ECE 100 Laboratory Manuals

Illinois Institute of Technology ECE Department

Last Modified: August 26, 2021

Contents

0.1   Preface

Welcome to the ECE 100 - Intro to Profession - Laboratory Section
In this laboratory, students will utilize Arduinos, sensors, code, and other items
to build an assortment of robots. Students will collaborate in groups and
participate in a variety of competetions between groups from all lab sections

Academic Honesty   All students must follow the IIT Code of Academic
Honesty during this laboratory session. Full text for the Code of Academic
Honesty can be found on IIT's website

Reference Material   There are several good reference sites for coding with
Arduino and Arduino Sensors. The Arduino IDE uses the C++ coding language,
so any reference material for C or C++ is also applicable

- Arduino Official Language Reference

- Arduino Tutorial Sketch

- Tutorialspoint.com Arduino Tutorials

Reports Format   Templates for Prelab and Postlab reports can be found on
Blackboard. Reports may be written using LaTeX or a text processor such as
Microsoft Word, Google Docs, etc.

Laboratory Session 1

1.1   Pre-Laboratory Report

Complete this report before coming to the Laboratory Session

Due Date Week of August 30th-September 3rd, 2021 in lab section. Submit report electronically before start of Lab via Blackboard (check assignments folder)

Subject Section #, FirstName LastName

Body "I have read and will comply with the ECE 100 Course policies"

Short Answer Questions
1. What is a microprocessor? What is a microcontroller?
2. What is the difference between a microprocessor and a microcontroller?
3. Is an Arduino a microprocessor or microcontroller?

Additional Task Please complete Google Form attached at link below. Attach a screenshot of the "Response Sent" screen to verify completion. Google Form Link

Additional Task Bring Robot Kit to your lab section

1.2   Post-Laboratory Report

Due Date Week of September 6th-September 10th, 2021 in lab section. Submit report electronically before start of Lab via Blackboard (check assignments folder)

Contents Please follow the template for Post-Laboratory Reports as given on Blackboard.

Laboratory Session 2

2.1 Pre-Laboratory Report

Due Date Week of September 6th-September 10th, 2021 in lab section. Submit report electronically before start of Lab via Blackboard (check assignments folder)

Format Follow the Pre-Laboratory Report Template found on Blackboard

Content Sections to be included in the Pre-Laboratory Report include

1. **Header**
2. **Problem Statement**
3. **Research & Investigation**
4. **Alternative Solutions**
5. **Optimum Solution (with flowcharts)**
6. **Sources/Works Cited**
7. **Code Attachments**

Additional Task Create Flowcharts for the code to be generated in Laboratory 2

a. Make 1 flowchart for the sample code that you have been provided in the Research & Investigation section
b. Make 1 flowchart for your Optimal Solution
c. You can use PowerPoint, or any other software, to create your flowcharts
d. Your flowcharts should use simple English, not IC syntax
e. Include the flowchart in the Optimum Solution section of your Pre-Lab report

Additional Task Begin implementing code for use in Laboratory 2

2.2   Post-Laboratory Report

Due Date Week of September 13th-September 17th, 2021 in lab section. Submit report electronically before start of Lab via Blackboard (check assignments folder)

Format Follow the Post-Laboratory Report Template found on Blackboard

Content Sections to be included in the Pre-Laboratory Report include

1. **Header**
2. **Problem Statement**
3. **Research & Investigation**
4. **Alternative Solutions**
5. **Optimum Solution**
6. **Analysis & Testing**
7. **Final Evaluation**
8. **Sources/Works Cited**
9. **Code Attachments (as needed)**

Laboratory Session 3

3.1 Pre-Laboratory Report

Complete this report before coming to the Laboratory Session

Due Date Week of September 13th-September 17th, 2021 in lab section. Submit report electronically before start of Lab via Blackboard (check assignments folder)

Format Follow the Pre-Laboratory Report Template found on Blackboard

Content Sections to be included in the Pre-Laboratory Report include

1. **Header**
2. **Problem Statement**
3. **Research & Investigation**
4. **Alternative Solutions**
5. **Optimum Solution (with flowcharts)**
6. **Sources/Works Cited**
7. **Code Attachments**

Additional Task Answer the following questions and include them in the Pre-Laboratory Report

a. What does the "digitalWrite()" function do in Arduino?
b. What does the "analogWrite()" function do in Arduino?
c. What does the "pinMode()" function do in Arduino?

Additional Task Create flowcharts for the code you plan to generate in Laboratory 3

a. Create 1 flowchart for your Optimum Solution
b. You can use PowerPoint, or any other software, to create your flowcharts
c. Your flowcharts should use simple English, not IC syntax
d. Include the flowchart in the Optimum Solution section of your Pre-Lab report

3.2   Post-Laboratory Report

Due Date Week of September 6th-September 10th, 2021 in lab section. Submit report electronically before start of Lab via Blackboard (check assignments folder)

Format Follow the Post-Laboratory Report Template found on Blackboard

Content Sections to be included in the Pre-Laboratory Report include

1. **Header**
2. **Problem Statement**
3. **Research & Investigation**
4. **Alternative Solutions**
5. **Optimum Solution**
6. **Analysis & Testing**
7. **Final Evaluation**
8. **Sources/Works Cited**
9. **Code Attachments (as needed)**

Laboratory Session 4

4.1 Pre-Laboratory Report

Complete this report before coming to the Laboratory Session

Due Date Week of September 20th-September 24th, 2021 in lab section. Submit report electronically before start of Lab via Blackboard (check assignments folder)

Format Follow the Pre-Laboratory Report Template found on Blackboard

Content Sections to be included in the Pre-Laboratory Report include

1. **Header**
2. **Problem Statement**
3. **Research & Investigation**
4. **Alternative Solutions**
5. **Optimum Solution (with flowcharts)**
6. **Sources/Works Cited**
7. **Code Attachments**

Additional Task Answer the following questions and include them in the Pre-Laboratory Report

a. What was your role on your team (i.e. main responsibilities)?
b. How would you describe your team's collaboration and communication throughout the previous lab sessions?

Additional Task Create flowcharts for the code you plan to generate in Laboratory 4

a. Create 1 flowchart for your Optimum Solution
b. You can use PowerPoint, or any other software, to create your flowcharts
c. Your flowcharts should use simple English, not IC syntax
d. Include the flowchart in the Optimum Solution section of your Pre-Lab report

4.2 Competition 1 Rules

Overview The first robot competition will be a race against the clock. Your robot will be timed as it follows a light masking tape path on a dark background. The team with the fastest cumulative time wins! The "path following" competition will test your robot's navigation skills via light sensors. The key to a winning performance lies in your robot's light sensing and navigation algorithms.

The competition rules are as follows:

1. The tape path will be continuous, i.e., no branches.

2. The tape path will be between 0.5 and 1.5 inches wide.

3. The tape path will not intersect itself.

4. All tape path turns will be less than or equal to 135 degrees to the left or right of the robot's forward direction. For example, the tape path may take any angle inside the green circle below.

Figure 4.1:

5. The shortest straight segment of the tape path will be 4 inches.

6. The minimum distance from one segment of the tape to another, measured perpendicularly from the tape edge, will be 2 inches. In other words, you are guaranteed a 2 inch wide dark buffer on either side of the tape path, except when path angles are greater than 90 degrees.

7. The overall outside dimensions of the playing field will be 4 feet by 8 feet.

8. Your robot will be positioned over the tape in whatever orientation you wish behind the starting line.

9. The clock will stop when your robot's light sensors reach the end of the tape path.

10. Each team will run two trials on its own individual chassis.

11. The maximum time allowed per trial is 60 seconds. If your robot does not finish within 60 seconds, then its position will be recorded.

12. If your robot leaves the tape path before the end, then its position will be recorded.

13. If the centerpoint of your robot's body skips more than 4 inches of the tape path, then the robot will be stopped for "leaving the tape path".

14. If no robot completes the path, then the robot which was closest to the finish during its trials will be declared the winner.

15. You will be allowed to observe your robot's performance during both trials.

16. You may modify your robot between trials.

17. In each laboratory section, the top team will be awarded bonus points (0.2*teamwork_score).

18. The top four teams, across all of the laboratory sections, will compete in a lecture runoff on the Monday following the laboratory competitions.

4.3   Post-Laboratory Report

Due Date   Week of September 6th-September 10th, 2021 in lab section. Submit report electronically before start of Lab via Blackboard (check assignments folder)

Format   Follow the Post-Laboratory Report Template found on Blackboard

Content   Sections to be included in the Pre-Laboratory Report include

1. **Header**
2. **Problem Statement**
3. **Research & Investigation**
4. **Alternative Solutions**
5. **Optimum Solution**
6. **Analysis & Testing**
7. **Final Evaluation**
8. **Sources/Works Cited**
9. **Code Attachments (as needed)**

Laboratory Session 5

5.1   Pre-Laboratory Report

Complete this report before coming to the Laboratory Session

Due Date Week of September 27th-October 1st, 2021 in lab section. Submit report electronically before start of Lab via Blackboard (check assignments folder)

Format Follow the Pre-Laboratory Report Template found on Blackboard

Content Sections to be included in the Pre-Laboratory Report include

1. **Header**
2. **Problem Statement**
3. **Research & Investigation**
4. **Alternative Solutions**
5. **Optimum Solution (with flowcharts)**
6. **Sources/Works Cited**
7. **Code Attachments**

Additional Task Answer the following questions and include them in the Pre-Laboratory Report

a. How does an ultrasonic sensor work?
b. In what applications are ultrasonic sensors commonly used?
c. What function is used in Arduino to process the reading of an ultrasonic sensor?

Additional Task Create flowcharts for the code you plan to generate in Laboratory 4

a. Make 1 flowchart for the sample code that you have been provided in the Research & Investigation section
b. Make 1 flowchart for your Optimal Solution
c. You can use PowerPoint, or any other software, to create your flowcharts
d. Your flowcharts should use simple English, not IC syntax
e. Include the flowchart in the Optimum Solution section of your Pre-Lab report

5.2   Post-Laboratory Report

Due Date   Week of September 6th-September 10th, 2021 in lab section.   Submit report electronically before start of Lab via Blackboard (check assignments folder)

Format   Follow the Post-Laboratory Report Template found on Blackboard

Content   Sections to be included in the Pre-Laboratory Report include

1. **Header**
2. **Problem Statement**
3. **Research & Investigation**
4. **Alternative Solutions**
5. **Optimum Solution**
6. **Analysis & Testing**
7. **Final Evaluation**
8. **Sources/Works Cited**
9. **Code Attachments (as needed)**

Laboratory Session 6

6.1 Pre-Laboratory Report

Complete this report before coming to the Laboratory Session

Due Date Week of October 4th-October 9th, 2021 in lab section. Submit report electronically before start of Lab via Blackboard (check assignments folder)

Format Follow the Pre-Laboratory Report Template found on Blackboard

Content Sections to be included in the Pre-Laboratory Report include

1. **Header**
2. **Problem Statement**
3. **Research & Investigation**
4. **Alternative Solutions**
5. **Optimum Solution (with flowcharts)**
6. **Sources/Works Cited**
7. **Code Attachments**

Additional Task Answer the following questions and include them in the Pre-Laboratory Report

   a. What is the function of the buzzer sensor module?
   b. Describe the purpose of the 3 pins of the buzzer sensor module (VCC, I/O, GND)

Additional Task Create flowcharts for the code you plan to generate in Laboratory 4

   a. Make 1 flowchart for the sample code that you have been provided in the Research & Investigation section
   b. Make 1 flowchart for your Optimal Solution
   c. You can use PowerPoint, or any other software, to create your flowcharts
   d. Your flowcharts should use simple English, not IC syntax
   e. Include the flowchart in the Optimum Solution section of your Pre-Lab report

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6.2 Post-Laboratory Report

Due Date Week of September 6th-September 10th, 2021 in lab section. Submit report electronically before start of Lab via Blackboard (check assignments folder)

Format Follow the Post-Laboratory Report Template found on Blackboard

Content Sections to be included in the Pre-Laboratory Report include

1. **Header**
2. **Problem Statement**
3. **Research & Investigation**
4. **Alternative Solutions**
5. **Optimum Solution**
6. **Analysis & Testing**
7. **Final Evaluation**
8. **Sources/Works Cited**
9. **Code Attachments (as needed)**

Laboratory Session 7

7.1   Pre-Laboratory Report

Complete this report before coming to the Laboratory Session

Due Date Week of September 6th-September 10th, 2021 in lab section. Submit report electronically before start of Lab via Blackboard (check assignments folder)

Format Follow the Pre-Laboratory Report Template found on Blackboard

Content Sections to be included in the Pre-Laboratory Report include

1. **Header**
2. **Problem Statement**
3. **Research & Investigation**
4. **Alternative Solutions**
5. **Optimum Solution (with flowcharts)**
6. **Sources/Works Cited**
7. **Code Attachments**

Additional Task Answer the following questions and include them in the Pre-Laboratory Report

a. What are servos and how do they work?
b. What Arduino functions are utilized to control the servo?

Additional Task Create flowcharts for the code you plan to generate in Laboratory 4

a. Make 1 flowchart for the sample code that you have been provided in the Research & Investigation section
b. Make 1 flowchart for your Optimal Solution
c. You can use PowerPoint, or any other software, to create your flowcharts
d. Your flowcharts should use simple English, not IC syntax
e. Include the flowchart in the Optimum Solution section of your Pre-Lab report

7.2   Post-Laboratory Report

Due Date Week of September 6th-September 10th, 2021 in lab section. Submit report electronically before start of Lab via Blackboard (check assignments folder)

Format Follow the Post-Laboratory Report Template found on Blackboard

Content Sections to be included in the Pre-Laboratory Report include

1. **Header**
2. **Problem Statement**
3. **Research & Investigation**
4. **Alternative Solutions**
5. **Optimum Solution**
6. **Analysis & Testing**
7. **Final Evaluation**
8. **Sources/Works Cited**
9. **Code Attachments (as needed)**

Laboratory Session 8

8.1   Pre-Laboratory Report

Complete this report before coming to the Laboratory Session

Due Date Week of September 6th-September 10th, 2021 in lab section. Submit report electronically before start of Lab via Blackboard (check assignments folder)

Format Follow the Pre-Laboratory Report Template found on Blackboard

Content Sections to be included in the Pre-Laboratory Report include

1. **Header**
2. **Problem Statement**
3. **Research & Investigation**
4. **Alternative Solutions**
5. **Optimum Solution (with flowcharts)**
6. **Sources/Works Cited**
7. **Code Attachments**

Additional Task Answer the following questions and include them in the Pre-Laboratory Report

a. What was your role on your team (i.e. main responsibilities)?
b. How would you describe your team's collaboration and communication throughout the previous lab sessions?

Additional Task Create flowcharts for the code you plan to generate in Laboratory 4

a. Make 1 flowchart for the sample code that you have been provided in the Research & Investigation section
b. Make 1 flowchart for your Optimal Solution
c. You can use PowerPoint, or any other software, to create your flowcharts
d. Your flowcharts should use simple English, not IC syntax
e. Include the flowchart in the Optimum Solution section of your Pre-Lab report

8.2   Competition 2 Rules

Overview   The first robot competition will be a race against the clock. Your robot will be timed as it navigates a simple maze. The team with the fastest run wins! The maze competition will test your robot's navigation skills via ultrasonic sensors. The key to a winning performance lies in your robot's obstacle avoidance algorithm.

The competition rules are as follows:

1. All angles will be 90 or 270 degrees, i.e., square corners.

2. Dead ends are possible.

3. The narrowest path will be 1 foot wide.

4. The overall outside dimensions of the maze will be approximately 4 feet by 8 feet.

5. Your robot must start completely behind the starting line In fact, your robot will be positioned by the TA, facing forward at the starting line.

6. Your robot must finish completely beyond the finish line.

7. Each team will run two trials.

8. The maximum time allowed per trial is 90 seconds. If your robot does not finish within 90 seconds, then its position will be recorded.

9. If no robot finishes the maze, then the robot which gets closest to the finish during its trials will be declared the winner.

10. You may then modify your robot in preparation for the second trial.

11. In each laboratory section, the top team will be awarded bonus points (0.2*teamwork_score) as described in the Lecture 1 slides.

12. The top team in each section will compete in a lecture runoff on the Monday following the laboratory competitions.

Good luck!

8.3   Post-Laboratory Report

Due Date Week of September 6th-September 10th, 2021 in lab section. Submit report electronically before start of Lab via Blackboard (check assignments folder)

Format Follow the Post-Laboratory Report Template found on Blackboard

Content Sections to be included in the Pre-Laboratory Report include

1. **Header**
2. **Problem Statement**
3. **Research & Investigation**
4. **Alternative Solutions**
5. **Optimum Solution**
6. **Analysis & Testing**
7. **Final Evaluation**
8. **Sources/Works Cited**
9. **Code Attachments (as needed)**

Laboratory Session 9

9.1   Pre-Laboratory Report

Complete this report before coming to the Laboratory Session

Due Date Week of September 6th-September 10th, 2021 in lab section. Submit report electronically before start of Lab via Blackboard (check assignments folder)

Format Follow the Pre-Laboratory Report Template found on Blackboard

Content Sections to be included in the Pre-Laboratory Report include

1. **Header**
2. **Problem Statement**
3. **Research & Investigation**
4. **Alternative Solutions**
5. **Optimum Solution (with flowcharts)**
6. **Sources/Works Cited**
7. **Code Attachments**

Additional Task Bring Robot Kit to your lab section

9.2   Post-Laboratory Report

Due Date Week of September 6th-September 10th, 2021 in lab section. Submit report electronically before start of Lab via Blackboard (check assignments folder)

Format Follow the Post-Laboratory Report Template found on Blackboard

Content Sections to be included in the Pre-Laboratory Report include

1. **Header**
2. **Problem Statement**
3. **Research & Investigation**
4. **Alternative Solutions**
5. **Optimum Solution**
6. **Analysis & Testing**
7. **Final Evaluation**
8. **Sources/Works Cited**
9. **Code Attachments (as needed)**