E-CAR CURRICULUM

Robert L. Aske **REV 9/19/00**

OBJECTIVE

Learn about (1) mechanics, (2) electricity, (3) how to work in teams, (4) how to make decisions and (5) how to safely use tools. This will be demonstrated by designing, fabricating, testing and racing your full sized Electric Car [E-Car] in competition with other schools.

SCHEDULE

Oct.	**Nov.**	**Dec.**	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**
Design, Build & Race a Model E-Car			Design & Build Full Sized E-Car			Test/Modify	Race

REQUIREMENTS

Model E-Car - Design and build a small model electric car.

Full Sized E-Car - The class must use the motor and 12 volt power supply provided. All other components to be scrounged. A budget of $100+ may also be used to purchase parts. All work is to be done by the class. A list of suggested materials and tools to be scrounged is attached.

Safety - Safety goggles must be worn when operating power tools. The Teacher or Engineer must be present when power tools are being used. Each student and his/her parent must sign a safety waiver to participate in all E-Car activities.

TOOL TRAINING

Provided by Teacher and Engineer.

E-CAR DEVELOPMENT PROCESS

Model E-Car

- Design and build a small car (less than 12" long) powered by a toy motor and flashlight batteries (provided).

"Full Sized" E-Car (big enough to carry 1 person at around 10 MPH, powered by a 12V automotive-style battery)

- **Individual Research**
  Suggest going to the library and continue visiting stores such as NH Northern [have many gas powered cars] Fleet Farm, Ax-Man, Radio Shack, Toy Stores and lumber companies such as Menards, Justin, etc. [have scrap barrels of free stuff]. This research will help you come up with some good ideas during brainstorming E-Car designs.
- **Brainstorm the Full Sized E-Car**
- **Create E-Car Specification**
  Specification defines E-Car performance such as acceleration, speed, weight, steering, maximum current, stopping distance, range, vehicle name, vehicle color, ergonomics, etc. Keep updating!!!!
- **Divide into teams responsible for:-Power Transmission, Weight Management, Steering, Braking, Testing, Documentation**
- **Drawings of the E-Car**
  - Assembly drawing of complete E-Car
  - Drawings of significant subassemblies such as (1) steering mechanism, (2) Motor mounting assembly, etc.
  - Keep updating!!!!
- **Scrounge and Bring in more Tools**
- **Scrounge and Bring in more Material**
- **Learn to use the Tools..... SAFETY**
- **Fabricate the E-Car..... SAFETY**
- **Test the E-Car..... SAFETY**
- **Redesign/Modify/Test the E-Car Again...and Again..... SAFETY**
- **Pre-Race Checkout..... SAFETY**
- **Race [Speed, Maneuverability and Endurance]..... SAFETY**

LIST OF MATERIALS & TOOLS FOR THE MODEL E-CAR

MATERIALS

Wood
- **Plywood**
- **Sticks**
- **Sheet**
- **Dowell Rod**

Tacks & Pins
Small Nails
Polystyrene Foam
Cardboard
Cigar Box [good cardboard]
Electrical Tape
Glue / Adhesives
Wheels [toy cars]
Wheels [wood]
Switches
Terminal Board
*****Battery Charger [AA battery]**
*****AA Rechargable Batteries**
*****AA Battery Holder**
*****Electric Motor**
Screws & Nuts
Wood Screws
Washers
Rubber Bands
Electric Wire
O-Rings
Springs
Cotter Pins
Spools

TOOLS

X-ACTO Basic Knife Set
Single Edge Razer Blades
Pliers
Wire Cutters
Screw Drivers
Files
Sand Paper
Drills [1/16" thru 1/4"]
Electric Drill
- **Electric Jig Saw with Blades**

Electric Sander with Sand Paper
Hand Drill [various types]
Hand Saws [various types]
Ruler
Hammer [various types]
Center Punch
Electric Soldering Iron
Solder
Solder Flux
C Clamps
Vice

***** Supplied by B*E*S*T**

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MATERIALS & TOOLS FOR THE FULL SIZE E-CAR

MATERIALS

- Wood
  - Plywood Sheets
  - 2"x4"'s [up to 8' long]
  - 2"x2"'s [up to 8' long]
  - 1"x4" Lumber
  - 1"x6" Lumber
  - Dowel Rods [various sizes]
  - Sticks
- Bicycles [at least 2 or 3]
- Wagons
- Golf Cart
- Chair and/or Tractor Seat
- Large Wood Box [for frame?]
- Lawn Mower
- Structural Metal Forms
- Pipe [metal and plastic]
- Fasteners
  - Wood Screws [up to 5/16"]
  - Machine Screws [up to 5/16"]
  - Nuts [up to 5/16"]
  - Flat Washers [up to 5/16"]
  - Lock Washers [up to 5/16"]
  - Nails [all sizes]
- Electrical Tape
- Duct Tape
- Masking Tape
- Glue / Adhesives
- Pulleys
- Muffler Clamps
- Other Clamps
- Bungy Cords
- 12 Volt Horn or Siren
- ***Wire
- ***Switches
- ***Amp Meter
- ***Electric Motor(s)
- ***Battery
- ***Battery Charger
- ***Terminals

*** Supplied by B*E*S*T

TOOLS

- Pliers
- Wire Cutter
- Wire Stripper
- Terminal Crimper
- Crescent Wrench
- End Wrench Set
- Box Wrench Set
- Socket Wrench Set
- Screw Drivers [various types]
- Files [smooth and rough]
- Sand Paper
- Ruler
- Tape Measure
- Drill Bits [1/16" thru 1"]
- Electric Drill
- Electric Jig Saw with Blades
- Electric Sander with Sand Paper
- Hand Drill [various types]
- Hand Saws [various types]
- Hammers [various types]
- Center Punch
- C Clamps [various sizes]
- Vice
- Weighing Scale [E-Car wt measure]
- Chisel [various sizes]
- Electric Soldering Iron
- Solder
- Solder Flux

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Lesson 1 - Scrounging E-Car Materials & Tools

What is needed?

- **List of Materials & Tools**
- **Progress to date**
- **Critical Items**

MATERIALS	TOOLS
Wood [2x2's, 2x4's 1x4's, 1x6's, plywood]	**Hand Tools You've been Using**
Bicycles [2 or 3]	**Ruler & Tape Measure**
Chair / Tractor Seat	**Electric Drill with Drills**
Wagon	**Electric Jig Saw with Blades**
Structural Metal Forms	**Center Punch**
Pipe [Metal & Plastic]	**Clamps & Vice**
Fasteners [screws, nuts, washers, nails]	**Wrenches [End, Box, Socket, Crescent]**
	Scale [Weigh E-Car parts]

Resources

- **You & Your Team**
- **Teacher & Engineer**
- **Parents, Siblings & Relatives**
- **Friends**
- **Businesses [Explain your E-Car Class Project]**
  - **- Bicycle Stores / Shops**
  - **- Lumber Yards [Justin, Menards, etc. - scrap barrels of free stuff]**
  - **- Garage Sales [lots of cheap stuff]**
  - **-**
  - **-**

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Lesson 2 - Creating E-Car Specification

Definition

- **The Specification is a written document that describes the car and its performance.**

What should be Defined?

- **Car Name & Color**
- **Electrical**
  - **- 12 VDC Battery [Amp-hours capacity]**
  - **- Maximum Current [20 amp, max]**
  - **- Motor Ratings [Voltage, RPM, Torque, Power]**
  - **- Switches**
  - **- Wiring [Red & Black per code (Red = Positive & Black = Negative)]**
- **Mechanical**
  - **- Brakes**
  - **- Number of Wheels, Wheel Size**
  - **- Weight**
  - **- Steering Mechanism**
  - **- Car Size [Wheel Base, Width, Height]**
  - **- Power Transmission**
  - **- Control Panel**
  - **- Frame**
- **Accessories**
  - **- Speedometer**
  - **- Amp Meter**
  - **- Horn**
  - **-**
- **Performance**
  - **- Velocity**
  - **- Acceleration**
  - **- Stopping Distance**
  - **- Hill Climb**
  - **- Range**
  - **- Ergonomics**
  - **- Should E-Car have a Reverse Mode?**

Continue to Update Specification as Changes / Tests Occur

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Lesson 3 - Creating E-Car Drawing

Definition

- **The Drawing defines the car design and its dimensions so it can be made.**

Types of Drawings

- **Sketch** **Drawn Free-Hand**
- **Scale Drawing** **Drawn with Instruments**
  - **Top View**
  - **Side View**
  - **Front View**

Scale

- **Your Car will be approximately 6 feet long**
- **Your drawing size is only 8-1/2" by 11"**
- **A Scale Factor Must Be Used. Example:-**
  - **1/12 [1 inch = 1 foot]**
  - **1/10 [1 inch = 10 inches]**
  -

Instruments Required

- **Pencil**
- **Ruler**
- **Compass**
- **Protractor**
- **Triangles [30 degree & 45 degree]**
- **Templates**

Example

- **Our Teacher - Engineer Team Built an E-Car**
- **See "Full Size E-Car" Drawing, Revision C**

Continue to Update Drawing(s) as Changes / Tests Occur

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Lesson 4 - E-Car Research

Why do Research?

- **Find out what others have done**
- **No need to "Re-invent" E-Car Concepts**
- **End up with B*E*S*T E-Car Design**

Resources

- **Your Model E-Car**
- **You & Your Team**
- **Teacher & Engineer**
- **Parents**
- **Siblings**
- **Relatives**
- **Friends**
- **Library**
- **Internet**
- **Stores**
  - **NH Northern [has many gas powered cars]**
  - **Fleet Farm**
  - **Ax-Man**
  - **Radio Shack**
  - **Toy Stores [Toys-R-Us]**
  -
- **Newspaper**
- **Catalog**
- **Magazines [Popular Science, Popular Mechanics, etc.]**
- **Car Shows**
-
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Lesson 5 - E-Car Brainstorming

Use Your Team to create E-Car Ideas

Chose Team Leader to:-

- **Lead Discussions**
- **Document Ideas**

Rules

- **Be Enthusiastic about all Ideas**
- **No Negatives ..... Until EVALUATION**

Select Area(s) to Brainstorm. Examples:-

- **Brakes**
- **Steering Mechanism**
- **Power Transmission**
- **How to Minimize Weight**
- **Overall Design [3 wheels ... or 4 wheels, etc.]**

Evaluation

- **Each Idea Should Be Discussed**
- **Create Matrix to Evaluate**
  - **Feasibility**
  - **Weight**
  - **Ergonomics**
  - **Aerodynamics**
  - **Cost**
  - **-**
  - **-**
  - **-**

Assign Ranking Numbers 5=Best / 1=Worst

Incorporate Selected Ideas into:-

- **E-Car Specification**
- **E-Car Drawing(s)**
- **The E-Car itself**

Lesson 6 - Tool Use & Safety

E-Car Parental Permission Form must be signed by Parent & Teacher for each Student.

Training of the Student by either the Teacher or Engineer is required before using the following Tools:-

- **Electric Drill**
- **Electric Jig Saw**
- **Electric Sander**
-
-
-
-
-

Safety Goggles must be worn when operating Power Tools

Teacher or Engineer must be present when Power Tools are Used

Lesson 7 - Team Requirements

The Design and Fabrication of the Full Sized E-Car requires Team Work. The Class cannot all work on the same element of the Car at the same time. Teams need to be formed. We will end up with what ever works the B*E*S*T by trial and error.

Some Initial Team Suggestions:-

- **Power Transmission Team**
- **Steering Mechanism Team**
- **Brake Design Team**
- **Documentation Team**
  - **Specification**
  - **Drawing(s)**
  - **Weight Management**
- **Frame Design Team**
- **Electrical Team**
- **Accessories Team**
  - **Speedometer**
  - **Amp Meter**
  - **Horn**
  -
  -
-
-

Lesson 8 - E-Car Physics

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Mechanics

F = Force — **Measured in pounds. The E-Car must overcome the following resistance forces:-**

Rolling Resistance	**Friction**
Air Resistance	**Head Wind**
Gravitational Resistance	**Going up a Hill**

D = Distance — **Measured in inches, feet and miles**

V = Velocity — **Distance per unit of Time (T). Measured in ft/sec and mph.**
V = D/T
1 mph = 5280 ft / 3600 sec = 1.467 ft/sec

Energy or Work — **Distance times Force (ft-lb)**

Torque — **Force times Lever Arm (lb-ft). Twisting action.**

Gear Ratio — **If the motor pulley of diameter, d, is driving a wheel of diameter, D:-**

Wheel Torque is amplified by	**D/d**
Wheel spin rate is lowered by	**d/D**

P = Power — **Energy or Work or Torque per unit of Time (ft-lb/sec)**
1 Horsepower = 550 ft-lb/sec
Output Power of E-Car = Resistance Force times Velocity = FV
Output Power of Motor = Output Torque times Angular Velocity

Electricity

I = Current — **Charge per unit of time. Measured in amperes (amp).**
Current flows from (+) to (-) terminal of the Battery.

E = Voltage — **Potential difference between (+) and (-) terminal of the Battery.**
Measured in Volts.

P = Power — **Input power to the Motor = Voltage times Current = EI. Measured in Watts.**
746 watts = 1 horsepower

e = Efficiency — **The efficiency of the E-Car = Output Power / Input Power**

Circuit — **A simple circuit or wiring diagram of the E-Car is shown below:-**

Sample E-Car Problems

1. The E-Car Motor draws 15 amp at 12 volts. How much power is being used?

Input Power = EI = 12 Volts x 15 Amps = 180 Watts or 180/746 = 0.24 Horsepower

2. The E-Car moves 120 feet in 10 seconds. What is its Velocity?

V = D/T = 120 ft / 10 sec = 12 ft/sec or 12 / 1.467 = 8.18 mph

3. The resistance force on the E-Car is 10 pounds when it is moving at 12 ft/sec. What is its Output Power?

Output Power = FV = 10 lb x 12 ft/sec = 120 ft-lb/sec or 120/550 = 0.22 Horsepower

What is its efficiency if the motor is drawing 15 amp at 12 volts (see problem 1, above)?

e = Output Power / Input Power = 0.22 / 0.24 = 92%

4. The 1" diameter Motor Pulley is spinning at 30 rev/sec. How fast is the 20" diameter wheel spinning (see diagram, below)?

Wheel Spin Rate = d/D x Motor Spin Rate = [1 in / 20 in][30 rev/sec] = 1.5 rev/sec.

How fast is the E-Car moving?

Wheel Circumference = 20 inch x 3.1416 = 62.8 inch or 62.8 / 12 = 5.24 ft.

Velocity = 1.5 rev/sec x 5.24 ft = 7.85 ft/sec or 7.85 / 1.467 = 5.4 mph.