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.

Table Connecting Challenges To Next Generation Science Standards

The Electric Motors Catalyst: Organized by Challenge

Catalyst Challenge	Disciplinary Core Idea	The Standard	Unit and Lesson Location
Challenge 1	Engineering Design Energy Waves and their Applications in Technologies for Information Transfer Motion and Stability: Forces and Interactions	K-2-ETS1-1, K-2-ETS1-2, K-2-ETS1-3, 1-PS4-1, 1-PS4-4, 3-5-ETS1-1, 3-5-ETS1-2, 3-5-ETS1-3, 4-PS3-4, 4-PS4-3, MS-ETS1-1, MS-ETS1-2, MS-ETS1-3, MS-ETS1-4, MS-PS2-3, MS-PS3-5	Unit #1 Lesson 6 Unit #4 Lesson 5
Challenge 2	Engineering Design Energy Motion and Stability: Forces and Interactions	K-2-ETS1-1, K-2-ETS1-2, K-2-ETS1-3, 3-5-ETS1-1, 3-5-ETS1-2, 3-5-ETS1-3, 4-PS3-4, MS-ETS1-1, MS-ETS1-2, MS-ETS1-3, MS-ETS1-4, MS-PS2-3, MS-PS3-5	Unit #1 Lesson 3 Unit #4 Lesson 7
Challenge 3	Engineering Design Energy Motion and Stability: Forces and Interactions	K-2-ETS1-1, K-2-ETS1-2, K-2-ETS1-3, 3-5-ETS1-1, 3-5-ETS1-2, 3-5-ETS1-3, 3-PS2-1, 3-PS2-2, 4-PS3-1, 4-PS3-3, 4-PS3-4, MS-ETS1-1, MS-ETS1-2, MS-ETS1-3, MS-ETS1-4, MS-PS2-1, MS-PS2-2, MS-PS2-3, MS-PS3-1, MS-PS3-5	Unit #1 Lesson 4 Unit #3 Lesson 7 Unit #5 Lesson 3
Challenge 4	Engineering Design Energy Motion and Stability: Forces and Interactions	K-2-ETS1-1, K-2-ETS1-2, K-2-ETS1-3, 3-5-ETS1-1, 3-5-ETS1-2, 3-5-ETS1-3, 3-PS2-1, 3-PS2-2, 4-PS3-1, 4-PS3-2, 4-PS3-3, 4-PS3-4, MS-ETS1-1, MS-ETS1-2, MS-ETS1-3, MS-ETS1-4, MS-PS2-1, MS-PS2-2, MS-PS2-3, MS-PS3-1, MS-PS3-5	Unit #1 Lesson 5 Unit #3 Lesson 3
Challenge 5	Engineering Design Energy Motion and Stability: Forces and Interactions	K-2-ETS1-1, K-2-ETS1-2, K-2-ETS1-3, 3-5-ETS1-1, 3-5-ETS1-2, 3-5-ETS1-3, 3-PS2-1, 3-PS2-2, 4-PS3-1, 4-PS3-3, 4-PS3-4, MS-ETS1-1, MS-ETS1-2, MS-ETS1-3, MS-ETS1-4, MS-PS2-1, MS-PS2-2, MS-PS2-3, MS-PS3-1, MS-PS3-5	Unit #3 Lesson 8 Unit #5 Lesson 4

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The Electric Motors Catalyst: Organized by Challenge (Continued)

Catalyst Challenge	Disciplinary Core Idea	The Standard	Unit and Lesson Location
Challenge 6	Engineering Design Energy	K-2-ETS1-1, K-2-ETS1-2, K-2-ETS1-3, 3-5-ETS1-1, 3-5-ETS1-2, 3-5-ETS1-3, 4-PS3-4, MS-ETS1-1, MS-ETS1-2, MS-ETS1-3, MS-ETS1-4	
Challenge 7	Engineering Design Energy	K-2-ETS1-1, K-2-ETS1-2, K-2-ETS1-3, 3-5-ETS1-1, 3-5-ETS1-2, 3-5-ETS1-3, 4-PS3-4, MS-ETS1-1, MS-ETS1-2, MS-ETS1-3, MS-ETS1-4	Unit #4 Lesson 8
Challenge 8	Engineering Design Energy Motion and Stability: Forces and Interactions	K-2-ETS1-1, K-2-ETS1-2, K-2-ETS1-3, 3-5-ETS1-1, 3-5-ETS1-2, 3-5-ETS1-3, 3-PS2-1, 3-PS2-2, 4-PS3-1, 4-PS3-4, MS-ETS1-1, MS-ETS1-2, MS-ETS1-3, MS-ETS1-4, MS-PS2-1, MS-PS2-2, MS-PS2-3, MS-PS3-1, MS-PS3-5	Unit #3 Lesson 5
Challenge 9	Engineering Design Energy Motion and Stability: Forces and Interactions	K-2-ETS1-1, K-2-ETS1-2, K-2-ETS1-3, 3-5-ETS1-1, 3-5-ETS1-2, 3-5-ETS1-3, 4-PS3-1, 4-PS3-2, 4-PS3-3, 4-PS3-4, MS-ETS1-1, MS-ETS1-2, MS-ETS1-3, MS-ETS1-4, MS-PS2-1, MS-PS2-2, MS-PS2-3, MS-PS3-1, MS-PS3-5	Unit #5 Lesson 8
Challenge 10	Engineering Design Energy Motion and Stability: Forces and Interactions	K-2-ETS1-1, K-2-ETS1-2, K-2-ETS1-3, 3-5-ETS1-1, 3-5-ETS1-2, 3-5-ETS1-3, 4-PS3-4, MS-ETS1-1, MS-ETS1-2, MS-ETS1-3, MS-ETS1-4, MS-PS2-1, MS-PS2-2	

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Next Generation Science Standard	Disciplinary Core Idea	Students Who Demonstrate Understanding Can	Electric Motors Catalyst	Unit and Lesson Location (1.1 = unit 1, lesson 1)
K-2-ETS1-1	Engineering Design	Ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool.	Catalyst Challenges: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10	1.1, 1.3, 1.5
K-2-ETS1-2	Engineering Design	Develop a simple sketch, drawing or simple model to illustrate how the shape of an object helps its function as needed to solve a given problem.	Catalyst Challenges: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10	1.1, 1.4
K-2-ETS1-3	Engineering Design	Analyze data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses of how each performs.	Catalyst Challenges: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10	1.6
1-PS4-1	Waves and Their Applications in Technologies for Information Transfer	Plan and conduct investigations to provide evidence that vibrating material can make sound and that sound can make materials vibrate.	Catalyst Challenge: 1	1.6
1-PS4-4	Waves and Their Applications in Technologies for Information Transfer	Use tools and materials to design and build a device that uses light or sound to solve the problem of communicating over a distance.	Catalyst Challenge: 1	1.6
3-5-ETS1-1	Engineering Design	Define a simple design problem reflecting a need or want that includes specified criteria for success and constraints on materials, time, or cost.	Catalyst Challenges: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10	3.3, 3.7, 3.8, 3.9 4.5, 4.8
3-5-ETS1-2	Engineering Design	Generate and compare multiple solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.	Catalyst Challenges: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10	3.5 and 3.9, 4.8

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Next Generation Science Standard	Disciplinary Core Idea	Students Who Demonstrate Understanding Can	Electric Motors Catalyst	Unit and Lesson Location (1.1 = unit 1, lesson 1)
3-5-ETS1-3	Engineering Design	Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.	Catalyst Challenges: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10	3.4, 3.8, 3.9 4.7, 4.8
3-PS2-1	Motion and Stability: Forces and Interactions	Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object.	Catalyst Challenges: 3, 4, 5, 8	3.2, 3.4, 3.5, 3.9
3-PS2-2	Motion and Stability: Forces and Interactions	Make observations and/or measurements of an object's motion to provide evidence that a pattern can be used to predict future motion.	Catalyst Challenges: 3, 4, 5, 8	3.6 - 3.9
4-PS3-1	Motion and Stability: Forces and Interactions	Use evidence to construct an explanation relating the speed of an object to the energy of that object.	Catalyst Challenges: 3, 4, 5, 8, 9	
4-PS3-2	Motion and Stability: Forces and Interactions	Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat and electric currents.	Catalyst Challenges: 4, 9	4.6, 4.7
4-PS3-3	Motion and Stability: Forces and Interactions	Ask questions and predict outcomes about the changes in energy that occur when objects collide.	Catalyst Challenges: 3, 4, 5, 9	
4-PS3-4	Motion and Stability: Forces and Interactions	Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.	Catalyst Challenges: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10	4.3 - 4.5, 4.8
4-PS4-3	Waves and Their Applications in Technologies for Information Transfer	Generate and compare multiple solutions that use patterns to transfer information.	Catalyst Challenge: 1	

The Electric Motors Catalyst: Organized by Standard (Continued)

Next Generation Science Standard	Disciplinary Core Idea	Students Who Demonstrate Understanding Can	Electric Motors Catalyst	Unit and Lesson Location (1.1 = unit 1, lesson 1)
MS-ETS1-1	Engineering Design	Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.	Catalyst Challenges: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10	
MS-ETS1-2	Engineering Design	Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.	Catalyst Challenges: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10	
MS-ETS1-3	Engineering Design	Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.	Catalyst Challenges: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10	
MS-ETS1-4	Engineering Design	Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.	Catalyst Challenges: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10	
MS-PS2-1	Motion and Stability: Forces and Interactions	Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects.	Catalyst Challenges: 3, 4, 5, 8, 9, 10	
MS-PS2-2	Motion and Stability: Forces and Interactions	Plan an investigation to provide evidence that the change in an object's motions depends on the sum of the forces on the object and the mass of the object.	Catalyst Challenges: 3, 4, 5, 8, 9, 10	

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MS-PS2-3	Motion and Stability: Forces and Interactions	Ask questions about data to determine the factors that affect the strength of electric and magnetic forces.	Catalyst Challenges: 1, 2, 3, 4, 5, 8, 9	
MS-PS3-1	Energy	Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object.	Catalyst Challenges: 3, 4, 5, 8, 9	
MS-PS3-5	Energy	Construct, use and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object.	Catalyst Challenges: 1,2, 3, 4, 5, 8, 9	