

**Driving the  
Next Generation  
of Electrified &  
Autonomous  
Vehicles**



## Transportation Electrification & Smart Mobility at

# MARC

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### **MCMASTER AUTOMOTIVE RESOURCE CENTRE (MARC)**

**200 Longwood Road South, Hamilton, ON L8P 0A6, Canada**

45 min drive from Toronto Pearson Airport | 60 min drive from Downtown Toronto

90 min drive from Buffalo Airport | 3 hr drive from Detroit

1 hr flight from Ottawa, Montreal, New York, & Chicago



**Driving the  
Next Generation  
of Electrified &  
Autonomous  
Vehicles**

**A  
Global Leader  
in Transportation  
Electrification &  
Smart Mobility**

# OVERVIEW

## Importance of Auto Industry in Canada

- Canada is the 4<sup>th</sup> largest exporter of cars in the world
- Automotive industry is Canada's largest manufacturing sector by gross domestic product
- Ontario is a leading jurisdiction for auto production in North America: 2.4 million vehicles built in Ontario annually

## Facilities

- Powertrain Tester Three-Machine Dyno
- High Speed Electric Machine Dyno
- MARCdrive Chassis Dyno
- MARCdrive Driving Simulator
- SoftAuto Laboratory
- Energy Storage Laboratory
- Power Electronics & Motor Drives Laboratory
- Automotive / Aerospace Electrification Laboratory
- Motor Control & Power Electronics Laboratory
- High Bay Laboratory

## Services

- Research & development
- Industry sponsored projects
- Contract design & development
- Modeling, simulations, & analysis
- Hands-on education & training
- Workforce development
- Collaborative workshops for short courses, as well as strategic & technical brainstorming
- Hardware & software testing
- Benchmarking & characterization
- Prototyping

## FAST FACTS

### McMaster University

- Established in 1887
- One of the world's top 70 universities
- 32,000 students; 1,500 full time faculty
- \$372 million sponsored research annual income
- #1 in Canada for research impact, research intensity, industry income, & sponsored industry research

### McMaster Automotive Resource Centre (MARC)

- 4 world class research groups under one roof
- Located at McMaster Innovation Park (MIP)
- 80,000 ft<sup>2</sup> - unparalleled in North America
- 40,000 ft<sup>2</sup> expansion in Q4 2021



**World-Class  
Expertise**

**World-Class  
Facilities**

# RESEARCH THRUSTS

## Research Thrust Areas Include:

- Electric & hybrid vehicles
- Autonomous vehicles
- Electrified powertrains
- Electric machines
- Motor drives/inverters
- Motor controls
- Power electronic DC/DC converters
- Chargers & V2X systems
- Embedded software & controls
- Functional safety
- Energy storage systems
- Energy management systems
- Advanced driver-assistance systems (ADAS)
- Artificial intelligence & machine learning
- Thermal management
- Modeling & simulations
- Driving simulation
- Vehicle dynamics

## Transportation Electrification Program

- **One of the largest** in academia in North America
- **400+** researchers
- **\$250+** million in programs & initiatives
- **Unique relationships** with major OEMs & Tier 1/2 suppliers
- Collaborations with **private & public sector** organizations





**Education,  
Research, &  
Development**

Access to  
**World-Class  
Facilities at  
MARC**

# STUDENT RECRUITMENT

**UNDERGRADUATE & MASTER'S STUDENTS:**

## What Are You Doing After You Graduate?

**Consider Master's & Ph.D. Studies within the Accelerating Field of Electrified & Autonomous Vehicles**

- ✓ Start your career with industry relevant experience
- ✓ Build close relationships with industrial partners
- ✓ Advance your career on industry sponsored projects with funding
- ✓ Broad research topics to match your interests

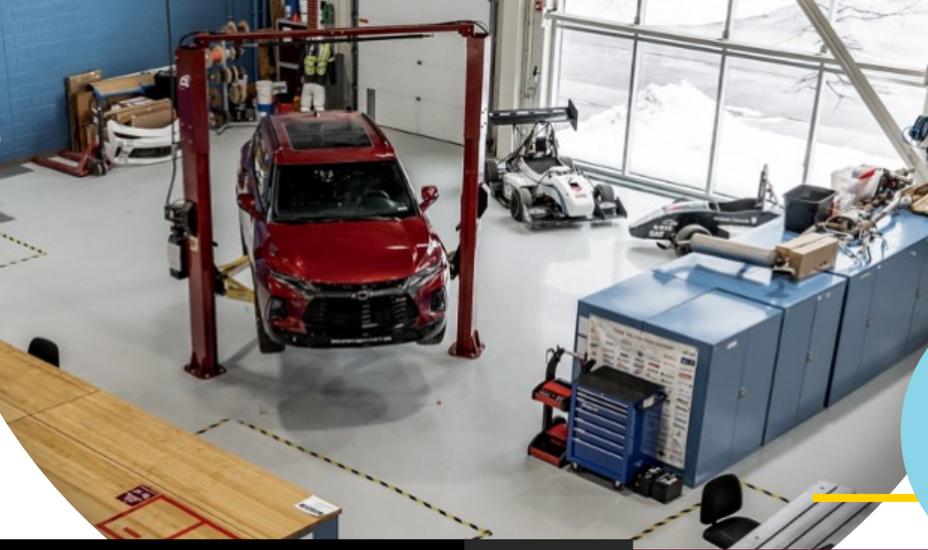
**If you are interested, send your C.V. & transcript to:**  
Dr. Ali Emadi, Professor & Canada Excellence Research Chair Laureate  
Email: emadi[at]mcmaster.ca

Powertrain Systems & Controls

Electric Motors

Power Electronics

Electrified & Autonomous Vehicles



**World-Class  
Expertise**

**World-Class  
Facilities**

# INDUSTRY RESEARCH LABS



**Automotive/Aerospace Electrification Lab**  
Dedicated industry partner research, testing, & prototyping labs



**Energy Storage Lab**  
Battery & power electronics testing up to 1,000V/400A or 500V/800A



**SoftAuto Lab**  
Comprehensive computing, hardware, software & Hardware-in-the-Loop capabilities

**Power Electronics & Motor Drives Lab**



**Motor Control & Power Electronics Lab**

**High Bay Lab (5,200 ft2)**





**World-Class  
Expertise**

**World-Class  
Facilities**

# EQUIPMENT & DYNAMOMETERS



## **Chassis Dyno & Driving Simulator**

Virtual electric & hybrid electric vehicle powertrain integration & chassis dynamometer with vehicle-to-grid capabilities



## **Powertrain Tester Three-Machine Dyno**

Comprehensive electric & hybrid electric powertrain dyno test capabilities up to 440 kW with battery/fuel cell emulator



## **High Speed Electric Machine Dyno**

Up to 22,000 rpm, 250 kW, direct drive dyno (no interface gearbox)





**North America's  
Premier Collegiate  
Automotive Engineering  
Competition**

**One of 11  
Participating  
Universities**

# ECO CAR COMPETITION

## Competition Overview

- McMaster University is proud to be one of 11 universities (one of two Canadian universities) participating in the **EcoCAR Challenge: North America's Premier Collegiate Automotive Engineering Competition**
- EcoCAR is the latest in the U.S. Department of Energy (DOE) Advanced Vehicle Technology Competition (AVTC) series.
- The competition will challenge teams to **apply advanced propulsion systems, as well as connected & automated vehicle technology** to improve the energy efficiency, safety, & consumer appeal of the 2019 Chevrolet Blazer—specifically for the carsharing market.



## 4 Year Challenge

**Y1**

**Customer identification & architecture selection.** Designing, evaluating, & refining the propulsion systems components needed to ensure the vehicle functions while maintaining safety.

**Y2**

**Y3**

**Test, validate, & fully integrate** the propulsion components into the car to enable dynamic testing. Vehicle testing includes chassis dynamometer testing & on-road testing.

**Y4**

More vehicle **testing, model refinement, & system modeling optimization** to improve energy consumption & functionality.

## FAST FACTS

- **One of two Canadian** universities
- **Goal:** Turn a 2019 Chevrolet Blazer into a hybrid vehicle & add autonomous features
- **4-year** challenge: 2018-2022

## The Team

- **100 team members:** including mostly undergraduate students & five graduate students
- **Diverse program background:** students from Engineering, B-Tech, Health Sciences, Computing & Software, Social Sciences, MBA, Psychology, etc.
- **Actively engaged** with student groups on & off campus

## Sponsorship & Management

- The main sponsors of this competition are **General Motors (GM) & MathWorks**
- The competition is managed by **Argonne National Laboratory**





**A Powerful  
Global Brand**

**More  
Collaborative  
Efforts**

# NEW INITIATIVES

## **MARCed**

### **A Series of Training Modules & Short Courses**

Several industry-customized courses are offered, including but not limited to:

- Vehicle electrification & electrified powertrains
- Artificial intelligence & machine learning
- Product development, systems engineering, & project management
- Software, functional safety, & E/E architectures
- Electric machines & motor drives
- Power electronics & motor control
- Energy storage systems
- Thermal management



## **MARCdrive**

### **Driving Simulation: The Future of Automotive Testing**

- MARCdrive Chassis Dyno & Driving Simulator
- Powertrain/autonomous systems testing
- Human machine interface testing
- Virtual environment creator

## **MARCstartup**

At MARC we **empower start-up companies** which play a significant role in economic growth.

Our researchers have successfully planned & launched multiple start-up companies.



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