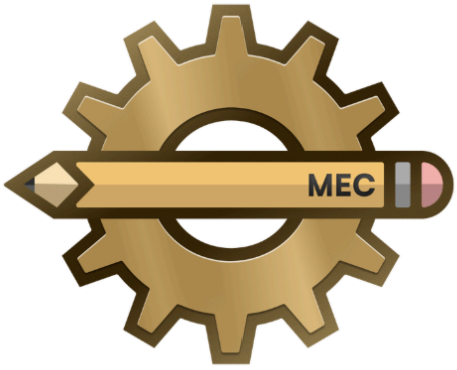

Metropolitan Engineering Competition 2025

Senior Design

Competition Package

Contents

1. Introduction

Welcome to the 20th Metropolitan Engineering Competition (MEC)! MEC 2025 aims to provide students with an opportunity to apply in-class knowledge and acquire skills for real-world problems. It is an opportunity to challenge oneself, meet like-minded peers, and network with industry professionals.

The Senior Design Competition challenges upper-year engineering students to apply their technical expertise, creativity, and teamwork to design and implement a functioning prototype that addresses a real-world engineering problem. Competitors are tasked with developing innovative systems that integrate mechanical, electrical, and software principles under time and material constraints.

The 2025 theme, “Optimizing a Sustainable Society Using AI and Automation,” encourages students to design solutions that enhance efficiency, sustainability, and quality of life through intelligent technologies. The Senior Design challenge focuses on reimagining parking systems to better serve the needs of dense urban environments through smart automation and AI-driven decision-making.

2. Problem Statement

2.1 Motivation

As urbanization accelerates, the demand for efficient parking solutions continues to grow. Conventional parking garages struggle with congestion, wasted space, and poor energy management. Implementing smart, data-driven parking systems can significantly improve space utilization, reduce emissions, and promote sustainable urban development.

This challenge invites participants to create an automated, sensor-driven parking structure that simulates how AI and microcontrollers can transform real-world parking operations. Teams will explore how intelligent systems can manage traffic flow, prioritize energy efficiency, and enhance safety.

2.2 Objective

Design and build a Smart Parking Garage that automatically monitors parking availability, controls entry and exit operations, and uses AI algorithms to allocate vehicles to optimal parking spots. The system should integrate environmental awareness, power management, and user safety into a cohesive automated design.

The structure must include:

- A multi-level (minimum 2) layout featuring entry and exit ramps, parking bays, and pedestrian pathways.
- At least four sensor-equipped parking spaces to detect occupancy and display real-time availability.
- An AI-inspired allocation system that assigns vehicles to parking spots based on logic and availability.
- Integrated EV charging bays and safety systems, including hazard detection and emergency response mechanisms.
- Automated energy management, such as dimming lights or shutting down idle components during off-peak periods.

2.3 Prototype Demonstration Steps

Teams must design a functional prototype that meets the following testing and demonstration criteria:

1. Vehicle Guidance and Spot Allocation

- The Competition Coordinators will operate an RC vehicle to simulate real-world parking.
    - The RC vehicle (L: 75mm, H: 45mm, W: 35mm) can handle slopes of up to 30 degrees.
- The system must detect the vehicle's entry, open and close servo-controlled gates, and guide it toward an optimal parking spot based on the AI logic.

2. Parking Detection and Indicators

- Four parking spaces must detect occupancy using photoresistors (LDRs).
- RGB LEDs should clearly display spot availability, including designated EV and handicap spots.
    - To program the LEDs, use the NeoPixel library.

3. Hazard Detection and Safety

- When the smoke sensor (MQ-2) is triggered, the system should respond with alarms, emergency lighting, or gate control for evacuation.
    - To program the smoke sensor, use the FastLED library
- The system should withstand snow on its roof.
    - Competition Coordinators will place bags of sand weighing up to 10 pounds.
- The system should withstand earthquakes.
    - Competition Coordinators will place the system on an earthquake simulator for 10 seconds.

4. Power Management

- The system should demonstrate energy efficiency by dimming or disabling non-essential systems during off-peak conditions.

5. System Reliability

- All subsystems including sensors, LEDs, servos, and alarms must function cohesively without reset or malfunction during testing.

2.4 Build Restrictions

The structure must feature a minimum of two levels, stable enough to support small-scale testing conditions.

The parking garage and surrounding buildings must occupy a minimum ground area of 600 square inches.

All control logic must be implemented using Arduino-based microcontrollers and associated sensors.

The system must complete all assigned tests within the designated time limit during evaluation.

Teams are expected to maintain safe electrical practices when wiring and operating their prototypes.

3. Competition Guidelines

3.1 Allowed Resources

The competitors can bring the following equipment:

- Any textbooks, course notes, or other reference materials
- Each team member is allowed one computer and access to the internet

3.2 Question Periods

- There will be a period for questions after the challenge is presented by the Competition Coordinators. During this time, competitors can ask for clarification on the problem statement, rules, scoring, etc.
- If you need help during the build phase, you can:
    - Ask the MEC team member in your room to assist you
    - Press the “Help” button on the MEC shop website
    - Send an email to seniordesign@mues.ca (for general inquiries) or mec.competitions@mues.ca (for team-specific questions)

4. Deliverables

Teams will have ten (10) hours for the designing, prototyping, and testing of their solution, and to create a presentation. Additionally, the physical prototype and any other physical deliverables must be submitted to the Competition Coordinators by this time. Failure to submit either electronic or physical deliverables will result in a 50-point deduction.

4.1 Final Presentation

The presentation portion should address the technical solution your team has created and its performance, as well as your team's design process, future improvements, and what makes your design stand out. The presentation order will be announced at check-in. It is advised that your team is on campus and ready to present by this time. Teams must show up a minimum of 5 minutes before their presentation time. A missing team member during the presentation will result in a 25-point deduction. Please contact the competition leads in advance if a team member is unable to attend the presentation. Teams will submit their presentations by **November 16, 9 AM.**

Presentation slides should include:

- Introduction/team name
- Idea generation process
- Justify your design choices
- Highlight what makes your design stand out
- Future improvements

Formatting:

- PDF with the file name "TeamName_SeniorDesign_Presentation"
- Total presentation length of 10 minutes, 10 minutes of testing, followed by a 5-minute question period from the judges
- Cite all sources in IEEE format.
- The speaking portion of the presentation should be equally shared by team members.

4.2 Code Submission

- Ensure that your code is well-structured and readable.
- Comment key aspects of your code to aid the reader/marker in its evaluation.
- Submit your code in a .ino or .txt file via Google Form with the naming convention “TeamName _SeniorDesign_Code”
- Code will be checked for AI generation.

4.3 Final Testing

Final testing will be performed in front of the judges on Sunday, November 16th. Each team will have 10 minutes to complete all requirements and tests that showcase the functionality of their prototype.

4.4 Plagiarism

The use of the Internet and other external resources is permitted in this competition, but work presented by the teams must be their own work. The teams may use and cite previously published work with proper IEEE referencing in the presentation. If they decide to use someone else's work, it must be clearly cited in the presentation.

5. Materials

5.1 Materials Provided

The following materials will be provided to each team in the quantity listed. Note that it is not a requirement to use all materials; however, no equipment or materials not provided by the team are permitted. Please be sure to confirm that your bag includes all the materials listed below before the start of the design phase.

Given Items	Quantity (per Team)
Breadboards	1
Arduino UNO	1
MM, FF, MF cables	20 each
10k resistor	6
Active buzzer	1
Barrel jack DC power (Arduino)	1
Positional servo	2
WS 2812B RGB LEDs	1
Photoresistors	6
Smoke sensor	1
Foam board	4
Paper	As requested
Electrical tape	1
Box cutters	1
Ruler	1
Pencil w/ eraser	1
Hot glue gun	1
Glue gun sticks (individual)	10

5.2 MEC Shop Items

Each team will have a budget of **100 MEC$**. Teams will submit all orders on the MEC Shop website and have them delivered to them promptly. All items in the MEC Shop have a **limited quantity**. As a result, there may not be enough materials for every team, so it is important for teams to plan for any abrupt changes in their ideas. The MEC Shop will have live and accurate counts for the stock of each item. Competitors may also choose to physically visit the MEC Shop to inspect the items before they order, but no in-person orders will be accepted. Refunds will be given for **valid reasons** and only at the discretion of the VP Competitions.

During the lunch period, the VP Competitions, Competition Coordinators, and the MEC Shopkeepers will go over the current stock and prices of the MEC Shop items. If deemed necessary, the VP Competitions will announce a sale in the MEC Shop via email with the list of items that are discounted. This sale may also increase the “max per team” amount for an item. Again, this sale will be evaluated only on a **situational basis** by the VP Competitions, so there is a likelihood that it may not happen.

Item	Price per (MEC$)	Quantity each team can buy
830 Point Breadboard	30	1
Uno R3	40	1
MM, FF, MF cables (pack) (20,20,20)	20	1
10k resistors	3	10
Active buzzer	5	1
Positional servo	10	2
Continuous servo	10	1
WS 2812B RGB leds	40	1
Photoresistors	5	4
Smoke Sensor	20	1
Foam board	10	1

String (20ft)	10	2
MUX	15	1
Magnets (Pack)(4)	5	2
Breadboard power supply	15	1
Electrical Tape	10	1
Glue gun Sticks (individual)	5	3