March 28th, 2019

Dr. Craig Scratchley
School of Engineering Science
Simon Fraser University
Burnaby, BC, Canada
V5A 1S6

Re: Project Proposal for Luminotes

Dear Dr. Scratchley,

The enclosed document provides the project proposal for our Capstone project, Luminotes. Our vision is to create a projection device that will be mounted over a piano,which will utilize a laser to indicate the piano keys that the user should play. Users will be able to select a song to play by choosing a MIDI file using an accompanying mobile application. Luminotes looks to provide a solution for users who wish to learn piano but struggle to read sheet music or prefer to play songs immediately. This device and application can also be a cost-effective introduction to learning piano and more powerful to use compared to equivalent learning methods, like YouTube videos.

This document looks to introduce Luminotes by discussing the background of the product and its scope. Also, the proposal will provide a more detailed analysis into the risks and benefits of our product along with presenting the research into the market and competition. Additionally, the document will provide a detailed project plan and the cost considerations.
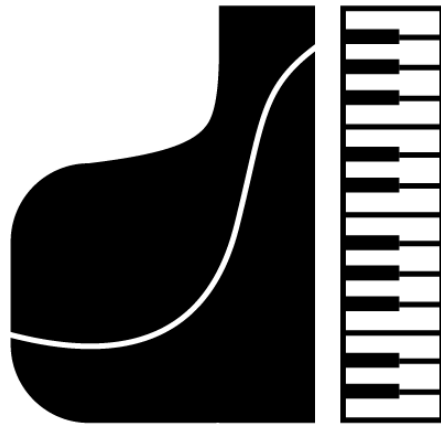
Simple Instruments is a company composed of six undergraduate engineering science students: Shahira A. Azhar, Caitlin Finnigan, Hsiao Chen Eldon Lin, Dayton Pukanich, Adnan Syed, and (Mike) Wei Hao Xu. This diverse group of students looks to utilize their skills in computer, electronics, and systems engineering to create Luminotes.

Thank you for your time in reviewing the enclosed proposal documentation. Please feel free to contact us through my email (wxa17@sfu.ca) regarding any questions and concerns.

Sincerely,

(Mike) Wei Hao Xu
Chief Communications Officer
Simple Instruments

# Project Proposal

ENSC 405W

Simon Fraser University
Faculty of Applied Science
School of Engineering Science

Team 14 Members:

Shahira A. Azhar
Caitlin Finnigan
Hsiao Chen Eldon Lin
Dayton Pukanich
Adnan Syed
(Mike) Wei Hao Xu

# Executive Summary

Luminotes serves as a tool for quickly learn how to play new songs on the piano. It does away with the need for a large monetary and time commitment, that comes with having to learn how to read sheet music. Luminotes achieves this by simply projecting lasers onto the individual keys that the user will follow to play the chosen song. To achieve this functionality, Luminotes is divided into four subsystems: software, firmware, hardware, and structural.

Software encompasses the mobile application, which is the user's main point of interaction with Luminotes' physical body. The hardware consists of a Raspberry Pi to run the firmware on, a laser and a 2-axis galvo. The firmware receives and decodes the transferred MIDI data, and uses it to calculate height calibration information to control the galvanometric scanning mirrors and laser. The structural component binds all the hardware together into a user-friendly device that can be placed onto a piano. This design allows for the conception of an intuitive product that will greatly aid in the learning of piano.

Though there are similar products available in market, they differ in some very key aspects. For example, the ability to learn kinesthetically with visual aids in the form of lighted keys on a piano is unique to Luminotes. The competition is constrained to electronic keyboards, which do not have the same effect and enjoyment as acoustic pianos.

Regardless this market is quite niche which does pose a risk for Luminotes' success. Furthermore the issue of laser safety can be raised as a risk as well, as a badly chosen laser could cause physical harm to the user. Nonetheless, this was taken into consideration when choosing which laser to buy, and has been accounted for.

All in all, Luminotes supplements a student's learning, simplifies the learning process for casual hobbyists, and acts as an engaging introduction to piano for newcomers. It is not dependent upon a user's knowledge of sheet music, and can work on acoustic pianos of any size and type. Thus, Luminotes has all the makings of a success.

# Table of Contents

# List of Figures

# List of Tables

# Glossary

| | |
|---|---|
| **ADC** | Analog to Digital Converter |
| **App** | Luminotes mobile application |
| **Arpeggios** | Group of notes played one after the other |
| **Chassis** | Structural framework of Luminotes device |
| **Device** | Luminotes device |
| **DSP** | Digital Signal Processing |
| **Flash** | An electronic non-volatile computer storage medium |
| **Galvo** | Galvanometer scanner |
| **LED** | Light Emitting Diode |
| **MCB** | Microcontroller Board |
| **Microcontroller** | Small computer on a single integrated circuit |
| **MIDI** | Musical Instrument Digital Interface; a protocol for digital music recording and playback |
| **Octave** | 8 consecutive white keys on the piano keyboard |
| **OS** | Operating System |
| **PoC** | Proof of concept |
| **Scales** | Piano theory that teaches chords, notes and certain tones that goes well together |

# 1 Introduction

Formally learning how to read sheet music in order to play specific songs on the piano can often be a barrier for casual musicians, as it is unintuitive and time consuming. The monetary and time commitment involved with doing so is much too steep for someone who simply wants to learn their favourite song to show off to friends. This road bump is often enough to discourage many hopeful pianists from learning more.

While alternatives exist in the form of electronic keyboards with fairly easy to follow tutorials using light up keys, they are just not the same as a traditional piano. The lack of string resonance in these keyboards produces a lacklustre tune when compared to a piano. Moreover, having to buy this sort of electronic keyboard is still quite the monetary commitment; especially for the casual hobbyist who already has free access to a piano through friends, family, or school.

With all this in mind we offer Luminotes as a solution. Our device acts as a low-cost, and small form factor accessory that makes learning new music easy. One just mounts it to their piano, selects a song from the mobile application that is connected via bluetooth, and follows along to the keys lit up by the device projector. The following figure outlines this functionality with a high-level behavioural diagram.
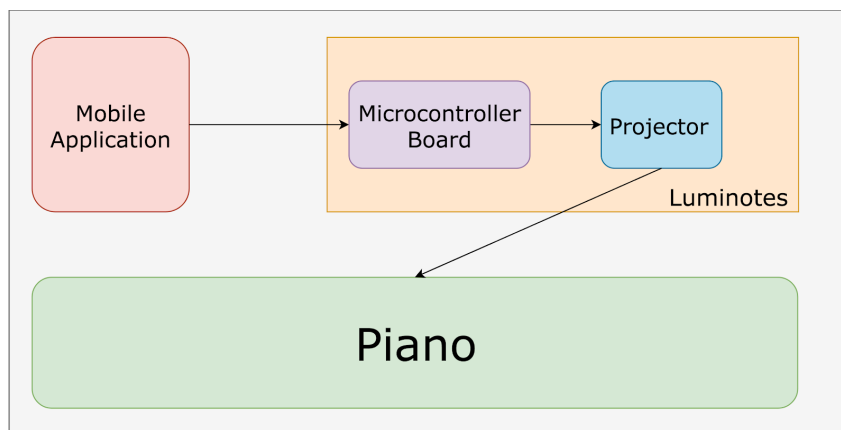


Figure 1: *High Level System Overview*

## 1.1 Intended Audience

This document acts as the main point of reference for Luminotes' project overview. It delves into the project scope, economic breakdown, market considerations and other aspects related to project planning. Use of this document is targeted towards Simple Instruments Inc. project managers, potential partners, potential investors, Dr. William Craig Scratchley, Dr. Andrew Rawicz, and teaching assistants.

## 1.2 Background Information

Musical Instrument Digital Interface (MIDI) is a file format created in the 1980's, which is used to encode musical information. The file consists of parallel tracks of note sequences as well as timing information. Since MIDI is digital, its file size is significantly smaller than an audio file, which allows for quicker information transfer. Because of MIDI's simplicity, it is easy to integrate into many systems. MIDI files of copyright-free music are widely available; these can be found on websites such as the Petrucci Music Library.

# 2 Project Overview

## 2.1 Background

The piano has been an outlet of creativity for musicians since its conception in the 1700s; though it was not popularized till a century later in the United States of America [1]. Today, millions of people worldwide play the piano [2]. Typically these individuals go about learning by hiring a private teacher. The instructor teaches music theory, history, and harmony as well as how to read sheet music and play the piano itself. Some students choose to take exams to attain the next level, while others just learn for fun. Either way, learning the piano requires focus and discipline.

Proper practice involves playing scales and studies that are repetitive and often uninteresting; however, they are necessary to develop proper technique. This process could become more enjoyable by having an interactive device to assist the learner. However, this device could also be of immense use to the casual hobbyist who wants to do away with the lengthy learning process all together. For them a means of quickly and intuitively learning how to play their favourite songs, without a large time or monetary commitment, is preferable.

Providing a solution to this niche problem is where Simple Instruments comes in with Luminotes. Our device offers a quicker and simpler method for learning piano. We do this by projecting notes directly onto the piano keys in tempo with the song, allowing the user to follow along and play as keys light up. With some repetition, muscle memory is cemented and the user learns the song.

## 2.2 Scope

The main goal of Luminotes is to create a device that allows users to quickly and intuitively play songs on an acoustic piano, without having to learn how to read sheet music. Our product consists of physical device that projects lights onto a keyboard, as well as a mobile application to interface with the projector. Upon opening the application, the user will be prompted with scaling the dimensions of the Luminotes projection. Upon completion of the setup, the user will be able to choose from the app's library of MIDI files, as well as any MIDI files on the user's own device. The Luminotes device sends these files to the projector, along with the user's selected tempo, which will be used to control the laser projector. The Luminotes device will be able to project onto multiple keys at a time, allowing for both the left and right hand to be used over 4 octaves, and for more complex songs to be played. The app will have standard functions, like start, pause, and reset the song. The device will record the audio produced by the piano, to determine how well the song was played. When the song completes, the user will be presented with a score representative of their accuracy in hitting the right notes at the right time. Although the Luminotes device could replace a piano teacher, it can be supplemented with a teacher.

# 3 Risks and Benefits

## 3.1 Risks

The risks associated with Luminotes can be broken down into two categories: product risks and market risks.

### 3.1.1 Product Risks

Regarding the product, the risks involved include laser safety, structure stability, inaccurate feedback, and the length of the power cord. Firstly, laser safety is a huge component of Luminotes as the laser will be directed onto glossy piano keys. This would allow the laser beam to reflect, which may cause injury to the user and those around the piano depending on the power of the laser. Therefore, to minimize the risk, the class of the laser needs to be Class 3A or below [3]. Secondly, the size and weight of the product may be an issue as the structure will be placed on the top of the piano with the galvo laser projection component hanging over the keys. If the weight is not balanced then it may cause the device to topple over and drop on to the keys or come into contact with the user. Thirdly, the product can suffer from inaccurate feedback. This would be an issue when the user is checking their accuracy at the end of the song and is presented with incorrect data that does not truly reflect the. Lastly, as the final product will require a power supply to power the various components, a cord to attach to the 120V outlet receptacle will most likely be required. The risk with the cord, other than it being a tripping hazard is the possibility that there will not be a receptacle near the piano. This would mean the device will either need extension cables to operate or would not be able operable at all.

### 3.1.2 Market Risks

Furthermore, the market risks must also be considered. There is the possibility that the intended market Luminotes hope to reach is not interested in the product or find it unappealing.
In order to address this possible issue, it would require a more thorough research into the market interest of the product. Additionally, there is also the risk that the product will have a niche market, which would limit the amount of users and profit.

## 3.2 Benefits

The main benefit of Luminotes is allowing users to instantly begin playing music on the piano without the need to be able to read sheet music. Besides the positive effect it would have on new piano learners, Luminotes would also encourage more people, who perhaps struggled with reading sheet music or found learning piano difficult, to try learning the instrument once more.

Luminotes is also more beneficial when considering the adaptability to various types and sizes of pianos. Other comparable products are mostly app based, or are only able to connect to electronic keyboards with MIDI input and output. For example, Flowkey [4] and Synthesia [5] that are discussed in Market and Competition Analysis below. However, Luminotes is an aftermarket product that is able to be used on various types of keyboards, whether it is electronic keyboards, upright pianos, or grand pianos. This allows the product to reach a larger audience, especially those with acoustic pianos.

An issue that beginners encounter is that they do not know where to place their hands. Therefore, for those visual and kinesthetic learners, Luminotes can help them by projecting lights onto the keys. This way users just have to follow the lights, instead of coordinating between notes and keys. Learning how to play the notes directly on the keys is better for their eyes, compared to playing the notes using an app where the screen is very small and possibly harder to read. Furthermore, the visual learning style that Luminotes uses would also make practicing technical skills such as scales or arpeggios more interesting.

Finally, buying the device will be a one time cost compared to lessons where one has periodic payments. This will be especially beneficial to beginners as it will be less of an initial financial commitment. In addition, there will be a variety of songs for users to choose from to allow their playing skills to expand. As well as the option to upload songs in MIDI form not available in the library, from the users' own personal collection.

# 4 Market and Competition Analysis

## 4.1 Market

Our product's market is aimed at families who own a piano, with members who are at the beginner or low intermediate level of playing piano.

Although piano sales have been decreasing as of 100 years ago, it is still quite common for households to own one. In the last 10 years, 378,809 new pianos were sold in the United States[6]. However, this does not represent the total number of pianos being used currently, as people often don't take their pianos with them when they move houses. Many pianos end up being left behind for the next family who moves in.

More than 40 million Chinese children are learning piano, as well as 6 million people in the US [2]. Accounting for an average household size of 3.14 in the US, and 3.17 in China, this gives at least 12.13 million households with a piano or keyboard. Even if most of these people are learning seriously, and would be paying for a teacher, there is still use for our product. It is often hard for children to focus on practicing properly. Since many parents are more enthusiastic about their children learning piano than the children themselves are, they will try different methods to get their children to enjoy it. Buying this device is one way to engage the children, since it makes the learning experience more interactive. It doesn't necessarily need to replace the teacher, but it can be useful for motivating and assisting the student to practice more repetitive techniques and scales.

We are predicting that 1% to 5% of households who own a piano will purchase our device. This gives 0.121 to 0.6065 million purchases of our device, in the US and China alone. This is a niche market, however there is still much opportunity to profit from this.

## 4.2 Competition

Currently, the available options for self-teaching songs on the piano are by either reading sheet music, or using a mobile or desktop application. The two most popular of these apps are Synthesia and Flow Key. A detailed comparison of these products is provided in *Table 1*.

The main difference between Luminotes and its competitors is that only Luminotes has a physical device that projects light onto an acoustic keyboard. If the user has a digital keyboard,

they will benefit more from Flow Key and Synthesia than someone who uses a piano, because these apps can give MIDI input and output. Our product is designed to be an extension to the piano, for someone who doesn't want to replace their piano with a keyboard. Since it would be sold for considerably cheaper than a keyboard, it is reasonable to assume the player would rather purchase our device than a keyboard.

Table 1: *Comparison of Luminotes' Competitors*

| | Luminotes | Flowkey | Synthesia |
|---|:---:|:---:|:---:|
| Track progress | ✗ | ✔ | ✔ |
| Displays sheet music | ✗ | ✔ | ✗ |
| Select speed | ✔ | ✗ | ✔ |
| Display finger numbers | ✔ | ✗ | ✔ |
| Projects onto acoustic piano | ✔ | ✗ | ✗ |
| Plays any MIDI file | ✔ | ✗ | ✔ |
| Can practice hands separately | ✗ | ✗ | ✔ |
| Note name displayed | ✔ | ✗ | ✔ |
| Processes audio feedback | ✔ | ✔ | ✗ |
| Gives feedback to user | ✔ | ✔ | ✔ |
| Can use without screen | ✔ | ✗ | ✗ |
| One time cost | ✔ | ✗ | ✔ |

# 5 Project Planning

Below is the Gantt chart which shows our project planning for ENSC 405 and a rough plan for ENSC 440. The charts are split up into three section: start of Spring 2019 to reading break, reading break to the end of Spring 2019, and ENSC 440 to Summer 2019
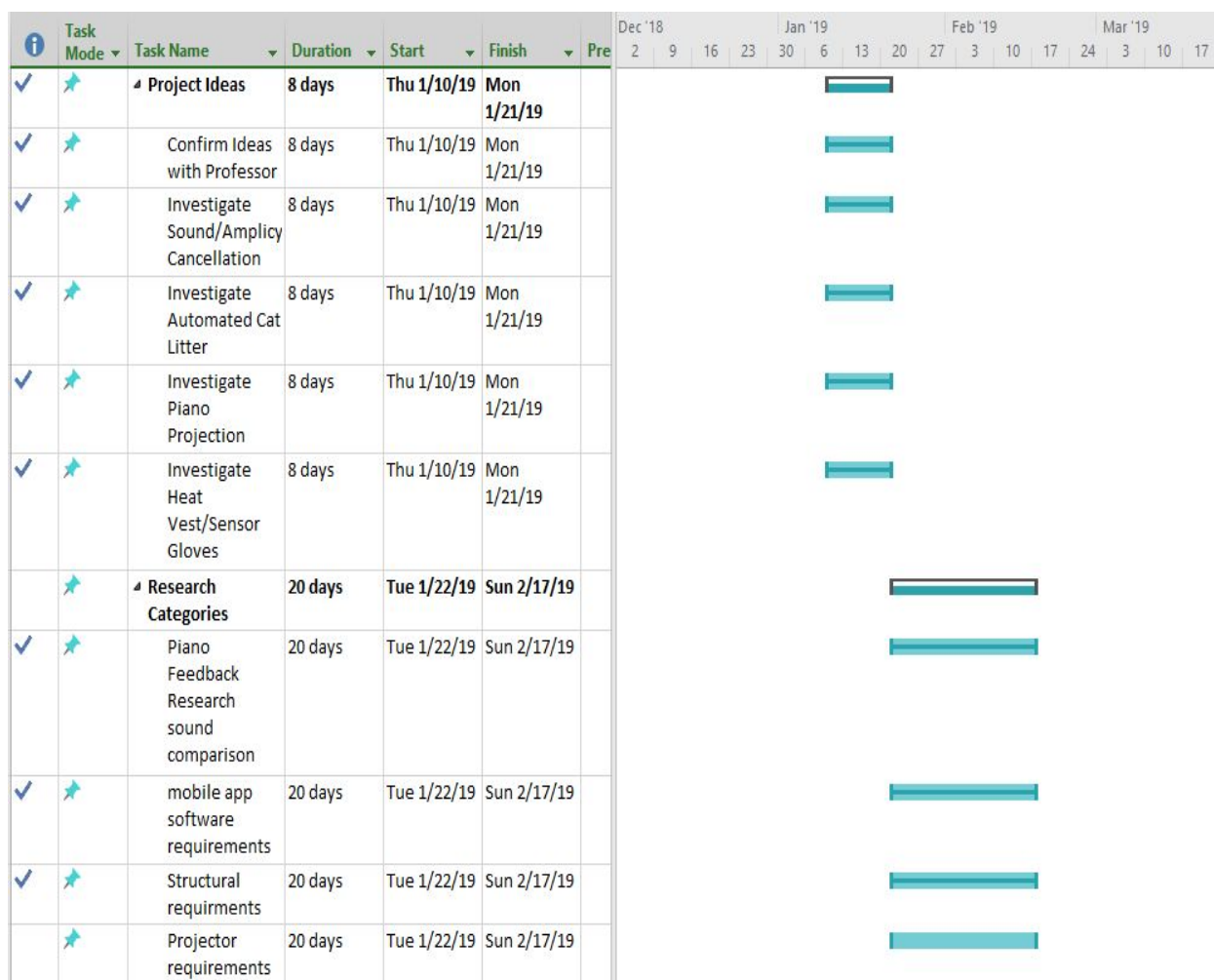


Figure 2: *First half (up to reading break) of project planning Gantt Chart*
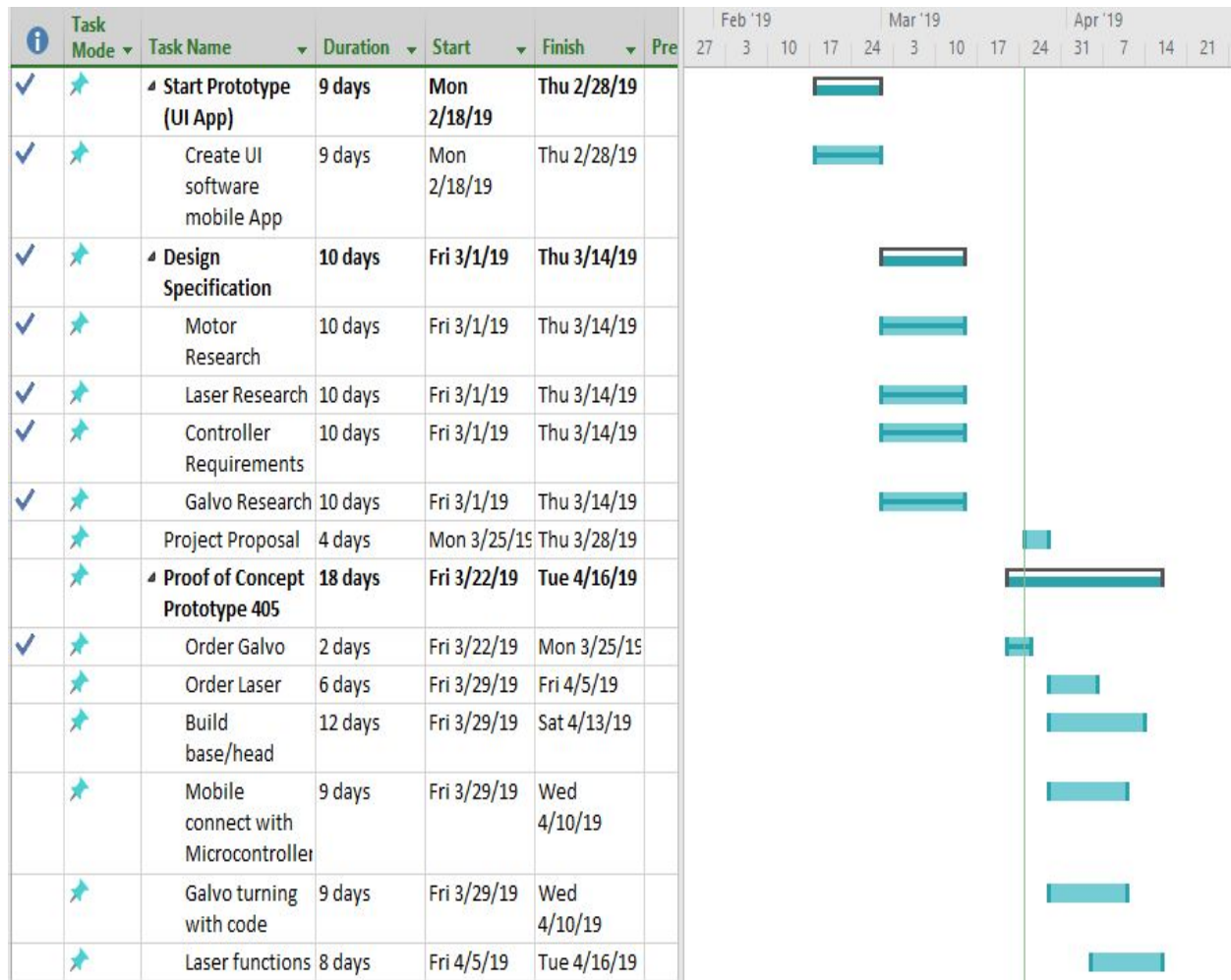
| ⓘ | Task Mode ▾ | Task Name ▾ | Duration ▾ | Start ▾ | Finish ▾ | Pre |
|---|---|---|---|---|---|---|
| ✓ | 📌 | ◢ Start Prototype (UI App) | 9 days | Mon 2/18/19 | Thu 2/28/19 | |
| ✓ | 📌 | Create UI software mobile App | 9 days | Mon 2/18/19 | Thu 2/28/19 | |
| ✓ | 📌 | ◢ Design Specification | 10 days | Fri 3/1/19 | Thu 3/14/19 | |
| ✓ | 📌 | Motor Research | 10 days | Fri 3/1/19 | Thu 3/14/19 | |
| ✓ | 📌 | Laser Research | 10 days | Fri 3/1/19 | Thu 3/14/19 | |
| ✓ | 📌 | Controller Requirements | 10 days | Fri 3/1/19 | Thu 3/14/19 | |
| ✓ | 📌 | Galvo Research | 10 days | Fri 3/1/19 | Thu 3/14/19 | |
| | 📌 | Project Proposal | 4 days | Mon 3/25/19 | Thu 3/28/19 | |
| | 📌 | ◢ Proof of Concept Prototype 405 | 18 days | Fri 3/22/19 | Tue 4/16/19 | |
| ✓ | 📌 | Order Galvo | 2 days | Fri 3/22/19 | Mon 3/25/19 | |
| | 📌 | Order Laser | 6 days | Fri 3/29/19 | Fri 4/5/19 | |
| | 📌 | Build base/head | 12 days | Fri 3/29/19 | Sat 4/13/19 | |
| | 📌 | Mobile connect with Microcontroller | 9 days | Fri 3/29/19 | Wed 4/10/19 | |
| | 📌 | Galvo turning with code | 9 days | Fri 3/29/19 | Wed 4/10/19 | |
| | 📌 | Laser functions | 8 days | Fri 4/5/19 | Tue 4/16/19 | |

Figure 3: *Second half of project planning Gantt Chart (post reading break to end of Spring 2019)*

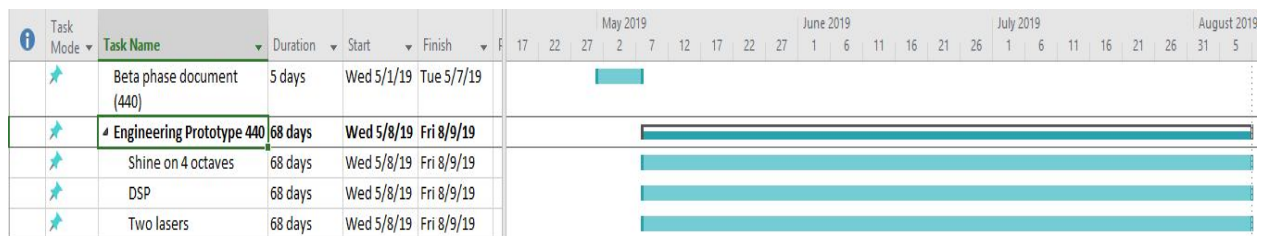| ⓘ | Task Mode ▾ | Task Name ▾ | Duration ▾ | Start ▾ | Finish ▾ | F |
|---|---|---|---|---|---|---|
| | 📌 | Beta phase document (440) | 5 days | Wed 5/1/19 | Tue 5/7/19 | |
| | 📌 | ◢ Engineering Prototype 440 | 68 days | Wed 5/8/19 | Fri 8/9/19 | |
| | 📌 | Shine on 4 octaves | 68 days | Wed 5/8/19 | Fri 8/9/19 | |
| | 📌 | DSP | 68 days | Wed 5/8/19 | Fri 8/9/19 | |
| | 📌 | Two lasers | 68 days | Wed 5/8/19 | Fri 8/9/19 | |

Figure 4: *Rough idea of ENSC 440 project planning (will be updated during Summer semester)*

# 6 Cost Considerations

## 6.1 Estimate of Costs

Table 2: *Proof of Concept (PoC) prototype cost estimate*

| Component | Description | Cost (CAD) |
|---|---|---|
| Galvanometer scanner | Two-axis, two octave laser projector | 135 |
| MCB | Raspberry pi | 50 |
| Laser | Low-powered laser pointer | 3 |
| Structure | Plywood or wood; screws and glue | 25[1] |
| Miscellaneous | Shipping costs, tax, gas, etc | 20 |
| Total | | 228 |

[1] Minimized by using resources available to the team by potential funding sources.

Table 3: *Final prototype cost estimate*

| Component | Description | Cost (CAD) |
|---|---|---|
| Galvanometer scanner (x2) | Two-axis, two octave laser projectors | 270 |
| MCB | Raspberry pi | 50 |
| Laser (x2) | Two low-powered laser pointers | 8 |
| Structure | ABS filament and H/D flexible arm; LEDs, button, etc | 100[1] |
| Miscellaneous | Shipping costs, tax, gas, etc | 30 |
| Total | | 458 |

[1] Minimized by using a 3D printer and filament available to the team by potential funding sources.

### 6.1.1 Mass Production Costs

We are currently focusing on the creation of a PoC and final prototype of Luminotes. However, if we achieve our requirements and design specifications, we may pursue the creation of a device worthy of mass production. We expect that the mass produced version of Luminotes will be far below the total cost of $458 (CAD) for the final prototype.

## 6.2 Potential Funding Sources

### 6.2.1 Engineering Science Student Endowment Fund

The Engineering Science Student Endowment Fund (ESSEF) provides funding to undergraduates at SFU that are interested in applying their knowledge to engineering and business solutions. We are particularly interested in Category B and C, which are entrepreneurial and class, respectively. As we are enrolled in ENSC 405 and proceeding to take ENSC 440, we believe that we satisfy the initial requirements for applying [7]. There is the caveat that parts purchased using money from ESSEF remain property of ESSS. Although this is a source of funding for us, we may not pursue it if we hope to keep our final prototype of Luminotes entact.

### 6.2.2 Engineering Science Machine Workshop

The machine workshop gives us access to resources such as tools and expertise that would otherwise cost us funding. We expect to make use of the machine workshop for the creation of our proof of concept structure.

### 6.2.3 Family Funding

Members of Simple Instruments' family have access to the resources necessary to complete aspects of Luminotes' structure. Although this is not funding, it could save us the funds it would take to purchase said resources.

### 6.2.4 Personal Funding

All six members have voiced willingness to split costs up to $50 each that the team agree upon prior to purchase. We hope we do not have to spend $300 to complete Luminotes, but are prepared to do so knowing that costs may not be recouped through potential funding sources. We therefore defined a procedure for company expenses by retaining physical receipts and all members splitting the bills' cost by the semester's end.

## 6.3 Contingencies

Our main source of sunk costs comes in the form of poor component selection and purchasing. Although we have thoroughly researched the components we intend to use as well as the sites we purchase them from, it is possible that either could fail. In the event of financial distress or timeline issues, we will notify the professors of ENSC 405 and 440 and ask for their opinion on what to do.

# 7 The Company

The creator of the Luminotes product is Simple Instruments. The company is made up of diligent and creative engineering science undergraduate students from Simon Fraser University. Please find detailed descriptions of them below.

## Shahira A. Azhar
Chief Operating Officer (COO)

Shahira is a computer engineering undergraduate student in her final year. Her interests lie in embedded firmware development, computer networking and security. She has extensive experience in developing firmware on a Linux environment and is excited to contribute these skills towards Luminotes' firmware.

## Caitlin Finnigan
Chief Technology Officer (CTO)

Caitlin is a final year undergraduate student, specializing in computer engineering. She has work experience with camera firmware testing, and implementing natural language processing models. Her role in Simple Instruments is to oversee the technological aspects of the project, ensure standards are met, and develop firmware. She is enthusiastic about music education, and hopes to engage young piano learners with Luminotes.

## Hsiao Chen Eldon Lin
Chief Information Officer (CIO)

Eldon Lin is an engineering science undergraduate specializing in systems engineering at SFU. Previously, in co-op he worked as a software developer using C#. He also worked as a Quality Assurance Engineer using different open source repository including gitlab, github and bitbucket to communicate with teams from different locations. As the CIO, he will oversee the milestones set for the project and ensure that the tasks for each milestones are properly documented. He will also ensure that all of the minutes and documentation are properly maintained.

# Dayton Pukanich
## Chief Executive Officer (CEO)

Dayton Pukanich is a senior undergraduate student in engineering science, specializing in computer engineering at SFU. His past experience extends to test automation engineer in enterprise medical imaging, and as a software developer in industrial automation for airports and airlines. As the CEO of Simple Instruments, Dayton is responsible for the direction of the company, and has therefore taken a keen interest in the structural and software side of Luminotes. However, he remains impartial between each chief officer, making sure that they each have the resources they need to succeed.

# Adnan Syed
## Chief Financial Officer (CFO)

Adnan Syed is a senior computer engineering student at SFU. He has experience in mobile app development as a full-time employee and contractor. He currently has two applications that are live on the app store, which make him the best choice for team lead of Luminotes' mobile application. In addition to these duties, he will also be responsible for all financial decision-making made at Simple Instruments.

# (Mike) Wei Hao Xu
## Chief Communications Officer (CCO)

Mike Xu is a senior engineering science undergraduate student specializing in electronics engineering at SFU. He is part of the hardware team at Simple Instruments, where he will use his electronics background as well as the testing skills that he has accumulated from his research co-ops towards making Luminotes successful. He is also applying the communication skills from his co-op and customer service experiences to effectively communicate for the company. As a piano player himself, Mike is excited to work with this motivated team to bring Luminotes to piano beginners, players, and enthusiasts everywhere.

# 8 Conclusion

Learning to play piano is no easy feat. Lessons cost quite a lot in both time and money, and it takes dedication to learn sheet music. For the casual hobbyist who simply wants to play their favourite songs, this is a discouraging commitment. The current methods for learning piano without sheet music are either app-based, or require a digital keyboard. None are versatile enough to be used on an acoustic piano without digital screens.

Luminotes offers a solution for the pianists who have access to an acoustic piano. It is a device made to assist beginners and casual hobbyists to learn piano, without having to learn sheet music first. It achieves this by simply shining lights onto keys in time with the notes, so that the user can follow along and play their song. This feature is easier to use than reading notes on an app, as the screen on a phone or tablet is not to scale with a real keyboard. Luminotes solves this by highlighting keys in time with the inputted music. It also has settings to display note names and finger positions directly on the keys, which matches the state of the art software in this market. Finally, it is able to score the user on their playing by processing the audio feedback. Overall, it has more features than existing products.

Each member of the Simple Instruments team contributes a unique skill set to the project that will allow Luminotes to be a success. Mike is the go to expert on all things electronic. Adnan leads development of the mobile application. Eldon deals with implementation of the galvanometric scanner and lasers. Dayton handles the structural subsystem. Shahira focuses on the firmware alongside Caitlin, who also has her hand and mind in each subsystem as the CTO. With an innovative idea, backed by a diverse and hardworking team, Luminotes is sure to be a success.

# 9 References

[1] "Social history of the piano," *Wikipedia*, 25-Mar-2019. [Online]. Available: https://en.wikipedia.org/wiki/Social_history_of_the_piano. [Accessed: 28-Mar-2019]

[2] Al Jazeera, "China's piano craze fuels production boom," *News | Al Jazeera*, 08-Apr-2015. [Online]. Available: https://www.aljazeera.com/news/2015/04/china-piano-craze-fuels-production-boom-1504080532 22031.html. [Accessed: 28-Mar-2019]

[3] G. Chapman, Class Lecture, Topic: "Laser Safety." ENSC470/894, Faculty of Applied Science, Simon Fraser University, Burnaby, Jun., 14, 2018.

[4] "Flowkey, learn piano with the songs you love" *flowkey*. [Online] Available: https://www.flowkey.com/en. [Accessed: 28-Mar-2019]

[5] "Synthesia, Piano for Everyone," *Synthesia, Piano for Everyone*. [Online]. Available: https://www.synthesiagame.com/. [Accessed: 28-Mar-2019]

[6] "Piano U.S. unit sales 2017 | Statistic," Statista. [Online]. Available: https://www.statista.com/statistics/452772/number-of-pianos-sold-in-the-us/. [Accessed: 28-Mar-2019]

[7] ESSEF. [Online]. Available: http://www.esss.ca/essef. [Accessed: 28-Mar-2019]