AggiE-Challenge: Stand-alone Surgical Light for Engineering World Health

Olivia Harrington[1], Ibukun Oni[1], Nicole Norwood[1], Ross Garrisson[2], Joyson Varghese[2], Astride Tchoffo[2], Carol Ebeid[2], and Greg Merrill[3]

Kristen Farris Duckworth[1] and Kristen Carlson Maitland[1]

Department of Biomedical Engineering[1], Electrical Engineering[2], Mechanical Engineering[3]

Dwight Look College of Engineering, Texas A&M University

Introduction

- Developing countries face many healthcare problems mainly due to poor socio-economic growth and development.
- A vast majority of medical equipment used in developing countries are donations of old equipment from Western countries.
- The problem with those donations is that 39% are dysfunctional upon arrival, 58.5% will be dysfunctional after 5 years in service, and only 2.5% will be functional for more than 5 years.
- In developing countries, surgery light bulbs are expensive to replace and not always locally available. Therefore, our aim is to design a universal, low-cost surgical light that is suitable to environment and has a long life time.

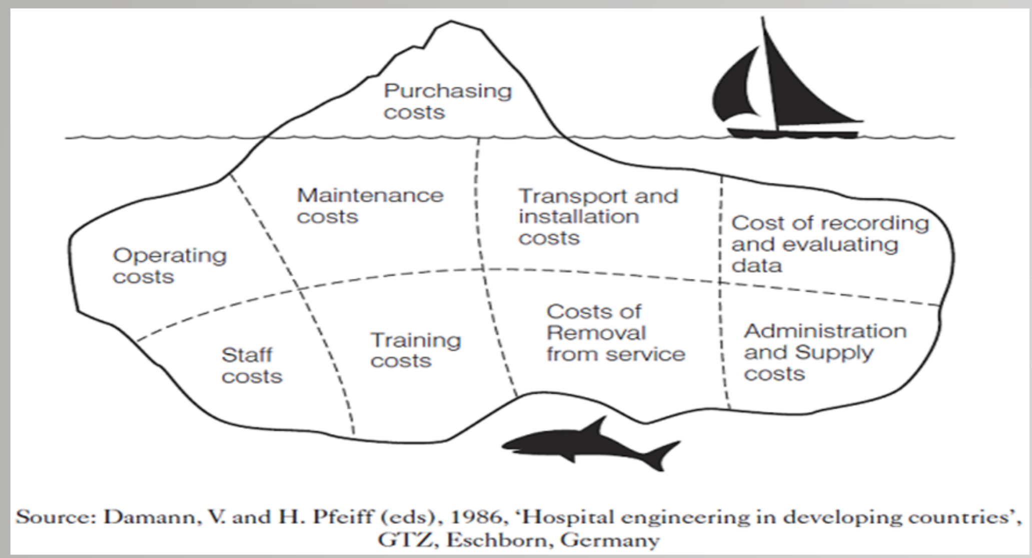

Figure 1: Costs in a typical hospital

Electrical Design

- 50 leds used to meet the light intensity specification
- Constant current driver with flyback converter drives the LEDs
- Constant current driver helps control brightness while flyback converter provides additional safety for the system
- Parallel strings configuration for LEDs arrays for better fault immunity

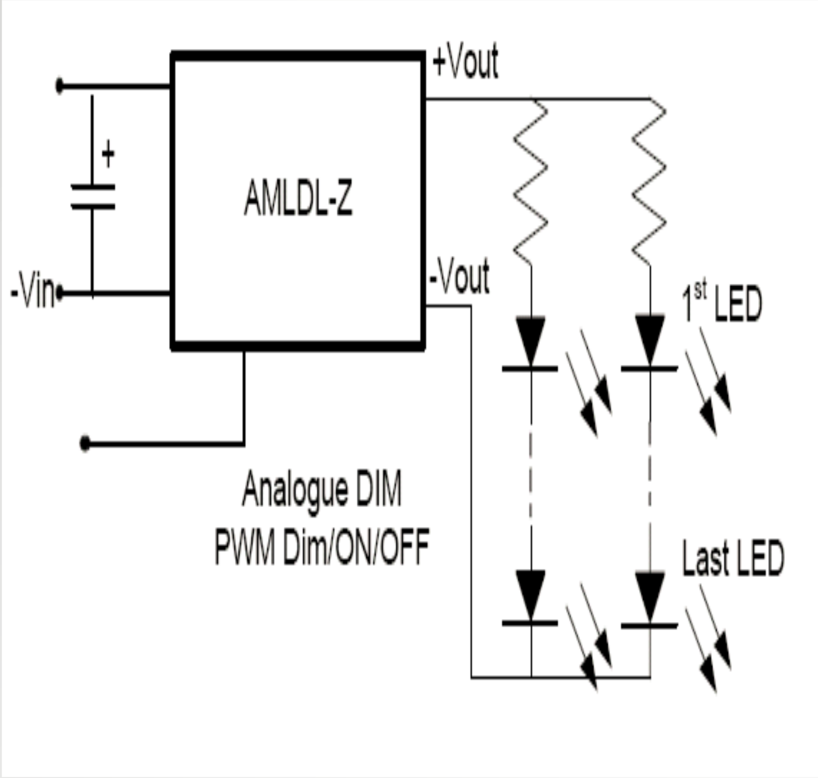

Figure 4: Parallel configuration with IC control

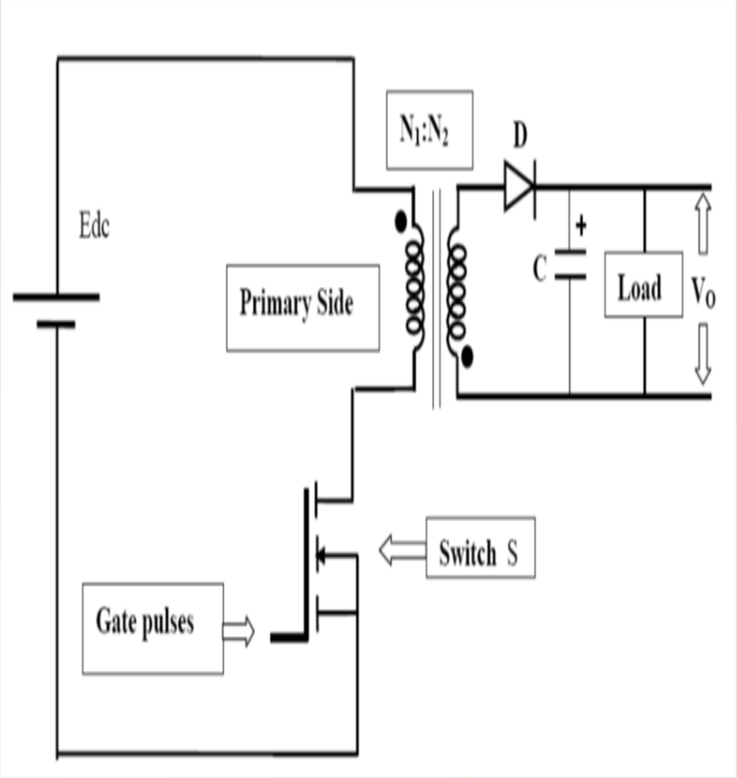

Figure 5: Flyback converter topology

Optical Design

- A lens will be used to focus the light.
- The lens would ideally be lightweight, inexpensive, and durable.
- A Fresnel lens has the capabilities of a traditional convex lens but reduces the amount of material used.
- Plastic Fresnel lenses are more lightweight, inexpensive and less likely to break than glass. They may be more readily available in developing countries than any other type of lens.
- The Fresnel lens concentrates and focuses light into a soft beam.

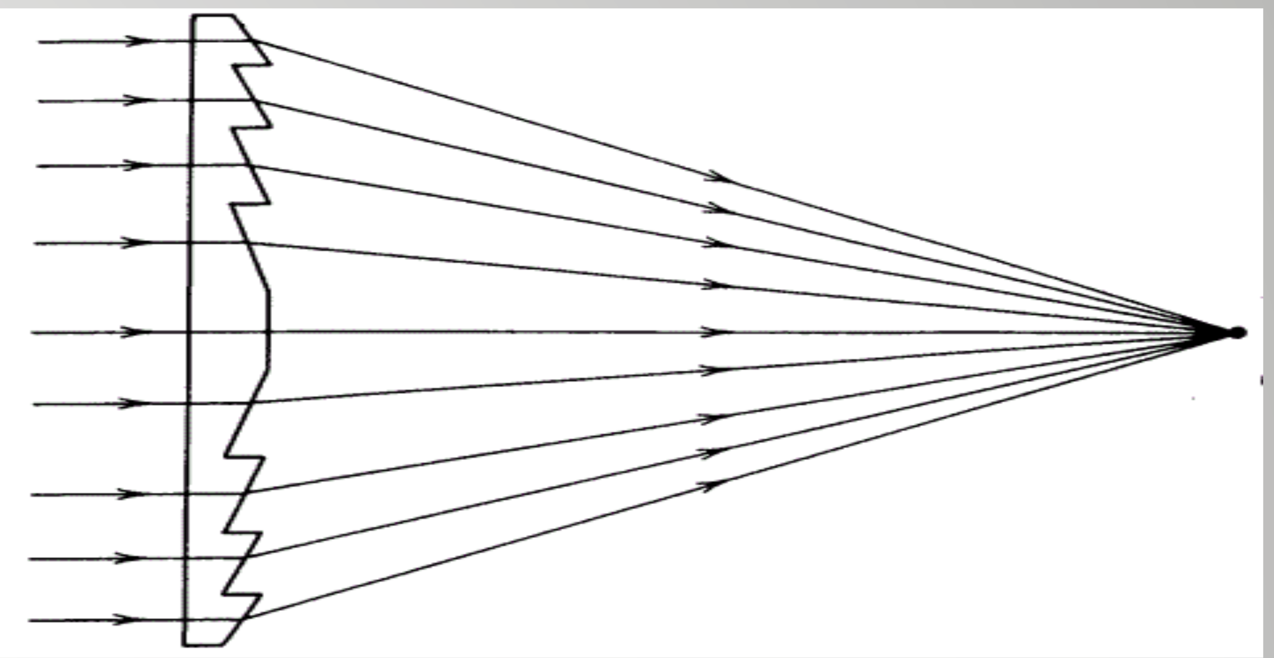

Figure 8: Fresnel lens focusing spectra

Mechanical and Electrical Analysis

Electrical Analysis

- Design specifications : light intensity in the range of 40,000 to 160,000 lux, adjustable brightness, reliability, safety, backup power system
- LEDs used as light source for their low-cost and long lifetime
- Backup power system uses car batteries since they are readily available in developing countries and can provide power for up to three hours.

Mechanical Analysis

Design mechanical requirements

- Physical Stability
- Physical Adjustability
- Mobility

Free body diagram created and calculations made to confirm the requirement will be met. The images below show the diagram and the calculations made for the mechanical design.

$$F_g + F_{Battery\,1} + F_{Battery\,2} + F_{Lighthead} = F_{Normal}$$
$$\sum F_x = 0$$
$$\sum F_y = 0$$
$$\sum M_{center} = 0$$
$$-1ft * F_{Battery\,1} + 1ft * F_{Battery\,2} + 3ft * F_{Lighthead} = 0$$
$$F_{Battery} = 39lbs$$
$$F_{Lighthead} = 25lbs$$

Figure 2: Free Body diagram Calculations

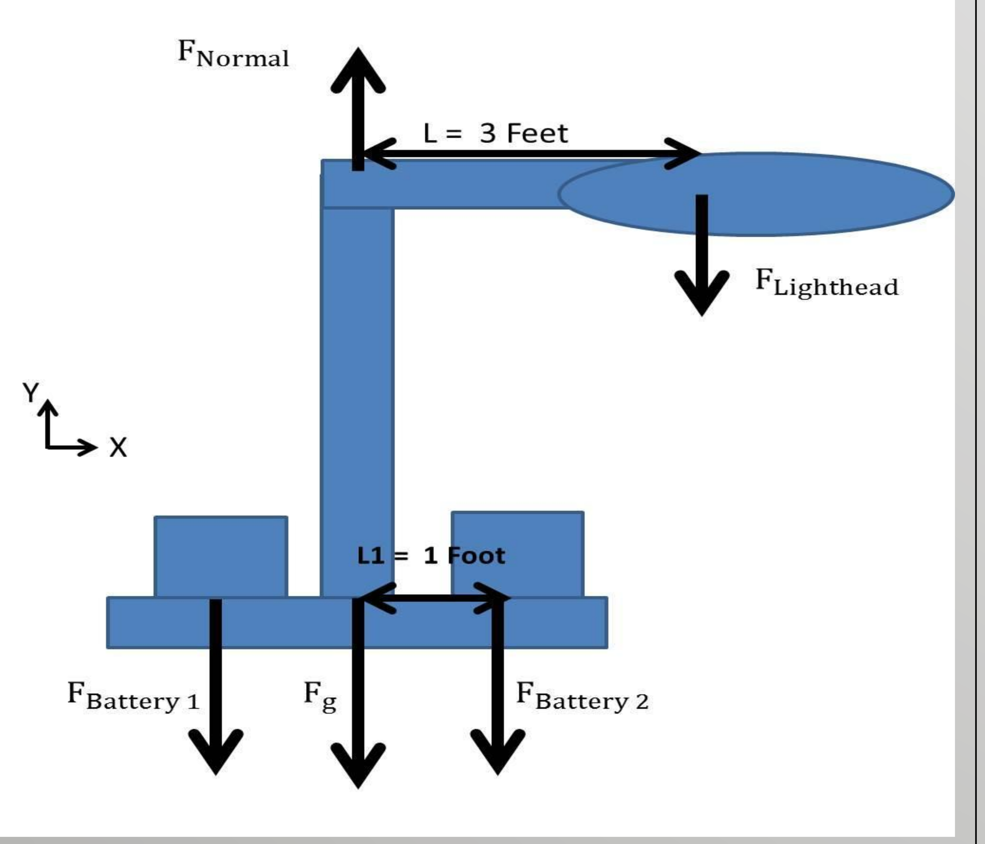

Figure 3: Free Body diagram

Mechanical Design

Requirements for Mechanical Design

- Sturdy (not easily broken)
- Adjustable
- High load bearing capacity (FBD)

Materials to be used for the design are :

- Aluminium
- Schedule 80 PVC

Reasons Material s were chosen

- Cost Efficiency
- Availability
- Met Requirements

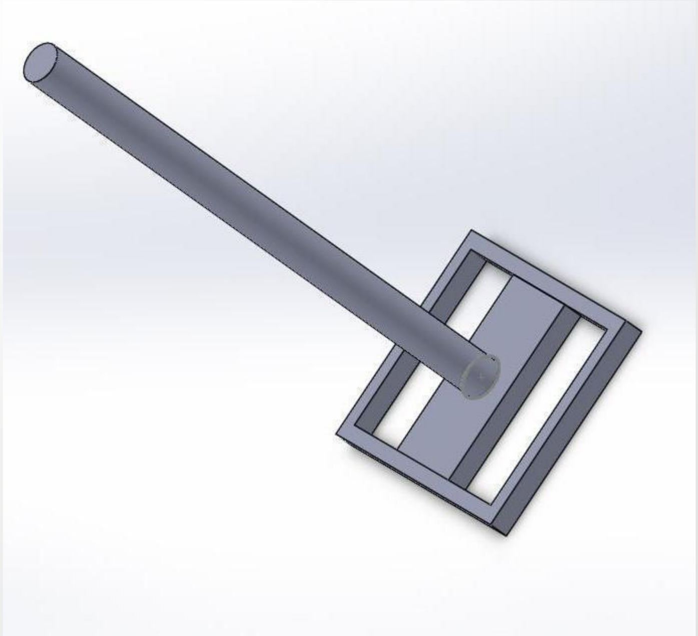

Figure 7: Rough Solid works sketch of Mechanical Design

Instead of designing the surgery light bulb only, we modified our end goal and decided to design a complete, free-standing surgery light system. We wanted be able to control the light's manoeuvrability ourselves and also not worry about a universal attachment mechanism which could get overly complicated considering there is such wide variety of surgery lights in current use. After viewing prior art of common surgery light configurations, we selected support structures that fit our design goals. We noted current designs that were not overly complex and had at least two axes of rotation. We talked to John Vilas of Vilas Motor Works for suggestion on how to build a cost effective support structure that could be implemented in the hospitals overseas. He was able to offer a considerable amount of advice about frame material, telescoping joint options, how we would want to implement wheels, and possible configurations for holding our backup car battery at the base of our support structure.

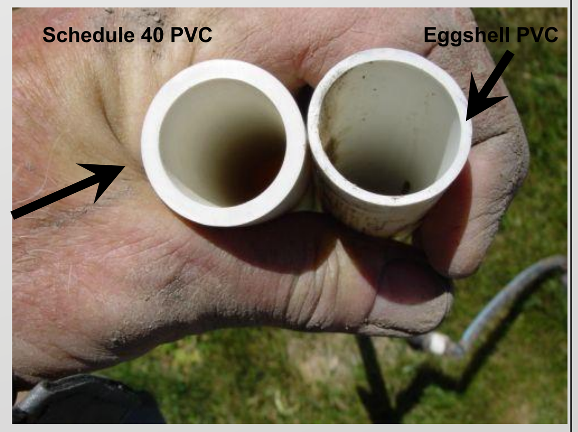

Figure 6: PVC pipe chosen

Testing

Mechanical Testing

- Load Bearing Testing: Ensure fixture does not topple over when the light head is attached
- Material Testing: Ensure the materials would be durable and last in the hospital environment.

Electrical Testing

- Battery Testing: Adequate power to the surgical light is needed
- Power Testing: due to the variable power this test is needed to ensure power regulation and reduce risk of overloading the circuit
- LEDs testing: Intensity test

Optical Testing

- Light Field Diameter
- Light intensity: 40-160,000 Lux as required

Figure 9: Lux meter

Challenges and Future Direction

This semester our team has

- Researched standards for surgical light bulbs and looked at design ideas
- Received feedback from the Rwanda SI students concerning the project.
- Decided on material for the mechanical design
- Started to design a prototype using SolidWorks
- Decided to use microcontrollers for electrical system diagnosis.

Next semester:

- Implement design and build prototype
- Receive feedback from engineers and students regarding prototype
- Improve prototype and build up to the final creation