



## **National Science Bowl® Middle School Electric Car Competition**

### **Engineering Design Document Guidelines and Rubric**

The engineering design process involves a series of steps that lead to the design, building and testing of a model electric car. In this design challenge, students must complete each step and provide evidence documenting their work as they design and test Lithium-ion battery-powered cars. Essays should be typed in twelve-point Times New Roman font with one inch margins and single line spacing on 8.5 inch x 11 inch paper. Drawings may be hand drawn or produced with computer software. Spelling, grammar, writing clarity, organization and neatness are part of the judging criteria. The Engineering Design Document is restricted to 6 pages excluding the cover page. If the length of the Engineering Design Document exceeds 6 pages, it will receive zero points and will not be reviewed by the judging teams. The Engineering Design Document will be evaluated in the following 11 components. Examples of some of the components are provided below. Each component will be scored using the criteria shown in Engineering Design Document Rubric.

#### **Components:**

##### **1) Cover Page**

Include the following: Name of School, School District, Team Advisor, Regional Competition, & Team Members. You will also need to include the NSB cover logo and at least one other creative graphing representing your team such as a photo or logo on the cover page.

Name of School: Thomas Jefferson Middle School

School District: Washington School District

Team Advisor: Mrs. Danica Patrick

Regional Competition: Thomas Jefferson National Accelerator Facility

Team Members: John Doe, Sally White, Arthur Brown, Alice Gray, Bobby Black



## 2) Introduction/Background

Write a one paragraph on the advantages and disadvantages of electric vehicles. The essay should include the following:

- Advantages of electric vehicles compared with internal combustion vehicles.
- Disadvantages of electric vehicles compared with internal combustion vehicles.
- A rationale for increasing the use of electric vehicles in the United States.
- Difficulties involved in increasing the use of electric vehicles in the United States.

## 3) Identify Design Goals and Define Design Challenges

Students should list the design goals (such as low weight) of the vehicle and describe the criteria (light chassis needed), constraints (needs to run straight hooked to a guide wire), and requirements (minimum material strength) necessary for the car to meet each of those goals.

## 4) Brainstorm Possible Solutions

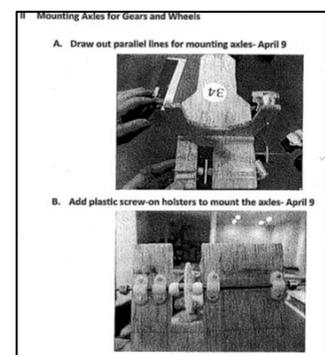
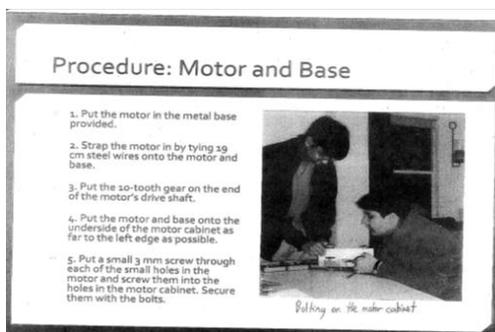
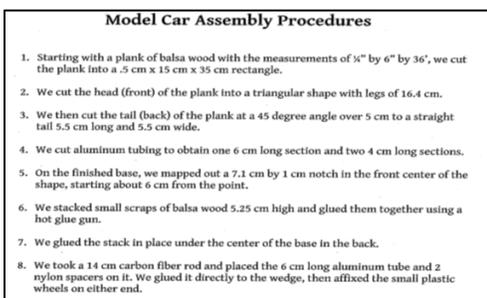
The team should submit sketches used to share ideas and elicit feedback as the group discusses ways to solve each design challenge listed in component 3. These quick rough drawings should include labels and arrows to identify the materials and functionality needed.

## 5) Explore Possibilities and Select an Approach

Students should list the pros and cons of each idea developed in the sketches and determine the vehicle design that appears to best address all aspects of the problem. Students should write a one paragraph statement that describes their arrival at consensus on the prototype design.

## 6) Build a Model or Prototype

Students will construct a full-size or scale model based from their drawings. The construction will be documented by listing the step-by-step procedures used to build the vehicle. Teams must include photos of the vehicle taken during construction with the assembly procedures. Teams may use additional drawings to enhance the description of the construction. Students must also include a full photograph of the completed prototype. Scoring will be influenced by the amount of clarity and the degree to which the procedures can be easily followed.



## Building a Model or Prototype

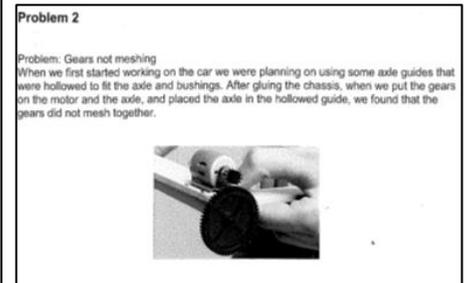
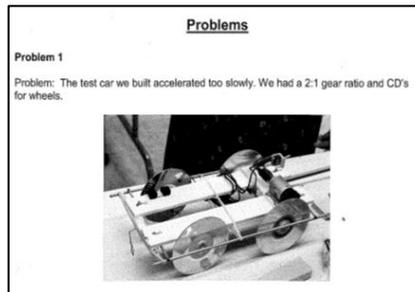
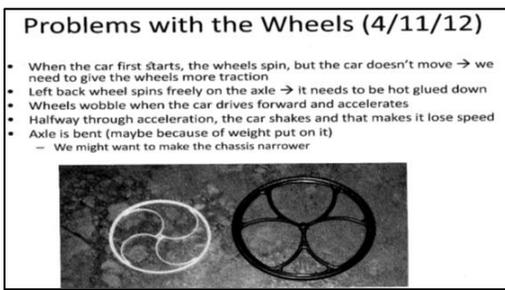
## 7) Prototype Testing & Measurement

Students should test, record and measure their prototype performance against the criteria, constraints, and requirements (as established in component 3).

## 8) Refine the Design

Students should examine the results of their testing and measurements. Students should then refine the design of their car in an effort to improve its performance when compared to the initial criteria, constraints and requirements (as established in component 3). The refinement process should include a three part sequence:

1. Identify the improvements needed by listing at least three issues or problems the team encountered during the planning, design, construction, or testing of the vehicle;
2. Propose refinement solutions for each of the problems or issues by describing the steps taken by the team to solve it; and
3. After refinements are employed, students should retest, record and measure their design again against the initial criteria, constraints, and requirements. Include which problem was the most difficult for the team to solve.

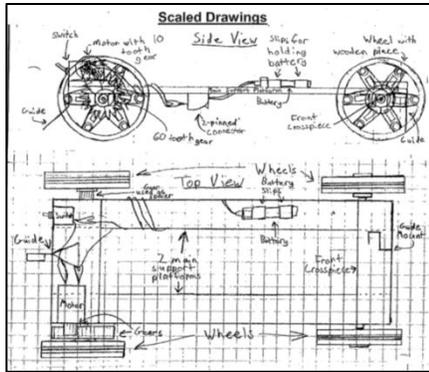


### Refine The Design

## 9) Final Design Description

Students should describe the final design by including:

1. A list of all components (and quantities used) in construction of the vehicle.
  - a. The component list should include an itemized cost for each part and total cost to build the car.
2. Final specifications including dimensions, gear ratio, drive type (direct, single gear, belt, front, etc.), top average speed, and vehicle mass with/without payload.
3. A final scaled drawing of the vehicle including the scale ratio used and orthographic projections (multiple views showing the top, front and one side).
  - a. These drawings are to be drawn using software or neatly by hand, using rulers to draw straight lines and to make parts proportional. Parts and measurements should be labeled clearly.
  - b. These drawings should be sized to fit a single 8.5 inch x 11 inch paper.
4. A digital photo of the final vehicle.



**Final Specifications**

<b>Dimensions</b>	<b>Weight</b>
Length (including wheels): 26.5 cm	Weight without bottle: 1.13 newtons
Length (Chassis): 23.8 cm	Weight with bottle: 6.09 newtons
Length (Wheelbase): 22.9 cm	
Height (Without Bottle): 7.0 cm	<b>Speed</b>
Height (With Bottle): 7.5 cm	Top speed: 3.12 meters per second
Width (Front Wheels): 13.1 cm	Average speed: 2.77 meters per second
Width (Back Wheels): 11.1 cm	
Width (Chassis): 6.4 cm	<b>Drive Type</b>
	Drive Type: Gear
<b>Mass</b>	<b>Gear Ratio</b>
Mass without bottle: 115.5 g	Gear Ratio: 2/5 or 0.4
Mass with bottle: 621.0 g	
Mass without bottle: 0.1155 kg	
Mass with bottle: 0.621 kg	

**Model Car Component List**

- Base: balsa wood, cut and shaped, .25" x 34 cm x 15 cm
- 2 - 2" diameter Super Lite Wheels by Du-Bro
- 2 - 1.25" diameter Pinewood Derby wheels
- 1 - carbon fiber rod, 16 cm long, .125" diameter
- 1 - carbon fiber rod, 14 cm long, .125" diameter
- 2 - plastic tubes, 4 cm long, .25" diameter
- 2 - aluminum tubes, 4 cm long, .25" diameter
- 1 - aluminum tube, 6 cm long, .25" diameter
- 2 - plastic gears, 5 cm diameter, .5 cm thick, 50 teeth
- 4 - 3/8" metal washers
- 1 - Cardboard tube (interior of a roll of packing tape), halved
- 16 - Balsa scraps, .25" thick
- 3 - Balsa wood squares, 4 cm x 4 cm x .1"
- 1 - Balsa wood square, 4 cm x 3 cm x .25"
- 1 - Balsa wood triangle, 3 cm legs x 4 cm hypotenuse x .25"
- 1 - ACE medium duty toggle switch
- 1 - Mashubi 280 motor (provided)
- 1 - motor harness (provided)
- 1 - lithium-ion battery (provided)
- 1 - battery connector (provided)
- 1 - Paper clip, 3 cm
- Solder - 60% tin 40% lead fine electrical solder
- Low-melt hot glue

Scaled Drawing (top, side views only), Component List (without itemized costs) & Final Specifications

### 10) Lessons Learned

In a one paragraph essay, describe lessons learned by the team while planning, designing, constructing and testing the lithium-ion battery- powered vehicle. Lessons learned may involve team work, scientific principles, engineering design, difficulties encountered or other aspects of the project.

### 11) Quality Work

The Engineering Design Document will be assessed for quality displayed components with appropriate spelling, grammar, writing clarity, organization and neatness. Components displayed otherwise or essays exceeding length limits will not receive a point value.



## Engineering Design Document Rubric

School Name \_\_\_\_\_

At the national competition, all teams are required to submit an Engineering Design Document. These design documents will be judged using the rubric below.

Components	Points Awarded				Score	Comments
<p><b><u>1) Cover Page</u></b></p> <p>Criteria: 1) Team information 2) NSB logo 3) Team logo or photo</p>	<i>Includes all 3 criteria</i>  3 POINTS	<i>Includes 2 of 3 criteria</i>  2 POINTS	<i>Includes 1 of 3 criteria</i>  1 POINT	<i>No criteria met</i>  0 POINTS		
<p><b><u>2) Introduction</u></b></p> <p>Six Line Limit Criteria: 1) Electric vehicles advantages and disadvantages, 2) Rationale for increasing use &amp; 3) Difficulties involved in increasing use.</p>	<i>Includes all 3 criteria</i>  4 POINTS	<i>Includes 2 of 3 criteria</i>  3 POINTS	<i>Includes 1 of 3 criteria</i>  2 POINTS	<i>No criteria met</i>  0 POINTS		
<p><b><u>3) Identify Design Goals and Define Design Challenges</u></b></p> <p>Criteria: 1) List Submitted 2) Includes design goals of the vehicle 3) Includes how to meet each of those goals</p>	<i>Includes all 3 criteria</i>  5 POINTS	<i>Includes 2 of 3 criteria</i>  4 POINTS	<i>Includes 1 of 3 criteria</i>  3 POINTS	<i>No criteria met</i>  0 POINTS		

<p><b>4) <u>Brainstorm Possible Solutions</u></b></p> <p>Criteria: 1) Sketches Submitted 2) Demonstrates sharing of ideas and eliciting feedback 3) Includes labels/arrows identifying the materials and functionality needed</p>	<p><i>Includes all 3 criteria</i></p> <p>4 POINTS</p>	<p><i>Includes 2 of 3 criteria</i></p> <p>3 POINTS</p>	<p><i>Includes 1 of 3 criteria</i></p> <p>2 POINTS</p>	<p><i>No criteria met</i></p> <p>0 POINTS</p>		
<p><b>5) <u>Explore Possibilities and Select an Approach</u></b></p> <p>Criteria: 1) List includes Pros/Cons for each idea developed in sketches 2) Six line limit-describes prototype design 3) Six line limit-describes team consensus on prototype selection</p>	<p><i>Includes all 3 criteria</i></p> <p>5 POINTS</p>	<p><i>Includes 2 of 3 criteria</i></p> <p>4 POINTS</p>	<p><i>Includes 1 of 3 criteria</i></p> <p>3 POINTS</p>	<p><i>No criteria met</i></p> <p>0 POINTS</p>		
<p><b>6) <u>Build a Model or Prototype</u></b></p> <p>Criteria: 1) Includes Step-by-step building procedures 2) including photos/pictures Drawings taken during construction 3) includes final prototype photo</p>	<p><i>Includes all 3 criteria</i></p> <p>5 POINTS</p>	<p><i>Includes 2 of 3 criteria</i></p> <p>4 POINTS</p>	<p><i>Includes 1 of 3 criteria</i></p> <p>3 POINTS</p>	<p><i>No criteria met</i></p> <p>0 POINTS</p>		
<p><b>7) <u>Prototype Testing &amp; Measurement</u></b></p> <p>Criteria: 1) Car performance tested 2) Record of testing results 3) Prototype performance measured against initial criteria, constraints, and requirements</p>	<p><i>Includes all 3 criteria</i></p> <p>4 POINTS</p>	<p><i>Includes 2 of 3 criteria</i></p> <p>3 POINTS</p>	<p><i>Includes 1 of 3 criteria</i></p> <p>2 POINTS</p>	<p><i>No criteria met</i></p> <p>0 POINTS</p>		

<b>8) Refine the Design</b> Criteria: 1) List of improvements needed 2) Refinement solutions proposed for each improvement 3) Refinement performance tested & recorded	<i>Includes all 3 criteria</i>  8 POINTS	<i>Includes 2 of 3 criteria</i>  7 POINTS	<i>Includes 1 of 3 criteria</i>  6 POINTS	<i>No criteria met</i>  0 POINTS		
<b>9) Final Design Description</b> Criteria: 1) Listed car components with actual costs 2) Final specifications 3) Final scaled drawing & digital photograph of the final vehicle	<i>Includes all 3 criteria</i>  5 POINTS	<i>Includes 2 of 3 criteria</i>  4 POINTS	<i>Includes 1 of 3 criteria</i>  3 POINTS	<i>No criteria met</i>  0 POINTS		
<b>10) Lessons Learned</b> Criteria: 1) Described 1 lesson learned 2) Described 2 lessons learned 3) Described 3 lessons learned	<i>Includes all 3 criteria</i>  3 POINTS	<i>Includes 2 of 3 criteria</i>  2 POINTS	<i>Includes 1 of 3 criteria</i>  1 POINT	<i>No criteria met</i>  0 POINTS		
<b>11) Quality Work</b> Criteria: 1) Components displayed with appropriate spelling, grammar and writing clarity 2) Components displayed with organization and neatness. 3) Essays do not exceed length limits, such as one paragraph.	<i>Includes all 3 criteria</i>  4 POINTS	<i>Includes 2 of 3 criteria</i>  3 POINTS	<i>Includes 1 of 3 criteria</i>  2 POINTS	<i>No criteria met</i>  0 POINTS		

 Document Within 6 Pages

 Document Exceeds 6 Pages - Zero Points

JUDGE \_\_\_\_\_

TOTAL \_\_\_\_\_ /50