SAMPLE

Kiwi Co

Drawbot

TEACHER GUIDE

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Lesson Overview

Students will explore physics and engineering concepts by building a simple motor-powered robot in small groups.

SECTION 1 features an experiment, in which each group will test modifications to the motor. As they work, they'll make predictions, note observations, and record results to investigate balanced and unbalanced forces.

SECTION 2 features a design challenge, which encourages students to use creativity, critical thinking, and what they've learned about forces to solve an open-ended engineering problem. Students will reflect on successes, constraints, and tradeoffs as they develop their drawbots.

SECTION 3 is optional and offers discussion topics to evaluate student takeaways. It also includes a jitterbug activity to extend student investigation and reuse some materials from the project.

Use these time estimates for planning. Keep in mind they'll vary depending on how quickly your students work and how much exploration they do.

35-45 minutes

SECTION 1:
Discover Forces with the Motor

1.A Motor Build
Students follow the instructions on the Motor Build card to connect and test the motor assembly.

1.B Motor Experiment
Students use clay and their motor to experiment with balanced and unbalanced forces.

60-80 minutes

SECTION 2:
Invent and Explore with the Drawbot

2.A Bot Build
Students follow the instructions on the Bot Build card to construct their drawbot.

2.B Robot Art
Students follow the instructions on the Robot Art card to modify their drawbots.

2.C Robot Art Design Challenge
Students adapt their drawbot to solve several drawing challenges.

optional!

SECTION 3:
Wrap-Up

OPTIONAL ACTIVITY:
Build a Jitterbug

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Hand out this worksheet:

Motor Experiment

Follow these steps:

1. Introduce this question to your students: *What happens to the motor if you change the shape of the clay?* Suggest a connection to balanced and unbalanced forces.
2. Have the groups experiment by following the instructions on the Motor Experiment worksheet.
3. Instruct your students to turn off the motor between tests. The battery pack can overheat if the motor is left on too long.
4. When your students are finished, start a discussion about their observations and how those observations relate to balanced and unbalanced forces.

Time needed:

20-25 minutes

Troubleshooting tips:

- **Example A** in the worksheet should spin quickly and produce a small vibration. If it doesn't, make sure the clay is firmly on the gear and that it's shaped evenly.
- If students are having trouble seeing the difference in the motor's movement, prompt them to hold it in their hands as it spins. They should be able to feel the vibration and speed.
- Stick the clay to the gear only, not the motor itself. If clay gets on the motor shaft, it will not be able to spin freely.
- If the clay flies off the gear, pinch it back in place and make sure to cover the whole gear.
- If students use too much clay, the motor may not spin quickly. Try removing some.
- The clay can be squished and stretched, or you can add more or less of it.

Discussion Time!

Notes For The Teacher

A. The motor applies force to the clay to make it move in a circle. If the clay is uneven, the heavy side of the clay needs more force to keep it moving than the light side does.

B. As the motor spins, the heavy side and the light side switch places many times each minute. The clay pulls unevenly on the motor, and the unbalanced forces cause the motor to vibrate — a lot!

It's like a shaky washing machine. An unbalanced load, like a wet blanket stuck to one side of the spinner, can cause the whole machine to vibrate.

C. If the clay is mostly even, the forces on the motor are more balanced, and the vibration is lessened.

D. The more lopsided the clay, the more force is needed to make it move in a circle. When the clay is even, it's easy to move, so the motor can spin quickly. When the clay is lopsided, it's harder to move, so the motor spins more slowly.

E. The clay will only move in a circle if a force is acting on it. If the clay falls off the gear, it will fly off in the direction it was moving when it let go.

It's like tying a ball to a string and swinging it in circles. If you cut the string or let go, the ball will fly off.

Thought-Starters

If students need help coming up with topics, start them off with these:

What happens if you use less or more clay?

How does the motor spin when the clay is lopsided?

How does the motor spin when the clay is shaped like a ball?

Can you adjust the clay to make the motor spin slower or faster?

Does the clay ever fly off the gear? When does that happen?

SECTION 2:
Invent And Explore With The Drawbot

In this section, students will:

- Take their investigation further by turning the completed motor into a drawbot
- Creatively explore the idea of balanced and unbalanced forces and build on what they learned in Section 1

By the end, students should be able to:

- Demonstrate how to create balanced and unbalanced forces with their drawbot
- Describe how balanced and unbalanced forces can cause the drawbot to create different patterns

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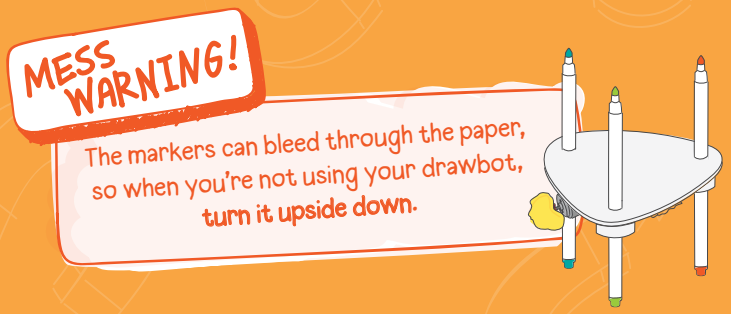
Hand out this card:

Robot Art

Follow these steps:

1. Remind your students what they've investigated about balanced and unbalanced forces so far. Ask your students: *How might you use the drawbot to explore this further?*
2. Have groups clean up their workspace to make room for the drawbot to run.
3. Have the groups work through the Robot Art card. Make sure students understand how to adjust the clay, the battery pack, and the legs.

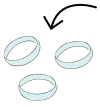


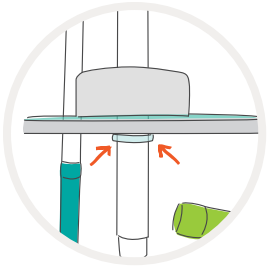
Build time:

15-20 minutes

Troubleshooting tips:

- If the drawbot doesn't move, that means it's too well balanced. To fix it, make one leg a little longer or shorter or move the battery pack slightly. Keep making small adjustments until it works.
- If the drawbot is falling over, adjust it to bring it back to balance. Try adjusting the legs, or try moving the motor and battery pack to a more balanced position.
- If the clay spins very slowly, try removing some. Make sure the clay hangs off the edge so it doesn't hit the drawbot's body.
- Adjust the height of the legs by sliding the markers up or down in the drawbot body.
- If the markers don't stay in place, slide an o-ring onto each and press them back into the drawbot.





- The drawbot may get stuck on the creases in the paper. Students can smooth out the paper and use tape to help keep it flat.

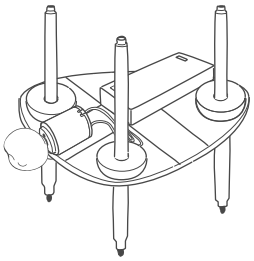
Name(s): _____ Date: _____ SAMPLE

Robot Art Design Challenge

By adjusting how your drawbot balances, you can change the pattern it makes. Adjust your drawbot as shown for these challenges, then draw the pattern it makes.

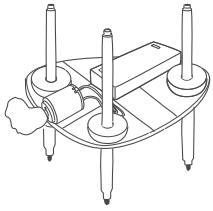
Challenge #1

Draw the pattern your drawbot makes.

DRAWBOT	PATTERN
Clay: Round **Legs:** Even **Motor and battery pack:** In a straight line Adjust these variables to get your drawbot ready. 	*If your drawbot doesn't move, make one leg a little longer or shorter and try again. Keep making small adjustments until it works!*

Challenge #2

Draw the pattern your drawbot makes.

DRAWBOT	PATTERN
Clay: Uneven ← Adjust the clay! **Legs:** Even ← Keep these the same. **Motor and battery pack:** In a straight line 	

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