MIE 444 Project Guideline

TABLE OF CONTENTS

1 INTRODUCTION

1.1 OBJECTIVES

This project is designed to provide students hands-on experience through designing a prototype rover that carries out a set of tasks autonomously *(no human control/interaction is allowed for the final design, only partial marks may be given if the rover is not completely autonomous)*.

Upon the successful completion of the first 5 labs, you are expected to be familiar with the following concepts that can be directly applied to building the prototype:

- Mechanical design & fabrication (CAD, 3D printing, laser cutting)
- Electrical design & fabrication (circuit design, soldering, troubleshooting)
- Input/output integration & calibration (Digital and analog interfacing with sensors and actuators)
- Microcontroller programming (maze-solving algorithm, localization)

1.2 TEAM FORMATION

Students will work in engineering design teams. You are expected to learn and develop the team dynamics that leads to the success of an engineering design project.

Each team should consist of 4 members. Over the last few years, most groups composed of members with the following specialties demonstrated outstanding performance in the prototype design and delivery of concept:

- Programmer
- Electrical designer
- Mechanical designer
- Presenter/writer

Once your team is set up, the team leader should send form the team on Quercus. Contact the teaching team if you require assistance with team formation. All team formations should be done as early as possible to allow time for design work.

1.3 MARKING SCHEME

The project mark will be based on both documentation, rover performance and presentation. The prototype performance will be evaluated in 3 milestones. Other detailed guidelines will be posted for each deliverable.

Item	Points
Request for Proposal	20
Prototype Performance (3 milestones)	
Milestone 1 – Obstacle Avoidance	10
Milestone 2 – Localization	10
Milestone 3 – Block Pick Up & Final Integration	30
Video Presentation	10
Final Report	20
Total	100

For each of the graded deliverables there will be a group and individual grade assigned based on member contributions.

2 PROJECT DESCRIPTION

2.1 PROJECT REQUIREMENTS

An autonomous rover will be designed and built to deliver a small load (i.e. a wooden block) through a walled-maze on a randomized checkered surface. The load is < 0.5lbs in weight and < 2" x 2" x 2" in volume, beige in color. The rover will be placed randomly in the maze, it then needs to identify and arrive at the loading zone, pick up the load, and deliver it to location B. The rover has to perform this series of tasks autonomously, within 5 minutes. While navigating, the rover should avoid collisions with any obstacles, and display a signal when 1) it arrives at the loading zone 2) detects the load 3) the delivery is finished. You will have 2 trials to complete the delivery.

Structural Design

- You must incorporate 3D printed components in your prototype
- The prototype must not exceed the overall weight of 5lbs and the size of 12" x 12" x 12"
- You cannot use any pre-made rover kits/components
- The block pick up mechanism should not simply use adhesives or velcro attachments

Electrical Design

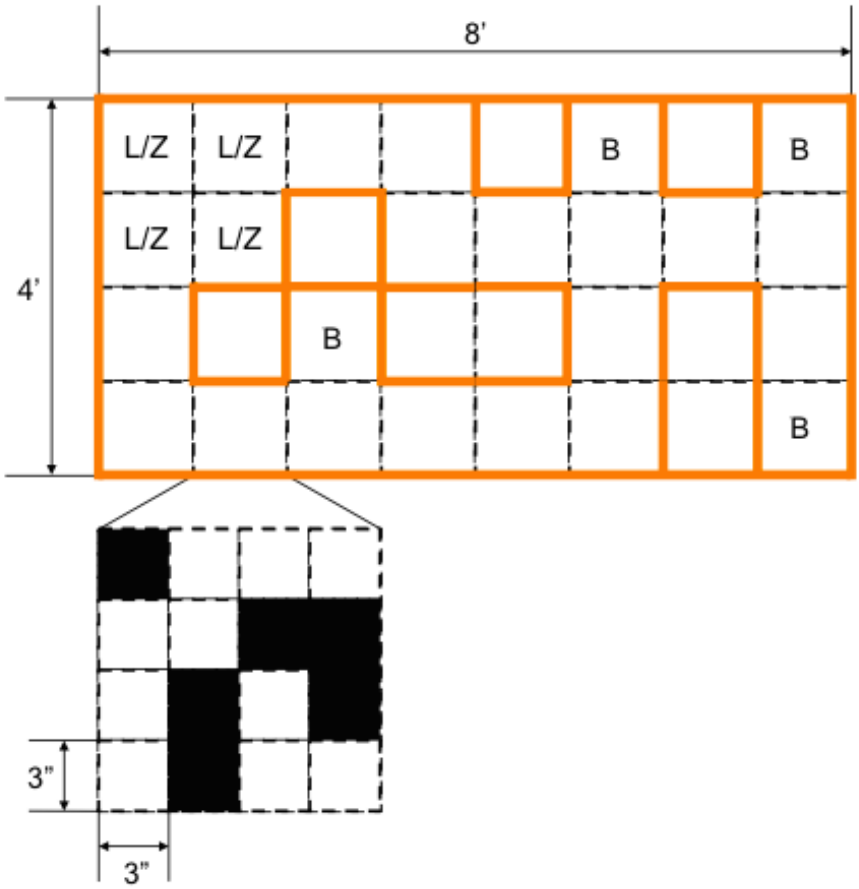
- The rover must be powered by battery packs on board (no external power supplies allowed)
- No touch sensors are allowed for detection of the obstacles/walls
- You must prepare for a method to visualize the localization during navigation (be creative!)

Program Design

- You will be informed where the drop-off location (B) is before you run the rover and must have a variable or prompt asking for this information at the start of your code sequence
- You are required to use your own localization technique to locate the delivery location (B).
- You are allowed to modify your program between trials

2.2 MAZE DESCRIPTION

- The overall dimension of the maze will be 4' x 8'.
- Each 1' x 1' square will be filled with 16 smaller squares, 3" x 3" each.
- The 3" x 3" squares will be in a randomized checkered pattern.
- The rover should be able to localize within at least the resolution of the larger 1' squares.
- Each of the 1' x 1' squares will possess a distinct pattern and the ratio of black and white will not necessarily be the same.
- The walls will be placed around the maze and the rover should navigate around the walls without any collisions.
- The location of the loading zone (L/Z) will be a 2' x 2' square area as shown below.
- The small load block will be placed randomly in the loading zone.
- There will be 4 pockets (1' x 1' square surrounded by 3 walls) and they will be randomly selected as the delivery location B.
- The entire maze layout will remain unchanged for the duration of the course.



Sample Maze Layout

2.3 OTHER RULES

- Although the size restriction for the rover is 12" x 12" x 12", it must be made smaller to avoid any contacts with the walls.
- The rover should demonstrate an indication (i.e. play a sound or blink an LED) when it:
  - Arrives at the loading zone
  - Detects the load at the loading zone
  - Returns the load at the delivery location B
- All groups will receive 2 trials of 5 minutes each to complete all given tasks, the trial with better performance will be recorded for grades.

2.4 MILESTONES

There are 3 milestones, obstacle avoidance, localization, and block pick and place.

In milestone 1, obstacle avoidance, the rover is required to drive autonomously for at least 20' in the maze without touching any obstacle.

In milestone 2, localization, the rover should be able to determine where it is after being placed randomly in the maze.

In milestone 3, the rover will integrate obstacle avoidance, localization to find a block, pick up the block and place it at the specified delivery location (B), outside of the loading zone. The entire series of tasks must be completed autonomously.

We highly encourage every group to record their own accomplishments throughout the semester and show them to the lab TAs whenever it is possible. Although designing for reliability is one of the paramount objectives of this project, it is equally important to design with modularity in mind to allow for modifications as you make progress.

3 PROJECT RESOURCES

3.1 BUDGET

The project budget should not exceed 300 CAD per team. Every item used in the rover should be included in the budget, except for 3D printing fees, plexiglass, fasteners, and any applicable taxes. Prices of any items used in the design should be matched to the ones from the cheapest online vendor to be included in the budget.

3.2 AVAILABLE PROJECT MATERIALS

Here is a sample list of item available for the design. For more detail, refer to the spreadsheet posted on the course website.

- DC motors with encoders
- Servo motors
- Arduino
- IR proximity sensors
- Ultrasonic sensors
- Perforated Arduino shields

- Breadboard
- 12V NiMH battery pack
- Connectors (2, 3, and 4 pins)
- DC-DC converter
- Motor controller (H-bridge)
- Toggle Switch
- Bluetooth modules

Your designs will be able to incorporate 3d printing and laser cutting.