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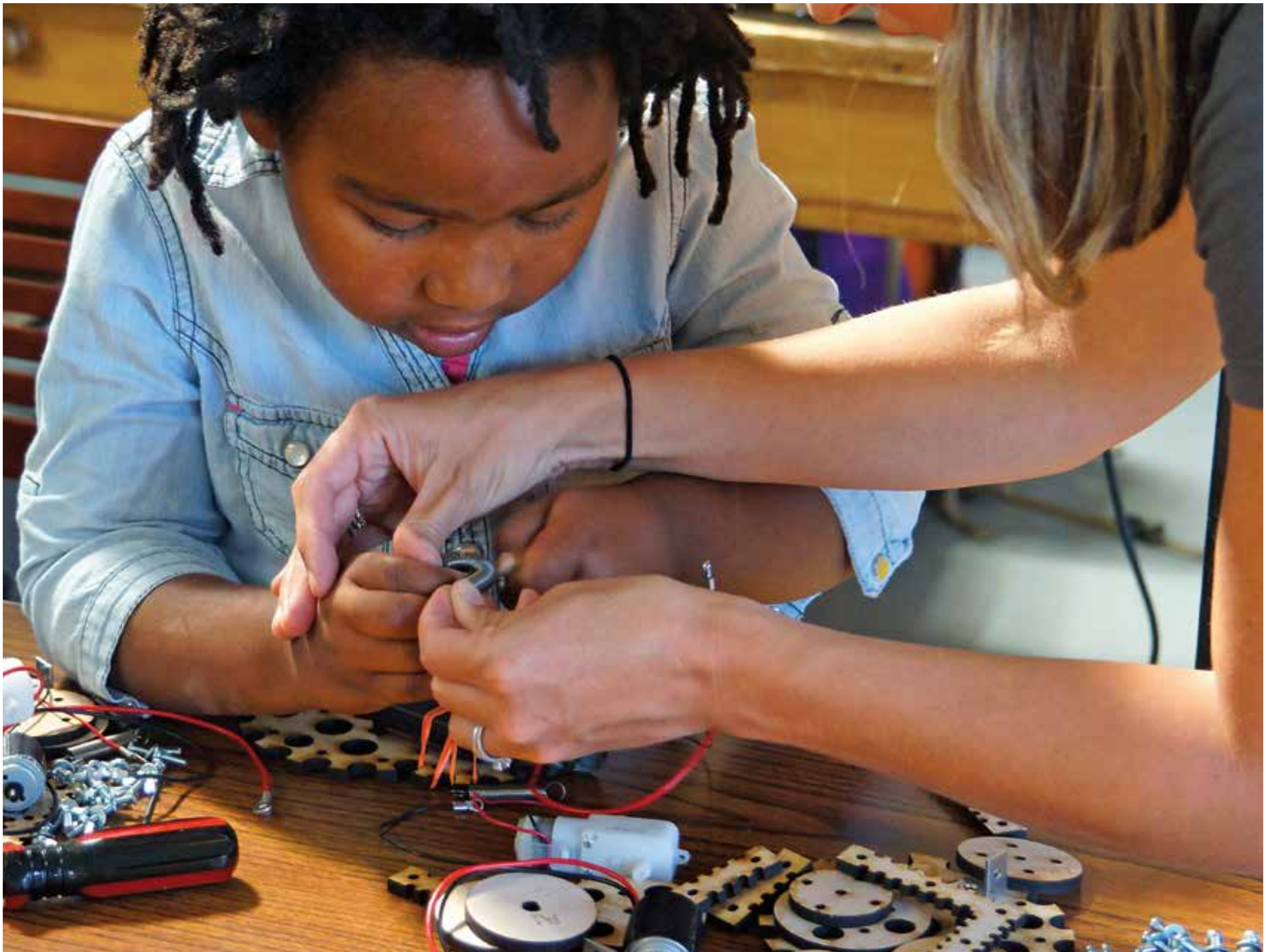

ELECTRIC MOTORS CATALYST

Curriculum Guide

By Marisa Miller and Matthew Brocchini

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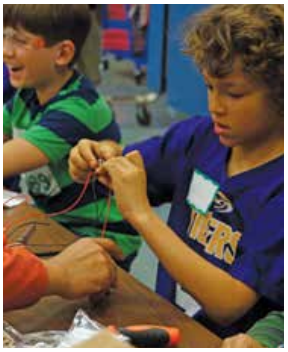


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Tinkering Labs – Electric Motors Catalyst: NGSS Curriculum User Guide

The Electric Motors Catalyst Class Pack can be used in classrooms in many ways, including in-school or after-school clubs and enrichment. It can also be used as a vehicle to teach students in elementary and middle school the Next Generation Science Standards (NGSS). While the kit provides many opportunities to connect student tinkering to energy, motion, and engineering, this curriculum has been developed to explicitly address when and how these connections can be made. The NGSS performance expectations (the official name for the standards) have been bundled with specifically identified Electric Motors Catalyst Challenges into an Electric Motors Catalyst NGSS Unit. Each unit is comprised of a series of lessons that will allow students multiple opportunities to wonder, test, invent (and yes, play!), while learning important physical science and engineering core ideas (content). Each unit also begins with a phenomenon for students to make sense of, embedded formative assessments, and a summative performance assessment.

How does the Electric Motors Catalyst support the NGSS?

The Framework for K-12 Science Education, upon which the Next Generation Science Standards are built, placed an emphasis on the engineering practices.

> *"The actual doing of science or engineering can also pique students' curiosity, capture their interest, and motivate their continued study; the insights thus gained help them recognize that the work of scientists and engineers is a creative endeavor [5, 6]—one that has deeply affected the world they live in. Students may then recognize that science and engineering can contribute to meeting many of the major challenges that confront society today, such as generating sufficient energy, preventing and treating disease, maintaining supplies of fresh water and food, and addressing climate change. Any education that focuses predominantly on the detailed products of scientific labor—the facts of science—without developing an understanding of how those facts were established or that ignores the many important applications of science in the world misrepresents science and marginalizes the importance of engineering."*
>
> *– A Framework for K-12 Education*

The Electric Motors Catalyst Class Pack is a teacher-friendly way of piquing student curiosity, engaging in creative science work, and confronting challenges. The Class Pack includes 10 engineering design challenges and materials to solve each challenge in a variety of ways. What is not included? A pre-defined procedure to create each device. Instead, students use their creativity and autonomy to build, create, and tinker! As students work through different engineering design challenges, teachers can highlight different aspects of the engineering process that students are utilizing. After the students have created their devices, the teacher can leverage their interest in their designs to discuss disciplinary core ideas in science such as force, motion, electricity, or energy.

How should I use an Electric Motors Catalyst NGSS Unit?

The units are designed to align to specific NGSS performance expectations for a grade band. By completing a unit in its entirety, students will be able to demonstrate an understanding of the **Science and Engineering Practices**, **Disciplinary Core Ideas**, and **Crosscutting Concepts** for the performance expectations identified. However, the units can be modified and adapted to blend with your current curriculum.

Ways to Use The Electric Motors Catalyst NGSS Units

- ***As is*** — Use the unit in its entirety as a stand-alone curriculum to align NGSS performance expectations.
- ***As a Capstone*** — Teach the unit in its entirety before and after science unit to inspire or extend learning.
- ***Blended*** — Weave individual lessons and challenges into existing curriculum.

The units include integrated engineering and physical science units, as well as stand-alone units to target engineering practices.

How do the Electric Motors Catalyst NGSS Units align to the NGSS?

The units are crafted so that students are figuring out specific elements of the **Disciplinary Core Ideas** and **Crosscutting Concepts** while engaging in the **Science and Engineering Practices**. Directions and support are provided to teachers to use the Electric Motors Catalyst challenges to drive student learning as students ask questions, define problems, and design solutions.

Is the Electric Motors Catalyst Class Pack right for my students?

The Electric Motors Catalyst Class Pack works in any classroom. Engineering design challenges provide all students, even those who struggle with traditional assessments, with an opportunity to shine and show their learning in non-traditional ways. Regardless of background, location, or previous science exposure, hands-on, inquiry learning provides a common experience with which all students can make sense of and communicate about.

Curriculum Unit Map:
An overview of the units & lessons in this guide

Unit #1: Grades K-2 Engineering: How do new things get invented?

Lesson #1.1: Introduce the phenomenon - How to make a device that makes a loud noise

Lesson #1.2: EMC Getting Started - Make a wheel spin

Lesson #1.3: EMC Challenge #2 - How to make a device that cuts paper

Lesson #1.4: EMC Challenge #3 - How to build a device that draws curvy lines

Lesson #1.5: EMC Challenge #4 - How to build a ride for a toy

Lesson #1.6: EMC Challenge #1 - How to make a device that makes a loud noise

Unit #2: Grades 3 - 5 Engineering: How do engineers make inventions better?

Lesson #2.1: Introduce the phenomenon - How to create a machine to scramble an egg

Lesson #2.2: EMC Challenge #3 - How to build a device that draws curvy lines

Lesson #2.3: EMC Challenge #4 - How to build a ride for a toy

Lesson #2.4: EMC Challenge #5 - How to build something that moves in a straight line

Lesson #2.5: EMC Challenge #6 - How to build a creature with spinning arms

Lesson #2.6: EMC Challenge #7 - How to create a machine to scramble an egg

Unit #3: Grades 3 - 5 Science - Force, Motion, and Engineering

Lesson #3.1: Introduce the phenomenon - How to build a robot that can push or pull another toy

Lesson #3.2: Why do objects move?

Lesson #3.3: EMC Challenge #4 - How to build a ride for a toy

Lesson #3.4: How to stop my invention without turning the motor off

Lesson #3.5: EMC Challenge #8 - How to build a moving robot with no wheels

Lesson #3.6: How to predict where an object will go

Lesson #3.7: EMC Challenge #3 - Why do objects move in curved lines?

Lesson #3.8: EMC Challenge #5 - Why do objects move in straight lines?

Lesson #3.9: Open challenge - How to build a robot that can push or pull another toy

Unit #4: Grades 3 - 5 Science - Energy and Engineering

Lesson #4.1: Introduce the phenomenon - How to create a machine to scramble an egg

Lesson #4.2: How can a windmill generate energy?

Lesson #4.3: EMC Getting Started - How can I make a wheel move with a motor?

Lesson #4.4: How does an electric motor work?

Lesson #4.5: EMC Challenge #1 - How to create a device that makes a loud noise

Lesson #4.6: What can electricity do?

Lesson #4.7: EMC Challenge #2 - How to create a device that can cut a piece of paper

Lesson #4.8: EMC Challenge #7 - How to create a device that can scramble an egg

How can I build a ride for a toy?

LESSON 2.3

Lesson Overview

Time	Performance Expectations	What students will figure out (Disciplinary Core Ideas)	How students will learn it (Science and Engineering Practices)	How it connects (Crosscutting Concepts)
2 sessions	3-5-ETS1-1	The success of a designed solution is determined by considering the desired features of the solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account. (ETS1.A)	Define a simple design problem by identifying criteria and constraints. Design a solution to a problem.	People's needs and wants change over time, as do their demands for new and improved technologies.

Objective:

SWBAT understand and explore the criteria and constraints of a design problem by designing a device that will be able to move a toy.

- *Teacher's note: Each team should have a toy to use for this lesson. It could be a doll or action figure, a small stuffed animal, or anything that might want it's own vehicle to get around on. Alternatively, the students could create their own riders using paper, pipe cleaners, or other materials.*

Lesson Flow:

Context: Introduce Challenge #4 - Build a Ride for a Toy (10 minutes)

- **Make it Applicable:** Ask students: What do we use vehicles for? What kinds of things do they carry, and for what reasons?
- **Introduce the Challenge:** Tell students their task today is to create an invention that will be able to move a toy using the Electric Motors Catalyst kit.
- **Ask for Ideas:** Ask students: What does your toy need in a vehicle? Where does it need to go, and what does the vehicle need to be able to do? Give students two minutes to talk to a partner about what their invention might look like. Call on some students to share their ideas.
- **Revisit the Engineering Design Process:** Remind students of what an engineer is and the Engineering Design Process. Call on students to explain each step in their own words. Then, focus students on the Ask step. Remind

students that before engineers start building they usually start by identifying a problem they want to solve and the ***criteria*** that will let them know they were successful. They also identify constraints. ***Constraints*** are the limits to their design such as materials or time.

Activity: Challenge #4 - Ask, Imagine, and Plan (30 minutes)

- **Ask (criteria):** Tell students the problem they are trying to solve is to make a device that can carry a toy. Ask students to think about the criteria for the solution - How will we know if our device is successful? What kind of toy does it need to carry? How big is the toy? How far does the machine have to carry the toy? Ask students to discuss with a partner or small group how they will test if the device they make is successful in carrying a toy. Give students three or four minutes to talk, then call on some volunteers. Decide as a class what the criteria for success will be.
    - *Teacher's Note: Some ideas for criteria include: must carry a small stuffed animal 10 feet across a flat floor.*
- **Ask (constraints):** Tell students the constraints for their device.
    - *Teacher's Note: Possible constraints include: Must use certain parts from the Electric Motors Catalyst Class Pack, Cannot use additional materials, Can use additional materials but only the items in the bin, etc.*
- **Imagine:** Provide teams (2-3 students) with some materials to start tinkering. Remind students the purpose of this time is to play and test in order to create a plan. Set a time limit for this (approximately 15 minutes). With five minutes left, collect materials and transition students to making a plan by jotting down three things they learned or discovered that will help them inform their plan.
- **Make a Plan:** Tell students to work as a team to create a plan for their invention. Tell students their plan should include a sketch of their invention, what materials will be used, and where the toy will be.

Possible Breakpoint – End of Day 1

Activity: Challenge #4 - Create and Improve (20 minutes)

- **Distribute Materials:** As each group completes their sketch, tell one person from each team to get a bin with the provided materials.
- **Facilitate and Support:** Circulate as students are working. Answer questions – but don't give them a solution!
    - *Teacher's Note: Some groups may finish faster or slower. See Adjustments for what to do if students are finished quickly or will not finish in the allotted time.*
- **End the Challenge:** Shout out students/groups that completed the challenge, persevered, or worked well together. Provide direction for returning materials to proper space.

Lesson 2.3 - How can I build a ride for a toy?

Analysis: How did we do? (10-15 minutes)

- **Test Devices:** Remind students that yesterday as a class they agreed on the criteria for success for their devices. If they haven't already, now is the time to test their devices.
- **Foster Reflection:** Ask students to write their responses to the following questions:
  - Did your device meet the criteria of the challenge? If so, what made your device able to carry a toy? If not, how would you improve your design?
- **Share Results:** Have students share their reflections with the class. Celebrate groups that completed the challenge and ask them to share how they made it work.

Sense-Making: What Engineers Do – Identify Criteria and Constraints (10 minutes)

- **Define Criteria and Constraints:** Ask students to share their ideas for what was the most challenging part of this task (students may say time, materials, the toy). Write any criteria or constraints on the board into two lists. Ask students: What did I tell you the design needed to do? Add relevant information to the criteria list on the board. Name this as ***criteria***. Identify that things that may have made it a ***challenge*** were limits that were placed on the design – these are known as ***constraints***. Have students write the words and definitions in their notebooks.
- **Check for Understanding:** Ask students to identify criteria and constraints for another design challenge:
  - *Create a new design challenge that will solve the problem of getting something (not a toy) from across a room. Be very specific about the expectations! Swap design challenges with your partner. Identify the criteria and constraints of your partner's design challenge.*

Lesson Assessment: Pretend you have a new design challenge. In this design challenge, you need to bring a toy to you, but this time the toy needs to be able to work in water and get from one end of the bathtub to the other. You can only use materials you have at your house or school right now. Identify the criteria and constraints of the problem. Sketch a design and include the materials you would use.