Makerspace Nation

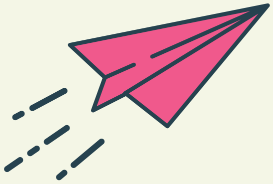
CIA Activity Book


idea

What is a Makerspace?

A makerspace is a place where people with shared interests, especially in computing and technology, can gather to work on collaborative projects.

A place for sharing ideas, equipment, and knowledge.



Where the only limit to what you can achieve is your imagination.


Exchange
Support
Trust
Teamwork
Share
Success
Inspiration
Assist

MAKERSPACE ACTION

"The best thing about a Makerspace is being able to collaborate with others to attempt the impossible. It fosters an environment that inspires thinking outside the box. There is no failure in a makerspace...only learning and doing it better next time. You can only fail if you give up, never give up!"

- CIA Software Engineer

The concept of a Makerspace is more than co-working, it is in the belief that creativity is fostered through collaboration, and that ideas should be shared freely. The "Makerspace" is not just a building, it is a hub where creators come to connect with each other to turn ideas into a reality. The workspace provides the building, infrastructure, and the positive "can do" environment; however, the creators make up the community and the community makes things happen. The Makerspace framework is based on social capital where every member of the community contributes to make the culture what it is.

This philosophy operates on the premise that membership does not require a monetary contribution, rather asks that members give back through time, talent, and relationships.

TEACHERS GUIDE

Middle School

- Competitions possible, moderate costs, introduce Scientific Method
- Divided attention span
- STEAM
  - Scientific Method: Hypothesis, Experiment, Conclusions
  - New Concepts
  - Goal driven (not open play or 'recess time'/sit and color)
  - Age/safety wise, able to do more
  - Need to draw out the method/ thinking
  - Need to get groups/teams to cross pollinate ideas
  - Instructor/Teacher may need coaching/outline to help

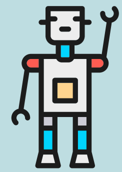
High School

- Instructor/Teacher not necessarily needed
- Focus attention/self-motivated
- Expect & Demonstrate STEAM concepts
- Contests can be more open-ended
- Costs can be higher
- Technical skills can be emphasized/ taught
- Teach the Teacher may be needed still, SMEs may be required if area is above high school level. Possible way to do college level research & collaborate

College/Professional

- More about access to tools
- Less time/divided attention possible. May be a new skill over understanding/ mastery
- Self-sufficient but needs Health/ Safety/troubleshooting. Self-motivated
- 'Hobbyist' STEAM can require more Middle/High School style coaching & little lessons
  - May need hands-on training
  - If you don't provide it, they'll find a way (could be wrong way)
  - Need to draw out full idea before offering help & info.
  - Cross pollinate ideas
  - Avoid any single-threaded SMEs/experts

MAKERSPACE CONCEPTS

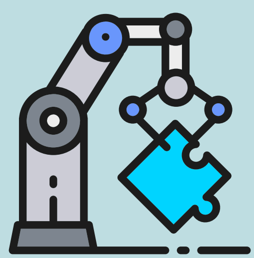


"Makerspaces are unique to the projects and teams using them. It can be a simple large table & containers or a well-equipped lab. Make your workspace work for you but don't forget to leave a clean space to build in!"

- CIA Computer Engineer

Makerspace Notes

Makerspaces make materials accessible to enhance development of science, technology, engineering, arts and mathmatics (STEAM) skills. Makerspaces are built in community buildings, libraries and schools but many build their own makerspace at home.



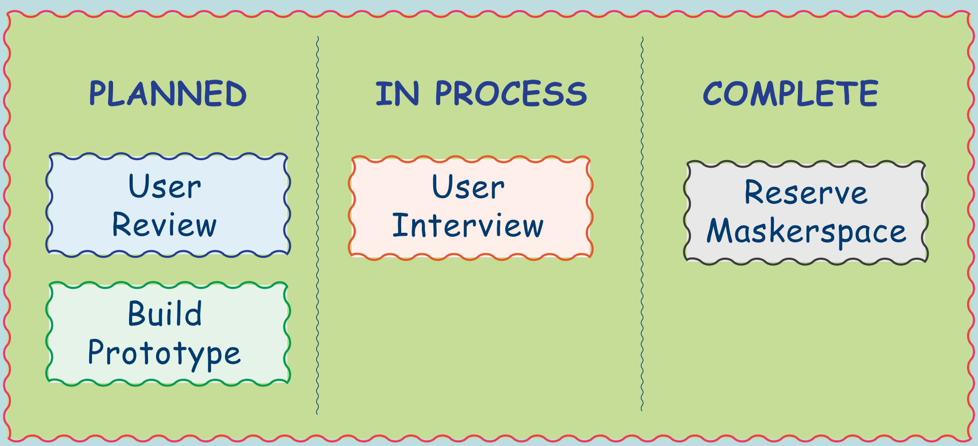
KANBAN

"Even though this is a simple planning tool, it has been used in the CIA by teams that span the intelligence community and industry to manage the integration of software and hardware to solve complex mission requirements. Running out of STEAM? Build a Team..."

- CIA Electrical Engineer and Quality Assurance Specialist

Kanban is a Japanese word for Digital Signal. It is a simple but powerful tool that can be used to track progress on projects. There are many forms of Kanban boards. Kanban boards are a creative tool for tracking your makerspace project. They are used for simple individual projects, and for highly complex hardware/ software integration teams. Here is an example of a simple Kanban Board to use for your makerspace project or to track your progress on one of the provided makerspace challenges.

A great free online tool for creating Kanban boards are Google Jamboards. You can also create a physical Kanban board by using sticky notes. Customize your Kanban boards to fit your needs. Be creative!



MAKERSPACE WORKBOOK PAGES

Design Thinking for Innovation

"As a grandmother and mom I create a makerspace at home with an Arduino, sewing machine, and craft supplies to help foster innovation for my children and grandchild. Design thinking fosters innovation both at home and in the workplace. It's all about the people!"

- CIA Electrical Engineer and Telecommunications specialist

Now that you have learned how to develop your inner maker — and you've found a makerspace where you can let your imagination run wild — it is now time to harness your creativity. This 5-step model on the following page is an iterative cyclical process that can foster innovation. Often used by design artists, this model has also been successfully applied to business applications, engineering, software design, and industrial applications.

5-Step Model

EMPATHIZE
Innovation should be Human Centered — Empathize with your user

DEFINE
Innovation should solve a problem — What does the world need — Human centric

IDEATE
Innovation is born from a clash of ideas — Gain Perspective — Brain Write

PROTOTYPE
Innovation brought to life — Makerspace here we come!

TEST
Innovation should constantly be refined — Take it back for human review — User feedback

Hack Nights

Every good maker community should provide an environment conducive to productive work, mixed with lots of fun! When the work day is over the best way to reach the greater community is to demonstrate the power of collaboration and creativity through fun events. One such example is the idea of “Hack Nights.” So, what is a “Hack Night?” We are glad you asked... A hack night is one or more nights a week where a group of makers come together to do fun and awesome things together. Here are a few examples of ways to run a “Hack Night.”

Theme Based Hack Nights:

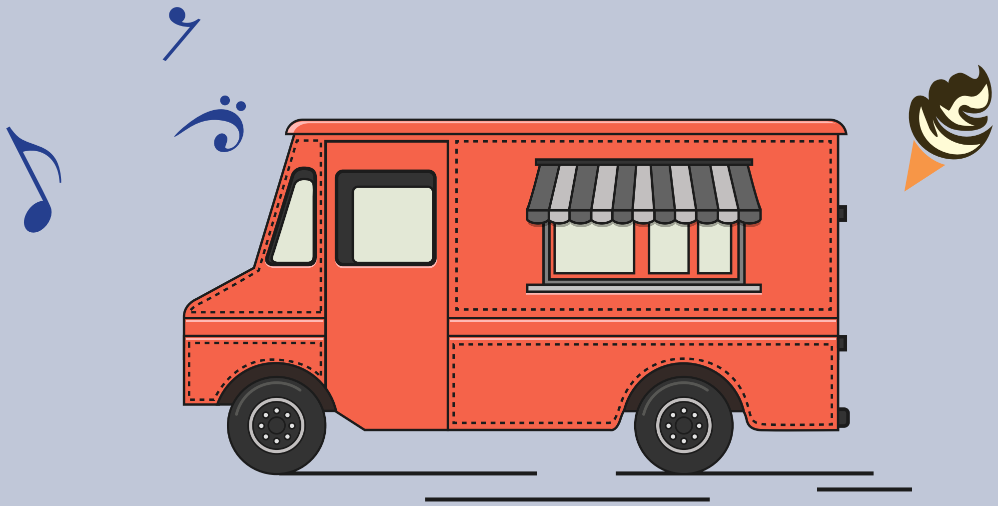
In a theme-based hack night, the group can assign a theme to a given month. For example, Halloween sparks a lot of interest in costume design, therefore, October could have the theme of “Hacking Halloween.” Now if someone has the idea of building an eight foot tall fully functional Hulk Buster suit equipped with lights, sounds, and an internal cooling system for the operator inside...start on this project long before October. By the way, this has been done and makes for a great “Trick-or-treat” photo. The important thing about any hack night is to be open and to share knowledge and talents with those who are interested.

Theme Based Hack Nights:

Event based hack nights are great for public outreach and engagement. Some examples of events for hack nights are:

- BBQs with music and games
- Having a food truck cater food while the group makes homemade ice cream
- Competitions to build the most unique "Corn Hole" game. Build one using 6 ft. boards, and bean bags made from a pillowcase.
- Build a cheeseball shooter! Yes, it literally shoots cheeseballs in mass and is so much fun, especially when unsuspecting patrons walk through the door.

Obviously anything with free food is a big winner when engaging the general public, but when building membership, these are the best ways to demonstrate what a Makerspace community is about!



Design Challenge Ideas

Bridges/Structures:

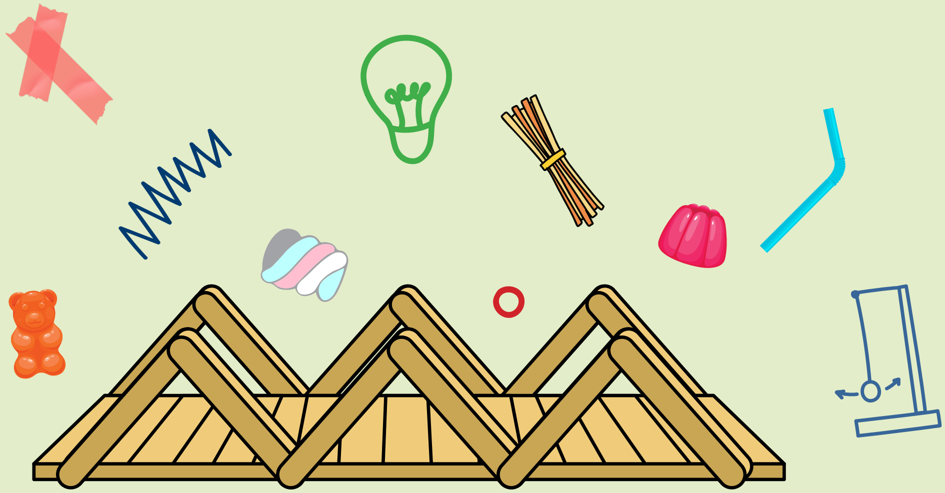
Challenge the team(s) with specific criteria that require them to design, build, and determine a solution. Encourage participation to think out of the box to spur innovation.

Goals: Design a bridge that can support weight on top (static load), have an object roll over top (dynamic load), or is tall enough for an object to pass under the structure.

Materials: Materials can include straws, popsicle sticks, marshmallows, gummies, uncooked spaghetti, tape, and other inexpensive household materials.
Be creative!

3D printer: A 3D printer can be used to construct different sections of the bridge. Don't have access to a 3D printer? Try the local Makerspace or library for instrument availability.

Challenge: Challenge some friends to build a structure that can support the most weight, or reach the tallest height without falling.



Gangplank's Manifesto

Example of a Manifesto outlining values and principles of a real-life Makerspace.

We are a group of connected individuals and small businesses creating an economy of innovation and creativity. We envision a new economic engine comprised of collaboration and community, in contrast to silos and secrecy. We have the talent. We just need to work together. Different environments need to overlap, to connect, and to interact in order to transform our culture. In order to create a sustainable community based on trust, we value:

This new economy cannot thrive without engaging the larger business, creative, entrepreneurial, governmental, and technical communities together.

We believe that innovation breeds innovation. We will transform our culture into one supportive of the entrepreneurial spirit, of risk taking, and by pioneering into the unknown territories as the founders of our municipalities once did. This requires education, entrepreneurship, and creative work spaces.

How to be a Maker

"Always begin with the end in mind."
"Create a vision of your highest goal, and make tiny steps every day that bring you closer to it."

– CIA Scientist

Solution

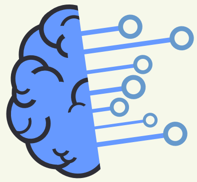
Don't be afraid to stand out from the crowd and think differently.

Remember that failure is all part of the learning process.

Be curious about the world around you.

Research things you are curious about and experiment with your own solutions.

Innovation



Engineering

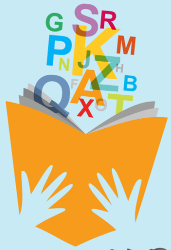
Science

Thinking

Always strive to make a difference in the world.

research

Never give up! Never stop learning!



Study

Learning

Activities & Topics

Electricity/Circuits: Can build off basics but using kits off the shelf may get expensive. For example, "Radio Shack 60/100/200/300-in-one kits".

Rubber band planes/pinewood derby car: To change this from a normal 'cub scout' activity, have each team modify their plane/cars for different performance/criteria. For planes – vary wing shape, add turns. For cars – vary weight distribution, size, and shape.

Arduino based: 101 basics, advanced coding, sensors/interfacing, controllers/state machines, complex modules, interaction with users.

Raspberry Pi based: 101 Linux basics, Linux coding (python, scripting), Interfacing the Pi, sensors/controllers with the Pi.

Computer Science: Python 101 (learn language), Linux 101 (learn OS), Data logging (computer alone, Arduino/Pi assisted) and big data concepts.

> Teach about computer networks (Ethernet, TCP/IP, packets, etc.) normally IT and Tech topics. A class room of R-Pies could be interconnected.

Computer Engineering: Any of the hardware/software topics above. Computer logic/circuits, using soldering/breadboards. Devices like flip flops can be built from primitive parts or exercised on logic chips to show memory.

Mathematics/Statistics: Combine with data gathering/logging, display & analyze results. Computer math via binary/hex and circuits like the half & full adder. In conjunction with design & measurement: fractions, conversions, accuracy/estimation.

Life Science/Biology: Experiments with plants, insect collection. 'Play act' reactions can be made with 'building sets'/paperclip models.

Chemistry: Safely doing interesting chemistry is hard. Cooking/kitchen chemistry is a good way to make controlled experiments.

Aerospace: Rocketry, forces on aircraft, gliding, quad copter/helicopter projects.

MAKERSPACE IN ACTION

Made You Blink

Getting started with Arduinos

What is an Arduino? It is not a fantastic beast from a movie. It is an electronics platform for students interested in programming. What does an Arduino do? Almost anything you want it to! It reads inputs such as a button press or a light shining on a sensor, and it turns it into an output like turning on a light or even sending a Twitter message. How do you get started? Step one is to get an Arduino. Kits are for sale on the Internet. Many schools and libraries have them available. Maybe you know a local Makerspace that teaches you how to use them. They are easily available.

Once you have your Arduino, you need to download the Integrated Development Environment or IDE onto your home computer. The IDE is available at https://www.arduino.cc/en/software. The IDE is available for Windows or Mac, so be sure to download the correct version!

Once the IDE is installed on your computer, you need to set up the software to match your particular Arduino, since there are many types. Next you set up your communications port to talk to your Arduino. Someone who is familiar with computers can help you.

Programming

The Arduino uses a version of the C programming language. It is easy to learn and there are many books available on how to program. A very simple program called Blink is useful to test your setup. It will help ensure that you have selected the correct Arduino board in the IDE and have the right communications port to talk to your Arduino. A copy of Blink is available in the IDE. Just select **File/Examples/01.Basics** and you will see it as one of the available selections.

Now, let's explore Blink. An Arduino program has three basic parts, the Declaration, Setup, and Loop. The Declaration contains calls to libraries and definitions. These libraries contain computer code that make it simpler to use other electronic components available for your Arduino such as displays or sensors. Libraries can save having to write the detailed code to make a character such as an "a" appear on a display. Blink is a very simple program, so it does not use any libraries or declarations.

The Setup portion is next. Here is the setup for Blink:

```
// the setup function runs once when you press reset or power the board
void setup() {
        // initialize digital pin LED_BUILTIN as an output.
```

The steps of the setup function are contained between the two curly braces "{ }" and they tell the Arduino what each of its pins will be doing. The Arduino pins are where you connect the inputs and outputs. In this case, set the mode of operation of the built in Light Emitting Diode (LED) to be an output. Each statement ends with a ";". Statements beginning with "//" are comments and do not affect the program, helping understand what is going on in the program.

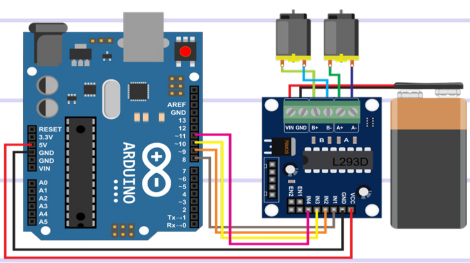
After "setup" we have the "loop." This is the section of the program that will run repeatedly. Normally, a loop like this is a problem in a computer program, but not for Arduinos. In the loop, the Arduino constantly checks the input pins for changes. Then, based on those input changes, makes changes to the outputs.

```
// the loop function runs over and over again forever
void loop() {
digitalWrite(LED_BUILTIN, HIGH); // turn the LED on
(HIGH is the voltage level)
delay(1000); // wait for a second
digitalWrite(LED_BUILTIN, LOW); // turn the LED off by making
 the voltage LOW
```

Like the setup function, the steps in the loop are contained between the curly braces. The comments in the program tell exactly what is going on. The LED is turning on and off every second. This will continue as long as the Arduino has power.

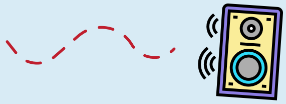
"Like many first time users, I started with this very basic program just to see if I could do it. Once I did, the Arduino became a mainstay in my home makerspace for projects."

- CIA Electrical Engineer and Radio Expert



What's Next?

Can you get an Arduino to blink? If so, then you are ready to move on and make the Arduino do other things. Getting an Arduino to blink is a great first step into the world of computer programming, electronics, and STEAM.



References

Websites

- https://arduino.cc/en - hardware and tutorials
- https://adafruit.com - hardware, tutorials, and project ideas
- https://www.sparkfun.com - hardware

Books

- Beginning C for Arduino, Jake Purdum, Apress, 2012
- Arduino Technical Reference, J.M. Hughes, O'Reilly Media, 2016
- Arduino Cookbook, Michael Margolis, O'Reilly Media, 2016

Cicada Sidewalk: Arduinos in Art

Putting the "A" in STEAM

"I was excited to collaborate with my artist spouse and use my makerspace at home to contribute to a multi-media work. Who says engineers can't do art?!"

- CIA Electrical Engineer and Radio Expert

You might remember the cicadas from the summer of 2021. A group of artists were challenged to create an artwork with the Brood X Cicada as the theme.

To fully experience the Brood X, the artist thought the visual presentation needed to be augmented with their most noticeable feature, the sound. The artist talked with an engineer who happened to be familiar with the Arduino. The engineer knew that the Arduino could be programmed to reproduce sounds. Searching the Internet to see if there was a simulation or recording of cicada that could be used, a simulation was found and it was incorporated into the system.

To enhance the visual, the engineer also found a 3D printable version of a cicada and was able to print one on a 3D printer. To have a little more fun, the printed cicada was modified to incorporate two light emitting diodes (LEDs) in the eyes and connected them to the Arduino such that they lit up when the sound played.

Finally, a motion sensor was added to start the sound when someone neared the installation. This added an element of surprise and helped prolong the battery life of the installation.

Here is the full installation. In addition to the sidewalk full of cicada wings, the artist created a tree stump to hide the Arduino and mount the 3D printed cicada.

Below is a close up of the element hiding the Arduino. In addition to the bright red eyes, notice the hole in the tree stump that allows the Arduino's motion sensor to see when someone walks by the installation.

Cicada Sidewalk was displayed in the fall of 2021.

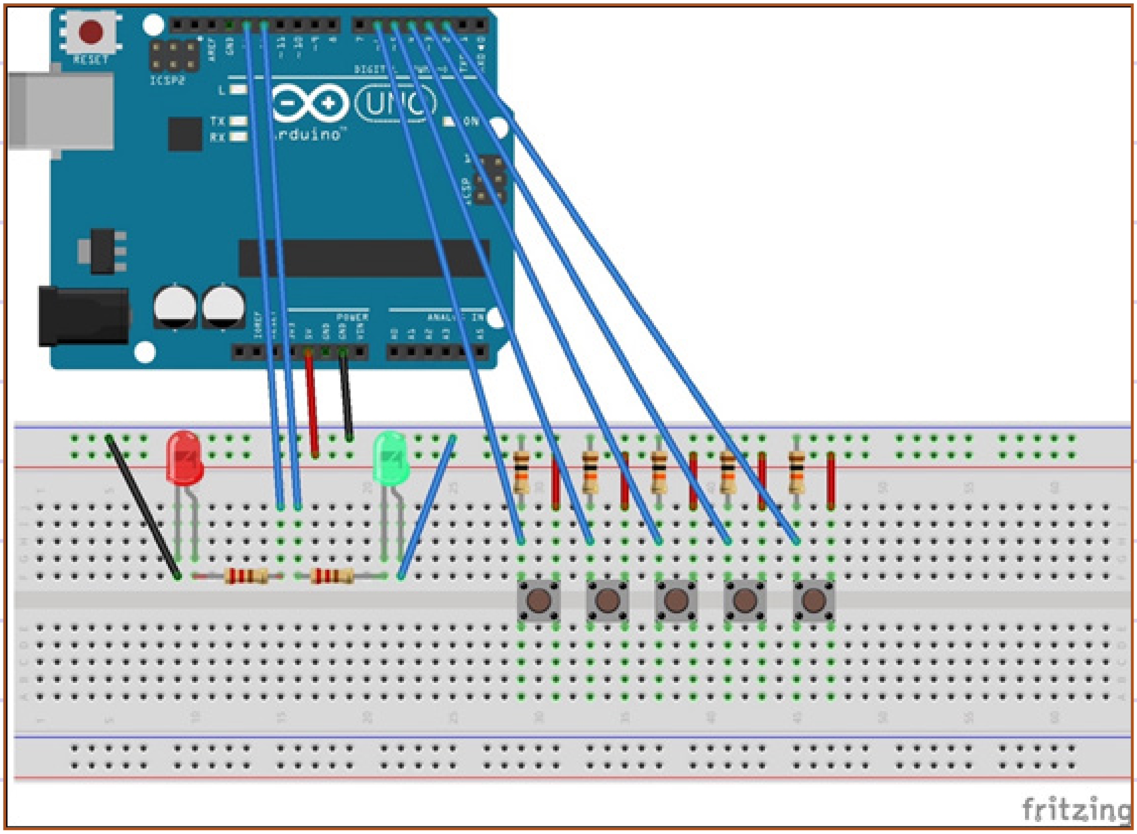
Arduino Challenge

At the CIA, it is important to keep secrets safe. Use an Arduino to create a digital lock. In the circuit below, LEDs are used to indicate locked and unlocked positions. How might the hardware be changed to lock a box or a door? How would a battery be opened? What happens if the battery goes dead? Questions like these are what Agency engineers have to answer when they have to build something to keep secrets safe.

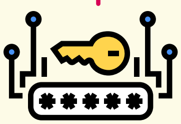
"Here is a project which you can use and makes you ask and answer the same types of project questions that our engineers do. I hope you have as much fun as I did!"

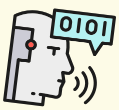
- *CIA Electrical Engineer and Radio Expert*

The Arduino below is connected to five push button switches and two light emitting diodes (LEDs). The red LED is lit when the lock is engaged. The green LED lights when the lock is open. The declaration section and the setup section of the code have been started. Write the code for the loop section that would operate the lock.



```
// Arduino Challenge - Lock
// Declarations
// Give a name to each button and assign it to an Arduino I/O pin
#define Button_1 6
#define Button_2 5
#define Button_3 4
#define Button_4 3
#define Button_5 2

// Assign a name and pin to each LED
#define RedLED 13
#define GreenLED 12

void setup() {
// put your setup code here, to run once:
// Set the buttons as inputs.
pinMode(Button_1, INPUT);
pinMode(Button_2, INPUT);
pinMode(Button_3, INPUT);
pinMode(Button_4, INPUT);
pinMode(Button_5, INPUT);

// Set the LEDs as outputs
pinMode(RedLED, OUTPUT);
pinMode(GreenLED, OUTPUT);

// Set the LEDs to the initial conditions, the safe is locked
digitalWrite(RedLED, HIGH); //Turn on the Red LED
digitalWrite(GreenLED, LOW): //Ensure the Green LED is off
}
```





```
void loop() {
/*
Repeatedly "digitalRead" the buttons to see if they have been pressed.
Use an "if" statement to see if the correct buttons are pressed in the correct
order. Use a counter to keep track of the combination. The counter
increases by one each time the correct button is pushed.
The counter can be reset to zero if an incorrect button is pushed.
*/
Combination_Counter = 0;


// Enter code
// If the correct combination has been entered, turn off the red LED and
turn on the green LED for 10 seconds.
// After 10 seconds the door gets locked again, the red LED is on and the
green LED is off.
}
```

The Design: DC Motor

How Does an Electric Motor Work?

A Makerspace Lab for all ages

How Electricity Flows:

- All matter is made of atoms. The center or nucleus is made of Neutrons (no charge) and Protons (positive charge). Orbiting around the nucleus is a cloud of Electrons (negative charge).
- If there is a missing electron, the atom has a positive charge. If there is an extra electron, the atom has a negative charge.
- A stream of electrons can move near the speed of light (186,000 miles per second!) and impart a lot of energy. Moving electrons create an Electric Current measured in Amperes, typically shortened to Amps. 1 Amp of current is equal to 1 Volt of electric potential, similar to a battery, over a 1 Ohm resistor.
- In Electrical Engineering, the relationship of Amps = Volts /Ohms, or more typically Volts = Amps x Ohms is called Ohm's Law. It's normally written by the variables V,I, and R as V= I x R.
- Electricity flows best in conductors like copper wires, and flow very slowly or not at all in insulators.

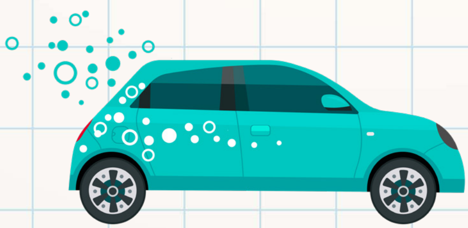
Generating Electricity: AC vs DC

- Direct Current - electricity flows in only one direction through a conductor.
- Alternating Current - electricity alternates in direction or polarity.
- These activities use DC power like batteries and USB chargers provide. The power in your home's wall socket is AC power. A converter is needed to change between AC and DC power.

- Batteries when in a circuit, allow electrons to flow one way from the Negative (-) side through the circuit to the Positive (+) side. If there is no circuit between + & - contacts, the battery will store its energy for a long time before it self-discharges or gets used again.
- Generators, like the ones at the power company, spinning coils inside magnets generate AC power as long as the coils rotate. AC power can be transmitted longer distances than DC power with fewer losses.
- In both cases, the flowing electrons carry a lot of potential energy and can do physical work (motors, speakers), logical calculation (digital computers), and provide illumination (lights).

Magnetics and Electricity

- Some materials are naturally magnetic and have two poles, a North and South. Using two magnets - like poles repel while different poles attract. A compass next to the magnet will help determine the polarity of the magnet
- Using DC power, send a stream of electrons down a wire (a conductor) to create an electromagnet. When the current flows, the coil will create a magnetic field. If a steel nail is put in the middle of the coil, it will magnetize and have a N and S pole end.
- A motor requires electric force to alternate and induce a magnetic field that causes motion.
- An AC motor alternates the poles over time, so the rotor can be a magnet and the outside coils are attached to an AC power source.
- A DC motor is a constant source. To cause an alternation in the power source a permanent magnet and coil are still used.
- DC motors use a commutator as a rotating switch to interrupt the circuit and reverse the polarity of the coil. The changing fields will cause the motor to keep rotating once in motion.



Optional:
If you have a Multimeter available...

- Meters can be Analog (moving needle in an arc) or Digital (7-segment display elements). Meters can be inexpensive, typically have a battery inside, and come with a set of probes.

- Some meters have set ranges (Ohms, Amps, Milliamps, 1-10-100 volts) while others have automatic ranges by function. Be sure to turn them off when not in use to save the batteries!

- Basic Uses:
  - Volt Meter (DC or AC), measured from (-) to (+) or from Source to Ground, typically in parallel (across a part)
  - Current Meter (DC or AC, Amps/Milliamps), measured in series (in circuit)
  - Ohm Meter (Resistance), measured across a part
  - Continuity: checks for a conductor between points, can buzz or display resistance slowly or not all in insulators.

- Example Use: Measuring across a new AA battery in DC Volt meter mode, the voltage is around 1.5 VDC. If the voltage is -1.5VDC, the probes are backward!

Basic Electronics Safety

Battery Safety:

- Do not short two sides of the battery with a conductor or wire. This will create heat and quickly drain the battery.
- Keep batteries away from younger children, they are a choking hazard.
- Dispose of dead batteries safely according to local laws.

Magnet Safety:

- Keep magnets away from younger children, they are a choking hazard.
- Some rare earth magnets are very strong, be careful handling them. Magnets can shatter if two are forcefully slapped together hard.

Multimeter Safety:

- Keep your fingers on the grip/non-conductive part of the probes. Don't touch the metal tips when measuring.
- Never exceed the electrical rating of the Probes or Meter – a fuse can blow inside the meter and damage equipment.
- Don't let the probe metal tips touch or cross – they can cause a short circuit by putting a conductor across both poles of a circuit (+ and -, or source to ground).
- Set the mode of the meter and plug the probes into the correct ports before attaching or touching the probes to a live circuit.
- Always wash hands after working with electric parts to wash off any oils/chemicals that could be present. Don't drink open containers/cups around your workspace, liquids can short electronics and cause damage.

Design Your Own DC Motor

"Seeing what you built in motion is exciting, but don't fret if you need to try multiple times to get it to work. I had to make changes based on the materials I used and check for wire contact step by step. Troubleshooting skills take time to learn but pay off big in the real world."

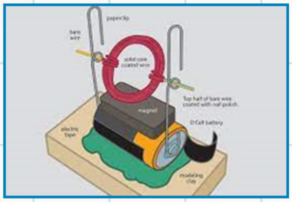
- CIA Computer Engineer

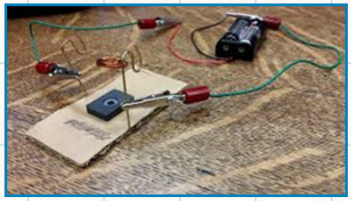
- The paper clips are conductors for the (+) and (-) sides of the battery
- The handmade coil of wire will be an electromagnet when energized
- The commutator feature will be made from the way the magnet wire is stripped to expose the conductor – it only makes a circuit for part of the time it spins.
- The permanent magnet provides a field to cause the energized coil to push against/be attracted to depending on the polarity.

A Homemade DC Motor: The Build & Testing It Out

1. Bend two paper clips as shown – the center will be where the coil rests & the axis it will spin on.
2. Build a small wire coil with two long axels. The coil should be about the circumference of a quarter. If too large, the coil will hit the battery & magnet.
3. Strip one side of the coil wire completely (conductor exposed 360 degrees).
4. Strip only the top side of the coil wire on the other side (conductor exposed on only the top strip of the wire (The rest has insulator still).
5. Mount the fresh AA battery on either the workspace or in a holder to anchor it. Use tape as needed. Tape the permanent magnet on top of the workspace or a piece of backer material.
6. Attach the paper clips to the backer material, space them so the coil rests in between the clips and can spin freely.

7. Attach the alligator clips to both sides of the battery, then one at a time attach the (-) side clip to one paper clip and the (+) side clip to the other paper clip.
8. The coil should spin once the battery is hooked up, you may need to give the coil a small push to get it spinning.





The DC Motor: Troubleshooting and Questions

Having trouble? Remove the alligator clips first:

- Use fresh batteries. If available, check the battery with the Multimeter.
- If the motor doesn't freely spin: Push the coil over once to get it going, check the paper clips are not too tight so the coil rests freely on the two clips.
- If the motor doesn't want to spin and battery is good: Check that the magnet wire is properly stripped on each side – remember one side will be completely exposed conductor and the other will only have one side exposed while the other is covered.
- If too much wire is stripped from each side: Try an ink marker or even White-out correction fluid to put an insulator back on the exposed conductor.
- The coil may require more loops/windings – the stronger the magnetic field.
- Try a new spare battery if the battery is too weak.
- Use tape as needed to keep the clips properly spaced and brace them so they don't fall down.
- The Multimeter can be used in continuity mode to check the clips are in-circuit and see if the coil properly interrupts the circuit when it spins. Don't connect the battery when checking this.
- The Multimeter can see the Voltage across the coil if each probe is touched to a different paper clip when in circuit with the battery attached.

What Do You Think?

- With a multimeter, find the current flowing through the coil.
- Extra clips & wire: Modify the setup to work without the permanent magnet.
- What things can be done to make it spin faster?

Links & Resources

Kits

- World's Simplest Motor™, Electricity & Magnetism: Educational Innovations, Inc. (teachersource.com)
- Search under "World's simplest motor kit" will turn up other kits

YouTube Explanations

- Build a Simple Electric Motor - YouTube
- HOW TO BUILD A SIMPLE ELECTRIC MOTOR - YouTube
- Simple DC Motor Explained - YouTube
- HOW TO BUILD A SIMPLE ELECTRIC MOTOR - WITHOUT PERMANENT MAGNETS - YouTube

Further Reading & More Ideas

- Scherz, Paul and Monk, Simon (2000-2016) Practical Electronics for Inventors; McGraw Hill Education, New York, NY.
- Mims, Forrest M. (1987) Getting Started in Electronics, Archer, New York, NY

For more ideas, see CIA Website

https://cia.gov

Take one of the challenges
on the Spy Kids website at
https://cia.gov/spy-kids