ENSC 305W/440W Grading Rubric for Post-Mortem

Criteria	Details	Marks
Introduction/Background	Introduces basic purpose of the project. Includes clear background and motivation for the project.	5 **/05%**
Body of the Document	Provides a high-level description of main functions and project modules. Outlines materials, costs, and schedule (both estimated and actual).	14 **/15%**
Problems/Challenges	Outlines major technical challenges encountered. Explains how these were resolved. Details any major changes in scope and design.	5 **/05%**
Group Dynamics	Includes a discussion of how the team was organized, any problems that arose, and how they were resolved	5 **/05%**
Individual Learning/Work-load Distribution Chart	Includes a one-page, individually written reflection upon what was learned from the project, both technically and interpersonally (each team member writes a page about their learning experience). **The workload distribution chart outlines major technical, administrative, and support tasks and indicates who participated significantly in those tasks.**	25 **/25%**
Conclusion/References	Summarizes outcome and evaluates the project. Includes discussion of future plans, if any (or explains why project will be abandoned).	10 **/10%**
Meeting Agendas/Minutes	Includes an appendix that provides all the meeting agendas and minutes produced by the team over the course of the semester. (NB. Neatness does not count here.)	20 **/20%**
Presentation/Organization	Document looks like the work of a professional. Ideas follow in a logical manner. Layout and design is attractive.	5 **/05%**
Format Issues	Includes title page, table of contents, list of figures and tables, and references. Pages are numbered, figures and tables are introduced, headings are numbered, etc. References and citations are properly formatted.	5 **/05%**
Correctness/Style	Correct spelling, grammar, and punctuation. Style is clear, concise, and coherent.	4 **/05%**
Comments		98

IDENTEC

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Post Mortem - OraLite Optical System for Visual Differentiation of Tooth Material from Composite Fillings

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Issued date:

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Professor Lakshman One
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Re: Post Mortem for OraLite Optical System

Dear Professor Lakshman One

The attached document is the post-mortem for the OraLite optical system developed by IDENTEC. The goal of this project was to implement an optical system with existing dental optics to assist dentists in visually identifying composite resin fillings from real tooth material. This system will help dentists visually differentiate between the two materials during composite filling removal procedures.

This document outlines the current state of the product, deviations from our original plans, and our future plans for the OraLite optical system. We have also outlined the problems faced by us in terms of budget and time constraints. And at last each member has described his individual experience and his contribution towards this dream project.

The diverse IDENTECH team of four brave and brilliant individuals - Two biomedical engineers (Damian Kayra and Leo Lee) and two electronics engineers (Harrie Sidhu and Rex Xue) – has been working extremely hard for the past 14 weeks to develop the OraLite optical system. Please feel free to forward any questions or concerns to dkayra@sfu.ca.

Sincerely,

Damian Kayra
Chief Executive Officer
IDENTEC

Table of Contents

List of Figures

List of Tables

1. Introduction

The IDENTEC team has been working tirelessly for the past 14 weeks to develop the OraLite optical system capable of visually identifying composite resin fillings from real tooth material. The successful implementation of this technology would help dentists immensely as they will be able to visually differentiate between the two materials during composite filling removal procedures. This document highlights all the ups and downs suffered by the four brave and brilliant individuals - Two biomedical engineers (Damian Kayra and Leo Lee) and two electronics engineers (Harrie Sidhu and Rex Xue) – in realizing their dream and it tracks down the path followed by them in their attempt to solve the problem.

2. Current State of the Product

2.1 Overall System

To develop a working prototype of the OraLite system that allows the user to visually differentiate between tooth material and composite fillings, the following project guidelines were utilized to lead the project in the correct directions:

- The system should be easily integrated with current dental optics
- The system must be easy to use and not hinder the user in other tasks
- The system will use passive optics to visually enhance the composite fillings
- The system will be safe to use for extended periods of time

With the guidelines in mind, we decided to divide the OraLite system into three main components and develop each of them separately: light source, optical filters, and mechanical adapters. The light source will be responsible for exciting the composite material to produce its fluorescence. The optical filters are lenses that will enhance the contrast between the optical differences of tooth and composite materials. And lastly, the mechanical adapters will provide an attachment mechanism to permanently combine the optical filters with existing dental loupes. To efficiently tackle the design of each component, we separated our team into two groups: optical team and mechanical team. The optical team consisted of Damian Kayra and Leo Lee whose main focus was on the design of both the light source and optical filters because they were closely related to one another. The mechanical team composed of Harrie Sidhu and Rex Xue, were solely responsible for the design of the mechanical adapters. Figure 1 is an image of the final prototype design of the OraLite system installed on a pair of Heinz dental loupes.

Figure 1: Completed OraLite system integrated with dental optics

2.2 Light Source

As mentioned earlier, the light source is responsible for emitting a specific wavelength of light to excite the composite material to a higher energy state and allow the user to visually differentiate between tooth and white fillings. After extensive research on the material optical properties, multiple approaches were explored for the light source development. The original system concept was designed to use 405nm LED's to excite fluorescence. However, due to multiple disadvantages of the concept, the optical team decided to change the light source to use a 405nm laser diode i... presents the advantages and disadvantages of LEDs and laser dio...

Provide some numbers to give an idea of what is cheap, low power, etc.

Ta... of LEDs and laser diodes

LEDs		Laser Diodes	
Advantages	**Disadvantages**	**Advantages**	**Disadvantages**
Cheap	Heat	Lower power consumption	Requires a heatsink
Minimal safety concerns	Broad spectral range	Narrow spectral range	Safety
	Power consumption	Generates less heat	
	Low fluorescence excitation	Excellent fluorescence excitation	
		Collimated beam	

However, because a laser diode was chosen, several additional components needed to be implemented to ensure its function and safety. First, a heatsink is necessary to prevent the laser spectrum shifts which are natural properties of laser diodes. Aluminum was chosen as the heatsink material because of its light weight and excellent thermal conductivity properties. Figure 2 represents the dimensions and specifications of the heatsink.

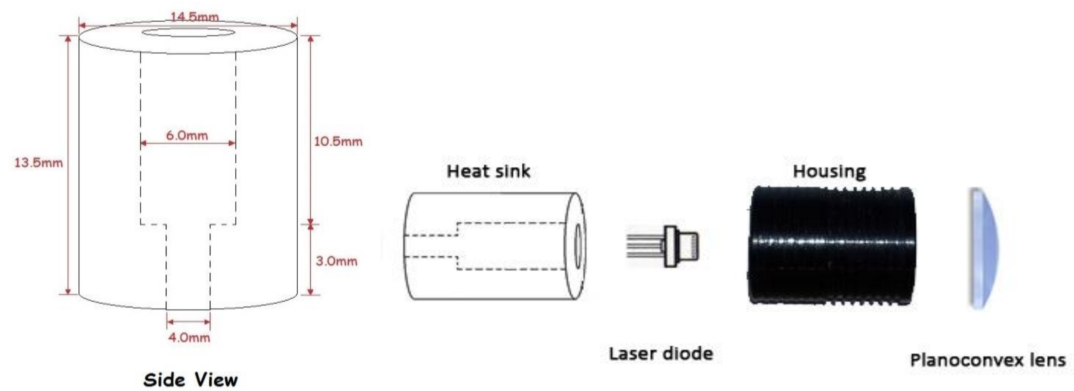

Figure 2: Heatsink dimensions and spec

General terms. Provide some numbers

Second, the chosen laser diode was found to have high rate of divergence of the laser beam which resulted in a lower optical intensity at distance. As a consequence, the composite did not fluoresce as well. By installing a planoconvex lens with a short focal length of 18mm, the laser diode's rate of divergence can be slowed as shown in Figure 3.

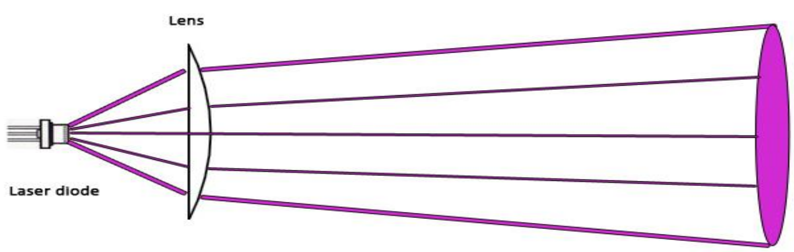

Figure 3: Planoconvex lens rate of divergence

Third, to lower the optical output power of the light source to be eye safe, a modulating circuit was designed to ensure safe clinical operations. To modulate the laser output while maintaining a reliable current flow through the diode, an oscillator in series with a current regulator circuit is used. A basic LM555 astable oscillator circuit designed with a duty cycle of 25% at a frequency of 52Hz was implemented. Because the OraLite system is powered from a battery source, a current regulator is necessary to ensure operating current of the circuit when the battery is low on power. Using a combination of two 2N3904 transistors, a common current regulator circuit was built. Figure 4 shows the two circuitries designed for the laser modulation.

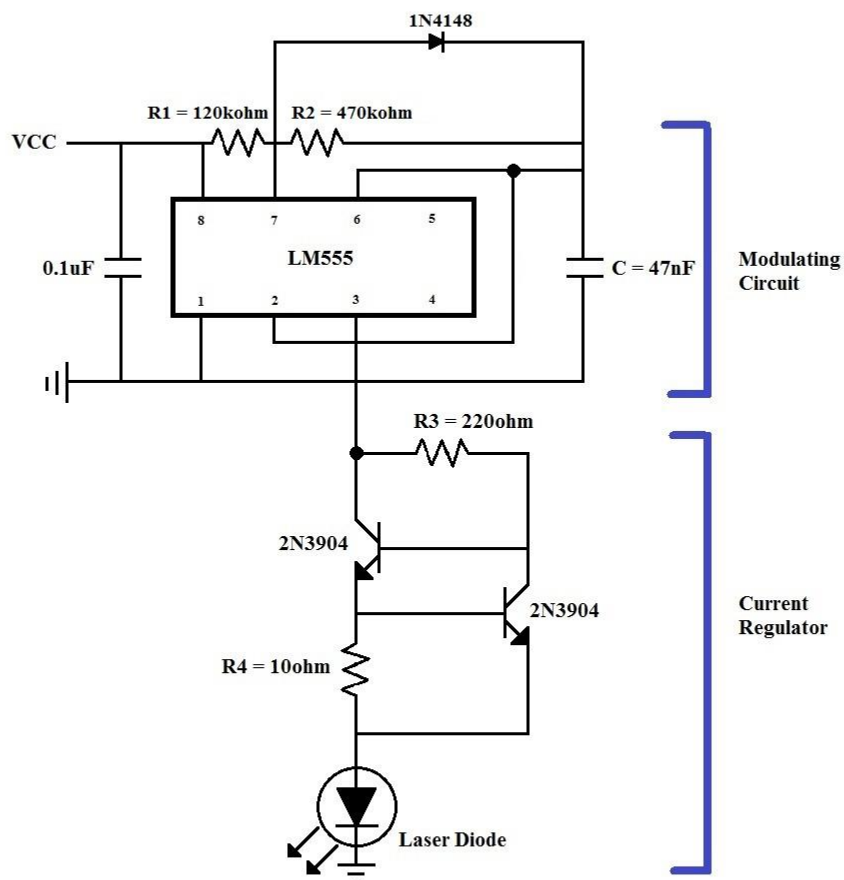

Figure 4: Laser modulation circuit design

By implementing the above mentioned components into the light source design, the OraLite system is capable of producing reliable 405nm light to visually separate tooth from composite materials.

2.3 Optical Filters

The optical filters have two main functions: the enhancement of the contrast between tooth and composite created by the excitation from the emitted light and the removal of 405nm from the user's vision. The enhanced visual contrast will allow the user to easily identify composite from the surrounding materials and the removal of the 405nm light is for safety concerns. The initial approach to the optical filters design was to utilize a bandpass filter at 430nm to 490nm with at least 90% transmittance. However, this design was soon abandoned when the filters were tested and found to impede the user's field of vision instead of enhancing it. As an alternative, 425nm longpass filters were selected and implemented as it provided much better contrast between the two materials as shown in Figure 5.

Without Longpass Filters **With Longpass Filters**

Figure 5: Visual comparison between with/without optical filters

2.4 Mechanical Adapters

The mechanical adapter design process proved to be an iterative process. First, a swivel attachment design was proposed as represented in Figure 6.

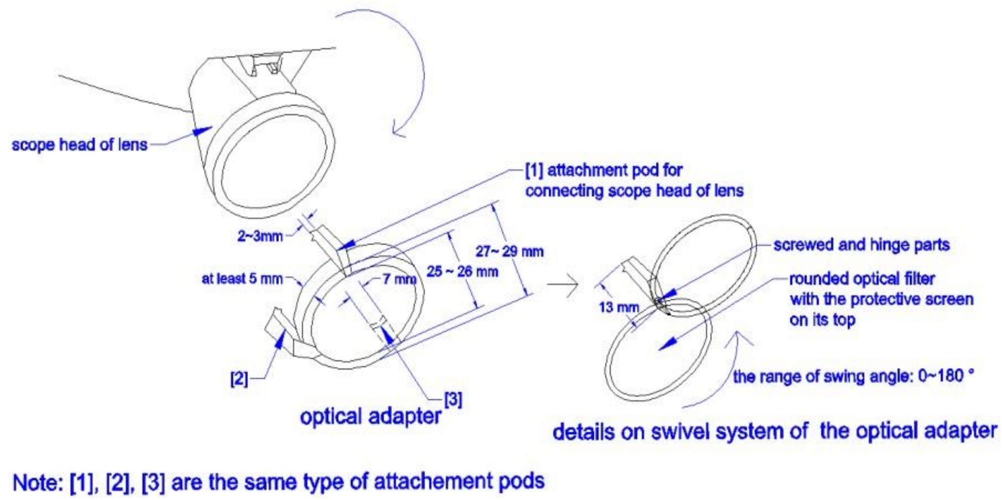

Figure 6: Swivel model design

The swivel system is an attachment that will allow the user to change between normal view and enhanced view with a simple flick of a finger. However, when the optics team altered their decision of using laser diodes instead of LEDs, safety became a vital concern to the project. The option of allowing the user to alternate between the normal and enhanced vision was eliminated to prevent potential dangerous actions by the users that may result in permanent eye damages. As a result, a second model known as the cap model was proposed which is shown in the figure below.

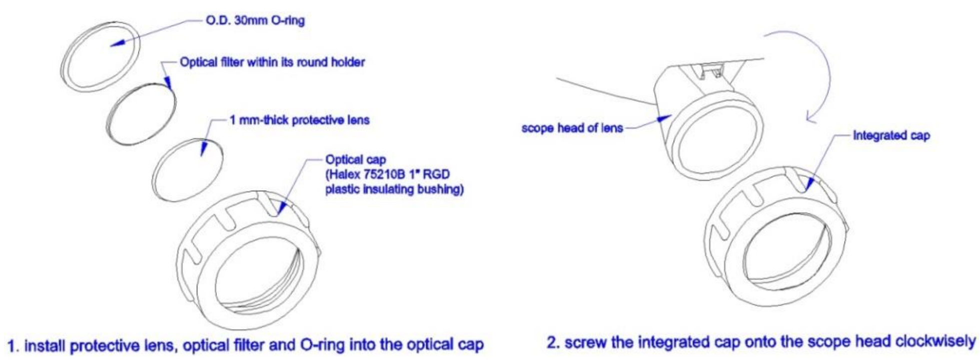

Figure 7: Cap model design

The cap model design utilized a common plastic cap that can be found in any hardware stores as an adapter. The plastic cap will encapsulate a protective lens, optical filter and O-ring together which will attach onto the dental loupe through a screw on method. This will permanently attach onto the dental loupe and prevent the user from alternating their vision.

However, the plastic cap is not an aesthetic pleasing design and the threads within the cap scratches the scope heads of the expensive loupes. As a result a tripod method was designed.

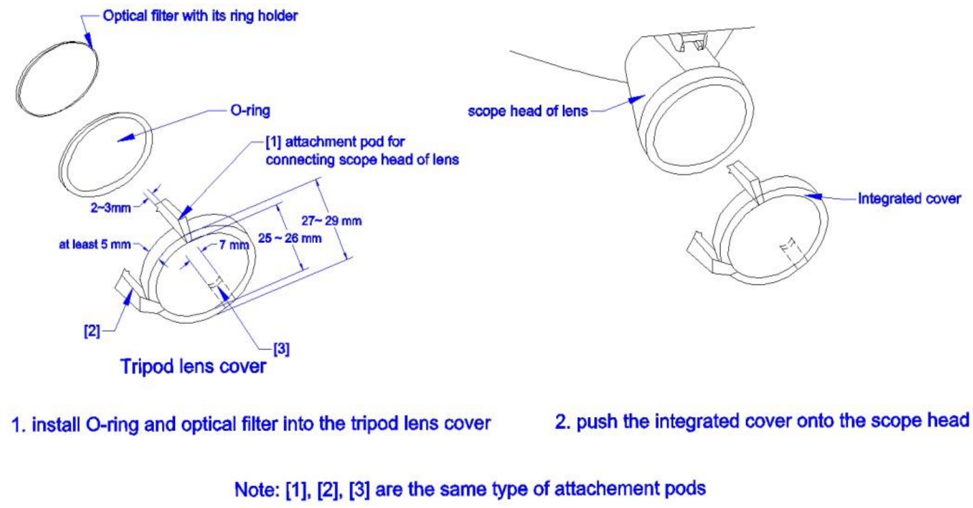

Figure 8: Tripod model design

The tripod model design, Figure 8, encompasses all the design specifications of the mechanical adapter. The design permanently attaches the optical filters onto the dental loupes. It is light weight and when attached, looks like any normal pair of dental loupes. Evidently, this was the clear choice as the OraLite system mechanical adapter.

3. Deviation of the Product

3.1 Overall System

Looking back at the goals outlined in the Proposal document at the start of this course, the final product matches very closely with what we had hoped to accomplish. The system allows to user to visually differentiate between tooth and composite fillings with ease, while not impeding their other tasks. We were able to integrate the system into currently used dental optics and believe that the system could easily be incorporated into a modern dental clinic.

3.2 Light Source

At the start of the project we were uncertain what type of light source we would use. Since most dental optics run a high power LED in their headlamps, it made sense to start our research and development with an LED. However, after a couple weeks of testing this approach proved impractical for reasons outlined in the Design Specification document, and we decided to move forward using a laser diode. This provided us with much better fluorescence at greater distances, and greatly reduced power consumption. The drawback to using a laser diode was that we had to make changes to the mechanical adapters in order to ensure that the user didn't sustain damage to their eyes.

3.3 Mechanical Adapter

Initially, we designed a swivel system to screw tripod lens covers onto the dental loupes by placing wooden piece hinders between them as a buffer. Based on the reason that we didn't want to change or break the original dental loupes, we abandoned this model and jumped into the cap model which is super light and easy to assemble or dissemble. When we considered that the inner screw thread of the cap may scratch the surface of scope heads when rotating onto the dental loupe or taking them apart, we had to move to the next level of designing. Finally, we adopted the tripod lens covers from the original model and clamped them onto the dental loupes with O-rings and optical filters inside. In this way, we delivered a much simpler attachment for the OraLite system.

4 Future Plans

This section will briefly detail the steps required to move our design from a prototype to a marketable product.

4.1 Composite Fluorescence Quantification

At the start of this project, it became apparent that there was very little information available about the fluorescence of the various composite resins in use today. We were able to identify the exciting wavelength for the specific sample that we had, which also happened to work for the six other samples we acquired later. However, certain composites are specifically designed not to fluoresce, which could prove problematic. In order to move the project forward, we would need to quantify the fluorescent properties of all available composites and see if the system needs to be adapted to improve functionality. Furthermore, it could prove useful to determine the fluorescent decay time of the composite materials in order to help optimize the laser modulation.

4.2 Laser Modulation Optimization

Towards the end of the project, it was evident that the optical output power of the light source was too high to be eye safe. As a result, the laser modulation circuitry was implemented into the design with the goal of reducing the output light power intensity and thus, increasing the safety of the system. The proposed design functioned properly with the OraLite light source; however, prior to mass production, both the modulation and current regulator circuit will need to be further optimized to be a functional commercial product. Even though the LM555 timer is the current industry standard for oscillators, the chip itself is not ideal to be implemented with a battery power source due to its high power demand. There are less power consuming oscillator chips in the market which would be more ideal for the modulation circuit. The optical power intensity of the modulated design will also need to be measured and iterated using an analog irradiance meter for optimization. The current regulator circuit also needs to be optimized to eliminate the possibility of transistor oversaturation. Other possible current regulator designs should be explored and selected to ensure the typical working conditions of the laser diode.

4.3 The Simplification of Mechanical Adapters

As we discussed, we would never give up any opportunity to seek a better solution to ease dentists' operating. To avoid that finger touching on the surface of optical filters affecting its function on transmittance, we consider permanently attaching O-ring, optical filter and tripod lens cover together before delivering the adapter to our end users. It means that we would provide one piece integrated adapter to avoid the complexity of assembling.

5. Budgetary and Scheduling

5.1 Budget

We received funding from the Engineering Undergraduate Student Society in the amount of $750.00 at the beginning of October. The amount was still sufficient although we actually spent $760 in total which exceeded the budget of $10.

The table below contains the cost of the project on each purchase of materials up to December 11th, 2013.

Table 2: Project Cost Breakdown

No.	Item	Manufacturer	Cost
#1	425nm Longpass Filter X2	Edmund Optics	$230.00
#2	Clear Loupe Covers	Henry Shein	$10.00
#3	20mm Optical Lens	Edmund Optics	$50.00
#4	Custom Heat Sink	Identec	$35.00
#5	405nm Laser Diode X2	US-Lasers	$110.00
#6	Bandpass Filters (450/80nm & 460/60nm)	Edmund Optics	$130.00
#7	395-405nm 30mA LEDS	Digikey	$40.00
#8	405nm 2W & 5W LEDS	Mouser Electronics	$120.00
#9	Miscellaneous - Electronic & Mechanical	Homeden[illegible]	$35.00
	Total Expenditure	[illegible]	[illegible]**0**

I prefer the projected and actual budget to be on the same table. Easier to compare.

However, the cost listed above does not indicate [illegible] e some of the components, such as bandpass filters, [illegible] phase of analyzing and testing tooth and composite mater[illegible]

The following table lists the cost of all components in the final prototype:

Table 3: Final Product Cost Breakdown

Item	Manufacturer	Cost for Prototype
425nm Longpass Filters	Edmund Optics	$230.00
Clear loupe covers	Henry Shein	$10.00
20mm Optical Lens	Edmund Optics	$50.00
Custom heat sink	Identec	$35.00
405nm Laser Diode	US-Lasers	$55.00
Miscellaneous		$15.00
	Total Amount	**$385.00**

The building of material cost for our OraLite system is roughly $385. For mass production, the estimated cost could be cheaper than the prototype due to bulk orders. If we order thousands in quantity for each component, we could potentially get 20%-30% discount from these vendors and lower the cost of final product to $280. If we assume that we sell $1000 per unit (with the assumed cost of $280) to 20% of dentists in Canada (Until January 2010, there are 19,563 licensed dentists in Canada), we can make approximately $2.8 million.

5.2 Scheduling

Gantt chart would be better.

Table 4: Comparison - Projected Milestone Date & Realized Milestone Date

Milestone	Projected Milestone Date	Realized Milestone Date
Project Planning/Proposal	26-Sep	26-Sep
Functional Specs	17-Oct	17-Oct
Group A - Spectrographic Analysis		
Group B - Mechinical Adapters Research		
Design Specs	14-Nov	**17-Nov**
Group A - Design & Build Optical Parts		
Group B - Design & Build Mechanical Adapters		
Integration / System Testing (Group A+B)	18-Nov	18-Nov
System Modification & Testing on Extracted Teeth Samples	25-Nov	**21-Nov**
System Modification for Electronic Circuit	6-Dec	6-Dec
Demo & Project Closure	27-Nov	**11-Dec**

From the above table of comparison projected milestone date with realized milestone date, basically we finished most of tasks on time at different stages. Although we strive to meet all deadlines we set for ourselves, some milestones at late stages were modified during the course of this project as unforeseen issues arose. For example, we got 3-day delay on design specification because there were some disagreements on the design of mechanical adapters. Also, because we underestimated the importance of light source modulation in the design, we needed more time to rebuild the circuit with LM 555 timer and transistors to output constant current for our light source. Due to exam conflicts, we had to reschedule the demonstration date to Dec 11th, 2013. Extra modifications were implemented to ensure safety and robustness of the OraLite system. Fortunately, the project was completed on time as we planned.

6. Individual Learning Curve

6.1 Damian Kayra

Over the course of this project I had the pleasure of working with a group of talented individuals who came together as a team to bring an abstract concept into a reality. Playing the role of CEO, my main objectives were to oversee the development of the project, ensuring that the mechanical, optics and electronics members stayed coordinated, while also applying the optics knowledge I had acquired through courses and co-op placements to help the project reach its goal. It has probably been one of the more work intensive courses I have taken since starting my Engineering degree, and has given me some valuable insight into what it takes to bring a concept to life.

Having worked for a year in the biomedical imaging field, as well as taking ENSC 470, it made sense for me to oversee the development of the optical component of the OraLite system. Right away we discovered that there was a serious lack of information regarding the optical properties of composite filling material and decided to do our own research to determine if the project was even feasible. Luckily, Derek Sahota was kind enough to lend us a few hours use of his lab and we were able to determine the excitation wavelength as well as quantify the fluorescent properties of the composite resin and tooth material. Once we had identified those key factors I felt a lot more confident in our ability to create a working prototype and set to work establishing what steps were needed to move forward. I think the biggest technical challenge I encountered during this project was making the transition from the LED light source to the laser diode. We had designed the entire optics assembly around using an LED, and the sudden transition to a laser diode meant having to redo all the testing as well as acquire all new components and a custom cut thermal heatsink. Looking back, it would have saved time and money to simply have bought the somewhat expensive laser diode at the same time we purchased our first round of LED's. If we had tested the fluorescence with the laser diode at the start, we likely would have realized that the diode provided far superior results and built our design around it instead of LED's.

In my role on the optics team I worked closely with Leo who proved to be an extremely capable and adaptable teammate. We spent many hours working in various optics labs around Vancouver during the research phase of this project. We would often review various optical components together and bounce ideas back and forth about how to implement certain design goals. This proved to be hugely beneficial to the project since if I overlooked an element of a component critical to the design, Leo would often catch what I had missed.

Overall this project was an excellent learning experience for me, and I was lucky to share it with a group of intelligent and hardworking individuals. It is a really rewarding experience to be able to look at something and say: "I made that."

6.2 Leo Lee

The entire semester of researching, planning, developing, and learning with the team has been an amazing and enjoyable experience for me. My team members, Damian, Rex and Harrie, are all wonderful individuals to work with, each with their own set of unique skills. On multiple occasions, our team overcame various obstacles by sharing each of our individual expertise and knowledge in our respective fields through open discussions. Over the past 16 weeks, I have been able to witness the true essence of teamwork and professionalism first hand as we combine all our potential together in the development of the OraLite system.

In my role as the Chief Technical Officer, apart from organizing team meetings and delegating individual responsibilities, I spent countless hours researching the optical properties of tooth and composite materials as well as testing multiple light source and optical filter configurations. Being a biomedical engineer and having experience in designing and fabricating prototype technology in my co-op position at St. Paul's Hospital, part of my job was to implement the different proposed methods and provide improvements while critiquing the feasibility of the approach. This meant testing the functionality of the LEDs and laser diodes during typical operations as well as ensuring reliable interactions with the heatsink, optical filters and modulating circuit. Being part of the optical team, I have spent the majority of the time working with Mr. Kayra, who proved to be an extremely talented and exceptional engineer. We shared our ideas and opinions about the different methods and reviewed each approach before testing. Mr. Kayra's knack for finding simple yet elegant solutions is unparalleled.

There were a few challenges we encountered in this project. First, was the difficulty in finding the appropriate equipments and apparatus for either testing or fabricating the OraLite system components. Finding the correct equipment to test took a lot of our time contacting various resources but luckily, many individuals at SFU are extraordinary in their field and extremely professional in letting our team borrow their equipment for the project. Second, was the extensive documentation needed to be completed on the different design aspects on the OraLite system. Fortunately, because the team`s excellent personals and professionalism, the optical and mechanical team interacted frequently and always remained respectful and constructive to successfully complete the documentations. Last but not least, was the over spending of budget. This was inevitable because some of the testing approaches were extremely expensive and having limited knowledge in the field, it was important to find out the most appropriate method to implement into the OraLite system.

Overall, the project itself was one of the most enjoyable and rewarding experiences I had at SFU. I am glad to have the opportunity to work together with such capable engineers on one of the most interesting and practical projects. Special thanks to all the amazing individuals at SFU who have contributed their help to our project. This project would have not been anywhere as successful without them.

6.3 Harrie Sidhu

For the past 14 weeks, I have been working diligently on the OraLite optical system with a wonderful group of individuals. The idea was one of a kind and we were the first to try and implement this kind of technology. Working on this project has taught me many interpersonal skills apart from the technical skills that I learned. This has been a life changing experience for me.

From the technical perspective, I increased my knowledge about optics. As the technology involved was based solely on finding the right wavelength, through this project I revisited all the things I learned about optics so far. In addition I learned about circuitry, implemented AutoCAD for 3-D designs, and worked with 555 Timer circuit.

This was my first time working on a major team project. When I first heard the idea, I was a little disappointed as the project was more medically based. I being an electronic engineer felt that I won't be able to help much. But as the project went on, it dragged me in. We divided the project into two parts which I feel was the right thing to do. Having two bio-medical and two electronic engineers in the group, we allocated the duties accordingly. This taught me how to work with people of different specialties and putting together all the ideas which is a vital job skill. We had difference of opinions occasionally but we managed to deal with it professionally.

The most important thing I learned is that if you are working in a team, you need to give each other space and listen to all the ideas. And then pick the best idea. Never leave a team member out of any discussion. Never take any criticism personally and treat your group members with the same respect as you want them to treat you with.

Trial and error is the way to go. The major aspect I learned about engineering projects is that there are no guarantees. You cannot follow a pre-decided path. In our project we changed our mechanical adapter design three times. Keep on trying until you find the right thing.

Finally, I learned that group meetings are essential part of team projects. There were some times when we did not know what to do. We called for team meetings and discussed the problems. And guess what, there were no problems just imaginary blockades. There will be hard times during the course of the project. But we have to keep going. Keep pushing and let yourself to be pushed. Never be afraid of making mistakes.

Capstone project taught me real world job skills - Group dynamics apart from technical skills. This course is time consuming. Due to my heavy course load this semester, I was not able to involve myself with other aspects of this project. Given the chance, I would love to work on this project in detail and not just my parts.

It has been a wonderful experience working with great group of people. In order to succeed, you need to trust one another and that is exactly what we did. Hence we succeeded.

6.4 Rex Xue

Over the whole project, I was mainly responsible for building mechanical adapters. Through group discussion and taking notes for meeting, I felt that I have become familiar with how to implement designing progress starting from initial ideas to the prototype and final product. Also, by drawing AutoCAD sketches for dental loupes and mechanical adapters including details of each part, I have enhanced my skills of 3D mechanical drawing, designing and drafting. By designing the company logo in Fireworks with group members, I gained better understanding aesthetics on patterns and colors.

Moreover, I'm pleased to have the opportunity to be exposed to calculation and modification of circuits for outputting constant current to our light source. Even though the circuit we built were relatively simple compared to more complex integrated circuits with temperature compensation, it was proved that it was working well for its function on current regulation during testing. I hope to work on projects that have current regulators and timers in the future to experiment in depth with power management techniques.

In addition, I have learned and acquired much more knowledge of optical spectrum analysis by joining in optic testing with group members. I was enlightened by every attempts and errors we made and learned how to summarize working or non-working parts.

I also found that adequate research could help us save time and speed up cooperating efficiency in the project. What I have learned so far is that how innovative one thinks one's ideas are, someone out there must have thought about it. It is possible to achieve our goal encouraged us to be focused and dedicated to our project by reviewing available resources from the wiser. Personally, I felt that it was crucial to know that a similar project has been progressed over the past few years and absorb their successful experience to avoid failing to disappoint.

Actually, we got a bit messy situation due to independent writing styles from each member when we wrote up the project proposal together for the first time. After then, our group has developed an excellent method for documentation by setting up some efficient rules for writing. Firstly, we set up a document template. Then, each member finished his own assigned part based on the template and sends it to the only one editor – Damian. Then Damian will put every piece together and send it back to rest of us for review. If any of us wants to change some parts or suggest ideas, he should notify rest of us before starting revising. Finally, we set up smooth procedures for reducing the workload of paperwork.

Interpersonally, our weekly meetings have given me the chance to present myself and listen to others. Because our system was divided into 2 sub-systems with optics and mechanical parts, every effective communication plays a vital role at each stage so that at the time of system integration, the system could be put together perfectly. It has been a very precious experience and I quite enjoyed working with my inspired group members.

7. Conclusion

The IDENTEC team has achieved their goals for the prototype of their OraLite Optical System. The system works as intended with general dental loupes. All modifications and testing were completed in the course schedule with no major issues apart from fitting all the components into one piece. Also, the system delivered a successful solution for comforting dental operations.

All documentation was done as a group and equally distributed as well as completed with a high degree of professionalism and quality. There is currently one electronic stethoscope on the market produced by 3M. This stethoscope is very expensive, but the company has a huge amount of capital and resources to reduce this price.

The team members worked very well together without any issues that needed to be resolved. Communication between members and teams was facilitated using face-to-face meeting, phone, text and email so that each group member was up to date on everything that was being discussed.

IDENTEC is very proud of what they produced and would readily work together again.

Appendix A: Meeting Minutes and Agendas

Meeting-1, (September 12, 2013)	Get to know the fellow group members and to discuss the project proposal
Meeting-2, (September 13, 2013)	Finalize the project proposal
Meeting-3, (September 17, 2013)	Discuss the project in detail and allocate individual responsibilities
Meeting-4, (September 20, 2013)	To start implementing the technology
Meeting-5, (September 24, 2013)	To test UV LED flash light with tooth and composite samples under a spectrometer
Meeting-6, (October 2, 2013)	Met with Derek Sahota to ask about using his equipments for testing; Purchase Materials.
Meeting-7, (October 3, 2013)	Discuss mechanical parts of OraLite optical system
Meeting-8, (October 8, 2013)	Set-up meetings with various individuals for the project
Meeting-9, (October 15, 2013)	Harrie and Rex to explain their ideas for the mechanical adapter
Meeting-10, (October 25, 2013)	Harrie to propose for new mechanical adapter design
Meeting-11, (November 8, 2013)	Finalize the design for the mechanical adapter
Meeting-12, (November 14, 2013)	To discuss mechanical adapter design change
Meeting-13, (November 22, 2013)	To decide about the changes to be made in the project
Meeting-14, (December 2, 2013)	To implement the 555 Timer circuit and finish the project for the final Demo

Agenda
September 12, 2013
12:30-13:30

Members Present: Damian Kayra, Leo Lee, Zhenpeng Xue, Harrie Sidhu

Members Absent: None

Purpose of the meeting: Get to know the fellow group members and to discuss the project proposal.

Items for Discussion:

- Familiarize yourself with other group members
- Share each other's contact information
- Assigning individual responsibilities
- Discuss various project ideas and select one

Minutes
September 13, 2013
14:30-16:00

Members Present: Damian Kayra, Leo Lee, Zhenpeng Xue, Harrie Sidhu

Members Absent: None

Purpose of the meeting: Finalize the project proposal

Minutes:
Damian called the meeting to order at 14:30

A. Business

Motion from Damian: To select his idea as a capstone project – "Design a system that allows dentists to visually differentiate between regular tooth material and composite (white) fillings."

Discussion: Harrie pointed out that the project might not fit our time frame. Questions were asked by Zhen about the total cost of the project. Damian stated all the facts and the potential cost of the project.

Vote: 4 voted for, 0 against

Action: Damian's idea was selected as the capstone project

B. Next Meeting Date

The next meeting was arranged for September 17, 2013 at 11:30

C. Other Business

None

Meeting was adjourned at 16:00.

Minutes
September 17, 2013
11:30-12:30

Members Present: Damian Kayra, Leo Lee, Zhenpeng Xue, Harrie Sidhu

Members Absent: None

Purpose of the meeting: Discuss the project in detail and allocate individual responsibilities

Minutes:
Leo called the meeting to order at 11:30

A. Approval of Minutes

Motion: To approve the minutes of the September 13, 2013 meeting

Vote: 4 voted for, 0 against

Action: Minutes of the September 13, 2013 meeting approved without modifications

B. Business

Motion: Damian and Leo to work on the experimental setup and procedure of the project. Harrie and Zhen to look after the technical stuff and to work on the frame to attach the optical filter to the dental loupe. Both groups to oversee each other.

Vote: 4 voted for, 0 against

Action: Motion approved

Motion: Damian to book lab times to work on the project next week

Vote: 4 voted for, 0 against

Action: Motion approved

Motion: Leo mentioned that we should start ordering instruments required for the project

Discussion: Harrie asked whether we should try to borrow them or not. Damian pointed out that we cannot experiment with the borrowed stuff. He then decided to buy some of the things for now.

Vote: 4 voted for, 0 against

Action: Motion approved

C. Next Meeting Date

The next meeting was arranged for September 22, 2013 at 12:00

D. Other Business

None

Meeting was adjourned at 12:30.

Minutes
September 20, 2013
12:00-12:30

Members Present: Damian Kayra, Leo Lee, Zhenpeng Xue, Harrie Sidhu

Members Absent: None

Purpose of the meeting: To start implementing the technology

Minutes:
Damian called the meeting to order at 12:00

A. Approval of Minutes

Motion: To approve the minutes of the September 17, 2013 meeting

Vote: 4 voted for, 0 against

Action: Minutes of the September 17, 2013 meeting approved without modifications

B. Damian showed the dental light, dental loupe and some old teeth to be used for the experiment.

Discussion: Zhen mentioned that now we have the dental loupe so he and Harrie can start working on the frame for the add-on.

Action: To begin experimenting on September 24, 2013

C. Next Meeting Date

To be decided

D. Other Business

None

Meeting was adjourned at 12:30.

AGENDA

September 24, 2013
11:30-13:00
Lab (Applied Sciences Building)

Purpose of the meeting: To test UV LED flash light with tooth and composite samples under a spectrometer

Items for Discussion:

- Preliminary tests under white light and UV light
- Need to purchase items to make the testing system more precisely
- Decided on types of UV LED we needed

MINUTES

September 24, 2013

11:30-13:00

Lab (Applied Sciences *Building)*

Members Present: Damian Kayra, Leo Lee, Rex(Zhenpeng) Xue, Harrie Sidhu

Members Absent: None

Purpose of the meeting: Test UV LED flash light with tooth and composite sample under spectrometer

Minutes:

Leo called the meeting to order at 11:30

A. Preliminary tests

Analysis & Actions:

1. Preliminary tests showed no difference in emission under white light. Damian is curious about blue light emissions so we need to find blue filters to cover up the white light source. Leo mentions that we need to find the differences in emission under different UV wavelengths. Basically, to find a specific and safe UV wavelength that will give us the maximum fluoresce. Along with a cable attachment, the UV LED needs to work with the standard ultra-light optics battery supply we borrowed from Dr. Brian Bostrom.

2. Rex noticed the root tooth fluoresces as well, so we needed to find the emission wavelength difference between tooth and composite and how deep it fluoresces. Depending on the differences, we can decide whether it is possible to filter out the root tooth fluorescence using a bandpass or a highpass filter.

3. Harrie observed the composite fluoresces starting at 425nm from the readings, but we still need to test different composites. We decided to buy (390nm, 400nm and 405nm) UV LED. However, Damian noticed the data of the wavelength spectrum collected using the spectrometer showed that the probe is

not sensitive enough with the current LED flashlight and the basic black box apparatus. We need to have more precise devices for doing tests.

B. Next Meeting Date

The next meeting was arranged for September 26, 2013 at 15:00. However, Harrie cannot make it due to his other commitments.

C. Other Business

None

Meeting was adjourned at 13:00.

AGENDA

September 26, 2013
15:00-16:30
P8444A & ASB

Purpose of the meeting: Meet with Derek Sahota to ask about using his optical filters and equipments; Purchase Materials.

Items for Discussion:

- Asked Derek to use/borrow his optical filters and equipments for our project
- Submit the final copy of the proposal
- Submit the application form of Wighton Funding
- Purchase LEDs from Digikey

MINUTES

September 26, 2013
15:00-16:30
P8444A & ASB

Members Present: Damian Kayra, Leo Lee, Rex(Zhenpeng) Xue

Members Absent: Harrie Sidhu (Due to work schedule)

Purpose of the meeting: Meet with Derek Sahota to ask about using his optical filters and equipments; Purchase Materials.

Minutes:

Damian called the meeting to order at 15:00.

A. Meet with Derek Sahota

Discussion: Derek was willing to share the laser system and optical filters in his lab with us. However, he preferred we set up our apparatus with the necessary materials before meeting up with him again.

Actions: We appreciated the help Derek is offering us and we plan to analyze and test efficiently when we meet up with him again.

B. Damian submitted the final copy of the proposal and the application form of Wighton Funding

C. Leo purchased LEDs from Digikey

4 X 400 nm	30° view angle
3 X 405 nm	15° view angle
1 X 405 nm	30° view angle
1 X 395 nm	15° view angle
1 X 390 nm	15° view angle
1 X 405 nm	30° view angle
Total Cost	**$35.11**

More Analysis & Actions: Rex, Leo and Damian looked for optical filters from different reputable companies: Semrock, Thorlabs and Edmonds etc.

D. Next Meeting Date

The next meeting (Sub-group for Optical Parts: Damian and Leo) was arranged for Oct 2nd, 2013 at 16:00

Meeting was adjourned at 16:30.

AGENDA

AGENDA

October 2, 2013
16:00-19:00
ASB

Purpose of the meeting: Testing with Derek Sahota using his equipments (Optical Group)

Items for Discussion:

- Test using a more precise spectrometer / laser system
- Find the differences through an optical bandpass filter from 450nm – 600nm
- How to enhance the image visually

MINUTES
October 2, 2013
16:00-19:00
ASB

Members Present: Damian Kayra, Leo Lee

Members Absent: Rex(Zhenpeng) Xue and Harrie Sidhu (Not in Optical Group)

Purpose of the meeting: Testing with Derek Sahota using his equipments (Optical Group)

Minutes:

Damian called the meeting to order at 16:00

A. Test with Derek Sahota

Analysis & Discussion:

1. Last testing session we found the root to fluoresce was very similar to the composite.
2. Damian sliced the tooth sample in half to test the fluorescence of the inner tooth. Leo set up apparatus using microscope plates with black electrical tape and tooth samples glued to the plate.
3. We saw differences through an optical bandpass filter from 450nm – 600nm
4. Derek showed us the enhancement of the image using polarized lens + filter
5. The spectrum data inside of the tooth showed peak *fluorescence* around 500 nm whereas the peak *fluorescence* of composite *was around 490nm. Damian suggested we should still be able to separate the two using optical filters due to the difference in intensity. However, the filters would be very expensive due to the specific bandpass and transmittance needed.*

Future Actions:

1. Get polarized film to block out incident light source at around 400 nm.
2. Set up LEDs at different wavelengths to see which one is the most optimal light source.

3. Test filters under bright light to simulate the brightness of clinics' operating environment.
4. Do research on function specification and documentations.

B. Next Meeting Date

The next meeting for all members was arranged for Oct 3rd, 2013 at 12:00

Meeting was adjourned at 19:00.

AGENDA

October 3, 2013
12:00-13:30
ASB

Purpose of the meeting: Discuss mechanical parts of OraLite optical system

Items for Discussion:

- Possible solutions for building the optical adapter
- Tested the UV LEDs and compare them with the dentist light
- Purchase of Specific items such as bandpass optical filters

MINUTES
October 3, 2013
12:00-13:30
ASB

Members Present: Damian Kayra, Leo Lee, Rex(Zhenpeng) Xue, Harrie Sidhu

Purpose of the meeting: Discuss mechanical parts of OraLite optical system

Minutes:

Leo called the meeting to order at 12:00

A. Possible solutions for building the optical adapter

Discussion:

1. Rex suggested using a larger cylinder tube to cover current dental loupe for attachments
2. Harrie added on the idea of separating the tube and connecting them by using a screw for fixing hinge
3. If possible, Harrie will look for an attachment similar to the dental loupe
4. Alternatively, using the same technique with the sliding hinge, insert and attached the optical lens.

Future Actions:

1. Rex would go to looking for a 25mm camera lens cap for a possible item
2. Leo would send an email to Heines to quote the attachment system

B. Testing (Damian & Leo)

1. Damian tested the LEDs and found that they were too low powered compared to the dentist light
2. Leo suggested we need higher powered LEDs (Ordered two 2W 405nm high powered LEDs from Digikey which cost $40.95)
3. Disassembled dentist light (Manufacturer quoted it to be $395)

Future Actions:

1. Replace the LED with high powered 405 nm LED when it arrives

2. Need to buy bandpass optical filters (between 440nm and 480nm) with at least 80% transmittance due to magnification, but each desired filter is $300. To save money, send email to Marinko, Michelle, Andrew to see if they have filters in the range 440nm-480nm.

3. Need to buy UV protection goggles for demo
4. Need to measure UV intensity
5. Measure the amount of current coming from battery supply

C. Next Meeting Date

The next meeting for all members was arranged for Oct 8rd, 2013 at 12:00

The meeting was adjourned at 13:30. Then, Damian & Leo did the test after meeting.

D. Other Business

None

Meeting was adjourned at 13:30.

Minutes
October 8, 2013
11:30-12:30
(Applied Science Building)

Members Present: Damian Kayra, Harrie Sidhu, Leo Lee, Zhenpeng(Rex) Xue

Members Absent: None

Purpose of the meeting: Set-up meetings with various individuals for the project

Minutes:

Harrie called the meeting to order at 11:30

A. Business

Motion from Harrie: Visit an optical centre to seek advice on the attachment system

Discussion: Harrie mentioned that he has contacts in an optical centre in Surrey and they are willing to have a look on the optical adapter system

Action: Harrie to visit the optical centre in the following week

B. Rex to explore Home Depot for the optical adapter parts.

Discussion: Damian mentioned as time is running very fast, we should start assembling the parts required for the adapter.

Action: Rex to visit Home Depot by the end of the weekend

C. Next Meeting Date

Next meeting to be held on October 15, 2013 in the Applied Science Building

D. Other Business

None

Meeting was adjourned at 12:30.

Minutes
October 15, 2013
12:00-12:30
(Applied Science Building)

Members Present: Zhenpeng(Rex) Xue, Harrie Sidhu, Damian Kayra, Leo Lee

Members Absent: None

Purpose of the meeting: Harrie and Rex to explain their ideas for the mechanical adapter

Minutes:

Rex called the meeting to order at 12:00

A. Approval of Minutes

Motion: To approve the minutes of the October 8, 2013 meeting

Vote: 4 voted for, 0 against

Action: Minutes of the October 8, 2013 meeting approved without modifications

B. Business

Motion from Harrie and Rex: Harrie put forward their idea of mounting a binocular system onto the dental loops with the optical filters attached at the end

Discussion: Leo raised concerns about the length of the binocular system. Damian pointed out that it should not change the current use of dental loupes in any respect

Action: The binocular system was accepted with some alterations in the size

C. Next Meeting Date

Meeting was adjourned at 12:30.

Minutes
October 25, 2013
12:00-12:30
(Applied Science Building)

Members Present: Zhenpeng(Rex) Xue, Harrie Sidhu (Only the mechanical adapter team)

Members Absent: Damian Kayra, Leo Lee (Optical team - not needed)

Purpose of the meeting: Harrie to propose for new mechanical adapter design

Minutes:

Harrie called the meeting to order at 12:00

A. Harrie proposed that new mechanical adapter design should be adopted as the old design is not feasible.

Discussion: Harrie explained that the old design is going nowhere and the deadline is fast approaching. He proposed an alternate cap design model for the mechanical adapter and explained its parts. Rex enquired about it and nodded positively.

Action: Mechanical team to adopt the new desing.

C. Next Meeting Date

Next meeting TBA

D. Other Business

None

Meeting was adjourned at 12:30

Minutes
November 8, 2013
1:30-2:30
(Applied Science Building)

Members Present: Harrie Sidhu, Damian Kayra , Zhenpeng(Rex) Xue, Leo Lee,

Members Absent: None

Purpose of the meeting: Finalize the design for the mechanical adapter

Minutes:

Harrie called the meeting to order at 1:30

A. Business

Motion from Harrie: Cancel the swivel system and opt for the simple cap system for the mechanical adapter.

Discussion: Harrie stated that the swivel system is too complicated and will not be completed in our timeline. Instead opt for the cap system as it is easy and simple to build, and the parts are also available. This cap system fits our budget too and easy enough for the final users to use. Rex also seconded it.

Vote: 4 voted for, 0 against

Action: To go ahead with the swivel system.

B. Talk about the progress in design spec and any problems, if any.

Discussion: Everyone stated that they are doing fine with their parts. Rex pointed out that we need to design the mechanical adapter part soon as we need to draw the final design for the design spec. Damian stated that he needs to do more testing on the light sure.

Action: Harrie to start assembling mechanical adapter and Damian and Leo to do more testing tomorrow.

C. Next Meeting Date

Next meeting to be held on November 14, 2013 in the Applied Science Building

D. Other Business

None

Meeting was adjourned at 2:30.

Minutes
November 14, 2013
12:30-1:30
(Applied Science Building)

Members Present: Zhenpeng(Rex) Xue, Harrie Sidhu, Leo Lee, Damian Kayra

Members Absent: None

Purpose of the meeting: To discuss mechanical adapter design change

Minutes:

Leo called the meeting to order at 12:30

A. Approval of Minutes

Motion: To approve the minutes of the November 8, 2013 meeting

Vote: 4 voted for, 0 against

Action: Minutes of the November 8, 2013 meeting approved without modifications

B. Business

Motion from Damian: To permanently put the optical filters inside the mechanical adapter instead of keeping it loose as previously proposed.

Discussion: Damian raised concerns that if our end users are able to take the filters in and out of the mechanical adapter it will ruin the optical filters.

Vote: 4 voted for, 0 against

Action: To permanently put the optical filters inside the mechanical adapter using a sealant.

C. Any question about design spec?

Discussion: Everything going well with the design spec report. No one has any major issues with their responsibilities.

D. Next Meeting Date

TBA

E. Other Business

None

Meeting was adjourned at 1:15.

Minutes
November 22, 2013
1:00-1:30
(Applied Science Building)

Members Present: Zhenpeng(Rex) Xue, Harrie Sidhu, Leo Lee, Damian Kayra

Members Absent: None

Purpose of the meeting: To decide about the changes to be made in the project

Minutes:

Leo called the meeting to order at 1:00

A. Approval of Minutes

Motion: To approve the minutes of the November 14, 2013 meeting

Vote: 4 voted for, 0 against

Action: Minutes of the November 14, 2013 meeting approved without modifications.

B. Business

Motion from Damian: To incorporate circuit in the project design as per prof's instructions.

Discussion: Damian discussed about prof's instruction in detail about adding a circuit to the project to meet engineering standards. Everyone acknowledged.

Vote: 4 voted for, 0 against

Action: To make changes in the project accordingly.

C. Final Demo date change?

Discussion: Everyone was okay with the final Demo date change due to new addition in the project.

C. Next Meeting Date

Next meeting TBA.

D. Other Business

None

Meeting was adjourned at 1:30.

Minutes
December 2, 2013
1:00-5:30
(Applied Science Building)

Members Present: Damian Kayra, Zhenpeng(Rex) Xue, Harrie Sidhu, Leo Lee

Members Absent: None

Purpose of the meeting: To implement the 555 Timer circuit and finish the project for the final Demo

Minutes:

Damian called the meeting to order at 1:00

A. Approval of Minutes

Motion: To approve the minutes of the November 22, 2013 meeting

Vote: 4 voted for, 0 against

Action: Minutes of the November 22, 2013 meeting approved without modifications.

B. Business

Motion from Damian: To start working on the 555 Timer circuit and finalize the project for the Demo.

Discussion: Optics team kept on working on the 555 Timer circuit. In the meantime, mechanical team to finish up the mechanical adapter implementation.

Result: In about 4 hours, optics team was able to finish up their work and the mechanical team permanently attached optical filters onto the mechanical adapter. No further changes are to be made now.

C. Next Meeting Date

No more official meetings.

D. Other Business

None

Meeting was adjourned at 5:30.