

## Engineering Design Midyear Project

### Electro-mechanical Musical Instrument

Build a primitive electro-mechanical musical instrument that you can use to play any simple tune on request, and that you can teach others to play their own tunes. You must be able to reliably play at least 12 notes: a major scale plus two (do re mi fa sol la ti do re mi), and fa-sharp and ti-flat. (*If you think of this as C to E plus F-sharp and B-flat, you can see that you can play almost any simple tune in C, a, F, d, G, or e, depending on where it lands in the scale – many carillons use this trick.*) In addition to delivering and demonstrating your instrument, you must also deliver an instruction manual for how to play it.

This project may be completed by anyone as an individual, or by a team of two. Each member of the team earns 70% of the points for the project as a whole.

Since a major portion of this project is exploring and evaluating design options, you also must deliver an Engineering Report that documents how you conducted your initial research into design options, which ones you considered, which you evaluated in detail and how, and why you chose your eventual solutions. Note that if you are maintaining a good lab notebook recording your data and decisions, this report will be easy to write!

	Milestone	Points	
1	Design Options	10	See below
2	Design Evaluations	15	See below
3	5-Note Arpeggio	10	Play C-E-G-C-E in any order requested as quarter-notes
4	12-Note “scales”	20	Play any requested 8-note scale that is possible using the 12 implemented notes as quarter-notes
5	4 Durations	20	Play whole, half, quarter and eighth notes in 4/4 time. Repeating shorter notes to form longer ones is NOT permitted – they must sound continuously.
6	$\frac{3}{4}$ Durations	10	In 3/4 time (think waltz), play whole, half (actually $\frac{2}{3}$ ), and quarter (actually $\frac{1}{3}$ ) notes. This must be possible during the same performance without reattaching the computer although a slight pause to change time signatures is permitted (think “between movements”)
7	Dotted Notes	10	Play dotted half and quarter notes in 4/4 or 3/4 time
	Volume control	10	Control the volume of notes when they are played, including during a sustained note.
	Chromatic (C-C-E)	10	Play any of these 17 notes in any order requested

	2 Octave Chromatic (C-C-C)	10	Play any of these 25 notes in any order requested
	Final Engineering Report	20	See below
	Instruction Manual	10	See below

Not all features must be implemented for the project. The instrument must not be connected to the PC during a “performance” consisting of many songs; the program used must be completely general. It must be playable (poorly) by an amateur musician such as Mr. Holthouse or Mr. Jibson, with suitable instruction. For final delivery, a single engineer will be asked to “sight play” simple songs to demonstrate the “playability” of the instrument.

Interim Milestones may be delivered in any order, but must show that all previously delivered features work in combination with the new feature(s). Note that Milestone 7 includes multiple features; those implemented must be delivered together.

To make a delivery, you must first submit the Interim Delivery or Final Delivery assignment on Canvas. All “play” Milestones deliveries must include a current draft of the Instruction Manual for all features to be demoed, as well as the .bs2 you will use, and a .dsn file showing the circuit(s). You then must demonstrate that all the features work during the class following delivery or at another time mutually agreed

You can use any of the electronic components in your kit, and as many resistors and capacitors and as much wiring as you like. Note that your kit includes a digital POT and two 2N3904 transistors (Chapter 9), two illegal-in-Europe photo-resistors, and two infrared LEDs and receiver pairs that you can use to determine distances from an object as described in Chapters 7 and 8 of the Boe-Bot book. If you wish, you can purchase up to \$20 of additional electronic components, ([www.digikey.com](http://www.digikey.com) and You-Do-It Electronics in Needham are handy sources), but any circuits must be powered solely by your Board of Education. You may also use any of the materials listed in the last section below for building and attaching user input mechanisms (keyboards, swell pedals, duration studs, etc.). The intended output is your piezo speaker, although you can use any off-the-shelf speaker you wish. *Remember that your Basic Stamp processor only has 16 on/off inputs and outputs!*

### Engineering Report

The Engineering Report consists of the sections described below. The Design Options and Design Evaluations sections can be delivered as separate Milestones, but should be combined into the Final Engineering Report.

#### Introduction (5 points)

- Photos of the instrument
- Summary of features implemented and quality of each

#### Design Options (10 points)

- Strategy use to research possibilities
- Summary of key web sites or other resources found, explaining the key conclusions drawn from each
- List of possible designs for intended features; there should be at least three each for controlling notes and for controlling durations and every feature should be addressed, even if only to eliminate it from the plan.

Design Evaluations (15 points) – for each of the possible designs:

- Specific tests performed
- Numeric or equivalent results obtained
- Conclusions drawn from these results

Results (10 points)

- Problems encountered in implementing the designs
- Design changes made as a result of these problems or opportunities discovered
- Recommendations for “Version 2”

The complete report must be delivered as a single, professional-quality .pdf file, double-spaced. It's important that the document look clean and “hang together”. Text should be free of obvious grammatical and spelling errors; use the spell and grammar checkers! Photos, drawings and figures should be embedded in the document electronically. Don't get carried away with fonts and formatting, but it should have consistent section headers, paragraph styles, fonts, etc. Before you turn it in, ask yourself “would I give this to the person responsible for my next raise, or for even keeping me on the payroll?” (5 points)

### Instruction Manual

This must provide detailed instructions for how to play the instrument, including all the features. It must also be delivered as a single, professional-quality .pdf file. It must show pictures of the instrument while it is being played. You can assume the reader knows how to read music, and can play some other melodic instrument such as piano, guitar, trumpet, violin, etc.

### Academic Integrity

It is critical that you record all the sources you used to come up with your ideas and designs in the Engineering Report, including your initial Google searches (or the equivalent). In the Real World, this would be the basis for a patent review both to defend yourself against infringement, and support possible patent filings of your own. For the purposes of this project, your solution should be original and “patentable” with respect to the class. If your project ends up closely resembling someone else's, you will both have to show convincingly that you came up with the ideas, including the sources you used for ideas, on your own.

You may start with any code or circuits you personally built as part of the class as long as you note that in comments in your code. Similarly, if you use any Basic Stamp code from the text or web, you must note that as a comment as well. You may NOT use anyone else's code from the

class, nor may you ask any other human in person, electronically, or telepathically to help you write your code or design your mechanisms or circuits.

### Allowable Electro-Mechanical Parts

You may use only the materials listed below and are responsible for acquiring them yourself. Some may be available in the lab, but no promises, and you may NOT use anything without asking nicely first.

Adhesive Tape; any kind	Paint	Spools and Bobbins
Aluminum Drink Cans	Paper	Staples
Binder Clips	Paper Clips	Straight Pins
Bottle Caps	Paper or Plastic Bags	Straws and Coffee Stirrers
Balloons (no helium)	Pencils	String and Thread
Cardboard	Pens and Markers	Styrofoam Peanuts
Caulk	Pipe Cleaners	Tacks
CDs and DVDs	Plastic Drink Bottles	Tongue Depressors
Cloth	Plastic Forks, Spoons and	Toothpicks
Crayons	Knives	Twistie-ties
Fishing Line	Plastic Mesh	Velcro
Foam	Popsicle Sticks	Washers
Foam Board	Rubber Bands	Wax paper
Glue; any kind	Safety Pins	Wire Coat Hangers
Manila file folders	Sandpaper	Wire; any type
Modeling Clay	Screws, Nuts and Bolts	Wood; any type
Nails	Solder	