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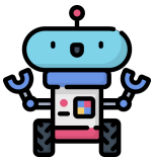
Build-a-Bot Packet

Power up your 3DuxDesign projects! Bring them to life with the Build-A-Bot Accessory Set and Project-Based Learning Resources for grades 3-5 and 5+. With this add-on kit, your engineers will be introduced to electricity, circuits, friction, mass, forces, design thinking and the engineering design process.

For the 3DuxDesign Build-A-Bot Project, you will need:

3DuxDesign Modeling Materials (sold separately)	
3DuxDesign Build-A-Bot Accessory Kit	
3DuxDesign Build-A-Bot Educator Packet	
facilitator tutorial https://bit.ly/3duxbuildabotguide workshop recording https://youtu.be/Vf7aKNqaznk	



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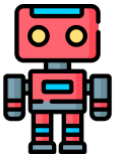
Build-A-Bot Project grades 3-5 Facilitator Guide



Overview of project:

- Students will explore basic concepts of mass, friction, transfer of energy, circuits, and electricity
- Students will use their knowledge to prototype a motorized bot and understand that different forces affect an object's direction and velocity
- Students will use the engineering design process to ideate, design, build, test, observe, and redesign their bot to travel in a straight path.
- Students may consider adaptive devices to assist their bot in travel.
- Students will collect data, draw conclusions, and draft a final bot design
- Students will gain life science knowledge as they choose an endangered animal for their bot and use digital literacy skills to research the natural features, habitat and survival needs of the chosen animal.
- Students will create an animal report, design a nature preserve site map, and include at least three natural resources needed for survival and one hazard.
- Students will create a barrier to protect their bot from potential hazards.
- Students will create a story and presentation for their bot based on their research and project.
- Students will build and decorate the final bot preserve in preparation for their bot's "release" into the preserve
- Students will release their bot into the preserve and determine if it can survive (access survival needs and protection from hazards).

- *Optional: Facilitators may expand the project, employing digital technology tools and applications available for students to create a final presentation that describes their animal, habitat, traits, and a story. Digital presentations may be submitted for publication on the 3DuxDesign Student Showcase*

Learning goals:

Physical science: friction, mass and forces, electricity, and circuits.
Engineering design - How friction and mass can affect bot design
Computational thinking (all ISTE standards)
ELA - creative story writing, research, presentation (speaking etc)
Math - basic geometry /measuring
Life science habitats, adaptations, endangered species
Digital literacy through animal research

Optional extension: Technology integration for presentations

Materials:

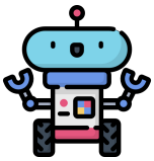
- Build-a-bot set (8 bot sets including: 1 motor, lithium 1 coin battery, 1 on/off switch, 1 LED light, 1 pipe cleaner, conductive tape, 2-sided

adhesive tape, assorted googly eyes, 1 "duxit" ruler, 1 sand timer, 1 student booklet)

- Any 3DuxDesign kit with both cardboard and connectors. (GOBOX, GOBOX-PRO, GO-pack maker kits, Mini-maker kits)
- Scrap paper 8.5 x 11" - smooth ideal for fasterr-moving bots. * If you have a laminator you can opt to laminate the paper after students complete their site plans.
- Scissors
- Markers
- Pencil
- Clear tape

Optional materials need to be available to all teams:

- Hole puncher
- Assorted craft materials like string, straws, pom poms, popsicle sticks, etc.
- Laminator (to make student preserves smoother for bots)



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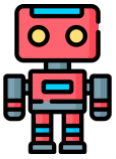


Lesson plan part 1, Building a Bot

Class Discussion: Bots, Physics, and Electricity

1. **What is a bot? (5-10 minutes)** (Adapt based on age group)

A bot is a model of a character, creature or object that moves by transfer of kinetic energy from a spinning motor causing vibration, through the robot to the ground. (Slideshow/video)

2. **The anatomy of a Bot. (5-10 minutes)**

What can we use to make a bot? We can make bots out of many materials including crafts and up cycled materials, but they must contain at the minimum, a motor, a battery, and wires (or conductive tape) to create a closed circuit. (Share video of a variety of cool bots)

3. **Project Overview for students. (2 minutes)**

Our goal will be to design, build and adapt a bot that will turn right, turn left and go straight quickly. In part two of the project, we will choose an endangered animal for our bot to represent and create nature preserves to help protect them.

4. **The Science behind a Bot (30-120 minutes depending on depth)**

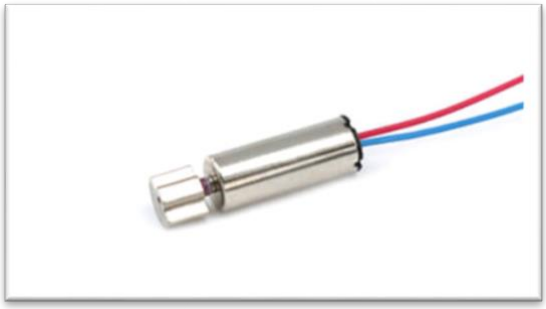
Discuss basic concepts of physics that will help students create a bot to perform it's intended function. The depth of discussion will vary based on student age and pre-existing knowledge. Student handouts are also available to support learning.

Newton's First Law

Definition: An object at rest stays at rest and an object in motion stays in motion with the same speed and in the same direction unless acted upon by an unbalanced force.

Example: Unless a force is applied to the robot (a push, pull, motor turning) the robot will stay at rest. It will not change direction or speed unless a new force is applied.

Because the motor used is unbalanced (look closely at the spinner), the direction of the force is constantly changing as the motor spins. Therefore, the bot tends to spin as well. Imagine an unbalanced washing machine that wobbles.



Newton's Second Law

Definition: The change in velocity of an object is directly proportional to the amount of force applied to that object. The more force exerted to move an object the faster the object will move. However, if the object is twice as massive

twice the force is needed to move the object at the same rate. The lighter the bot the less force it needs to move, therefore a light bot is more likely to move faster.

Electricity
Facilitator may guide students through the worksheets or use student worksheets to discuss electricity concepts

Friction
Facilitator may guide students through the worksheets or use student worksheets to discuss friction concepts

Vocabulary terms (more term available on student worksheets)

Mass = The amount of matter within an object.
Volume = Amount of space an object takes.
Density = The amount of mass within a certain volume. Density = mass / Volume
Friction = The resistance that one surface or object encounters when moving over another.
Electric Current = The movement or flow of electrically charged particles.
Example: The flow of electrons in a wire when connected to a battery.
Electric Circuit = An electrical device that provides a path for electrical current to flow.
Example: The connection between the positive terminal of the battery, the motor, and the negative terminal of the battery is a circuit.

5. **The Engineering Design Process (EDP) (5 minutes)**

The engineering design process involves solving a problem through prototyping, testing solutions, refining design until the problem is solved. In this project, students will use their understanding of physics and the engineering design process to build a bot that can travel in different directions. Here is a wonderful short video to share with students about the EDP

Activity1: Build-a-Bot Prototype (1 to 1 ½ hours)

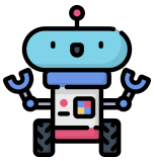
- Teams of 3-4 students will use 3DuxDesign cardboard, connectors, and Build-A-Bot Kit materials to create a simple circuit using the motor and batteries. Here is a diagram to help your students learn a bit more about circuits
- Students will observe the "natural" tendency of the bot based on the first design.
- Students will use the engineering design process alter the design of their bot to achieve different goals:
    - Turn right
    - Turn left
    - Travel in straight path

This may be done by …

1. manipulating mass distribution altering the center of gravity
2. altering friction by using different connectors
3. altering friction by adding appendages (or "assistive devices")
4. changing the orientation of the bot (upright vs crawling position)

- Here is a short video that might help you explore adaptations to design might affect mobility
- During the design process, students will document observations, make predictions as to how to improve outcome, rebuild and then test.
- Students should repeat this process multiple times until they achieve the desired outcomes. Students can use the ED worksheets to document their journey.
- Students should be prepared to explain why adjustments made result in a change in direction/velocity of their bot



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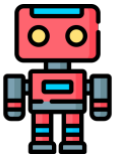


Lesson plan part 2, Bringing our Bots to Life

Class Discussion: Life Science (1-2 hours depending on depth)

Students will learn about animals and habitats, choose an animal for their bot, research their animal and then incorporate their new knowledge into a themed nature preserve.

Facilitator may adapt or expand a class discussion based on grade level and learning goals. Discussion may include:

- Characteristics of living and non-living things (video resource)
- Relationships between animals, plants, and the environment / food chains (video resource)
- Essential life needs
- Life cycles (fun 3dux life cycle project)
- Habitats(assorted resources)
- Adaptations (video resource)
- Endangered species (WWF learning resources)

Discuss survival needs of all life forms, animals, and review vocabulary based on grade and learning standards.

1. Classification and nomenclature (genus and species)
2. Habitat
3. Biome
4. Population
5. Diet and dietary types
6. Adaptations for survival
7. Predators
8. Food chain

Activity 2: Create a Nature Preserve an Endangered Bot

Students will be instructed to design their bot to represent an endangered animal species of their choice. They will design a nature preserve that includes at least three essential elements needed for its survival and at least one potential hazard. They will create a barrier to protect their animal bot from danger while allowing free movement for access to all elements it needs for survival. Students may create a story and presentation based on their project.

- We recommend this video as introduction to nature preserves https://youtu.be/-W96c5biZoo
- Choose an endangered animal for their bot to represent. Here are some resources: https://www.worldwildlife.org/species

https://animalfactguide.com
https://youtube.com/playlist?list=PLQInTIdJs0ZSj-wK7xeOgIfd0c4IOgmVq

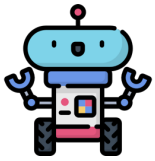
- Research their animal species
- Create a report on their animal including description, habitat, behaviors, special adaptations, risks to survival and any other items needed based on grade/learning goals
- Create a Bot ID Card
- Create a 1-2 paper sheet "nature preserve" depicting that animal's natural habitat, at least three essential elements needed for its survival and at least one potential hazard. They will need to create a barrier to protect their bot from danger while allowing free access to survival needs. Materials for this should be the same for all groups
- Decorate and do final prep for bots and preserve.
- "Bot Release Day" Challenge. Student teams will activate and release their bot into the "safe zone" of the preserve with a goal for the barriers created to keep their bot withing the area designated for survival. Using the 1-minute sand timers, students will aim to flip the timer 3 times for a total of 3 minutes without the bot escaping into the "danger zone".
- Create a presentation/story** that helps highlight key animal features, their bot design, their preserve design and their bot's success/challenges during the project.
- Student Choice Awards. Each student votes on the best bot and presentation. They cannot vote for their own bots.
- Scoring sheets. Facilitator will grade each project from 1-5. Student team will tally up their scores using the Bot Scoring Sheet.

**Presentation (1-5 hours)

This may be live or include technology and digital applications for a video presentation.

Live presentations should include a description of the bot design, bot challenges and successes, the endangered animal species, the nature preserve design, students story, and either recap or reenactment of "Release Day".

Digital presentations (video, photography, creative writing) under 7 minutes may be submitted to 3DuxDesign for acceptance onto the Global Student Showcase on the 3DuxDesign website for families and 3DuxDesign Community members to enjoy. The Student Showcase is public so please submit only materials that can be posted. Projects admitted to the showcase will receive special 3DuxDesign awards based on innovative and creative projects.



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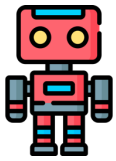
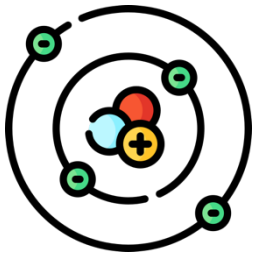


Learning about electricity, circuits and physics is much more fun when you work together to build your own Bot!

What is electricity?

Electricity is a type of energy that can flow from one place to another. It is a huge part of your everyday life. For starters, it keeps your home and school warm in the winter and cool in the summer. It is used to make your lights, microwave, and hair dryer work.

To understand electricity, you must first understand what an **atom** is because electricity comes from atoms. Everything in the universe is made of atoms. Atoms are tiny particles (way too small to see without special microscopes). They are so small a single ant is made of billions of atoms!



Atoms have three parts. The center (called the **nucleus**) is made of **protons** (which have a positive charge) and **neutrons** (which have no charge). The outer part of an atom has **electrons** which have a negative charge. Electrons can float and spin (or **orbit**) around the nucleus, but they typically stay close because the negatively charged electrons are attracted to the positively charged nucleus. But electrons can also float from away from one atom to another. The flow of electrons from one material to another is called **current electricity**.

Electricity is made from releasing energy stored in materials and other natural sources by the flow of electrons to another material.

Where does electricity come from?

The easy answer is that it comes from a socket in the wall. But that's not where it really comes from. It starts with an energy source like wind or solar power. This energy is then **converted** into electricity as electrons flow along wires and ultimately travel to your home. Electricity can

be stored at your community energy station and flows along wires to get to your home. It can also be stored in a **battery**. We will be creating circuits with batteries in our project.

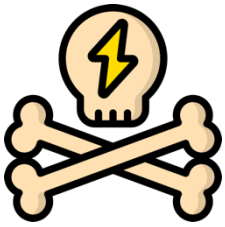
When electrons flow from the negative side of a battery, through a conductor (metal wire) and then to the positive side, that is a complete circuit, or a closed circuit. This creates current electricity. If you connect a conductor directly to both sides of a battery, it's called a **short circuit.** When you create a short circuit, two things happen…

1. you waste the electricity because this will drain all the energy out of the battery
2. the wires will get **REALLY HOT!** A short circuit is something that should NEVER create. It can cause severe burns and fires.

The same is true for the electricity that comes through the wires in your home.

But if you put a **resistor** somewhere along the circuit, the electricity can be used to power something. A resistor (also called **a load**) can be a light bulb, a motor, an appliance in your home, a car and lots of other things. If there is a load along the circuit, much of the energy is used by it so there is less energy being release as heat. The wires won't get quite as hot (but they can still burn you). When you add a light bulb, the energy is seen as light. When you add a motor, the energy is used to spin the motor.

Have you ever noticed that all electrical wires in your home are covered in plastic or rubber? Metal is a **conductor**, so electricity can flow through it. But conductors that have current electricity going through them can get very hot. Plastic is called an **insulator**; electricity cannot flow through it. When you touch the plastic-covered wire, you will not get a shock or hot. If you were to put uncovered metal into a socket, you would get electrocuted!

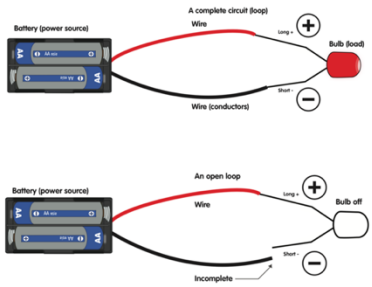


The Simple Circuit

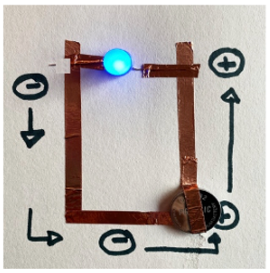
We know you are excited to power up your Bumble Bee Bot. We are too. But first we need to review a few things about electricity.

Electricity, as you know, is a form of energy. It can flow through conductive wires or stored in one place, like in a battery. When it stays in one place, it is called **static** electricity, and when it flows, it is called a **current** (like water flowing in a river). For this activity, you will be making the electricity flow from the battery to the load that you want to power up (like a motor) and then back to the battery. You will be creating a loop, or a closed circuit.

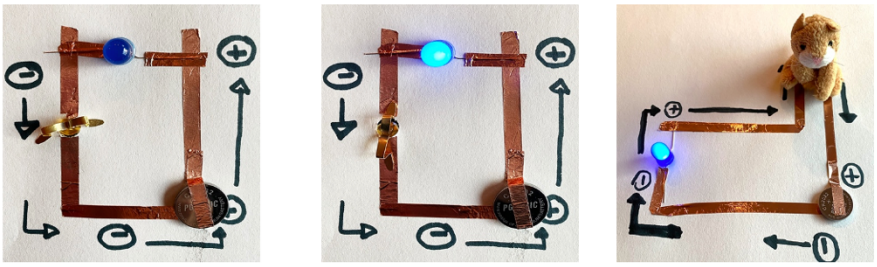
Simple circuit open/closed



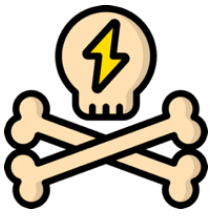
simple circuit



Simple circuit with switch off/on/conductive kitty (copper on bottom)

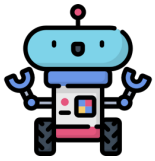


We will be using a special kind of load called a vibrating motor and a special type of battery called a lithium button battery. These batteries are small and safe to use for activities but are **poisonous** if eaten!



FUN FACT: How much energy is stored in a battery is called a volt. A battery needs to have enough volts to power different loads. Most

lithium button batteries have 1.5-3 volts. Your vibrating motors need 1.5-3 volts. LED lights need 5 volts.



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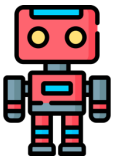
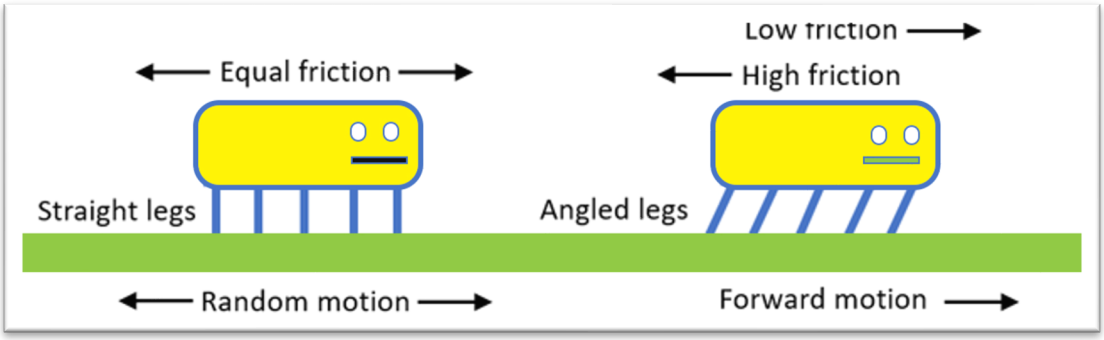
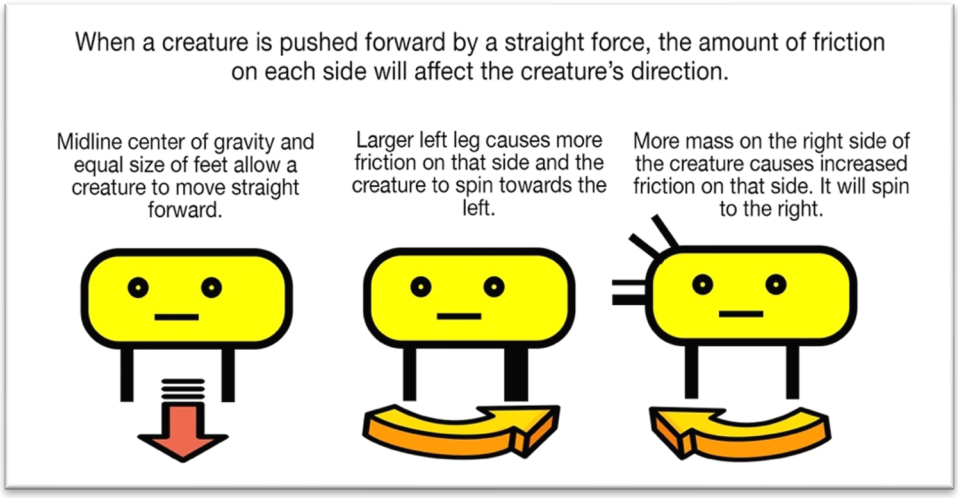


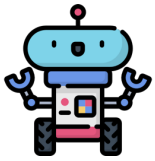
It's all about Friction:

In this activity, the vibrating motors have off-center weights inside. Unlike a balanced motor, they will wobble when the motor inside spins. They are commonly in mobile phones to make them vibrate. Without careful design choices, your Bot will tend to spin in circles. The key to making your bot move in a straight line is **directional friction**. You can do this by making sure the parts of the robot that contact the ground have more friction in one direction or on one side than the other. Think about rubbing your finger along sandpaper—it will be rough in any direction. Now think about petting a dog — it will feel smooth in one direction but rough in the other direction. The same concept is true for your Bot. Bots with slanted legs will tend to move in one direction.



Another way to make a bot go straight is to alter the amount of friction on one side of the bot in an effort to counter it's tendency to spin. The diagram below highlights the concept when there is a straight force exerted on an object.





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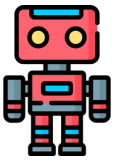

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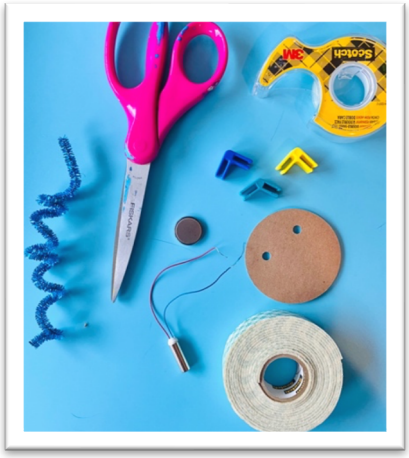
Building a Bot:

materials:

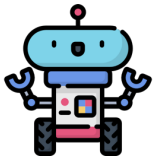
- 3DuxDesign cardboard shapes
- 3DuxDesign connectors
- 6 mm vibrating motor
- 1.5-3V lithium button battery
- tape
- 2-sided foam adhesive tape
- Optional: assorted items including pipe cleaners, toothpicks, Q-tips, straws, switch, LED light, googly eyes, markers and anything else you can think of!



Build a Bot:

Your Bot can be designed and built in a million different ways! The only requirement is that your Bot includes a closed circuit that allows it to move. Depending on the project mission, your goal will be either to design and build a bot that moves straight as quickly as possible or to design a protected Bot Refuge where it can roam free, safe from hazards. In both cases, you will experiment with different sized bots, different appendages in a variety of materials and positions, and any other design features you can think of to satisfy the goal.

Engineers design, build prototypes, test, evaluate and refine. Your job is to use the engineering design process to build a prototype that will satisfy your mission. You will also want to repeatedly document your observations and redesign your bot until you are satisfied with the results.



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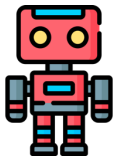


After a class discussion about bots, electricity, circuits and forces, each team will be ready to design and prototype their own bot. Start with a drawing of a closed circuit with battery, motor, and conductive material (wire/copper tape)

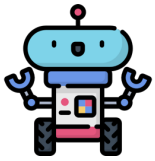
- Use 3DuxDesign cardboard, connectors, and Build-A-Bot Kit materials to create a Bot with a simple circuit using the motor and batteries. Draft out a design before building.

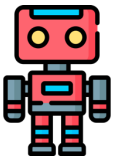
- Once you get your bot moving, take note of how the bot moves. Is it going straight, sideways, spinning left, or right?

_____

_____

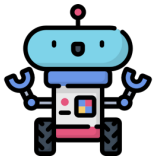
_____





- Now see if you can adapt your prototype bot to change it's direction. Think about how you might adapt the design to make your bot:
    - Spin left
    - Spin right
    - Travel in a straight path

Use the engineering design worksheets to design, build, test, make observations and adjust your design as needed. Document your journey!



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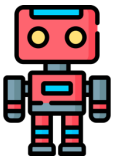
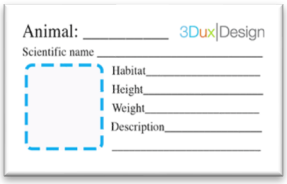


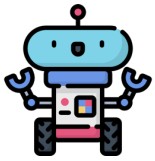
Bring your Bot to Life!

After a class discussion about animals, life science and animal habitats, your mission will be to assign your bot an endangered animal and design a nature preserve to help protect the species.

Once you have chosen the animal your bot will represent, you will need to do some research to learn as much as you can about the animal, it's needs for survival, potential enemies, hazards, and why the species is endangered. Create a report to document and share your discoveries. Don't forget to fill out your Bot's ID card!



Once you have completed this part of the mission, your team can redesign and decorate your bot to represent the animal you chose. Feel free to draft out ideas first.



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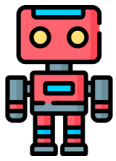


Protect your Endangered Bot

Now that your animal bot is complete with ID card and all, it is time to use your knowledge and engineering skills to create a safe haven to ensure it's survival. Your mission is to design and build **a nature preserve** using the paper (or other material) supplied. This preserve will need to replicate your animal bot's natural **habitat.** Once the preserve construction is complete, you will activate and release your bot. But there are some guidelines:

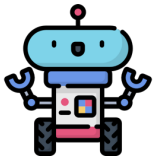
- Preserve needs to be designed to represent the natural habitat of the animal your bot represents.
- The preserve needs to include at least 3 naturally occurring features the species needs for survival.
- Preserve needs to include at least 1 feature that is a hazard to your bot's survival. This hazard can be a naturally occurring element, a human-made element, or even humans
- The preserve should be engineered with a way to protect your bot from accidentally running into the hazard(s) in the preserve. You can use materials supplied to your facilitator to build anything you need to that will protect your bot.

Time for the big Event - Bot Release Day!

Now it is time to test your preserve design. You will activate, release your bot into the preserve, and see if your bot can survive 3 turns of the sand timer supplied (each turn is one minute)

If your bot cannot escape the safe zone in two minutes, your mission is a success! If you bot did escape, you will get points based on how many turns of the timer your bot was maintained in the safe zone.

Document your Bot's results here by circling the correct number:
Our animal bot remained in the safe zone for
0 1 2 3 turns of the sand timer



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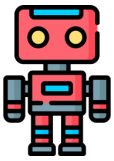
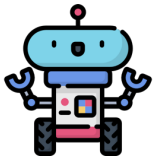


Reflections:

After the race is complete, your team should take time to describe

1. How did you design your bot for speed?
2. Why you chose the materials for your bot?
3. Why did you choose the size and shape of your bot?
4. Describe if your bot was successful. Why or why not?
5. What changes might you make to your bot next time?
6. Describe how you designed the track for your bot
7. Why did you design the track that way?
8. Was the track design successful? Why or why not?
9. What changes might you make to your bot next time?



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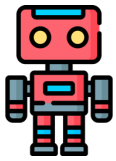


A Day at the Races (advanced version).

Each team will design their own bot track using materials supplied

- Each team will have access to the same track materials
- Teams can add paper, tape or other materials to adjust the speed as long as each team has the same options).
- Tracks can be straight or have turns.
- Tracks may include guard rails
- Tracks need a "start" and "end" sign placed appropriately.
- The center of each track should be the same length. 10-20 duxits (architectural scale) is recommended but this will be determined by the facilitator.

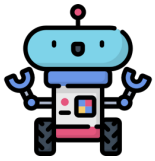
The Rules:

- Once all teams have completed their bot and track design, the game can begin.
- Each team will place their bot at the start of their track
- Your facilitator will call out 3..2..1 GO!
- The Team with the first bot to reach the finish line wins. If a team needs to adjust their bot during the race (which WILL happen), they can, but the Bot needs to begin at the start again.
- First bot to cross the finish line wins!!

Reflections:

After the race is complete, your team should take time to describe

10. How did you design your bot for speed?
11. Why you chose the materials for your bot?
12. Why did you choose the size and shape of your bot?
13. Describe if your bot was successful. Why or why not?
14. What changes might you make to your bot next time?
15. Describe how you designed the track for your bot
16. Why did you design the track that way?
17. Was the track design successful? Why or why not?
18. What changes might you make to your bot next time?



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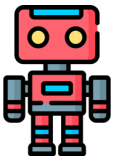
Build-a-Bot Score Card



Bot Name: _____

Classification: _____

Team members:

_____

_____

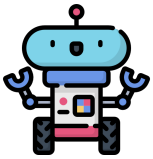
_____

_____

Scoring System (circle all that apply)

We were able to get our bot to spin right:
0 1
We were able to get our bot to spin left:
0 1
Our bot was able to travel straight for one full sand timer turn
0 2
Our bot stayed in the preserve's safe zone for ___ complete turns of the sand timer:
0 1 2 3
Our bot preserve contains 3 life essentials for the species and 1 hazard:
0 1
Animal Report and Bot ID Card score (your facilitator can give you this number)
0 1 2 3 4 5
Student choice award (1st place gets 3 points, 2nd place gets 2 points, 3rd place gets 1 point)
0 1 2 3

Total Score: _____



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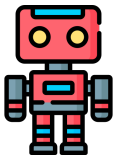


Overview of project:

- Students will explore basic concepts of mass, friction, transfer of energy, circuits, and electricity
- Students will use their knowledge to prototype a motorized bot and understand how different forces affect an object's direction and velocity
- Students will use the engineering design process to ideate, design, build, test, observe, and redesign their bot to travel in a straight path.
- Students may design adaptive devices to assist their bot in directional travel.
- Students will collect data, draw conclusions, and draft a final design/assistive device to allow their bot to move straight.
- Students will create a themed site plan with a 10 *duxit* (unit of measurement) track and a story line based on bot design and theme of choice.
- Students will optimize their bot and any assistive device with a goal for bot to travel from start to end in as quick a time as possible.
- Students will prepare a presentation, highlighting their engineering design process, successes and failures and the storyline chosen

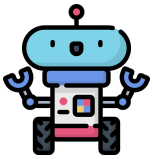
- *Optional: Facilitators may expand the project, employing digital technology tools and applications available for students to create a final presentation. Presentation may be multimedia and describe their bot, story including details about the adaptive device, the engineering design process and their bot's journey. Digital presentations may be submitted for publication on the 3DuxDesign Student Showcase*

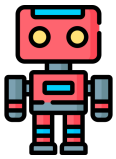
Learning goals:

Physical science: friction, mass and forces, electricity, and circuits.
Engineering design: How friction and mass can affect bot design
Computational thinking (all ISTE standards)
ELA: creative story writing, presentation
Digital technology: employing tools for presentation (for example PowerPoint, iMovie, photoshoot, green screen, stop motion and other technology tools).

Materials:

- 3DuxDesign Build-a-Bot Kit (bot sets including: 1 motor, 1 lithium coin battery, 1 on/off switch, 1 LED light, 1 pipe cleaner, conductive tape, 2-sided adhesive tape, assorted googly eyes, 1 "duxit" ruler, 1 sand timer, 1 student booklet)
- Any 3DuxDesign modeling kit with both cardboard and connectors. (GOBOX, GOBOX-PRO, GO-pack maker kits, Mini-maker kits)
- White paper 8.5 x 11" - smooth ideal for faster-moving bots.



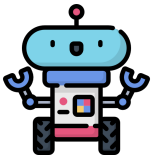


- Scissors
- Markers
- Pencil
- Clear tape

Optional materials need to be available to all teams:

- Hole puncher
- Assorted craft materials like string, straws, pom poms, popsicle sticks, etc.
- Laminator or clear packing tape (to make student tracks smoother for bots)

- Groups and group sizes.
    - If using the 8-piece set, this project may be done with groups of 3-4 students. "Race Day" event will be presented by the team to the entire class.
    - If using the 25 piece set, each group should include 4-5 students. Each student will create their own bot and site plan and collect their own data. Timer and ruler will be shared by the students in the group. "Race Day" event and voting will be amongst team members rather than entire class



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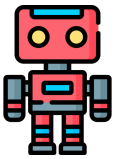


Lesson plan part 1, Building a Bot

Class Discussion: Bots, Physics, and Electricity

1. **What is a bot? (5-10 minutes)** (Adapt based on age group)

A bot is a model of a character, creature or object that moves by transfer of kinetic energy from a spinning motor causing vibration, through the robot to the ground. (Example of making junk bots YouTube video)

2. **The anatomy of a Bot. (5-10 minutes)**

What can we use to make a bot? We can make bots out of many materials including crafts and up cycled materials, but they must contain at the minimum, a motor, a battery, and wires (or conductive tape) to create a closed circuit. (Share video of a variety of cool bots)

3. **Project Overview for students. (2 minutes)**

"Your goal will be to design, build and adapt a bot that can spin right, spin left and go straight quickly. In part two of the project, you will choose theme for your bot based on observed "natural" tendencies and design an adaptive device to help the bot travel in a straight line. You will create a themed "site plan" with a 10 duxit (unit of measurement) track for your bot to complete as quickly and safely as possible. You will create a storyline based on your project design and prepare a 5-7 minute presentation". *this presentation may be live, prerecorded video or multimedia based on facilitator or student goals

4. **The Science behind a Bot (30-120 minutes depending on depth)**

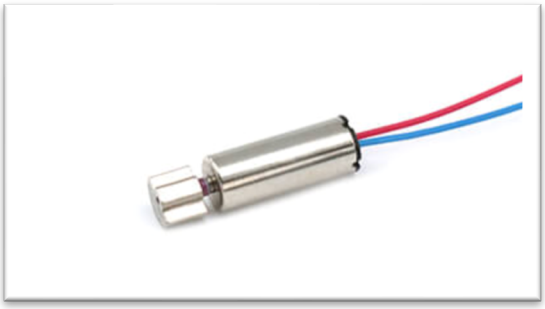
Discuss basic concepts of physics that will help students create a bot to perform it's intended function. The depth of discussion will vary based on student age and pre-existing knowledge. Below is an overview of concepts. Student handouts are also available to support learning.

Newton's First Law

Definition: An object at rest stays at rest and an object in motion stays in motion with the same speed and in the same direction unless acted upon by an unbalanced force.

Example: Unless a force is applied to the robot (a push, pull, motor turning) the robot will stay at rest. It will not change direction or speed unless a new force is applied.

Because the motor used is unbalanced (look closely at the spinner), the direction of the force is constantly changing as the motor spins. Therefore, the bot tends to spin as well. Imagine an unbalanced washing machine that wobbles.



Newton's Second Law

Definition: The change in velocity of an object is directly proportional to the amount of force applied to that object. The more force exerted to move an object the faster the object will move. However, if the object is twice as massive twice the force is needed to move the object at the same rate. The lighter the bot the less force it needs to move, therefore a light bot is more likely to move faster.

Electricity

Facilitator may guide students through the worksheets or use student worksheets to discuss electricity concepts

Friction

Facilitator may guide students through the worksheets or use student worksheets to discuss friction concepts

5. **The Engineering Design Process (EDP) (5 minutes)**

The engineering design process involves solving a problem through prototyping, testing solutions, refining design until the problem is solved. In this project, students will use their understanding of physics and the engineering design process to build a bot that can travel in different directions. Here is a wonderful short video to share with students about the EDP

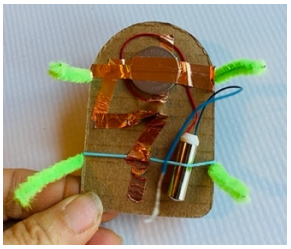
Activity1: Build-a-Bot Prototype (1 to 1 ½ hours)

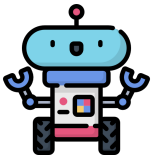
- Teams of 3-4 students will use 3DuxDesign cardboard, connectors, and Build-A-Bot Kit materials to create a simple circuit using the motor and batteries. Here is a diagram to help your students learn a bit more about circuits
- Students will observe the "natural" tendency of the bot based on the first design.
- Students will use the engineering design process to alter the design of their bot to achieve different goals:
    - rotate right
    - rotate left
    - Travel in straight path

This may be done by …

1. manipulating mass distribution altering the center of gravity
2. altering friction by using different connectors
3. altering friction by adding appendages (or "assistive devices")
4. changing the orientation of the bot (upright vs crawling position)
5. changing orientation and position of the motor

- Here is a short video that might help you explore how adaptations to the bot design might affect mobility.
- During the design process, students will document observations, make predictions as to how to achieve desired outcome, rebuild and then test.
- Students should repeat this process multiple times until they achieve the desired outcomes. Students can use the *Engineering Design Worksheets* to document their journey.
- Students should be prepared to explain why certain adjustments result in a change in direction/velocity of their bot.



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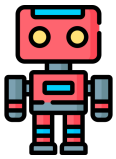


Lesson Plan Part 2, Bringing Bots to Life

Class Discussion:

Student teams will be instructed to design their bot and a track with a theme of choice. The theme can be based on a movie, a book, historical event, a topic from class (like civics) or purely made up. The project goal will be to for the bot to complete a 10 duxit (unit of measurement) course in as short a time as possible. Students should prepare a story based on the project and the theme chosen.

Activity 2: Create a Story, Site Plan, and Track for your Bot

Materials suggested:
Paper
Tape
Scissors
3DuxDesign modeling materials including connectors and cardboard shapes
Maker bot kit materials
Markers
Pencils
Student engineering design

Site Plan and Track design rules:

1. Each team will have the same size site plan (1-2 sheets of paper) to work on.
2. Each team will have access to exact same materials.
3. Track should be decorated based on the theme and story.
4. Track should have a starting and ending point.
5. Track should be a total of 10 duxits long (architectural scale)
6. Track may be straight or curved
7. Track may include adaptive devices (guard rails, floor ridges, tape, string etc) to help the bot navigate the track efficiently

Activity 3: A Day at the Races!

Each bot will have an opportunity to participate at Race Day.

One at a time, students (or student teams) will share a brief presentation of their bot in front of the group (or class). Presentations will include the storyline, some characteristics about their bot and the track design. Student presentations should also include some of the challenges they encountered and how they adapted their bot and track design to overcome those hurdles.

For the challenge:

- bots will be placed at the "start" point
- sand timer will be turned over as the bot is released
- as the bot continues to travel, the timer can be turned if the bot needs more time. Number of turns of the sand timer should be tracked
- The bot and track cannot be touched during the timed race.
- If the bot goes off track, the timer can be reset but the bot needs to return to the start.
- If the bot requires more than three sand-timer turns to reach the end point, the bot mission is incomplete.

Presentations:

- Students will create a presentation/story** that helps highlight the project theme, the bot and track design, and their bot's success/challenges during the project.
- Student Choice Awards. Each student votes on the best bot and presentation. They cannot vote for their own bots.
- Scoring sheets. Facilitator will grade each project from 1-5. Student team will tally up their scores using the Bot Scoring Sheet.

**Presentation (1-5 hours)

This may be live or include technology and digital applications for a video presentation.

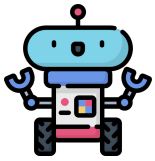
Digital presentations (video, photography, creative writing) under 7 minutes may be submitted to 3DuxDesign for acceptance onto the Global Student Showcase on the 3DuxDesign website for families and 3DuxDesign Community members to enjoy. The Student Showcase is public so please submit only materials that can be posted. Projects admitted to the showcase will receive special 3DuxDesign awards based on innovative and creative projects.

Scoring:
Project will be scored based on a number of features including engineering design, aesthetic design, story line and the student journey. See scoring sheet for details.

- For race day, scoring is based on time to complete track. Completes the track in under one sand-timer turn, the bot will receive a full 3 points for the event. If the bot completes the track in under 2 sand-timer turns, the bot will receive 2 points. If the bot completes the track in under 3 sand-

timer turns, the bot will receive 1 point. If the bot requires more than three sand-timer turns to reach the end point, the bot mission is incomplete.

- Projects will also be scored based on complexity of circuits (LED light and on/off switches)



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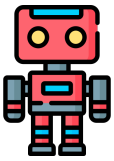
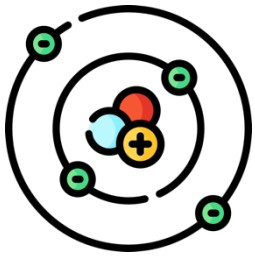


Learning about electricity, circuits and physics is much more fun when you work together to build your own Bot!

What is electricity?

Electricity is a type of energy that can flow from one place to another. It is a huge part of your everyday life. For starters, it keeps your home and school warm in the winter and cool in the summer. It is used to make your lights, microwave, and hair dryer work.

To understand electricity, you must first understand what an **atom** is because electricity comes from atoms. Everything in the universe is made of atoms. Atoms are tiny particles (way too small to see without special microscopes). They are so small a single ant is made of billions of atoms!



Atoms have three parts. The center (called the **nucleus**) is made of **protons** (which have a positive charge) and **neutrons** (which have no charge). The outer part of an atom has **electrons** which have a negative charge. Electrons can float and spin (or **orbit**) around the nucleus, but they typically stay close because the negatively charged electrons are attracted to the positively charged nucleus. But electrons can also float from away from one atom to another. The flow of electrons from one material to another is called **current electricity**.

Electricity is made from releasing energy stored in materials and other natural sources by the flow of electrons to another material.

Where does electricity come from?

The easy answer is that it comes from a socket in the wall. But that's not where it really comes from. It starts with an energy source like wind or solar power. This energy is then **converted** into electricity as electrons flow along wires and ultimately travel to your home. Electricity can be stored at your community energy station and flows along wires to get to your home. It can also be stored in a **battery**. We will be creating circuits with batteries in our project.

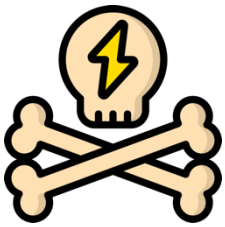
When electrons flow from the negative side of a battery, through a conductor (metal wire) and then to the positive side, that is a complete circuit, or a closed circuit. This creates current electricity. If you connect a conductor directly to both sides of a battery, it's called a **short circuit.** When you create a short circuit, two things happen…

1. you waste the electricity because this will drain all the energy out of the battery
2. the wires will get **REALLY HOT!** A short circuit is something that should NEVER create. It can cause severe burns and fires.

The same is true for the electricity that comes through the wires in your home.

But if you put a **resistor** somewhere along the circuit, the electricity can be used to power something. A resistor (also called **a load**) can be a light bulb, a motor, an appliance in your home, a car and lots of other things. If there is a load along the circuit, much of the energy is used by it so there is less energy being release as heat. The wires won't get quite as hot (but they can still burn you). When you add a light bulb, the energy is seen as light. When you add a motor, the energy is used to spin the motor.

Have you ever noticed that all electrical wires in your home are covered in plastic or rubber? Metal is a **conductor**, so electricity can flow through it. But conductors that have current electricity going through them can get very hot. Plastic is called an **insulator**; electricity cannot flow through it. When you touch the plastic-covered wire, you will not get a shock or hot. If you were to put uncovered metal into a socket, you would get electrocuted!



The Simple Circuit

We know you are excited to power up your Bumble Bee Bot. We are too. But first we need to review a few things about electricity.

Electricity, as you know, is a form of energy. It can flow through conductive wires or stored in one place, like in a battery. When it stays in one place, it is called **static** electricity, and when it flows, it is called a **current** (like water flowing in a river). For this activity, you will be making the electricity flow from the battery to the load that you want to power up (like a motor) and then back to the battery. You will be creating a loop, or a closed circuit.

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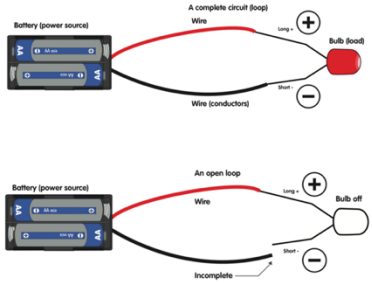
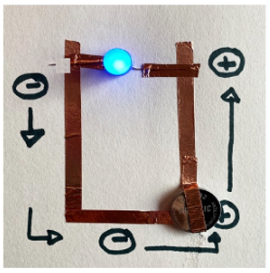
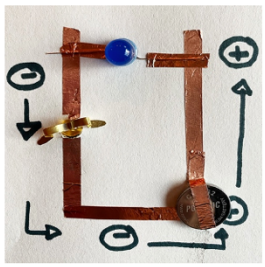
Simple circuit open/closed

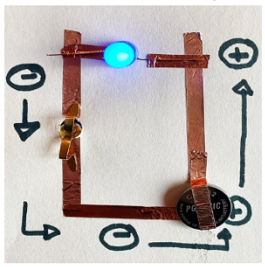


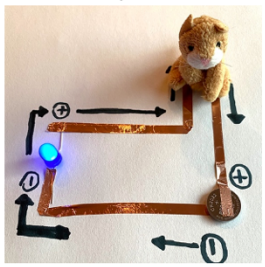
simple circuit



Simple circuit with switch off/on/conductive kitty (copper on bottom)

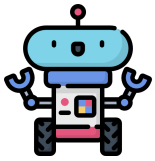






We will be using a vibrating motor and a lithium button battery. The batteries are small and safe to use for activities but are highly **poisonous** if eaten!

FUN FACT: How much energy is stored in a battery is called a volt. A battery needs to have enough volts to power different loads. Most lithium button batteries have 1.5-3 volts. Your vibrating motors need 1.5-3 volts. LED lights need 5 volts.



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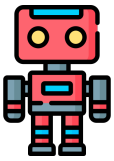
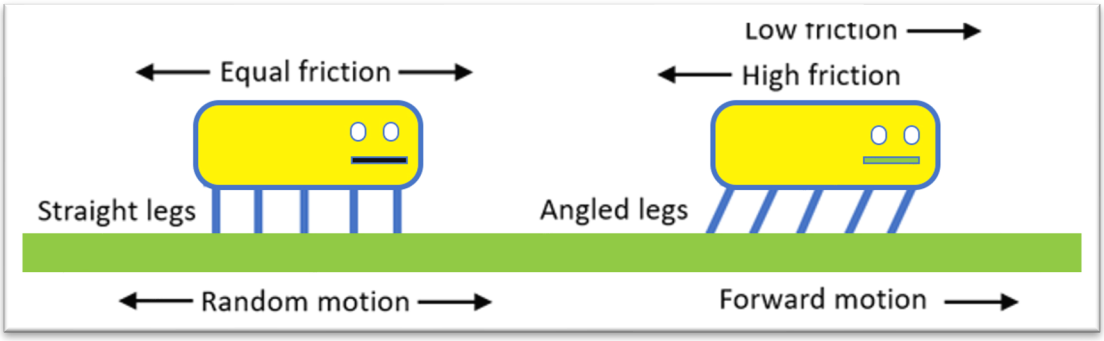
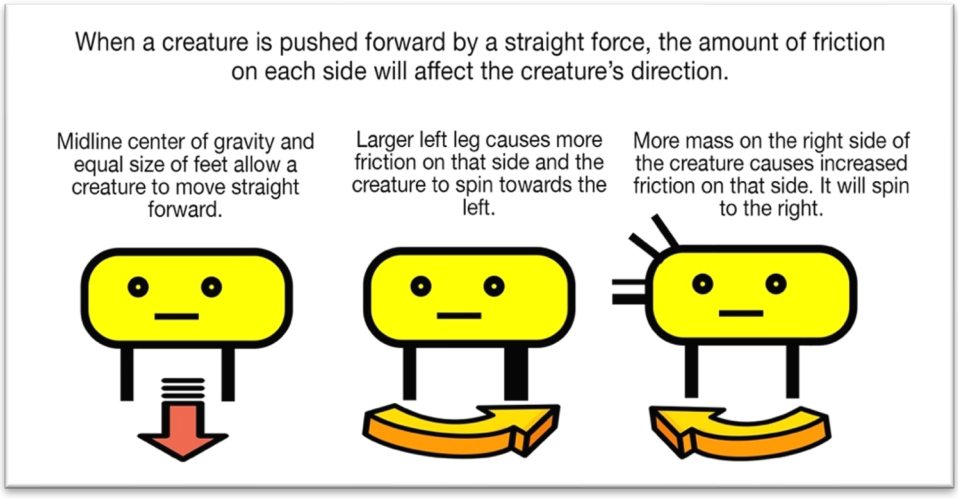


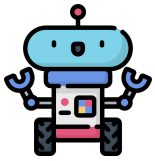
It's all about Friction:

In this activity, the vibrating motors have off-center weights inside. Unlike a balanced motor, they will wobble when the motor inside spins. They are commonly in mobile phones to make them vibrate. Without careful design choices, your Bot will tend to spin in circles. The key to making your bot move in a straight line is **directional friction**. You can do this by making sure the parts of the robot that contact the ground have more friction in one direction or on one side than the other. Think about rubbing your finger along sandpaper—it will be rough in any direction. Now think about petting a dog — it will feel smooth in one direction but rough in the other direction. The same concept is true for your Bot. Bots with slanted legs will tend to move in one direction.



Another way to make a bot go straight is to alter the amount of friction on one side of the bot in an effort to counter it's tendency to spin. The diagram below highlights the concept when there is a straight force exerted on an object.





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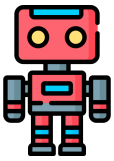

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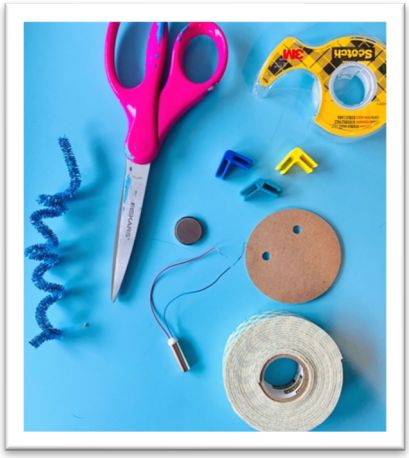
Building a Bot:

materials:



- 3DuxDesign cardboard shapes
- 3DuxDesign connectors
- 6 mm vibrating motor
- 1.5-3V lithium button battery
- tape
- 2-sided foam adhesive tape
- LED light bulb
- On/Off switch
- Copper conductive tape
- Optional: assorted items including pipe cleaners, toothpicks, Q-tips, straws, switch, LED light, googly eyes, markers and anything else you can think of!

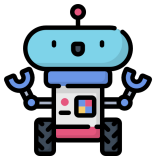
Building a Bot:

Your Bot can be designed and built in a million different ways! The only requirement is that your Bot includes a closed circuit that allows it to move.

Your project mission will be to design and build a bot that moves as quickly as possible along a measured course. To achieve the goal, you will experiment with different sized bots, different designs, different appendages and adaptive devices based on the "natural tendencies" or your bot's behavior. You will be allowed to adapt your bot and the track however you like as long as you follow the guidelines and use ONLY materials specified by your facilitator.

Engineers design, build prototypes, test, evaluate and refine. Your job is to use the engineering design process to build a prototype that will satisfy your mission. You will also want to repeatedly document your observations and redesign your bot until you are satisfied with the results.

After a class discussion about bots, electricity, circuits and forces, each team (or student) will be ready to design and prototype their own bot. Start with a drawing of a closed circuit with battery, motor, conductive material (wire/copper tape), and any other components like an LED light or on/off switch.



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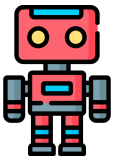


- Use 3DuxDesign cardboard, connectors, and Build-A-Bot Kit materials to create a Bot with a simple circuit using the motor and batteries. Draft out a design before building.

- Once you get your bot moving, take note of how the bot moves. Is it going straight, sideways, spinning left, or right?

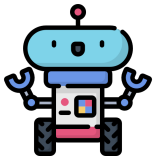
_____

_____

_____

- Now see if you can adapt your prototype bot to change it's direction. Think about how you might adapt the design to make your bot:
    - Spin left
    - Spin right
    - Travel in a straight path

Use the engineering design worksheets to design, build, test, make observations and adjust your design as needed. Document your journey.



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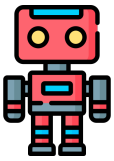


Bring your Bot to Life!

After the bot design phase, you will create a site plan with a track and create a theme and story for your bot. Your facilitator will review the details of the project but here are the basics:

Site Plan and Track design rules:

1. Each team/student will have the same size site plan (1-2 sheets of paper) to work on.
2. Each team will have access to exact same materials.
3. Track should be decorated based on the theme and story.
4. Track should have a clearly marked start and endpoint.
5. Track should be a total of 10 duxits long (architectural scale).
6. Track may be straight or curved. 10 duxits should be measured along the center of the track.
7. Track may include adaptive devices (guard rails, floor ridges, tape, string etc) to help the bot navigate the track efficiently

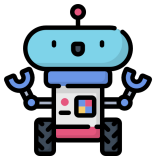
A Day at the Races!

Each bot will have an opportunity to participate at Race Day.

One at a time, students (or teams) will share a brief presentation of their bot in front of the group. Presentations will include the storyline, some characteristics about the bot and the track design. Student presentations should also include some of the challenges you encountered and how you adapted your bot and track design to overcome those hurdles.

For the challenge:

- bots will be placed at the "start" point
- sand timer will be turned over as the bot is released
- as the bot continues to travel, the timer can be turned if the bot needs more time. Number of turns of the sand timer should be tracked
- The bot and track cannot be touched during the timed race.
- If the bot goes off track, the timer can be reset but the bot needs to return to the start. All timer turns count even if you need to start over.
- If the bot requires more than three sand-timer turns to reach the end point, the bot mission is incomplete.
- Scores will be tabulated after all bots have had a chance to compete. Your facilitator will review the scoring system with you.



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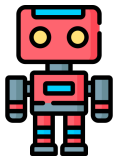
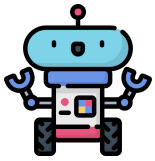


Reflections:

After the race is complete, your team should take time to describe

1. How did you design your bot for speed?
2. Why you chose the materials for your bot?
3. Why did you choose the size and shape of your bot?
4. Describe if your bot was successful. Why or why not?
5. What changes might you make to your bot next time?
6. Describe how you designed the track for your bot
7. Why did you design the track that way?
8. Was the track design successful? Why or why not?
9. What changes might you make to your bot next time?



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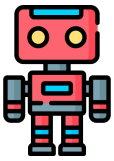

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A Day at the Races (advanced version).

Each team will design their own bot track using materials supplied

- Each team will have access to the same track materials
- Teams can add paper, tape or other materials to adjust the speed as long as each team has the same options).
- Tracks can be straight or have turns.
- Tracks may include guard rails
- Tracks need a "start" and "end" sign placed appropriately.
- The center of each track should be the same length. 10-20 duxits (architectural scale) is recommended but this will be determined by the facilitator.

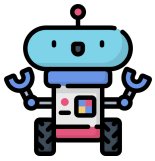
The Rules:

- Once all teams have completed their bot and track design, the game can begin.
- Each team will place their bot at the start of their track
- Your facilitator will call out 3..2..1 GO!
- The Team with the first bot to reach the finish line wins. If a team needs to adjust their bot during the race (which WILL happen), they can, but the Bot needs to begin at the start again.
- First bot to cross the finish line wins!!

Reflections:

After the race is complete, your team should take time to describe

10. How did you design your bot for speed?
11. Why you chose the materials for your bot?
12. Why did you choose the size and shape of your bot?
13. Describe if your bot was successful. Why or why not?
14. What changes might you make to your bot next time?
15. Describe how you designed the track for your bot
16. Why did you design the track that way?
17. Was the track design successful? Why or why not?
18. What changes might you make to your bot next time?



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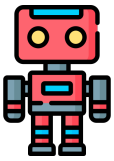
Build-a-Bot Score Card Grade 5+



Bot Name: _____

Team members:

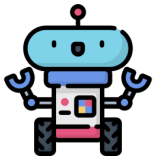
_____ _____

_____ _____

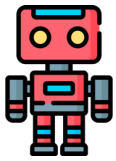
Scoring System (circle all that apply)

Able to get bot to spin right:
0 1
Able to get bot to spin left:
0 1
Bot was able to reach finish line in 4-X sand timer turns
For example, if bot reaches endpoint in less than 1 timer turn: 4 - 1= a score of 3
0 1 2 3
An LED light was incorporated into bot circuit design
0 1
An on/off switch was added to bot circuit design
0 2
At least 3 data sheets filled out
0 1
Presentation includes more than one media format (writing, oral prenetation, photography, video, video editing apps etc.)
0 1
Facilitator score (data, student work, storyline, presentation)
0 1 2 3 4 5
Student choice award (1st place gets 3 points, 2nd place gets 2 points, 3rd place gets 1 point) based on design, story, and presentation.
0 1 2 3

Total Score: _____



Build-a-Bot Engineering Design Sheets



Engineering Design Goal: _____ design # ____

Observation: _____

_____

_____

Interpretation of Observation:

_____

_____

_____

Proposed changes:

_____

_____

_____

_____