ME 218a Fall 2018: Operation Earth
A Mildly Convenient Solution to an Inconvenient Truth

Grading Session on November 28 from 1-5 pm.
Project Presentation on November 28 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 Tiva LaunchPad. We expect to see all of these elements in every solution. Your lab kit contains sensors and signal & power transistors, although you are not limited to using only these. You are limited to an expenditure of **$160.00 / 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:

Al Gore, "inventor" of the internet, is mad.

He's been giving increasingly desperate talks for the better part of two decades, and nothing continues to happen. Even the IPCC[1] Special Report on Global Warming of 1.5 °C didn't cause any lasting discussion. At a loss for things that will *actually* get people to *actually* make changes in their own lives and advocate for policy, he's decided to go to the smartest people on the planet.

For some reason, he thinks that's the students of ME218A.

He's asked for prototypes of ways to get people passionate about climate and the environment, but there's no funding for it, so you'll have to make do with just a Tiva, Duron, and some random nuts and bolts.

You need to turn these meager supplies into a Training Resource for Environmental Education (TREE). These TREEs will then be displayed to the general public; your goal is that after having interacted with your device, the populace will leave as an Apprentice enviRonmentalist Behaving Optimistically to Reduce Impact via Science and Technology (ARBORIST).

The Task:

Your TREE will be planted in Ms. Frizzle's classroom (that is, distributed around the Atrium of Bldg. 550 (our classroom building)) to be presented to the ARBORISTs. The ARBORISTs will wander around the room interacting with the TREEs to harvest knowledge about good environmental practices. You should strive to make your TREE exciting, active, durable, educational, and electromechanical.

> *It is my mission to change the world. I'm not kidding: make no small plans, dream mighty things. I feel if we get enough people engaged in climate change, we will get enough people to change the world.*
>
> *Bill Nye the Science Guy*

Specifications

TREE Operation:

- ☐ The TREEs will power up into a welcoming mode, encouraging interaction with the ARBORIST. Whenever the device is in this mode it should inspire curiosity in the ARBORISTs.
- ☐ As a representation of how easy it can be to make these changes in one's life, it should take the average ARBORIST approximately 60 seconds to interact with your TREE. No one except Al Gore should be able to completely evaluate your TREE in less than 30 seconds.

[1] Intergovernmental Panel on Climate Change

- ☐ To create a sense of urgency, each TREE should include a creative display of the passage of the time since the ARBORISTs have begun their evaluation. **7-segment displays don't count.**
- ☐ Since ARBORISTs cannot effectively learn without doing[2], your TREE must interact with the ARBORISTs. The TREE should reset within 30 seconds after the ARBORIST stops interacting with the TREE.
- ☐ To accommodate ARBORISTs with different learning modalities, your TREE should involve at least 3 distinct ARBORIST interactions.
- ☐ Your TREE should require large scale motion on the part of the ARBORIST for at least one of its interactions.
- ☐ When the TREE completes its educational experience, it should provide a clear audio and/or visual indication that will inspire the ARBORISTs to change their behavior to save the world. This indication may last no more than 30 seconds before the TREE resets.
- ☐ The TREE should be usable without the guidance of a Master Environmentalist of the 218th Rank. To respect the diverse languages of Earth, any static instructions must be only in pictorial form (Think IKEA[3] instructions).

Basic Specifications:

- ☐ A team of four class members will construct a TREE.
- ☐ The TREE must have parts that visibly move under the control of the Tiva LaunchPad.
- ☐ While it is permissible to use consumer devices as components in a TREE, environmental regulations require that such devices must be substantially reduced, reused, and recycled 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 TREE 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 Tiva from the user. The analog input must be used to produce some behavior by the TREE 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 TREE 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 TREE must be a self contained entity, capable of meeting all specifications while connected only to the provided project power supply.
- ☐ In order to fit into a USPS[4] Flat-Rate Box, all components of the TREE **MUST** fit into a total volume no more than 18" wide by 18" deep by 36" high. During operation, the TREE should not require user input from more than 24" away from any part of the TREE. Two teams' TREEs must both be usable while sitting together on one of the 5' wide tables in our classroom. The entire TREE must be easily and safely moved from the construction site to the grading session and then shipped to Ms. Frizzle's classroom (to the Atrium) for evaluation in an educational context. 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, 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!

[2] Bonwell, C. and Eison, J. (1991) *Active Learning: Creating Excitement in the Classroom*. Washington, D.C.: Jossey-Bass.
[3] I'm Kind to the Environment Assembly
[4] Actually the United States Postal Service

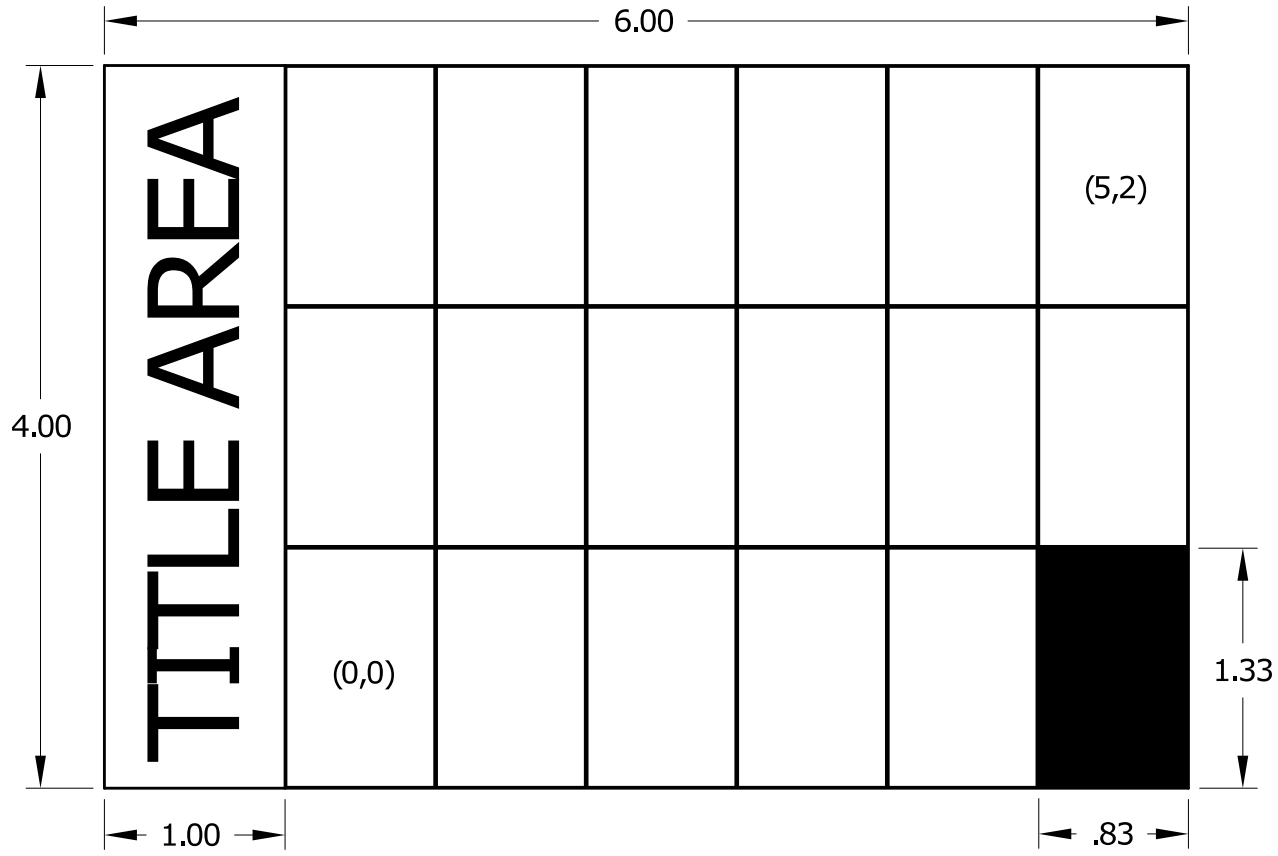

Figure 1: Schematic of the LEAF. The LEAF is a 4” by 6” index card; at one edge there is a 1” strip reserved for adding a title commemorating the public presentations. The remainder of the LEAF is divided into 18 regions, assigned coordinates as `(<longitudinal index>, <transverse index>)`, where indices are zero-indexed. Each team will be assigned one region. The location at `(5,0)` is filled entirely in black to aid in card validation. All dimensions in inches.

- ☐ 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.
- ☐ 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.

The LEAF:

- ☐ To provide a memento and track the educational experience of the evening, each ARBORIST will be provided with a standard Lightweight Environmental Actions File (LEAF) by SPDL, as shown in Figure 1.
- ☐ The TREE should only operate when a LEAF is correctly inserted, and should stop interacting with the ARBORIST if the LEAF is removed prior to completion of the learning experience.
- ☐ One corner of the LEAF is colored black to assist in accurate detection of the LEAF.
- ☐ Sensing and interaction elements required to interface with the LEAF do not count towards project requirements defined in the previous section.
- ☐ All TREEs should be clearly marked to indicate the orientation that the LEAF should be inserted. It is

encouraged that TREEs be designed to accept LEAFs[5] such that the title remains visible.

- ☐ Each TREE should stamp, mark, or otherwise modify the LEAF to indicate the successful completion of the learning module by the ARBORIST.
- ☐ It should be impossible to modify the LEAF without first completing the full experience of your TREE.
- ☐ Each team will be assigned a particular coordinate within the LEAF; that team's TREE may only affect the LEAF within this region. If your team wishes to pre-populate a black-and-white graphic within this region, the graphic must be submitted to SPDL by the Monday prior to the public presentation session. Be aware that the image will be scaled to fit the region on the LEAF, and ensure that your graphic will be legible at this scale.
- ☐ Modifications made by TREEs to the LEAF are encouraged to be representative of the lesson your TREE is presenting.

Safety & Hygiene:

- ☐ The TREEs 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 TREE in the SPDL.
- ☐ No painting in the SPDL (or anything attached to the SPDL).
- ☐ No part of the TREEs may become ballistic unless completely constrained within the TREE.
- ☐ No pyrotechnics or fire of any kind! These are not only dangerous, they also increase the amount of CO2 in the atmosphere and aid in global warming. Smoke contains chemicals known to the State of California to cause cancer, birth defects, or other reproductive harm[6].
- ☐ If the TREEs contain any liquids, they may not be conductive (with the exception of water) or corrosive, and **MUST** be packaged in a fail-safe manner.

Checkpoints

Design Review:

During the day on **November 7** in room 162 & the Grove of the Peterson building (our classroom building) we will conduct design reviews. Signups for the hour-long slots for 4 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 be used in connecting 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.

Our planet's alarm is going off, and it's time to wake up and take action!

Leonardo DiCaprio

First Checkpoint:

On or before **11/9/18**, you must submit a schematic of at least the core functionality initially identified on 11/7/18 and a refined set of events with details on the responses. Modifications to the core functionality may

[5] Remember that this is an acronym. *The New York Times* has addressed this in the past. This is how you pluralize an acronym.
[6] Proposition 65, California Health and Safety Code §25249.6 et seq.

take place up to this point. An Altium schematic in a word document describing your core functionality should be uploaded to Gradescope. Only one team member needs to submit your checkpoint documentation.

It's time to take chances, make mistakes, get messy!

Valerie Frizzle

Second Checkpoint:

On or before **11/15/18** 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)
  - detect the correct insertion of a card
  - make decisions (state machine with at least 3 states driven by keyboard input)
  - implement electromechanical actuation and user feedback
- Submission of an Altium schematic of your circuit will also be required.

Only waste time on things that are important.

J Edward Flahie

Third Checkpoint:

On **11/26/18** 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.

It's not easy being green.

Kermit the Frog

Grading Session:

On **11/28/18** from **1:00 pm to 5:00 pm** you will be required to demonstrate your fully integrated and finished machine.

I speak for the TREEs for the TREEs have no tongues.

The Lorax

Public Presentation:

This will take place on **11/28/18** at **7:00 pm** in the Atrium of Building 550. At this event, members of the public will be encouraged to act as operators of the TREEs.

Time spent among TREEs is never wasted.

Anonymous

Report:

Draft due on **12/3/18** by 4:00 pm. The final version (with revisions incorporated) is due by 5:00 pm on **12/7/18**.

What you do makes a difference, and you have to decide what kind of difference you want to make.

Jane Goodall

Evaluation

Performance Testing Procedures:

All TREEs 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 TREE. 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 TREE, 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 TREE will be photographed. Starting at 5:00 pm you will move your TREE 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 TREE. 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 **December 3, 2018** 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 submitted as **a single Zip file** (7-zip is installed on all the workstations in the lab). In addition, if your website is hosted, you must **include a text file with the URL to your site**. It is critical that your report be in the Reports folder 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 (also in the form of a single zip file plus URL) by 5:00 pm on 12/7/18. The front page of your project description must be in a file called `index.html` at the root folder of the web site. Test your zip-file by unzipping it into an empty folder. Once un-zipped, you should be able to view the entire site starting from the `index.html` file. **Do not embed video files directly into your site.** If you want to include video, link to YouTube or another video sharing site.
- ☐ **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 TREE realistically be built for $160? 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 submitted be in the form of a Word document that you place into one of your team members folders by 4:00 pm on 12/4/18.

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, you only have 456 hours available to complete the project (and tend to the other things in your life) before it is due.

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, so don't spend time looking for it. While brainstorming, look to your favorite science and environmental educators (real or fictional) 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:

J&M Hobby House in San Carlos
Jameco in Belmont
TAP Plastics in Mountain View

Gems of Wisdom:

Be sure to check out The ME218 Archive (me218archive.weebly.com) for guidance from past generations.