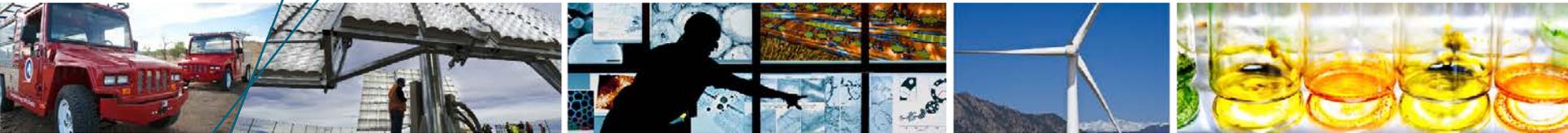


Tips for Planning, Building, and Testing Your Lithium- Ion Battery Powered Car



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TEACHER OVERVIEW

- The Lithium-ion battery powered car competition is designed to be an engineering challenge for middle school students.
- Students will be exploring the following concepts while planning, building and testing their cars:
 - Alternative energy sources
 - Engineering design
 - Aerodynamics
 - Force and motion
 - Teamwork
 - Problem solving
- **Teams who do not have a completed car at the national event will be disqualified from both the academic and car events.**

WHAT CAN TEACHERS DO TO HELP?

- Develop Safety Precautions.
 - Supervise students and instruct them in the proper use and care of utility knives, saws, drills, hot glue, soldering irons, and other dangerous tools.
 - Review Safety Hazards of Batteries and Material Safety Data Sheet at <http://science.energy.gov/nsb/middle-school/middle-school-coaches/>
- Follow the Rules!!
 - Be sure to read and follow all rules found at: <http://science.energy.gov/nsb/middle-school/middle-school-coaches/>
 - The vehicle cannot exceed the following dimensions: 20 cm wide by 40 cm in length.
 - A 8.5 x 2.5 cm space must be on the side, top or front of the car for a decal that will be provided at the national competition.
 - An on and off switch must be incorporated into the car design.
 - The vehicle must be designed to carry a payload of one 737 gram salt container.
- Set a schedule for planning, building, testing and revising.
 - See Student Design Plan
- Review the Teacher Workshop 2013 powerpoint.
 - <http://science.energy.gov/nsb/middle-school/middle-school-coaches/>

STUDENT DESIGN PLAN

- Building a Lithium-ion battery powered car is similar to building a real car. Since the energy is limited, the designer must do everything possible to make the car efficient so that the maximum amount of energy is used to make the car go.
- Basic Plan Outline
 - Brainstorm ideas
 - Research your ideas
 - Test your ideas
 - Choose a preliminary design
 - Build a prototype
 - Test the prototype
 - Make improvements

BRAINSTORMING

- The key principle in the process is to start your designs with many ideas, then investigate and evaluate them before locking into a design.
 - When brainstorming ideas remember to include
 - Materials for chassis, gears, axels, and wheels.
 - You must use the battery, battery connector and motor supplied in your kit to power your car.
 - Aerodynamics
 - Weight
 - Payload
 - Friction
 - Drive type
- Research
 - After brainstorming, research your ideas to determine which will work the best.
 - Research may include using books, online sources, expert recommendations, or hands on experimentation.

MATERIALS

- Materials included in the teacher kit are only intended to be used as learning tools. Faster cars will use parts from many different sources.
 - **You must use only the battery, battery connector and motor supplied in your kit to power your car.**
- Materials may be found in many different places. Use your imagination and creativity.
- Materials may be found at the following:
 - Toy vehicles
 - Snap together car kits
 - Construction kits (LEGO, K'NEX, etc.)
 - VHS, Cassette or 8-Track tapes
 - Hobby shops
 - Hardware stores
 - Discount stores

CHASSIS

○ Design

- When planning your design remember to consider the following:
 - Aerodynamics both above and below the chassis.
 - Weight distribution.
 - Placement of payload, eyelets, battery, switch and motor.

○ Choose Materials

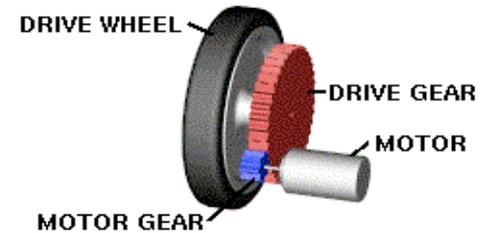
- Consider the weight and strength of materials used to construct your car. Use materials that are strong but lightweight as well as easy to work with.

TRANSMISSION

- How we get power from the motor to the wheels.
 - Gears should mesh well and not be overly loose or tight.
 - Only connect gears with the same pitch.
 - Belt drives may be used in place of gears.
 - Choosing the right gear ratio will be one of the most important decisions in building a competitive car.
 - Research gear ratios to give yourself a head start.
 - Do lots of experiments to find the right gear ratio.
 - Different gear ratios are best for certain wheel sizes.

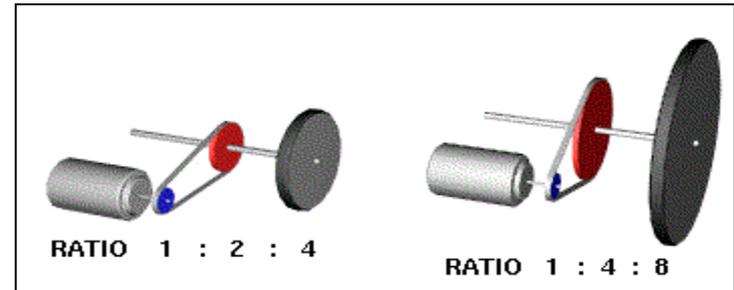


GEAR RATIOS



- A gear is a wheel with teeth on the outer edge. By itself a gear does not do much of anything. Gears must be teamed up with other gears in order to provide torque. Generally, if a gear gives you more force, it must give you less speed. If it gives you more speed, it has to give you less force.
- In a simple arrangement, one gear is attached to the motor shaft and another is snugly and firmly affixed to the axle, their teeth are in contact (meshed together) and this transmits the turning of the motor to turn the axle and its attached wheels.
- Gears with teeth make it possible to determine exact gear ratios - you just count the number of teeth in the two gears and divide. So if one gear has 60 teeth and another has 20, the gear ratio when these two gears are connected together is 60:20 or 3:1.
- Gears without teeth are more difficult. To calculate these gear ratios you need to use the diameter or circumference of the gears.

WHEELS AND BEARINGS



○ Wheel Size

- The size of the wheels will affect the torque-vs-speed performance of your gear ratio. Experiment to find the best wheel size for your transmission.

○ Rolling Resistance

- The choice of materials for the wheels and wheel alignment can make a big difference on the amount of friction. There should be minimal rolling resistance but enough friction on the drive wheels to propel the car.

○ Attaching Wheels

- Axels should be straight.
- Bearings should be low friction.
- Any lubrication should be very light.

TESTING

- Build your own track.
 - Use a smooth surface like a gym floor.
 - Tracks are 20 meters long and 60 cm wide.
 - At the national competition the track surface will be black neoprene rubber.
 - Test your car with a full payload.
- Use the guide wire when testing.
 - Use a guide wire such as fishing line to keep your vehicle from going off the track.
 - The guide wire should not be more than 1.5 cm above the track surface.
 - Cars usually go significantly slower when using the guide wire.
- Use the results of your testing to improve your cars performance.
 - What, if anything could you change to improve your cars performance?

BATTERY

- Battery does not need to be recharged after each use. A fully charged battery has an estimated 50 minutes of running time.
- For a fully depleted battery, allow 40 minutes to recharge.
- When the battery is first plugged in, the charging light is solid red. Then it will begin blinking very slowly when fully charged.
- Do not overcharge the battery. This does not improve performance and can destroy the battery.

TROUBLE SHOOTING

- If your car does not go check the following:
 - Electric connections and switches
 - Are the gears too tight or too loose?
 - Are the gears too loose on the shafts?
 - Is there glue on the gears, axels or wheels?
 - Are the wheels too close to the bearings?
 - Are the wheels too loose on the axels? (use hot glue)
 - Does your gear ratio provide enough torque?
- If your car goes backward reverse the connections from the battery connector.
- If your car goes off the track.
 - Try adding more eyelets for guidance.
 - Try shifting weight on your chassis.
- If your car is too slow.
 - Try changing combinations of gears and wheel sizes.
 - Try reducing the weight of your vehicle.
 - Try reducing the amount of friction or resistance on the vehicle.

ADDITIONAL RESOURCES

- Teacher resources

- <http://www.nrel.gov/docs/gen/fy01/30829.pdf>

- Chassis design

- <http://www.nrel.gov/docs/gen/fy01/30828.pdf>
- http://www.fsec.ucf.edu/en/education/k-12/curricula/heh2/documents/HEH2_11-HOH-Chassis.pdf

- Transmission

- http://www.fsec.ucf.edu/en/education/k-12/curricula/heh3/documents/HEH3_13_H2Sprint-Gears.pdf

- Gear ratios

- <http://www.nrel.gov/docs/gen/fy01/30830.pdf>
- <http://www.howstuffworks.com/gears.htm>
- http://www.ehow.com/how_12071010_tune-gear-ratios.html

- Wheels and bearings

- http://www.fsec.ucf.edu/en/education/k-12/curricula/heh2/documents/HEH2_12-HOH-Wheels.pdf