

**DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING
THE UNIVERSITY OF TEXAS AT ARLINGTON**

**SYSTEM REQUIREMENTS SPECIFICATION
CSE 4316: SENIOR DESIGN I
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**LIGHT LUTHIERS
LASER HARP**

**SOHAIB SIDDIQUI
SIDDHARTH BANERJEE
ZACKARY G
MITCHELL LUX
MICHAEL MORROW**

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1 PRODUCT CONCEPT

This section describes the purpose, use and intended user audience for the Laser Harp. Laser Harp is an electronic system that mimics the performance of a harp, a musical instrument. The 13 lasers emitted by the system represents a full musical octet. User of this system will be able to play this portable and semi-mobile device with them without having to carry a bulky musical instrument. This is intended to be used as a complete replacement of a traditional music device and will future concept systems like these would revolutionize the electronic musical space. The 'coolness' factor will attract school students, musical educators, professional musicians to try out digital musical devices. Electronic sound production is already replacing use of traditional musical instruments in online space such as YouTube, where You-Tubers can produce their own music for their channels using software. This system will take that concept and create a hardware based approach where users can produce cool digital music on the fly by learning some basic instrument moves. The revolution in this space is already happening today where we see professional competitions for musical performances with a laser harp.

1.1 PURPOSE AND USE

The product should play corresponding notes from an actual harp when the user interrupts one of the 13 laser beams. The distance will measure the note to be played. We expect that the user switched on the device and lets the system initialize the hardware. Once that is done, the user can select an output volume and the voice to be played and start blocking laser beams to produce sound patterns.

1.2 INTENDED AUDIENCE

This is where you describe the intended audience(s) of your product. If this product were to be made available publicly or commercially, who would purchase or use it? Is the product designed for a particular customer, or an overall class of customers? Is it intended for general use, or is it a specific component of a more complex system? The intended audience of this system are students, musical educators and professional musicians. We want students to learn music and gain interest in electronic and embedded systems through something interesting. This will help generate curiosity in production of such systems and their vast applications and hopefully encourage them to choose a path in engineering to design systems. Musical educators can use them to teach music in a more interactive and fun way, making their students feel more immersed with the use of their hand gestures. We also would expect professional musicians to adopt devices such as this and others to make performances seem cool and different. When used at concerts, attendees would be more enamored by musicians actually moving their hands and producing music.

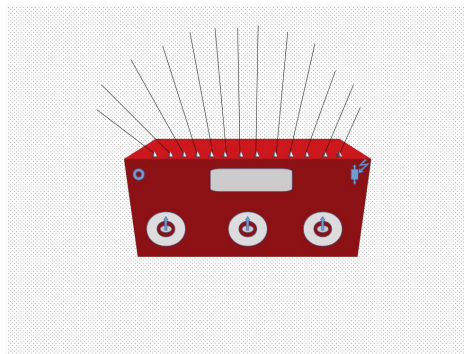
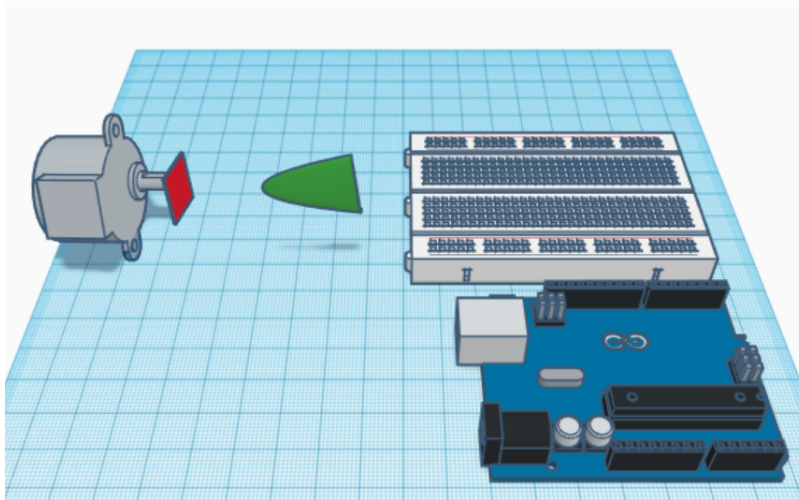


Figure 1: Laser Harp conceptual drawing



2 PRODUCT DESCRIPTION

The purpose of this section is to provide the reader with a more detailed overview of the Laser Harp by the Light Luthiers. The primary functional facets of the Laser Harp are defined here for end users as well as stakeholders/administrators. The key operational aspects of the Laser Harp are defined here as well in all manners of detail, ranging from how it works to how to operate it.

2.1 FEATURES & FUNCTIONS

The Laser Harp, or simply the Harp, will be able to play music like a normal harp would, except instead of having physical strings, it will have green lasers that, when interrupted (such as by an end user's hands), will play the tones that a normal harp would. It will have thirteen distinct lasers that will play thirteen distinct notes, allowing users to play one complete octave. As shown in the image at the top of this page, there will be a mirror (red) attached to a stepper motor (grey). A single laser (green) laser will be pointed at the mirror. The motor will have 13 steps and will go through the steps to give the illusion of having thirteen laser beams constantly pointing upwards. This set up will be connected to an Arduino and breadboard (shown in the figure). There will be a built in speaker (not pictured) that is to play the notes when the corresponding laser is broken.

2.2 EXTERNAL INPUTS & OUTPUTS

There will be an on/off switch to turn the Harp and lasers on and off. The lasers will need to be broken by the end user to play the notes. There will be built-in speakers that will play the notes of the harp.

2.3 PRODUCT INTERFACES

The user must turn on the Harp, and there will be thirteen lasers that will shoot upwards. Users must be careful so as not get any of the beams in their eyes. The user must interrupt the lasers so as to play the notes.

3 CUSTOMER REQUIREMENTS

The product should mimic the use of a harp and play all the tunes a harp can produce. In order to achieve this, the customer would require the presence of 13 laser strings to represent tunes on a full chromatic scale. The customer expects the product to be portable and semi-mobile. The product should have in-built speakers so that customer does not need to scramble for compatible speakers. The device should have, at minimum, one knob that can be used to adjust the volume of the speakers. Additional knobs maybe used for changing the voice or the volume output device. The lasers emitted should be visible in low-light setting. For an additional volume output, the customer would like to a quarter-inch output, as well as a MIDI over USB. In addition and if possible a distortion knob would be nice to have

3.1 LASER STRINGS

3.1.1 DESCRIPTION

the device should have 13 laser string in order for the product to be accepted by the customer. In the absence of this, the device cannot reproduce music as 13 strings represent the full chromatic string. Each string should be visible in low-light settings and should not be harmful to the skin. The laser strings should also have distance sensor that senses the distance at which the user breaks the laser string. This represents the specific sound that position of the finger on the harp would produce.

3.1.2 SOURCE

The source of the requirements is the CSE senior design specifications as assigned to us by our instructor.

3.1.3 CONSTRAINTS

The laser should be visible in low-light setting and must not be harmful to the skin.

3.1.4 STANDARDS

ANSI Z136.1 - Safe Use of Lasers

ANSI Z136.5 - Safe Use of Lasers in Educational Institutions

3.1.5 PRIORITY

The priority of this requirement relative to other specified requirements. Use the following priorities:

- Critical (must have or product is a failure)

3.2 IN-BUILT SPEAKERS

3.2.1 DESCRIPTION

The device should have in-built speakers. This ensures that the client does not need to worry about purchasing the right compatible speakers. Additionally, one of the major requirements for the device is its portability. Having in-built speakers ensures that the device does not need additional items in order for it to be used at its minimum specifications.

3.2.2 SOURCE

The source of the requirements is the CSE senior design specifications as assigned to us by our instructor.

3.2.3 CONSTRAINTS

The speakers should be able to fit in the 3-D printed case and should draw not draw too much power.

3.2.4 STANDARDS

AES3 (2-channel digital audio)

3.2.5 PRIORITY

Critical (must have or product is a failure)

4 PACKAGING REQUIREMENTS

This section describes how the product will be packaged when delivered to or used by the end user, as well as how the product is supposed to look. The product will be housed in a 3D printed case to protect the internal circuits, mechanisms and devices. The design of the housing is yet to be determined, though it depends wholly on the configuration of the internal parts. If the product needs to be shipped, it will be shipped in a box and protected with bubble wrap as, though the product will not be too fragile, it will not be designed to take knocks and bumps continuously. No assembly or software installation will be required to use the product. The product will be a singular piece that is to be placed on the floor to be used. The product is intentionally not designed to be handheld in order to reduce the chances of it breaking.

4.1 SINGULAR PIECE

4.1.1 DESCRIPTION

All of the internal components are to be housed in a singular 3D printed casing. This is to allow for easy carrying and relocating the product.

4.1.2 SOURCE

Product sponsor.

4.1.3 CONSTRAINTS

The product has to be as portable as possible.

4.1.4 STANDARDS

N/A.

4.1.5 PRIORITY

High.

4.2 SHIP PRODUCT AS FRAGILE

4.2.1 DESCRIPTION

The product will not be particularly fragile, but it will not be designed to withstand the continuous bumps and knocks that may occur when items are shipped. Therefore, if the product is to be shipped, it MUST be treated as fragile.

4.2.2 SOURCE

Team.

4.2.3 CONSTRAINTS

The product is to be wrapped in bubble wrap before being placed in it's shipping box. Any gaps in the shipping box that remain after the product (wrapped in bubble wrap) is placed in the box are to be filled with bags of air. The box is to have an indication on it that shows the contents of the box are fragile.

4.2.4 STANDARDS

N/A.

4.2.5 PRIORITY

High.

4.3 PRODUCT IS NOT HANDHELD

4.3.1 DESCRIPTION

The product must be portable, but it cannot be handheld. This is to prevent accidental damage to the product caused by excessive handling.

4.3.2 SOURCE

Team.

4.3.3 CONSTRAINTS

The product is to be used while it is placed on the floor.

4.3.4 STANDARDS

N/A.

4.3.5 PRIORITY

High.

5 PERFORMANCE REQUIREMENTS

The laser harp is a digital instrument, as such it needs to generate the sound at the right pitch with low noise and read an interaction fast enough to feel like a playable instrument. The harp will also have speakers and must be loud enough to hear in a classroom setting.

5.1 FRAME RATE

5.1.1 DESCRIPTION

Sound is digitally produced in frames. These frames must occur fast enough and regularly enough to create the desired pitch with little to no additional noise.

5.1.2 SOURCE

Team

5.1.3 CONSTRAINTS

Clock speed of the CPU

5.1.4 STANDARDS

N/A

5.1.5 PRIORITY

Critical

5.2 INPUT LATENCY OF 10MS OR LESS

5.2.1 DESCRIPTION

When the input latency of a digital instrument is too high it can become difficult to play.

5.2.2 SOURCE

Team

5.2.3 CONSTRAINTS

Clock speed of the CPU and fidelity of the sensor array

5.2.4 STANDARDS

N/A

5.2.5 PRIORITY

Critical

5.3 MAX VOLUME APPROXIMATELY 80DB

5.3.1 DESCRIPTION

The volume of device must be loud enough to be heard in a classroom setting without external amplification.

5.3.2 SOURCE

Team

5.3.3 CONSTRAINTS

The internal speakers must be receiving enough power to generate a loud enough sound.

5.3.4 STANDARDS

N/A

5.3.5 PRIORITY

High

6 SAFETY REQUIREMENTS

When developing this device we must keep safety at the forefront of development since this product will be used not only by others in the STEM field but also by children. Keeping this in mind, our team must take into account all factors that could go wrong in development and after the product is finished. Also if the device is used for unintended purposes we must take into account safety measures there as well. No matter if you use this device correctly or not, all users and spectators should be safe at all times.

6.1 LABORATORY EQUIPMENT LOCKOUT/TAGOUT (LOTO) PROCEDURES

6.1.1 DESCRIPTION

Any fabrication equipment provided used in the development of the project shall be used in accordance with OSHA standard LOTO procedures. Locks and tags are installed on all equipment items that present use hazards, and ONLY the course instructor or designated teaching assistants may remove a lock. All locks will be immediately replaced once the equipment is no longer in use.

6.1.2 SOURCE

CSE Senior Design laboratory policy

6.1.3 CONSTRAINTS

Equipment usage, due to lock removal policies, will be limited to availability of the course instructor and designed teaching assistants.

6.1.4 STANDARDS

Occupational Safety and Health Standards 1910.147 - The control of hazardous energy (lockout/tagout).

6.1.5 PRIORITY

Critical

6.2 NATIONAL ELECTRIC CODE (NEC) WIRING COMPLIANCE

6.2.1 DESCRIPTION

Any electrical wiring must be completed in compliance with all requirements specified in the National Electric Code. This includes wire runs, insulation, grounding, enclosures, over-current protection, and all other specifications.

6.2.2 SOURCE

CSE Senior Design laboratory policy

6.2.3 CONSTRAINTS

High voltage power sources, as defined in NFPA 70, will be avoided as much as possible in order to minimize potential hazards.

6.2.4 STANDARDS

NFPA 70

6.2.5 PRIORITY

Critical

6.3 SAFE LASERS FOR SKIN AND EYES

6.3.1 DESCRIPTION

The main interaction with this device will be via lasers, and there are many potential hazards when using them. The laser must be safe for human interaction with skin or eyes.

6.3.2 SOURCE

Project Owner

6.3.3 CONSTRAINTS

Laser must be in Class 1 or 2 and users must wear protective eye wear.

6.3.4 STANDARDS

ANSI Z136 Standard and FDA Title 21 Chapter I Subchapter J Section 1040.10

6.3.5 PRIORITY

Critical

6.4 LIGHTWEIGHT FOR PORTABILITY

6.4.1 DESCRIPTION

This device must be portable and to achieve this and also for it to be safe for the user it must be light enough for the average human to carry with ease.

6.4.2 SOURCE

Project Owner

6.4.3 CONSTRAINTS

Keep device under 10 lbs

6.4.4 STANDARDS

N/A

6.4.5 PRIORITY

High

6.5 AVOIDANCE OF SHARP OBJECTS/EDGES

6.5.1 DESCRIPTION

This product will likely be used in demonstrations to young students so it must avoid any harmful sharp edges that the children could interact with.

6.5.2 SOURCE

Project Owner

6.5.3 CONSTRAINTS

No harmful or sharp edges anywhere on the exterior of the device.

6.5.4 STANDARDS

N/A

6.5.5 PRIORITY

Critical

7 MAINTENANCE & SUPPORT REQUIREMENTS

Maintenance should be minimal, due to the fact that the Laser Harp should have no moving parts. However, like any electronic device, proper storage and temperature awareness should be considered when not in use

7.1 STORAGE

7.1.1 DESCRIPTION

Device should be stored in a clean and dry location between the temperatures of 10 °C and 35 °C (50 °F and 95 °F).

7.1.2 SOURCE

Team

7.1.3 CONSTRAINTS

Requirements must be achievable by college

7.1.4 STANDARDS

N/A

7.1.5 PRIORITY

High

8 OTHER REQUIREMENTS

The harp consisting of thirteen string is intended to play in one octave. To make the instrument more flexible an octave knob will allow the musician to change the octave available to them. To make this instrument more flexible and be able to fit into a broader range of venues, the harp will also have midi output and line level output. This is not needed in the initial release but will add flexibility to future releases of the product and make it more appealing to the students we are hoping to attract to STEM.

8.1 OCTAVE KNOB

8.1.1 DESCRIPTION

The device will allow th user the ability to play in a single octave. This knob allows the player to choose which octave they will be in.

8.1.2 SOURCE

Team

8.1.3 CONSTRAINTS

Space on the front plate

8.1.4 STANDARDS

N/A

8.1.5 PRIORITY

Moderate

8.2 MIDI OVER USB OUTPUT

8.2.1 DESCRIPTION

Generating a MIDI sequence will allow the device to play external electronic instruments giving more flexibility to the end user.

8.2.2 SOURCE

Team

8.2.3 CONSTRAINTS

Time

8.2.4 STANDARDS

MIDI 1.0

8.2.5 PRIORITY

Future

8.3 LINE LEVEL AUDIO OUTPUT

8.3.1 DESCRIPTION

Line level audio output will allow the device to be setup in a professional audio venue and played for a much larger audience.

8.3.2 SOURCE

Team

8.3.3 CONSTRAINTS

Time

8.3.4 STANDARDS

Line Level

8.3.5 PRIORITY

Future

9 FUTURE ITEMS

9.1 DISTORTION KNOB

9.1.1 DESCRIPTION

This is a knob that affects the pitch of the music notes. This will adjust the notes without loading a new set of pre-programmed musical notes.

9.1.2 SOURCE

Client

9.1.3 CONSTRAINTS

This knob must fit on the machine without interfering with the regular operation of the device.

9.1.4 STANDARDS

N/A

9.1.5 PRIORITY

Future

9.2 MIDI OVER USB OUTPUT

9.2.1 DESCRIPTION

Generating a MIDI sequence will allow the device to play external electronic instruments giving more flexibility to the end user.

9.2.2 SOURCE

Team

9.2.3 CONSTRAINTS

Time

9.2.4 STANDARDS

MIDI 1.0

9.2.5 PRIORITY

Future

9.3 LINE LEVEL AUDIO OUTPUT

9.3.1 DESCRIPTION

Line level audio output will allow the device to be setup in a professional audio venue and played for a much larger audience.

9.3.2 SOURCE

Team

9.3.3 CONSTRAINTS

Time

9.3.4 STANDARDS

Line Level

9.3.5 PRIORITY

Future

REFERENCES