

ChE-455/ChE-555: Analysis of Electrochemical Systems

Winter 2009

Ohio University

Department of Chemical and Biomolecular Engineering

Due: 03/12/09

Course Project: Electro-Chem-E-Car

As part of your course grade, you will design and construct an electro-chemically powered vehicle within certain size constraints. The vehicle must be designed to also carry a specified cargo. The constraints and rules of the vehicle are given (they are similar rules to the chem.-E-car competition of the AIChE). You will work in groups. The team members will be chosen by the instructor.

You are required to submit (by written in memo style) a title and a sketch of your cars describing: energy sources, design, materials to be used, and safety issues to the instructor on 02/03/09. The instructor and the chemical and biomolecular engineering department will give recommendations about your design (approval, denial, or approve with changes) a week later. By February 10, 2009 your team must have ordered all the materials required for the construction of the car within the budget constraints. Orders for the cars will be placed through Carrie Linscott (administrative associate of the chemical and Biomolecular Engineering Department). In addition, you must demonstrate to Dr. Botte by February 19, 2009 the operation of the electrochemical device constructed to power the vehicle. Failure to fulfill any of these three requirements (memo with sketch, ordering of parts, and demonstrating the electrochemical device to Dr. Botte) will result on a Failing grade in the project.

Your grade will be assigned based on the originality and performance of your design. 50% will be assigned to an oral presentation, and the other 50% will be assigned to the operation of your car. To get the 50% for your car performance, the car should move at least 60 ft with the constraint cargo of 500 ml of water. The car should stop as close as possible to the given distance. A penalty of 10 points will be applied to cars that do not stop in a range of $60 \text{ ft} \pm 3 \text{ ft}$ (that is $60\text{ft} \pm 5\%$).

The oral presentation should not be longer than 20 minutes; each team member should participate in the presentation. The presentation should include:

1. Description of the electro-chemical reaction / power source
2. Unique features of the vehicle
3. Design creativity
4. Environmental and safety features
5. Vehicle control (distance and cargo calibration)

Your presentation grade will be given by your individual performance and the team's performance. The electronic file of the presentation should be delivered to Dr. Botte the day the project is due.

The maximum amount of money that you are allowed to spend in your car is \$250. The chemical and biomolecular engineering department will paid for the materials needed to build the car until the specified limit. The chemical and biomolecular engineering department will own the cars built with all the rights. The following rules applied for the construction of the car:

- a. Each car will be given two opportunities to travel the 60 ft distance with a load of 500 ml of water. It should stop as close as possible to this distance (a good calibration curve is required). A penalty of 10 points will be applied to cars that do not stop in a range of $60 \text{ ft} \pm 3 \text{ ft}$ (that is $60 \text{ ft} \pm 5\%$).
- b. An objective of this project is a demonstration of the ability to control an electrochemical reaction. The only energy source for the propulsion of the car is a chemical reaction. Commercial batteries (for example, AA batteries) are not allowed as the power source.
- c. The car must be an autonomous vehicle and cannot be controlled remotely.
- d. No mechanical force can be applied to the wheel or ground to slow or stop the car (e.g. no brakes).
- e. There can be no mechanical or electronic timing device to stop the electro-chemical reaction.
- f. All components of the car must fit into a shoebox with dimensions equal to or smaller than $32 \times 20 \times 12 \text{ cm}$. The car may be disassembled to meet this requirement.
- g. The car must carry a container that holds up to 100 ml of water without spilling. An example container is a Nalgene Low-Density Polyethylene Narrow-Mouth Bottles (500 ml) Nalge No. 38-430 20039016 or Fisher Cat. No 02-923-11G. At the time of the grading, only the water will be supplied, thus each car must already have its own container.
- h. The cost of the contents of the "shoe box" and the chemicals must be maximum \$250.

The chemical and biomolecular engineering department will select the best project to participate in the regional or national chem.-E-Car competition. The winners will be sponsored by the chemical and biomolecular engineering department to attend the competitions. Only registration, traveling, and hotel expenses will be covered by the department (no meals will be covered). The winner team will received additional money in parts to upgrade the car for the competition (the amount of money will be requested and justify according to the changes and the justifications for the changes). The selection of the best electro-chem-E-car will be done sometime during week 10. The exact day will be given later during the class. Faculty from our department and/or other engineering department will integrate the jury. The best project will be selected based on a poster presentation and a car test. The poster presentation should include all the information covered in the Project presentation. All the rules described before applied for the car performance. In addition, the car winner car will require to perform a specific task as describe below:

1. The car will have two opportunities to traverse a specified distance carrying a 500 mg weight of water. The required distance will be given to each team member 2 hours prior to the start of the competition. The distance will be between 15-30 m. Teams are allowed to adjust fuel or reactants that participate in the car's chemical reaction.
2. The car will start with its front end just touching the designated starting point. There will be a designated finish line. The distance will be measured with respect to the front end of the car. The goal of the competition is to have your car stop

closest to the specified finish line (not being out of bounds) while carrying out the specified weight. A car that goes out of the bounds will have a penalty.

For more information about chem-E-car competitions visit the AIChE web site at <http://students.aiche.org/events/chemecar.asp>.

Electro-Chem-E-Car Competition Guidelines

Date: to be announced

Time: to be announced

Place: to be announced

1. Competition Evaluation Criteria:

Poster: 45 %

The criteria that will be evaluated in the poster are given below:

1. Overall presentation (5)
2. Preparation of the team members (5)
3. Description of the electro-Chemical Reaction/Power Source and understanding of the operation of the vehicle (5)
4. Control and calibration of the vehicle (5)
5. Design Creativity (8)
6. Unique features of the vehicle (5)
7. Budget/Design Ratio. How appropriate is the budget according to the design (6)
8. Environmental and Safety Features (6)

The sum of all these items will totalize maximum 40 points.

Performance: 55%

The maximum number of points that the team will receive is 55 points. The number of points will be calculated according to:

$$\text{Points} = \frac{55}{D} \quad (1)$$

where d is the distance measured (see rules for the definition of d), and D is the target distance for the task.

The team with the highest score (over 100) will be declared the winner of the competition.

2. General Rules:

3. The car will have two opportunities to traverse a specified distance (D) carrying a weight of water (W).
4. Only the best-measured distance (d) will be used for the performance score.
5. The required distance (D) will be given to each team member 2 hours prior to the start of the competition. The distance "D" will be between 15-30 m (49-98 ft).

Teams are allowed to adjust fuel or reactants that participate in the car's chemical reaction.

6. The weight of water (W) will be given to each team member 2 hours prior to the start of the competition. The weight "W" will be between 50-500 g of water.
7. The car will start with its front end just touching the designated starting point. There will be a designated finish line. The distance will be measured (d) with respect to the front end of the car. The goal of the competition is to have your car stop closest to the specified finish line (not being out of bounds) while carrying out the specified weight. A car that goes out of the bounds will have a penalty. The penalty rules are given below.
8. The car must be an autonomous vehicle and cannot be controlled remotely.
9. No mechanical force can be applied to the wheel or ground to slow or stop the car (e.g. no brakes).
10. There can be no mechanical or electronic timing device to stop the chemical reaction.
11. All components of the car must fit into a shoebox with dimensions equal to or smaller than 32 x 20 x 12 cm. The car may be disassembled to meet this requirement.
12. The car must carry a container that holds up to 100 ml of water without spilling. An example container is a Nalgene Low-Density Polyethylene Narrow-Mouth Bottles (500 ml) Nalge No. 38-430 20039016 or Fisher Cat. No 02-923-11G. At the time of the grading, only the water will be supplied, thus each car must already have its own container.

Penalty rules:

1. If the car goes out of bounds it will be disqualified. The bounds will be given the day of the competition
2. If the car goes after goal distance (D) but it is still inside the bounds:

$$d = D - (d_{\text{measured}} - D) = 2D - d_{\text{measured}} \quad (2)$$

Suggestions:

Try your car in the competition place at least once before the event.

Incentive:

To qualify for the 4% extra-credit all members of the team need to be present during the competition. The amount of extra credit earned will depend on the total score of the team and it will be calculated according to:

$$\text{Extra - credit} = \frac{4(\text{Score})}{100} \quad (3)$$

Where Score = Poster + Performance

Example if the total course grade of a student without the incentive is 87 (B⁺), and the group Scores 85 points in the electro-chem-e-car competition, the extra credit earned will be 3.4. Therefore, the final grade of the student in the class will be 90.4 (A⁻).