ME 218a Fall 2023: Ed's Grand Edventure
Semi-Automated Motor Home #vanlife

Grading Session on November 29 from 1-5 pm.
Project Presentation on November 29 starting at 7:00 pm.
Revision 3: 11/8/23

Goal:

The goal of this project is to provide a framework in which you can apply your knowledge of microcontrollers to provide an enjoyable experience for users and observers.

Purpose:

The underlying purpose of this project is to give you some experience building an electromechanical widget. We expect that this will involve working with sensors, driving actuators, designing event-driven software, and implementing that software in C on a PIC32 microcontroller. We expect to see all of these elements in every solution. Your lab kit contains sensors and several kinds of display, although you are not limited to using only these. You are limited to an expenditure of $120.00 / team *of your own money* for all materials and parts used in the construction of your project. Materials from the lab kit, the Cabinet of Freedom and any consumable supplies do not count against the limit; all other items count at their Market Value.

Background:

Ed is eagerly anticipating new adventures beyond the limits of the Stanford bubble, and has acquired a motor home to make berth anywhere, at any time. Excited as he may be with his new vehicle, Ed cannot help but notice the lack of ”smart” features incorporated into it. Non-mobile homes now feature products that automate everything from opening the windows to folding clothes, but it seems that the motor home market for ”smart” products has been forgotten! Novice and veteran 218ers, unwilling to let Ed return from teaching ”smart” product design to an adventure-filled life filled with ”dumb” chores, have decided to focus on designing and building a number of ”smart” products with which to festoon Ed's motor home, making the dream of a ”smart”, adventurous, on-the-road lifestyle a reality.

The Task:

Your task is to design and build a Portable Ed Automation & eNlightenment Tool (PEdANT), which is a device that semi-automates one key aspect of life in a motor home. Which aspect you choose to focus on can run the gamut from motor home essentials (deploying an awning, emptying the dump tank, navigating to the next destination, etc.) to the basics of everyday living (washing dishes, waking up, keeping insects away from food, etc.). The part to keep in mind is to **semi**-automate the task. We don't want to make anything too easy for Ed!

Specifications

Operation:

- ☐ The PEdANTs will power up into a welcoming mode, offering Ed the opportunity to interact with your PEdANT. Whenever it is in this mode it should indicate what action must be taken in order to commence the semi-automated task.
- ☐ It should take Ed approximately 60 seconds to complete the semi-automated task with your PEdANT. Even if Ed becomes very skilled at such interaction, it should never take less than 30 seconds.
- ☐ To provide Ed with a sense of progress toward task completion, each PEdANT should include a creative display of the passage of the time elapsed since starting the task. 7-segment displays don't count.
- ☐ To avoid leaving too many tasks unfinished, each PEdANT should display an error/timeout condition after 20 seconds after the last input from the user (Ed). After this, it should reset to the welcoming mode.
- ☐ The completion of the semi-automated task must involve at least 3 distinct interactions with the user and 3 distinct displays of feedback from the PEdANT.

- ☐ Your PEdANT should require large scale motion on the user's part for at least one of its interactions. Exercise is important when on an adventure!
- ☐ When the PEdANT determines that the semi-automated task is complete, it should provide a clear audio and/or visual indication of such completion. This indication may last no more than 30 seconds before the PEdANT resets to the welcoming mode. If the task has varying degrees of completeness (e.g. number of toasts buttered, or number of clothes folded), the PEdANT should also display the degree of completeness at this time.
- ☐ The PEdANT should be usable without the guidance of a ME 218 design/applications engineer. Any static instructions must be only in pictorial form (Think IKEA instructions).

Basic Specifications:

- ☐ A team of three class members will construct a PEdANT.
- ☐ The PEdANT must have parts that visibly move under the control of the PIC32 .
- ☐ While it is permissible to use consumer devices as components in a PEdANT, in order to avoid intellectual property (IP) issues, such devices must be substantially modified before being incorporated into your project. We don't want you to just buy significant portions of your project. If there is any question as to whether or not the purchased component has been modified significantly enough, please see the teaching staff.
- ☐ Each PEdANT must respond to at least three distinct inputs/interactions from the user.
- ☐ At least one of the user interactions must be interpreted as an analog input to the PIC32 from the user.
- ☐ The analog input must be used to produce some behavior by the PEdANT that makes use of the analog nature of the input. No simple thresholds.
- ☐ In addition to the analog input, at least one of the user interactions must involve non-contact sensing.
- ☐ Each PEdANT must provide the user with feedback about his/her actions. The feedback can take the form of an expression or gesture that the PEdANT displays. The feedback must include at least one of: haptic/audio/tactile feedback. Multiple modes of feedback, including modes not listed here, are encouraged.
- ☐ Interactions that involve cumulative action (e.g. counting repetitions over a set time period) are encouraged.
- ☐ The complete PEdANT must be a self contained entity, capable of meeting all specifications while connected only to the provided project power supply.
- ☐ In order to meet federal DOT requirements for motor homes, all components of the PEdANT MUST fit into a total volume no more than 50 cm wide by 50 cm deep by 100 cm high. During operation, the PEdANT should not require user input from more than 75 cm away from any part of the PEdANT. Two teams' PEdANTs must both be usable while sitting together on one of the 1.5 m wide tables in our classroom (550-200). The entire PEdANT must be easily and safely moved from the SPDL to the grading session and then to the trade gallery (i.e., to the 550 Atrium) for evaluation. Make sure that you plan for this.
- ☐ The emphasis in the project is on robust electronics, software and mechanical systems built with real craftsmanship. Paint alone does not add to either functionality or craftsmanship. This is not to say that you may not decorate the machine, but simply that it should not become a focus. Any painting that is done near the SPDL must be done using appropriate masking so that no paint residue is left on the building, furniture, sidewalk, driveways, grass, or trees. No painting in the SPDL! And no glitter!
- ☐ While it is normally not a good practice, the finished circuitry may be constructed on your solderless breadboards. This has been done to allow you the maximum time to spend on your project, without having to learn electronic prototyping techniques as well. Be sure to secure the bread-board and con-

nections so that they will not be disturbed during turbulence, take-off, landing or the moving process.

- ☐ Accurate schematics and state diagrams are such a useful aid in debugging that you should be prepared to show your up-to-date schematic or state diagram to any coach or TA whenever you ask them for help on your project.

Safety & Hygiene:

- ☐ The PEdANTs must be safe for both users and spectators.
- ☐ No glitter!
- ☐ Be considerate of your neighbors in the lab when debugging any audio output; use headphones.
- ☐ There is a strict ban on toxic materials. This prohibition includes Volatile Organic Compounds (VOCs) (i.e. hydrocarbon based spray paints or other noxious fumes). This prohibition also includes while you are working on the PEdANT in the SPDL.
- ☐ No painting in the SPDL (or anything attached to the SPDL).
- ☐ No part of the PEdANTs may become ballistic unless completely constrained within the PEdANT.
- ☐ No pyrotechnics or fire of any kind! Be advised that smoke contains chemicals known to the State of California to cause cancer, birth defects, or other reproductive harm.
- ☐ If the PEdANTs contain any liquids, they may not be conductive (with the exception of water) or corrosive, and MUST be packaged in a fail-safe manner while always being shaken, not stirred.
- ☐ The use of gremlins in you project is ferby-dden.

Checkpoints

Design Review:

During the day on **11/6/23** in room 162 of the Peterson building (our classroom building) we will conduct design reviews. Signups for the hour-long slots for 3 teams will happen via a Google Sheet. Each group should prepare a few **simple** PowerPoint slides (scans of sketches are OK). **No code, no state diagrams, no circuits.** The slides should show your concepts, a preliminary event list with responses, and a list of how you are going to meet the user interface requirements along with the feedback from the meeting with your coach. One member of the team must bring a laptop and any necessary adapters to produce a VGA or HDMI video signal to connect to the screen for your presentation. You will present these to other members of the class, members of the teaching staff and coaches (crewmates) so that all may hear about your ideas and provide feedback and advice. At this time you will be required to identify the core functionality of your proposed design and how it meets the interaction requirements.

First Checkpoint:

On or before **11/10/23**, you must submit a schematic of at least the core functionality initially identified on **11/6/23** and a refined set of events with details on the responses. Modifications to the core functionality may take place up to this point. A KiCad schematic within a word document describing your core functionality should be uploaded to Gradescope. Only one team member needs to submit your checkpoint documentation.

Second Checkpoint:

On or before **11/17/23** you will be required to demonstrate a minimal level of function:

1. The hardware & software necessary to do each of the following:
   (a) sense inputs (at least 3 user inputs)
   (b) make decisions (state machine with at least 3 states driven by keyboard input)
   (c) implement electromechanical actuation and user feedback
2. Submission of a KiCad schematic of your circuit will also be required.

Third Checkpoint:

On **11/28/23** you will be required to demonstrate integrated functionality of all sensing inputs, plus software and timing, plus activating all actuators that will be required. In other words, everything should be complete with the exception of improvements in user experience and fit, finish, and appearance.

Grading Session:

On **11/29/23** from **1:00 pm** to **5:00 pm** you will be required to demonstrate your fully integrated and finished machine.

Public Presentation:

This will take place on **11/29/23** starting at **7:00 pm** in the Atrium of Building 550. At this event, members of the public will be encouraged to act as Ed, and will interact with your PEdANTs.

Report:

Draft due on **12/4/23** by **4:00 pm**. The final version (with revisions incorporated) is due by **5:00 pm** on **12/7/23**.

Evaluation

Performance Testing Procedures:

All PEdANTs will be tested by a demonstration, performed by a team member, that should show all of the possible user interactions.

Grading Session Presentation:

Each team should prepare a 30 second (no more) presentation to introduce their PEdANT. This presentation should highlight the unique features of the design, not the circuit or software details. As an example, think back to the xylophone descriptions that were played on the first day of class. You will be setting up your PEdANT, one at a time, and delivering your presentation in room 202 Thornton between 1:00 pm & 5:00 pm on the day of the presentations. During this time each team and their PEdANT will be photographed. Starting at 5:00 pm you will move your PEdANT into the Atrium for the public presentation, which will begin at 7:00 pm.

Grading Criteria:

- ☐ **Concept (20 %)** This will be based on the technical merit of the design and coding of your project. Included in this grade will be evaluation of the appropriateness of the solution, as well as innovative hardware, software and use of physical principles in the solution.
- ☐ **Implementation (20 %)** This will be based on the prototype displayed at the evaluation session. Included in this grade will be evaluation of the physical appearance of the prototype and quality of construction. We will concentrate heavily on craftsmanship and finished appearance.
- ☐ **Performance (40 %)** Half of this (20 %) will be based on the results of the checkpoints, the other half will be based on the results of the performance testing during the evaluation session. Full performance credit will be given only if the machine works on the first attempt during the grading session. Performance will be judged first on the ability to demonstrate the core functionality and second on any embellishments to the core functionality. **To earn the performance points, you must demonstrate at least the core functionality.**
- ☐ **Report (10 %)** Preliminary project reports are due **12/4/23** at **4:00 pm**. The report should be in the form of a stand-alone web site and must include schematics, pseudo-code, header & code listings, dimensioned sketches/drawings showing relative scale, a complete Bill-of-Materials (BOM) for the project as well as a 1 page description of function and a "Gems of Wisdom for future generations of 218ers" page. The actual website must be hosted and you must submit the URL to your site in the specified spreadsheet. It is critical that the URL to your report be in the spreadsheet on time so that the peer reviewing team will have an adequate opportunity to review it before class the following day. Final versions of the reports, incorporating the review comments are due by **5:00 pm** on **12/7/23**.

- ☐ **Report Review (10 %)** These points will be awarded based on the thoroughness of your review of your partner team's report. Read the explanations, do they make sense? Review the circuits, do they look like they should work? Could this project realistically be built for $120? If, during grading, we find things that don't make sense or circuits that won't work we will consult your review. If the review caught them, then the team will lose points on their report. If the reviewers missed it, then they will lose points for their review. The report review should be submitted on Gradescope by **5:00 pm** on **12/7/23**.

Resources

Websites:

SparkFun (www.sparkfun.com)
Jameco (www.jameco.com)
Newark (www.newark.com)
Adafruit (www.adafruit.com)
Digi-Key (www.digikey.com)
HobbyKing (www.hobbyking.com)
Seeed Studio (www.seeedstudio.com)
Mouser (www.mouser.com)
Ponoko (www.ponoko.com)
Hackaday (www.hackaday.com)
McMaster-Carr (www.mcmaster.com)
ServoCity (www.servocity.com)

You may also find PlantUML and PlantText helpful for creating diagrams of various types.

Local Stores:

Anchor Electronics in Santa Clara
Sheldon's Hobbies in San Jose
Jameco in Belmont
TAP Plastics in San Mateo

Gems of Wisdom:

Be sure to check out The ME218 Archive for guidance from past generations.

Revision History

Revision 0: Initial version. (11/4/23)
Revision 1: Typographical errors, title change, "progress" clarification. (11/4/23)
Revision 2: Removed errant sentence from First Checkpoint (11/6/23)
Revision 3: Clarification on project expenses (11/8/23)