MTE100/GENE 121 Course Project Fall 2015

For groups with **All** members enrolled in **Both** MTE 100 and GENE 121

The course project is to design and implement a mechatronic system. The project will be completed in groups of 3 (or 4) students from the same lecture section. All group members are expected to contribute significantly to:

- the software design and implementation,
- the mechanical design and implementation, and
- the report writing.

If you use an idea for your mechanical design and/or computer code (including any non-ANSI standard C++ libraries) from another source, you must acknowledge it. Code or mechanical elements designed or implemented by group members prior to the project start date or submitted for credit elsewhere should be treated as being from another source and acknowledged. Follow the guidelines for references used in the MTE 100-CHE reports. Clearly indicate which parts of the project are designed / authored by others or written outside the scope of GENE 121 or MTE 100, and which parts are designed / authored by group members during Fall 2015 for the course project. Marks will be assigned based on the part of the design that is the group's original project work. The design report and the final report should be formatted using the MME Department Work Report Guidelines:
https://uwaterloo.ca/mechanical-mechatronics-engineering/sites/ca.mechanical-mechatronics-engineering/files/uploads/files/Work%20Report%20Guidelines%20for%20website.pdf
A list of common errors when writing reports is available at:
https://uwaterloo.ca/mechanical-mechatronics-engineering/sites/ca.mechanical-mechatronics-engineering/files/uploads/files/WorkTermReportCommonErrorChecklistF09_000_0.pdf

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Project Information

Your design should involve:

- A mechanical re-design of some part or all of the robot
- The use of at least three motors, one of which must have controlled movement
- The use of:
  - At least four different types of the following "sensors": button, motor encoder, ultrasonic, color, touch, intensity, sound, accelerometer sensors**,** and/or communication to a laptop or other approved device (using either Bluetooth or USB)
- The use of timers (e.g. time1[T1], time1[T2])
- Repetition (while, do-while, or for loops)
- Decisions (if-else statements)
- At least six non-trivial functions, not including **main**, that use appropriate parameter passing; **Each group member should write at least one function**
  - **At least one function must return something**
  - **At least one function must have parameters, either passed by value, or by reference**

All code that is submitted for grading must be written in C++ and/or RobotC. If you choose to write additional code (that will not be graded) in another programming language, prior consent of the GENE121 instructor is required.

Project Platform

The platform for the project is the Lego NXT/EV3 system. The Lego NXT robot system was introduced in the GENE 121 labs. To sign out a Lego NXT kit, you should complete the Project Sign Out Form and take it to Fiona Yiu in E2-1318B. You will be able to sign out the robot kits starting on Thursday November 5. Additional Lego parts kits can be signed out if required. All students in the group will be responsible for the parts in the robot kit as well as any additional parts you sign out. The "standard kit" will have an NXT brick, 3 motors, 1 or 2 touch sensors, an ultrasonic sensor, and a color sensor.

Additional sensors available include intensity sensors, sound sensors, and accelerometers. Additional motors and motor multiplexers, or an EV3 kit are also available upon request. As we have these additional parts in limited amounts, you may be asked to justify your request.

Project Deadlines

1. **Team Member List and Draft Problem Description – Due Thurs Oct 29 for 8 stream and Mon Nov 2 for 4 stream, Submitted to the boxes outside WEEF (Required as a milestone)**

   Your group **must** be made up of people from the same GENE121 Lecture Section (001 or 002).

   The proposal must include:
   - Names, student ID numbers, and signatures of the group members
   - A very brief (i.e. one or two sentence) description of the problem that your mechatronic system will solve

   You may choose of the suggested problems (from Course Project Ideas on Learn) or select your own problem to solve.

   Note:
   - When selecting a problem, take into consideration that you have approximately 3 weeks to complete the project.
   - The design and implementation must conform to all safety regulations, including electrical safety requirements, safe handling of chemicals/liquids, guarding, etc.
   - The Lego elements may NOT be damaged or permanently altered as a result of building or testing your design.

2. Team Presentation: Initial Mechanical Design – Tuesday, Nov 3 (9:30-11:20) for 8 stream and Thursday, Nov 5 (10:30-12:20) for 4 stream (Graded for MTE 100, Milestone for GENE 121)

You will be presenting your project problem description, a list of 4+ tasks your robot will perform to solve this problem, and your criteria and constraints for your design to the MTE 100 TAs. This presentation will be 5 minutes long, followed by questions from the teaching team.

- The Task List should be a sequential list of the steps that your robot must complete to perform its overall objective. This list can be point form as it will not be included with your final report, but will make up a "checklist" used in your final project demonstration with your TA. A sample task list for a crane project could be:
  - Robot must "locate" the object to be lifted
  - Robot must grab object
  - Robot must lift object to platform
  - Robot must set object down
- Constraints are defined as things that your project "must have". For example, if you were building a crane, the crane "must have" some means of grabbing on to the object it is lifting, and "must have" a motor assigned to do the lifting operation (that must be strong enough to lift whatever objects you are moving around).
- Criteria are defined as things that "would be nice to have" in your project (given enough time, resources, material, etc.). For example, if you were building a robot which sorts red parts from blue parts, it "would be nice to have" a robot which sorts defective parts from both piles (let's say they are yellow in color).

3. Formal Problem Description, Freehand Sketches – Due Friday, Nov 6 at 8:20am, Submitted to the boxes outside WEEF (Graded for MTE 100, Milestone for GENE 121)

Submit the following:

- The design problem definition. This should be clear and concise and should not exceed 2 paragraphs. The design problem definition should describe the problem your project is trying to solve. **This document should not elaborate on the solution to the problem**. A classmate who is unfamiliar with your project should be able to understand the problem definition.

  The design problem definition can change as the project progresses.

- Freehand sketches of the various, alternative, mechatronic systems, plus any additional sketches of interesting components (e.g. show how support is provided, or vertical/horizontal motion is to be achieved). Each group member should submit an individual sketch of one of the alternative designs, clearly labeled with his or her name

4. Design Report – Due Monday, Nov 16 at 8:20am, submitted to the boxes outside WEEF (Graded for MTE 100)

The main body of the design report is expected to be approximately 5 pages (3 pages of text and description, and 2 pages of diagrams, drawings and photos). Follow the MME work report guidelines when formatting your report.

The main body of the report should include:

1) Brief Introduction and Background
2) Design Problem Definition
3) Goals and Objectives
   - Include the expected outcomes (i.e. what the result of your project should be)
4) Design Criteria and Constraints ("must haves", "should haves"). The constraints/criteria should be specific to the problem you are trying to solve.
5) Several alternative solutions to the mechanical design part of the project, and evaluations of the options. The sketches that were previously submitted should be included.
6) List of Tasks that your robot will perform
7) Project Plan (Gantt chart or Critical Path Method)

Any sources should be cited properly and included in a list of references at the end of the report.

5. Team Presentation: Software Design and Physical Mockup – Takes place Nov. 16 for 8 stream and Nov 17 for 4 stream during GENE 121 Labs (Graded for MTE 100 and GENE 121)

You are required to meet with your assigned final project Tutor during a GENE121 lab session. You will be discussing your software design and flowchart, the final versions of which are described below. In addition, you must bring either your finished mechanical design, or a working model of your mechanical system (the mock-up). This is a time for your Tutor to provide feedback with enough time for you to act on it. Any concerns must be addressed before moving forwards.

In this presentation, you should be discussing how you are breaking down your program into smaller pieces (your functions) including how these smaller pieces interact with each other.

You should also outline how you are going to verify that the individual pieces, and the whole, are working (i.e. unit testing!). For each function, describe test inputs and expected behavior (including any/all outputs).

For this presentation, you must bring a high level flowchart of your project. This should not include fine details like variable declarations, for instance. This flowchart needs to be well laid out, should be legible and **should fit on one page**.

6. Checklist and Demo – Due Tuesday, Nov 24 from 2:30pm – 5:30pm in WEEF (Graded for MTE 100 and GENE 121)

All members of your group must be present. You will demonstrate your working robot to a TA. At the demo you should bring the final checklist of 4+ meaningful items that the TA will use when verifying the operation of your project.

This checklist should be based on the task list which you have submitted previously.

Your checklist sheet **must** also include:

We declare that the design, including configuration of the robot and the software, in this project is our original work completed during the current school term for the MTE100/GENE 121 course project.

We have neither given nor received an electronic copy or a printed version of any part of this design.

This project was completed by the group members except as noted below.

If not, please state all sources, including who you collaborated with and what the collaboration entailed, or under what circumstances some of the work was completed in a previous term or outside the scope of the MTE100/GENE 121 course project:

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Name (Printed)	Signature

7. Final Report – Due Friday, Dec 4 at 8:20 am – Submitted to the boxes outside WEEF (Graded for MTE 100 and GENE 121)

The main body of the project report is expected to be 8 - 12 pages, not including the preliminary pages, summary, appendices, and the source code which should be included as an appendix. Please use 12 point font and 1.5 line spacing in the main body of the report. Section headings should be either 12 or 14 point bold font with 2 to 3 line spacing between sections. Each page should have a 3.18 cm left margin, suitable for binding the report and 2.54 cm top, bottom and right margins. Main body pages are numbered using regular numerals (1, 2, 3,…). The report should be printed single-sided.

Graphics (tables and figures) should be formatted using the conventions given in Chapter 9 of "Introduction to Professional Engineering", 4th edition by Andrews, Aplevich, Fraser and MacGregor.
If your report references a picture, **include that picture in the body text, not in the appendices.** The appendix is for supplementary information, so you should not be referring to it in the main body of the report.

Reports should follow the format given in Chapter 8 of Andrews, *et.al*. This is the report writing style that will be used on your first coop work term. The final report for MTE100/GENE121 should be laid out in a similar format. Guidelines for MTE and ME work reports can be accessed at: https://uwaterloo.ca/mechanical-mechatronics-engineering/current-students-mechatronics-engineering/work-reports#Detailed%20guidelines

If you use an idea for your mechanical design and/or computer code (including any non-ANSI standard C++ libraries) from another source, you must acknowledge it. Code or mechanical elements designed or implemented by group members prior to the project start date or submitted for credit elsewhere should be treated as being from another source and acknowledged. Follow the guidelines for references used in the MTE 100-CHE reports. Clearly indicate which parts of the project are designed / authored by others or written outside the scope of GENE 121 or MTE 100, and which parts are designed / authored by group members during Fall 2015 for the course project. Marks will be assigned based on the part of the design that is the group's original project work. The design report and the final report should be formatted using the MME Department Work Report Guidelines:
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The report should include the following sections:

- Preliminary Pages
  - Includes front cover, title page, table of contents, list of figures and tables, and acknowledgements
  - The title page should include the **descriptive** title of your project, your group member names and ID's, the signature of each group member beside their name, the course numbers and the date of submission. It should not include a page number.
  - Use roman numerals (ii, iii, …) for page numbering the preliminary pages

- Summary

- The summary is a summary of your report, not of the project. This should include a brief description of the problem you are solving, how you implemented it, how you tested it, and finally a summary of the review and recommendations.

- Design Problem Definition
  - This section of the report is used to introduce the design problem that your group is attempting to solve. It should be based on what you have submitted previously.

- Goals and Objectives

- Constraints and Criteria
  - This section of the report should be an improved version of what has been submitted previously
  - This section should include a discussion of how you met the constraints that were set early in the project, or how the constraints changed over the design and build process

- Mechanical (Re-)Design and Implementation
  - This will likely be the longest section of the report and in it you should explain why you designed the robot the way you did, comment on any tradeoffs in design that you made and also any possible extensions of the project if you had more time. It is recommended that this section be split into the various components of your design. For example, a line following robot could be split into the following sections:
    - Chassis Design
    - Motor Drive Design
    - Sensor Attachment Design
  - Include explanations of design decisions, and any tradeoffs

- Software Design and Implementation
  - A description of the design to solve this task (explain, don't just include the code), including
    - Flowcharts or block diagrams to explain the software design
    - Explanation of how the overall program was broken down into smaller blocks/tasks and why these blocks/tasks were chosen. This should **not** be a line by line description of your functions.
    - Explanations of design decisions
    - Any tradeoffs
  - A description of how your program was tested throughout the project
  - A description of any significant problems experienced and/or re-design of features in your code
  - This section of the report should be an improved version of what was presented previously.

- Project Management
  - This section should include information on how tasks were split among the group members and list timelines for the project. Comment on differences between the project plan given in the design report and times and priorities changed during the project implementation

- Conclusions
    - This section should briefly summarize the technical report including the design objective and whether or not the design was capable of meeting the constraints and criteria. It should also outline important features of the design.

- Recommendations
    - This section of the report outlines recommendations or changes that you would make to the design in order to improve it. These recommendations only need to be concepts, not proven to work designs. This section **MUST** include possible extensions to both the mechanical design and the software design.

- References
    - This section should include all references used in the report. This includes any ideas or diagrams that have been taken from another person.
    - Use IEEE style for documenting sources

- Appendices
    - Any appendices should be at the end of the report and should be labelled as in the following example: Appendix A – Source Code, Appendix B – Robot Photos, etc... You will need at least one appendix that will have all of your source code written for your project.
    - Please use single spacing and Consolas for the appendix including your source code.
    - ***Note: You must indicate in your code which function was written by which group member(s). All group members must have written at least one function (including main). Marks will be deducted if this is missing.***

The software design and implementation, and the appendix containing the source code will be marked as part of your GENE 121 grade. All other parts of the report will be marked as part of your MTE 100 grade.