University of Toronto
Minor Modification Proposal: New Graduate Courses or Changes to Existing Graduate Courses

This template should be used to: create a new graduate course; reactivate a closed/deactivated course; rename an existing course; renumber an existing course; etc.

If you have questions while you are filling out this document, please contact your Dean's Office.

Graduate Department/Unit/Centre/Institute For courses offered by collaborative specializations, list supporting unit.	Electrical & Computer Engineering
Faculty/academic division	Faculty of Applied Science & Engineering
Dean's Office contact	

Part 1: ROSI

Please complete this section. The data will be used to complete the ROSI record.

New Course—fill out all fields	
Course designator and number (e.g., HIS 5XXXH)	ECE 1049
FCE weight (e.g., 0.5, 1.0)	0.5
Full course title for transcript (max 60 characters)	Autonomous EV - Propulsion & Perception
Abbreviated title (max 30 characters)	AEV: Propulsion & Perception
Available via Student Web Services (yes or no)	Yes
Course type (regular, modular, continuous or extended)	Regular
Evaluate* function in ROSI used by unit (yes or no) *university's online course evaluation system	Yes
Online course (yes or no)	No
Required course (yes or no)	No
Grading scale (letter grades or CR/NCR)	Letter grades
Course prerequisites; if yes, please list (e.g., HIS 5XXXH)	Graduate standing in ECE or permission of the instructor.
Course credit exclusions; if yes, please list (e.g., HIS 5XXXH)	
Or Changes to an Existing Course fill out applicable fields	

Current course designator and number (required) (e.g., HIS 5XXXH)	N/A
Deactivated course designator, number and weight (e.g., HIS 5XXXH)	N/A
Splitting or amalgamating courses (list course designators, numbers and weights)	N/A
New designator and number (e.g., HIS 5XXXH)	N/A
New/renamed full course title for transcript (max 60 characters)	N/A
New/renamed abbreviated title (max 30 characters)	N/A
New FCE weight of an elective course (e.g., 0.5, 1.0)	N/A
Change to grading scale (from letter grades to CR/NCR or vice versa)	N/A
Change to course type (from regular to continuous, modular, extended, etc.)	N/A

Effective Date

Required Field—Effective date must be September 1, January 1 or May 1 and not retroactive.

May 1, 2026

Part 2: Other Changes to Existing Courses

Optional Field—This section may be used to describe other types of changes to existing courses your Faculty/Division tracks.

N/A

Part 3: New Course Documentation

For Faculty/Divisional approval of new courses, please append the approved course documentation, or complete the template below.

Course Description

This course provides an introduction to the design and integration of autonomous and electric vehicle (AEV) systems, emphasizing hardware–software synergy, system-level design, and artificial intelligence. Students learn how propulsion, perception, and control subsystems interact within autonomous electric vehicles.

Through a combination of lectures, simulations, and laboratory work, students progressively build a small-scale AEV platform that integrates LiDAR, radar, and vision sensors with electric propulsion, embedded control, and real-time decision-making algorithms.

Emphasis is placed on real-time implementation, sensor fusion, and the use of AI techniques (e.g., neural networks, path planning, and reinforcement learning) for perception, localization, and control. The course culminates in a team-based project, where students design, build, and demonstrate a functional autonomous EV prototype operating in a controlled environment.

Number of contact hours: 2 lecture hours per week + 5 laboratory sessions of 3 hours each

Topics:
- Overview of electric vehicle propulsion and drive systems
- Energy management and system-level design principles
- Perception technologies: LiDAR, radar, and vision systems
- Embedded controllers and communication protocols (CAN, ROS, I²C, UART)
- Real-time control and sensor fusion
- AI and machine learning for perception and decision-making
- Hardware–software integration and system testing
- Autonomous navigation and safety considerations
- Team-based AEV design and demonstration project

Labs and Project

Item	Title	Description	Learning Outcome
Lab 1	EV Propulsion & Motor Control	DC or BLDC motor drive setup, current and speed control	Implement and characterize an electric drive subsystem using PWM and feedback loops
Lab 2	Perception and Sensor Fusion	LiDAR, radar, and camera integration; environment mapping	Acquire and synchronize sensor data for object detection and mapping
Lab 3	Localization and Path Planning	SLAM and waypoint navigation in a controlled environment	Implement localization and simple path-planning algorithms
Project (2 Lab Sessions)	Autonomous EV Demonstration	System-level design, integration, and performance evaluation	Design and demonstrate a small-scale AEV capable of autonomous navigation with obstacle avoidance

Academic Rationale

The University of Toronto is strongly committed to advancing sustainability, clean technology, and the transition to a low-carbon future. Electric and autonomous vehicles are at the forefront of this transformation, combining renewable-energy utilization with intelligent mobility solutions.

This proposed course, *Synergy between Propulsion & Perception in Autonomous EV*, directly supports these institutional goals by equipping graduate students with interdisciplinary knowledge in electric propulsion, energy-aware design, and AI-enabled autonomy. Students will learn to integrate hardware and software systems that connect efficient propulsion with advanced perception, using LiDAR, radar, and vision sensors to enable energy-conscious and intelligent vehicle operation.

Unlike most graduate courses that rely primarily on simulation and analytical modeling, this course emphasizes and integrates hands-on experimentation and hardware development. Students will design, build, and test real embedded systems and perception platforms, gaining practical experience with sensors, actuators, and control hardware. This experiential approach bridges theory and practice, complements existing ECE offerings, and advances the department's leadership in sustainable and intelligent transportation systems.

Learning Outcomes

Upon successful completion of this course, students will be able to:

1. Explain and analyze the architecture and interaction of propulsion, perception, and control subsystems in autonomous electric vehicles (AEVs).
2. Perform system-level design and integration, including the selection and sizing of key components such as motor drives, gearboxes, batteries, and perception sensors, to meet specified performance and energy objectives.
3. Implement and evaluate perception algorithms using LiDAR, radar, and optical sensors, integrating AI-based fusion for localization and situational awareness.
4. Integrate hardware and software components into a functioning AEV prototype that demonstrates real-time propulsion control, perception, and decision-making using industry-standard tools and platforms (e.g., ROS, MATLAB/Simulink, Python, and embedded controllers such as Raspberry Pi or Jetson Nano systems).
5. Collaborate effectively in multidisciplinary teams, demonstrating project management, communication, and leadership skills throughout the design, integration, and testing phases.
6. Assess and optimize system performance with respect to energy efficiency, autonomy, and safety under realistic design constraints, and communicate technical results through professional reports and presentations with reflective and ethical engineering practice.

Similarity/Overlap With Other Courses & Consultation

Autonomous and electric vehicle technologies are converging to define the next frontier in transportation and energy systems. While ECE currently offers strong courses in electric vehicle propulsion (e.g., *ECE1049 – Electric Vehicles*) and in robotics and control systems, there is currently no graduate course that integrates propulsion, sensing, embedded control, and AI-driven perception into a unified hardware–software framework.

The proposed course complements ECE1049 – Electric Vehicles, which focuses primarily on propulsion modeling and powertrain efficiency, by addressing system-level integration between propulsion and autonomous perception systems. It also complements ECE1510 – Robotics and Control Systems, which emphasizes control theory and motion planning. However, this new course goes beyond both, and for the first time in an ECE course, it marries AI algorithms with LiDAR, radar, vision-based perception, and electric propulsion, creating a fully integrated intelligent mobility platform.

To the best of my knowledge, no other graduate course within ECE, Mechanical and Industrial Engineering, or Computer Science integrates AI, EV propulsion, and multi-sensor perception within a single experiential, system-design framework. This course therefore fills a unique curricular gap, bridging energy systems, control, and intelligent autonomy, and aligns with the department's broader emphasis on sustainable transportation and intelligent systems.

Resource Requirements

This course requires a combination of classroom-based lectures and laboratory sessions. Lectures can be delivered in a standard ECE graduate classroom equipped with audiovisual support. Laboratory and project activities will take place in existing departmental facilities such as the Energy Systems Laboratories, which are well equipped and already support the ECE1049 - Electric Vehicle course.

Additional resources required include hardware kits for system integration projects consisting of scaled electric vehicle platforms, motor drives, LiDAR, radar, and vision sensors, as well as embedded computing units (e.g., Raspberry Pi or Jetson Nano). Students will use industry-standard software tools including MATLAB/Simulink, ROS, and Python for modeling, control, and perception implementation.

The hardware kits represent a fixed, one-time setup cost and will be reused in subsequent course offerings, making the course financially sustainable over multiple years.

One or two (depending on enrollment) graduate teaching assistants will be required to support laboratory activities, hardware setup, and student troubleshooting. The course will make extensive use of shared lab infrastructure and will not require new dedicated space.

Governance Approval

Unit Sign-Off (Committee name and meeting date)	
Faculty/Division Council (or delegated body) approval, if applicable (name and date)	