ECE 110L
Conceptual Design Report

Team Hercules
Team Members: Justin Zwiebel, Tong Fu
Date: 03/2052018

To uphold the Duke Community Standard:

- I will not lie, cheat, or steal in my academic endeavors;
- I will conduct myself honorably in all my endeavors; and
- I will act if the Standard is compromised.

Signature: **Tong Fu Justin Zwiebel**

Conceptual Design Report Grading Criteria

Note: Components Requests must be submitted by the IDC Week 1---Communication demonstration so that components can be placed in Bot Boxes.
(Components Request site: http://ecelab.pratt.duke.edu)
SAVE THE CONFIRMATON E-MAIL to submit with the Conceptual Design Report!

Team Members:_____

1. Introduction	**Possible**	**Earned**
Grand Overview of Team Challenge	5	
Group Robot Problem Statement or Task	5	
Group and Team Objectives and Deliverables	10	
Total	***20***	
2. Planning and Management		
Gantt Chart (Project Schedule, Milestones, Task Assignments)	15	
Written description of Gantt chart (incl. ind. group member contributions & recorded time spent in lab by each ind.)	15	
Cost estimate	10	
Total	***40***	
3. Technical		
Trade Study Results (at least 3 sensors compared)	40	
Total	***40***	
Components Request confirmation e-mail attached	✓/–	
Total Score	***100***	

*** Report should include a cover page with title, group name and membership, date, and Community Standard statement (signed by all).**

*** See additional handouts for a description of how to complete a Pros and Cons evaluation as part of a Trade Study and how to construct a Gantt Chart.**

1. Introduction

Team Challenge Overview:

This year's Integrated Design Challenge requires five autonomous bots to act as judges for the BOE-lympics. Each group's bot must first follow a line around the ring of the competition area. The bots will then each individually use sensors to take measurements such as color, size, angle, distance, and magnetic strength of an object. Based on the measurements taken, each bot will then transmit and receive a 0, 1, or 2 to the each other bot. The judge bots will all then add together the values it receives in addition to its own value, and take the modulus of 3 of that number. Based on the final value each bot comes up with, they will all have to complete a certain task to demonstrate that they sent and received the correct messages.

In order to complete this project, the groups of our team will have to work individually and together to ensure that each bot is functioning properly. Each group will first begin by testing sensors for their event and methods of communication between the bots. Once each group decides on a sensor, to complete their task, the groups will work on the line following task for their bot. After this, the groups will all integrate their sensors into their bots and work to finalize the bots ability to complete all the tasks in addition to sending and receiving messages. Each group will be required to give a short presentation each week to update the other groups in the team on what progress they have made. At the end of the project, the team will demonstrate each groups' bot's capabilities. Lastly, each group will have to write a written report about their bot and its challenge in addition to delivering a presentation.

Group Task:

The challenge for our group, which is the weightlifting event, is to determine which kettlebell weight is in the middle. The weights differ in size, color, and magnetic field. The BOE-

Bot must first inspect the competition surface by completing a full circle of the black ring. The robot will then determine if the weight in the ring is small, white, and not magnetized (Bronze); medium, gray, and moderately magnetized (Silver); or large, black, and strongly magnetized (Gold) by using one or more sensors to detect these characteristics. Once our bot correctly judges the weight, it must relay this information to the other bots with the numeric message: 0 for Bronze, 1 for Silver, and 2 for Gold.

Group and Team Objectives:

Each group will have to successfully follow the line around their ring, make the measurements of the objects, and then transmit and receive their medal value to the other bots. The bots will demonstrate completion of these tasks successfully by completing certain tasks that demonstrate the correct value was calculated. Finally, each group will demonstrate a thorough understanding of the design and functionality of their bot by creating a written report and delivering an oral presentation.

2. Planning and Management

The attached Gantt chart lays out our general outline for how we feel we can best work on this project. Due to scheduling, each task will require individual work from both group members during the week, and group work on weekends and Mondays. This schedule will accommodate the group member's schedules and allow us to efficiently complete each task. In addition, we have not delegated the tasks out yet as we are waiting to determine where our strengths lie. As we work, we will have a better understanding of who will work more on certain tasks. We used the Lab Assignments as our guide for when certain tasks needed to be completed by. We are unsure as to the exact amount of time each member will spend in the lab, but based

on previous work we predict that each milestone (in red on Gantt chart) will require at most 5 hours from each member. This will amount to a total of 40 hours of work expected from each member. We want to stick to our current plan, but these procedures are subject to change.

3. Cost Estimate (Without Sensor)

Object	Quantity	Cost ($/unit)
Arduino ATMEGA 2560	1	51.91
BOE Shield	1	39.99
XBEE Module	1	22.99
Continuous Rotation Servomotor	2	13.99
BOE-Bot Li Ion Power Pack with cable and barrel plug	1	49.99
BOE- Bot plastic wheel with tire	2	3.99
Wires/Resistors (In case they are needed)	TBD	5.00
Led Light	2	0.32
Total	10+	206.48

Notes: We are unsure how many extra components such as wires or resistors are needed, but based on the price we predict $5.00 will be plenty to cover what the bot will need. Additionally, we did not include a the cost of the sensor as we are still unsure which sensor we will use. Our trade study will include the cost of each sensor.

4. Trade Study

4.1 Problem:

The bot must follow a line around a circle, and then determine which kettlebell is in the ring. The kettlebells have different sizes, colors, and magnetic strength.

4.2 Possibilities:

a. Hall-Effect Sensor A1234: This sensor changes its output voltage based on its measurement of the magnetic field it senses. It can be used to determine the strength of the magnet in the kettlebell.
b. Tactile Whisker Wires: This sensor senses when it makes contact with an object. By measuring the distance from the circle to the kettlebell, placed in the center, the bot will stop at different distances based on the size of the kettlebell.
c. QTI Sensor: This sensor measures shades of light, and can be used to determine the different shades of color on the kettlebell.
d. Flexiforce Sensor: This sensor changes its resistance based on the weight of the object placed on top of it, and could measure the weight of the different kettlebells.
e. This sensor determines the color of an object, and can be used to determine the color of the kettlebell.

4.3 Trade Factors

a. Cost: Cost of the sensor
b. Size: Size of the sensor and how well it fits on the bot
c. Reliability: How well the sensor performs in varying conditions.
d. Accuracy: How well the sensor can detect the differences between kettlebells.
e. Complexity: How easy or difficult the circuit and code will be to properly integrate the sensor onto the bot and complete the task.

4.4 Trade Factors for Each Sensor

Sensor	Cost	Size	Reliability	Accuracy	Complexity
Hall-Effect Sensor A1324	$2.33	Very Small	Very Reliable	Accurate	Moderately Simple
Tactile Whisker Wires	$3.00	Large	Unreliable	Not Accurate	Complex
QTI Sensor	$9.99	Medium	Very Reliable	Accurate	Simple
Flexiforce Sensor	$24.99	Large	Unreliable	Extremely Inaccurate	Moderately Complex
RGB Color Sensor with IR filter and White LED	$7.95	Medium	Very Reliable	Very Accurate	Moderately Simple

4.5 Scale for each Factor:

Factor	5	4	3	2	1
Cost	$0-$2.99	$3.00-$4.99	$5.00-$9.99	$10-$19.99	>$20
Size	Very Small	Small	Medium	Large	Very large
Reliability	Extremely Reliable	Very Reliable	Reliable	Unreliable	Very unreliable
Accuracy	Extremely Accurate	Very Accurate	Accurate	Not Accurate	Extremely Inaccurate
Complexity	Simple	Moderately Simple	Moderately Complex	Complex	Very Complex

4.6 Weight of Each Factor

Factor	Weight	Reason
Price	1	Minimizing cost is not considered one of the main goals of the challenge.
Size	2	A larger bot could be more difficult to work with.
Reliability	4	We need the bot to perform correctly in all conditions.
Accuracy	4	The bot must correctly identify the object.
Complexity	3	A more complex bot will be harder for us to construct and properly troubleshoot.

4.7 Calculations

	Hall-Effect Sensor A1324 (weight*Value)	Tactile Whisker Wires (W*V)	QTI Sensor (W*V)	Flexiforce Sensor (W*V)	RGB Color Sensor with IR filter and White LED (W*V)
Price	1*5	1*4	1*3	1*1	1*3
Size	2*5	2*2	2*3	2*2	2*3
Reliability	3*4	3*2	3*4	3*2	3*4
Accuracy	4*3	4*2	4*3	4*1	4*4
Complexity	4*4	4*2	4*5	4*3	4*4
Total	55	30	53	27	53

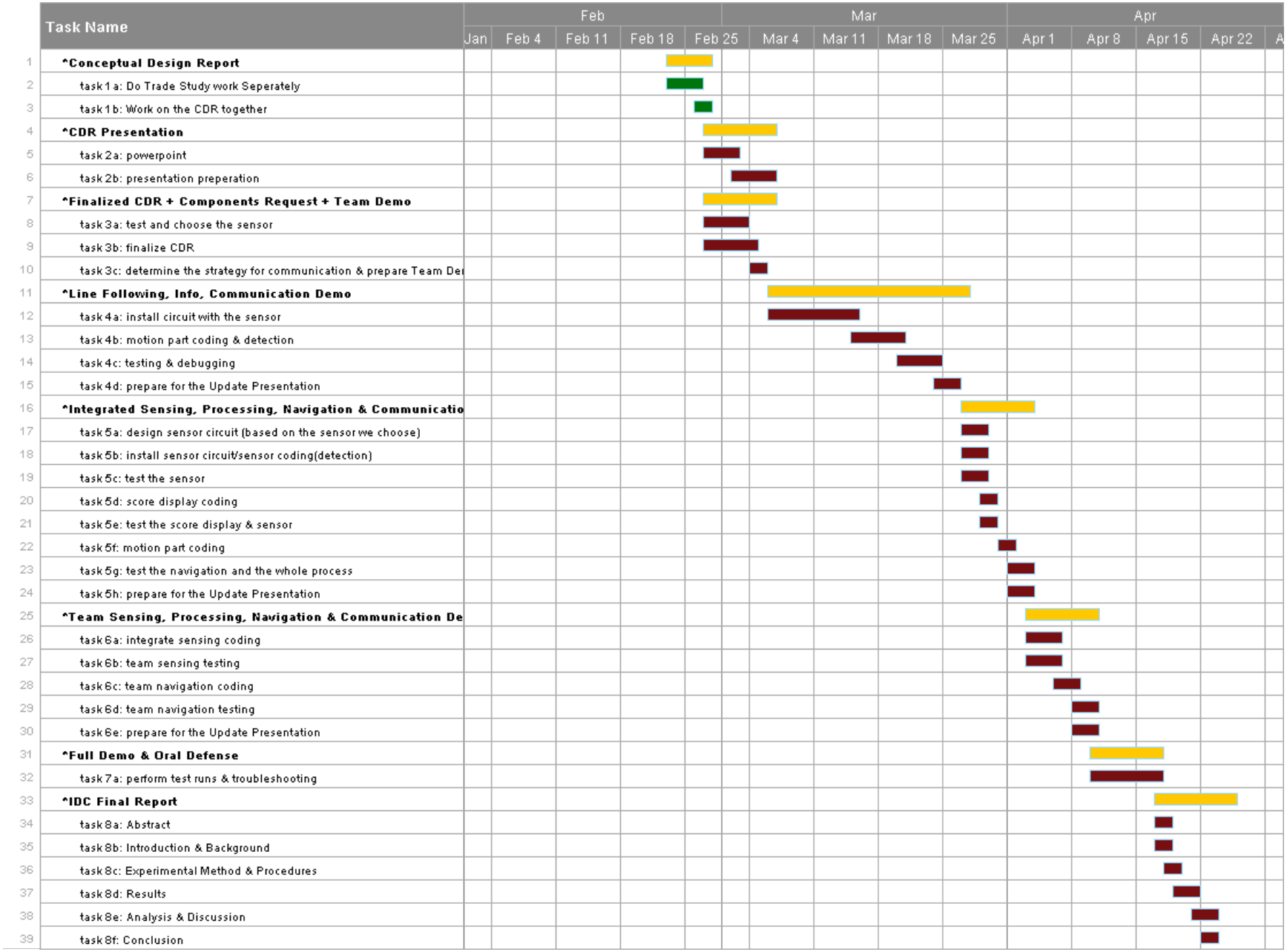
5. Discussion and Conclusion

The Hall-Effect, QTI, and RGB sensors all scored fairly similarly. Since we have not had full experience with these sensors in the lab, we are considering all three and will test each method in order to determine which sensor works best for our challenge. One concern we have with the Hall-Effect Sensor is that it is reported to have a large margin of error when measuring magnetic fields and outputting a voltage. This could lead to inaccurate measurements if the strength of the fields in the kettlebells are too similar. Additionally, our concern with the QTI and RGB sensors is that the color of the kettlebells will be too similar, and the sensors will not be able to accurately discern the differences. Overall, the only way for us to move forward with our bot's design is to test the accuracy of each sensor with the kettlebells.

6. Planning & Gantt Chart

Task Name	Start	Finish	Duration	Tong	Justin
***Conceptual Design Report**	**02/23/18**	**02/27/18**	**4**		
task 1a: Do Trade Study work Seperately	02/23/18	02/26/18	3	1.5h	1.5h
task 1b: Work on the CDR together	02/26/18	02/27/18	1	3h	3h
***CDR Presentation**	**02/27/18**	**03/06/18**	**7**		
task 2a: powerpoint	02/27/18	03/02/18	3	1h	
task 2b: presentation preperation	03/02/18	03/06/18	4		1h
***Finalized CDR + Components Request + Team Demo**	**02/27/18**	**03/06/18**	**7**		
task 3a: test and choose the sensor	02/27/18	03/03/18	4		
task 3b: finalize CDR	02/27/18	03/04/18	5		
task 3c: determine the strategy for communication & prepare Team Demo	03/04/18	03/05/18	1		
***Line Following, Info, Communication Demo**	**03/06/18**	**03/27/18**	**21**		
task 4a: install circuit with the sensor	03/06/18	03/15/18	9		
task 4b: motion part coding & detection	03/15/18	03/20/18	5		
task 4c: testing & debugging	03/20/18	03/24/18	4		
task 4d: prepare for the Update Presentation	03/24/18	03/26/18	2		
Integrated Sensing, Processing, Navigation & Communication Demo	**03/27/18**	**04/03/18**	**7**		
task 5a: design sensor circuit (based on the sensor we choose)	03/27/18	03/29/18	2		
task 5b: install sensor circuit/sensor coding(detection)	03/27/18	03/29/18	2		
task 5c: test the sensor	03/27/18	03/29/18	2		
task 5d: score display coding	03/29/18	03/30/18	1		
task 5e: test the score display & sensor	03/29/18	03/30/18	1		
task 5f: motion part coding	03/31/18	04/01/18	1		
task 5g: test the navigation and the whole process	04/01/18	04/03/18	2		
task 5h: prepare for the Update Presentation	04/01/18	04/03/18	2		
***Team Sensing, Processing, Navigation & Communication Demo**	**04/03/18**	**04/10/18**	**7**		
task 6a: integrate sensing coding	04/03/18	04/06/18	3		
task 6b: team sensing testing	04/03/18	04/06/18	3		
task 6c: team navigation coding	04/06/18	04/08/18	2		
task 6d: team navigation testing	04/08/18	04/10/18	2		
task 6e: prepare for the Update Presentation	04/08/18	04/10/18	2		
***Full Demo & Oral Defense**	**04/10/18**	**04/17/18**	**7**		
task 7a: perform test runs & troubleshooting	04/10/18	04/17/18	7		
***IDC Final Report**	**04/17/18**	**04/25/18**	**8**		
task 8a: Abstract	04/17/18	04/18/18	1		
task 8b: Introduction & Background	04/17/18	04/18/18	1		
task 8c: Experimental Method & Procedures	04/18/18	04/19/18	1		
task 8d: Results	04/19/18	04/21/18	2		
task 8e: Analysis & Discussion	04/21/18	04/23/18	2		
task 8f: Conclusion	04/22/18	04/23/18	1		

(Milestones in asterisk)


Task Name
Feb
Mar
Apr
Jan
Feb 4
Feb 11
Feb 18
Feb 25
Mar 4
Mar 11
Mar 18
Mar 25
Apr 1
Apr 8
Apr 15
Apr 22
1 *Conceptual Design Report
2 task 1 a: Do Trade Study work Seperately
3 task 1 b: Work on the CDR together
4 *CDR Presentation
5 task 2 a: powerpoint
6 task 2 b: presentation preperation
7 *Finalized CDR + Components Request + Team Demo
8 task 3 a: test and choose the sensor
9 task 3 b: finalize CDR
10 task 3 c: determine the strategy for communication & prepare Team Der
11 *Line Following, Info, Communication Demo
12 task 4 a: install circuit with the sensor
13 task 4 b: motion part coding & detection
14 task 4 c: testing & debugging
15 task 4 d: prepare for the Update Presentation
16 *Integrated Sensing, Processing, Navigation & Communicatio
17 task 5 a: design sensor circuit (based on the sensor we choose)
18 task 5 b: install sensor circuit/sensor coding(detection)
19 task 5 c: test the sensor
20 task 5 d: score display coding
21 task 5 e: test the score display & sensor
22 task 5 f: motion part coding
23 task 5 g: test the navigation and the whole process
24 task 5 h: prepare for the Update Presentation
25 *Team Sensing, Processing, Navigation & Communication De
26 task 6 a: integrate sensing coding
27 task 6 b: team sensing testing
28 task 6 c: team navigation coding
29 task 6 d: team navigation testing
30 task 6 e: prepare for the Update Presentation
31 *Full Demo & Oral Defense
32 task 7 a: perform test runs & troubleshooting
33 *IDC Final Report
34 task 8 a: Abstract
35 task 8 b: Introduction & Background
36 task 8 c: Experimental Method & Procedures
37 task 8 d: Results
38 task 8 e: Analysis & Discussion
39 task 8 f: Conclusion

7. Appendix

Form submission from: ECE 110 Component Request

K

kip.coonley@duke.edu on behalf of ECE Laboratory Site <justin.miles@duke.edu

Reply all

Today, 17:10

Tong Fu

This is a confirmation email for your submission.

Submitted on Monday, February 26, 2018 - 6:10pm
Submitted by user: tf79
Submitted values are:

Last Name: Fu
First Name: Tong
Bot Box Number: 37
Part Number or Description: Hall Effect Sensor
Quantity: 1
Email: tong.fu@duke.edu

Form submission from: ECE 110 Component Request

K

kip.coonley@duke.edu on behalf of ECE Laboratory Site <justin.miles@duke.edu

Reply all

Today, 17:10

Tong Fu

This is a confirmation email for your submission.

Submitted on Monday, February 26, 2018 - 6:09pm
Submitted by user: tf79
Submitted values are:

Last Name: Fu
First Name: Tong
Bot Box Number: 37
Part Number or Description: RGB Sensor
Quantity: 1
Email: tong.fu@duke.edu

Form submission from: ECE 110 Component Request

K

kip.coonley@duke.edu on behalf of ECE Laboratory Site <justin.miles@duke.edu

Reply all

Today, 17:10

Tong Fu

This is a confirmation email for your submission.

Submitted on Monday, February 26, 2018 - 6:10pm
Submitted by user: tf79
Submitted values are:

Last Name: Fu
First Name: Tong
Bot Box Number: 37
Part Number or Description: QTI Sensor
Quantity: 1
Email: tong.fu@duke.edu