University of British Columbia
Electrical and Computer Engineering
ELEC 291/292

Magnetic Field Controlled Robot

Introduction

For the second project of ELEC291/ELEC292, you will design, build, program, and test a remote controlled robot using a magnetic field. The robot must be battery operated and controlled using a microcontroller system. The robot will receive commands from the transmitter via the magnetic field and actuate as required by such commands.
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Project Requirements

The project **must** include the following components and/or functionality:

1. **Two different microcontroller Systems:** For this project you'll need at least two microcontroller systems: one microcontroller is used in the robot while the other microcontroller is used in the transmitter. The microcontrollers used for the robot controller and transmitter must be from different families. Parts to assemble microcontroller systems based on these popular microcontrollers will be provided in the lab to each group:

Maker	Family	Microcontroller
NXP	ARM	LPC824
ST Microelectronics	ARM	STM32F051
Microchip	PIC32	MX130F064B
Texas Instruments	MSP430	MSP430F2553
Atmel	AVR	ATMega328P[1]

Additionally you can use one of the two microcontrollers used in previous labs:

Maker	Family	Microcontroller
Atmel	8051	AT89LP51RC2
Silicon Labs	8051	EFM8LB1

For your project select one of each family from the tables above. For example, for the robot controller you can use an 8051 microcontroller (such as the EFM8LB1) and for the transmitter controller you can use an ARM microcontroller (for example the SMT32F051). You may as well use any other microcontrollers not included in the lists above provided that you acquire both the IC and developing system.

[1] This is the same processor used in the Arduino board. Arduino boards, programs, or anything to do with the Arduino environment are not acceptable for this project. If you choose to use this processor it must be programmed in plain 'C' using either GCC or any other available C compiler.

2. **Robot Battery operated:** The robot must be battery operated. Batteries are neither provided in any of the kits nor will be provided to you at any moment because they are very expensive. You need to buy your own batteries. An AA battery holder and a 9V battery clip are included in the project kit. The transmitter can be powered with an external power supply.
3. **Robot construction:** You can use any material you find available for the chassis of the robot (paper, cardboard, wood, plastic, metal, etc.). You can also use the materials and tools available in the MCLD workshop (the technicians may charge you for expensive material). If you plan to use the workshop, you need to complete the workshop safety training first. Also remember that you are required to wear safety glasses and safety shoes while in the workshop. The parts listed below have been used successfully in similar projects in the past and are included in the project kit.

Part #	**Description**
Solarbotics GM4	Gear Motor 4 - Clear Servo
Lynxmotion Servo Wheel	2.63" x 0.35" (pair)
Tamiya 70144	Ball Caster
4 x AA	Battery holder
1 x 9V cable	9V battery clip
Unfolded chassis	Aluminum chassis made using the water jet cutter.

You can buy the project kit for 40$ by visiting this web page

https://eng-services-payments-site.sites.olt.ubc.ca/about/ece-shopping-cart/

The password is ‘ece2018’ (no quotes). Then you pick the kit up in MCLD112b.

4. **C programming:** The code for this module must be completed using the C programming language. The integrated development environment CrossIDE available in the course’s web page includes a C compiler that works for the 8051 family of microcontrollers. A few C programming examples are provided with CrossIDE. For other processors CrossIDE works also. The instructions to obtain compilers, assembly instructions, and flash loaders are posted or will be posted in the web page for the course.
5. **MOSFET drivers:** To drive and control the motors of your robot you must use MOSFETs (Metal Oxide Semiconductor Field Effect Transistors). If you find the motors are too noisy (electronically noisy, that is) you may want to consider isolating those using optoisolators to control the MOSFETs in a similar manner to that of lab 6. The LTV847 optoisolator is included in one of your parts kit. Obviously, the robot should be able to move forward and backward as well as turn left or right.
6. **Transmitter:** While one microcontroller system is used to control the robot, another microcontroller system is used to transmit an electromagnetic signal at some frequency. The robot controller reads this signal using an inductive sensor and determines which commands to execute. Your design must support at least these five commands:

    1) Move Left. When the user pushes the Nunchuk joystick left, the robot must turn left.
    2) Move Right. When the user pushes the Nunchuk joystick right, the robot must turn right.
    3) Move Forward. When the user pushes the Nunchuk joystick up, the robot must move forward.

4) Move Backward. When the user pushes the Nunchuk joystick down, the robot must move backward.
5) Stop.

You can use any controller interface you want. Push buttons are a simple and effective option. Joysticks and Nintendo nunchucks (example code provided for the EFM8LB1 microcontroller) are also popular options.

7. **Distance**: The robot must be able to receive commands from the transmitter when they are both separated by at least 100 cm. The farther your robot can detect the transmitter the better. In order for detection distance to be considered an extra feature, it must be at least 1.5 times the required distance: 150 cm. To design your transmitter/receiver you can use Microchip's application note 232: "Low-Frequency Magnetic Transmitter Design" available at

   http://ww1.microchip.com/downloads/en/AppNotes/00232B.pdf

8. **Purpose:** The purpose of this robot is to move three objects from one circle with a diameter of 20 cm to another circle with the same diameter located 100 cm apart (center to center) as fast as possible one object at a time. The three objects should be large and heavy enough to be moved precisely by the robot; therefore the objects must have a minimum volume of 200 cm^3. You can pick any object you wish, but be aware that balls are hard to stop!

Project Evaluation

The evaluation of this project consists of a demonstration (worth 35% of the final mark) and a written project report (worth 5% of the final mark). In the project demonstration, your design is evaluated using the following criteria:

Mark	The project is:
10	Exceptional, did everything it was supposed to do well, plus maybe some additional functionality. The project looks great and it has **original/innovative ideas**!
9.0-9.5	Did everything required. Circuitry / project well designed and constructed. It could use a little improvement. The project has some original/innovative ideas.
8.0-9.0	Did everything required, lesser quality but still worked. The project lacks originality/innovation.
7.0-8.0	Mostly worked, not entirely, not the greatest design.
6.0-7.0	Didn't really work, ok design but didn't really come together.
4.5-6.0	Didn't work, not very good design.
0.5-4.5	Didn’t work, poor design.
0	What project?

The project demonstration evaluation will be carried out by the course instructor and/or one or more laboratory TA(s) on April 5, 2016. This demonstration should not take more than 4 or 5 minutes, if everything is working reasonably well. The project report is due by April 8, 2016. You need to submit the project report using the format described in the following section.

Project Report Format

The project report should be written for a reasonably expert reader such as a project manager (an engineer) in a company for whom you might have designed this prototype product. The project report should have sufficient detail that someone skilled in the art could reproduce or improve upon your results. The number of pages for the report should be ≤ 20 (not including the title page and appendices, double spaced, ‘Arial’ or ‘Times New Roman’ font size 12 for text, and ‘Courier New’ font size 8 or 10 for the source code, approximately one inch margin for the top, bottom, left, and right margins) and include the following sections:

1. **Title Page –** It should include the course name and number, instructor name, section, project name, <u>group number</u>, names and student number of the students in the group, and the date of submission.

2. **Table of Contents**

3. **Introduction –** Design objective and specifications. Overview of the overall design approach including **system block diagrams for both the hardware and software designs**.

4. **Investigation –** This section must include the following subsections:

A. **Idea Generation** – Describe how your group generated ideas and working hypotheses.
B. **Investigation Design** – Describe how you group perform the design investigations involving information and data gathering, analysis, and/or experimentation.
C. **Data Collection –** Describe how your group used appropriate procedures, tools, and techniques to collect and analyze data.
D. **Data Synthesis –** Describe how your group synthesized data and information to reach appropriate conclusions.
E. **Analysis of Results –** Describe how your group appraised the validity of conclusions relative to the degrees of error and limitations of theory and measurement.

5. **Design –** This section must include the following subsections:

A. **Use of Process –** Describe how your group adapted and applied general design processes, accesses to design systems and components, or processes to solve open-ended complex problems as relevant for this project.

B. **Need and Constraint Identification –** Describe how your group identified customer, user, and enterprise needs, and applicable constraints.

C. **Problem Specification –** Describe how your group specified additional design requirements based on needs and constraints presented in the point above.

D. **Solution Generation –** Briefly describe potential design solutions suited to meet functional specifications. If possible, include even those that didn't work!

E. **Solution Evaluation** - Perform systematic evaluations of the degree to which several design concept options meet project criteria. Clearly explain why you choose the final design.

F. **Detailed Design –** Explain how you applied appropriate engineering knowledge, judgment, and tools, in creating and analyzing design solutions. This has to be one of biggest parts of the report. In this section you must include the description and evaluation of each block (e.g. "A-stable Circuit", or "Counter Initialization"): Describe the approach taken to design each block. For circuits, include a detailed circuit diagram and describe how it works. For programs, include the source code in the appendices, and refer to it while you describe it.

G. **Solution Assessment –** Describe how you assessed the design performance based on requirements, needs, and constraints. This section must include an **evaluation of the complete system** by mean of tests you carried out including plots of performance, reproducibility numbers, tables, etc. as judged appropriate for this project. Describe how each relevant part of your design was tested and the testing results. Also in this section, the strengths and weaknesses of the design must be pointed out.

6. Live-Long Learning – Identify a specific learning need or knowledge gap. For example, did your learn something new by yourself? You didn't take a course that would have helped with the project? You found that one of the courses you took was particularly useful for the project?

7. Conclusions – Summarize the design and functionality of your project. Summarize also the problems you encounter, and how many hours of work the project took.

8. References – A specific book, paper, datasheet, or website is referred to in the **body** of the report at the point at which you say something about it, by a numerically-ordered, square-bracketed number, the first one being [1]. Then, at the end of the Report in a section called **REFERENCES** located just before the **Appendices** section**,** the same square-bracketed number is followed by the Author List, Article Title, Journal or Book Title, Volume, Number, Pages, ISBN Number, Publisher, Date of Publication. Although the Reference list can be listed alphabetically by author, instead we do not recommend this for an Engineering Report. With an alphabetical listing, the location in the body where any particular reference is discussed is then hard to find, since the references are no longer in order of appearance. Examples of references are [1] and [2] (note that the numbers in the square brackets here refer to the appropriate numbers in the Reference list). The Reference list itself might look like:

REFERENCES
[1] Smith, J, and F. Jones, "Designing an universal logic circuit", Journal of Impossibly Wonderful Electronic Circuits, v.3, n.1, pp. 21-35, March, 1910.
[2] Jones, F and J. Smith, "Why universal logic circuits are impractical" , …

9. Bibliography – Items in a section at the end of a report called **BIBLIOGRAPHY** are NOT referred to in the body of the report. It is a list of appropriate background or additional reading and is located after the **References** section and before the **Appendices** section. The items in the Bibliography are usually ordered by last name of the first author. It is sometimes appropriate to have BOTH a Reference list and a Bibliography list. An example Bibliography looks like:

BIBLIOGRAPHY
• Sedra, A., and K.C. Smith, Microelectronic Circuits, 4th Edition, Oxford University Press, 1998.

10. Appendices – Supporting documents such as extensive theoretical analyses, mechanical drawings, and source code. Your source code should be properly documented and indented. Do not append datasheets, compiler manuals, or other already published material to the report.

Project Report Marking Rubric.

Report Content	**Worth**	
Title page (all information present including student names/numbers/section?)	0.2	
Table of contents	0.25	
Introduction	0.3	
Investigation		
Idea Generation	0.2	
Investigation Design	0.2	
Data Collection	0.2	
Data Synthesis	0.2	
Analysis of Results	0.25	
Design		
Use of Process	0.25	
Need and Constraint Identification	0.25	
Problem Specification	0.25	
Solution Generation	0.35	
Solution Evaluation	0.2	
Safety/Professionalism	0.2	
Detailed Design		
Hardware block diagram?	0.5	
Circuit explained?	1.0	
Software block diagram?	0.5	
Software explained?	1.0	
Solution Assessment		
Tests include data/plots?	0.5	
Life Long Learning	0.2	
Conclusions	0.5	
References (present and used correctly?)	0.25	
Bibliography (present and used correctly?)	0.25	
Appendices (if present, used correctly?)	0.25	
Report Format		
Double space?	0.25	
Correct Fonts?	0.25	
Margins?	0.25	
Number of pages? (<20 not including appendices)	0.25	
Clear & clean figures? (Bad scans of poorly hand drawn figures are not acceptable)	0.25	
Page numbers.	0.25	
Clean presentation.	0.25	
Weeks late (-2 points per week)		
GRADE (out of 10)		

Sample report front page

University of British Columbia
Electrical and Computer Engineering
ELEC291/ELEC292 Winter 2017
Instructor: Dr. Jesus Calvino-Fraga
Section 201

Project 2 – Magnetic Field Controlled Robot

Group #: B4

Student #	Student Name	%Points	Signature
91234567	Liu Kang	90	
97878474	Johnny Cage	100	
96456637	Goro	100	X
94214331	Raiden	100	
96562002	Sonya	105	
99873737	Scorpion	105	

Date of Submission: February 26, 2018