ATTACHMENT B.2 – COURSE ACTIVITIES

Michigan Tech
College of Engineering
http://www.mtu.edu/engineering/

Course Number MEEM 5990 Laboratory
Advanced Propulsion for Hybrid Vehicles with Concentration in Battery Engineering

Laboratory Description, Syllabus and Schedule

Offered by Michigan Tech in Collaboration with
AVL and Engineering Society of Detroit (ESD)

2009 Fall Semester
3 credit hours: 2 Lecture + 1 laboratory
Sept. 3 – Dec. 11, 2009

Application Details
http://ww2.esd.org/EDUCATION/2009-09-FreeTraining.htm

Lectures:

On Campus:
Course not available at MTU
for Fall Semester

DL:
Thur: 5:00 : 8:00 PM
ESD, Southfield Michigan
http://ww2.esd.org/

Laboratories:
See Schedule Below

Instructor: **Team Taught**

Lead Course Instructor: Jeffrey D. Naber
ME-EM Dept
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Lead Lab Instructor: Jeremy Worm
ME-EM Dept
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906.487.2686

Textbook: **None**
Reference and supplemental material to be supplied via MTU's Blackboard.
https://courses.mtu.edu/

Office Hours: TBD

Laboratory Description:

The laboratory section of this course is intended to reinforce the concepts covered during the lecture portion of the class. This will be done through a variety of activities involving individual subsystems as well as fully integrated vehicles. The lab activities will take place at a number of test facilities. Subsystem testing, including batteries, electric machines, and power electronics will take place at AVL's powertrain test laboratories in Plymouth MI. Computer based laboratory exercises will be completed at ESD in Southfield and/or the Michigan Tech Research Institute in Ann Arbor. Vehicle testing will occur at a racetrack facility in the Southeast MI area. ***All student participation will take place in Southeast MI. Students will NOT be required to travel to the main Michigan Tech campus.***

Throughout the duration of the course, the laboratory activities will have reinforced several key learning objectives including:

- HEV specific safety issues such as high voltage precausions and safe working procedures,
- HEV testing procedures,
- The role of integration level, subsystem level, and model level analysis, testing, development, calibration, and validation,
- Model based design, analysis, calibration, and validation,
- Energy storage and conversion through the entire HEV energy flow pathway including the battery,
- Key battery concepts including testing procedures, performance attributes, constraints, and sizing for HEV's and EV's,
- Key electrical machine concepts including testing procedures, performance attributes, constraints, and sizing for HEV's and EV's,
- Vehicle dynamics with relation to energy conversion, regenerative braking, battery design, and model based design, calibration, and validation.

Final Challenge:

The learning objectives described above will be covered through a variety of team based activities ranging from model based design, analysis, and calibration to full vehicle integration level experimentation. A final team challenge will encompass the culmination of all of the learning objectives. In the final challenge the teams of students will be pitted against each other in a head to head competition to determine which team has best applied the concepts they learned in this course. The teams will be given a set of vehicle design constraints and a customer demographic. The competition will involve several facets including; battery sizing, hybrid system calibration with specific emphasis on regenerative braking, subsystem and powertrain calibration, and vehicle level and subsystem level model correlation.

Teams will be judged in the categories of regulated fuel economy, drive quality, projected vehicle cost, presentation quality, decision making and risk management abilities, battery sizing, and model correlation. Final results requiring vehicle testing will be determine by operating a single hybrid vehicle on a chassis dynamometer. This will ensure all testing variability is minimized. Judging will be conducted by a panel consisting of course instructors, contributing industry experts, and other key

industry representatives such as automotive executives. Teams will be rank ordered in each of the judged categories, with the points awarded being scaled by the rank ordering.

The following provides a schedule of laboratory based activities.

Laboratory Outline*

Wk	Location[1]	Instr.[2]	Learning Topic
2	TBD	WWW JJW IE	HEV and High Voltage hazards and safe work procedures
3	AVL	SAH WWW JJW IE	DOE Battery Test Procedures Battery Performance and Capacity Electric Machines & Power Electronics Energy Storage & Conversion
7	TBD	JJW JDN JEB	Model Based Calibration; Regenerative Braking & Powertrain Calibration
10	TBD	SAH JJW	Battery Size Factor Determination Battery Thermal Analysis Vehicle Level Regenerative Braking Calibration Energy Storage & Conversion
14	TBD	JJW et al.	Final Challenge: Vehicle Level Results Testing & Presentations

* The above are the regularly scheduled lab activities; however as with the lectures, we realize from previous courses of this nature where students from diverse backgrounds are in the course that additional background is needed. Significant supplemental material will be available including streaming video of tutorials in Matlab/Simulink, vehicle dynamics, and supplemental homework. Additionally Faculty, Staff and Graduate students with backgrounds in Mechanical, Electrical, Chemical and Materials Science and Engineering will be available for assistance through email and web meetings.

Schedule

As indicated above the lab sessions will all occur at various testing and engineering facilities. Specific details will be given during regular and supplemental lectures.

[1] Location Abbreviations: ESD = Engineering Society of Detroit in Southfield Michigan; MTRI = Michigan Tech Research Institute in Ann Arbor Michigan; AVL = AVL North American Engineering Headquarters in Plymouth Michigan; Milan = Milan Dragway in Milan Michigan; Mich Tech = Michigan Tech in Houghton Michigan.
[2] Instructor Abbreviations: WWW = Wayne Weaver, JJW = Jeremy Worm, IE = Industry Experts, SAH = Steve Hackney, JDN = Jeff Naber, JEB = John Beard.

Lab Reports

There will be five lab reports. The reports will be a team effort. Report formatting requirements are as follows:

- The title page of the report should include the team number, student names, lab topic, and the lab number.
- The report text must be the first section, followed by figures. The text section of the report is not to exceed 4 pages when single spaced with 12 point font.
- You may include as many figures as you wish, however, there must be discussion in the text for every figure.
- All figures at a minimum must have a figure number, title, and axis labels with units.

Specific questions and discussion topics that are to be addressed in the lab reports will be provided by the end of each lab session.

Hard copies of lab reports are due at the beginning of the next lab session, with the exception of the report detailing the final challenge, which will be due at the scheduled class final exam.

Course Grades

The following percentages will be used to determine the final grade for the laboratory portion of the class:

Lab Reports (5 equally weighted)	60%
Final Challenge (7 equally weighted categories)	40%

GRADING: A: 90-100, AB: 85-89, B: 80-84, BC: 75-79, C: 70-74, CD: 65-69, D: 60-64