work? MIT School of Engineering
https://engineering.mit.edu/engage/ask-an-engineer/how-does-a-battery-work/

Don's vimeo channel on batteries and circuits
https://vimeo.com/album/1897420

Q & A

I always stacked nickels and pennies, or dimes and pennies or quarters and pennies. Now I am going to sand my pennies. Can 6th graders do the penny battery experiment?

Yes, we have implemented the penny battery experiments among middle school students and kids had lots of fun! Here are some tips when students work on the penny battery,

- The pennies need to be made after 1982.
- The sanding will take quite some time, especially for young children. The side with Lincoln memorial is relatively easy to sand. Please ask your students to sand that side.
- The copper layer of one side of the penny needs to be completely removed, otherwise it will reduce the power of the battery.
- Make sure the size of the paper towel squares is smaller than that of the penny. If the squares are so big that they touch each other, it will create shorts in the circuit and the LED won't light up.
- Make sure the paper towel square is wet, but not too soaked that the solution will flow to create shorts in the circuit.
- The LED only lights up when the electrons flow in one direction. If the LED is not on, switch the direction of the legs.
- The red LED needs the power of approximately five pennies. Each penny cell can generate obout 0.6 volts. The penny battery you created using five pennies has four cells. To light a red LED, you will need approximately 2 volts, that's why you will need five pennies. A blue LED will need more power, so you will need at least six pennies to light it up.

Q & A

Is it safe to open a 4.5 volt battery to get the zinc out?

No!

The electrolytes inside batteries are very acidic. Cutting a dry cell battery is very dangerous. We do NOT recommend doing this!

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THANK YOU!

Contact Us at PD-lemelson@mit.edu

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Webinar Series

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