# Course Outline

## 1. COURSE INFORMATION

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| **Session Offered** | FALL 2023 | |
| **Course Name** | Electric Drive Vehicles | |
| **Course Code** | MECH ENG 760 / SEP 722 | |
| **Date(s) and Time(s) of lectures** | Tuesday, 11:30 a.m. – 2:20 p.m. , MARC 268 | |
| **Program Name** | M.Eng., M.A.Sc., and PhD in Engineering | |
| **Calendar Description** | The course covers topics related to electric and hybrid electric vehicles. It begins with an introduction to the automotive industry and explains the need for electrification, and then continues with an introduction to internal combustion engines and electric machines. The course covers electrical and hybrid energy storage systems and chargers, and concentrate on the fundamentals of hybrid electric powertrains, hybrid electric vehicles, plug-in hybrid electric vehicles, all-electric vehicles, and range-extended electric vehicles. | |
| **Instructor** | Dr. Dan Centea | E-Mail: Avenue Email<br>Office Hours & Location: virtual, by appointment |

## 2. COURSE SPECIFICS

**Course Description**

Problem-Based Learning (PBL) course in which groups of students research, analyse, compare, present, submit reports and evaluate drivetrain architectures and the related subsystems that are implemented in vehicles with electric drives. The fundamental systems that are characteristic for electric or hybrid-electric vehicles are divided in eight major problems that differentiate the vehicles with electric drives from traditional vehicles. A final project focuses on an open-ended conceptual design of an electric or hybrid-electric vehicle with a certain autonomous level. The conceptual design is expected to include the major elements covered in the course. Students are encouraged to combine their imagination in designing the features of a vehicle that is expected to be on the market in three years with the engineering challenges that they expect to be reduced or solved within this period. The PBL approach allows students to develop or reinforce important skills such as problem solving, self-reflection, decision making, group work with strict deadlines, communication skills, technical writing, engineering inventivity, and innovation.

**Instruction Type**

| Code | Type | Total Hours |
|---|---|---|
| C | Classroom instruction | 30 |
| L | Self-study group work | 6 |
| T | Tutorial | |
| DE | Distance education | |
| **TOTAL HOURS** | | 36 |

**Resources**

| ISBN | Textbook Title & Edition | Author & Publisher |
|---|---|---|
| 978-1-4665-9769-3 | Advanced Electric Drive Vehicles | Ali Emadi, CRC Press, Taylor & Francis Group https://doi-org.libaccess.lib.mcmaster.ca/10.1201/9781315215570 |

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|---|---|
| **Prerequisite(s)** | |
| **Corequisite(s)** | |
| **Antirequisite(s)** | |

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| **Course Specific Policies** | Attendance is mandatory for all classes as they include collaborative work. |
| **Departmental Policies** | Where group work is indicated in the course outline, such collaborative work is mandatory.<br>The use of cell phones, iPods, laptops and other personal electronic devices are prohibited from the classroom during the class time, unless the instructor makes an explicit exception.<br>Announcements made in class or placed on Avenue are considered to have been communicated to all students including those individuals that are not in class.<br>The instructor has the right to submit the work submitted by students to software packages that identify plagiarism. |
| **3. SUB TOPIC(S)** | |
| Sept. 12, 2023 | Introduction to Problem-Based Learning (PBL). Organization.<br>Automotive industry and electrification |
| Sept. 19, 2023 | Problem #1: Propulsion systems<br>- Internal combustion engines<br>- Electric machines<br>- Hybrid powertrains |
| Sept 26, 2023 | Problem #2: Electrical energy storage systems<br>- Electrical energy storage systems<br>- Batteries<br>- Ultracapacitors<br>- Hybrid energy storage systems |
| Oct. 3, 2023 | Problem #3: Chargers and charging infrastructure<br>- Chargers and charging stations<br>- Charging infrastructure<br>- Vehicle-to-grid and vehicle-to-home concepts |
| Oct. 10, 2023 | Market research and analysis – group work (no class) |
| Oct. 17, 2023 | Problem #4: Hybrid electric powertrains<br>- Hybrid electric powertrains and architectures<br>- Electric powertrains architectures<br>- Regenerative braking and powertrain control |
| Oct. 24, 2023 | Problem #5: Hybrid Electric Vehicles (HEV)<br>- Advantages of technologies for HEVs<br>- Characteristics, challenges, and areas for developments<br>- HEV implementations |
| Oct. 31, 2023 | Problem #6: Plug-in Hybrid Electric Vehicles (PHEV)<br>- Components and operating principles of PHEVs<br>- Plug-in vehicular architecture<br>- 48-Volt electrification |
| Nov. 7, 2023 | Problem #7: All electric and range extended vehicles, vehicle communication systems<br>- All electric vehicles<br>- Range-extended electric vehicles, fuel cell vehicles and solar electric vehicles<br>- Vehicle communication systems |
| Nov. 14, 2023 | Problem #8: Autonomous vehicles<br>- Levels of automation<br>- Connected Autonomous Vehicles (CAVs)<br>- Advanced Driver Assistance Systems (ADAS) |
| Nov. 21, 2023 | Project consultations |
| Nov. 28, 2023 | Project work (no class) |
| Dec. 5, 2023 | Project submission deadline (no class) |

Note: this structure represents a plan and is subject to adjustment term by term. The instructor and the university reserve the right to modify elements of the course during the term. The university may change the dates and deadlines for any or all courses in extreme circumstances. If either type of modification becomes necessary, reasonable notice and communication with the students will be given with explanation and the opportunity to comment on changes.

| 4. ASSESSMENT OF LEARNING* including dates* | Weight |
|---|---|
| Presentation - technical content – schedule posted on Avenue | **5** |
| Presentation skills | **5** |
| Reports (individual contribution) – schedule posted on Avenue | **30** |
| Active participation in weekly discussions | **10** |
| Project report – due Dec. 6, 2023 | **50** |
| **TOTAL** | **100** |

Percentage grades will be converted to letter grades and grade points per the University calendar.

## 5. LEARNING OUTCOMES

1. Explain the needs for electrification in the transportation industry and the future of mobility using key statistics.
2. Summarize the principles of internal combustion engines and electric motors used in electric drive vehicles
3. Analyze the operating principles of electric batteries and electric charging systems used in electric vehicles
4. Evaluate and compare hybrid electric powertrains used in vehicles
5. Evaluate and describe various architectures for electric drive vehicles that match given technical specifications
6. Define connected vehicle systems and advanced driver assisted systems for an autonomous vehicle equipped for level 2 autonomy
7. Prepare the conceptual design of a modern electric or hybrid electric vehicle and explain the advantages and challenges of the chosen specifications, powertrain, electric storage system, and autonomous features

## 6. COURSE OUTLINE – APPROVED ADVISORY STATEMENTS

### ANTI-DISCRIMINATION

The Faculty of Engineering is concerned with ensuring an environment that is free of all discrimination. If there is a problem, individuals are reminded that they should contact the Department Chair, the Sexual Harassment Officer or the Human Rights Consultant, as soon as possible. https://secretariat.mcmaster.ca/app/uploads/Discrimination-and-Harassment-Policy.pdf

### ACADEMIC INTEGRITY

You are expected to exhibit honesty and use ethical behaviour in all aspects of the learning process. Academic credentials you earn are rooted in principles of honesty and academic integrity. It is your responsibility to understand what constitutes academic dishonesty.

Academic dishonesty is to knowingly act or fail to act in a way that results or could result in unearned academic credit or advantage. This behaviour can result in serious consequences, e.g. the grade of zero on an assignment, loss of credit with a notation on the transcript (notation reads: “Grade of F assigned for academic dishonesty”), and/or suspension or expulsion from the university. For information on the various types of academic dishonesty please refer to the Academic Integrity Policy, located at https://secretariat.mcmaster.ca/university-policies-procedures-guidelines/

The following illustrates only three forms of academic dishonesty: The following illustrates only three forms of academic dishonesty:

- plagiarism, e.g. the submission of work that is not one’s own or for which other credit has been obtained.
- improper collaboration in group work.
- copying or using unauthorized aids in tests and examinations.

## AUTHENTICITY / PLAGIARISM DETECTION

Some courses may use a web-based service (Turnitin.com) to reveal authenticity and ownership of student submitted work. For courses using such software, students will be expected to submit their work electronically either directly to Turnitin.com or via an online learning platform (e.g. A2L, etc.) using plagiarism detection (a service supported by Turnitin.com) so it can be checked for academic dishonesty.

Students who do not wish their work to be submitted through the plagiarism detection software must inform the Instructor before the assignment is due. No penalty will be assigned to a student who does not submit work to the plagiarism detection software. All submitted work is subject to normal verification that standards of academic integrity have been upheld (e.g., on-line search, other software, etc.). For more details about McMaster's use of Turnitin.com please go to www.mcmaster.ca/academicintegrity.

Students are not permitted to use generative AI in this course. In alignment with McMaster academic integrity policy, it "shall be an offence knowingly to … submit academic work for assessment that was purchased or acquired from another source". This includes work created by generative AI tools. Also state in the policy is the following, "Contract Cheating is the act of "outsourcing of student work to third parties" (Lancaster & Clarke, 2016, p. 639) with or without payment." Using Generative AI tools is a form of contract cheating. Charges of academic dishonesty will be brought forward to the Office of Academic Integrity.

## COURSES WITH AN ON-LINE ELEMENT

Some courses may use on-line elements (e.g. e-mail, Avenue to Learn (A2L), LearnLink, web pages, capa, Moodle, ThinkingCap, etc.). Students should be aware that, when they access the electronic components of a course using these elements, private information such as first and last names, user names for the McMaster e-mail accounts, and program affiliation may become apparent to all other students in the same course. The available information is dependent on the technology used. Continuation in a course that uses on-line elements will be deemed consent to this disclosure. If you have any questions about such disclosure, please discuss this with the course instructor.

## ONLINE PROCTORING

Some courses may use online proctoring software for tests and exams. This software may require students to turn on their video camera, present identification, monitor and record their computer activities, and/or lock/restrict their browser or other applications/software during tests or exams. This software may be required to be installed before the test/exam begins.

## COMMUNICATIONS

It is the student's responsibility to:

- Maintain current contact information with the University, including address, phone numbers, and emergency contact information.
- Use the University provided e-mail address or maintain a valid forwarding e-mail address.
- Regularly check the official University communications channels. Official University communications are considered received if sent by postal mail, by fax, or by e-mail to the student's designated primary e-mail account via their @mcmaster.ca alias.
- Accept that forwarded e-mails may be lost and that e-mail is considered received if sent via the student's @mcmaster.ca alias.
- Check the McMaster/Avenue email and course websites on a regular basis during the term.

## CONDUCT EXPECTATIONS

As a McMaster student, you have the right to experience, and the responsibility to demonstrate, respectful and dignified interactions within all of our living, learning and working communities. These expectations are described in the Code of Student Rights & Responsibilities (the "Code"). All students share the responsibility of maintaining a positive environment for the academic and personal growth of all McMaster community members, whether in person or online.

It is essential that students be mindful of their interactions online, as the Code remains in effect in virtual learning environments. The Code applies to any interactions that adversely affect, disrupt, or interfere with reasonable participation in University activities. Student disruptions or behaviours that interfere with university functions on online platforms (e.g. use of Avenue 2 Learn, WebEx or Zoom for delivery), will be taken very seriously and will be investigated. Outcomes may include restriction or removal of the involved students' access to these platforms.

## ACADEMIC ACCOMMODATION OF STUDENTS WITH DISABILITIES

Students with disabilities who require academic accommodation must contact Student Accessibility Services (SAS) at 905-525-9140 ext. 28652 or sas@mcmaster.ca to make arrangements with a Program Coordinator. For further information, consult McMaster University's Academic Accommodation of Students with Disabilities policy https://secretariat.mcmaster.ca/app/uploads/Academic-Accommodations-Policy.pdf

## ACADEMIC ACCOMMODATION FOR RELIGIOUS, INDIGENOUS OR SPIRITUAL OBSERVANCES (RISO)

Students requiring academic accommodation based on religious, indigenous or spiritual observances should follow the procedures set out in the RISO policy. Students should submit their request to their Faculty Office normally within 10 working days of the beginning of term in which they anticipate a need for accommodation or to the Registrar's Office prior to their examinations. Students should also contact their instructors as soon as possible to make alternative arrangements for classes, assignments, and tests.
https://secretariat.mcmaster.ca/app/uploads/2019/02/Academic-Accommodation-for-Religious-Indigenous-and-Spiritual-Observances-Policy-on.pdf

## COPYRIGHT AND RECORDING

Students are advised that lectures, demonstrations, performances, and any other course material provided by an instructor include copyright protected works. The Copyright Act and copyright law protect every original literary, dramatic, musical and artistic work, including lectures by University instructors
A recording of lectures, tutorials, or other methods of instruction may occur during a course. Recording may be done by either the instructor for the purpose of authorized distribution, or by a student for the purpose of personal study. Students should be aware that their voice and/or image may be recorded by others during the class. Please speak with the instructor if this is a concern for you.

## EXTREME CIRCUMSTANCES

The University reserves the right to change the dates and deadlines for any or all courses in extreme circumstances (e.g., severe weather, labour disruptions, etc.). Changes will be communicated through regular McMaster communication channels, such as McMaster Daily News, A2L and/or McMaster email.