ME218

ME 218a Fall 2021: SPIfall
The World is Not Enough
Grading Session on November 17 from 1-5 pm.
Project Presentation on November 17 starting at 7:00 pm.

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 a driver suitable for 8 LEDs, although you are not limited to using only these. You are limited to an expenditure of **$120.00 / team** 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:

The Q-division is dealing with supply shortages and needs your help in developing training devices for the next generation of Double-O agents. While Blofeld may be gone, there are legions of his minions looking to pick up where he left off. In particular there is a group that refers to themselves as the 3Teners that have made surprisingly fast progress on a replacement for Spectre. In order to stop their plans, we need more agents to be trained by as soon as possible. However, Q hasn't figured out exactly how one would go about training agents in defusing a bomb, rappelling down a building, offensive driving, walking away from a helicopter crash unharmed...— you know, the basics. Don't worry, Q has given you 3 PIC32s, 3 LED matrix displays and 3 boxes of miscellaneous parts to use as a starter, with the promise of more parts to be available in the SPDL branch of Q-Division.

Your mission, should you 'decide' to accept it: develop a Government Approved Device for Global Espionage Training (GADGET) to help turn out new Double-Os as fast as possible. Your trainer needs to be ready before the first crop of new recruits arrives for their Basic Training (on November 17).

The Task:

Your GADGET will be installed in the remote MI6 branch hidden in Building 550 on Stanford Campus (that is, distributed around the Atrium of Bldg. 550 (our classroom building)). There they will be presented to the Advanced Global Espionage ageNt Trainees (AGENTs). The AGENTs will wander around the room interacting with the GADGETs[1] to prepare to take on the 3Teners. You should strive to make your GADGET exciting, active, durable, educational, and electromechanical.

> *My doctor says I can't have bullets enter my body at any time.*

> *Casino Royal*

Specifications

GADGET Operation:

☐ The GADGETs will power up into a welcoming mode, offering AGENTs the opportunity to interact with your GADGET. Whenever it is in this mode it should inspire a sense of loyalty to Queen and Country in the AGENTs.

☐ To quickly bring people up to speed on how to keep calm and carry on, it should take the average AGENT approximately 60 seconds to interact with your GADGET. No one except James Bond should be able to completely master your GADGET in less than 30 seconds.

---

[1]Remember that this is an acronym. *The New York Times* has addressed this in the past. This is how you pluralize an acronym.

☐ To emphasize the lurking menace of the 3Teners, each GADGET should include a creative display of the passage of the time since the AGENTs have started using the GADGET. **7-segment displays don't count.**

☐ To avoid detection, your GADGET must only operate when in active use by AGENTs. The GADGET should reset to the welcoming mode within 30 seconds after the AGENT stops interacting with the GADGET.

☐ To account for any unforeseen situations that could arise in the field, your GADGET should involve at least 3 distinct AGENT interactions.

☐ Your GADGET should require large scale motion on the part of the AGENT for at least one of its interactions.

☐ When the GADGET completes its task, it should provide a clear audio and/or visual indication that it is no time to die. This indication may last no more than 30 seconds before the GADGET resets.

☐ The GADGET should be usable without the guidance of a member of Q branch. To respect our American colleagues in the CIA, any static instructions must be only in pictorial form (Think IKEA[2] instructions).

Basic Specifications:

☐ A team of three class members will construct a GADGET.

☐ The GADGET must have parts that visibly move under the control of the PIC32 .

☐ While it is permissible to use consumer devices as components in a GADGET, Q requires that 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 GADGET must respond to at least three distinct inputs/interactions.

☐ 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 GADGET 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 GADGET must provide the user with feedback about his/her actions. The feedback must include at least one of: haptic/audio/tactile feedback. Multiple modes of feedback, including modes not listed here, are encouraged.

☐ The complete GADGET must be a self contained entity, capable of meeting all specifications while connected only to the provided project power supply.

☐ In order to hide it in an Aston Martin DB-5, all components of the GADGET **MUST** fit into a total volume no more than 50 cm wide by 50 cm deep by 100 cm high. During operation, the GADGET should not require user input from more than 75 cm away from any part of the GADGET. Two teams' GADGETs must both be usable while sitting together on one of the 1.5 m wide tables in our classroom. The entire GADGET must be easily and safely moved from the construction site to the grading session and then shipped to the MI-6 review space (i.e., to the 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 bread-boards. 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 connections so that they will not be disturbed by the moving process.

---

[2]Intragalactic Knowledge Enforcement Agency

☐ 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 GADGETs 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 GADGET in the SPDL.

☐ No painting in the SPDL (or anything attached to the SPDL).

☐ No part of the GADGETs may become ballistic unless completely constrained within the GADGET.

☐ No pyrotechnics or fire of any kind! Vodka is **EXTREMELY FLAMMABLE**, so do not test the fire suppression system. Be advised that smoke contains chemicals known to the State of California to cause cancer, birth defects, or other reproductive harm[3].

☐ If the GADGETs 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.

Checkpoints

Design Review:

During the day on **November 1** in room 162 & the Grove 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. 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 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.

> *Time to face gravity!*
>
> *Die Another Day*

First Checkpoint:

On or before **11/5/21**, you must submit a schematic of at least the core functionality initially identified on 11/1/21 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.

> *I think he got the point.*
>
> *Thunderball*

Second Checkpoint:

On or before **11/11/21** you will be required to demonstrate a minimal level of function:

- The hardware & software necessary to do each of the following:
  - sense inputs (at least 3 user inputs)

---

[3]Proposition 65, California Health and Safety Code §25249.6 et seq.

- make decisions (state machine with at least 3 states driven by keyboard input)
- implement electromechanical actuation and user feedback
- Submission of a KiCad schematic of your circuit will also be required.

Shocking. Positively shocking.

Goldfinger

Third Checkpoint:

On **11/15/21** 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.

There's a saying in England. When there's smoke, there's fire.

From Russia with Love

Grading Session:

On **11/17/21** from **1:00 pm to 5:00 pm** you will be required to demonstrate your fully integrated and finished machine.

In your defense, a moving target is harder to hit.

Skyfall

Public Presentation:

This will take place on **11/17/21** at **7:00 pm** in the Atrium of Building 550. At this event, members of the public will be encouraged to act as AGENTs, and will interact with your GADGETs.

Q: Age is no guarantee of efficiency. James Bond: And youth is no guarantee of innovation.

Casino Royale

Report:

Draft due on **11/29/21** by 4:00 pm. The final version (with revisions incorporated) is due by 5:00 pm on **12/3/21**.

A good agent doesn't need GADGETs. The only GADGETs I've ever needed are a sharp eye, sensitive hearing and a whole bunch of bigger brains.

Johnny English

Evaluation

Performance Testing Procedures:

All GADGETs 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 GADGET. 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 GADGET, 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 GADGET will be photographed. Starting at 5:00 pm you will move your GADGET 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 for the GADGET. 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 **November 29, 2021** 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 12/3/21.

☐ **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 GADGET realistically be built for $175? 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 4:00 pm on 11/30/21.

Suggestions

We understand that the project definition is probably a bit more open than you might be used to. To help you get your creative juices flowing we offer some reflections that you might want to consider.

☐ Don't just think buttons. Think about novel ways to sense an action and give feedback. Remember, you have more than just fingers available to actuate and you are mechanical engineers (at least most of you). Think fun linkages!

☐ **The Tao of 218:** Simplicity Leads to Reliability. Remember, Diamonds Are Forever, but you have only 456 hours available to complete the project (and tend to the other things in your life) before it is due.

☐ Consider your person-power. If you reference the ME218 Archive (me218archive.stanford.edu), be sure to note that most of the ME218a projects there were completed by a team of 4 and you only have a team of 3. We will be taking that into account. Be sure that you do too.

Exercise your creativity:

We encourage, and hope to foster, a wide range of solutions to the problem. This will make for the most enjoyable presentation for your audience. There is no "best" way to solve this problem (or best problem to solve), so don't spend time looking for it. While brainstorming, consult Dr. No, The Man with the Golden Gun or The SPI Who Loved Me for inspiration.

Remember that we interact with electronic devices every day. People tend to have more fun with projects that don't try to emulate the look and feel of actual products. ME218 is an opportunity to design things that are **fun** and **whimsical**. Take advantage of that.

Make your project robust:

Your machine must be rugged enough to survive your testing as well as "testing" by the audience. Don't be timid about playing with your project before the presentation. Play with it as if you didn't know its weaknesses. Let your friends play with it. Find out if it can survive people playing with it before the presentation.

While the emphasis in the lecture has concentrated on the electronics and software, don't forget the mechanical aspect. Historically, project failures are often due to poor mechanical design or implementation. Pay attention to craftsmanship. It will pay dividends in many ways.

Resources

Websites:

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

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 (me218archive.stanford.edu) for guidance from past generations.