## Contents

## COMP 444 - The Instructor's Notebook

This part of the WIKI and all subsequent sub-topics comprise what I have called The Instructor's Notebook, elsewhere on the landing as well as in the study guide.

The instructor's notebook consists of my own diary of work in this course (incomplete at present), as well as exercises and other materials which correspond to topics and references in the course study guide (found on Moodle).

I've also made notes with respect to the course text companion workbook, where applicable. This is presently a work in progress.

## First Steps

Greetings! Having enrolled in this course, you have just received your course package from Athabasca University. Inside you found some paperwork, the textbook, plus the Sparkfun Inventor's Kit. If you are anything like me, you tossed the paperwork and the text onto a convenient table and immediately opened the Inventor's kit.

Inside the rather nice plastic holding case you found a number of small ziploc baggies containing various electronic components, some hookup wires, a cardboard box about the size of a deck of cards containing the Arduino inside an anti-static bag, a manual and some instructional cards, a plastic base and a small perfboard.

Before you can begin, you need to assemble the Arduino and the perfboard onto the plastic base. Please have a quick read through the supplied manual before you begin. You should refer to the next section about obtaining the most recent version of this manual.

The manual contains good general instructions as well as important information about preventing static damage to your Arduino. Be careful when handling the Arduino, especially until you have it properly attached to your base. **If you damage your Arduino, you will have to order and pay for a replacement yourself.**

Once you have the Arduino and perfboard mounted to the base, you can begin examining the other components. You can try some of the experiments in the supplied tutorial, but you won't be able to run the programs until you install the Arduino programming environment. Again, the supplied manual has excellent instructions.

If you encounter difficulties in any of these first activities, post your questions on the Landing (Comp 444 group) or on the course's moodle forums.

## Sparkfun Inventor's Kit Manual (SIK Guide)

One thing I discovered in using this kit is that the supplied printed manual does not always agree 100% with the kit componenets. That is because this kit is used in hundreds of schools in North America, and feedback from educators causes Sparkfun to adjust the instructions, experiments, and even kit components to provide a better learning experience. As a result, the best source for the kit manual is the on-line version, which you can find here: Sparkfun SIK Guide

When I refer to the kit manual in my discussions, I am always referring to the on-line manual which will reflect the latest changes. Should I deviate from the on-line manual, I will note that in my discussion.

Update (2017-08-16): Thanks to John Gerassimou for mentioning in his discussion post a link to the latest Sparkfun SIK Guide (SIK 3.3 Manual pdf). The older SIK guide link is still posted above, but I notice the version number is somewhat obscure (SFE03-0012?).

Anyway, if you get the new SIK with the redboard, be sure to check out the new link.

## Other Useful Links

In addition to the on-line SIK Guide, there are several other links that contain a wealth of information on the Arduino and the SIK.

- Sparkfun SIK Guide
- Sparkfun Inventor's Kit for Arduino
- Arduino Homepage
- LadyAda's Arduino Tutorial
- SteamPunk R&D Arduino Introduction

When I refer to the kit manual in my discussions, I am always referring to the on-line manual which will reflect the latest changes. Should I deviate from the on-line manual, I will note that in my discussion.

## Programming

As with many things involving the Inventor's kit, the supplied instruction manual has a wealth of information on programming the Arduino. The Arduino is programmed in the C programming language, but you don't have to "know C" to program an Arduino. That is because most of the C houskeeping is already done by the Arduino programing environment. For all simple programs, all you have to do is write program statements (called procedural code) inside one of the two supplied subroutines (called *functions* in C). Procedural program statements are almost identical in programming languages you learned or may know prior to taking this course; languages such as C, C++, C#, Java, to name a few. Follow along with the examples to familiarize yourself with simple programs using the Arduino programming environment. As with all things in this course, if you encounter difficulties, post on the course Landing group or on the course Moodle forum.

## Study Guide Exercises

In the study guide, each unit has an 'exercises' section, in which you are directed to this guide. The sections below contain the hardware and programming instructions to go with each unit.

In the following exercises, I will be referring to several documents, mentioned elsewhere in the course materials and supplied as part of your course materials in the form of websites on Moodle, the Landing or via links in the Study Guide and this document.

The first is the course study guide, referred to here as the "Study Guide". this is found on the course page on Moodle. The second is this document, "Robotics Notebook" or "Notebook", also known as "The Instructor's Blog". This is found on the Landing in the COMP 444 group. The third document is the textbook's companion workbook, called here "Workbook". Finally there is the Sparkfun Inventor's Kit "SIK Guide", which is a PDF document you download from the Sparkfun link provided above. This last document is the latest version of the paper SIK Guide that came with your kit. At the time of writing this notebook, the most current version of the SIK guide is "SFE03-0012-SIK.pdf". When new versions of the SIK Guide are released, I will update these pages as appropriate.

Please note that a link to the Robotics Primer companion workbook is provided in Unit 0 of the study guide on Moodle. The workbook is hosted by sourceforge. Here is the same direct link to the sourceforge page:

http://sourceforge.net/projects/roboticsprimer/

**EDIT 2018-01:**

Materic's group seems to love messing with the workbook. It used to be a set of html docs in a zip. Now the link contains a zip with ... ??? (a messy bunch of stuff).

There is a link to an on-line version of the primer here:

http://roboticsprimer.sourceforge.net/wiki/index.php/Main_Page

I would recommend using this link from  now on. I am trying to contact the author for permission to host the original workbook that was actually pretty good before they kept "improving" it.

## Unit 0

The SIK Guide is the gateway to your Experimetner's Kit. At this time you should review Section 1 of the SIK guide if you have not already done so.

In your own notebook that you create on the Landing, describe the Arduino in your own words. Also describe your own experiences with downloading, installing and testing the Arduino programming environment. Include any difficulties you may have encountered, and what steps you took to resolve them.

**I strongly urge you to resist the temptation to download all the examples and just run them. I have taught programming for many years, and have found both in teaching and in learning myself that the greatest benefit in learning to program a new system/device/language can be obtained if you type all the example code in yourself. Typing in the code, even for simple examples, engages your brain in the process of writing code, compiling code, running code, and diagnosing and resolving problems that may arise. It is the latter skill - problem solving - that can become the most powerful tool in learing to program.**

Once you have completed the steps above for Section 1 of the SIK, continue on to the first few parts of Section 2 - specifically up to the creation of Circuit #1 - Blinking a LED. Again, describe your journey in your own Landing notebook.

**Remember, the assignments in this course are comprised of you submitting your completed notebook at certain points in the course. Your mark in this course is comprised of a summative assessment of your diary/notebook at those weypoints. The more you describe what you are observing and understanding as you progress through these exercises, the better you will meet the objectives of the course.**

## Unit 1

As mentioned in the Study guide and this notebook, the companion text workbook is somewhat incomplete, and does not completely apply to our chosen hardware platform. The workbook also does not correspond well to the SIK Guide, in that the guide explores some hardware elements in different order than the text's workbook. However, this is not really a significant difficulty, as we want to first explore the various hardware elements in our Inventor's kit, after which we can tackle some of the text's robotic questions.

Unit 1 is a general discussion of locomotion. Unit 2 will further explore robotic locomotion, but for now we shall begin by working through the SIK tutorials.

Bearing that in mind, you should begin to work through the SIK Guide tutorials in Section 2, making notes of your progress, questions, challenges and solutions as you go. Due to the structure of the SIK Guide, I recommend you tackle the circuits and programs in the order they are presented, starting with Circuit #2 and continuing through Circuit #7. These circuits comprise the tutorial's coverage of sensor inputs, which will be put to further use in Unit 4, and pave the way for the next unit's circuits.

Activities using the text Companion Workbook: Read through the text companion workbook section titled Robotic Components. Answer the questions posed in this section of the workbook in your own weblog.

## Unit 2

This unit begins the discussion on locomotion and robotic movement. It corresponds nicely to the SIK circuits involving motors. Work through the SIK Guide tutorials for Circuits #8 through #12, inclusive. Keep notes of your progress as before on the Landing.

Once you have completed the Circuits #1 through #12, you may wish to create a video of one or more of your favorite circuits in action if you have video recording capability. If you do, be sure to upload your video to your weblog on the Landing to share with everyone in the class.

Activities using the text Companion Workbook: Read through the text companion workbook section titled Locomotion. Answer the questions posed in this section of the workbook in your own weblog. You will not be able to do the exercises in the workbook, but compare what they are doing with the iRoomba to robot kits like Lego Mindstorms. How do they compare? How do the motors used in the iRoomba compare to the various motors in your Inventor's kit? Discuss how you might build a robot like the iRoomba using your Inventor's kit, including and additional parts you might have to acquire.

**TME 1 is due at the end of this unit, so your diary on the Landing should encompass everything you have done to this point, including the tutorials through Circuit 7, inclusive.**

## Unit 3

This unit completes the section on robotic movement. By now you should have completed all SIK Guide tutorials and circuits from Circuit #1 through Circuit #12, inclusive.

**Design Question:** How many motors, and of what type, would you require to make a fully functional robotic arm that had a working elbow, wrist, and end affector (i.e. a simple clamp)? What components would you add if you wanted the clamp to be able to tell how hard it was grabbing an object such as an egg (i.e. to avoid crushing it)? Discuss your design in your weblog in detail, especially describing the choice of motor for each joint, the degrees of freedom and the range of motion.

**Programming/Circuit Task:** Since we don't have all the hardware to build a robotic arm, imagine you have been given the task of creating the elbow joint. Select the appropriate motor for this task, and then create a program and circuit using your Arduino which can demonstrate your motor performing the correct elbow movement. It may help if you tape an object such as a popcicle stick,drinking straw, or long skinny piece of paper to your motor to demonstrate the movement of the lower portion of the arm under control of your program. Your program should take as input a number of degrees to move the elbow from an arbitrary starting position. For example, if you choose 'fully straight' as the starting position, this will be designated 0 degrees (start). The arm could then bend about 170 degrees, indicating 'fully bent' (check the amount of bend on your own elbow from hand straight out to hand near your shoulder for reference).

As always, keep detailed notes in your weblog of the entire development, testing and debugging process. If you have video capabilities, upload a video of your completed project. You should also include a listing of your code in your weblog, as well as a description of the final wiring of your project.

## Unit 4

Activities using the text Companion Workbook: Read through the text companion workbook section titled Sensors. Answer the questions posed in this section of the workbook in your own weblog. You will not be able to do the exercises in the workbook, but compare what they are doing with the iRoomba to robot kits like Lego Mindstorms. How do they compare? How do the sensors used in the iRoomba platform comare to the sensors in your Inventor's Kit?

## Unit 5

There is no exercise for this unit.

## Unit 6

There is no exercise for this unit.

## Unit 7

There is no exercise for this unit.

## Unit 8

There is no exercise for this unit.

## Unit 9

There is no exercise for this unit.

## Unit 10

There is no exercise for this unit.

## Unit 11

There is no exercise for this unit.

## Unit 12

There is no exercise for this unit.

## Unit 13

There is no exercise for this unit.

## Unit 14

There is no exercise for this unit.

## Unit 15

There is no exercise for this unit.

## Unit 16

There is no exercise for this unit.

## Assignments

In this section I will discuss items specific to the three Assignments in this course.

## Project

In this section I will discuss items specific to the project for this course.

The Moodle section on the Project contains information on grading and timing (before the final exam), but only touches on the documentation you should submit to the instructor for grading.

Here is what I am seeking as documentation to be submitted for your project:

> In your own words, please describe your project by answering the guiding questions below. Be specific and detailed in your answers.

- **Design decisions** ? How did you approach the overall design of the project? What resources did you employ at this stage to assist you in creating an overall design?

- **General programming considerations** ? Were any special programming considerations required to implement your design? Where did you seek resource information to assist in this process?

- **Program implementation** ? Discuss your robot?s programming. What major categories of robotic control did you implment? What control approach did you employ to manage the overall control of your robot?

- **Testing** ? Discuss your test approach, your test plan and test results. That is, how did you test your robot and program to ensure you had met your design goals? Discuss any deviations from your expected test plan output and what you did about this.

- **Outcome** ? Discuss the outcome of your project. Did your robot meet all design expectations? Now that you are done, what would you do differently were you to undertake the same project again?

## Project Notes

At this time, we have no example projects - the course is so new that very few students are currently working on a project. However, several students have inquired about the project, and hence this new page in my notebook.

**What is the project all about?** I'm looking for a synthesis of techniques used in the course.

**What can/shall we use in the project?** You may elect to add additional hardware, or just use that in the Sparkfun Kit.

**Where can we go for ideas?** There's a ton of interesting ideas on the web, so I do understand the biggest difficulty is choosing from all the options. My advice is to begin with the elements of robotics that intrigue you most, and go from there.

You can either email me to discuss your proposed ideas, or open a discussion page for the group. I am totally open to multiple students working on the same project, and even sharing ideas, design pointers and code. (yes, even sharing code!).

**What? You are willing to let us work together?** Yes. You will be creating a hardware/software solution. Even if a number of you work on the same problem, you all must still end up creating your own hardware and working software. The design decisions are something YOU must discuss when you submit the project. You also write up your work in your own notebook, and this is something unique to you alone.

Now, if you were to do nothing at all but copy another's hardware and software, it will show in the notes and reflections. So, you won't. You will be part of a synthesis and THAT will show.

**But what if I want to work alone?** Then do so. This course is under your control. Even if you participate in a group discussion about a project, I'm not going to 'tag' you as a member of some group. You would only be a member of a group if you TELL me you are working in a group.

**What sorts of things have you built?** Me? I've built temperature controllers using processors and lightbulbs (and temp sensors), weather stations, 'sort of' underwater robots (never had the money to achieve any real depth), and so on.

**I'm going to leave comments open so feel free to add  and comments.**I will create a separate notebook entry for project ideas, so please do not post project ideas in the comments for this post.

## Project Ideas

Gradually, I'm going to write down a few ideas for projects in the comments for this page. Please feel free to discuss them or add your own.

However, do not depend on this list. The whole point of the project is for you to find something that YOU want to do and then to create it. I've given some pointers in the Project Notes page, and I'd much prefer that you come up with ideas. Once the instructor makes a list, it has a bad tendency to be viewed as "THE LIST" and then everyone just picks something from that list. If you MUST choose something from the list, see if you can't do something to make it new and unique.

Comments are turned on.

## Group Work Collaboration 'Assignment' (15% of mark)

The official description of this 'assignment' in the study guide on Moodle states:

*Sometime before you write the final exam, you will submit a summary of your group wo*

*Make a copy of various discussion postings that you have made and emails or messages*

*Upload the PDF file documenting your group work and collaboration here for tutor eva*

As the person who wrote this, I think it can be open to some interpretation. For example, I do not think you must make copies of every post you made on Moodle or the landing and incorporate it into the document.

However, as Ian asked in a discussion post, I also do not think simply submitting your entire personal notebook is the correct approach. For one thing, your notebook may not capture your discusson posts.

What I am looking for is a reflective document from each person. That is, a document in which you reflect upon what you've done in this course that directly involves discussion / participation / collaboration with the other people in this course (myself included). I think it is perphaps most appropriate as a new entry in your personal notebook. You can reflect on all the discussions you've had in the course, and how they have shaped the way your work in the course may have changed - for example there was a very good discussion a few weeks ago about how to bend component leads without 'smushing' the wires. Many participated, and I think everyone came away with something. So if you read or particpated, you can write about that.

Much of this course is based on participation - hands on working with the SIK, discussion and reflection (on Moodle & the Landing), and hopfully even outside the course with interested persons. Describe your interactions and what the outcome was.

In the end, I guess the point is to convince me to award you 15% towards your final grade. I know that sounds ever so crass, but it's reality. This is a course, and in the end I know everyone would like an "A". I want to give the best mark possible, so your role as it relates  to this particular course is to convice me that I should.

So again, I think a single new page/entry in your personal notebook describing your interactions with colleagues in the course, and how it influenced your work in the course, WITH SOME SPECIFIC EXAMPLES, is what I'm looking for.

Comments are welcome.

-Richard

## Final Exam

The final exam must be requested from the exam office before your contract ends. The details are here on the exam prep link: http://www.athabascau.ca/policy/registry/ugexamrequest.htm

The actual exam is a paper exam, 3 hours long. It was not designed to be difficult, but you will do quite a bit of writing.

There are two questions. The first question asks you to discuss your project and tell me all about it. The second question asks you to reflect on your experience with the course.

Currently the exam is a paper exam that you must take at an invigilation center (see the link for details) and write your answers in an exam booklet.

Athabasca University is converting all their exams to on-line format, so this exam will be moving on-line in the near future. I do not know the exact date, but it may be next year (2014).

## Hardware

This course requires hardware to be effective. Students will receive a kit of hardware in addition to the text upon which to conduct experiments, explore the study guide and complete the course assignments. The final decision on which kit to supply was a rather long and arduous one, as outlined below.

The fundamental processing device for this course is the Arduino prototyping board. The Arduino is an extremely popular programming platform for robotics as well as many other types of science and hobby projects. It is relatively easy to program, is fully open source, and quite inexpensive. It can be purchased individually or together with a variety of kits.

## What should you submit for an assignment?

What should you submit for an assignment?

An assignment is an opportunity for you to gather your thoughts and landing posts together into a format suitable for presentation and marking. The optimum format for a submitted assignment is a single pdf file for each assignment. Submitting a single PDF file can be done without zipping the PDF.

However, if you include videos (and I love videos), these should be zipped together with the single PDF document into a zip file and submitted as a single zip file.

Now, as to content of the PDF document for an assignment. One does not simply link to the landing posts and expect that to constitute a submitted assignment. In fact, I will NOT follow links to landing posts when marking. If you can't spend the effort to copy/paste your landing posts into the submitted PDF, then why should I spend any effort marking? So a submission of landing links will lose marks accordingly.

To clarify - your landing posts are there to document your progression through the course, including thoughts, ideas, challenges and solutions. However, an assignment for marking is a prepared document that should take from those posts and condense it into a single essay style document that fulfills the requirements of the assignment. No formal essay style is required, but you should take the opportunity to condense your landing posts and make them into a single "story" that addresses all the assignment requirements in a systematic fashion (i.e. answer all 'points to ponder' questions in one section, and show all SIK builds in another).

I understand there is complete overlap between the landing posts and the assignment requirements - it was designed that way. However, marked assignments still should be considered something to "write up" - allowing you to reflect on the landing posts and condense or edit them.

-R