2012 2.007 Electric Vehicle Special Section

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Section: Monday and Friday 7-9PM **Office Hours:** Wednesday 7-9PM
Location: N52-337

Syllabus and Overview

Introduction

Welcome to the EV Special Section! This section was created as a means to teach you the fundamental practices of design, engineering, and fabrication through the construction of Personal Electric Vehicles (PEVs). A PEV is defined as a two- to four-wheeled, single-passenger electric vehicle, and you will be allowed to design practically any contraption that will briskly (and safely!) carry a single passenger, so use your imagination.

Over the course of the semester, you will engineer a electric vehicle drivetrain, chassis, and electrical system in preparation for a final contest in which you take on your classmates in a race that will test the endurance, maneuverability, and efficiency of your vehicle. Moreover, you will be allowed to keep your final vehicle as a demonstration of the practical fruits of your labor over the course of the semester.

You may choose to design in the interest of pure utility, as a tool to get around campus. Or you could choose to optimize to win one of the challenges, such as efficiency, and construct a sleek and low vehicle. The section is crafted to allow you to explore design and manufacturing more in depth than what the mainstream 2.007 course is styled for.

Grading and Attendance

Grading for the course will follow the mainstream 2.007 framework for homeworks, quizzes, and lab notebooks. **You will still be obligated to turn in mainstream 2.007 Homeworks and Exams**. However, in lieu of mainstream 2.007 design milestones, you will complete milestones relevant to vehicle design such as motor and drivetrain calculations, solid modeling of chassis and frame components, ride and drive testing to validate your design, etc.

The lab section will meet on **Monday** and **Friday** from 7pm to 9pm on each day in **N52-337**. Office hours will be on **Wednesdays** from 7-9PM, in N52-337. Additional lab hours may be scheduled as the semester proceeds. Attendance is critical to remaining on schedule and using your available fabrication time wisely, and is a component of your final grade.

Example Milestones and Pacing

Here is the schedule for the semester along with some example deliverables each week. The example are not definitive, and more details will be provided in each week's Milestone document.

Week of	**2.007 EV Milestone**	**Example Deliverable**
6 Feb	Preliminary vehicle design - ideas, brainstorming	Design sketches in notebook
13 Feb	Preliminary vehicle design - sketches, methods of execution	More detailed sketches, commentary, preliminary math and analysis
22 Feb	Present motor, drivetrain, efficiency calculations. Frame modeling.	Motor sizing, anticipated loading, wind loading, Wh/mi estimates, etc.
27 Feb	Refinement of design calculations. Solid modeling of drivetrain.	Solid CAD models of drivetrain components
5 Mar	Finish and refine solid models	Updated and additional CAD models
12 Mar	Fabrication week	Commentary on weekly progress
19 Mar	Fabrication week	Demonstrate rolling chassis
Spring Break Week	Fabrication week	N/A
2 Apr	Fabrication week	Completion of vehicle mechanical systems and solid model of vehicle.
9 Apr	Refinement of vehicle systems, powered testing.	Commentary on weekly progress, vehicle performance, areas of improvement, etc.
16 Apr	Fabrication week	N/A
23 Apr	Vehicle Trials and Testing	Working vehicles!
30 Apr	Final Contest	Reflection

Your Notebook

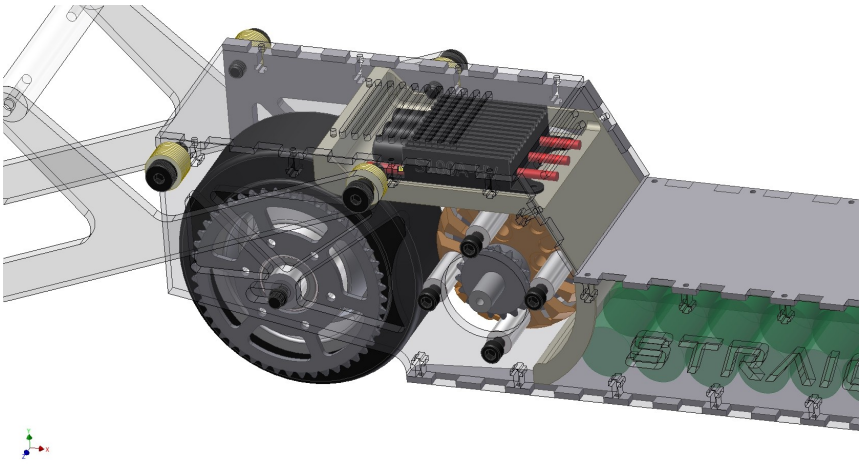
You are expected to keep a design notebook which documents your thoughts, design processes, calculations, etc.. This notebook will be due at the end of every week and returned to you by the beginning of the next. The grading for the notebook will follow the 2.007 standard. An "A" entry represents a notebook entry which exposes your design process in detail, is clear and legible, and well exceeds the documentation requirements for each milestone. If you fail to turn in a notebook, you will receive no points for that week unless reasonable prior notice is requested and accommodated.

Notebooks will be collected at the end of Monday lab sections and will be returned outside **3-436** by Tuesday 5pm.

Supplementary Lectures

The first hour of each lab session may be reserved for a supplementary mini-lecture. A mini-lecture is designed to cover a topic relevant to EVs that is not touched upon in mainstream 2.007. Mini-lectures are flexible and are intended to cater to specific questions and issues. Additional ones may be scheduled and held by consensus if students choose to explore a topic together.

Week of	**Topic**
6 Feb	Briefings on EV design, introduction to parts and resources
13 Feb	Introduction to electric motors; vehicle drivetrain design and dynamics
22 Feb	Solidworks session and chassis; motor & dynamics Q&A
27 Feb	Solidworks session and chassis design; shop training
5 Mar	Introduction to motor control and power converters; design q&a
12 Mar	EV electrical systems: battery and power delivery systems
19 Mar	EV electrical systems q&a
Spring Break Week	N/A
2 Apr	EV electrical systems: signals systems, communication
9 Apr	Guest lectures - Electric Vehicle Team motorcycle racing
16 Apr	Guest lectures - Student-built vehicles at MIT
23 Apr	N/A
30 Apr	N/A



Materials and Budget

Unlike mainstream 2.007, you do not get a kit of parts to assembly your vehicle from. Instead, you receive a budget to order parts to your own specification. The total budget per student is $300.00 excluding parts already provided.

The budget will go towards purchasing components to fulfill your design requirements. Only major component purchases (motors, controllers, frame materials, drivetrain components, battery charging components if applicable) will be deducted from the budget. Required, minor, or consumable materials are not deducted from the budget. Consumables are defined as wiring, electrical connectors, hardware, cable ties, etc. which are already available on campus. Reasonable common fastener use will not be counted in the budget.

Shipping is not counted in the budget for standard or ground services. Express, next-day, or rush shipping will be deducted from the budget.

Parts orders will begin during the **Week of February 23rd** and will occur on Mondays and Wednesdays. Part requests are to be sent to the instructor to be aggregated and sent out. You are advised that shipping is a process which could introduce up to a week of delay!

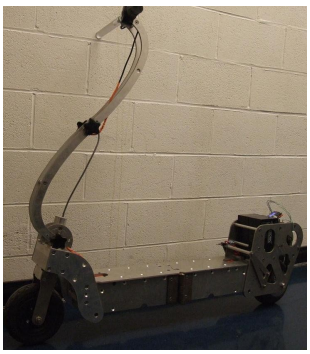
Provisions and predetermined parts

Each vehicle (whether constructed by individual students or in groups) will be assigned one 8" x 2" (200x50) pneumatic tire and wheel to start. Other drive wheels **may** be purchased and used. Only one regulation wheel will be provided at no cost.

Batteries are provided free by A123 Systems. The stock battery is 13.2 volts and 4.5Ah. Using stock batteries is free of (monetary) charge. A cost of $0.50 per watt hour will be subtracted from the budget if a custom battery is desired, and a charging solution must be included in the budget also.

A Razor A3 scooter can be provided to the student or group as a convenient source of a handlebar, folding joint, front wheel fork, and steering column. The A3 shall be provided at a discount rate if requested. (MSRP $49.99, discounted price $25.00)

Students may elect to retrofit or modify the drive system and electrical system of an existing small vehicle frame. This is not encouraged and must be reviewed on a case by case basis. A fair market value must be assigned to the existing frame and deducted from the budget, and more in-depth work will be expected in the design, analysis, and construction of the retrofit.



Special Design Rules

Each vehicle (whether constructed by individual students or in groups) will be assigned one 8" x 2" (200x50) pneumatic tire and wheel to start. The tire can have premounted a drive sprocket, drive belt pulley, or be plain (undriven), according to choice. The final vehicle may have additional regulation drive wheels, but these must be purchased and the price deducted from the budget.

Reference drive wheels:
Monsterscooterparts #W02-221 for chain drive
Monsterscooterparts #W02-219 for belt drive
Monsterscooterparts #W01-205 for undriven

The vehicle may use **up to three** A123 Systems 13.2v 4.5Ah Lithium Nanophosphate batteries. If a custom battery is desired, it must not exceed three A123 Systems 4.5Ah batteries worth in total watt-hours.

The A123 Systems battery is to be considered a black box. it may not be taken apart or reconfigured.

If the vehicle does not use the provided A123 Systems battery, then the vehicle electrical system must contain a fuse or resettable circuit breaker rated at no more than 40 amps. The fuse must be placed between the battery and any master switch, removable link, etc. such that no voltage appears across the switch if the fuse is blown and the switch is open circuit.

The vehicle is limited to a design speed of 20 miles per hour. The limit will be enforced via timing between two markers, radar gun, or the instructor riding the vehicle at full power.

The vehicle must have a mechanical brake that can bring the vehicle to a stop on its own, from full speed, in under 100 feet. The mechanical brake may be installed on the drive wheel(s) or an undriven wheel(s). The mechanical brake must be able to prevent forward motion of the vehicle if deployed. If more than one drive wheel is used, the brake lever or pedal must stop all driven wheels (whether by multiple braking elements or mechanical coupling, etc.)

Lithium ion polymer batteries are explicitly disallowed due to fragility and potential flammability.

Final Challenges

All vehicles must **complete** the final challenge to be considered Working for grading purposes. However, ranking in the final challenge is **not** considered as part of grading.

The final challenges will occur over two days during the week of 1 May (April 30th and 1 May).

The final challenge shall consist of three parts:

1. Drag Race

The Drag Race shall test vehicle acceleration and the fast time is the winner.
The race shall occur along a 200ft stretch of smooth asphalt under **Building 46**.

2. Endurance Race

The Endurance Race shall test vehicle longevity by maximizing range while emphasizing maneuverability. The vehicle able to complete the most number of complete laps is the winner.

The Endurance Race shall occur in the **N10 Annex Lot** around a course demarcated by cones. The course is flat.

The Endurance Race course will be run "rally style" where a minimum and maximum time per lap is enforced. The time band will be determined beforehand using previous student-built vehicles.

A vehicle ends the race by either exceeding the maximum time per lap, or reaching the automatic internal cutoff point of the A123 Systems 13.2v, 4.5Ah batteries. If a custom battery is used, the motor controller must be programmed to cut off power at an equivalent voltage, or other circuitry must be used to intervene in the motor command.

3. Hillclimb Race

The Hillclimb Race shall test vehicle efficiency by applying a constant load over a distance. The vehicle with the lowest energy consumption * time product (Wh * s) is the winner.

The hillclimb race shall occur in the **N10 (Albany Street) parking garage**. The timed interval is from the street level entrance to the second highest parking level.

Approval is pending on all three challenges and these rules may change.