Electric Vehicles Toolkit

EV GRAND PRIX

HIGH SCHOOL PHYSICS

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EV Grand Prix

How can we maximize the work done by our electric vehicle?

Lesson Overview	Career Highlight
Students will build battery-powered cars by creating a simple circuit, calculate the acceleration and work done, make iterations for maximum performance, and race them.	Automotive Technician

STEM Course Connections	21st Century Skills	CTE Alignment
Physics Algebra	Creativity Innovation	Engineering Technology

Engineering Activity	
Science and Engineering Practices #2 & 8	Students will build a model of a vehicle, calculate work and power of their vehicle, and troubleshoot how to maximize the speed of their electric vehicle.

Materials

- Car kits for each group that include:
  - 4 wheels
  - 1 large (8 x 16 peg) lego sheet (2.5 x 5”)
  - 4 technic lego bricks
  - 1 skewer
  - 1 spool
  - 1 rubber band
  - 1 electric motor
  - 1- 2 AA batteries
  - Hot glue/tape
- Meter Sticks
- Stop watches
- A “track” (taped off section of classroom floor)
- Student Handout

Essential Questions

1. How do we power a car electrically?
2. What factors affect the performance of the car?
3. Using the electric vehicle as a model, how can we explain what work is?

Mission Prep

Engage (5 mins)

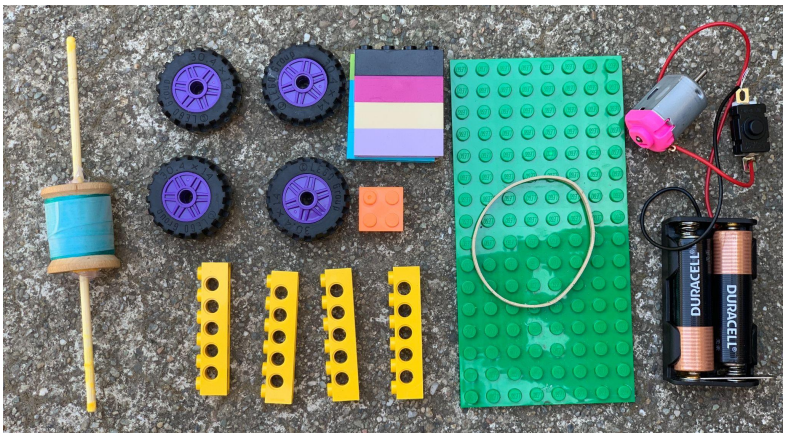
Warm-Up

Case Study: High School Students Building an EV

- Have students check out this high school auto shop class in Arizona that builds electric vehicles.
- There is an accompanying news video clip at the bottom of the article that could be watched as a whole class or individually.
- Have students respond to the following questions in their student handout:
  - How is the auto industry changing?
  - What new skills do mechanics need in order to work on electric vehicles?
- Additionally, they can check out this Master Guild Technician for Audi's career profile to learn more about automotive industry pathways.

Explore (30 mins)

BUILD IT Activity

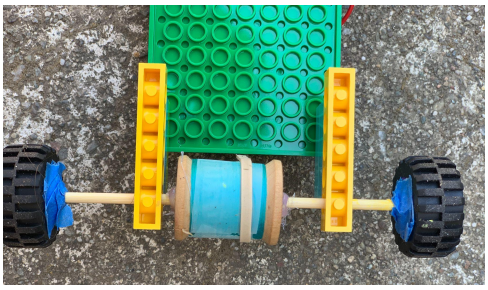


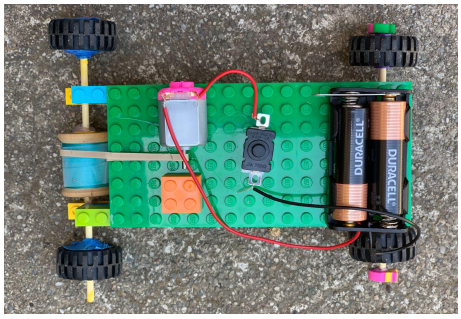
Materials:

4 wheels
1 large lego sheet
4 technic lego bricks
1 skewer
1 spool
1 rubber band
1 electric motor
1- 2 AA batteries
Hot glue/tape

Building the EV Car Directions:

1. Create chassis: Find a flat lego sheet (or cut cardboard), attach a technic lego brick to each corner.
2. Create axles: Cut skewers (4 inches), place through the holes of the technic lego, and attach wheels to the end of the skewers. For the drive shaft only: additionally thread the spool and rubber band through the skewer prior to placing through the holes of the technic lego.
3. Motor: Position the motor, switch, and battery on the top of the chassis.



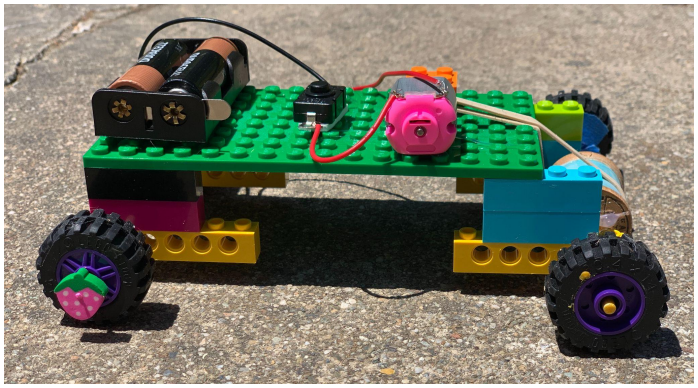


4. Position the rubber band: Place the rubber band around the spool attached to the drive shaft, pull it up to the top of the chassis where the motor is located and hook it onto the needle of the motor. Pull the motor back until the rubber band is taut.
5. Secure motor/battery pack: Once proper location is determined based off of the rubber band, glue motor and battery pack down onto the chassis.
6. Build a simple circuit: Make sure that your motor is connected in a simple circuit to the battery and the switch.

Tips:

- If the wheels or spool do not fit snugly onto the skewer, you may need to use tape or glue to keep them from moving independently.

- Sometimes the rubber band slips off of the needle of the motor. Either placing another lego brick at the edge of the needle or creating a stopper to attach at the end of the needle can help keep the rubber band in place.



- Students will create a car using the supplies and directions mentioned above
- Students will then sketch the model that they built in their student handout
- Students can then try releasing it down the classroom "track" to learn how it works

Launch

Explain (20 mins)

1. Define Work
    - Show the class the "What is Work?" video clip from GPB Education (0 - 6:25 mins)
    - Using the student handout, students can revisit the concepts of Newton's 2nd Law, mass, force, acceleration, and work. Students can then use their cars to calculate these for their own model EV.

Elaborate (40 mins)

1. Class Brainstorm
    - Now that students have established working definitions for power and work, pose to the class: How could we make our cars perform better? Travel farther? Travel faster?
    - Using the whiteboard, or a digital platform like Jamboard, hold a class brainstorm session to determine ways to improve the design of their model cars
    - Students will share ideas like widening/narrowing wheels, increasing/decreasing mass at front of car, increasing mass at back of car, adding a sail, incorporating a thicker rubber band, etc.

2. REV IT UP Activity
    - Have students pick one of the variables from the brainstorm session and change their car accordingly
    - For these adjustments, you may want to be ready with some common classroom supplies for them to use. Examples might include things like paper clips, binder clips, tape, paper, cardstock/index cards, erasers, etc. Students can also rummage through their desk/backpack to source materials.
    - Students will collect data, complete calculations, and analyze their results in their student handout

Exploration

Evaluate (25 mins)

EV Grand Prix Race Day

- Student share: have students share their design, what they chose to change and why it improves their car's performance. (This can be as a whole class or as partners/small groups)
- Students will set up their new and improved car models to race their classmates. Depending on class size and space, you may need to set up a series of "heats" that narrow down the competition.
- Once students have raced, they can complete the race day reflection in the student handout

Extend (Optional)

Have students create a pitch to sell their design to an interested auto company. The pitch should include design components (name / logo) as well as key structural features that lead to improved performance.

CA NGSS Standards

- HS-PS2-1. Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.
- HS-PS3-2. Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative positions of particles (objects).
- HS-ETS1-2. Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
- HS-ETS1-3. Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.

CTE Alignment

- B2.3 Present conceptual ideas, analysis, and design concepts using freehand graphic communication techniques.
- B3.8 Predict the effects of circuit conditions on the basis of measurements and calculations of voltage, current, resistance, and power
- B4.1 Describe Newton's laws and how they affect and define the movement of objects.
- B5.0 Understand how the principles of force, work, rate, power, energy, and resistance relate to mechanical, electrical, fluid, and thermal engineering systems.
- B6.0 Employ the design process to solve analysis and design problems.
- B6.3 Choose between alternate solutions in solving a problem and be able to justify the choices made in determining a solution.
- B6.6 Construct a prototype from plans and test it.
- B6.7 Evaluate and redesign a prototype on the basis of collected test data.

Resources

GPB Education. (2019). What Is Work? | Physics in Motion [YouTube Video]. In *YouTube*.

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