

**The fire alarm is going off  
and you have no idea  
where the nearest exit is.**

**What are you going to do?**

**Follow the LGES of course!**



**The LGES will guide you to  
the nearest and safest exit  
allowing you to escape the  
fire.**

**Laser Guided Evacuation System**

**Team LazrSavr**

**EE 585/595**

**2011**

**PROJECT REPORT  
LASER GUIDED EVACUATION SYSTEM  
EE585/EE595  
SENIOR DESIGN**

**Prepared By:  
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December 9, 2011**

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## Table of Revisions

Rev.	Description of change	By	Approved	Date
IR	Initial Release	Harlan E. Sharpe	<hr/>	<u>12/09/2011</u>

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# 1.0 Introduction

## 1.1 Purpose

This document describes the detailed methods used in the design, development, construction, and analysis used to complete the Senior Design project. The project our group developed is the Laser Guided Evacuation System (LGES). This report explores both the concept of the LazrSavr, as well as a consumer usability guide.

NOTE: *In some figures the Laser Guided Evacuation System is referred to as LGES.*

## 1.2 Reference Documents

**Table 1.2-1– List of References**

No.	Description
1.	<i>Mark's Standard Handbook for Mechanical Engineers, 11<sup>th</sup> Edition. ISBN: 978-0071428675</i>
2.	Fundamentals of Physics, 8 <sup>th</sup> Edition. ISBN: 978-0470044742
3.	<i>Google Patent Search – <a href="http://www.google.com/patents">http://www.google.com/patents</a></i>
4.	<i>Arduino Duemilanove - <a href="http://arduino.cc/en/Main/ArduinoBoardDuemilanove">http://arduino.cc/en/Main/ArduinoBoardDuemilanove</a></i>

## 1.3 Abbreviations & Acronyms

**Table 1.3-1– Abbreviations/Acronyms**

Abbreviation/Acronym	Definition
A	Amps
BPS	Back-Up Power Supply
LGES	Laser Guided Evacuation System
°C	Celsius
cm	Centimeter
dB	Decibels
Dc	Deflection Angle
DC	Direct Current
ECU	Electronic Control Unit
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
ESD	Electrostatic Discharge
°F	Fahrenheit
Hz	Hertz
kHz	Kilo-Hertz
kPa	Kilo-Pascals
m	Meters
mA	Milli-Amps
MHz	Mega-Hertz
mm	Millimeter
ms	Millisecond
pF	Pico-Farad
RF	Radio Frequency
RH	Relative Humidity
uF	Micro-Farad
V	Volts

Abbreviation/Acronym	Definition
VDC	Volts Direct Current
W	Watts

## 1.4 Safety Precautions

The operator must exercise standard safety procedures. LGES uses a high power laser diode. This laser light is not harmful to persons; however, proper safety procedures shall be followed when dealing with direct laser light.

## 1.5 Standard Ambient Conditions

The term “standard ambient conditions” as used in this report shall mean the environmental conditions controlled to within the following limits:

Temperature: 0°C to 100°C (32°F to 212°F)

Humidity: Less than 95% R.H.

Atmospheric Pressure: 84 to 107 kPa

## 1.6 Standard Input Power

The term “standard input power” as used in this report means DC power input to the LGES system. The voltage shall be controlled to 12  $\pm$ 0.5 VDC.

## 2.0 Project Scope

The CDC (Center for Disease Control) states that statistically every 31 minutes someone is injured in a fire; every 175 minutes someone dies from fire or fire related issues (smoke and toxic gases). Experts across the nation agree that the reason for these deaths is the lack of warning and evacuation planning during a fire or fire related emergency. Team LazrSavr endeavors to help keep you from becoming a fire related statistic, by providing a new and innovative laser guided evacuation system.

### 2.1 Proof of Concept

The LGES system originated to help solve inadequacies that team LazrSavr found with existing fire alarm systems. In public buildings, the general public is often unaware of all available emergency exits. The exits are required to be marked per national codes; however, this system can, and often does, have flaws. LGES works to provide a visible aid that will direct persons, with little to no knowledge of where the exits are, to the nearest exit. If the nearest exit is unsafe, an alternate route is selected, thus providing the safest exit possible. This is accomplished by a highly visible laser beam (ref. figure 2.1.1) shown upon a solid surface traveling in the direction of the best route.

Figure 2.1.1



A design guideline team LazrSavr followed during development of the product was to keep systems simple. The overall operation of the system is basic in both design and operation. This is to keep the product reliable, easy to produce, and easy to maintain. Increasing reliability is important since the product may only be operated once a year during maintenance tests. When an alarm is triggered, the system is required to operate consistently and reliably regardless of the last time of operation. Design simplicity also works to reduce the overall cost of the product. By reducing the required number of parts, thus reducing cost, the product is able to be constructed of higher grade materials. This reduction in cost also permits the product to be more obtainable to a wider group of consumers.

## 2.2 Benefits

Benefits the LGES product has to offer is a high intensity laser light along with easy to service parts and high reliability. The high intensity laser light is incased in a solid aluminum housing that dissipates heat generated by the laser, thus providing the longest laser operation of its kind. For added security, a model will be available that will have an additional low power fan to help cool the entire unit for extremely long periods of operation. These features alone help distinguish the Laser Guided Evacuation System as a leading product among all other competitors.

The benefits of the Laser Guided Evacuation System are ultimately endless. Not only is there an apparent need for a more adequate emergency evacuation system, other applications have been discovered for the product. One example of this is locating items in a warehouse. An operator could find the item required on a computer database that lists the location of the item. The computer then sends the location to the LGES which would direct the operator to the correct location of the desired item. Another example in which the product could be incorporated is a hospital setting. Families could be direct to patient's rooms by a simple push of a button from the attending nurse at the nurse's station removing the confusion and frustration of trying to navigate in an unfamiliar place. This system could also provide less confusion for medical staff during a patient's call by providing a lighted route to the room requiring service potentially making medical care quicker and more efficient.

## 2.3 Features

Features that help distinguish the product developed by team LazrSavr are listed here. Many of the features are also benefits and many of the benefits are features. The Laser Guided Evacuation System is an innovative concept with very few, if any, competing products on the market today. Because of this, team LazrSavr believes the LGES system and its features are the best the market has to offer and are to be considered the industry standard for such a product. Some of the features are listed below.

- High intensity red laser
- Eco-Friendly and efficient laser cooling system
- Low power consumption
- Readily available/durable/dependable components
- Cost effective to produce and maintain
- Easy to integrate into existing alarm systems
- Minimal maintenance required, less than a standard smoke detector

## 2.4 Usability and Customer Feedback

A usability study was initiated for this product and its functionality. This study allowed team LazrSavr to gain better insight into LGES’s viability in the world market place. The study was performed by first gaining professional opinions on the matter of better fire evacuation systems. An experienced fire marshal/inspector who works at a state university where fire safety is extremely important (and wishes to remain anonymous) is quoted as follows when asked if the LGES product would be a viable product:

“In my professional opinion, the Laser Guided Evacuation System would prove to be an invaluable tool and resource for safer emergency evacuation. I would highly recommend a system as invaluable as this one could prove to be.”

The second part of the study was conducted by posting a survey to a social media site, where a selected number of random individuals were given the opportunity to comment and evaluate the LGES system. At the end of the study, the results were collected, analyzed and recorded in table 2.4.1 below. From the results it is apparent that the need for an improved emergency evacuation system is readily required.

**Table 2.4.1**

<b>Response</b>	<b>Percentage</b>	<b>Comments</b>
<b>Yes</b>	<b>87</b>	“Great idea, simplistic design, much needed idea, great concept, extremely practical, great to boost emergency evacuation, etc.”
<b>No</b>	<b>10</b>	“Will it continue to work after building fire, earthquake, etc? Will the laser be harmful to eyesight? What about the visually/hearing impaired?”
<b>Maybe</b>	<b>3</b>	“Great concept, but is it practical to produce? Will all buildings be required to update to this system? What about costs that some may not want to pay if forced to upgrade?”

## 2.5 Serviceability and Reproducibility

As mentioned in section 2.1, the Laser Guided Evacuation System was designed to be simple and thus easily serviceable and reproducible. Maintenance will be minimal. The product should be properly maintained by performing an operations check bi-annually. If the product does not appear to be operating correctly, reference section 3.2: Troubleshooting. The simple design allows for the product to be serviced by a trained fire marshal, or other official performing fire alarm system checks.

Reproducibility is accomplished by designing the product with internal components that are universal and easily obtainable. This eliminates the lack of replacement parts (if required), along with high production costs due to rare/unique components used for production.

## 3.0 User Guide

### 3.1 Product Instructions

The Laser Guided Evacuation System (LGES) was created to help save lives by assisting people to building exits in the event of a fire. The fire alarm systems currently in use operate on one general principle, if a smoke detector senses heat or smoke the alarm sounds to alert people that there is a problem and they should evacuate the area. The alarm will also sound if someone activates the alarm by pulling the fire alarm pull station located in most public buildings. Some systems also incorporate signaling devices that notify an area fire station that there is a problem. The LGES is simply an addition to the existing fire alarm system. The LGES is a dome that contains a high intensity laser and two servo that are integrated into the existing fire alarm system. The servo move the laser so it points towards the building exits thereby guiding people out of the building. Typically servo are located in hallways in the vicinity of exits. The sensors that detect the fire relay that information to the servo and it directs people away from the fire to the nearest exit allowing for a safer and quicker evacuation of the building.

Since the LGES system is tied into the existing fire alarm system the user interaction required is extremely low once the system is installed. It operates on the same power as the existing system and does not require additional actions by the user to function properly after installation with the exception of annual cleaning and testing.

There are several recommended locations for the LGES. At least one LGES should be installed on each floor of the building allowing people to find their way down to the main floor. Additional alarms should be located near all stairways in the building to assist in floor evacuations in the event of a fire as all building elevators should be inoperable. It is also recommended that an alarm system be located in rooms where major electrical appliances are located. This will allow people to quickly exit the room and locate the easiest way out of the building.

As with most alarm systems the LGES also has several locations where it should not be installed as the manufactures cannot guarantee the functionality of the product. The LGES system should not be placed anywhere the temperature may fall below 40 °F or rise above 100 °F as extreme temperature may cause the device to malfunction. Dusty areas should also be avoided as dust particles may cause false alarms or the alarm may not function at all. The LGES system should not be placed near fluorescent lights as electronic “noise”, or interference, may cause false alarms as well.

The maintenance of the LGES is fairly simple. The alarm system should be cleaned and checked a minimum of once a year to insure proper operation of the system. The connection of the alarm into the building fire system should be examined to ensure that the alarm is still properly connected and functioning.

## 3.2 Troubleshooting

Several issues were encountered during the creation of the LGES system. Overheating of the system caused the laser to cease working. To combat this a laser was created using a flashlight as a cover and placing a heat sink in to top of the laser diode. This kept the laser from overheating and allowed it to function properly.

Due to the limited ability to test the system it has not been connected to an existing fire alarm system. To simulate the situation a circuit board was built to represent various rooms in a building and the LGES was integrated into the circuit board. Once this system was built the LGES system was tested and found to be fully functioning and operating as expected.

In the unlikely event that the LGES is malfunctioning there are several things that should be checked. If the LGES unit ceases to function properly the power should be checked first. Make sure all switches have not been turned off or to the test position. Ensure that the power supply is still functioning and connected to the unit. Check for any loose or broken wires. If the unit still has power and there are no loose or broken wires check to make sure that the unit is wired into the existing system correctly. Finally, should the laser stop working a replacement laser can be obtained and installed at a relatively low cost.

## 4.0 Product Information

### 4.1 Product History/Team Dynamics

The origin of team LazrSavr’s product comes from a noticed need for an improved building evacuation system. The product is one solution to help solve the inadequacies that team LazrSavr feel have yet to be addressed in many commercial building fire evacuation systems. The team members responsible for the development of the Laser Guided Evacuation System are listed in table 4.1.1.

**Table 4.1.1**

<b>Member’s Name</b>	<b>Role</b>	<b>Role Description</b>
Don Crawford	Team Captain	Works to organize the group and keep all members on task when meetings occur.
Mohammad Abdelhaq	Designer/Skeptic/Researcher	Exhausts all resources to determine faults and other options with all ideas stated during team member meetings.
Pawan Upadhayay	Project Manager/Researcher	Works to keep the project on task and keep members focused on task at hand. Also contributes data pertaining to project ideas.
Harlan Sharpe	Researcher/Reporter/Critic	Responsible for all notes, paperwork, monetary issues, etc. Also contributes data pertaining to project ideas.

All members were responsible for meeting as a group as frequently as deemed necessary. Meeting times were varied depending on the level of work required to complete the project.

Team members were held responsible for the following behaviors:

- Provide assistance and support to other members
- Verbally voice opinions and matters of concern in a non-demeaning manner
- Contribute fully to team participation
- Respect one another

Team members were held responsible for the following:

- Actively participate in meetings
- Be open minded to ideas and opinions of other members
- Use proper communication to effectively describe thoughts and ideas
- Be diligent in your work; carry your own load

## 4.2 Revision History

Revision histories of hardware and software components are to be kept in a table format. Table 4.1.2 is an example of the preferred form. The major revisions for the LGES product is listed in table 4.1.2 as well.

**Table 4.1.2**

<b>Revision</b>	<b>Description of Change</b>	<b>Date</b>
0.1	Mounted laser to servo instead of attaching mirror to small computer fan in order to produce traveling beam on wall.	Feb. 10, 2011
0.1.1	Designed reliable laser with heat sink for continuous operation without experiencing failure. This laser replaces the current laser that would fail after overheating.	Sept. 20, 2011
0.1.2	Built a simulation building fire alarm system control panel to simulate/test the Laser Guided Evacuation System. This will also provide mock situations to demonstrate the functionality of the LGES to the public.	Nov. 15, 2011

## 4.3 Patent Research

A significant amount of patent research has been completed concerning the Laser Guided Evacuation System. Most research has been conducted with the aid of Google's patent search tool (<http://www.google.com/patents>). Results from the research are located in table 4.2.1 below. It can be gathered from the table that although LGES is not a new concept, it is a unique one of a kind concept at this time (from the fact that there are very few patents concerning laser guided emergency evacuation).

**Table 4.2.1**

<b>Item</b>	<b>Patent Number</b>	<b>Filing Date</b>	<b>Issue Date</b>
1	5140301	Sep. 19, 1989	Aug. 19, 1992
2	US 2011/0157486	Dec. 8, 2010	Jun. 30, 2011
3	US 2011/0261553	Sep. 8, 2010	Oct. 27, 2011

#### 4.4 Industry Standards

The product has not yet been tested to meet any industry standards. From a design standpoint, the product should interfere very little with other systems already integrated into the current installation location. For example, pre-existing wireless communications should not be interrupted by installing the LGES. Further testing will be required of the product before more knowledge can be obtained concerning industry standards.

From an installation standpoint, the product will meet/follow guidelines set forth by both the national electric code and the national fire code. When installing the electrical components of the product, all wiring shall follow the NFPA 70: National Electrical Code, 2011 edition, or equivalent. Locating and installation of the product shall follow NFPA 1: Fire Code, 2012 edition, or equivalent.

#### 4.5 Liability/Warranty

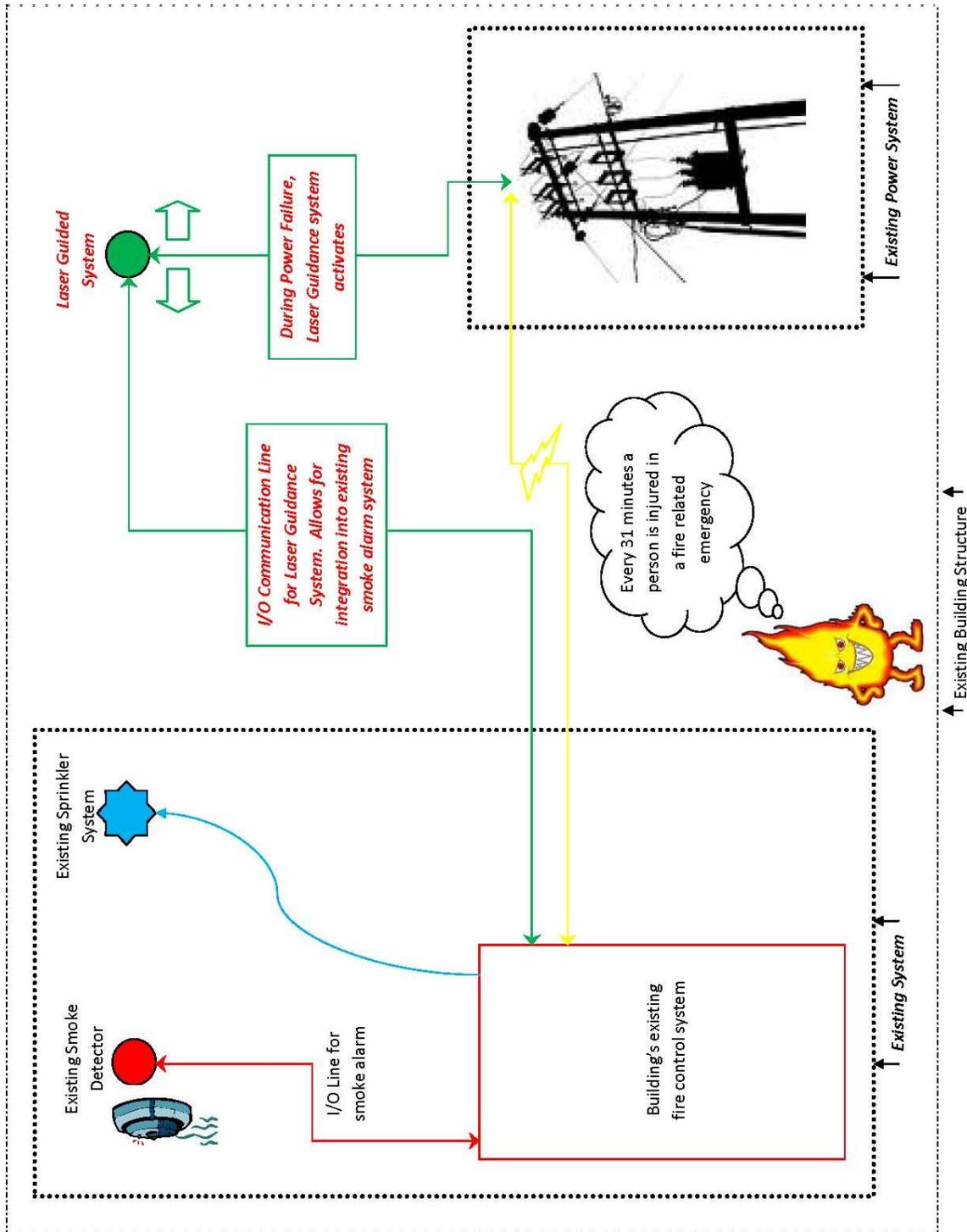
Team LazrSavr assumes no responsibility for accidents that may occur due to emergency evacuations with large masses of individuals. Team LazrSavr does not guarantee the safe evacuation of every individual during an emergency situation. Team LazrSavr is also not held responsible for malfunctioning of the LGES's operation due to improper installation, improper maintenance practices, or tampering with the unit. Although part replacement should not occur often, Team LazrSavr is not responsible for malfunctions that may occur due to the use of improper or non-recommended replacement parts.

There will be a warranty offered with the Laser Guided Evacuation System. The LGES will come with a one (1) year guarantee of all functioning parts and accessories. If for any reason the LGES fails to perform as expected, Group 7 will diagnose the problem and implement a solution. Please note that if the defect is from improper installation, tampering with the device, etc. the warranty may be null and void. This decision will be left up to a member of Group 7 that will inspect the defected product.

Please note that Group 7 reserves the right to change the Liability/Warranty statements anytime deemed necessary without any prior notice given. Contact Group 7 in order to obtain the most recent revisions concerning section 4.5.

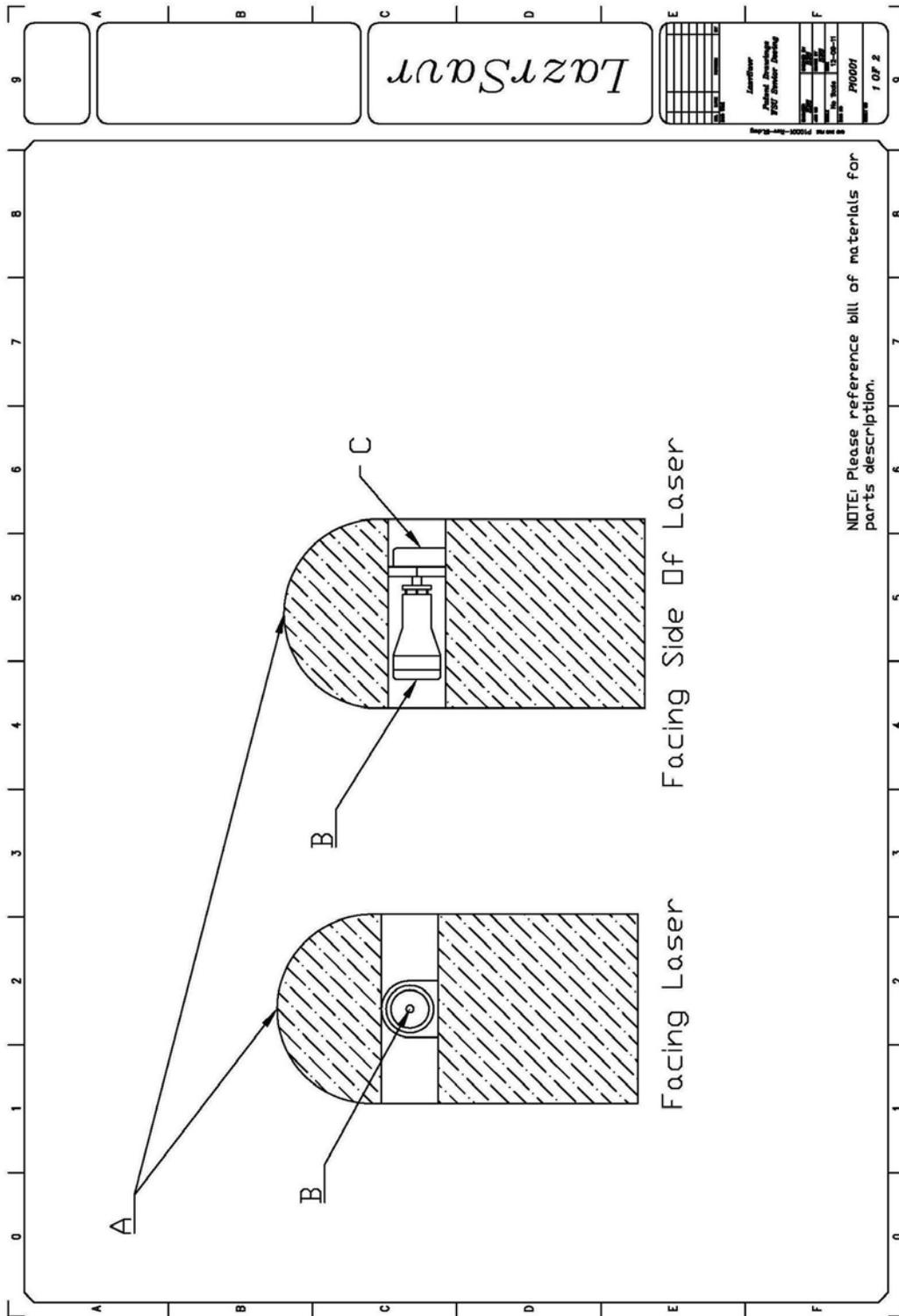
## 5.0 Product Documentation

### 5.1 Final Assembly Flow Chart

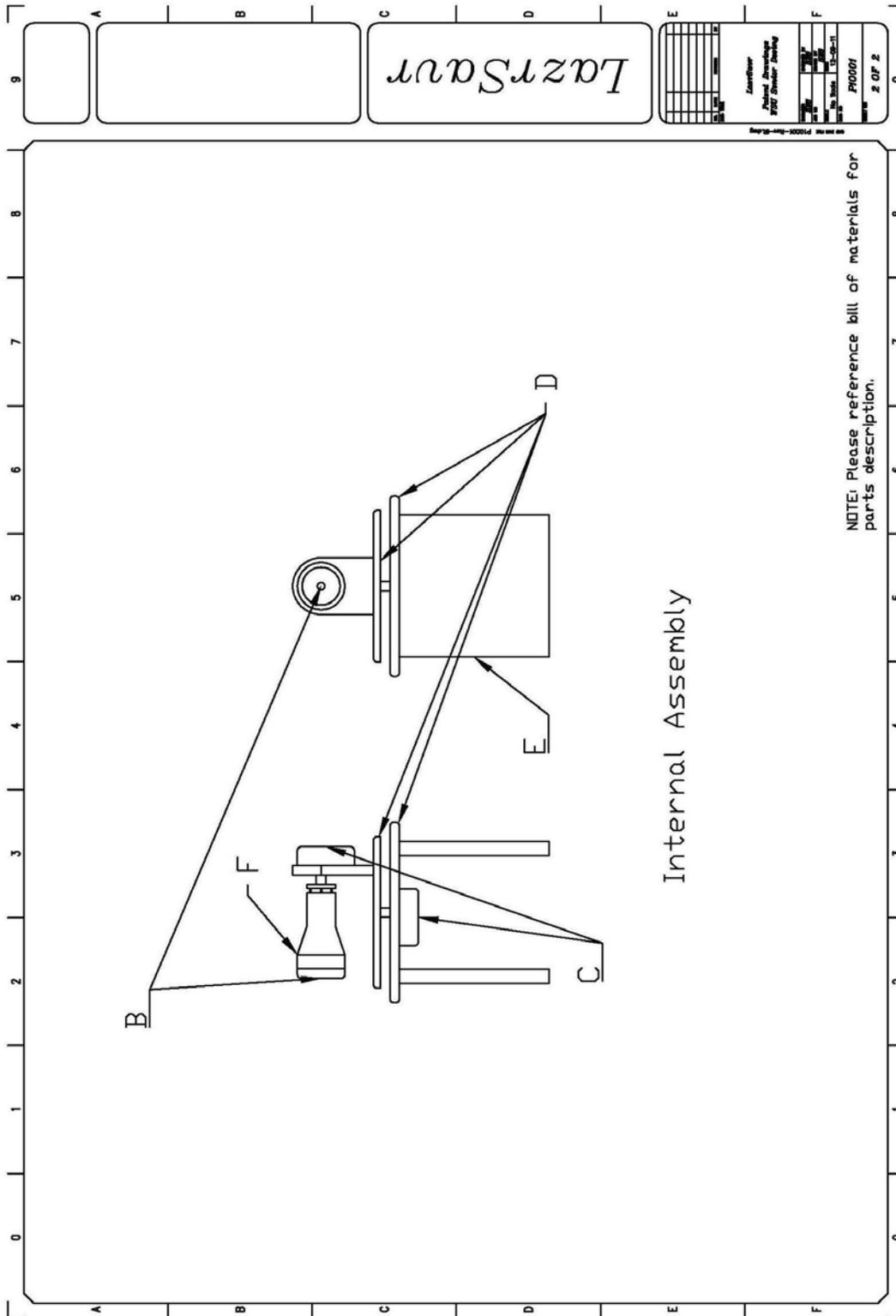


## 5.2 Assembly Drawings/Schematics

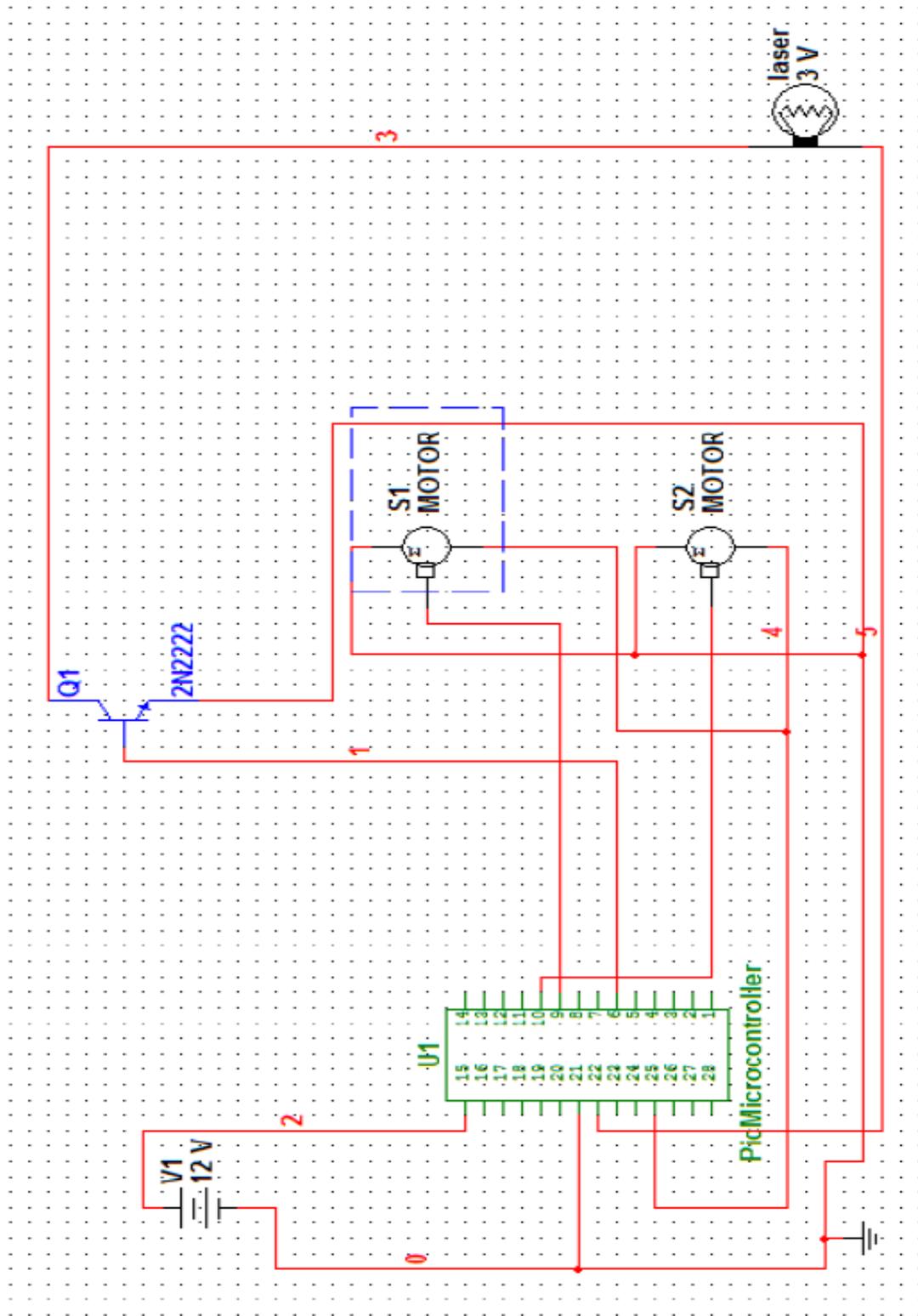
**Drawing 1: Basic drawing of completely assembled product**



**Drawing 2: Basic drawing of internal assembly**



**Schematic 1: Basic schematic of electrical connections between components.**



### 5.3 Programming Code

The following is the programming code used for the microcontroller. This code controls the operation of the servos along with the laser light. The code is highlighted green for easy distinction.

```
#include <Servo.h>

Servo myservo; // create servo object to control a servo
Servo myservo2; // a maximum of eight servo objects can be created

// set a variable to store the byte sent from the serial port
int incomingByte;

int targetPosition=90;
//0-stop
//1-left
//2-right
int currentPosition=90;
boolean laserOn=0;

void setup() {

  // start sending data at 9600 baud rate
  Serial.begin(9600);
  myservo.attach(9); // attaches the servo on pin 9 to the servo object
  myservo2.attach(10); // attaches the servo on pin 9 to the servo object
  pinMode(7, OUTPUT);

}
void loop() {
  // check that there's something in the serial buffer
  if (Serial.available() > 0) {
    // read the byte and store it in our variable
    // the byte sent is actually an ascii value
    incomingByte = Serial.read();
    // note the upper casing of each letter!
    // each letter turns a motor different way.

    // start of left laser sweep, moving left 90 degrees.
    // arrow laser spins and points to left.
    if (incomingByte == 'L') {
      targetPosition=0;
    }
    if (incomingByte == 'R'){
      targetPosition=180;
    }
  }
}
```

```
}
if (incomingByte == 'S'){
  targetPosition=90;
}
}

//procedure to move servo
if (targetPosition>currentPosition){
  currentPosition+=10;
  digitalWrite(7, 0);
}
if (targetPosition<currentPosition){
  currentPosition-=10;
  digitalWrite(7, 0);
}
if (targetPosition==currentPosition){
  myservo2.write(90);
  digitalWrite(7, 1);
  delay(100);
}
if ((currentPosition<=0)||((currentPosition>=180))){
  currentPosition=90;
  digitalWrite(7, 1);
  myservo.write(currentPosition);
  myservo2.write(currentPosition);
  delay(250);
}
myservo.write(currentPosition);
myservo2.write(currentPosition);
Serial.println(currentPosition);
delay(50);
}
```

## 5.4 Microcontroller Specifications

The microcontroller board used for the LGES product is the Arduino Duemilanove. It contains 14 digital input/output pins, 6 analog pins, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. The board has three screw holes which allow for attachment to a surface or case.

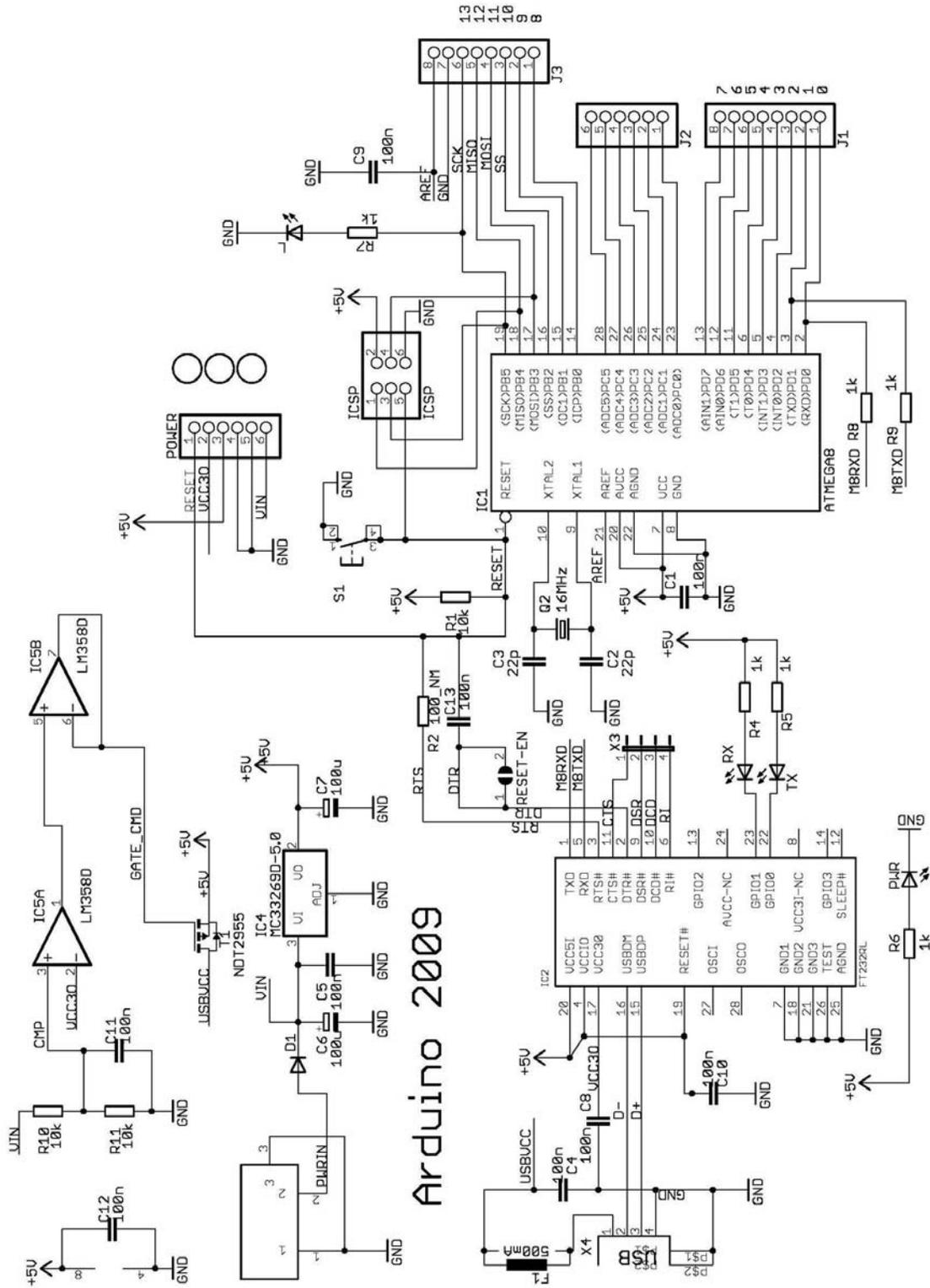
A summary of the Duemilanove board can be found in table 5.4.1. More information on the Duemilanove is available at the Arduino's main website:

<http://arduino.cc/en/Main/ArduinoBoardDuemilanove>.

**Table 5.4.1**

<b>Microcontroller</b>	ATmega168
<b>Operating Voltage</b>	5V
<b>Input Voltage (Recommended)</b>	7-12V
<b>Input Voltage (Limits)</b>	6-20V
<b>Digital I/O Pins</b>	14 (6 with PWM output)
<b>Analog Input Pins</b>	6
<b>DC Current per I/O Pin</b>	40 mA
<b>DC Current for 3.3V Pin</b>	50 mA
<b>Flash Memory</b>	16 KB (ATmega168)
<b>SRAM</b>	1 KB (ATmega168)
<b>EEPROM</b>	512 Bytes (ATmega168)
<b>Clock Speed</b>	16 MHz
<b>Board Length</b>	2.7 Inches
<b>Board Width</b>	2.1 Inches
<b>Spacing of Pins</b>	0.1 Inches

The microcontroller board schematic can be found on the following page. Note that a full scale version is available at the website listed above.



## 5.5 Bill of Materials

Item	Ref.	Qty.	Description	Mfg.	Part. No	Source	Price
1	N/A	1	Duemilanove	Arduino		arduino.cc	\$30.00
2	B	1	Laser diode, color: red	Electron	LQB-3.5L-650T3	<a href="http://www.electrolaser.com">www.electrolaser.com</a>	\$10.00
3	F	1	Laser heat sink	Electron	LQB-3.5L	<a href="http://www.electrolaser.com">www.electrolaser.com</a>	\$10.00
4	C	2	Servo	N/A	N/A	HobbyTown	\$10.00
5	E	2	3/8" thk PCB Plastic	N/A	N/A	Yard Store	\$5.00
6	D	2	1/4" thk PCB Plastic	N/A	N/A	Yard Store	\$5.00
7	A	1	1/8" thk glass housing	N/A	N/A	HobbyLobby	\$10.00

NOTE: Since this product is neither in production, nor have a patent filed yet, concerns arose pertaining to copy write issues. To help combat this, simplistic sketches, as well as a simplistic bill of materials is provided; this format is similar to filing a US patent.

## 6.0 Product Summary

This product was designed initially as an emergency evacuation device. Throughout the design process of a year, our team discovered many more practical uses for the Laser Guided Evacuation System. These uses range from the stated purpose (emergency evacuation) to specific item location in large warehouses. It could be used to direct medical personal to a patient's room, or give directions to newcomers in a foreign environment.

The senior design course this project developed from was broken into two semesters of productivity. The first semester started out with a different design concept, along with some realizations in flaws associated with those design ideas. After much research and brainstorming, the design realized in this report was conceptualized, designed, and then implemented in physical form. By the end of the first semester, a working prototype was complete and ready for show. However, it was soon discovered that this prototype had imperfections as well. A problem that would need to be overcome, for example, was the fact that the laser diode would overheat (leading to failure) during the first few minutes of operation. Obviously, this could be deadly were it to happen during a real emergency evacuation.

This leads to the second and final semester. Instead of redesigning our working prototype, our group set out to diagnose, repair, improve, and repair again. This problem solving process was utilized to develop the best product available for consumer use. During analysis of our current prototype, our group tried to incorporate "simplicity of design" into the product as well. It is believed that the less complex a system becomes, the less there is available to fail during operation/non-operation. This leads to our groups current design, which is the product reported on in this document.

Due to time restraints, budgetary concerns, etc. some aspects of our group's product was eliminated. An example of this was the use of a pre-existing fire alarm control panel in a multi-level building. This control panel will eventually control the operation of the Laser Guided Evacuation System by activating the product on the floor level that contains the fire, power outage, etc. By determining the triggered alarm's position, the product will direct to the safest exit accordingly. Obviously this design was excessive for our project scope.

From a year's worth of work for this project, much was learned and new skills were developed. This project worked to teach leadership, collaboration, communication, critical thinking, and analysis skills. It also helped reinforce theories learned from prior class work. Most importantly, it built upon the foundation of practicing the science of engineering.

*"If we knew what it was we were doing, it would not be called research, would it?"*

- Albert Einstein

## Final Product Assembly Photographs



**Figure 1: Final product assembly, view facing towards laser.**



**Figure 2: Final product assembly, view facing side of laser.**



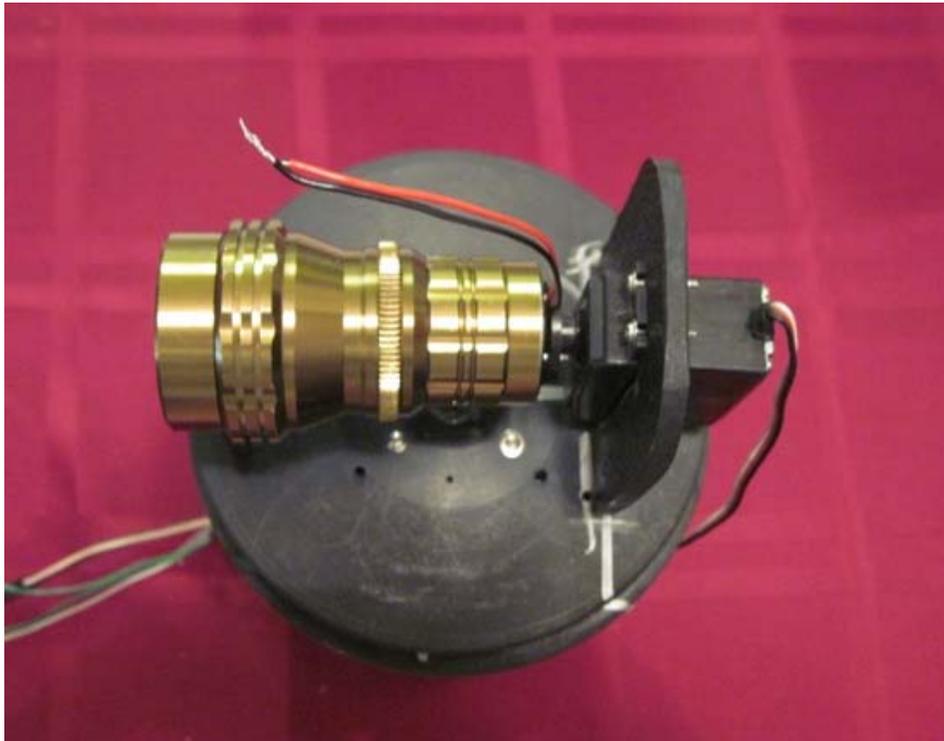
**Figure 3: Break down of internal laser assembly.**



**Figure 4: Break down of internal laser assembly, view of laser diode.**



**Figure 5: Completely assembled internal laser assembly.**



**Figure 6: Internal laser assembly attached to control servos, top view.**



**Figure 7: Internal laser assembly attached to control servos, front view.**



**Figure 8: Final internal assembly minus housing, side view.**