ENG PHYS 4A06
Design and Synthesis Project
Fall/Winter 2016/2017
Course Outline

Instructor Office Hours and Contact Information

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Teaching Assistant Office Hours and Contact Information

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Course Website/Alternate Methods of Communication

http://engphys.mcmaster.ca/undergrad-studies/ug-courses/eng-phys-4a06/
Avenue to Learn (ATL) http://avenue.mcmaster.ca/
All students are expected to have a McMaster email account and to check Avenue to Learn regularly for messages. As the class will not meet formally as a group, Avenue to Learn is how the instructor or designate will communicate information and expectations to the group.

Course Objectives

Upon successful completion of the course, a student has completed an engineering design project including modern physics concepts.

Scheduled Time & Place

4A06 is offered Tuesdays from 1430 to 1720. Attention to 4A06 during the assigned time is not considered by the Department to be optional. It is expected that a minimum of three additional hours per week is dedicated for work on the design project.

1. The first day you are expected to be in attendance from 1430 to 1720 for formal discussions and important presentations
2. The Practice Pitch Presentations, Project Pitch Day, and Project Milestone Demos will have a specific schedule posted on ATL listing the time and place your group needs to present and will span a larger 1330-1800 timeslot
3. On regular project-room Tuesdays (any day in which a WPR or WPR+ is due; see the Course Schedule), your group is expected to meet with your TA in the project room at 1430 to hand in your WPR for marking.
    a. Exception: IF your group has a course conflict during the 1430-1720 timeslot it is your responsibility to communicate this with the instructor and your TA, because you will need to schedule a specific time in that range to meet your TA as a group and your TA will need to give your group priority during that time. If there is *no* time in the 1430-1720 timeslot where your entire group is free you must choose different courses or a different group!

PROJECT DESCRIPTION & RULES

Project of your choosing with a group of 4 (or 3 if necessary) of your choosing, subject to the following rules:

1. Your project must:
    a. be a physical robot/device/product, not a piece of information;
    b. include both hardware and software components (it must include a microcontroller or equivalent that you've programmed);
    c. include sensors (it must read something from the outside world) and probably include feedback control (it must influence the external world in a controlled way based on its readings using its microcontroller), but may include only sensors and display information if the project is impressive enough with sensors alone;
    d. apply your undergraduate Eng Phys education in its design; and
    e. require significant engineering challenge on your part.
2. The project must involve the design, construction, evaluation, and refinement of a device to meet a need. The project is not to be an assembly of kits. Application of knowledge and skills presented in the undergraduate program, use of modern engineering tools, team work, project management, ingenuity, and synthesis are expected. Any projects that include parts from commercially available kits must include other significant engineering design elements that demonstrate in a non-trivial manner the expected application of knowledge, skills, ingenuity, synthesis, and use of modern engineering tools. In particular, you must design for manufacturability, safe fail etc. (see the description of the final report sections).
3. All projects and work must comply with all applicable regulations, codes, and practice. No lasers beyond Class II are to be used.
4. You must submit a list of your group members during the first day of 4A06. Students who fail to do this will be randomly assigned to groups by midnight of that day.
5. Practice Pitch Presentations:
    a. On weeks 2 & 3 of class your group will make Practice Pitch Presentations to the class and watch other groups' Practice Pitch Presentations.
    b. You must present:
        i. A description of the problem you aim to solve
        ii. Why you want to solve it (and why society would want to solve it)
        iii. Goals of what specifically you're going to do to solve it
        iv. A rough idea of how you're going to do it (to allow the audience to assess feasibility)
    c. The practice pitch presentations have a presentation time limit of 5 minutes, need to be done without using the room's A/V equipment, and you need to bring 4 copies of a sheet summarizing your presentation (one for each of the TAs and one for the instructor).
    d. The audience will then give feedback and ask questions for your benefit
    e. You must present a different idea each week. Furthermore, you can't present the same project in the second week another group already has in the first week.
    f. You must be in the class from 1430-1720 (minus scheduled breaks) to participate in the audience for other groups presentations - groups with members that arrive late or leave early may be penalized.
6. Your group must pitch your project on the **Project Pitch Day** on the 4th week of class.
    a. The Project Pitch Day is a pitch to a panel of Eng Phys faculty members and Industry Sponsors
    b. Your group will make a 5 minute pitch of the final robot/device/product you aim to achieve, and why we should support it.
    c. You must sign up for a timeslot for the Project Pitch Day in advance online.
    d. The panel will evaluate your project as presented. However, they will also make suggestions on how you could improve your project to make it more feasible, have more societal impact, or be more of an appropriate challenge.
    e. You may present one of your ideas from the practice pitch presentations, or another idea (even another group's idea that they're not using). If more than one group pitches the same idea on the Project Pitch Day they may earn lower engineering challenge and societal impact scores than otherwise.

7. Your group must submit a final **written project statement** (**WPS**) on the 5th week of class:
    a. Your written project statement determines what your project will be. It includes *what* you are going to design & build, *how* you're going to do it, the *purpose* of your device, and your projected *budget* for the project.
    b. Your selected project should consider the recommendations you received during the Project Pitch Day, but does not need to be exactly the project you pitched at that time. However, any large deviations from your pitch on the Project Pitch Day should include written justification.
    c. Your project statement must include a description of your bronze, silver, and gold milestone objectives:
        i. Bronze Milestone: achieving this demonstrates that you are roughly 1/3 of the way to the device's goal (You must have something physically built, either 1/3 of the device or a device that achieves 1/3 of the performance you're going for; whichever appropriately demonstrates you are 1/3 of the way to the goal for your particular project.)
        ii. Silver Milestone: achieving this demonstrates that you are roughly 2/3 of the way to the device's goal.
        iii. Gold Milestone: achieving this demonstrates that you are have achieved the device's goal
    d. Your project description and milestone goals must be approved by your TA at this time. Your TA will not accept your written project statement if its Bronze and Silver Milestones are not
        i. Accurate reflections of 1/3 and 2/3 of the way towards the final project, and
        ii. Things you can physically demonstrate.
    e. You must include what each group member's individual area of responsibility will be
    f. You should consider how you will be able to demonstrate your individual deliverable sections for each milestone in the event that your teammates fail to deliver on theirs. Other things equal it's good to select projects that are modular enough to accommodate this.
    g. The WPS should further breakdown the partial performance marks for each milestone. It should specify the performance mark you expect to achieve for each subsection of your goal. These performance marks should be nonlinear.
        i. E.g., "Our project objective is to have a flying quadcoptor that creates maps of caves it autonomously explores using ultrasonic sensors and deliver this back to a groundstation to create the map in realtime. Of this, autonomous flight is 50%, autonomous cave navigation is 30%, mapping is 12%, mapping in real time on the ground station is 8% for a total of 100%. Autonomous flight means it can hover in one spot without crashing or other input for 60 seconds. 20s of autonomous hover in this way still demonstrates the core functionality with a lack of robustness, so would be 80% of the full autonomous flight mark. 5s of hover is much less stable so would only mean 30% of the mark. Just having the components working (motors, sensors, motor drivers, flight controller) without integration polished enough for flight would mean half of this, or 15% of the mark." etc. By writing this level of detail in the WPS you make sure you and your TA are on the same page about your project's requirements and make your job at the demos much easier.
    h. The written project statement itself is not worth marks. However, failure to submit an acceptable written project statement by the deadline of October 20th will incur the following penalties:
        i. 0 < weeks late <= 1: 2.5% reduction of final grade.
        ii. 1 < weeks late <= 2: 5% reduction of final grade.
        iii. 2 < weeks late <= 3 10% reduction of final grade.
        iv. 3 < weeks late <= 4: 20% reduction of final grade.
        v. 4 < weeks late <= 5: 40% reduction of final grade
        vi. > 5 weeks late: 100% reduction of final grade.
8. Your group must make a **weekly progress report** (**WPR**) to your TA every week we have class from October 20th until the week after the Gold Milestone Demo, except for the weeks with milestone demos (see the Course Schedule for details).
    a. WPRs are made during the course's scheduled time, in its scheduled location for that week
    b. WPRs should:

i. *demonstrate* that you've made *progress* from last week and
ii. *present* what you *plan to achieve* for next week.

c. WPRs include two parts:
   i. Individual **weekly letters** from each group member:
      1. Weekly letters are written summaries of what you personally did and what the group did that week, as well as your individual goals and group goals for next week.
      2. Your weekly letters should go in a duotang (each group member has a separate duotang, but all duotangs are turned in together) along with all of your past *marked* weekly letters to make it easy for your TA to refer to your progress over the weeks.
      3. Your weekly letters should be accompanied by a projected *schedule* of your entire project at the end of your duotang so your TA can help you identify potential delays in advance and determine whether your project is on-track.
      4. Weekly letters must be produced using a word processor. Your TA will explain the details of the format your weekly letter should be in.
      5. Weekly letters should also include
         a. Documentation of expert & instructor meetings each month (see below and WPR+ in the Course Schedule)
         b. Reference to new **safety reports** filed at the back of your duotang (see 4A06-Specific Safety Information)
      6. Your weekly letter duotang should start with your written project statement (once it has been accepted on October 20th) with your deliverables highlighted.
   ii. Verbal reports from the group & TA discussion:
      1. Following reading all of your group members' weekly letters, your TA will meet with the group together to ask questions verifying or clarifying your progress and goals as stated in the weekly letters, as necessary.
      2. In addition, your TA may choose to meet with individual group members to clarify points brought up in the weekly letters before and/or after the TA-group meeting.

d. Weeks that don't include a WPR are covered by adjacent ones. e.g., because there is no WPR during the December break, the last WPR before it should include a plan until the first week back in January while the WPR that week should include a recap of how that plan went. This also applies to the spring reading week, and the milestone demo days. Be sure to look ahead in the Course Schedule when preparing your WPRs.

e. While your work on other courses is important and life may include things other than 4A06, non-4A06 material is irrelevant for the WPRs and should not be included.

9. Instructor & Expert Meetings:
   a. **Instructor meetings**: Once per month, your group must meet with the instructor for a full discussion of how the project is going.
      i. You must have an instructor meeting:
         1. 3 times in September:
            a. Before the first pitch presentation
            b. After the first pitch presentation and before the second one
            c. After the second pitch presentation and before the Project Pitch Day
         2. Once in October, November, January, February, and March
   b. **Expert meetings**: Once in October and once in November, your group meet with a faculty advisor / technical expert of your choosing for expert advice on how to proceed on your project. The experts need not necessarily be affiliated with McMaster university. E.g., University technical staff, Faculty members other than the course instructor, Faculty from other departments / institutions, industry experts. Graduate or undergraduate students are not normally acceptable experts; consult your TA in advance to make sure your planned expert meeting makes sense.
   c. You will verify in writing during your last weekly progress report to your TA of the month (indicated as "WPR+" on the schedule) who you met with, when, and what you learned as a result. Because the

WPR+ is on the last Tuesday of each month, you need to complete your instructor & expert meetings prior to this to be able to document them in your WPR. Plan ahead!

10. Milestone Demos:
    a. The demonstrations will all take place in a lecture style classroom, between your group, the instructor, and the TAs. A digital projector with VGA cable will be provided, but the structure (including whether you use the projector) is open ended. You will be evaluated on how well you *demonstrate* the EPS of your device (see below). A live demonstration of your device's functionality is required but you can supplement the demonstration with videos or PowerPoint. Videos of your device working may be able to count for up to 50% of a live demo of that functionality, at the instructor's discretion. The time limit for the demonstrations is 10 minutes. A schedule will be distributed in advance via ATL.
    b. While during most of the year your main goal is to achieve your promised level of performance, your goal during the demos is to make a clear argument for what your performance mark should be at that time. This involves, with reference to your WPS:
        i. Reminding what your *objectives* were overall and for this milestone,
        ii. *Demonstrating* which of these you've achieved, and
        iii. Presenting a *performance mark* based on this.
    c. You should only have about 3 slides for the presentation.
    d. Remember that the focus of the demo is to make a case for specifically what performance mark you should receive (with reference to your WPS). You're not there to re-explain what your project is or re-pitch why it's useful.
11. Your group must present a demonstration of your project for the Eng Phys Capstone Expo at the end of the term, to be attended by faculty, undergrad & grad students, and invited industry / community members. The department will buy breakfast and lunch for your group. The location will be the MUSC Marketplace. You must make a poster or other media to help demonstrate the EPS of your device, and you must include a live working demonstration of your device achieving its function. You are encouraged to invite family and friends. The Capstone Expo includes a People's Choice Award which will factor into your grade. Let your TA know at least 1 week in advance if you will need assistance moving your project to the marketplace or other concerns you have and we will attempt to accommodate.
12. Your group must submit a Final Report of your project at the end of the term which explains what your project does and how it does it, as well as a Video commercial for your device, and a Self Evaluation of your achievements within the group. Video commercials are expected to be posted on YouTube. You should also submit your final report and video early to see what mark they would receive so you can correct errors and get a better final mark. See the Course Schedule for details.
13. Your individual mark may be lower than your group's mark on any evaluation component if your contribution is deemed unsatisfactory at the discretion of the evaluator(s).

PROJECT OPTIONS

1. You may seek external funding for your project via Kickstarter or equivalent. A successful funding campaign will positively influence your societal impact score (specifically, the "Appeal" subcomponent).
2. You may seek patenting or otherwise commercializing your project subject to the university's Joint IP Policy, http://milo.mcmaster.ca/policies/joint_ip_policy. Doing so will positively influence your societal impact score.
3. You may choose a project which aims to win a robotics or similar competition of appropriate level (as long as what you design & build to enter into the competition satisfies all of the regular course requirements). If your group successfully demonstrates a project which could win the competition, in addition to positively influencing your societal impact and engineering challenge scores, the Eng Phys department will at its discretion provide partial or full necessary funding for your group to represent us in the competition. Your group members will keep any prize money you earn as a result. Competitions you may want to consider include (but aren't limited to):
    a. McMaster The Forge and its Student Startup Competition (previously "McMaster Spectrum"): https://theforge.mcmaster.ca/student-startup-competition/
        i. Applications for the student startup one will open in January and the process continues into March and April.

ii. In addition, The Forge is a startup incubator which provides advice and facilities ideal for continuing to bring your 4A06 project to market after the course is complete.

b. Innovation Nation Robotics Competition: http://innovation-nation.ca/robotics-competition
c. AUVSI Foundation Competitions
d. IEEE Micromouse competitions
e. Lion's Lair: http://lionslair.ca/
f. Falling Walls: http://graduate.mcmaster.ca/graduate-students/graduate-student-life/professional/falling-walls-lab
g. OEC http://www.oec2015.ca/ (& CEC http://2015cec.ca/en/about)
h. Python's Pit: http://pythonspit.ca/the-contest/

4. In the past, 4A06 projects needed to have feedback control implemented on a microcontroller. This is no longer strictly the case: in the interest of promoting more photonics / nuclear options in addition to microelectronics, you may select "Eng Phys" projects of appropriate engineering challenge which don't strictly satisfy this requirement.

Content and Format of the Final Report

Report is worth 10% of final mark, video is worth 5%.

Report Sections and associated marks:

1. Title page with link to YouTube (or equivalent) for the commercial for the product that you produced. The commercial should be a 2-5 minute video introducing the product, showing what it does & why society would want it, briefly showcasing the engineering work your group personally did to achieve it, and demonstrating its performance.
2. Acknowledgement
3. Table of contents
4. Introduction, including:
   (i) statement of the problem your device solves, limitations of existing solutions, and motivation for a new one; 10
   (ii) brief overview of solution and brief description of the solution – what it is supposed to do; including how your solution meets objectives (things that you want to optimize) and constraints (things that must be present for the device to solve the problem); 10
5. Design:

For the following sections on: design for manufacturability; design for repair; design for reliability; design for safe fail; design for life cycle define each term using citations from two different authorities: state how these features were incorporated by design from inception by **no more than three specific examples**. Refer to the drawings, schematics, and/or data that are included in the final report to substantiate the claims.

(i) design for manufacturability 5
(ii) design for repair 5
(iii) design for reliability 5
(iv) design for safe fail 5
(v) design for life cycle 5

Note: Design sections should include Mathematical Modelling to describe the physics of your project, especially related to your control system. 25

6. Manufacture and assembly instructions – refer to mechanical drawings, schematic diagrams, exploded views, and/or photographs; assume that people know how to read engineering drawings; describe in detail only the non-standard operations 10
   (i) Refer to Appendix with: Bill of Materials (at reproducible prices from reputable retailers) 5
   (ii) Refer to Appendix with: Proper mechanical drawings done using a CAD software package (proper mechanical drawings for all parts that must be fabricated plus schematic and/or exploded views and/or photographs for assembly) 5

(iii) Refer to Appendix with: Proper schematic diagrams of circuits done using a software package; all circuits must be on a PCB and analyzed using MultiSim or equivalent; include waveforms from analysis at test points; include copies of PCB mask/board with location of components 5

7. Operating instructions including a check list for operation 10
8. Environmental/health/safety/code considerations 5
9. Précis of relevant information from MSDS for all materials and processes; include full MSDS in a compressed folder 5
10. Performance and Testing 25
    (i) Determine and substantiate your device's performance.
    (ii) Refer to Technical specifications and features datasheet Appendix
11. Conclusion and suggestions for improvements 10
12. Bibliography
13. Appendix A: Technical specifications and features datasheet: A table to give relevant dimensions, and performance measures, such as degree of meeting your objectives and constraints i.e.,
    (i) overall cost,
    (ii) power consumption,
    (iii) battery specifications,
    (iv) mass,
    (v) etc.
14. Appendices with commented code and other relevant information

In addition to the section marks, there are some mark categories for no section in particular:

1. Presentation and Formatting: 10
2. Overall Impression of the report and how well the project was done: 25

The final report & commercial video will constitute 15% of the grade. Only one report is required per group. Reports should be submitted via email in pdf format to your TA.

CONTENT OF THE WRITTEN PROJECT STATEMENT

Your group's written project statement must include:

1. A description of your Bronze, Silver, and Gold Milestone objectives.
2. What each group member's individual area of responsibility will be
3. Explanations of how you will be able to demonstrate your individual deliverable sections for each milestone in the event that your teammates all fail to deliver on theirs
4. What you are going to design & build, how you're going to do it, the purpose of your device, and your projected budget for the project.
5. Performance mark breakdown for each of the demos (the Capstone Expo has the same expectation as the Gold Demo, so doesn't need to be listed separately); i.e., what percent you expect on your performance mark for demonstrating various parts of your project at that time.

Remember that the level of detail expected for the project statement is higher than in the pitch presentations. To accurately express this detail, you should probably have these additional suggested sections:

1. Components Spreadsheet
    a. Break down by sections / modules of your project
    b. Include the cost of each part (if applicable) and the source
    c. Include algorithms or code you're using in relevant sections as well
2. Flowcharts for operation
    a. Define bulletproofing: what should happen if the inputs are incorrect. (see below for examples)
3. Sketches

   a. Can be rough sketches, just to give us an idea of the specifics. You'll want good ones for your marketing material later.
   b. Include dimensions and materials for components
4. Specifications
   a. How big, how fast, how heavy, what power, etc.

Bulletproof your designs as part of the specifications and flowcharts. That is, define how you'd like the device to behave in non-ideal input scenarios (i.e., what happens if you back the Golden Snitch into a wall? What happens if you tell the Robocopdroneter to follow a heat signature and that heat signature turned out to be two people that split apart? What happens if you give VIRGIL back a different tool than you told him? What happens if the Cavecopmapter comes up to a 3-way passage split, one of which is vertical, and what kind of gems can it detect? What happens if the batteries die or get disconnected mid-operation?)

Your components and solutions aren't being set in stone here, these are projections. Feel free to list backup components if you have some in mind at this stage. Nevertheless it's important to have things as sketched out as possible so it's clear what your plan is.

Work with your TA while developing your WPS. While it isn't explicitly worth marks itself, having a very clear WPS will make your life much easier for the rest of the course, especially when you refer to it during the Bronze, Silver, and Gold Milestone Demos to determine your performance score.

ASSESSMENT

Component	Weight (%)
Practice Pitch Presentations	2% (1% each * 2)
Weekly Progress Reports	8% (0.5% each * 16)
Project Pitch Day	5%
Instructor Meetings	4% (0.5% each * 8)
Expert Meetings	1% (0.5% each * 2)
Bronze Milestone Demo	10%
Silver Milestone Demo	15%
Gold Milestone Demo	20%
Final Report & Video	15%
Capstone Expo	20%
Total	100%

All work must be prepared with a word processor; scanned or photographed hand-written work is not accepted. However, diagrams and/or drawings may be hand-drawn (neatly) and pasted into the report.

EPS EVALUATION

Your marks for the Practice Pitch Presentations, Project Pitch Day, milestone demos, and expo (together worth 72% of the final mark, with the remainder being the weekly progress reports (8%) instructor & expert meetings (5%) final report (10%) and video (5%)) are based on the EPS evaluation, which is a geometric average of 3 scores:

EPS: ("Eng Phys Score")

1. **Engineering challenge** of achieving your group's target for the device
2. **Performance** of the device, regardless of how well you explain it
    a. Practice Pitches & Project Pitch Day: Believability of performance metric; how likely it looks like you will actually be able to achieve what you're proposing.
    b. Demos & Expo: Your actual device's performance relative to your proposed performance. Not exactly a direct fraction; refer to your WPS.
3. **Societal Impact** of the device, which is a combination of:
    a. **Appeal** to society of the final product
        i. i.e., how much value would society place on having this device?
    b. **Believability/Achievability** that this project will succeed at its stated objectives: Relevance of presented device to your big picture final objectives
        i. i.e., how likely it looks, based on presented performance, that this device can/will achieve its fundamental purpose
        ii. This is similar to your performance mark, but could be different in a couple of ways, e.g.
            1. If you achieve secondary features you didn't need to but failed to achieve things important to your main goal, your Relevance score will be lower than your Performance score (because they improve your Performance but your Relevance focuses on your main objective).
            2. If your device doesn't perform very well but you focused on the right areas (i.e., your design looks like it will work with some fine tuning rather than being unable to ever work) then your Relevance score will be higher than your Performance score.
            3. If during the bronze milestone demo you present a design which technically achieves your bronze goals, but is not ever going to be part of or steps towards your final project, then your Relevance score will be much lower than your Performance score.
    c. **Clarity** of presentation (how well you explain the device and its performance)
        i. Milestone Demos: The point of the milestone demos is for you to explain what Performance mark you should get and why. The clarity of how well you justify your mark (i.e., how convincing your argument is) is your clarity mark for that demo.
        ii. Practice Pitches, Project Pitch Day, and Capstone Expo: clarity is how clearly you explain your device.

Each criteria is given a score out of 100%, then your mark is calculated as $\sqrt[3]{EPS}$. It is possible to earn a bad mark if one category is lacking, even if your other categories are done very well. To earn a good mark, you'll need to:

1. Pick a project with an appropriate level of engineering challenge,
2. Pick a project that if completed would be useful to society, and do a good job of explaining it, and
3. Achieve your project goals.

Exceptions / clarification to the EPS evaluation:

1. For the Practice Pitch Presentations & Project Pitch Day, your Performance score will instead be an evaluation of how feasible your design is; i.e., how convinced the markers are that you would achieve it.
2. For the Bronze & Silver Milestone Demos, the *E* is based on the final project, the *P* evaluation is based on the milestone itself, and the *S* criteria is based on both the impact of the final project *and* how well this achievement seems like an important step towards it.

3. For the weekly progress reports to your TA, your mark is instead based on whether the TA is satisfied that you have made sufficient progress over the past week based on your weekly letter and group discussion. Your weekly progress marks are individual.
4. The video and report have their own separate marking scheme.
5. The instructor and expert meetings are marked on attendance only, to encourage using these to get technical advice on the project rather than trying to impress.
6. The marks are assessed separately at the time of each evaluation. e.g., if during the Bronze Milestone Evaluation it becomes apparent that your project was actually far easier or more difficult than we thought it was during the Project Pitch Day, your *E* mark at that time will be different than it was earlier.
7. If you exceed your initial performance goals, your performance mark may be larger than 100% at the discretion of the TAs and instructor. This is more likely than your *E* score changing.
8. Not all challenge is Engineering Challenge. E.g.,
    a. Designing a robot to give perfect high-fives to a human when prompted may have the same Engineering Challenge as designing one to give perfect high-fives to a 200 lb tiger because the robot itself might be similar, but the second project has much more non-engineering challenge since you have to take care of and train a tiger for 8 months.
    b. Designing a robot to spray water has similar Engineering Challenge as one designed to spray Coke, but the second project will get all of your equipment sticky and covered with ants.
    c. Designing a quadcopter has a similar amount of Engineering Challenge as designing a comparably difficult robot arm, but is much more challenging because:
        i. If the quadcopter fails mid-operation it breaks itself and you need to build it again
        ii. The quadcopter requires batteries which are inconsistent during development
        iii. The quadcopter is very all-or-nothing rather than modular; it requires all parts to be functioning to work. That is, a quadcopter doesn't work at all until it works nearly perfectly, so it's difficult to show partial progress or to develop in separate modules and then bring them together.

NOVELTY:

Previous 4A06 projects and other prior art are available for you to receive inspiration and technical information from; it's not necessary to reinvent the wheel. However, while prior art can make up parts of your project, this will only help your evaluation if it enables a *new* device that wouldn't have been possible otherwise. Specifically, novelty is a big part of both engineering challenge (it's not nearly as hard to do something that's been done before) and societal impact (novel inventions have much more impact potential). If your project appears to be a clone of another group's (or an existing device), we will determine who had the idea first and penalize the idea stealer (with lowered marks or lawsuits, as appropriate.)

ON THE USE OF A PRINTED CIRCUIT BOARD (PCB):

Using a PCB rather than a breadboard or protoboard requires additional engineering challenge, and certainly makes for a more marketable device, other things equal. In addition, there is less chance of something going wrong during a demonstration day if you're not moving wires around. So, while prototyping kits (e.g., MSP430 Launchpad, Arduino) and breadboards are useful for the development, it's expected that your circuit will be entirely on PCBs by the Gold Milestone. Failing to do so will negatively impact your *M* and *P* scores, other things equal.

FINAL REPORT MARKING RUBRICS:

(See also the Content and Format of the Final Report section)

Level	1	2	3	4	
Section	**Fails to Meet Expectations (0-49%)**	**Below Expectations (50-59%)**	**Meets Expectations (60-79%)**	**Exceeds Expectations (80-100%)**	**Marks**
Intro: Problem Identification	Significant ambiguity in the problem or specifications	Some ambiguity in the project or specifications	Problem is clearly stated, specs adequately presented	Problem is clearly stated including all specifications and the solution is motivated very well	10
Intro: Solution Description	Unclear solution	Some ambiguity in the solution description	Solution clearly explained	Solution clearly explained including correct diagrams including tolerances, materials, and units where applicable	10
Design: Mathematical Modelling	Mathematical model only partially developed or lacking, little to no analysis with modern engineering tools, model stability not addressed	Slight errors or ambiguity in mathematical model, somewhat lacking stability analysis	Mathematical modelling completed with little to no errors, used at least one modern design tool, made some study robustness of model	Very clear and precise mathematical and physical modelling, used multiple simulation tools and adequately explored robustness of model resulting from them	25
"Design for" Sections	Minimal design process or justification	very few alternate designs considered, designs not explored fully, little software optimization	Some alternate designs critically considered, software partially optimized	Multiple designs critically considered, explored, and justified for all significant design choices, including software design choices and optimizations	25 total (5x5)
Manufacture / Assembly Instructions	Unclear assembly instructions	Somewhat ambiguous assembly instructions	Moderately clear assembly instructions	Very clear assembly instructions including pictures	10
Bill of Materials	Many parts missing or incorrectly sourced	Several parts missing or incorrectly sourced	Lists almost all materials correctly, but some inconsistent or suspect listings	Clearly lists all materials in accessible format, with reasonable vendors at correct quantities	5
Mechanical Drawings	Major errors or omissions in drawings	Drawings have several ambiguities or are insufficient for manufactured parts	Drawings correct with minor ambiguities	Drawings correctly dimensioned, materials listed, easy to use to reproduce device	5
Circuit Schematics	Major errors or omissions in schematics or testing	Several errors or omissions in testing or schematics	Schematics & testing complete with minor ambiguities	Complete schematics in accessible format along with testing for complete electrical picture of project	5
Operating Instructions	Unclear instructions	Somewhat ambiguous instructions	Mostly clear instructions	Very clear instructions	10
EHS Code Considerations	Absence of important relevant codes	Some missing codes or lack of relating it	Acceptable consideration of all	Insightful consideration of all relevant codes	5

		to your designs	relevant codes	and proof of design with them in mind	
MSDS Précis	Key MSDSs missing or clearly misunderstood	Several MSDSs missing for parts of project, or improperly summarized	Nearly complete MSDS material summary	Key summary of all important MSDS information relevant to someone manufacturing and using your device	5
Performance and Testing	Many unjustified claims	Some claims unjustified, error analysis lacking, partially unclear explanation of whether performance goals were reached	Most claims justified with data, decent error analysis, clear explanation of performance reached	All claims justified with data, statements quantified, error analysis clear, clear explanation of performance reached	25
Conclusion	Very confusing conclusion with very weak future work proposals	Some confusion in conclusion, lacking future ideas	Clearly describes the project's success and wraps up report, ideas for improvements proposed	Inspiring wrap up that clearly describes the project's success, and proposes justified ideas for improvement	10
Presentation and Formatting	Significant errors in spelling or formatting, sections missing	Moderate errors in spelling or formatting	Some errors in spelling and formatting	Beautifully formatted, very few errors	10
Overall Impression	Unsatisfactory design and report	Marginally successful design and report	Adequate report and design carried out	Very impressive and robust solution, impressive report and design carried out	25
				Total	**185**

Video Marking Rubric

The video is evaluated on a single open-ended rubric: Overall Impression. The videos available on the Eng Phys website from 2016 were all excellently done to give some ideas of various ways you could approach it: http://engphys.mcmaster.ca/undergrad-studies/project-gallery/201516-ep-4a06-capstone-project-gallery/

Group & Self Assessment

At the time of your final report, you should also submit a group & self assessment. You can report on your contributions and those of other group members. The assessment should be no more than 2 pages long.

You may present comments on the course; comments on your own performance and that of your group members. Any criticisms of other group members must be supported by reference to weekly progress reports or previous meetings with TAs or instructors.

Together with observations made by the instructor or TAs, the group assessment documents will be used to gauge if an individual's grade should be modified due to lack of effort or for any other reason.

ANY CONCERNS REGARDING THE COURSE, YOUR GROUP MEMBERS OR PROGRESS MUST BE RAISED AT THE EARLIEST OPPORTUNITY.

COURSE SCHEDULE

Date	Topic / Deliverable	Location	Marks	Total
Tue 6 Sep 2016	**Intro Lecture**	**BSB/108**		0.0%
	Instructor Meeting		0.5%	0.5%
Tue 13 Sep 2016	Practice Pitch Presentation	**BSB/104**	1.0%	1.5%
	Instructor Meeting		0.5%	2%
Tue 20 Sep 2016	Practice Pitch Presentation 2	**BSB/104**	1.0%	3.0%
	Instructor Meeting		0.5%	3.5%
Tue 27 Sep 2016	**Project Pitch Day**	**BSB/104**	**5.0%**	8.5%
Tue 4 Oct 2016	**WPS Due**	**BSB/B101**	**0%**[1]	8.5%
Tue 11 Oct 2016	*Mid-term recess*			8.5%
Tue 18 Oct 2016	WPR	BSB/B101	0.5%	9.0%
Tue 25 Oct 2016	WPR+	BSB/B101	1.5%	10.5%
Tue 1 Nov 2016	WPR	BSB/B101	0.5%	11.0%
Tue 8 Nov 2016	WPR	BSB/B101	0.5%	11.5%
Tue 15 Nov 2016	WPR	BSB/B101	0.5%	12.0%
Tue 22 Nov 2016	**Bronze Demo**	**BSB/104**	**10%**	**22.0%**
Tue 29 Nov 2016	WPR+	BSB/B101	1.5%	23.5%
Tue 6 Dec 2016	End of Term WPR	BSB/B101	0.5%	24.0%
9 Dec 2016 - 4 Jan 2017	*First-term Exams and Recess*			
Tue 10 Jan 2017	Start of Term WPR	BSB/B101	0.5%	24.5%
Tue 17 Jan 2017	WPR	BSB/B101	0.5%	25.0%
Tue 24 Jan 2017	**Silver Demo**	**BSB/B155**	**15%**	**40.0%**
Tue 31 Jan 2017	WPR+	BSB/B101	1%	41.0%
Tue 7 Feb 2017	WPR	BSB/B101	0.5%	41.5%
Tue 14 Feb 2017	WPR	BSB/B101	0.5%	42.0%
Tue 21 Feb 2017	*Mid-term recess*			42.0%
Tue 28 Feb 2017	WPR+	BSB/B101	1%	43.0%
Tue 7 Mar 2017	WPR	BSB/B101	0.5%	43.5%
Tue 14 Mar 2017	WPR	BSB/B101	0.5%	44.0%
Tue 21 Mar 2017	**Gold Demo**	**BSB/B155**	**20%**	64.0%
Tue 28 Mar 2017	WPR+, Report & Video Due for advance marking	BSB/B101	1%	65.0%
Tue 4 Apr 2017	Report & Video Advance Marks Discussion with your TA	BSB/B101	0%	65.0%
Thu 6 Apr 2017	**Capstone Expo**	**MUSC Marketplace**	**20%**	85.0%
Tue 11 Apr 2017	**Report & Video Due**	**online**	**15%**	100%

WPR = Weekly Progress Report.

WPR+ = Weekly Progress Report + documentation from the month's Instructor/Expert Meetings.

The End & Start of Term WPRs should include a plan of action and recap, respectively, for the entire break as well.

[1] While not directly worth marks itself, the Written Project Statement has a large impact on your evaluation for the rest of the course, and failing to submit an acceptable Written Project Statement on time carries an increasingly severe penalty with each week it is late.

MATERIALS AND FEES

REQUIRED TEXTS:

- This Course Outline describes in detail the requirements for the course.
- Supporting technical information is available on Avenue to Learn.
- For refreshing their knowledge on the engineering design process, students could read chapters 3, 7, 11 and 12 of http://itll.colorado.edu/courses_workshops/geen_1400/resources/textbook/ ;
- For engineering ethics: http://www.peo.on.ca/index.php?ci_id=1815&la_id=1 .

Other Materials:

Lab equipment and consumables (limited amount provided).

FACILITIES

In the 4A06 project room there are oscilloscopes, power supplies, signal generators, soldering irons, a wifi connection, and a number of other useful tools and facilities. People working on Eng Phys 4A06 have priority, and no one who isn't in or responsible for 4A06 should be in the room without being accompanied by someone who is. See the Safety Quiz section for more details.

Each group will be signed out a toolkit with a number of useful hand tools. The toolkits need to be returned at the end of the course in working condition; you're responsible for the costs of any tools that need replacing due to loss or perceived misuse, but regular wear and tear over the course of 4A06 is expected.

You're expected to clean up after yourself, and when in doubt to clean up for others as well to keep the room in presentable fashion. If necessary, a room cleaning schedule will be posted.

If replaceable supplies (e.g., shrink wrap, soap, paper towels, wire, etc.) in the 4A06 room have run out or nearly run out, email your TA and/or Chris to notify us to obtain more.

FUNDING

$150/team is available to reimburse project costs. Please submit the reimbursement form (available on ATL) along with receipts. In addition, the 4A06 room has a number of supplies available that will be of interest to everyone (cost sheet available on ATL). Talk to your TA for information.

ACCREDITATION LEARNING OUTCOMES

The Learning Outcomes defined in this section are measured for Accreditation purposes only, and will not be taken into consideration in determining a student's actual grade in the course.

Outcomes	Indicators
Recognized and followed an engineering design process.	4.1
Recognized and followed engineering design principles including economic design principles. (Social aspects and safety to the public are not covered in this course)	4.2
Proposed solutions to open-ended problems	4.3
Employed appropriate techniques for generation of creative ideas such as brainstorming and structured inventive thinking.	4.4
Included appropriate health and safety considerations	4.5
Integrated standards, codes of practice and legal requirements relevant to the activity.	4.6
Evaluated and selected appropriate modern tools.	5.1
Was able to use modern/state-of-the-art tools.	5.2
Was Able to manage time and processes effectively, prioritizing competing demands to achieve personal and team goals and objectives.	6.1
Developed and implemented processes and methodologies to manage the effectiveness of a team both in terms of the quality of the work produced by the team as well as the inter-personal relationships within the team.	6.2
Worked in a group, took a leadership role as appropriate and relinquished the leadership role as appropriate.	6.3
Demonstrated an ability to respond to technical and nontechnical instructions and questions	7.1
Presented instructions and information clearly and concisely as appropriate to the audience	7.2
Constructed effective oral or written arguments as appropriate to the circumstances	7.3
Assesses possible options and design configurations from a sustainability engineering perspective, which emphasizes environmental stewardship, life-cycle analysis, and long-term decision-making principles.	9.3
Applied economic principles in decision making	11.1
Planned and effectively managed time, resources, and scope	11.2
Triple Bottom Line – Designs and evaluates complex open ended engineering systems using a triple bottom line of sustainability dimensions: social, economic and environmental. Shows an awareness of the wide range of engineering societies, literature, conferences, and other information sources.	13.1

ACADEMIC INTEGRITY

You are expected to exhibit honesty and use ethical behaviour in all aspects of the learning process. Academic credentials you earn are rooted in principles of honesty and academic integrity.

Academic dishonesty is to knowingly act or fail to act in a way that results or could result in unearned academic credit or advantage. This behaviour can result in serious consequences, e.g. the grade of zero on an assignment, loss of credit with a notation on the transcript (notation reads: "Grade of F assigned for academic dishonesty"), and/or suspension or expulsion from the university.

It is your responsibility to understand what constitutes academic dishonesty. For information on the various types of academic dishonesty please refer to the Academic Integrity Policy, located at http://www.mcmaster.ca/academicintegrity.

The following illustrates only three forms of academic dishonesty:

1. Plagiarism, e.g. the submission of work that is not one's own or for which other credit has been obtained.
2. Improper collaboration in group work.
3. Copying or using unauthorized aids in tests and examinations.

ACADEMIC ACCOMMODATIONS

Students who require academic accommodation must contact Student accessibility Services (SAS) to make arrangements with a Program Coordinator. Academic accommodations must be arranged for each term of study. Student Accessibility Services can be contact by phone at 905.525.9140 ext. 28652 or e-mail at sas@mcmaster.ca.

For further information, consult McMaster University's Policy for Academic Accommodation of Students with Disabilities.

NOTIFICATION OF STUDENT ABSENCES AND SUBMISSION OF REQUEST FOR RELIEF FOR MISSED ACADEMIC WORK

1. The McMaster Student Absence Form is a self-reporting tool for Undergraduate Students to report absences DUE TO MINOR MEDICAL SITUATIONS that last up to 3 days and provides the ability to request accommodation for any missed academic work. Please note this tool cannot be used during any final examination period.
2. You may submit a maximum of 1 Academic Work Missed request per term. It is YOUR responsibility to follow up with your Instructor immediately (NORMALLY WITHIN TWO WORKING DAYS) regarding the nature of the accommodation. Relief for missed academic work is not guaranteed.
3. If you are absent for reasons other than medical reasons, for more than 3 days, or exceed 1 request per term you MUST visit the Associate Dean's Office (JHE/A214). You may be required to provide supporting documentation.
4. This form must be submitted during the period of absence or the following day, and is only valid for academic work missed during this period of absence.
5. It is the prerogative of the instructor of the course to determine the appropriate relief for missed term work in his/her course.
6. You should expect to have academic commitments Monday through Saturday but not on Sunday or statutory holidays. If you require an accommodation to meet a religious obligation or to celebrate an important religious holiday, you may submit the Academic Accommodation for Religious, Indigenous and Spiritual Observances (RISO) Form to the Associate Dean's Office. You can find all paperwork needed here: http://www.eng.mcmaster.ca/current/documents.html

NOTICE REGARDING POSSIBLE COURSE MODIFICATION

The instructor and university reserve the right to modify elements of the course during the term. The university may change the dates and deadlines for any or all courses in extreme circumstances. If either type of modification becomes necessary, reasonable notice and communication with the students will be given with explanation and the opportunity to comment on changes. It is the responsibility of the student to check their McMaster email and course websites weekly during the term and to note any changes.

ON-LINE STATEMENT FOR COURSE REQUIRING ONLINE ACCESS OR WORK

In this course, we will be using Avenue to Learn. Students should be aware that, when they access the electronic components of this course, private information such as first and last names, user names for the McMaster e-mail

accounts, and program affiliation may become apparent to all other students in the same course. The available information is dependent on the technology used. Continuation in this course will be deemed consent to this disclosure. If you have any questions or concerns about such disclosure, please discuss this with the course instructor.

REFERENCE TO RESEARCH ETHICS

The two principles underlying integrity in research in a university setting are these: a researcher must be honest in proposing, seeking support for, conducting, and reporting research; a researcher must respect the rights of others in these activities. Any departure from these principles will diminish the integrity of the research enterprise. This policy applies to all those conducting research at or under the aegis of McMaster University. It is incumbent upon all members of the university community to practice and to promote ethical behaviour. To see the Policy on Research Ethics at McMaster University, please go to
http://www.mcmaster.ca/policy/faculty/Conduct/ResearchEthicsPolicy.pdf.

ATMOSPHERE

The Faculty of Engineering is concerned with ensuring an environment that is free of all adverse discrimination. If there is a problem that cannot be resolved by discussion among the persons concerned, individuals are reminded that they should contact their Department Chair, the Sexual Harassment Officer or the Human Rights Consultant, as soon as possible.

MACHINE SHOP

We have permission to use, under supervision, a subset of the equipment in the Engineering and Science Machine Shop in JHE-115. The lead hand of the Engineering and Science Machine Shop, Mr. Clealand Berwick, will instruct you on using the subset of equipment in the shop and will provide advice. Mr Berwick will be at the second course meeting. You must obey the safety rules, some of which are: wear safety glasses at all times; tie back loose hair, clothing, and jewellery; wear proper footwear – no open shoes or sandals; no bare legs; the shop supervisors have final authority over access to tools and equipment; and, all injuries and near misses are to be reported immediately to the shop supervisor. Suggestion: take a CAD drawing with you to the shop; this will reduce the time it takes to get started (dimensions should be in imperial measurement –i.e. inches and feet). You must attend a machine shop orientation session in the machine shop before you are permitted to use the facilities of the machine shop. Mr Berwick can provide information on registration. Register in the machine shop for the orientation sessions. The machine shop hours are 8:30 am to 12:00 noon and 1:00 pm to 4:00 pm, with breaks at 10:00 am and 2:30 pm. You are not permitted to use power tools during the breaks.

4A06-SPECIFIC SAFETY INFORMATION

LSH: A Laboratory Safety Handbook (LSH) and other safety information and links can be accessed at www.mcmaster.ca/CEDTsafety/ Databases of safety information can be accessed from a McMaster computer at http://ccinfoweb.ccohs.ca At this site, MSDS (material safety data sheets), Cheminfo, RTECS (registry of toxic effects of chemical substances), and bibliographic information are available.

Safety Quiz: Prior to accessing the 4A06 project room, you are required to watch the two safety videos and submit your safety quiz via the online drop box. You can do this at any time, but will not be granted access to the room until you do, so an effective deadline is the end of September.

Access: You may work in the 4A06 project room 24-7, but you must never work in the project room alone. Note that your keycards will not work overnight or on days where the university is closed (stat holidays and the 10 or so days between 25 Dec and 1 Jan, see Sessional Dates on the McMaster Website for details), and that propping the door open will sound an alarm that security will respond to, likely kicking everyone out.

Food: Eating and drinking in the 4A06 room is only permitted in the central area, and only away from hazardous materials. Remember to wash your hands before and after eating or touching your face!

Safety Reports: Safety reports must be filed (in your weekly letter duotang) for materials and processes prior to first use! This includes but is not restricted to: lamps, LEDs, lasers, high-speed mechanical components, epoxy, glue, metal, composites, plastics, lubricants, solder, and soldering. To file a safety report is to include the report with your weekly progress demonstration to your TA. The safety report is to be a précis (i.e., a concise summary written in your words) of the relevant health and safety information (i.e., what are the risks, and what precautions do you need to take). Appropriate safety precautions and adherence to all regulations, codes, and practices must occur at all times. The safety reports are required for all materials worked with. You must cite where you obtained the information. Ask your TA whether something warrants a safety report. If asking your TA is not possible, assume it does.

Breakers: Note that the electrical breakers for BSB/B101 are located in BSB/B102, so students that trip breakers should notify Chris immediately.

Cameras: The 4A06 room is subject to video surveillance, but the video feed is not watched until after the fact where necessary. In the event of an emergency, call security (88 or 905-522-4135) rather than waving your arms at the cameras.

ADDITIONAL LAB SAFETY INFORMATION

INTRODUCTION

This document describes the application of McMaster's Workplace Environmental Health and Safety Policy to the particular situation of undergraduate labs in the Engineering Physics Department. The policy is written for students, but applies to all people involved in the labs.
McMaster's Workplace Environmental Health and Safety Policy is reviewed by the Central Joint Health and Safety Committee each year as well as signed by our University President.
The policy applies to students, visitors and volunteers.
The policy is available at http://www.workingatmcmaster.ca/eohss/prevention/policy/

CHAIN OF REPORTING FOR SAFETY TRAINING AND RESPONSIBILITY

You will be provided with a health and safety lecture at the beginning of the first lab. **You are responsible for ensuring that you understand this safety information.** The lab technician is responsible for ensuring that all equipment is in good working order. In the event of an emergency, notify your Teaching Assistant (TA) and the lab technician. They are responsible for calling medical aid if needed.
You must report any hazardous situation of concern to one level up according to the chart below. In case this person is not available, either contact the person delegated in their absence or the person positioned at the next level up. **You are expected to know this chain of reporting.**

DEPARTMENT CHAIR

Ray LaPierre (X 27764)

↑

INSTRUCTOR

Matt Minnick (X 23132, minnick@mcmaster.ca)

↑

LAB TECHNICIAN

Chris Mitchelitis (X 22657) or Peter Jonasson (X 24935)

↑

TA

Austin Brown	**Garik Patterson**	**Kevin Boyd**
browna42@mcmaster.ca	pattergg@mcmaster.ca	boydkm@mcmaster.ca

↑

STUDENT (YOU)

FIGURE 1. CHAIN OF COMMAND FOR HAZARD REPORTING.

PROPER LAB BEHAVIOUR

Everyone in the lab is responsible for their own safety as well as the safety of others.

GENERAL GUIDELINES

1. Conduct yourself in a **responsible** manner at all times in the laboratory.
2. Follow all written and verbal instructions carefully. If you do not understand a direction or part of a procedure, **ASK YOUR TA or LAB TECHNICIAN BEFORE PROCEEDING WITH THE ACTIVITY.**
3. **Never work alone** in the laboratory.
4. Perform only those experiments indicated by the lab manual or your TA/lab technician. Carefully **follow all instructions**, both written and oral. Unauthorized experiments are not allowed.
5. **Do not eat** food or drink beverages outside of the designated area in the laboratory. Do not use laboratory glassware as containers for food or beverages.
6. **Be prepared** for your work in the laboratory. Read all procedures thoroughly before entering the laboratory. Never fool around in the laboratory. Horseplay, practical jokes, and pranks are dangerous and prohibited.
7. Observe good housekeeping practices. Work areas should be kept **clean and tidy** at all times. Keep backpacks and overcoats out of traffic areas.
8. **Be alert** and proceed with caution at all times in the laboratory. Notify the TA or lab technician immediately of any unsafe conditions you observe.
9. Labels and equipment instructions must be read carefully. Set up and **use the equipment as directed** by your lab manual.
10. Experiments must be personally monitored at all times. Do not wander around the room, distract other students, startle other students or interfere with the laboratory experiments of others.
11. **Dress properly** during a laboratory activity. Long hair, dangling jewelry, and loose or baggy clothing are a hazard in the laboratory. Long hair must be tied back, and dangling jewelry and baggy clothing must be secured. **Proper footwear** must be worn, no flip flops, high heels, roller blades, etc..

12. **Report any accident** (spill, breakage, etc.) or injury (cut, burn, etc.) to the TA or lab technician immediately, no matter how trivial it seems.
13. **Cell phones and use of music headphones should be avoided** while working in the lab. They can be distracting and thereby increase the potential for an accident to occur.
14. Do not store food and drinks in refrigerators that are for lab supplies and vice versa (The refrigerator in BSB/B101 is ONLY for food & drinks)
15. For specific safety guidelines (e.g., electrical, chemical, etc.), consult your lab manual and McMaster's lab safety handbook: http://www.workingatmcmaster.ca/med/document/Lab-Safety-Handbook-1-36.pdf

PROCEDURE TO FOLLOW IN THE CASE OF AN ACCIDENT

Know the locations and operating procedures of all safety equipment including: first aid kit(s), and fire extinguisher. Know where the fire alarm and the exits are located.

Know what to do if there is a fire drill during a laboratory period; turn off any electrical equipment in the event of a fire drill and leave the building.

In the case of an accident, notify your TA and the lab technician immediately. They will phone the emergency extension **88** in the event of an accident. Remain until medical aid arrives. If the TA or lab technician is unavailable, dial **88** yourself from a campus phone or 905-522-4135 (Security).