Remote Control Laser Pointer

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Team 12

Engineering Analysis

Submitted towards partial fulfillment of the requirements for
Mechanical Engineering Design I – Fall 2013

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1.0 ABSTRACT

Engineering analysis is required to fully understand the system being designed for our client, Mr. Anderson. Two designs have been proposed to our client for approval and both will be analyzed in this document. The analysis will investigate structural, fluid, and thermal effects on our designed systems and discuss the implications of our findings.

2.0 BACKROUND

The goal of this project is to provide our client, Mr. Edwin Anderson of the NAU Physics department, with a means to conduct presentations of the night sky using a 20mW laser. The use of a 20mW laser is desired because 5mW laser pointers are not powerful enough for larger groups to see. However 20mW lasers are much more dangerous, if direct contact were made with someone's eye it would result in instant blindness. The primary location that the system will be used is the NAU observatory grounds. The system will also be used in various other outdoor locations in and around Flagstaff, Arizona. Operating conditions range from cool summer night temperatures to below freezing winter night conditions. The laser operates poorly in cold climates. Therefore, an insulated housing unit will be designed along with an electrical heating element to keep the laser within operating temperatures while in use.

3.0 INTRODUCTION

Two overall design concepts will be analyzed in this report. One is the hand-held design, concept one seen in Figure 1, and the other incorporates a tripod-turret-joystick system, concept two seen in Figure 2. For the hand-held design, thermal analysis is done so that our group can design the system to remain within operating temperatures. The event of dropping the hand-held design from a height of six feet is also considered and analyzed from a structural standpoint. For the tripod based design, most of the components will be purchased and implemented as is, and used in conditions well below maximum loadings. For this reason, analysis for these components will not be conducted. The analysis for concept two will be focused on the housing for the laser.

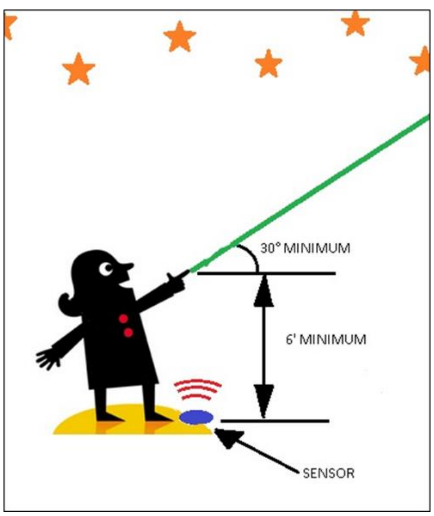

Figure 1 – Concept One

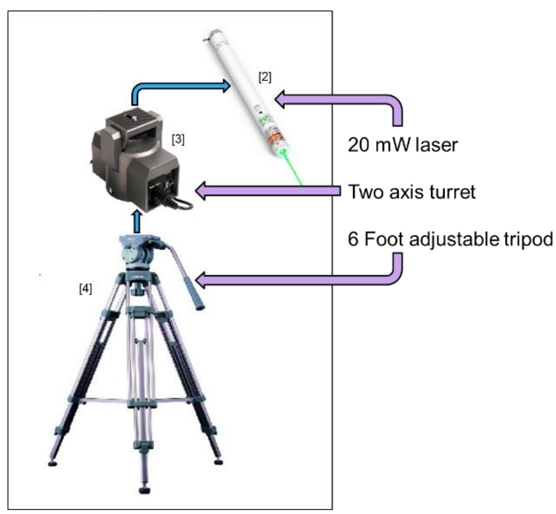

Figure 2 – Concept Two

4.0 CONCEPT GENERATION

Two concepts are illustrated below with detailed component descriptions.

4.1 CONCEPT ONE

The handheld design will function much like the existing laser from a user stand point. The laser and all supporting electronics will be housed in an insulated cylinder, see Figure 3 below. A system of gyroscopes and proximity sensors will ensure that the laser shuts off when pointed below an adjustable minimum angle or drops below a certain height. Concept 1 is thermally insulated to enable the laser to be used in Flagstaff winter conditions. For the thermal analysis see the thermal analysis section.

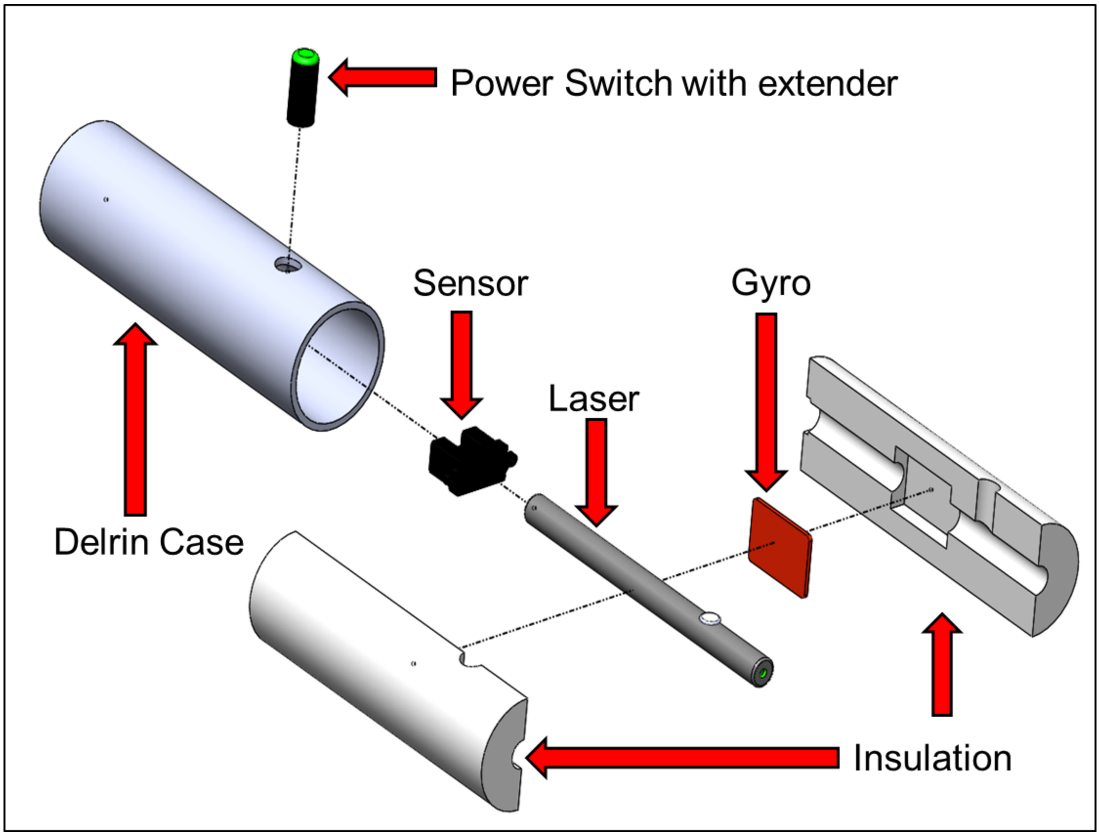

Figure 3 – Concept 1 Hand Held

As shown in the figure above, the proximity detector, gyroscope / accelerometer, and the laser are all contained in a two piece insulation shell. This shell will be inserted into a Delrin case which has been structurally analyzed in the structural analysis section. The design allows the user to remove the laser components for inspection and battery replacement, battery not shown for simplicity.

The power switch will be integrated into the circuitry of the gyroscope / accelerometer and sensor system. The switch will be activated by a switch extender. The switch extender is a mechanism which transfers force from the outer case, through the insulation shell and to the laser pointer's existing power switch. The signal from the power switch will be interrupted by the gyroscope / accelerometer circuitry so that at dangerous angles, the laser power is cut. By interrupting the power circuit, all safety features are contained in the programming of the device.

4.2 CONCEPT TWO

This design incorporates a tripod and joystick controlled video camera turret to hold the laser at a safe height of 78 inches and move it into the desired positions. Similar to concept one, the laser itself will be housed in an insulated cylinder, this cylinder will then be mounted to the camera turret. There will also be a cylindrical block, made likely from sheet metal that fits around the turret and blocks the laser if it should drop below a certain angle.

4.2.1 LASER HOUSING FOR TRIPOD DESIGN

The housing containing the laser will be constructed of Delrin. A stock piece of Delrin will be machined to the specifications in the engineering drawings provided in Appendix A. The Northern Arizona University (NAU) machine shop will machine the case and the cap of the housing. The solenoid cover will be rapid prototyped in the NAU rapid prototyping lab from ABS. Figure 4 below shows the components of the proposed design.

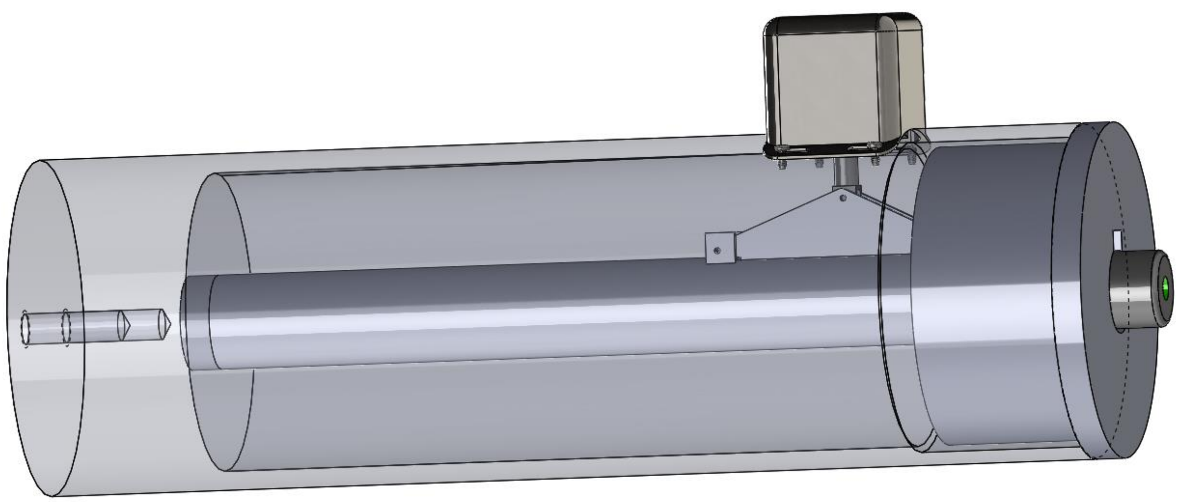

Figure 4 - Tripod mounted laser housing

The image above shows the locations of the internal components for the design. Each of these components will be briefly described in the following paragraphs.

The outer case will be machined out of Delrin. Figure 5 below shows the solenoid mounting location and the hole necessary for the actuator to contact the switch ramp as well as the turret mounting holes. The solenoid will be mounted to the outer case with two M1.4 x 0.3 – T5 drive screws (not shown). These screws will be further analyzed when the mass of the solenoid is known. However, these screws are often used to install electrical components in soft metal, and thus will be more than adequate for the solenoid attachment in Delrin. The turret mounting holes are tapped with $\frac{1}{4}$ inch NCP threads. Bolts will be placed through the mounting slots on the turret assembly and into these holes. Grade 5 steel bolts are capable of 6.15E+05 $\frac{N}{m^2}$ of tensile stress. The mass and motion of the turret and laser assembly will not produce a fraction of this maximum stress. Also, the turret assembly is rated for 5 pounds (2.26796 kg). Consequently, no force analysis was conducted on these bolts or the turret assembly.

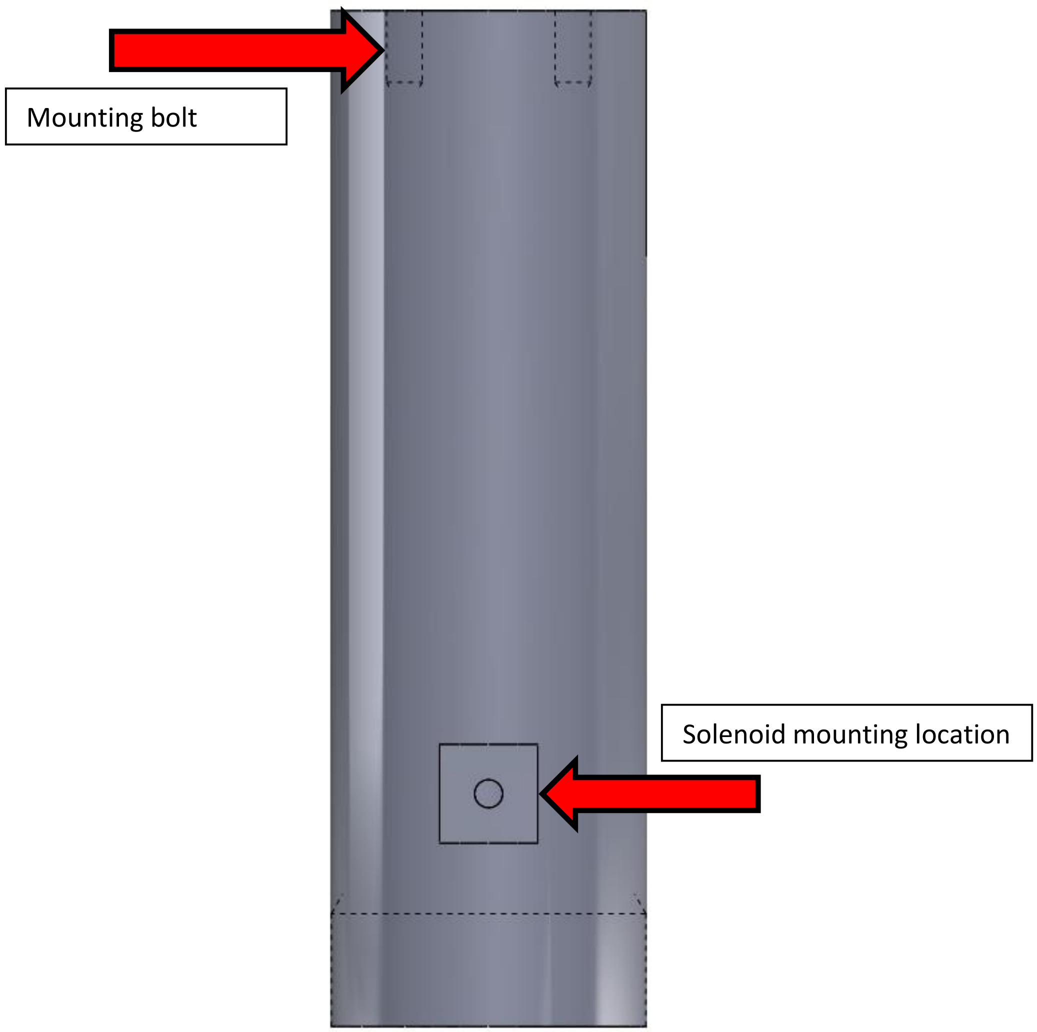

Figure 5 - Outer case with solenoid mounting location shown

The inner tube rests in a recess in the bottom of the outer case. The recess is shown in Figure 6 below.

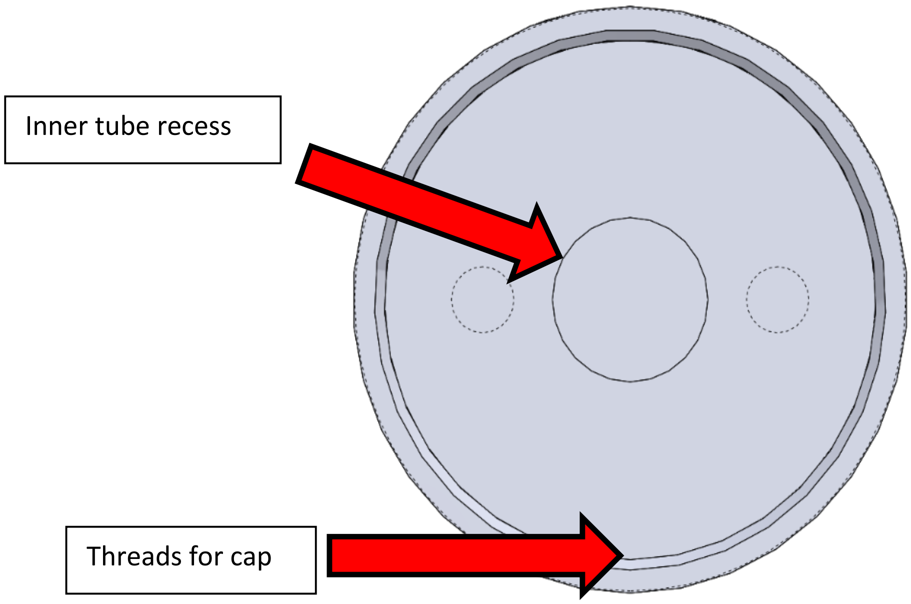

Figure 6 - Outer case with inner sleeve mount cutout shown

The inner tube is the compartment where the laser will be placed, see Figure 7 below. This compartment is designed such that a variety of laser models can be placed inside. It will be constructed from $\frac{1}{2}$ inch electrical conduit. This material is very inexpensive, strong, and easily machined. The inner tube will also contain pivot tabs, and a groove for the switch trigger, explained below.

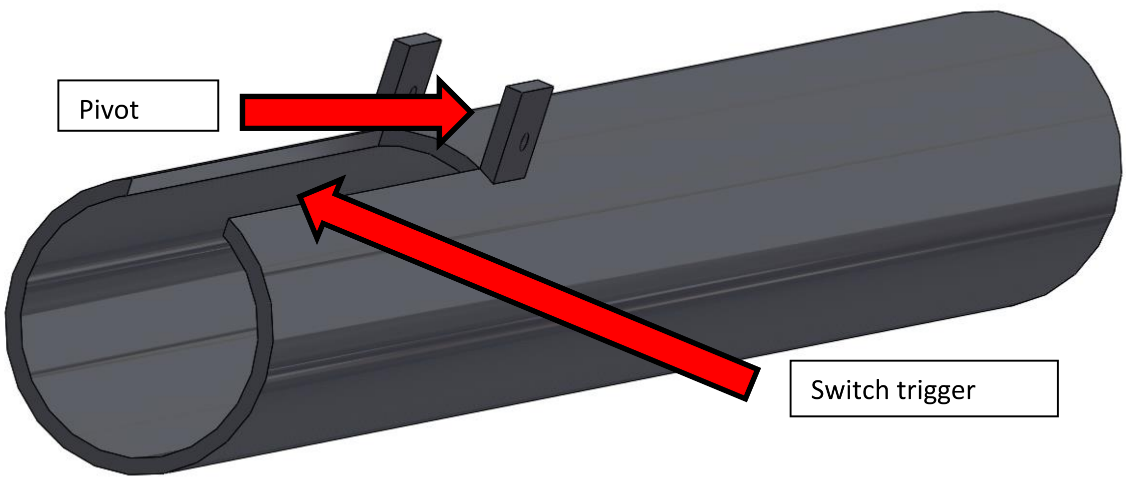

Figure 7 - Inner tube with switch trigger mounting tabs

The switch trigger is a device necessary to accommodate several laser models. Not all laser are designed with the power switch in the same location. Thus it is necessary to design an actuator capable of operating switches in various locations. The switch trigger distributes the solenoid actuation over a longer functional distance. A specialized solenoid will be required for this application. A manufacture has been contacted for specifications;

once received, force calculations can continue on the switch trigger and inner tube. Figure 8 below shows the switch trigger with the pivot point toward the viewer. The switch trigger pivots in the switch trigger groove via the pivot point tab pin welded to the inner tube. When the solenoid is inactive, the switch trigger will be elevated such that the power switch for the laser is not depressed. When the solenoid is actuated, the switch trigger will depress the power switch, turning on the laser.

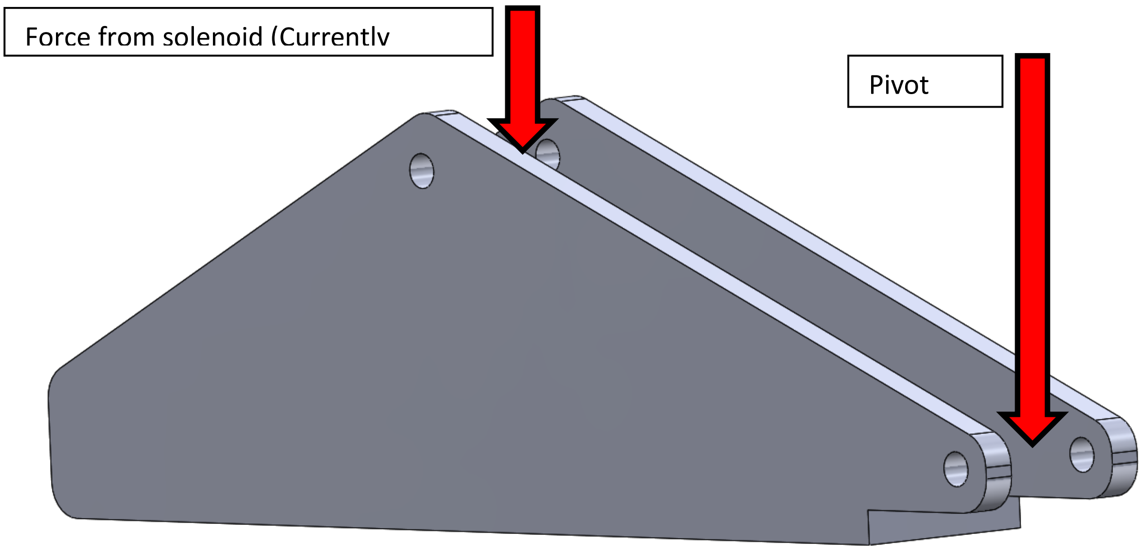

Figure 8 - Switch trigger, with pivot side facing

The solenoid is not a weather resistant device. To ensure that the solenoid will remain operational in outdoor conditions, a cover must be designed and constructed. Figure 9 below shows the solenoid cover with the mounting slots visible. This cover has not yet been analyzed because various other covers are still being investigated. The cover design shown is representative of any electronics cover. If a purchased option cannot be found, then the design presented here will be rapid prototyped in the NAU rapid prototype lab. The rapid prototyping materials range between ABS, and polycarbonate. These materials will be tested and analyzed before making the final design choice.

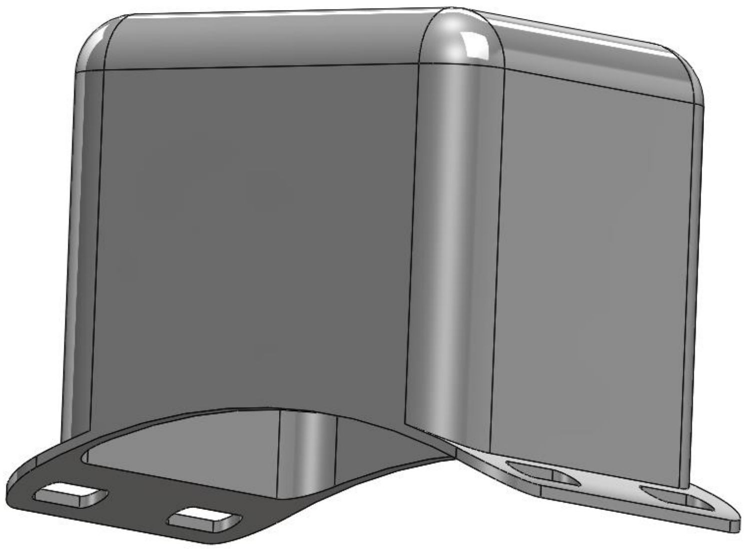

Figure 9 - Solenoid Cover

To cap the internal components and support for the inner tube on the upper end, a Delrin cap was designed, see Figure 10 below. The cap is currently modeled with threads that match the outer case opening; however, the threads may be replaced with set screws for ease of access to the internal components. If the threads are replaced, the outer case will no longer have the step shown toward the opening. The step shown in Figure 5, is a result of the threads and would no longer be necessary. The determining factor in this decision will be the availability of the NAU machine shop to machine the necessary threads. A discussion with the machine shop operators will ensue in the week beginning on November 12th. Another design component in the cap is the switch groove. This groove is necessary for the power switch to enter the inner tube. This notch is aligned with the notch in the inner tube and the switch trigger.

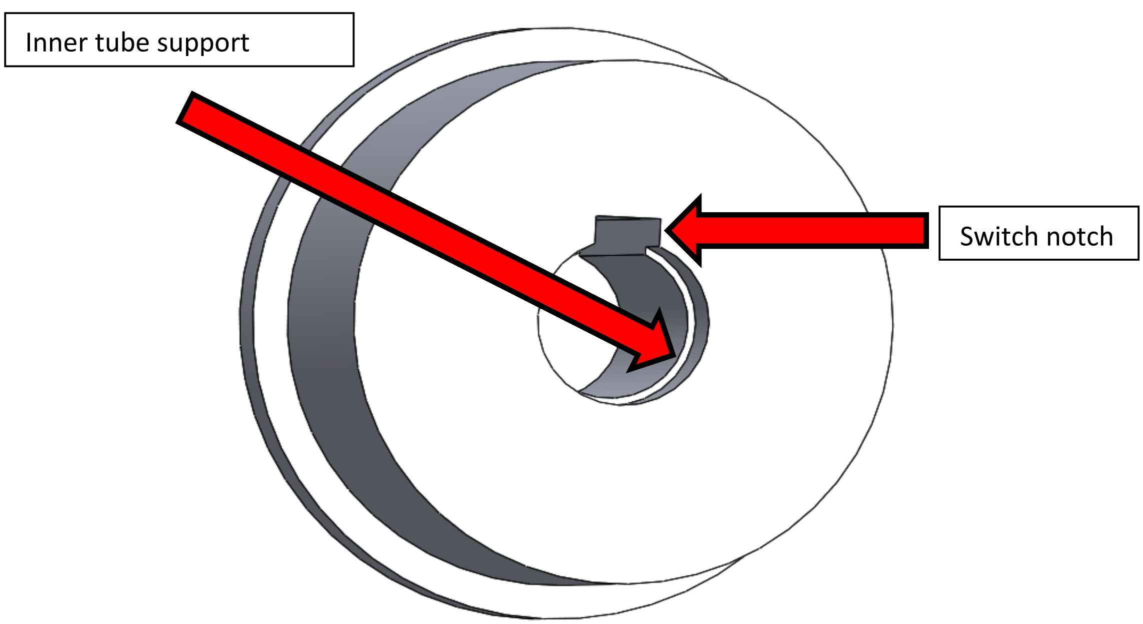

Figure 10 - Outer case cap

4.2.2 TRIPOD DESIGN MODIFICATION

The tripod for concept two will be a purchased component. This component is capable of height adjustment from 34 inches to 78 inches. This adjustability poses a potential safety concern for the laser operational height. One solution could be to remove the locking mechanisms and implement holes and pins to make only the operational height allowable. Mounting of the turret to the tripod will be accomplished via a camera quick connector capable of handling an 8 pound camera. This quick connect is shown in Figure RRR with the tripod, in the selected design component images section.

Both designs will use a small electric heating element inside the laser housing to maintain the lasers temperature within operating limits.

Manufacturer specifications for the tripod and turret we have selected for concept two are shown below in Tables 1 and 2.

Table 1 – Turret Specifications

Physical	
Dimensions (WxHxD)	10" x 14" x 4"
Weight	4.5 lbs.
Cable Length	12 Feet
Mounting	Upright or Inverted
Mounting Plate	3" x 3" with 3/8" hole
Controls	
2 Axis Thumbstick P/T	30/30 degrees
Ramp	none
Linear	none
Logarithmic	fixed
Speed Limit	0 to 100%

Electrical	
Power Supply	110-230 VAC to 12 DC 1000 MA
Connector	5.5 X 2.1 center Pos.
Capabilities	
Slowest Speed	1 rev in 10 minutes
Max Speed	4 RPM @ 12 V
Pan Revolution	360° +
Tilt Revolution	360° +
Capacity	5 ponds/2.3 kilos

Table 2 – Tripod Specifications

Overall Specifications	
Max height	78" (1.98 m)
Min height	31" (0.7874 m)
Folded length	34" (0.8636 m)
Center post adjustment	15" (0.381 m)
Weight	9 lb (4.08 kg)

Max Tripod load	25 lb (11.34 kg)

4.3 SELECTED DESIGN COMPONENT IMAGES

The tripod selected for concept 2 is shown in Figure 11 below.

Figure 11 – Camera turret, laser mounting slots shown

The tripod selected for concept 2 is shown in Figure 12 below.

Figure 12 – Tripod

5.0 STRUCTURAL ANALYSIS

For concept one, structural analysis consisted for developing a model that describes the event of dropping the devise from a height of six feet onto solid ground. The system must be able to withstand an impact with the ground sustaining minimal permanent deformation to the enclosure and no damage to internal electrical components. The results for this model are shown below.

5.1 STRUCTURAL RESULTS

Structural analysis was conducted for the outer casing of the handheld design using two different materials. The two options were 6061-O Aluminum and Delrin 100. The purpose of the structural analysis was to estimate the impact force the handheld unit would sustain if dropped from 6 feet (1.83m) and calculate whether or not the outer casing would undergo plastic deformation. First, the velocity that the unit hits the ground at from 6 feet was calculated using the kinematic equation listed below.

$$V_f^{\,2} = V_O^{\,2} + 2 * a * h \tag{1}$$

Where:

V_f = Final velocity [m/s]
V_O = Initial Velocity [m/s]
a = Acceleration [m/s^2]
h = Height [m]

The calculation for the velocity just before impact when dropped from 6 feet is listed below.

$$V_f^{\,2} = (0)^2 + 2 * \left(9.81\frac{m}{s}\right) * 1.83m$$

$$V_f = 5.99\frac{m}{s} \approx 6\frac{m}{s}$$

In order to calculate the force that is exerted at impact, the acceleration the unit undergoes during impact must be calculated. The equation for acceleration is listed below.

$$a = \frac{dv}{dt} \tag{2}$$

Where:

a = Acceleration [m/s^2]
dv = Change in velocity [m/s]
dt = Change in time [sec]

This calculation is only an estimation of the actual acceleration the unit would undergo. Therefore, it is assumed that the time is takes for the unit to go from 6 m/s to 0 m/s is 0.1 seconds. This is a rough estimate that was generated by dropping similar weighted objects from 6 feet on a hard concrete surface and estimating the time it took for the object to bounce.

$$a = \frac{(6-0)\,{}^{m}/_{s}}{(0-0.1)s} = 60\,{}^{m}/_{s^2}$$

Once the acceleration the unit undergoes during impact was calculated, the force was calculated using Newton's 2nd law of motion.

$$F = ma \tag{3}$$

Where:
F = Force [N]
m = Mass of object [kg]
a = Acceleration [m/s^2]

To make this calculation the mass of each option, Aluminum and Delrin, had to first be calculated. The volume of the outer case was calculated by modeling the case in SolidWorks and looking up the volume under the "material properties". Volume calculated and weight of each option is listed in Table 3 below.

Table 3 – Casing material properties

	Aluminum (6061-O)	Delrin (100)
Volume [cm^3]	117.6	117.6
Density [g/cm^3]	2.70	1.41
Weight [g]	317.4	165.7

In addition to these weights, each design option shares all other components. A list of the components and their respective weights is listed in Table 4 below.

Table 4 – Mass of components

	Mass [g]
Polystyrene (Expanded)	4.7
Gyro / Accelerometer	4
Proximity Detector	5
Heating Element	12
Batteries (2 x AAA)	23
Laser Pointer	26
Total	**74.7**

The weights were then totaled and forces calculated.

Aluminum case: $F = (0.3921\ kg) * \left(60\ {}^{m}/_{s^2}\right) \approx 23.5\ N$

Delrin case: $F = (0.2404\ kg) * \left(60\ {}^{m}/_{s^2}\right) \approx\ 14.4\ N$

For the Aluminum, any stress that exceeds .02% of the yield strength will cause plastic deformation. Using the known properties of Aluminum 6061-O, this stress was calculated using the relationship below.

Stress

$$\sigma = E\varepsilon \tag{4}$$

Where:

σ = Stress [Pa]
E = Modulus of elasticity [Pa]
ε = Strain [m/m, Dimensionless]

The modulus of elasticity for Aluminum is 68.9 GPa. Using this, the minimum stress to cause plastic deformation was calculated.

$$\sigma = (68.9\ GPa)(.0002) = 13.8\ MPa$$

For Delrin 100, the modulus of elasticity is not listed in any sources. The modulus of elasticity was estimated by analyzing the stress-strain curve of Delrin at room temperature (23°C) as seen in Figure 13 below.

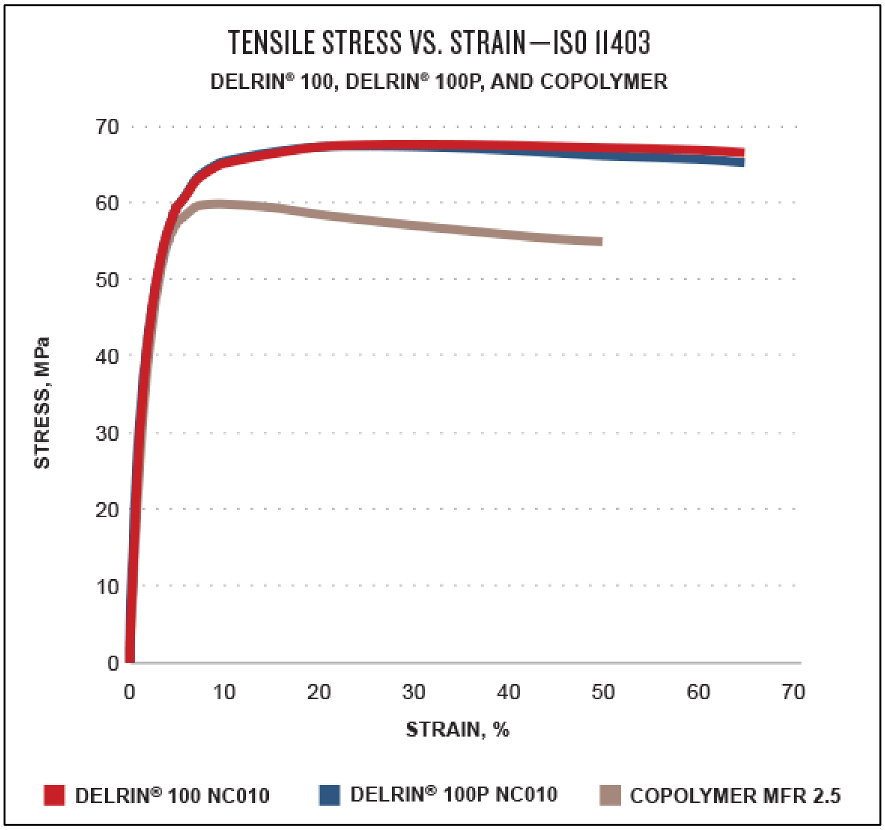

Figure 33 – Stress-Strain Curve Delrin 100 [12]

Listed below is the calculation for the modulus of elasticity.

$$E = \frac{(60\ MPa)}{(.03\ \frac{mm}{mm})} = 2\ GPa$$

The modulus of elasticity for Delrin was estimated to be 2 GPa. Using this information, the stress necessary to cause plastic deformation was calculated.

$$\sigma = (2\ GPa)(.0002) = 0.4\ MPa$$

Finally the actual stress the unit will undergo if dropped from 6 feet (1.83m) can be estimated. The way this is calculated is to calculate what area will undergo the stress when the unit is dropped and see if this is realistic. This area is calculated using the relationship to stress.

$$\sigma = \frac{F}{A} \tag{5}$$

Where:

σ = Stress [MPa]
F = Force [N]

$A =$ Area $[m^2]$

The area necessary to undergo stress is calculated for each Aluminum and Delrin. The force and stress used in the calculation were calculated above.

Aluminum: $13.8\ MPa = \frac{(23.5\ N)}{A}$

$$A = 0.017\ cm^2$$

Delrin: $0.4\ MPa = \frac{14.4\ N}{A}$

$$A = 0.36\ cm^2$$

These calculated areas represent the maximum area that the force from the impact can be spread across. If the same force is exerted on a smaller area, there will be plastic deformation. The area for the aluminum is significantly smaller than the area for the Delrin. Simply, the aluminum case is much stronger and less likely to plastically deform if dropped. If either unit is dropped and lands either on along the length of the unit or on the top of the unit, there will be no plastic deformation. However, there is a possibility of plastic deformation if the unit is dropped and lands on one of the corners along the top or bottom for both the aluminum and the Delrin. The conservativeness of these calculations needs to be taken into consideration to make any decisions about which material should be used.

A time of 0.1seconds was assumed for the calculation of acceleration. This was assumed by dropping the unit on hard concrete. It is known that Mr. Anderson often conducts his guided talks in the forest or on grassy fields. This makes the calculation of 0.1s for the unit to come to complete stop very conservative.

It also must be taken into consideration the type of stress the unit would undergo if it were dropped. All calculations were based on the tensile strength of Delrin and Aluminum. However, the yield strength of Delrin is almost double in compression than it is for tension; 60MPa in tension vs. 125MPa in compression. This can be seen in Figure 14 below.

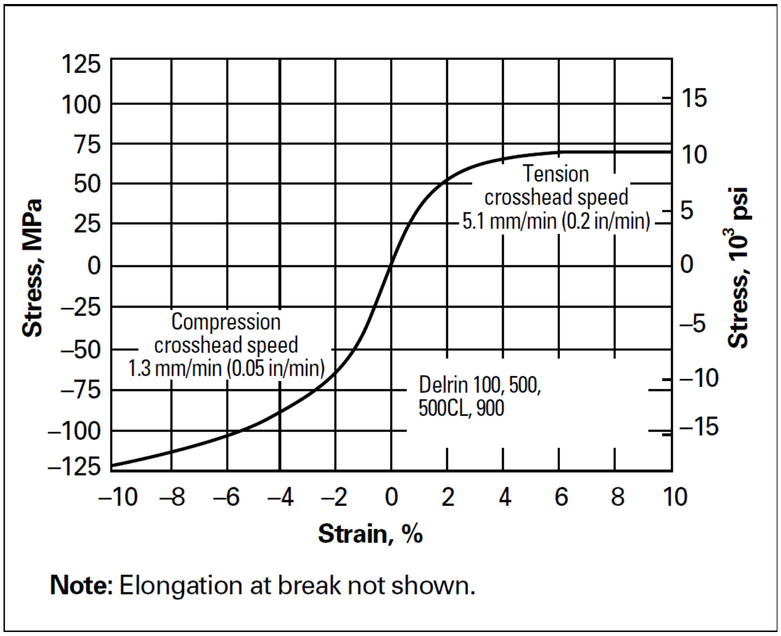

Figure 14 - Delrin Compressive and Tensile Stress Curve [6]

In conclusion, all estimates for the amount of stress needed to plastically deform the hand held unit when dropped from 6 feet are extremely conservative. This makes both the Aluminum and Delrin relatively equal candidates to be used in the final design. There is one material property that makes Delrin a much better choice than Aluminum and that is the thermal conductivity.

One of the main concerns with the hand held unit is keeping it above a certain temperature so the unit operates even in harsh winter environments. The thermal conductivity of Aluminum is significantly higher than Delrins; 237 vs 0.3 W/m*K. Since both materials are structurally sufficient for this design, but the ability for Delrin to act as an insulator is much better than Aluminum's, Delrin will be used as the casing for the final design.

6.0 FLUID ANALYSIS

Fluid analysis would have consisted of calculations of a maximum endurable sustained wind speed needed to cause the tripod system to fall over. However our team reasoned that these wind conditions would be uncomfortable for attendees of the presentation as well as the instructor. If such conditions were present, the presentation would not occur and our system would not be in use, therefore these calculations were omitted.

7.0 THERMAL ANALYSIS

The laser must remain within operating temperatures at all times. For this reason thermal analysis was done for both concepts one and two on the laser housing. Both designs incorporate electric heating elements as well as insulation to regulate the temperature of the laser during operation. The important quantity is the heat loss through the housing under predicted worst case conditions. Once this value is determined the group can identify an adequate heating element to incorporate.

7.1 THERMAL RESULTS

Both design concepts involve surrounding a laser or a combination of the laser and the electrical components in insulation with an outer shell of material. The laser housing is been assumed to be equivalent in geometry for both concepts; the subsequent thermal analysis applies to both concepts and is considered at the worst case scenario (i.e. system exposed to cold air and wind conditions). The geometry has been simplified to a cylinder with a length equal or slightly longer than the length of the laser and variable radii for the insulation and outer shell. An Excel spreadsheet was created that determines total heat flow through our system while being able to change material type, geometry dimensions, and temperatures for operating conditions. The team chose Delrin to be the outer shell material and Polystyrene foam for insulation because they have relatively low thermal conductivities compared to other materials. Delrin was found to have a thermal conductivity of 0.3 $\left[\frac{W}{Km}\right]$ [6]. Polystyrene was found to have a thermal conductivity of 0.026 $\left[\frac{W}{Km}\right]$ [7]. The dimensions presented are an estimate of the needed thickness of our laser housing and can be altered if needed during construction. The laser operating temperature was determined using an average of the laser's specified operating temperature. The ambient temperature was assumed based on lowest temperatures seen in Flagstaff in which would be comfortable for a night sky presentation. Tables 5-7 show the chosen material properties, highlighted in green, and other variables described above.

Table 5 – Laser Housing Materials

Housing Material	**K (W/(m*K)**
LD PolyE	0.3
HD PolyE	0.48
PolyProp	0.2
Delrin	0.3
Insulation Material @270K	**K (W/(m*K)**
Polystyrene extruded	0.026
Blanket mineral fiber	0.04

Table 6 - Temperatures

Temp outside	Deg F	Deg C	Kelvin	Appx Temp (K)
	-5	-20.56	252.44	260
Temp laser functional	Deg F	Deg C	Kelvin	Appx Temp (K)
	32	0.00	273.00	280

Table 7 – Variable Dimensions for Laser Housing

K (insulation)	0.026
K (housing)	0.3
Length (in)	6

r inner (in)	1
r inner (in) insul	0.25
r outer (in)	1.5
r inner in meters	0.0254
r inner insul in meters	0.00635
r outer in meters	0.0381
Length in meters	0.1524

In order to calculate the convection from the outer shell surface to the ambient air, a heat transfer coefficient was determined. This coefficient was calculated using equation 7.54 from the textbook "Fundamentals of Heat and Mass Transfer", see Equation 6 below [12].

$$\overline{Nu_D} = 0.3 + \frac{0.62 Re_D^{\frac{1}{2}} Pr^{\frac{1}{3}}}{\left[1+\left(\frac{0.4}{Pr}\right)^{\frac{2}{3}}\right]^{\frac{1}{4}}} \left[1 + \left(\frac{Re_D}{282{,}000}\right)^{\frac{5}{8}}\right]^{\frac{4}{5}} \quad (6)$$

Where:

$Nu_D = 182.77$

$Re = 7.73E4 \left(based\ on\ 30\ \frac{mi}{hr}\right)$

$\mathrm{Pr} = .7205$

Once the average heat transfer coefficient was calculated, the equivalent resistances were calculated and used to determine the heat transferred from the system. Equations 7 and 8 were used to determine resistances from the surface of the laser to the ambient air.

$$R_{conv} = \frac{1}{hA} \quad (7)$$

Where:

R_{conv} = Thermal resistance $[m^2K/W]$

h = Heat transfer coefficient $[W/m^2K]$

A = Surface area $[m^2]$

$$R_{cond\ (cyl)} = \frac{ln\frac{r_2}{r_1}}{2Lk\pi} \quad (8)$$

Where:

$R_{cond\ (cyl)}$ = Thermal resistance for a cylinder $[m^2K/W]$

r_2 = Outer radius of cylinder $[m]$

r_1 = Inner radius of cylinder $[m]$

The total heat transfer in our system was found using equation 9 below.

$$q = \frac{T_i - T_\infty}{\frac{1}{L\pi}\left[\frac{1}{hD_0} + \frac{\ln\frac{r_2}{r_1}}{2k_{ins}} + \frac{\ln\frac{r_3}{r_2}}{2k_{shell}}\right]} \quad (9)$$

Where:
T_i= Initial Temperature [K]
T_∞= Ambient Temperature [K]
r_3= Outer radius delrin [m]
k_{ins}= Thermal conductivity of insulation $[\frac{W}{m^2}]$
k_{shell}= Thermal conductivity of Delrin $[\frac{W}{m^2}]$
D_0= Outermost diameter

Table 4 shows calculated heat transfer coefficients and total heat transfer for wind speeds ranging from 0 to 50 miles per hour.

Table 8 - Calculated h in cross flow

U air (mph)	U air (m/s)	Re	h bar	Nusselt	Q total
0	0.00	0.00E+00	0.09	0.30	0.06
5	2.24	1.29E+04	19.49	62.14	0.34
10	4.47	2.58E+04	29.02	92.54	0.34
15	6.71	3.86E+04	37.02	118.02	0.35
20	8.94	5.15E+04	44.23	141.01	0.35
25	11.18	6.44E+04	50.95	162.43	0.35
30	13.41	7.73E+04	57.33	182.77	0.35
35	15.65	9.02E+04	63.45	202.29	0.35
40	17.88	1.03E+05	69.37	221.17	0.35
45	20.12	1.16E+05	75.13	239.53	0.35
50	22.35	1.29E+05	80.75	257.46	0.35

The total heat transfer was determined to be 0.35 Watts when using a wind velocity of 30 mph, a heat transfer coefficient of 57.33$\left[\frac{W}{Km^2}\right]$, and the parameters from Tables 5-7. Therefore, a heating element will be selected that can produce at least 0.35 Watts.

In order to validate our theoretical calculations, ANSYS was used to plot our temperature distribution for the conditions described above. Figure 15 below, shows the resulting temperature distribution.

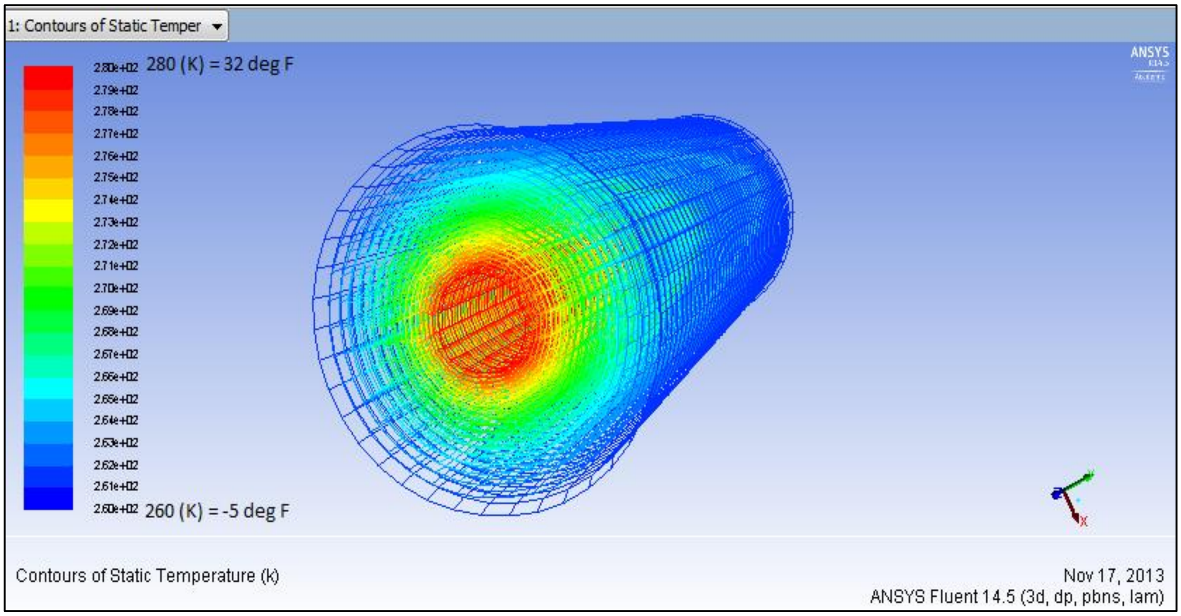

Figure 15 – Temperature Distribution

The temperature distribution shows the inner surface temperature of the laser at 280K, the appropriate operating temperature, and the ambient temperature at 260K. As seen in the figure, the insulated section retains more heat than the Delrin outer shell. This observation was expected due to the difference in equivalent thermal resistance between the outer shell and the insulation.

Equations 10 and 11 were used for the transient analysis.

$$F_o = \frac{\frac{k}{\rho C_p} * t}{r_0} \tag{10}$$

Where:

$k = Thermal\ conductivity\ of\ air\ \left[\frac{W}{mK}\right]$

$\rho = Density\ of\ air\ \left[\frac{kg}{m^3}\right]$

$C_p = Specific\ heat\ of\ air\ \left[\frac{KJ}{kgK}\right]$

$r_0 = Radius\ of\ cylinder\ [m]$

$$\theta^* = C_1 * exp(-\delta^2 F_o) * cos(\delta_1 x^*) \tag{11}$$

Where:

$\theta^* = \frac{(T_0 - T_\infty)}{(T_i - T_\infty)}$

$C_1 = 1.1539$

$\delta_1 = 1.0873$

Transient conduction analysis was conducted to determine how long it takes for the laser temperature to drop below operating temperature. The average operating range for 20mW lasers in 32-95°F. Assuming the initial temperature of the laser is 70°F and the ambient temperature is worst case at -5°F, the laser will reach 32°F in 24.64 minutes. This is how long it takes for the temperature to reach the low end of the operating range. Additionally, when assuming the initial temperature of the laser is 70°F and the ambient temperature is worst case at -5°F, the laser will reach 50°F in 12.68 minutes. Additionally, when assuming the initial temperature of the laser is 70°F and the ambient temperature is 20°F (not worst case), the laser will reach 50°F in 16.16 minutes. The insulation alone is sufficient in our design only if the outside temperature is above the minimum operating temperature. With the above analysis, the need for a small heating element has been confirmed to ensure the laser temperature does not drop below the operating specification.

8.0 PROJECT PLAN

The progress of our project is tracked using a Gantt chart. Figure 16 shows the updated Gantt chart.

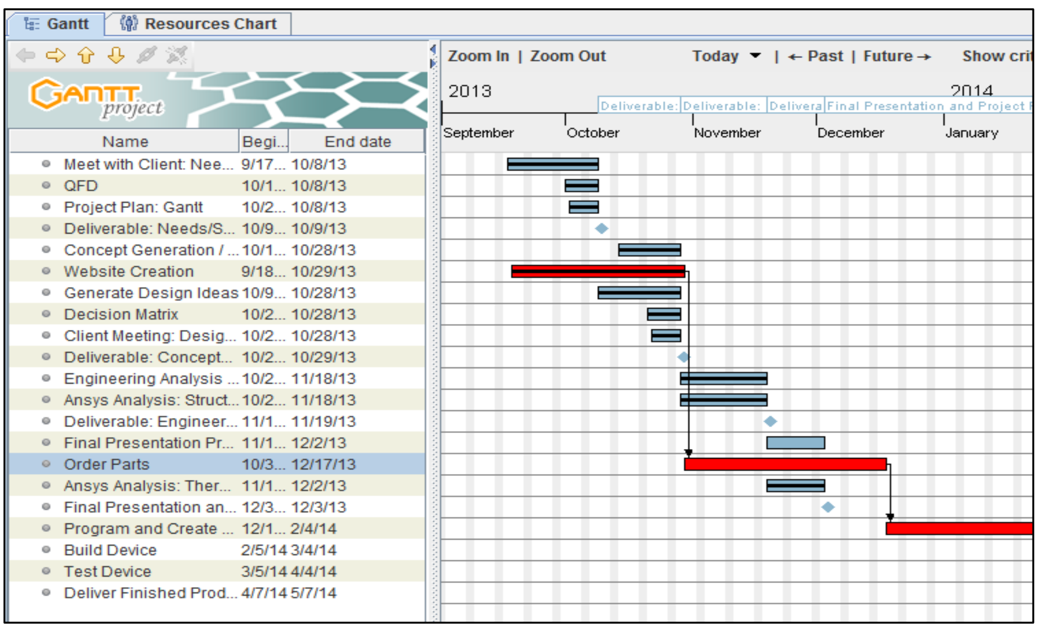

Figure 16 – Gantt Chart

Per the project plan, the team should have ordered parts by the middle of December. Our group will also need to complete our final presentation and report by the beginning of December.

9.0 SUMMARY

Many of the components for our design are purchased off the shelf and are to be used well below the maximum recommended loading. For this reason the analysis for our design reduced to the housing for the laser, which the group will be developing for this project. A mathematical model was developed for the event of the devise being dropped from a height of six feet onto solid ground. The housing will need to be designed to withstand this sort of event with little to no permanent deformation and no damage to the internal laser or electronics. By using Delrin 100 as the material for the outer case not only will the handheld unit be capable of withstanding numerous impacts, it will contribute to insulating the laser to maintain sufficient operating temperatures.

The tripod design was going to be analyzed for the event of being toppled over by the strong winds. However, our team reasoned that if there were strong enough sustained winds to knock the tripod over, an audience would not be comfortable sitting and watching a presentation. Therefore this portion of the analysis was omitted.

Thermal analysis was conducted on the laser housing for both concepts. The objective was to find the amount of heat leaving the system under worst case conditions which were determined to be a temperature of -20 °C or -5 °F and a wind speed of 13.4 m/s or 30 mph. Once this quantity of heat loss was determined an electrical heating element could be selected and installed to maintain the operating temperature of the laser. The resulting total heat transfer through our system was determined to be 0.35 Watts at worst case environmental conditions. With this information, a heating element that can produce at least 0.35 Watts. The thermal analysis has been derived such that variable and materials can be changed easily.

10.0 REFERENCES

Images:

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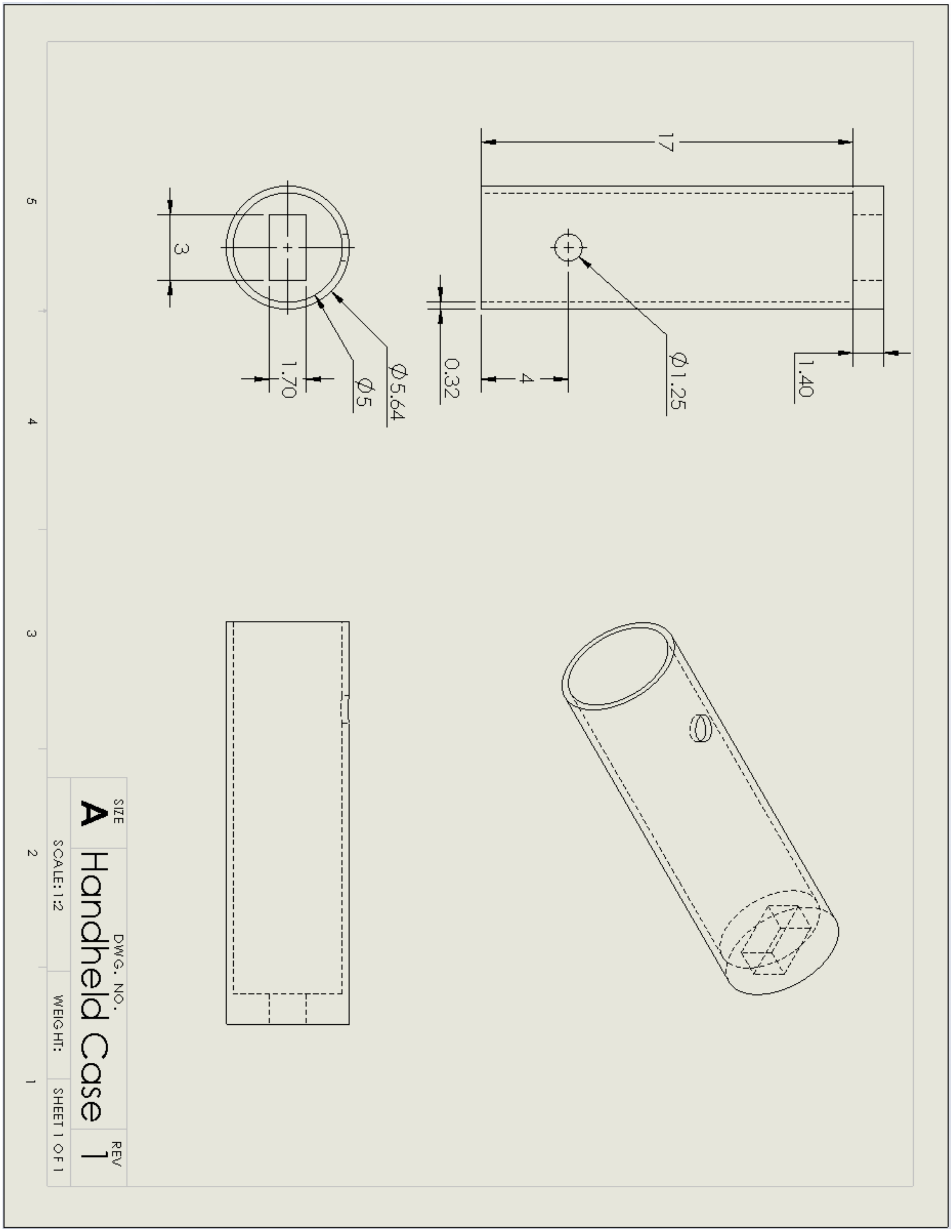
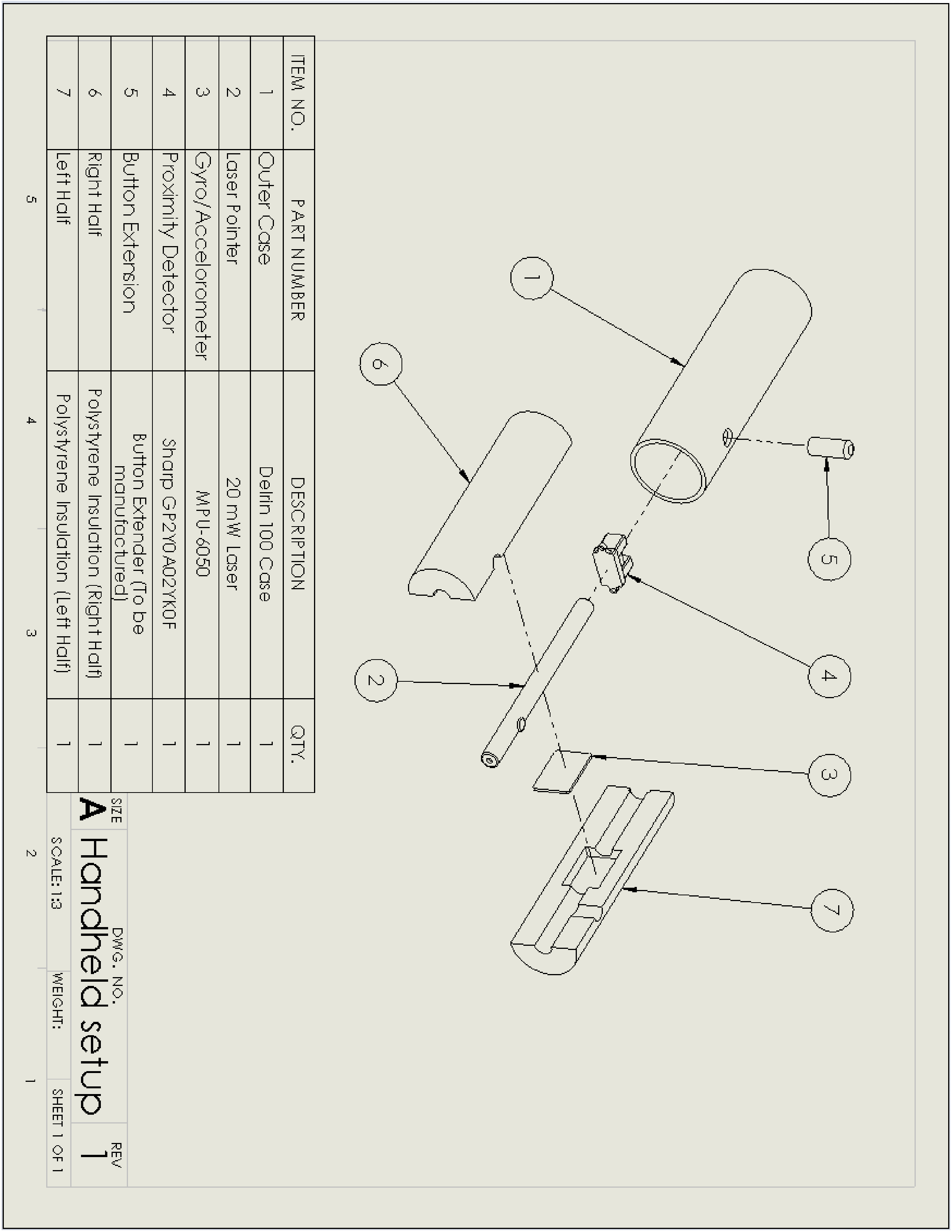
APPENDICES

APPENDIX A: Engineering drawings
Appendix A

Concept 1 – Case Design

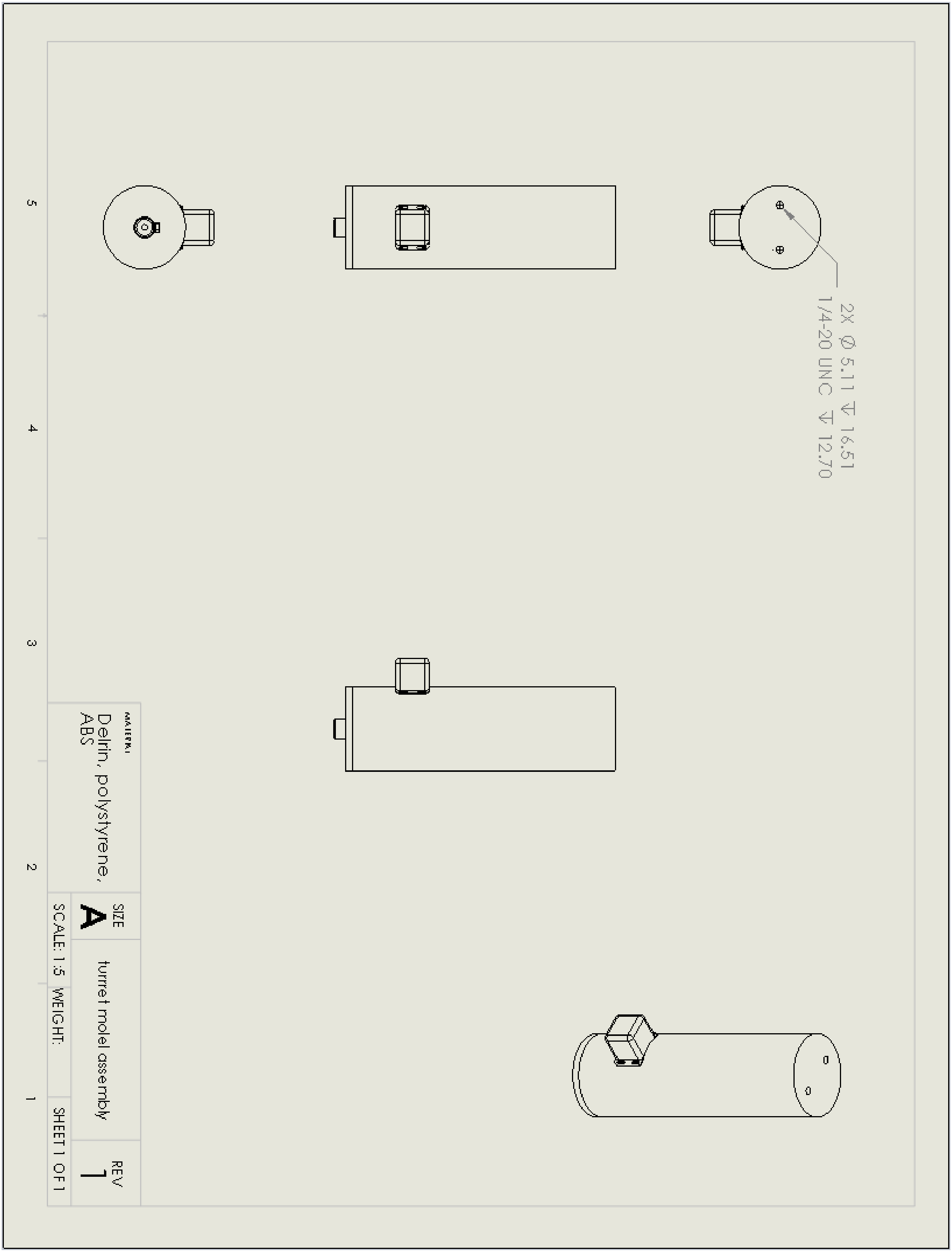


Concept 1 – Overall System

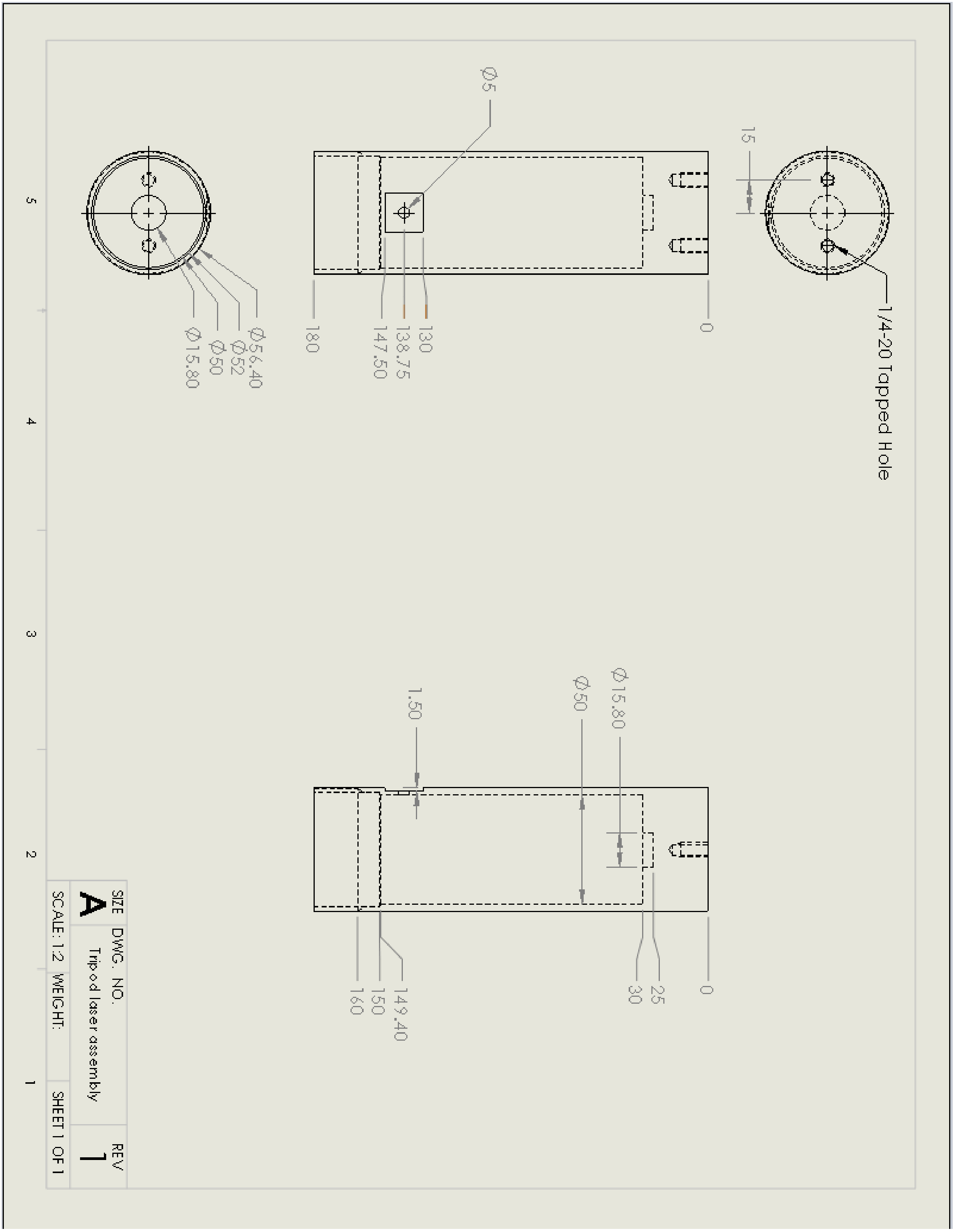


ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	Outer Case	Delrin 100 Case	1
2	Laser Pointer	20 mW Laser	1
3	Gyro/Acceloromenter	MPU-6050	1
4	Proximity Detector	Sharp GP2Y0A02YK0F	1
5	Button Extension	Button Extender (To be manufactured)	1
6	Right Half	Polystyrene Insulation (Right Half)	1
7	Left Half	Polystyrene Insulation (Left Half)	1

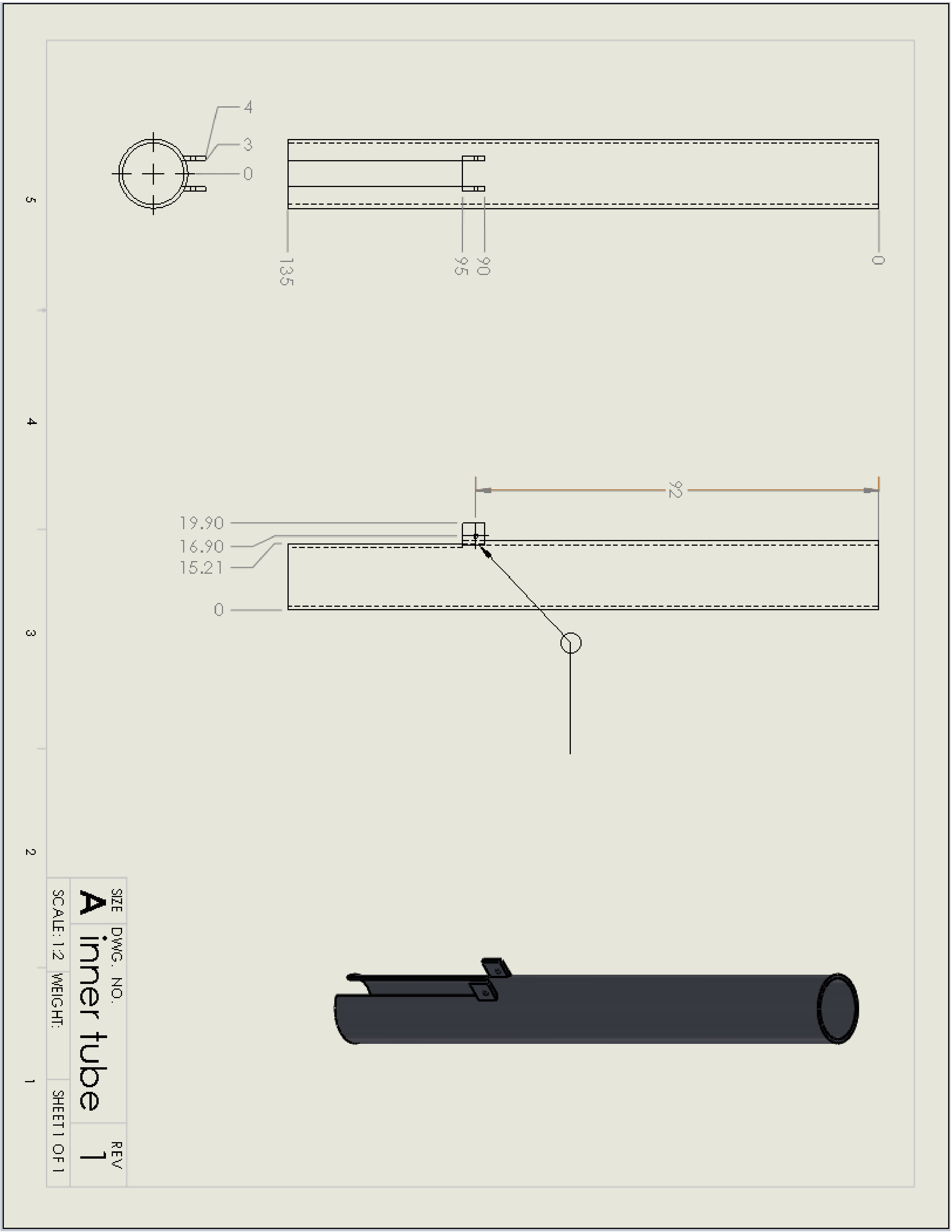
Concept 2 - Overall Design



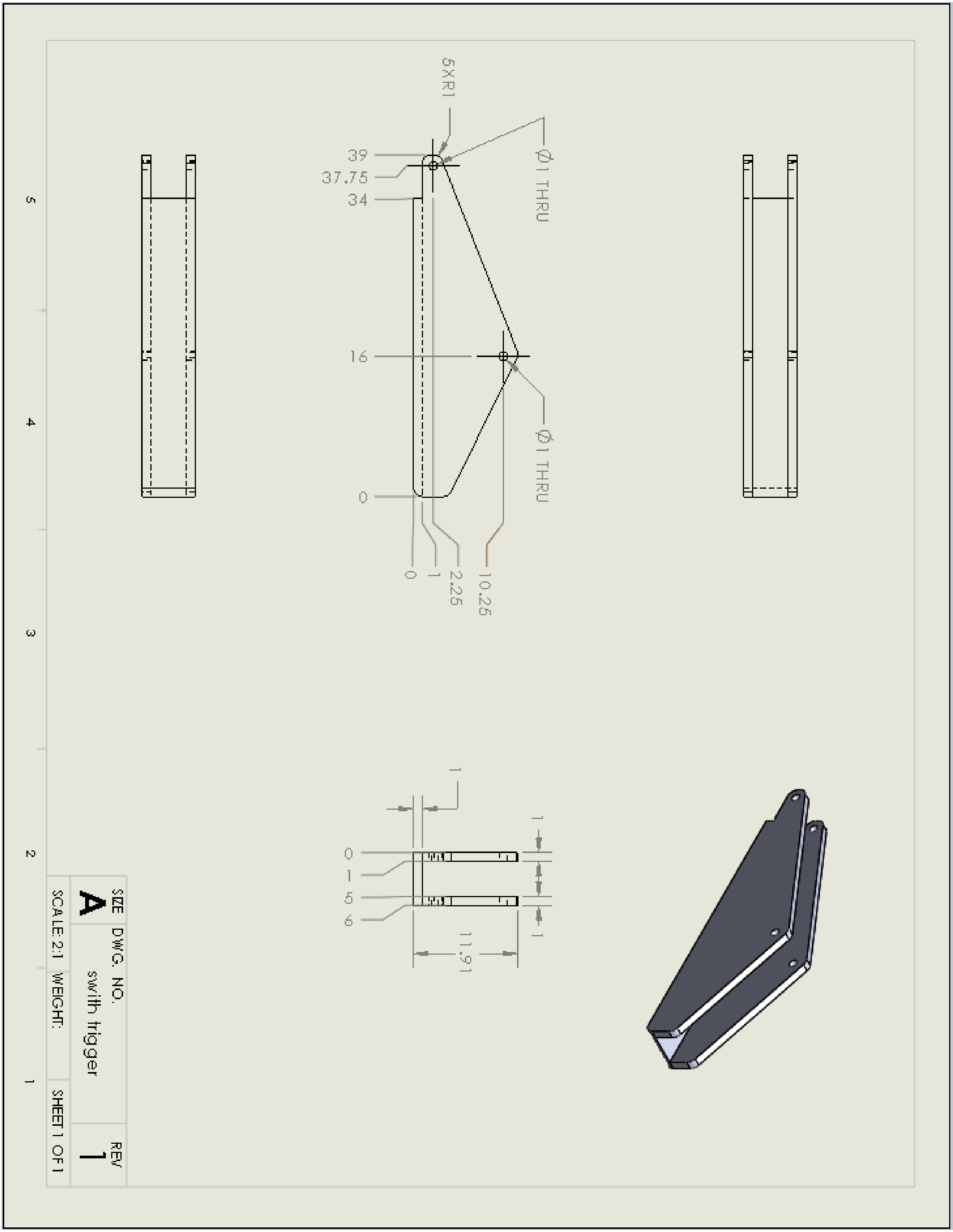
Concept 2 - Outer Case



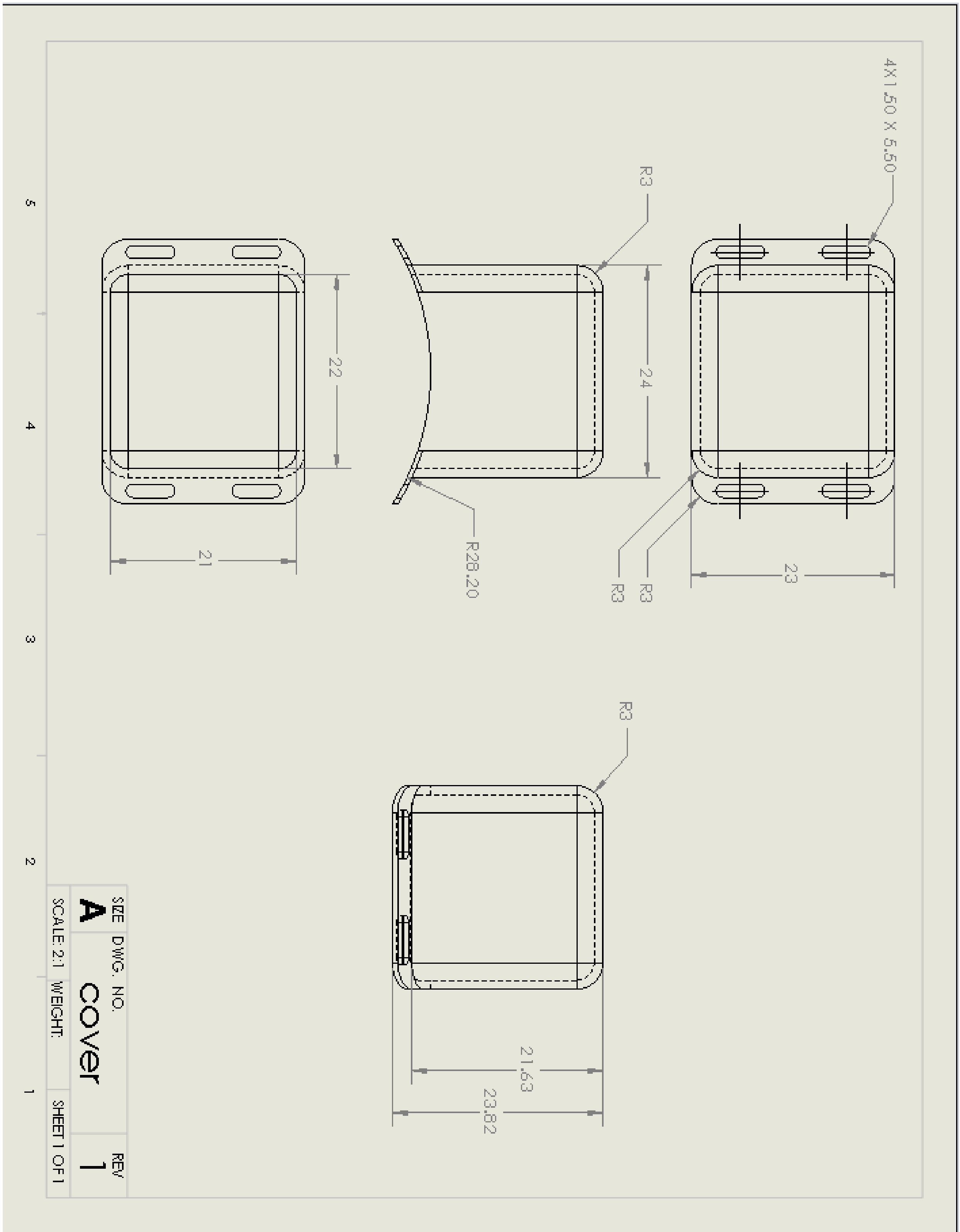
Concept 2 - Inner Tube



Concept 2 - Switch Trigger



Concept 2 - Solenoid Cover



Concept 2 - Cap