McMaster University

IBEHS 5P06

Justification of Disciplinary Focus

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Submitted by:

Name	**Email**	**Student ID**
Anna Green	greena18@mcmaster.ca	400117023
Anna Lopatukhin	lopatuka@mcmaster.ca	400116519
Eric Hillebrand	hillebre@mcmaster.ca	400143468
Janek Wolos	wolosj@mcmaster.ca	400131936

Introduction

The objective of this project is to develop a smart mannequin for CPR training. The ideal design solution will give live feedback of the quality of chest compressions, including measuring the compression rate and depth. These data will also be used as a means for providing remote certification on CPR performance for use in developing countries.

Mechanical Team (Anna Green, Anna Lopatukhin)

Mechanical team members will be responsible for designing and fabricating physical components of the mannequin. We envision outfitting an existing CPR mannequin with the instrumentation required for a smart mannequin, and thus we do not expect to be fabricating the mannequin's outer body shell. Mechanical components that we expect to be included are a structure that mimics a ribcage, sensor housings, strain gauges, springs, and mounting systems. The brainstorming/sketching part of the design process will involve all team members, but the mechanical team members will focus on honing the chosen design. Several design courses have given us opportunities to brainstorming ideas, conducting qualitative and quantitative analyses on them, and create CAD models, including IBEHS 1P10/ ENG 1C03, IBEHS 3P04, ME 2C04 and ME 3E05. Co-ops in design roles have also given us opportunities to hone these skills. Our background in anatomy from HTHSCI 2F0/FF3 will prepare us to understand CPR requirements in depth and implement them in our physical design where applicable. Material selection will fall under the mechanical members' responsibilities, which will employ knowledge acquired in MATLS 3M03, ME 3E05, build projects completed on co-ops, and work on the Baja Racing Team. Mechanical component selection will use skills developed in ME 2D03, ME 3E05, and build projects from co-ops. The Mechanical team will conduct the appropriate calculations and/or FEA to ensure that the designed parts will respond as expected during CPR loading. This task will employ skills from ME 2P04, ME 3E05, ME 3A03, and various build and FEA-related co-op projects. Mechanical members will fabricate parts, which could be done by 3D printing, or fabrication in the machine shop. 3D printing skills were practiced in IBEHS 1P10/ ENG 1C03, ME 2C04, IBEHS 3P04, and various co-op positions. Machining skills have been developed in ME 3M03, as well as various co-op positions where manual and CNC machines were used. Additionally, the Mechanical team will collaborate with the Electrical and Mechatronics team for data acquisition. It is expected we will develop testing and validation procedures using the knowledge from measurements, lab, and data handling courses. Within data handling it is expected we will assist in conducting an uncertainty analysis of our measurement methods, and properly represent data with the appropriate graphs and charts. Courses that have prepared us for these tasks are ME 2B03 for measurement techniques, HTHSCI 2G03, IBEHS 4C03 and STATS 3Y03 for statistical analysis/data handling, and ME 3M03, ME 4P03 and IBEHS 2P03 for experimental design. If analyzing the data requires any numerical methods, the Mechanical Team will assist when needed.

Hardware & Software Team (Janek Wolos - Electrical & Eric Hillebrand - Mechatronics)

From the electrical engineering side the team member will be able to put to practice the knowledge gained from the circuit design, software and embedded system courses taken during the course of their undergraduate studies. Signal filtering principles learned in IBEHS 3A03 and IBEHS 4F04 will be used extensively when designing the signal acquisition part of the project, this will be a major component of the design as it will be the main datapoint used for providing feedback to the user. The member will be responsible for ensuring that all hardware requirements are met for the device, ensuring stability, longevity, and proper functioning. To meet this the hardware team must calculate power delivery and signal integrity requirements when laying out the PCB and choosing components. Circuit design theory taught in ELECENG 2CI5, ELECENG 2CJ4 as well as transmission line theory taught in ELECENG 3FK4 will be applied to meet this objective. The programming of the microcontroller will be achieved with the microcontroller architecture knowledge obtained in COMPENG 2DX4, along with the software fundamentals of COMPENG 2SI4 and COMPENG 2SH4. Experience gained in design courses will be crucial to ensure that the project is approached from a true engineering point of view, with good problem solving and following the design process techniques taught in IBEHS 1P10, IBEHS 2P04 and IBEHS 3P04, all while keeping focus on ethics and safety learned in ENGINEER 4C03. On top of the education background, the electrical team member will apply the board layout and platform architecture learned while on co-op.

Courses in the mechatronics team member's undergrad align with the embedded systems and software objectives of the project. This project involves a range of challenges related to mechatronics engineering from selecting microcontrollers to designing firmware to meet data acquisition and performance requirements. Project-based integrated courses have also provided experiences that align with the capstone project experience. IBEHS 1P10 is an example where design and engineering content has been learned using healthcare problems. Ethics and professionalism, health and safety, computer science, programming, and materials are some of the topics that align with the current project objectives. A problem-solving approach to learning continued through IBEHS 2P04 and 3P04. Circuits courses such as design and analysis of analog and digital electrical circuits as well as component analysis, circuit analysis and digital circuit design will be utilized in this project. Data structures, algorithms, and language concepts learned in mechatronics will ensure good software practices are in place during software development. Advanced programming in mechatronics focused on embedded systems and specifications of software programs using pre-and post-conditions, loop and data type invariants as well as tools needed in demonstrating correctness. All these tools will be implemented in the design process within the scope of the group's project. Algorithm analysis for both time and memory, can be used to further explore the project during testing. Furthermore, programming in mechatronics focused on learning high-level programming languages like C, their features and how to implement systems using the CPU and the memory hierarchy. Additionally, the anatomy knowledge taught to both members in HTHSCI 2F03 and 2FF3 will be crucial in understanding how to design the UX to provide the feedback necessary for successfully performing CPR.