Conestoga College

Institute of Technology and Advanced Learning

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0.1	First Draft for 2017-28 (Monzur)	Jan 15, 2018

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ESE Capstone Project Guidelines

1. Introduction

This document provides a set of guidelines for students to use while planning and implementing their Electronic Systems Engineering (ESE) Capstone Project.

Capstone project consists of two 4th year courses:

1. Engineering Project VII (Capstone, Part 1)
2. Engineering Project VIII (Capstone, Part 2)

Capstone project is about design and development of a solution to a complex engineering problem. Students will practice engineering design and development activities including electronic design, software development, project management as well as applications of engineering process that takes safety, environmental and societal impact into consideration.

1.1. Objectives

The objective of the ESE Capstone Project is to prepare students for engineering practice through a major design experience based on the knowledge and skills acquired in earlier program work.

"3.4.4.4 The engineering curriculum must culminate in a significant design experience conducted under the professional responsibility of faculty licensed to practise engineering in Canada, preferably in the jurisdiction in which the institution is located. The significant design experience is based on the knowledge and skills acquired in earlier work and it preferably gives students an involvement in team work and project management."

~ CEAB Accreditation Criteria and Procedure, 2015
https://engineerscanada.ca/sites/default/files/Accreditation_Criteria_Procedures_2015.pdf

The project must be about design and development of a solution to a complex engineering problem.

"In 2012, the CEAB adopted the definition of "complex problem" used in the Washington Accord (WA) exemplar of graduate attributes. A defining characteristic of the engineering profession is the ability to work with complexity and uncertainty given that all real engineering projects are different from one another. Accordingly, the notion of complex engineering problems and the solving of complex problem are central to the definition of certain attributes.
According to the CEAB, a complex engineering problem is defined by the following characteristics:

1. *It must require the application of in-depth knowledge*
2. *It must satisfy at least one of the following additional characteristics:*
   - *involves wide-ranging or conflicting issues*
   - *has no obvious solution such that originality is required*
   - *involves infrequently encountered issues*
   - *is outside accepted standards and codes*
   - *involves diverse stakeholders and needs*
   - *is posed at a high-level with many components or sub-problems "*

~ CEAB Guide to Outcomes-Based Criteria, 2015
https://engineerscanada.ca/sites/default/files/draft_program_visitor_guide_v1.25.pdf

The capstone project incorporates engineering standards and realistic constraints that include most of the following considerations:

- economic
- environmental
- sustainability
- manufacturability
- resource management
- ethical
- health and safety
- social
- achievability
- marketability

A number of CEAB graduate attributes are associated with the capstone project (see Appendix D, which also provides the complete list of CEAB graduate attributes.

1.2. Academic Outcomes

See the course learning outcomes in the course outlines

1.3. Project Outcomes and Skill Development

Project Outcome

Upon successful completion of the capstone project, each team will deliver a fully functional integrated electronic system prototype that consists of significant electronic hardware and software components of the team's own design.

The system must provide a solution to an authentic real-world problem with societal, industrial and/or economic implications.

Skill Development

The capstone project is intended to emulate an industry project in its design and implementation lifecycle. Throughout the project work, students will practice:

- Engineering process of new product development - investigation/research, engineering design, product prototyping, test-plan development, verification & validation tests, and performance analysis.
- Lab safety procedure, safety aspects of an engineering design & product implementation, and assessment of adverse societal/environmental impact.
- Project management, professionalism, work ethics and lifelong learning.
- Communication skills and salesmanship through oral presentation, practical demonstration and technical reports.

2. Project Topic and Team Related Guidelines

Project Topic Related Guidelines

Each project should include both electronic hardware and software design/implementation at an engineering level.

Each project should have an industry sponsor. In case of no sponsor, students should consult with knowledgeable professionals in the field related to their project in order to make sure that their project is professionally meaningful. For example, if one is going to do something for the blind, should consult with a professional association like CNIB (Canadian National Institute for the Blind).

Any research projects that involve human testing must be approved by the College's Research Ethics Board. Depending on the nature of the proposed project, teams may be required to apply for project approval prior to proceeding with any further project work. Approval must be received before any involvement of human subject occurs.

Project Team Related Guidelines

Suggested team size is between two and three members. Single-person projects are not permitted under normal circumstances, and teams larger than three must be approved by faculty team. In that case the team must be divided into two or more distinct sub-groups of two/three members. Each sub-group will be treated like a separate team in most of the time for the purpose of performance evaluation.

All teams are to be reviewed and approved by faculty team. Faculty team has the right to disallow a particular team, and may assign students into teams.

Every team member must be responsible for engineering investigation and design. Workload should be divided more or less equally. A significant portion of evaluation marks will be assigned to individual performance.

3. Project Milestones (Deliverables and Deadlines) and Marks Distribution

The project is divided into two parts:

- Part 1 (Semester 7) focuses on research/investigation and design. It is expected that most of the key investigations and design works/decisions will be completed in this part.
- Part 2 (Semester 8) focuses on final design, implementation, and testing.

Each submission must be in the designated eConestoga drop-box. The deadline for each submission is before 9:00 am on the briefing day, unless specified otherwise.

Part 1 (Semester 7)		Proposal	Project Management	Specification and Planning	Investigation and Design	Presentation and Demonstration
Wk #	**Activity**	**Marks**				
1	• Project Outline - submission	5%				
2	• Proposal - progress review and mentoring					
3	• Proposal - progress review and mentoring					
4	• Proposal – Evaluation (report and Presentation) • Project Management Evaluation	15% 5%	 4%			
5	• Specification and Plan - progress review and mentoring					
6	• Specification and Plan -submission • Project Management Evaluation		 3%	10%		
7	• Investigations and Design - progress review and mentoring					
8	• Investigations and Design - progress review and mentoring					
9	• Investigations and Design -**Assessment 1** • Project Management Evaluation		 4%		15%	
10	• Investigations and Design - progress review and mentoring					
11	• Investigations and Design - progress review and mentoring					
12	• Investigations and Design -**Assessment 2**				25%	
13	• Semester Final - presentation and demo Project Management Evaluation		 4%			10%
14						
	Total	25%	15%	10%	40%	10%

Part 2 (Semester 8)		Specifications and Plan - update	Engineering Design and Test Plan	Prototype Dev. and Testing	Project Management and Professionalism	Presentation and Demonstration	Final Report
Wk #	**Activity**						
1	• Updated Specifications and Plan • Engineering Design and Dev. - progress review and mentoring	5%					
2	• Engineering Design and Dev. - progress review and mentoring						
3	• Engineering Design and Dev. - progress review and mentoring						
4	• Engineering Design and Dev. – **Assessment 1** • Project Management Evaluation		2%	5%	5%		
5	• Engineering Design and Dev. - Progress Review and Mentoring						
6	• Engineering Design and Dev. - Progress Review and Mentoring						
7	• Engineering Design and Dev. – **Assessment 2** • Project Management Evaluation		3%	10%	5%		
8	• Engineering Design and Dev. – Progress Review and Mentoring						
9	• Engineering Design and Dev. – Progress Review and Mentoring • Detail Design and Test Plan Document - **Evaluation**		10%				
10	• Engineering Design and Dev. – Progress Review and Mentoring						
11	• Engineering Design and Dev. – **Assessment 3 (Final)** • Project Management Evaluation			15%	5%		
12	• Final Presentation and Demonstration					15%	
13	• Final Report • Oral Review and online survey (no marks)						20%
14	• Tech Showcase (nominated team only) (no marks)						
	Total	**5%**	**15%**	**30%**	**15%**	**15%**	**20%**

4. Evaluation

Evaluation items and marks distribution are presented in the previous section (Section 4). This document also provides template/guideline/format, as appropriate, for each evaluation item. Each evaluation will be done using specific evaluation rubric.

- The grade for **Engineering Project VII** is **Pass/Fail** grade. The evaluation scheme will produce a numerical grade first, and then decide pass/fail. Passing score is 60%. The grade for **Engineering Project VIII** is **standard numerical grade**.
- Each part of a capstone project (semester 7 and 8) includes a **safety evaluation**. This evaluation is **Pass/Fail**, and student must pass before allowed access to lab equipment for any courses taken in either semester. Passing score is 60% or more. Faculty team will specify separately how this will be evaluated.
- Students' progress will be reviewed in weekly basis as indicated section 4. If the faculty team determines that a team or team member is significantly underperforming, the faculty team may assign a faculty member for special mentoring.
- A significant portion of evaluation marks will be assigned to individual performance. It is expected that all team members will contribute equally to the success of their project. If faculty team determines that a team member is not doing his/her fair share of work, or is significantly underperforming, faculty has the right to readjust that member's team marks to reflect lower achievement and work level.

5. Project Deliverables Description – Part 1 (Semester 7)

Each student shall use industry standard techniques and best practices for all design, fabrication, and testing. An engineering log book shall be used to document all work including the investigation, design, development, and testing of all systems and subsystems. Project management tools will be used to control the project.

The capstone project is intended to emulate an industry project in its design and implementation lifecycle. Therefore, reports and documentation will be kept to a minimum with the onus on quality and progress. Any documents described in this section must be submitted using the standard ESE format specified in Appendix A. The evaluation rubrics for the project deliverables are available in a separate document. The evaluation rubrics for the project deliverables are available in a separate document.

5.1. Project Proposal

Associated Key Grad Attributes:

- Design (description of a complex engineering problem, outline of proposed solution and requirements)
- Investigation (literature review)
- Impact of Engineering on society and environment
- Communications skills (proposal documentation)

Project Deliverables: Project idea, outline and full proposal document (see detail below)

This is the first phase of your capstone project. You will describe your project and make a case for it in this phase. This phase has three sub-phases:

- **Project Idea**: this sub-phase occurs prior to the official beginning of the capstone project (semester 7 in winter). Indeed, talk about capstone project starts in your semester 6 (spring/summer). In the following semester when you will be off campus for co-op, you are expected to brain storm with potential team members to develop a project idea. You are encouraged to share your idea with any ESE faculty members, and also find an industry sponsor in this sub-phase.

  You will submit your project idea in accordance with the guideline and template (available in **Appendix B.1a)** to the designated professor. This professor will be the contact person for you in this phase

  Faculty team will review your idea and return their feedback through the designated professor as quickly as possible.

- **Project Outline**:

  Project outline is refined and extended form of the project idea. You will write your project outline in accordance with the guideline and template available in **Appendix B.1b**.

- **Project Proposal**:

  Project proposal is the most comprehensive and final presentable document in the proposal phase of your project.

  You will write your project proposal in accordance with the guideline and template available in **Appendix B.1c**. The project proposal must be submitted to the faculty team for approval. The faculty team will assess the feasibility of the proposed project with respect to technical difficulty and complexity, available expertise and resources, cost, etc. Faculty team may ask you to revise your proposal. Once the final approval is received, any significant changes to the project, its group and/or its scope must be re-submitted for approval.

Evaluation: There is no mark associated with the Project Idea sub-phase. See section 4 for the deadlines and associated marks for Project Outline and Project Proposal sub-phases. The evaluation rubrics for these two deliverables are given as a separate document.

5.2. Specifications and Plan

Associated Key Grad Attributes:

- Design (design specifications)
- Project Management (project plan, and risk analysis & management plan)
- Communications skills (documentation)

Project Deliverables:

- Engineering design specification
- Project plan including work breakdown, resource allocation, risk assessment & risk management plan, and schedules such as Gantt-chart

The template for this deliverable is available in **Appendix B.2**.

Evaluation: See section 4 for the submission deadline and associated mark for this deliverable. The faculty team will evaluate your achievement based on the written document as well debriefing. The evaluation rubric for this deliverable is given as a separate document.

5.3. Engineering Investigation and Design

Associated Key Grad Attributes:

- Problem Analysis (problem analysis and formulation of solution, procedure and/or method)
- Investigation (research and experimentation)
- Design (hardware/software)
- Life-long Learning (identifying learning needs and acquiring the skills/knowledge)
- Engineering Tools

Project Outcomes: Appropriately documented results of investigation (research, experiment and simulation, for example) and engineering design. There is no specific template is suggested for these outcomes at this stage. Refined form of some of the outcomes may be included in design document and/or final report (Capstone, Part 2 in semester 8). For that reason, you may use those templates for you work in this phase.

Evaluation: See section 4 for the evaluation date and associated marks for this deliverable. The faculty team will evaluate your achievement based on the written documents as well as debriefing. There are two evaluations as indicated in section 4. Assessment 1 (mid-term/interim) and Assessment 2 (end-term/final) The valuation will be conducted with an evaluation rubric, which is available as a separate document.

5.4. Project Management and Professionalism

Associated Key Grad Attributes:

- Project Management (status review and change & risk management)
- Professionalism (research and experimentation)
- Ethics and Equity
- Individual and Team Work

Project Deliverable: Status report of the project using the template (given in **Appendix B.4**.) The report must identify and describe any major deviation from the project plan, design specification and/or previous design with justifications/reasons.

Evaluation: See section 4 for the submission deadline and associated marks for this deliverable. It is expected that each team will demonstrate project management skills and professionalism throughout the project duration. Students are to be evaluated a number of times as indicated in section 4 against deadlines and plans, project status (completion and quality), performance as a team player, and professionalism. The evaluation rubric is available as a separate document.

5.5. End-term Presentation and Demonstration

Associated Key Grad Attributes:

- Communications Skill (presentation skill)
- Professionalism

Project Deliverables:

- Oral presentation
- Presentation material such as power-point document
- Demonstration of experimental and simulation work
- A document that describes the demonstration setup and highlights the key items of the demonstration (the purpose of the document is to convey what and how you are going to demonstrate)

Each project team will present and demonstrate all achievements at the end of semester. It is expected that most of the major investigations and key engineering design are completed by this time (*students will be focusing on final design, implementation and testing in the next part of the project in semester 8*). See **Appendix B.5** for further guidelines.

Evaluation: See section 4 for the submission deadline and associated mark for this deliverable. ESE students, non-capstone faculty members and staffs may attend as audience. Representatives of project sponsors and other interested professional and technical people may attend as audience as well.

Two separate evaluation rubrics will be used for evaluating your oral presentation and project demonstration. The rubric is available as a separate document. The capstone faculty team and optionally other ESE faculty members will be the evaluators.

6. Project Deliverables Description – Part 2 (Semester 8)

It is expected that most of the key investigations and design works/decisions have been be completed in part 1 (semester 7), and each team will focus on final design, implementation, and testing in part 2 (semester 8)

Each student shall use industry standard techniques and best practices for all design, fabrication, and testing. An engineering log-book (paper or electronic) shall be used to document all work including the investigation, design, development, and testing of all systems and subsystems. Project management tools will be used to control the project.

The capstone project is intended to emulate an industry project in its design and implementation lifecycle. Therefore, reports and documentation will be kept to a minimum with the onus on quality and progress. Any documents described in this section must be submitted using the standard ESE format specified in Appendix A. The evaluation rubrics for the project deliverables are available in a separate document.

6.1. Updated Design Specifications and Plan

Associated Key Grad Attributes:

- Design (design specifications)
- Project Management (project plan and risk analysis & management plan)
- Communications skills (documentation)

Project Deliverables: Revised/updated design specifications and project plan document (see the template in **Appendix B.2**)

It is not unusual that some of the requirements, design specifications and initial design work need changes due to a variety of reasons. In this phase, each project team will thoroughly and carefully evaluate the project status and revise Specifications and Plan document realistically. Highlight the portions you modified or added, and strike through the deleted items.

Evaluation: See section 4 for the submission deadline and associated mark for this deliverable. The faculty team will evaluate your achievement based on the written document. The evaluation rubric for this deliverable is available in a separate document**.**

6.2. Design and Test Plan

Associated Key Grad Attributes:

- Design (hardware/software design and test plans)
- Communications Skills (documentation)

Project Deliverables:

- Final design of all modules and the integrated system
- Test plans for verification and validation

See the document template in **Appendix C.2**

Evaluation: See section 4 for the submission deadline and associated marks for this deliverable. The faculty team will evaluate your achievement based on the written document as well debriefing. The evaluation rubrics for this deliverable is available in available as a separate document**.**

6.3. Prototyping and Testing

Associated Key Grad Attributes:

- Design (implementation and testing)
- Investigation (documentation & analysis of data, and interpretation of results)
- Communications skills (documentation)

Project Deliverables:

- Demonstration of all modules, which are designed by the team.
- Demonstration of fully functional integrated system
- Documented evidence of all significant verification and validation testing.

There is no specific template suggested for these outcomes. However, it is expected that each team will present its work in a structured way so that the reader can understand easily. Image and video might be considered in addition to real-time demonstration.

Evaluation: See section 4 for the submission deadline and associated marks for this deliverable. The faculty team will evaluate your achievement based on real-time demonstration as well as documented evidence such as logbook, test results, image and video, as well debriefing. The evaluation rubric for this deliverable is available available in a separate document**.**

6.4. Project Management and Professionalism

See section 5.4

6.5. Final Technical Presentation and Demonstration

Associated Key Grad Attributes:

- Communications Skill (presentation skill)
- Professionalism

Project Deliverables:

- Oral presentation
- Presentation material such as power-point document
- Demonstration of completely integrated system
- A document that describes the demonstration setup and highlights the key items of the demonstration (the purpose of the document is to convey what and how you are going to demonstrate)
- A video of the project work

Each team will present and demonstrate its final form of the project work. They will compare what was promised and what is achieved. See **Appendix C.2** for further guidelines.

Evaluation: See section 4 for the submission deadline and associated marks for this deliverable. ESE students, non-capstone faculty members and staff may attend. Representatives of project sponsors and other interested professional and technical people may attend as well.

Two separate evaluation rubrics will be used for evaluating your oral presentation and project demonstration. The rubric for this evaluation is available available as a separate

document. The capstone faculty team and optionally other ESE faculty members will be the evaluators.

The faculty team will also nominate a team for the Mastercraft Award competition. Selection will be based on evaluation rubrics that are used for determining the award winner (the ESE program doesn't control this evaluation criteria).

6.6. Final Report

Associated Key Grad Attributes:

- Communications Skill (presenting info and writing mechanics)

Project Deliverables:

- A formal project report (Final Report) to present the project.

This document will be available to external readers. **Appendix C.3** provides the template.

Evaluation: See section 4 for the submission deadline and associated marks for this deliverable. The rubric for this evaluation is available available in a separate document.

6.7. Oral Review and Online Survey

The oral review is an interview where the students will share their project experience with the faculty team. Students will identify strength and weaknesses of their project work, what went well and what not, what they would do differently if they would have another chance and so on. The questionnaire is available in **Appendix C.4**.

The students will take an on-line survey in eConestoga to express their opinion on Capstone project at the end of semester.

Evaluation: no marks associated with this.

6.8. Tech Showcase

Project Deliverables: None

Only one team will be nominated for technical showcase and to participate in Mastercraft Award. The students are expected to put forward the best display and demonstration preferably with slide-show and/or video.

Selection Criteria: projects will be judged on the following criteria: first impression, innovation, creativity, skills and quality

Evaluation: none for the project course (no ESE evaluation). The participating team will be evaluated by the team of Judges of Mastercraft Award (not ESE faculty team). No course mark is associated with this.

Appendix A: ESE Document Format

Each technical report must be word processed and checked for spelling and grammar. It is to be 1.5 line-spaced using 12 point Times New Roman or 12 point Calibri or 10 point Verdana font.

Pages in the Front Matter are numbered using Roman numerals. The Title Page is considered page "i" but is not numbered. The Abstract is not included in the page numbering at all. The Table of Contents is the second page of the Front Matter and is numbered with a small Roman numeral "ii" centred in the footer at the bottom of the page. All subsequent Front Matter pages are numbered in a similar way.

Pages in the Main Body of the report are numbered using Arabic numbers. The "1" for the first page is centred in the footer at the bottom of the page. All subsequent Main Body pages are numbered in the top right corner of the page.

Pages in the Back Matter are numbered in the top right corner of the page and continue on from the number assigned to the last page of the Main Body.

Headings must be used to identify the sections within the technical report. As in this document, headings in the technical report are to be outline numbered, with each major section getting a new number.

All figures and tables should be referenced in the text at the relevant point. The reference should precede the graphic which is normally presented along with the text. All graphics must be numbered, titled and referenced appropriately. All illustrations, drawings, maps, graphs and charts are considered figures and should be included in the list of figures. Place the number and title below the figure. All tables should be included in the list of tables. Place the number and title above the table.

Avoid typographical anomalies like "orphans" and "widows". Orphans are short sections (usually single lines or headings) that belong with the text on the following page. Widows are single lines or words that are isolated at the top of a page but belong to the text on the previous page.

Appendix B – Guidelines/Templates for Part 1 (Semester 7)

B.1 Project Proposal

B.1a Project Idea Document

- Project teams should have 2 or 3 members.
- Project must include engineering design work that a group will carry out.
- Design work should include both electronic hardware and software design.
- All members in a group must carry out a part of engineering design.
- Students should strive to have a goal. It can be an entrepreneurial, industrial, or a community service goal.
- Students should consult with knowledgeable professionals in the field related to their project to make sure that their project is professionally meaningful. For example, if one is going to do something for the blind, should consult with a professional association like CNIB.
- Students should think about the 'showcase day', where they may present their project to the public. Others including industrial partners may see your project as well, so it should be something that represents you and your program well.

A project idea document includes:

- Project title
- Team members
- Project justification (why is needed?)
- Target beneficiary group (who needs it?)
- Project description (what needs to be done?)
- Anticipated budget
- Sponsors or professional supporters

B.1b Project Outline Document

A project outline includes the following sections:

- Cover page with the following information: institute and program name, course title and code, students' name and ID, project title, semester and year
- Problem/need statement:
  -identify what problem the project will solve.
  -specify why this problem needs to be solved.
- Project background:
  -identify current solutions for this problem.
- Project description:
  -describe your proposed solution to the problem.
  -identify successive or parallel steps required to realize the solution.
  -compare your solution to existing solutions.
- Budget:
  -how much money is needed to cover all costs of the project?
- Professional support or sponsorship:
  Project should have positive impact on society demonstrated by one or more of the following:

- Academic, industrial or professional sponsorship, support or endorsement.
- Reasoned argument as to the societal relevance of the project

B.1c Project Proposal Document

A project proposal includes the following sections:

- **Cover Page**
  - Cover page with the following information: Institute and program name, course title and code, students' name and ID, project title, semester and year
- **Table of Content**
- **Introduction**
  - Purpose: identify the purpose and audience of the document.
  - The Project: name and briefly describe the proposed project.
  - Background
    - Identify what problem the project will solve.
    - Specify why this problem needs to be solved.
- **Literature Review**
  - Survey on existing solutions for this problem (citation of authoritative source required. Authoritative source includes well-known technical/scientific journals, magazines, industry white papers, product descriptions from original vendor).
  - Compare your solution to existing solutions.
- **Project Description**
  - Describe what the proposed system will be and/or do.
  - Identify what will be achievable after the project is complete that isn't achievable now.
  - Identify project context as adding societal, industrial (business or entrepreneur) and/or economic value.
  - Identify professional responsibility attribute(s) such as safety, ethics, societal impact and environmental concern.
- **Project Feasibility**
  - Expertise
    - identify the knowledge and skills that are required for successful completion of the project
    - identify any knowledge must be acquired to complete this project
    - identify sources of expertise that are available to help complete this project
    - identify possible external advisors for this project
  - Resources
    - identify the tools and resources that are required for successful completion of the project
    - Specify the estimated cost of the project.
    - Identify possible sponsors of this project.
- **Risk Analysis**
  The risk analysis is a document that describes which risks might affect the project. It is part of the Proposal. It includes:
    - technical, quality and performance risks

  - project management risks
  - organizational risks
  - external risks

The risk analysis report must include:

  - an evaluation of the impact of each risk on the major project objectives
  - the overall risk for the project
  - a list of prioritized risks

- **Reference and Bibliography**

  Template with examples:

  [1] J. Yick, et al., "Wireless sensor network survey," Computer Networks, vol. 52, pp. 2292-2330, 2008.

  [2] Y. E. Krasteva, et al., "Remote HW-SW reconfigurable Wireless Sensor nodes," in Industrial Electronics, 2008. IECON 2008. 34th Annual Conference of IEEE, 2008, pp. 24832488.

  [3] J. Jones. (1991, May 10). Networks (2nd ed.) [Online access on June 14, 2016]. URL: http://www.atm.com,

  For more examples see: http://www.ieee.org/documents/ieeecitationref.pdf

  Note: You may use the built in Bibliography functionality in word. We recommend the IEEE 2006 Style.

B.2 Specifications and Plan

For a successful specification and planning phase you may consider the following guidelines:

- Clearly identify which part of the project will be based on off-the-shelf components, and which part will be based on your own design.
- Break down the project work into a number of tasks, and distribute the tasks among group members in such a way that the total work-load as well as design work is divided among the members more or less equally.
- The design task of each member should be further divided into two parts for the purpose of mid-term and end-term evaluation (Assessment 1 and 2 as stated in Section 4)
- Develop a schedule such as Gantt-chart
- Develop design specification for 'to be designed' parts/modules in line with project the requirements.
- Identify high risk items and plan how you will manage the risk.
- Identify the new knowledge/skill/training requirements and plan how you will acquire those.

A specification and plan document includes the following sections:

- **Cover Page**
  - Cover page with the following information: Institute and program name, course title and code, students' name and ID, project title, semester and year
- **Table of Content**
- **Complete System Diagram and Description**
  - block diagram of the complete system
  - Description of each block
  - Identification of off-the-shelf components and 'own design' components.
  - Breakdown the 'own design' components into a number of modules (one module per group member)
  - Risks and risk management plan
- **System Level Design Specification**

  "A **design specification** is a detailed document providing information about the characteristics of a project to set criteria the developers will need to meet. Its use is called for where a structure or product has to be specially made to meet a unique need." ~ Wikipedia

  When you develop a system, and measure its performance, you need to compare it with some criteria to evaluate the performance. These criteria must be met when you perform validation test at the end of the project (in semester 8)

  The specification should be a SMART (**S**pecific, **M**easurable, **A**chievable, **R**ealistic, **T**imely) specifications with MuSCoW (**Mu**st, **S**hould, **Co**uld, **W**on't), risk and effort ratings (high, medium, or low) for each functional/work block
- **Design Task 1: <*title*>** //one task for one group member//
  - Design specification and methodology/process
  - Assessment 1 and Assessment 2
  - Requirement of new knowledge and skill, if any
  - Requirement of tools and resources
  - Risks and risk management plan
- **Design Task 2: <*title*>**
  - Design specification and methodology/process
  - Assessment 1 and Assessment 2
  - Requirement of new knowledge and skill, if any
  - Requirement of tools and resources
  - Risks and risk management plan
- **Design Task 3: <*title*>**
  - Design specification and methodology/process
  - Assessment 1 and Assessment 2
  - Requirement of new knowledge and skill, if any
  - Requirement of tools and resources
  - Risks and risk management plan
- **Project Schedule** (Gantt chart or equivalent)

Modularity is expected in your system development work. It is expected that each group member will work on individual component separately as long as it

makes sense, and tests each module separately to ensure that the module works properly. At one point two or more components/modules are to be integrated. This process will continue until final complete integrated system is developed. The schedule should give a timeline of this process.

Group should identify the most complex, challenging and/or uncertain part first and start working on it as early as possible. Research, prototype & experiment, simulate, acquire knowledge/skill, and also ask for help, as needed, in order to reduce risk.

Some procurement and out-sourcing task may cause delay. You should send orders out as early as possible. Also, plan your work in such a way that you don't need to sit idle until ordered resources are available.

In the first week of Part 2 (semester 8) you will revise this document based on your project status and risk at that time, and use it for the remaining part of the project.

B.3 Engineering Investigation and Design

In this phase, you will start your design work as per specification and plan. For a successful design phase, you may consider the following guidelines:

- Explore more than one design solution and be able to defend your design decision.
- Present your engineering design using appropriate means of engineering communication such as circuit/schematic diagram, flow-chart, state-machine diagram, mathematical formula, and 3D graphics, as appropriate.
- Identify the most complex, challenging and/or uncertain part of the design/development work first, and start working on it as early as possible. Research, prototype, experiment/simulate, acquire knowledge/skill, and also ask for help as needed in order to reduce risk.
- When you select an off-the-shelf hardware or open-source software, be thorough in your selection process and do it based on a sound engineering decision making process.
- List (with short description) the selected key electronic components, open-source software, CAD tools, programming language, communication protocols/systems, mathematical methods/algorithms and so on along with a comparative study on alternatives/options and justification behind your selection.
- Be thorough in your engineering investigation:
    - Produce a record of key investigation work such as prototype & experiments and simulation.
    - Record test data/results, and perform data analysis for the purpose of design decisions.
    - maintain engineering log

There is no single formal document necessary for this phase. However, during evaluation of your performance, you are expected to present/demonstrate/defend the following items:

- engineering design alternatives and your design
- justification behind engineering design decisions
- experiments and simulation
- record of measurement data, experiment/simulation results, and data analysis
- engineering log
- a list of newly acquired (and/or to be acquired) knowledge/skill along with justification why these are required, and status of these acquirements
- an assessment on safety as well as environmental and societal impact the proposed design may have if it is implemented and put into operation
- justification behind selection of specific off-the-shelf hardware or open-source software
- list of incomplete design works and risk assessment

B.4 Project Management and Professionalism

For high score in project management and professionalism you may consider the following guidelines:

- Never miss deadlines, and complete work 100%.
- Never miss attendance/participation. If deemed necessary, notify as early as possible with acceptable reason of absence.
- Your attitude and behavior must not have adverse impact on people around you in the college
- Though you are in project group, all evaluations, at least partially, are individual evaluations. Do your part well. Don't create any situation due to which the performance of any other group members may be adversely affected.
- Accurately produce project status report in every evaluation cycle.
- Produce engineering log regularly and effectively
- Record meeting minutes/notes

Project Status Report Template (see next page)

Project Status Report – Week #

2018-MM-DD

Project Name: **Team Members**:

Project Overall Status: GREEN/YELLOW/RED

Status Overview:

Activity Title with start date and also planned completion date and name of responsible team member	**Status** (Last Week) G/Y/R	**Status** (This Week)		**Plan** (Next Week)
		Plan (as planned last week for this week)	**Actual** Green/Yellow/Red	

- Overall Status: Green is the best, Red is the worst, and Yellow is in between. You may add + or – suffix to indicate the status more accurately.
- Planned completion date and name of responsible team member: indicate if these are unchanged or changed/new.
- You have to compare your status in three ways:
    1. Status of this week versus the status in last week
    2. Status of this week versus the plan for this week
    3. Planned completion date and responsible person (this week) versus the planned completion date and responsible person (last week)

B.5 End-term Presentation and Demonstration

For a successful presentation and demonstration, you may consider the following guidelines:

- First impression: dress professionally, be ready to start, and start on time.
- Background information: expect that some of the audience is not familiar with your project, so start with a brief overview. Use generic terms wherever possible.
- Organization: presentation and demonstration must be organized in such a way that the faculty members, who are not involved in the project, can easily understand.
- Quality of research, investigation and design: this is the core topic of your presentation. Give your best effort to highlight design complexity, depth and breadth of your research & investigation, precisely present your design with appropriate means of engineering communication (circuit-diagram/schematic for electronic hardware, flow-chart for software, mathematical formula for engineering computation and 3D graphics for mechanical components, for example). You should also highlight all design options and defend your design decisions.
- Quality of demonstration: this is the core topic of your demonstration. Though you are not expected to implement any significant hardware or software at this stage, you are expected to perform experiment, simulation and/or test, for example, off-the-shelve components/modules and open-source software in order to make design decisions. You are also expected to prototype some hardware and software to support/verify your design work.

  Describe the demo setup (perhaps with a block-diagram), clearly state the test plans and compare each measurement with the expected outcome. At the end, you should be able to prove that the experiments, simulations and/or tests are useful for your design decisions.
- Quality of communication (presentation/demonstration): coherence, flow, aural quality, visual aid and articulation

Appendix C – Format/Template for Part 2 (Semester 8)

C.1 Detailed Design Document – Template

Detail design document includes the following sections:

- Title page: include the document name 'Final Technical Report', project title, student names & IDs, academic term 'Summer 2018', course title, program name and college name.
- Table of content and page number
- Project definition/description and scope
- **System design**
  - System level diagrams & drawings, principle of operation with brief descriptions of each functional unit, indication of what components are 'off-the-shelf' and what are designed and developed.
  - System-level safety, societal and environmental issues and mitigation plans.
  - Remaining risks to the project and risk management plan
  - System verification and validation plan
- **Design of functional units or modules** (multiple sections with appropriate titles – one for each functional unit)
  - Definition of functional unit
  - Principle of operation, schematics, flowchart, pseudocode and any other engineering drawing as appropriate
  - Specifications of off-the-shelf components (such as microcontroller, wireless transceivers, embedded modules, electrical & electronic components; communication devices and client-server software; open-source software and protocols).
  - Test plans for the unit
  - Safety, societal and environmental issues associated with the unit and mitigation plans.
  - Remaining risk to the functional unit development and risk management plans.
- **Appendices**
  - Specifications of off-the-shelf components (if these are too big to accommodate in the main body of the document)
  - New research, investigation and literature review.
  - Any other materials as appropriate
- **References:** See Appendix B.1.c

C.2 Final Technical Presentation and Demonstration

- See section Appendix B.5
- In addition, students will do the following:
  - Present & demonstrate their project implementation (prototype) and test results.
  - Provide performance evaluation and comment on the outcome (what went well, what could be done better and recommendations on future work).
- Show video clip as per the guide-line below:
  - 2 to 3 minutes long
  - Elevator pitch
  - Covering the following aspects
    - the problem the project tried to solve
    - the solution detail highlighting innovative aspects of the solution
    - future directions for the project, specifically commercialization potential

C.3 Final Technical Report

Final Technical Report includes the following sections:

- Title page: include the document name 'Final Technical Report', project title, student names & IDs, academic term 'Summer 2018', course title, program name and college name.
- Table of Contents: Include page index
- Abstract: Include a summary of the key salient points in the project

- **Introduction**
  - Background: provide some background information on your project.
  - System Description: provide system description with a block diagram. Identify which part of the system your project is focusing on.
  - Literature Review

    Summarize your literature review with appropriate reference to authoritative source to report existing solutions that are comparable or alternative to what you proposed for this project. Authoritative source includes technical journal, magazines, industry white paper, and product description from original vendor. Literature review should address the following:

    - Establish that the research/project topic is currently a topic of active research and development and has potential to be a practical solution to a real-world problem.
    - Provide the readers of this report with some examples of research/project that are already reported in authoritative journal and technical magazines (this is a sort of environment/boundary scan)
    - Identify and describe the literatures that form the basis or starting point of your research/project work (these can be any combination of, for example, a project idea, research work, off-the-shelf components, industry white papers on 'coming soon' products or solutions, new regulations and open standards)

    Note: You may use selected elements of the literature review you performed in your proposal

- Proposed Solution and Rationale
  - Describe your solution. You should compare your solution with already available solutions.
  - List the goals you wanted to achieve at the beginning of the research/project (this part should be from the latest version of your proposal)
  - Highlight the benefit of your proposed solution.

- **Design and Test Methods**
  - System Modules: show how you break down the whole system into smaller and simpler modules in order to design, develop and test those modules individually and independently.

    Note: You may create one subsection per module to present your design work. The following sub-section is provided as an example.

  - Module 1 (you may give an appropriate title)
    - Show your design of individual module using circuit/schematic diagram, flow-chart/pseudocode, 2D/3D mechanical drawing, mathematical model/algorithm or any other standard engineering design description methods as appropriate).
    - Some of the design may involve engineering principles (circuit theory, algorithm, natural science principles, for examples). Includes those as well.
    - You may use engineering tools (CAD, measuring tools, machine tools, for example). List those here.
    - State the test requirement (that is, what you need to test in order to confirm that the module is working and bug/trouble free)

    <Add further sub-sections for your other modules>

  - Test Methods and Plan: Provide a summary in this section and refer to your design document for further details

  - Implementation: Add some evidence of your implementation.

    Example:

    - Photograph of hardware you implemented and its experimental setup
    - PCB layout you developed
    - Video clip to show the operation
    - Reference to software code you developed (should be placed as an appendix if small, or separate files if large)

  - Safety and Impact on Environment and Society:
    - Describe how your solution may impact on the environment and society (positive or negative).
    - Describe how to reduce the negative impact, if any.
    - Describe required safety precautions if the product may cause any safety hazard.

- **Results and Analysis**
    - Qualitative Analysis: Present your qualitative test results here. It is expected that you will present results under different test conditions.
    - Measurement Results: Collect measured data and present those data here. Data tables are expected here.
    - Quantitative Analysis: Analyze the data to present the key characteristic features. Graph of different kinds may be appropriate here.

- **Conclusion and Recommendations**
- **Appendices:** Add additional materials that you may have but not included in the main body of the report. Here are some examples:
    - Software code that you have written
    - Specifications of off-the-shelf components and equipment
    - Information about APIs and open-source code you used in your project
    - Drawings and schematic diagrams
- **References and Bibliography:** See Appendix B.1.c

C.4 Oral Review

This review is to collect students' feedback on their capstone project experience. Faculty team will follow the following rubric for this task.

	Project							
	1.	**2.**	**3.**	**4.**	**5.**	**6.**	**7.**	**8.**
Prepared (0-5) Team came prepared with discussion points								
Participation (0-5) All team members participated in discussion								
Openness (0-5) Team members were open to discussion, criticism. Everything on the table and willing to examine it all.								
Outcomes (0-5) Can identify most successful and least successful outcomes.								
History (0-5) Team can identify things that might have been done differently in the history of the project.								
Future (0-5) Team can identify opportunities for improvement going forward (future development, 2nd version, etc)								
Learning (0-5) Team can clearly expound on what they have learned from the project.								
Conclusions (0-5) What would you tell next year's class?								
OVERALL IMPRESSION (0-5) Impression of the professionalism & standards of this group's work.								
TOTAL (0 - 45)								
Additional Comments:								

Appendix D – Graduate Attributes

https://engineerscanada.ca/sites/default/files/Accreditation_Criteria_Procedures_2015.pdf

3.1.1 **A knowledge base for engineering:** Demonstrated competence in university level mathematics, natural sciences, engineering fundamentals, and specialized engineering knowledge appropriate to the program.

3.1.2 **Problem analysis:** An ability to use appropriate knowledge and skills to identify, formulate, analyze, and solve complex engineering problems in order to reach substantiated conclusions.

3.1.3 **Investigation:** An ability to conduct investigations of complex problems by methods that include appropriate experiments, analysis and interpretation of data and synthesis of information in order to reach valid conclusions.

3.1.4 **Design:** An ability to design solutions for complex, open-ended engineering problems and to design systems, components or processes that meet specified needs with appropriate attention to health and safety risks, applicable standards, and economic, environmental, cultural and societal considerations.

3.1.5 **Use of engineering tools:** An ability to create, select, apply, adapt, and extend appropriate techniques, resources, and modern engineering tools to a range of engineering activities, from simple to complex, with an understanding of the associated limitations.

3.1.6 **Individual and team work:** An ability to work effectively as a member and leader in teams, preferably in a multi-disciplinary setting.

3.1.7 **Communication skills:** An ability to communicate complex engineering concepts within the profession and with society at large. Such ability includes reading, writing, speaking and listening, and the ability to comprehend and write effective reports and design documentation, and to give and effectively respond to clear instructions.

3.1.8 **Professionalism:** An understanding of the roles and responsibilities of the professional engineer in society, especially the primary role of protection of the public and the public interest.

3.1.9 **Impact of engineering on society and the environment:** An ability to analyze social and environmental aspects of engineering activities. Such ability includes an understanding of the interactions that engineering has with the economic, social, health, safety, legal, and cultural aspects of society, the uncertainties in the prediction of such interactions; and the concepts of sustainable design and development and environmental stewardship.

3.1.10 **Ethics and equity:** An ability to apply professional ethics, accountability, and equity.

3.1.11 **Economics and project management:** An ability to appropriately incorporate economics and business practices including project, risk, and change management into the practice of engineering and to understand their limitations.

3.1.12 **Life-long learning:** An ability to identify and to address their own educational needs in a changing world in ways sufficient to maintain their competence and to allow them to contribute to the advancement of knowledge.

Appendix E: The Capstone Grad Attributes

Professional Body of Knowledge

KB	KB1	KB2	PA	PA1	PA2	PA3	IV	IV1	IV2	IV3	ED	ED1	ED2	ED3	ED4	ED5	ET	ET1	ET2	ET3	ET4
Knowledge base	Facts	Concepts	Problem analysis	Decomposition	Methodology	Validation	Investigation	Research	Measure	Experiment	Design	Problem Design & Research	Preliminary Design	Detailed Design	Implementation	Verification & Validation	Use of engineering tools	Models/Simulations	Measurement Tools	Manufacturing Tools	CAD Systems
								A	A	A		A	A	A	A	A		A	A		A

Employability Skills

TM	TM1	TM2	TM3	CM	CM1	CM2	PR	PR1	PR2	PR3	PR4	LL	LL1	LL2	LL3	LL4
Individual and team work	Personal Contribution	Collaboration	Infrastructure	Communication skills	Log Engineering Info	Convey Engineering Info	Professionalism	Work Ethic	Professional Conduct	Professional Contribution	Professional Practice	Life-long learning	Autonomous Learning	Applying Knowledge & Skills	Self Direction & Reflection (Metalearning)	Learning Strategies (Metacognition)
					A	A		A					D	D	I	

Professional Responsibility

SC	SC1	SC2	SC3	EE	EE1	PM	PM1	PM2	PM3	PM4	PM5
Impact on society and the environment	Environmental Awareness	Product Life Cycle	Balance & Tradeoff	Ethics and equity	Ethical Responsibility	Economics and project management	Project Scheduling	Resource Allocation & Costing	Risk Management	Business Planning	Economic Analysis
							A	A	A		

LEGEND		
I	**Introduced**	first experience/use
D	**Developed**	continued experience/use
A	**Applied**	integration/extension of knowledge & skills