ABSTRACT

The Illinois Junior Academy of Science

Category	Engineering	State Region#	12
Name	Amanda L. Clessa		
Grade	7		
Other Team Members:			
Name(s)		IJAS	
Grade(s)		School#	12019
School	Good Shepherd Lutheran School		
City / Zip	Collinsville, IL 62234		
Phone	(618) 344 - 3153		
Sponsor	Mr. Eric Semler		
Project Title	Give Me a Brake!		

Purpose: The purpose of my project was to find out whether a light-emitting diode lamp or an incandescent lamp would make a safer automobile tail lamp. My hypothesis was that a person will react faster to an LED tail light that to an incandescent tail light, making it safer.

Procedure: The LEDs and incandescent lamps were tested in four different combinations, 10 times per combination, five on the left and five on the right. A lamp test fixture was built to test the reaction time for both lamps. Then the test subjects' reaction times were averaged and the difference between the LED and incandescent lamp reaction times were calculated. By doing this we were able to figure out which lamp type had the faster reaction time.

Conclusion: My hypothesis that a person will react faster to an LED tail lamp that to an incandescent tail lamp was proven correct. The LED was shown to produce a reaction time that, on average, was 79.1 milliseconds faster that the incandescent lamp. This resulted in a reaction distance decrease of 2.2 meters when traveling at 100 km/h, making the LED lamp safer that the incandescent lamp.

1) Limit Abstract to 3 paragraphs (about 200 words or less). a) Purpose - what you set out to investigate; b) Procedure - how you did it; c) Conclusion - based on your results.
2) Must be typed, single spaced on the front of this form. DO NOT write on the back side of this form.
3) THREE (3) copies of your complete paper are required at the State Science Project Exposition. Four (4) copies of your complete paper are required for the State Paper Session Competition.

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Directions: The student is asked to read this introduction carefully, fill out the bottom of this sheet, and sign it. The science teacher and / or advisor must sign in the indicated space.

SAFETY AND THE STUDENT: Experimentation or research may involve an element of risk or injury to the student and to others. Recognition of such hazards and provision for adequate control measures are joint responsibilities of the student and the sponsor. Some of the more common risks encountered in research are those of electrical shock, infection from pathogenic organisms, uncontrolled reactions of incompatible chemicals, eye injury from materials or procedures, and fire in apparatus or work area. Countering these hazards and others with suitable controls is an integral part of good scientific research.

In the space below, list the principal hazards associated with your project, if any, and what measures you have used as safeguards. Be sure to read the entire section in the Guidebook of the Illinois Junior Academy of Science entitled "SAFETY GUIDELINES FOR EXPERIMENTATION" before completing this form.

One of the hazards of my experiment was the risk of fire from a shorted circuit. The heat from a shorted circuit could also burn someone. As a precaution I was always careful not to touch the lamp test fixture while it was in use and I always kept a fire extinguisher nearby.

Another hazard of my experiment was the chance of battery leakage and exposure to the battery's chemicals. If the battery leaked there was a chance of chemicals getting in my eyes or on my hands causing injury. My adult helper handled the battery and its connection to the tester. I also took the precaution of performing my experiments near running water so that if the battery leaked the electrolyte could be easily rinsed off.

A final hazard was the possibility of electric shock from the battery. Since the battery voltage was low this was not judged to be a risk.

SIGNED ______________________________ / Amanda L. Clessa ________

Student Exhibitor(s)

SIGNED ______________________________ / Mr. Eric Semler __________

Sponsor*

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1. No cultures involving humans (mouth, throat, skin, or otherwise) will be allowed. However, tissue cultures purchased from reputable biological supply houses or research facilities are suitable for student use.
2. Quantities of normal food and non-alcoholic beverages are limited to normal serving amounts or less. "Normal" must be substantiated with reliable documentation. This documentation must be attached to the form. No project may use over-the-counter or prescription drugs or any other chemical agents in order to measure their effect on a person.
3. The only human blood that may be used is that which is either purchased or obtained from a blood bank, hospital, or laboratory. No blood may be drawn by any person or from any person specifically for a science project. This rule does not preclude a student making use of data collected from blood tests not made exclusively for a science project.
4. Projects that involve exercise and its effect on pulse, respiration rate, blood pressure, and so on are allowed provided the exercise is not carried to the extreme. A valid, normal physical examination must be on file for each test subject. Documentation of same must be attached to this form.
5. Projects that involve learning, ESP, motivation, hearing, vision, and surveys present no problem.
6. No project will be allowed that is in violation of any of these rules. No person may perform any experiment for the student that violates any of these rules.
7. No person may give permission for a project that is in violation of these rules except in special cases as described in the guidebook under the section entitled "Exceptions to Humans as Test Subjects and Non-Human Vertebrate Rules".

In this space, briefly describe the use of humans in your project. Use the back page, if necessary.

In my experiment the reaction time of human test subjects to the illumination of a lamp was measured. This required the test subjects to press a button when a lamp illuminated. Each test subject pressed the button a total of 40 times over a period of about 15 minutes.

/ Mr. Eric Semler
Sponsor

/ Amanda L. Clessa
Student

February 6, 2003
Date

Student

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GIVE ME A BRAKE!

Submitted by:
Amanda L. Clessa
Grade 7
Good Shepherd Lutheran School
Collinsville, IL
February 6, 2003

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ACKNOWLEDGEMENTS

I would like to thank my mother and father, Cheryl and Bruce Clessa, for assisting me with this project and for the construction of the brake lamp test fixture. I would also like to thank Mr. Voss and Mr. Semler for the assistance they have given me.

PURPOSE AND HYPOTHESIS

I chose this experiment because I saw an ad claiming that LEDs are safer than incandescent lamps because they illuminate quicker. I wanted to see if using LED lamps would make a significant difference in the reaction time to the lamp illumination.

QUESTION

Will a light-emitting diode (LED) lamp or an incandescent lamp make a safer automobile tail light?

HYPOTHESIS

I hypothesize that a person will react faster to an LED tail light that to an incandescent tail light, making it safer. I believe that this will happen because an incandescent lamp's filament takes time to heat up before the light will turn on, while an LED light comes on almost instantly.

REVIEW OF THE LITERATURE

During the 1870 gas lit lamps were used to light home. The gas lights were not very safe and often the smoke from the lamp damaged walls. There was also the risk of breathing in poisonous fumes from the lamps. In some places electric arc lights were already being used but these electric lights were much too bright for use in the home (Adler, 1990).

Thomas Edison was the inventor of the first practical incandescent lamp. Edison started his experiments on the incandescent lamp with a strip of carbon in a jar with a partial vacuum. It burned for eight minutes. He decided to test other metals with the hope that they would last longer that the piece of carbon. Platinum seemed to do the best out of the other metals he tested. But it also melted at high temperatures. Edison invented a device to make the wire blink of for just an instant. This blink was enough to keep the platinum from melting. He wasn't really happy with platinum because it cost too much so he went on testing other materials and mixtures. He experimented with platinum, chromium, molybdenum, osmium, boron, silicon, nickel, and platinum again. He then found a pump that created a better vacuum. He learned how the seal the bulbs. Slowly but steadily he was making progress. After testing all the other substances he went back to testing carbon. After a lot of experimenting Edison found that a piece of tough carbonized cardboard burned up to 170 hours (Greene, 1985).

A modern incandescent lamp is a very simple device:

> In an incandescent lamp, an electric current flows through a thin tungsten wire called a filament. The current heats the filament to about 3000° C (5400° F), which causes it to emit both heat and light. The bulb must be filled with an inert gas to prevent the filament from burning out. For many years

> incandescent lamps were filled with a mixture of nitrogen and argon. Recently the rare gas krypton has been used because it allows the filament to operate at a higher temperature, which produces a brighter light. (Encarta, 2002)

Nick Holonyak is the inventor of the visible spectrum light-emitting diode. He was born on November 3, 1928 in Zeigler Illinois. When he finished graduate school in 1954 he was hired to work on a number of silicon devices, including transistors. He continued work in solid-state science, working for the US Army Signal Corp and general electric. He then returned to be a professor at the University of Illinois. (Nick Holonyak, www.pbs.org, [Online]). He first began word on the visible-spectrum light-emitting diode in 1960 while working at General Electric. He had discovered that the wavelength of the GaAs diode (gallium arsenide) could be shifted from infrared to the visible spectrum by merely changing the composition of the crystal itself to GaAsP (galluim arsenide phosphide). Holonyak invented the first practical visible spectrum LED in 1962 (Nick Holonyak, www. si.edu. [Online]).

LEDs are found in all kinds of devices. They make the numbers on digital clocks, transmit information from remote controls, light up watches and they also tell you when your appliances are turned on. When many LEDs are put together they can for the image on a television screen or light up a traffic light. LED can fit easily into an electrical circuit like a light bulb but unlike a light bulb they don't have a filament that will burn out. They also don't particularly hot. "They are illuminated solely by the movement of electrons in a semiconductor material, and they last just as long" (How Light Emitting Diodes Work. [Online]).

"The efficiency of LEDs is most evident in application requiring color." Light from a normal incandescent lamp must be filtered so that light from a certain part of the spectrum is visible. They can waste as much as 90 percent or more of their energy in light blocked by the filter. LEDs deliver 100 percent of their energy as colored light. Filtering is not usually required to achieve the desired color. Incandescent lamps also waste 80 to 90 percent of their energy on heating the filament to the point where it generates visible light (Utilizing Light-Emitting Diodes...[Online]). LEDs are much more efficient that incandescent lamps:

> Incandescent light bulbs give off most of their energy in the form of heat-carrying infrared light photons - only about 10 percent of the light produced is in the visible spectrum. This wastes a lot of electricity. Cool light sources, such as fluorescent lamps and LEDs, don't waste a lot of energy generating heat - they give off mostly visible light. For this reason, they are slowly edging our the old reliable light bulb. (How Light Bulbs Work. [Online]).

Several manufacturers of light-emitting diodes make direct replacements for automobile tail lamps. One manufacturer, Ledtronics, claims that using LED tail lamps will make an automobile safer:

> Due to faster turn-on times than conventional incandescent signal lamps, AUT-1157 LED lamps promote safe driving by increasing the amount of response time available for motorists. AUT-1157 LED lamps operate 0.2 seconds quicker than incandescents. That's an extra 19 feet of response time at 65 mph for the trailing vehicle. [distance traveled = (mph)(5280 feet/mile)(1/3600 hour/sec)(0.2 sec.)] The results? Less rear-end collisions, which are the second most frequent type automotive accidents. The AUT-1157 LED lamp's advantages over equivalent incandescents are not limited to automotive repairs and accidents, but extend to collateral issues such as

property damage claims, productivity losses, medical expenses, legal and court costs, etc. (LedtronicsNEWS, [Online]).

MATERIALS AND METHODS OF PROCEDURE

I. Materials

<u>Material list A - Material for the taillight tester</u>

Material for the tester base

1	23 cm x 25 cm x 2 cm rectangle of wood
1	15 cm x 25 cm x 2 cm rectangle of wood
2	12mm diameter x 2.5cm wooden dowel
3	#8 x 1.5" wood screw

Material for the circuit board

1	680 ohm ½ watt resistor - Radio Shack 271-1117
1	470 ohm ½ watt resistor - Radio Shack 271-1115
1	LM7805 voltage regulator - Radio Shack 276-1770
1	MXO45HST-1.0000 oscillator - Digi-Key CTX180-ND
1	1N5230 4.7 Volt zener diode - Digi-Key 1N5230BMSCT-ND
1	Shielded phono jack - Radio Shack 274-346
1	General purpose IC PC board - Radio Shack 276-150A

Material for the test control box

1	SPDT paddle switch - Radio Shack 275-648
1	SPST momentary pushbutton switch - Radio Shack 275-646
1	SPST power switch - Radio Shack 275-694
1	project enclosure - Radio Shack 270-1801
1	4m length of CAT5 network cable
2	Ty-rap - Radio Shack 278-1632

Material for the brake box

1	Plunger Switch Actuator - EAO 704.910.7
1	Switch block - EAO 704.910.2
1	project enclosure - Radio Shack 270-1803
1	100' Roll 22 Gauge speaker wire - Radio Shack 278-1385

Material for final assembly of the tester

1	12 position barrier strip - Radio Shack 274-679
1	12 Volt Garden Tractor Battery
1	pair large alligator clips - Radio Shack 270-344
2	Tail Lamp housing - Tiger Accessory Group 20-3931-8
1	20cm length 22 gauge wire - red
1	20cm length 22 gauge wire - black

Material for the eye target

1 photographic tripod
1 orange tennis ball

Tools for assembly

5 #4 x .75" wood screw
1 Hot glue gun with glue sticks
1 roll rosin core solder
1 electric drill
1 side cutter
1 each, 3mm, 6mm, 8mm, 12mm, 16mm and 26mm drill bits
1 metric tape measure
1 phillips screwdriver
1 counter sink bit

<u>Material list B - Material for running the experiments</u>

2 1157R automotive bulbs (LED)
2 1157R automotive bulbs (incandescent)
1 Phone jack to BNC Plug adapter - Radio Shack 278-254
1 phone cable - Radio Shack 15-1520
1 HP 5314A Timer / counter

II. Procedure for construction of the tail light tester

a) Construct the wooden platform by attaching the two pieces of wood together as shown in figure 1 note "A" using three #8 x 1.5" wood screws. Drill a 3mm diameter pilot hole for each of the screws and countersink the holes so the wood screws are flush with the bottom of the platform. Next drill two 6mm diameter holes in the vertical piece of the platform as shown in figure 1 note "B". These holes are to allow the wires from the tail lamp housings to pass through the wood to the other side of the platform. Drill two 12mm diameter holes 1cm deep for the circuit card mount as shown in figure1 note "C". Glue the two wooden dowel pieces into the 12mm holes using the hot glue gun as shown in figure 1 note "D".

b) Construct the clock circuit card using the Radio Shack 276-150A prototype board. Drill a 6mm diameter hole for J1 as shown in figure 2. Mount J1 (Radio Shack 274-346) into the hole with the jack on the non-copper side. Place the following electronic components onto the non-copper side of the prototype board as shown in figure 2 so that the legs of the parts are each on separate copper pads:

U1 LM7805 voltage regulator - Radio Shack 276-1770
U2 MXO45HST-1.0000 oscillator - Digi-Key CTX180-ND
R1 470 ohm ½ watt resistor - Radio Shack 271-1115
R2 680 ohm ½ watt resistor - Radio Shack 271-1117
CR1 1N5230 4.7 Volt zener diode - Digi-Key 1N5230BMSCT-ND

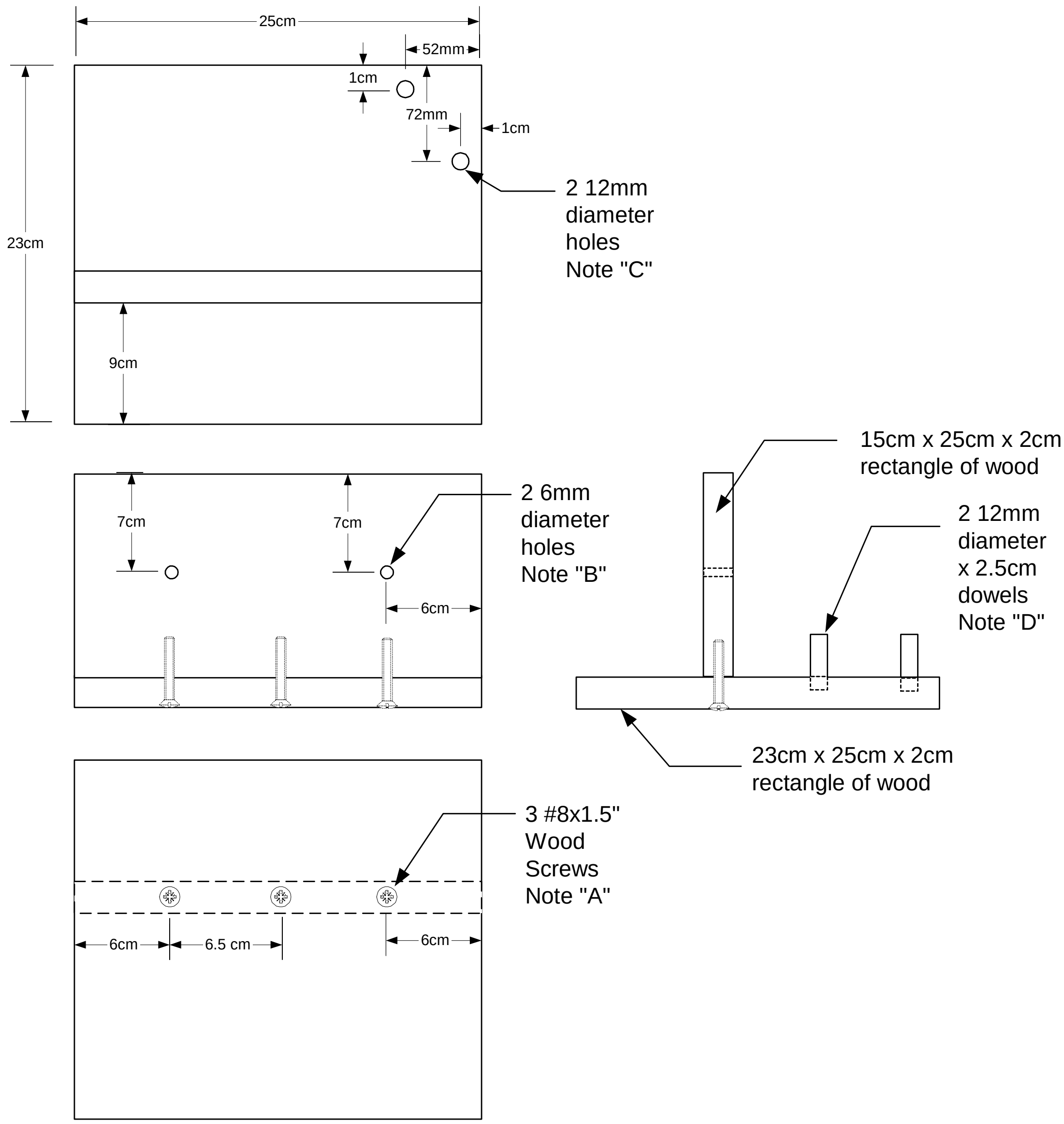


Figure 1

Solder the electronic components onto the circuit card pads using rosin core solder. Once the components are soldered to the board, wire the circuit as shown in figure 3 by bending the component legs so that they connect properly. Solder these connections in place. Trim the excess lead length using a side cutters. Strip the jacket from a 20cm piece of network cable so that the inner wires are exposed. Cut off a green, brown and orange / white wire from the cable. Remove the twists from each of the three wires and strip 2cm of insulation from both ends of each of the three wires. Solder one end of the green wire to point A, the orange / white wire to point B and the brown wire to point C as shown in figure 2. Make sure that each wire is soldered to a separate copper pad.

Connect these wires to the circuit as shown in figure 3. Solder and trim the excess length from each of the three wires.

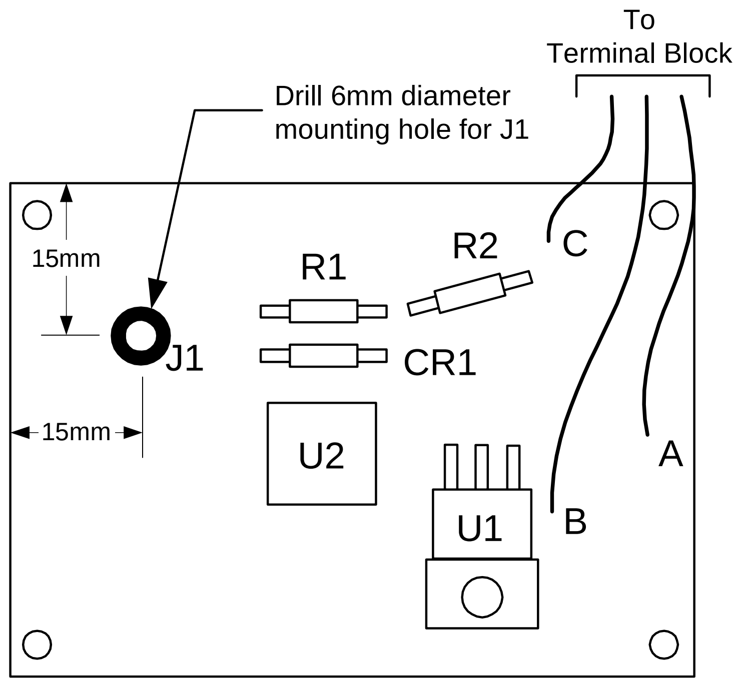


Figure 2

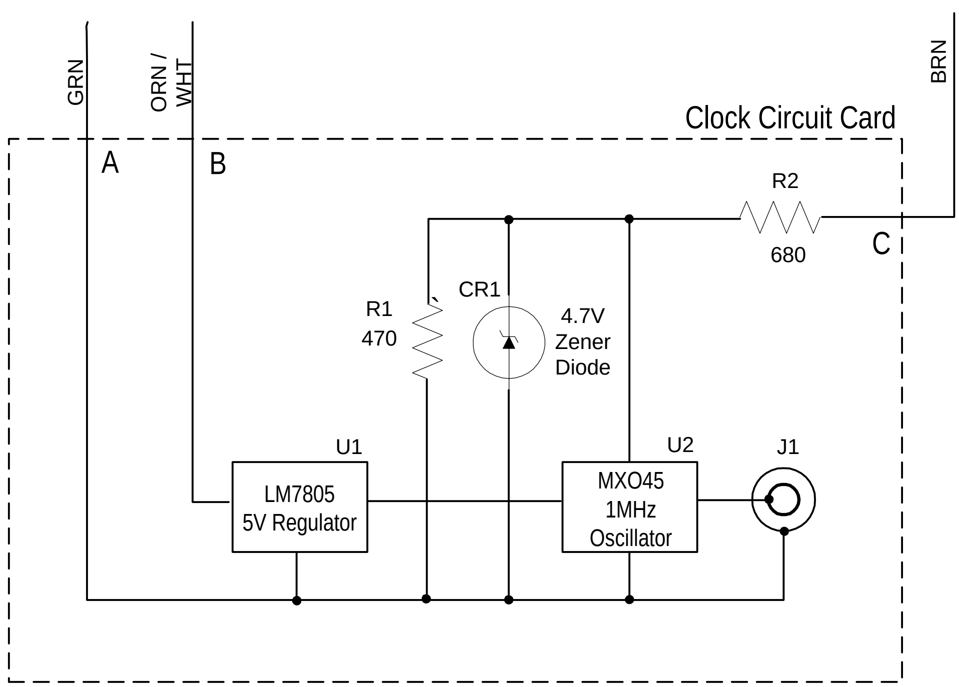


Figure 3

c) Construct the test control box using a Radio Shack 270-1801 project enclosure. Mount the three switches in the box as follows.

i) Drill an 8mm diameter hole for the momentary switch in the end of the enclosure as shown in note "E". Place the Radio Shack 275-646 momentary switch in the hole with the button side out as shown in note "I". Fasten the button tightly with the supplied hardware.

ii) Drill a 12mm diameter hole for the paddle switch in the bottom of the enclosure as shown in note "F". Place the Radio Shack 275-648 paddle switch in the hole with the paddle side out as shown in note "J". Fasten the button tightly with the supplied hardware.

iii) Drill a 16mm diameter hole for the power switch in the end of the enclosure as shown in note "G". Place the Radio Shack 275-694 power switch in the hole with the button side out as shown in note "K". Fasten the button tightly with the supplied hardware.

Drill a 6mm diameter hole for the cable exit on the enclosure end opposite of the momentary pushbutton switch. See Note "H". Cut an 3 meter length of network cable. Push one end through the hole drilled in note "H" into the enclosure for about 20cm. Strip the outer jacket from the cable end located inside the box for about 10cm. Strip the ends of the orange, orange / white, blue, green and green / white wires for about 2cm. Solder the stripped ends to the switches as shown in figure 5. Trim the excess wire length from the soldered connections. Pull the excess cable out of the box so that only the necessary length remains inside the box. Install one 278-1632 ty-rap inside and one 278-1632 ty-rap outside the box around the cable next to the hole to prevent the cable from pulling out of or pushing into the box. See Note "M" for the correct ty-rap location.

Place the plastic lid on the box and install the four supplied screws.

d) Construct the brake box using a Radio Shack 270-1803 project enclosure. Drill a 26mm diameter hole in the center of the plastic lid supplied with the enclosure. See Note "N" to properly locate the hole. Drill a 6mm diameter hole in the end of the box as shown in Note "O". Mount the plunger switch in the middle of the lid as shown in Note "P" with the plunger facing the outside using the instructions supplied with the switch.

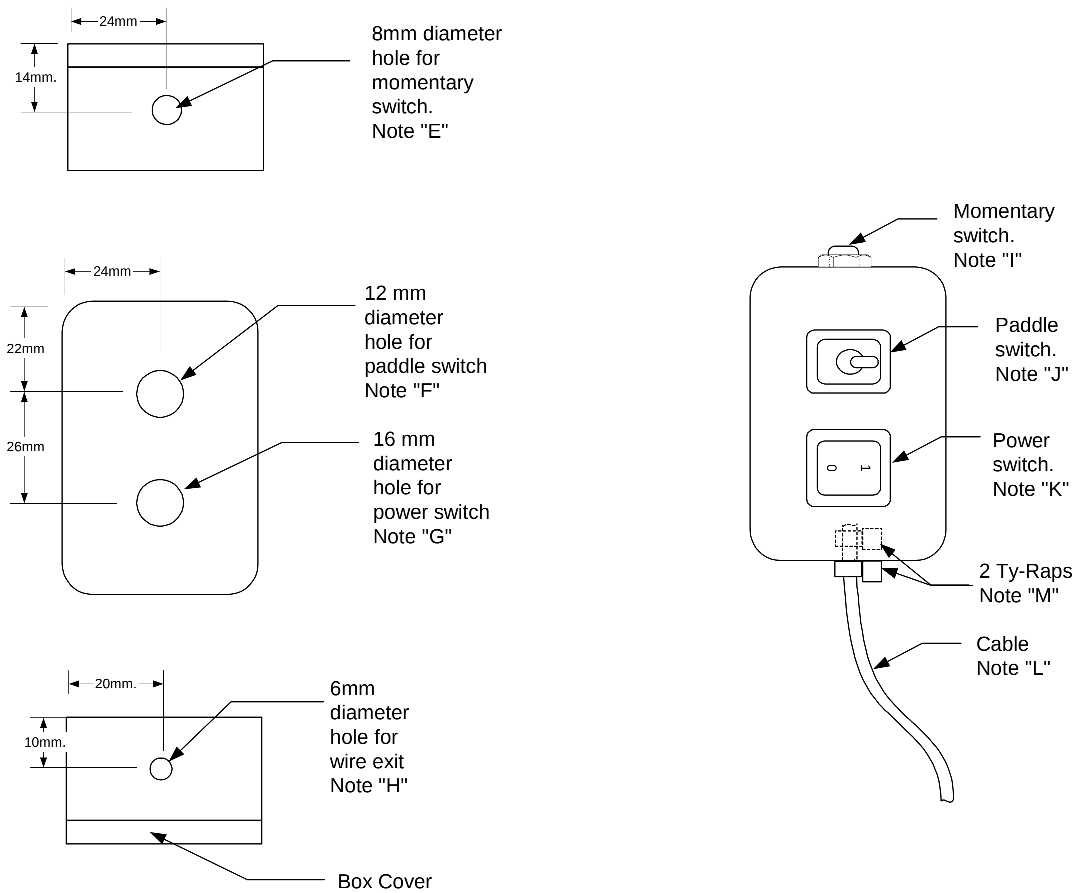


Figure 4

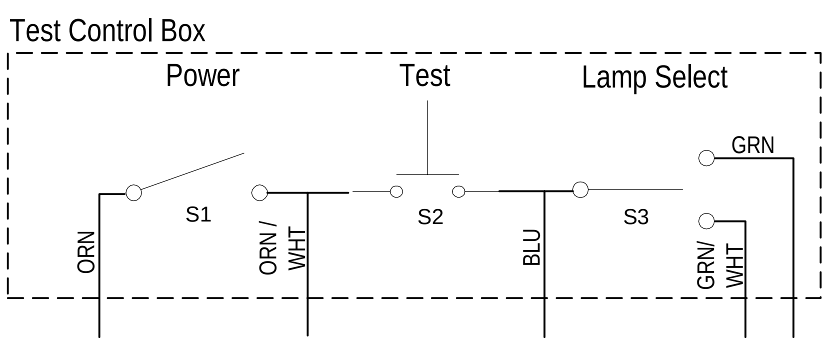


Figure 5

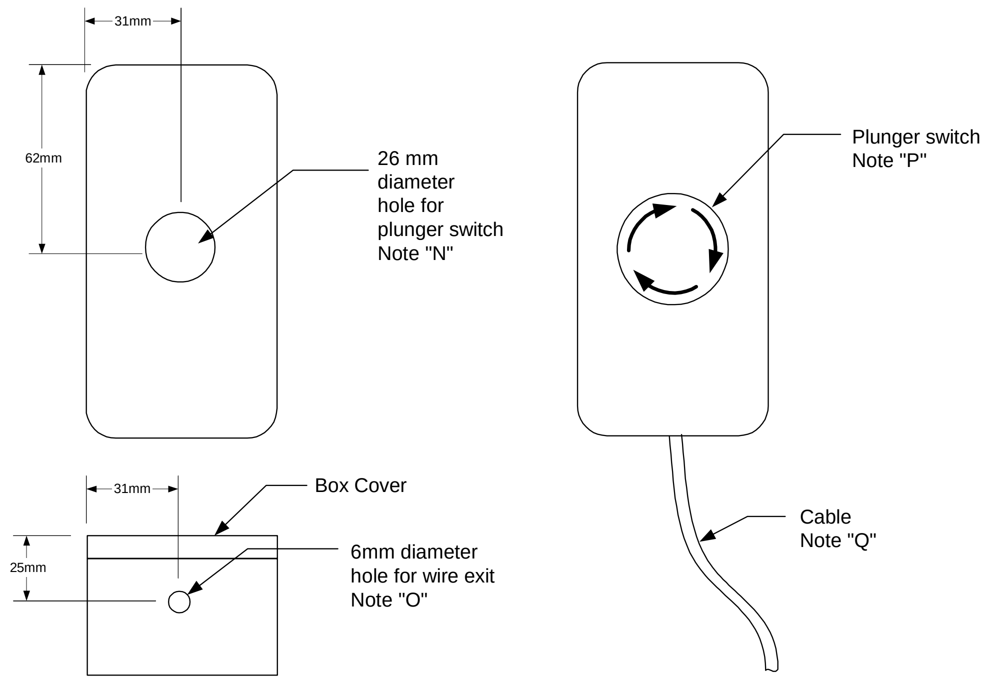


Figure 6

Cut a 20 meter length of 22 gauge speaker wire. Split the wires apart on each end of the cut speaker wire for 20 cm. Strip 1 cm of insulation on each of the split wires on both ends of the cut wire. Pass one end of the cut wire through the small hole in the enclosure bottom as shown in Note "Q".

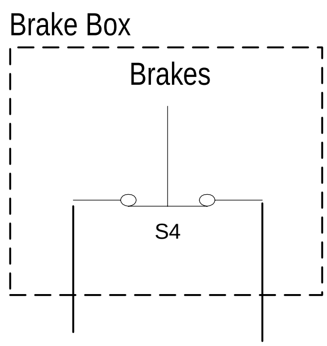


Figure 7

Tie a knot in the wire inside the box about 30cm from the stripped ends. Wire one stripped end to each of the two switch terminals as in figure 7 and tighten the terminal screws. Pull the excess wire out of the box until the knot contacts the inside of the box. Place the lid with switch on the box and install the four supplied screws.

e) Finish assembly of the tester by first installing the terminal strip using 3 #4 x .75" screws as shown in figure 7 Note "S". Install the circuit board on the dowels using 2 #4 x .75" screws as shown in figure 7 Note "T". Install the tail lamp housings by pulling the wire pigtails of both tail lamp housings through the holes drilled in figure 1 Note "B" so that the tail lamp housings are positioned as shown in figure 7 Note "U". Hot glue the tail lamp housings to the tester. Strip the ends of the 20cm red wire for approximately 1cm on both ends. Install the red alligator clip on one end. Attach the other end to terminal strip position 8. Strip the ends of the 20cm black wire for approximately 1cm on both ends. Install the black alligator clip on one end. Attach the other end to terminal strip position 5.

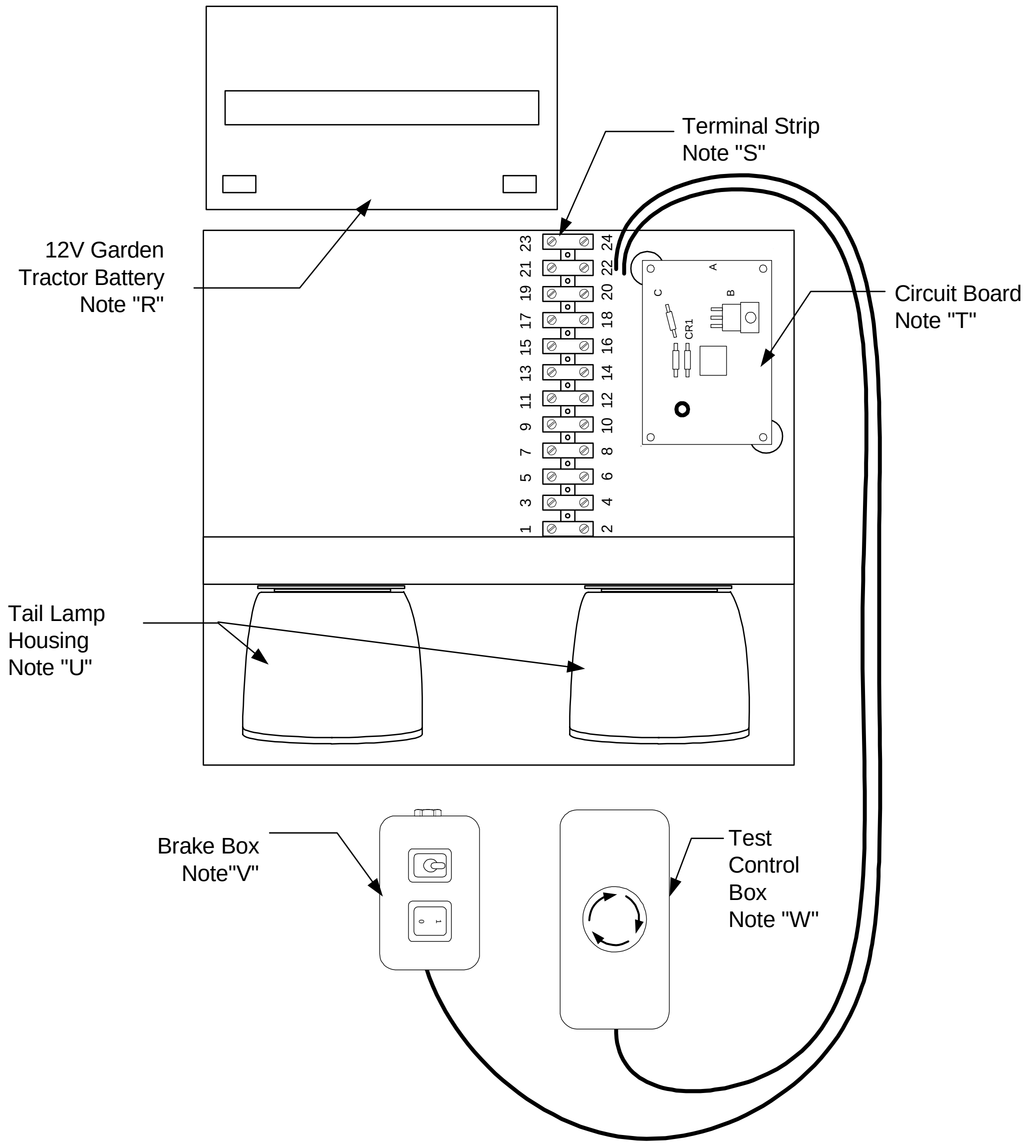


Figure 7

Wire the battery, tail lamp housings, circuit board, brake box (Note "V") and test control box (Note "W") to the terminal strip as show in figure 8.

f) Construct the eye target by drilling a 6mm hole in an orange tennis ball. Mount the ball (Note "X") on the tripod (Note "Y") using the hold-down screw where the camera normally mounts. Poke the screw through the hole in the tennis ball so that it is held securely.

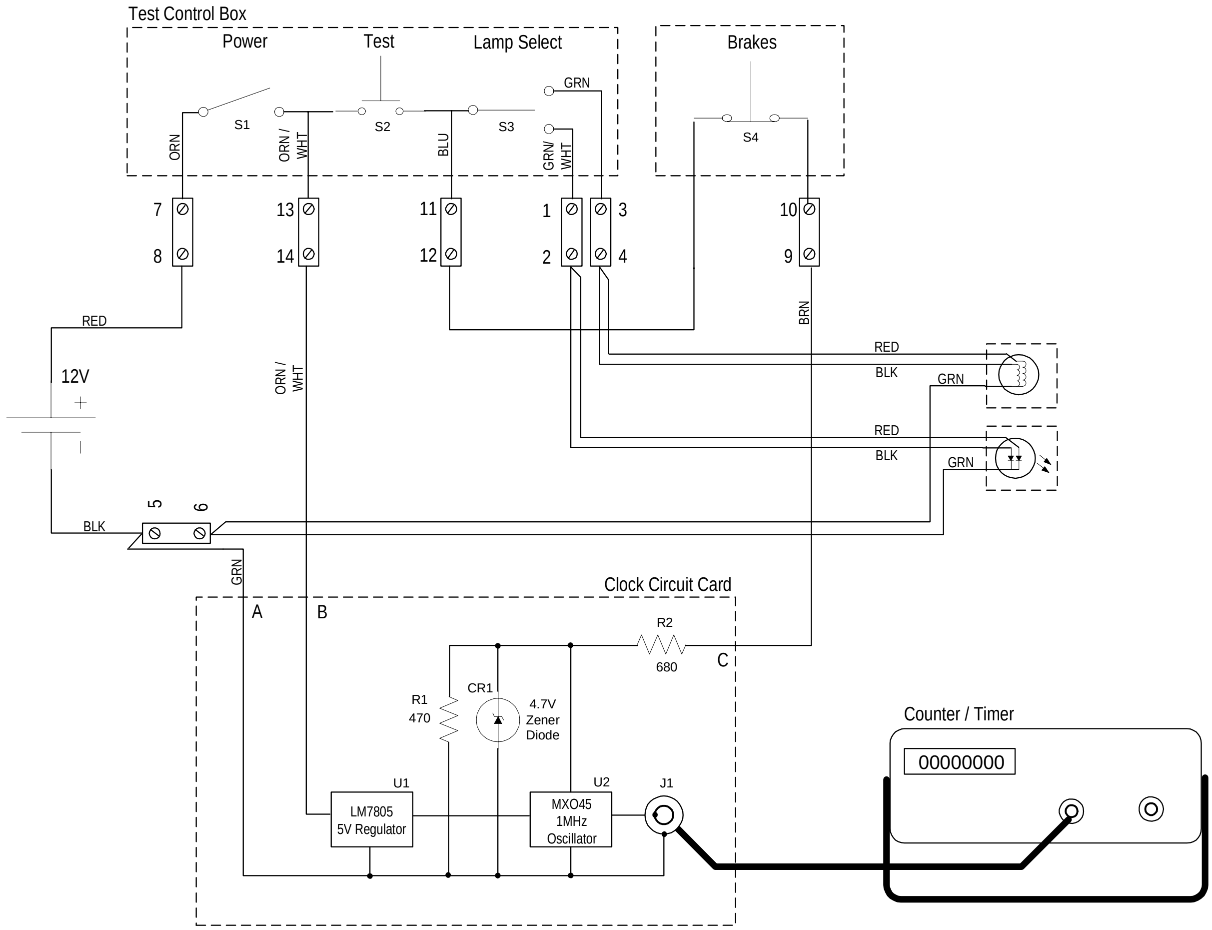


Figure 8

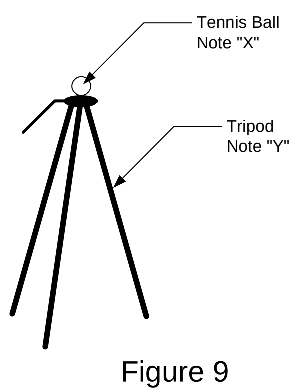


Figure 9

III. Procedure for running the experiments

a) Set up the experiment in a large room where the tester can be located at least 10 meters from the test subject.

b) Connect the HP 5314A Universal Counter to wall power. Turn the STBY/ON switch of the counter to "ON". Set the NORM/HOLD switch to "NORM". Set the FREQ A/START A switch to "START A". Depress the 10HZ/N=1 switch. Install the BNC to phone adapter (Radio Shack 278-254) on the INPUT A BNC connector on the front of the counter. Connect J1 of the tester (see figure 2) to the BNC to phone adapter using the Radio Shack 15-1520 phone cable.

c) Remove the lenses of the tail light housings using a screwdriver and install two 1157R incandescent automotive bulbs in the tail light housings. Replace the lenses.

d) Attach the red alligator clip to the positive terminal of the garden tractor battery. Attach the black alligator clip to the negative terminal of the garden tractor battery. Double-check the connections to make sure that they are not reversed. Turn the S1 power switch of the tester "ON" (to the 1 position).

e) Place the test subject in a chair at least 10 meters from the tester. Give the brake box to the test subject. Instruct the test subject to watch the eye target and to depress the plunger switch when the lamp lights.

f) Make sure that the S4 plunger switch is reset by turning it clockwise until it pops out.

g) Depress the blue button on the HP 5314A counter so that it is in the "IN" position.

h) Set the S3 paddle switch on the test control box to a random position.

i) Make sure that the test subject is ready; then press the S2 momentary switch and hold it in the depressed position. The test subject should press the plunger switch as soon as the lamp lights.

j) Read and record the time elapsed in milliseconds from the HP 5314A counter display. Depress the blue button on the HP 5314A counter so that it is in the "OUT" position.

k) Reset the plunger switch by turning it clockwise until it pops out.

l) Repeat steps f through j for 10 experiments. Make sure that the S3 paddle switch is set left for 5 times and right for 5 times for the 10 experiements.

m) Turn off the power switch. Remove the left lens of the tail light housings and install an 1157R LED tail lamp. Replace the lens. Repeat steps d through l

n) Turn off the power switch. Remove both lenses of the tail light housings and install an 1157R LED tail lamp in the right housing and an 1157R incandescent tail lamp in the left housing. Replace both lenses. Repeat steps d through l.

o) Turn off the power switch. Remove the left tail lamp housing lens and install an 1157R LED tail lamp. Replace the lens. Repeat steps d through l.

p) Repeat steps a through o for at least 6 test subjects.

DATA

In the experiment a reaction time tester was constructed and used to test the reaction time of 7 test subjects to a simulation of both incandescent and LED tail lamps. The lamps were tested in four different combinations for each test subject. The control for the experiment was chosen to be when incandescent lamps were installed in both the left and right simulated tail lamps. The four combinations are as follows:

1)	Left lamp is incandescent	Right lamp is incandescent	(control)
2)	Left lamp is incandescent	Right lamp is LED	
3)	Left lamp is LED	Right lamp is incandescent	
4)	Left lamp is LED	Right lamp is LED.	

Each combination of incandescent and LED lamps was tested 10 times for each subject. In every test the left and right lamps were tested 5 times each. The order in which the lamps were tested was randomly chosen. Since there were 4 combinations of lamps each person went through a total of 40 tests.

Tables A through G show the reaction times for each of the seven test subjects. The tables show all four of the combinations with five tests on the left and five on the right for each of the four combinations.

Table H shows the average reaction times for each test subject. The averages were calculated by including all the LED lamp reaction times for the LED average and including all of the incandescent lamp reaction times for the incandescent average. This was calculated for each of the 7 test subjects. The difference between the LED and the incandescent reaction times was then calculated for each test subject. For the last column of the table the LED reaction times of all the test subjects were averaged, as well as the incandescent reaction times and the difference between the LED and incandescent reaction times.

Table I shows the reaction distances for each test subject. This was calculated by determining the distance in meters that a car traveling at 100 km/h would travel during the test subjects' reaction time. The last column shows the average reaction distance for all the test subjects for both LED and incandescent lamps.

Graph J shows the reaction distance in meters for each of the seven test subjects for both the LED and incandescent lamps. This data was taken from the test subject entries of Table I.

Graph K shows the average reaction distance for all the test subjects. This data was taken from the last column of Table I.

Table A - Subject #1 reaction times, milliseconds.

Left	Right	Left	Right	Left	Right	Left	Right
INC	INC	INC	LED	LED	INC	LED	LED
352	326	305	220	223	318	208	188
287	283	308	199	265	298	195	180
300	289	417	208	215	325	241	196
327	294	285	347	227	296	230	195
273	290	323	325	245	263	197	210

Table B - Subject #2 reaction times, milliseconds.

Left	Right	Left	Right	Left	Right	Left	Right
INC	INC	INC	LED	LED	INC	LED	LED
370	499	352	316	393	433	338	265
428	408	454	265	259	369	367	264
374	401	404	311	367	361	343	290
471	444	340	262	310	405	385	223
438	381	448	340	413	404	313	242

Table C - Subject #3 reaction times, milliseconds.

Left	Right	Left	Right	Left	Right	Left	Right
INC	INC	INC	LED	LED	INC	LED	LED
328	278	354	247	212	347	223	221
314	328	279	246	244	346	214	241
295	304	296	226	237	329	250	215
282	376	380	208	231	291	268	252
281	293	334	235	214	304	221	238

Table D - Subject #4 reaction times, milliseconds.

Left	Right	Left	Right	Left	Right	Left	Right
INC	INC	INC	LED	LED	INC	LED	LED
353	384	339	237	259	309	252	357
335	363	335	256	270	395	225	271
281	330	302	260	342	358	461	289
361	482	356	213	232	332	263	262
378	337	387	263	274	319	271	280

Table E - Subject #5 reaction times, milliseconds.

Left	Right	Left	Right	Left	Right	Left	Right
INC	INC	INC	LED	LED	INC	LED	LED
320	472	320	253	256	338	272	425
334	375	307	338	289	350	307	275
361	340	371	303	280	333	278	299
320	328	305	259	323	382	335	386
331	357	342	262	281	427	316	341

Table F - Subject #6 reaction times, milliseconds.

Left	Right	Left	Right	Left	Right	Left	Right
INC	INC	INC	LED	LED	INC	LED	LED
302	269	287	223	187	276	187	226
258	347	240	185	207	285	184	199
282	277	251	257	271	296	200	224
296	266	294	200	217	264	180	192
264	408	296	235	229	263	172	182

Table G - Subject #7 reaction times, milliseconds.

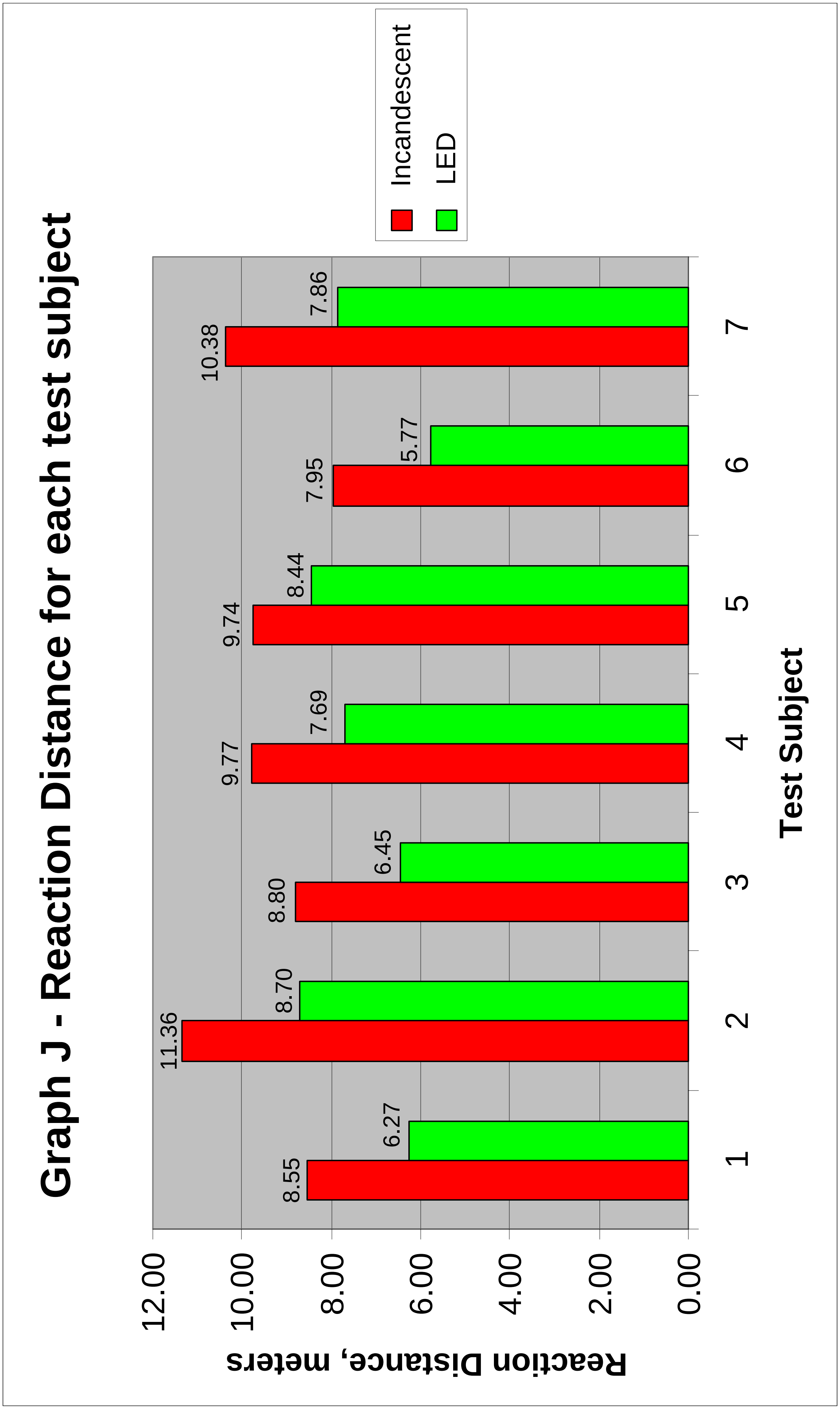
Left	Right	Left	Right	Left	Right	Left	Right
INC	INC	INC	LED	LED	INC	LED	LED
373	344	403	257	384	324	281	267
323	367	373	240	263	369	242	225
358	386	369	301	267	347	332	263
422	374	370	363	276	361	337	251
396	417	430	268	316	366	275	254

Table H - Average reaction times, milliseconds.

	Subject							Avg All
	1	2	3	4	5	6	7	Subjects
Incandescent	308	409	317	352	351	286	374	342
LED	226	313	232	277	304	208	283	263
Difference	82.1	95.7	84.7	74.8	46.9	78.2	90.6	79.0

Table I - Reaction distances, meters at 100 km/h.

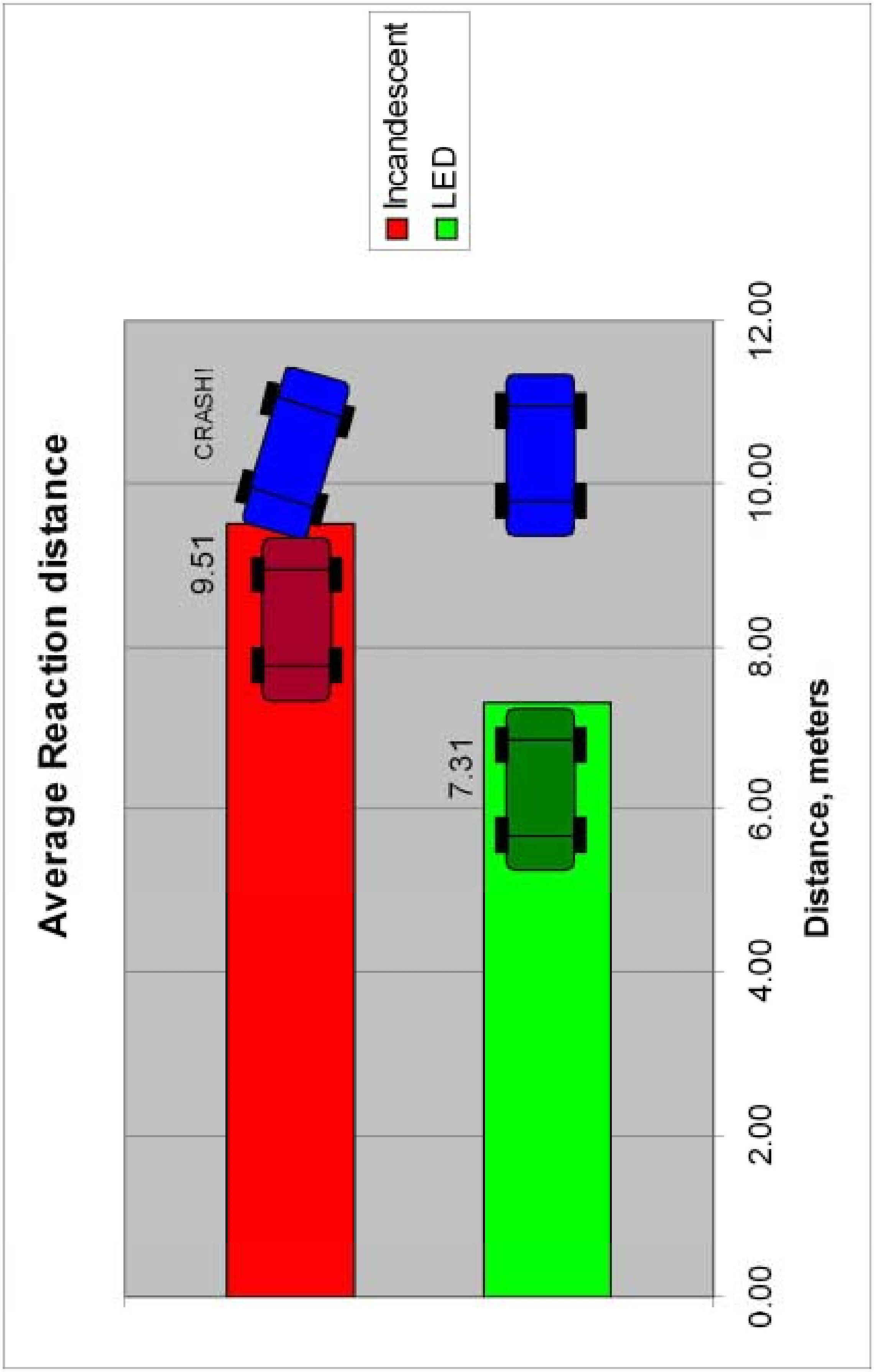
	Subject							Avg All
	1	2	3	4	5	6	7	Subjects
Incandescent	8.6	11.4	8.8	9.8	9.7	7.9	10.4	9.5
LED	6.3	8.7	6.4	7.7	8.4	5.8	7.9	7.3
Difference	2.3	2.7	2.4	2.1	1.3	2.2	2.5	2.2


Graph J - Reaction Distance for each test subject
Reaction Distance, meters
12.00
10.00
8.00
6.00
4.00
2.00
0.00
Test Subject
1
2
3
4
5
6
7
8.55
6.27
11.36
8.70
8.80
6.45
9.77
7.69
9.74
8.44
7.95
5.77
10.38
7.86
Incandescent
LED

RESULTS

The average reaction time for all the test subjects for the incandescent lamp was 342 milliseconds. The average reaction time for all the test subjects for the LED lamp was 263 milliseconds. Therefore the test subjects' reaction time was 79 milliseconds quicker for the LED lamp than for the incandescent lamp.

The average reaction distance, defined as the distance in meters that a car traveling at 100 km/h would travel during the test subjects' reaction time, was found to be 9.5 meters for the incandescent lamp and 7.3 meters for the LED lamp. That is a difference of 2.2 meters. This means that the car would travel 2.2 meters less while stopping for a car that has LED tail lamps, than when the car ahead has incandescent tail lamps.


Average Reaction distance
Incandescent
LED
CRASH!
9.51
7.31
0.00
2.00
4.00
6.00
8.00
10.00
12.00
Distance, meters

CONCLUSIONS

My hypothesis that a person will react faster to an LED tail lamp than to an incandescent tail lamp was proven correct. The LED was shown to produce a reaction time that, on average, was 79.1 milliseconds faster than the incandescent lamp. This resulted in a reaction distance decrease of 2.2 meters when traveling at 100 km/h, making the LED lamp safer than the incandescent lamp.

Other factors that could be tested include changing the lamp colors and intensity. The project could use a larger group of test subjects. Also, the test could be changed so that the test subjects operated the brake switch more like a brake pedal.

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