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**Experimental Testing of Vehicles**
Community College Course
Syllabus

**Part 1: Course Information**

Course Description

This is a new and unique community college-level course that enhances the automotive engineering curriculum, develops hands-on skills and applied knowledge of students/automotive test technicians in main areas of vehicle experimental testing.

Students will do practical laboratory-based studies on various sensors and data acquisition systems (DAQ), setting up test procedures, wiring up sensors for measurements, conducting experiments, recording experimental data, and analyzing test results. Gaining experience on estimating experimental vehicle characteristics and writing a test report is an important part of the course.
An experimental project based on the testing of a virtual hybrid-electric vehicle with the use of an actual DAQ is included in the course. The lab work and the course project are supplemented by lectures. National Instruments LabVIEW and myRIO, MATLAB/Simulink are in use for laboratory work and course project. The course is designed to meet over a period of 15 weeks, 2 meetings per week, and 1h 30min per meeting.

Student Assessment Material

Lab reports, a course project report, and two quizzes.

References

Listed in course material for each week and provided for the instructor

Handouts

Provided with the course material when needed

**Part 2: Course Learning Outcomes (CLOs)**

The course learning outcomes are to have students:

1. Understand the role and types of experiments in vehicle engineering
2. Realize the importance of providing safety during experiments and study major safety instruciton
3. Set up test procedures, wire sensors, condusct experiments, obtain and analyze experimental data, write a report
4. Gain knowledge on major experimental test characteristics and on estimating experimental vehicle characteristics
5. Be familiar with some FMVSS and NHTSA test procedures and SAE standards related to the course project
6. Understand calibration procedures
7. Gain sufficient knowledge on test instruments
8. Understand static and dynamic characteristics of signals
9. Gain and apply practical knowledge on DAQ for measuring electrical signals and recoerding experimental data
10. Gain knowledge on strain gauge designs
11. Apply practical skills to conduct experimental studies with strain gauges for measuring forces and torques
12. Be familiar with Hall-effect sensors and their vehcile applications

13. Gain and apply skills to conduct experiments with Hall-effect sensors in e-motor control systems
14. Understand principles of sensors to measure wheel normal reactions
15. Gain practical skills to measure wheel normal reactions
16. Understand and conduct unique tests to measure off-set of the wheel normal reaction
17. Gain knowledge of wheel transducers to measure forces and moments at the wheel axis
18. Gain knowledge on acceleration sensors and applications
19. Learn and apply knowledge on e-motor and controller tests
20. Apply knowledge and skills on wheel transducers to measure data and determine tire rolling radii in the driven and driving modes of operation
21. Be familiar with a 4x4 vehicle chassis dynamometer and test procedures
22. Set up and conduct experiments on a 4x4 vehicle chassis dynamometer
23. Set up a project on experimental estimaiton of wheel rotational velocity of a 4x4 hybrid-electric vehicle

**Part 3: Course Topics, Main Concepts, Terms, Procedures, and Week Roadmap**

| Week | Topics and CLOs | Main Concepts, Terms, Procedures |
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| Week 1 | Lecture 1<br>Safety Instructions for Working in the Laboratory<br>Role of Experiments in Automotive Engineering<br>• 1, 2<br><br>Lecture 2<br>Measurement System: Structure and Components<br>Experiment Test Characteristics<br>• 3, 4 | • Experiments in vehicle design process<br>• Experimental tests:<br>-Laboratory tests and equipment<br>-Proving ground tests and main test facilities<br><br>• Variables<br>• Parameters<br>• Noise<br>• Random tests<br>• Replication and repetition |
| Week 2 | Lecture 1 Calibration<br>• 6<br><br>Lecture 2 Instruments<br>• 7 | • Static and dynamic calibration<br>• Static sensitivity<br>• Range<br>• Accuracy<br>• Precision and bias errors<br><br>• Safety and Electrometer<br>• Digital Multi-meter<br>• Source-Measure Unit<br>• Source-Meter<br>• Micro-ohmmeter |
| Week 3 | Lecture 1 Instrument Specifications<br>• 7 | • Terms and definitions<br>• Accuracy<br>• Deratings<br>• Noise and noise rejection<br>• Speed |

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| | Lecture 2 Signals:<br>Static and Dynamic Characteristics<br>• 3, 8<br>Analysis of Experimental Data<br>• 3, 8 | • Inputs/Outputs<br>• Signal analysis<br><br>• Types of experimental errors<br>• Sources of errors<br>• Bias and precision errors<br>• Statistical analysis<br>• Required number of experiments |
| Week 4 | Lecture 1 DAQ for measuring electrical signals and recording experimental data in computer<br>• 9<br><br>Multiple Choice Quiz #1: Weeks 1 to 3<br>Lecture 2<br>NI LabVIEW Fundamentals and Use in DAQ<br>• 9 | • DAQ concept, structure and components<br>• Inputs/Outputs<br>• Real-time DAQ<br><br>• What is LabVIEW<br>• Virtual Instrument<br>• Front panel toolbar<br>• Block diagram toolbar and block diagram<br>• Common data types<br>• Numeric controls and functions<br>• Data flow |
| Week 5 | Lecture 1<br>NI myRIO Fundamentals and Use in Experiments<br>• 9<br><br>Lecture 2<br>Test Report Writing and Presentation<br>• 3 | • What is NI myRIO<br>• RT Template VI<br>• Advanced VIs<br>• Palette<br>• Connecting myRIO to Computer<br>• Start your first project<br>• Testing an accelerometer<br>• Testing LEDs<br>• Error checking<br><br>• General Comments<br>• Types of Reports<br>• Contents of a Report<br>• Graphical Presentations<br>• Processing of Reports<br>• Oral Presentation |
| Week 6 | Lecture 1<br>Overview of FMVSS and NHTSA Test Procedures Related to the Course Project<br>• 5 | • Overview of NHTSA<br>• Electronic Stability Control<br>• Test Maneuvers<br>• Rollover Testing<br>• Federal Motor Vehicle Standards<br>FMVSS Organization<br>FMVSS: Crash Avoidance<br>FMVSS: Crashworthiness<br>FMVSS: Post-crash<br>FMVSS: Other Regulations |

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| | Lecture 2<br>Overview of SAE Standards Related to the Course Project.<br>• 5 | • Overview of SAE Standards and Topics<br>• SAE Vehicle Axis System<br>• SAE Classification of Stability Features<br>• Critical Speed Measurement<br>• Fuel Economy Testing |
| Week 7 | Session 1<br>Course Project Assignment: "Virtual Experimental Estimation of Wheel Rotational Speeds of a 4x4 Hybrid-Electric Vehicle".<br>• 12, 21<br><br>Session 2<br>Working on the Project.<br>• 12, 21 | • Project manual is provided to students<br>• A separate manual is provided for instructor (contains solution with graphs)<br>• Computer models in MATLAB are provided for project<br>• Students in teams work on the project with instructor in the lab using the project manual and computer program |
| Week 8 | Lab 1<br>Strain Gauge Designs, Wiring and Calibrating Strain Gauges<br>• 3, 10<br>Lab 2<br>Strain Gauges for Measuring Forces and Torques in Automotive Applications<br>• 3, 11 | • One manual (two labs) for students<br>• One manual (two labs) for instructor (with an assessment rubrics; the rubrics can be used by instructor for developing similar rubrics for other labs) |
| Week 9 | Lab 1<br>Hall-effect sensor concept design and applications for measuring wheel rotational speed in traction control systems and anti-lock brake systems<br>• 3, 12, 13<br>Lab 2<br>Hall-effect sensor concept design and applications for measuring wheel rotational speed in traction control systems and anti-lock brake systems (continuation)<br>• 3, 12, 13 | • Lab manual (two labs) for students<br>• Lab manual (two labs) for instructor with an assessment rubrics<br>• LabVIEW VIs |
| Week 10 | Working on the Project (in teams)<br>• 12, 21 | Students in teams work on the project with the instructor in the lab using the manual and computer program from week 7 |
| Week 11 | Lab 1<br>Force Plate Transducer<br>• 14, 15, 16<br><br>Lab 2<br>Acceleration sensor Accelerometers in Automotive Control<br>• 3, 18 | • Lab manual for students<br>• Lab manual for instructor with answers<br>• Excel spreadsheet with experimental data for students<br>• Excel spreadsheet with experimental data and solution for instructor<br><br>• Lab manual for students<br>• Lab manual for instructor with answers<br>• LabVIEW VIs |

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| Week 12 | Working on the Project (in teams) | Students in teams work on the project with instructor in the lab using the manual and computer program from week 7 |
| Week 13 | Lab 1<br>A lifting system with control - design<br>• 19<br>Lab 2<br>A lifting system with control – a feedback control and data collection<br>• 3, 4, 19 | • Lab manual for students<br>• Lab manual for instructor with answers<br>• LabVIEW VIs |
| Week 14. | Multiple Choice Quiz #2: Weeks 4 to 13<br>Lab 1<br>Kistler Wheel Transducer – Design and Measurement of Wheel Forces and Torques<br>• 3, 4, 17, 20<br><br>Lab 2<br>Virtual Vehicle Test on 4x4 Chassis Dynamometer with Individual Wheel Control<br>• 4x4 Chassis dynamometer design<br>• 4x4 Chassis dynamometer operational modes<br>• Test procedure to study the tire rolling radius in the driven mode<br>• Use of Kistler wheel transducer<br>• 21, 22, 17, 23 | • Lab manual for students<br>• Lab manual for instructor with answers<br>• Excel spreadsheet with experimental data for students<br>• Excel spreadsheet with experimental data and solution for instructor<br><br>• Lab manual for students<br>• Lab manual for instructor with answers<br>• Excel spreadsheet with experimental data for students<br>• Excel spreadsheet with experimental data and solution for instructor |
| Week 15 | Writing Project Report and Presenting Project Outcomes (in teams)<br>• 3 | • Students in teams write project report using references and material of Week 5, Lecture 2<br>• Students in teams present their project findings in the class |