CHAPTER 4

DESIGN

Archer (1973) quoted that *"Design is that area of human experience, skill and knowledge which is concerned with man's ability to mould his environment to suit his material and spiritual needs"*. Design is a rational, logical, sequential process intended to solve problems. He also explained that the process of design begins with the identification and analysis of a problem or need and then proceeds through a structured sequence in which information is researched and ideas explored and evaluated until the optimum solution to the problem or need is devised. The selection process, specification of the components and costing are explained in this chapter.

4.1 Selection Process

Selection process is one of the most crucial activities for this project that must be done thoroughly. The design process starts with the identification of project requirements and followed by the analysis of requirements (Table 4.1), sketching, schematic drawing and selection of components or materials. The main requirements in designing the measurement system for this project are flexibility, safety, reliability, movability, stability and lightness.

There are four sketches that have been made for this measurement system but only two sketches are selected to go further for schematic drawing. The unselected sketches are not too good looking and seemed awkward thus it better to leave them off. Basically, the design for system must have the components such as the laser source, lens holders, light intensity power meter and platform. Without these components, this system is not able to produce expanded laser beam, create a measurement area and also detect the transmitted laser beam.

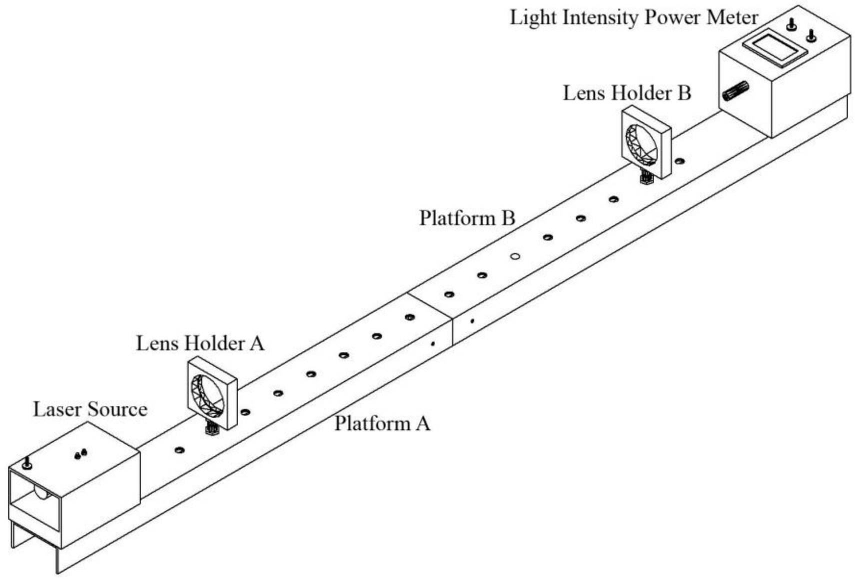

Figure 4.1: The first design of laser attenuation measurement system

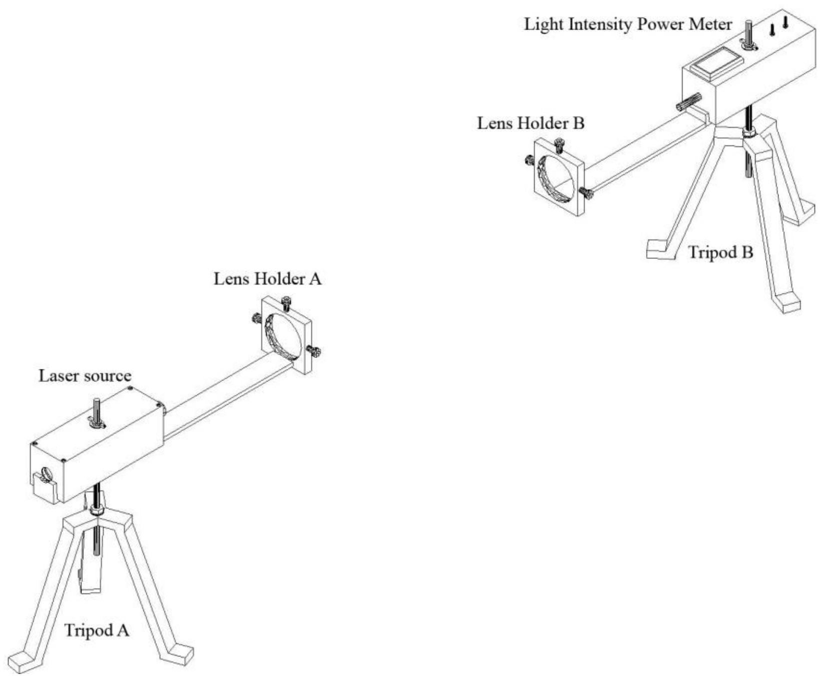

Figure 4.2: The second design of laser attenuation measurement system

Figures 4.1 and 4.2 show the schematic drawings of laser attenuation measurement system and both designs have all the required components as mentioned earlier. The first design uses two separable Aluminum U-channels as the platform while the second design uses two tripods. The platforms in the first design are placed on the floor or other flat surfaces and this condition has given it a much better stability compared to the second design which needs to support loads on the tripods. The unselected sketches are shown in Figures 4.3 and 4.4.

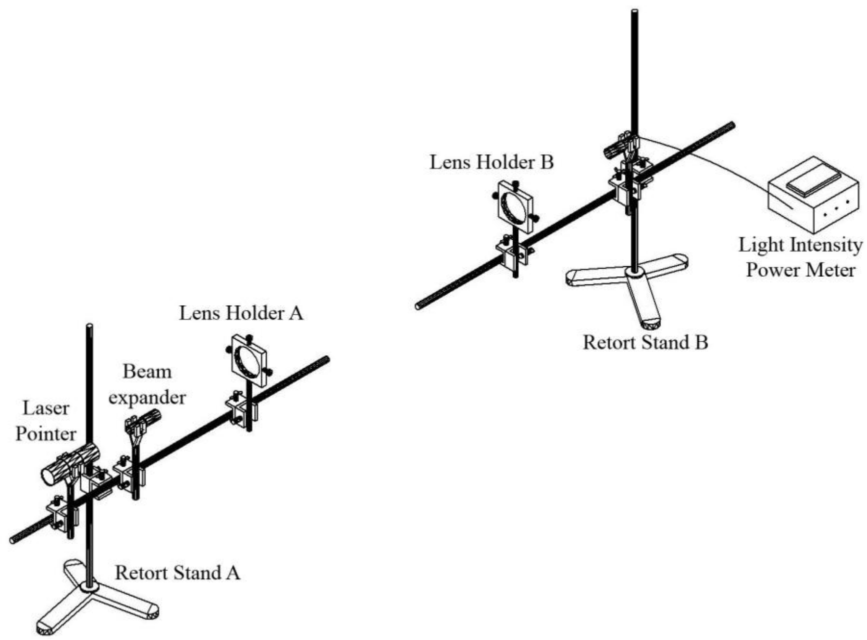

Figure 4.3: The first unselected sketch of laser attenuation measurement system

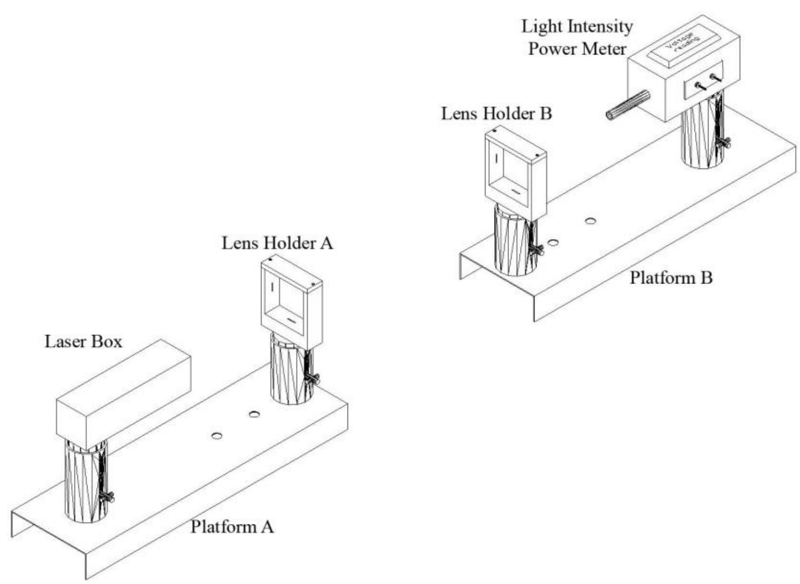

Figure 4.4: The second unselected sketch of laser attenuation measurement system

Table 4.1: The weighted score comparison between Design 1 and Design 2

Requirements	Weight	Score (out of 100)		Weighted score	
		Design 1	Design 2	Design 1	Design 2
Safe	0.25	75	70	18.8	17.5
Flexible	0.25	70	68	17.5	17.0
Stable	0.20	75	65	15.0	13.0
Movable	0.15	80	60	12.0	9.0
Light	0.15	85	70	12.8	10.5
Total	**1.00**			**76.1**	**67.0**

The weighted scores for the comparison between Design 1 and Design 2 which incorporating the main requirements such as safety, stability, flexibility, movability and lightness are shown in Table 4.1. From the table, the total weighted score of Design 1 is higher than the weighted score of Design 2 by 9.1 points. The score is given by analyzing how well each design meets the requirements. Therefore, Design 1 is chosen as the final design after making consideration based on the weighted score. Figures 4.5 and 4.6 below show the completed measurement system of Design 1.

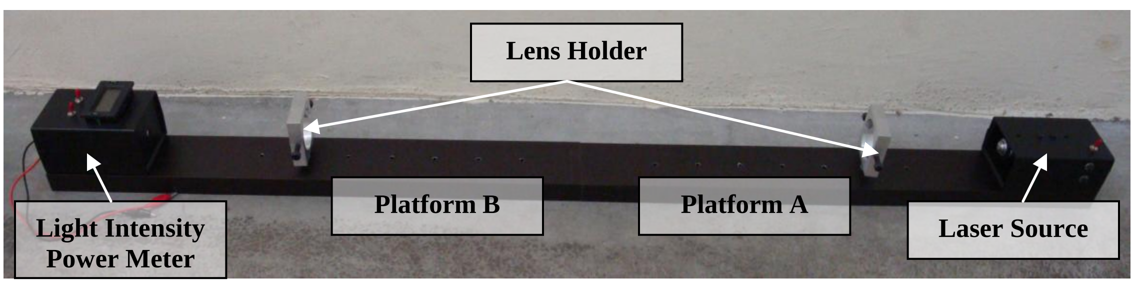

Figure 4.5: The completed laser attenuation measurement system

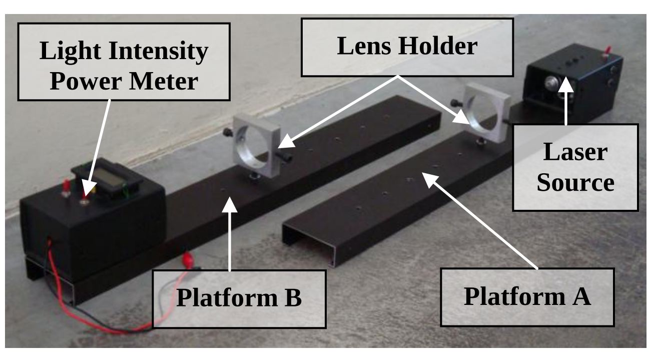

Figure 4.6: The detached measurement system

4.2 Laser Source

The class IIIa laser pointer and Aluminum connector are placed in a box (Figure 4.7). Figure 4.8 shows the external view of laser source and this laser source is fixed at a point on the platform because it is easier to adjust the laser beam. Beam expander is actually a microscope objective and used to expand the thin laser beam into a wider beam. The magnification factor of the beam expander is 40×. The Class IIIa laser pointer has the wavelength range within 635nm to 670nm, maximum output power of 3mW and operating voltage of 5V. The original push-button switch of laser pointer is replaced with the toggle switch because it is easier to operate. The beam expander and laser pointer are shown in Figures 4.9 and 4.10.

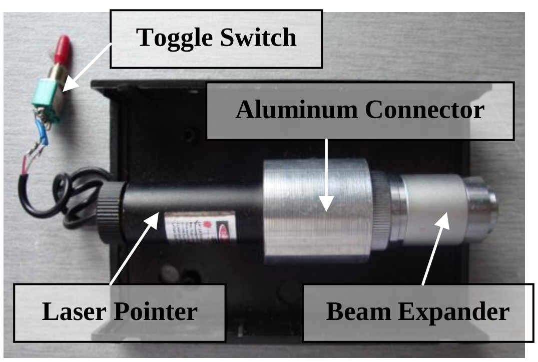

Figure 4.7: Internal view of laser box

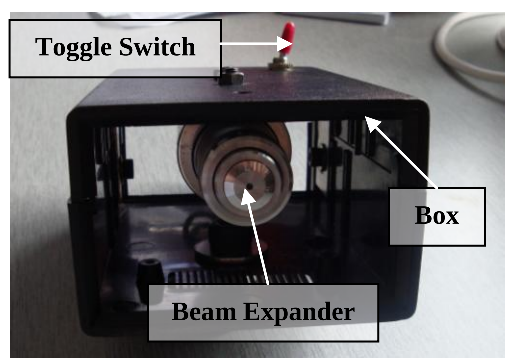

Figure 4.8: External view of laser box

Figure 4.9: Beam expander


Figure 4.10: Laser pointer

4.3 Light Intensity Power Meter

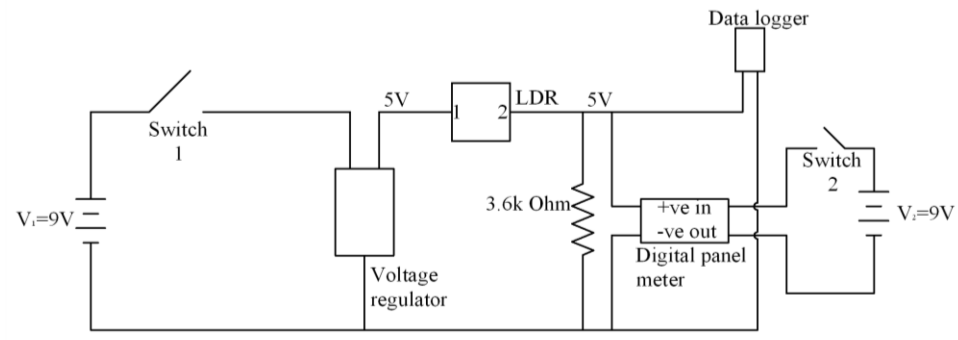

Figure 4.11: Circuit diagram of the light intensity power meter

The light intensity power meter is used to record the laser beam intensity and then it displays the reading in voltage. This power meter consists of a box, a light dependent resistor (LDR), a toggle switch, a voltage regulator, a digital panel meter and a resistor. Figure 4.11 shows the circuit diagram of power meter and it is constructed on a veroboard. The internal and external views of light intensity power meter are shown in Figures 4.12 and 4.13, respectively. When the LDR is blocked from receiving the laser beam, it records the maximum voltage which is 5V but the voltage is reduced when the laser beam hits the LDR.

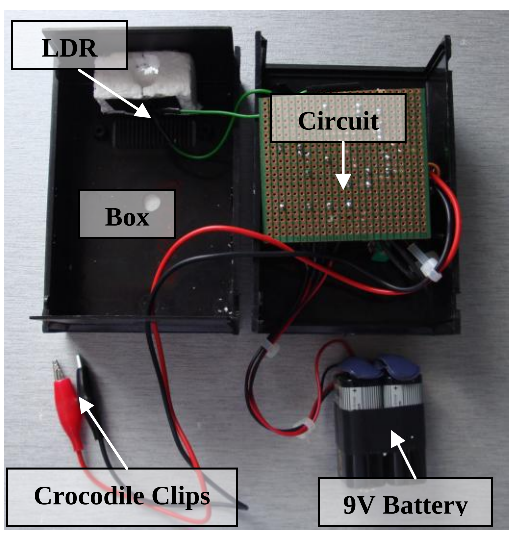

Figure 4.12: Internal view of power meter

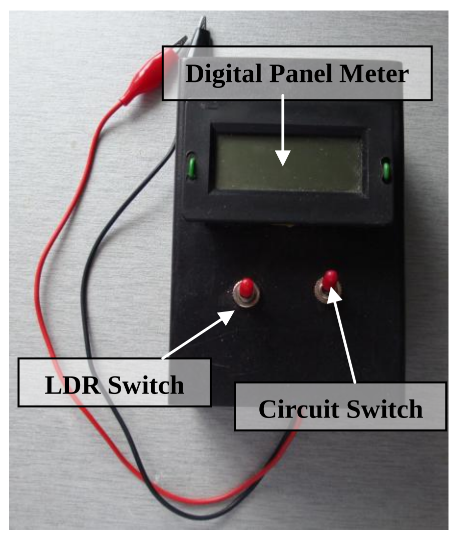

Figure 4.13: External view of power meter

4.4 Lens Holders

An Aluminum plate is milled by using Computer Numerical Control (CNC) into a square plate of 60mm×60mm with 15mm thickness. A through hole of 48mm±0.50mm diameter is made and then another 50mm±0.50mm hole with the depth of 10mm. Figures 4.14 and 4.15 show the milled plates with two different diameters and completed lens holder while Figure 4.16 shows the 5cm diameter plano-convex lenses with the focal length of 15cm.

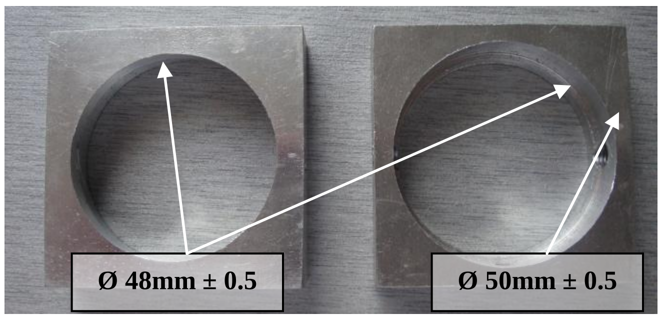

Figure 4.14: Diameter of the lens holders

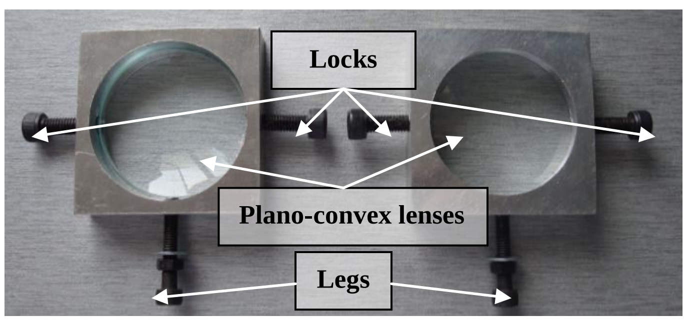

Figure 4.15: The completed lens holders with plano-convex lens


Figure 4.16: Plano-convex lenses

4.5 Platform

Two Aluminum U-channels are used as the platforms for the finalized measurement system to replace the plywood which has been used in the prototype. The dimension of each platform is 7.6cm×60.0cm×2.5cm. These two platforms are able to be attached and detached to fit the various conditions of testing and also for the flexibility.

4.6 Data Acquisition System

Data acquisition system is basically an electronic-based equipment which consists of hardware and software. It is used to record the data from the light intensity power meter and transfer them to the computer. The system that has been used in this project is ScienceWorkshop 750 Interface (Model CI-7599) from Pasco as shown in Figure 4.17. This system has three different fixed gains which are 1, 10 and 100 while the sampling rates are 250 kHz, 100 kHz, 50 kHz, 20 kHz, 10 kHz and <100 Hz. By referring to the manual, it is recommended to use the setting of gain of 1 and sampling rate of 10 Hz.

ScienceWorkshop 750 is connected to the computer by using a Universal Serial Bus (USB) cable and a voltage-sensor cable is used to connect the light intensity power meter to the analog channel. Figures 4.18 and 4.19 show the cables used in the data acquisition system. DataStudio software is needed to be installed in the computer first before the data can be transferred in.

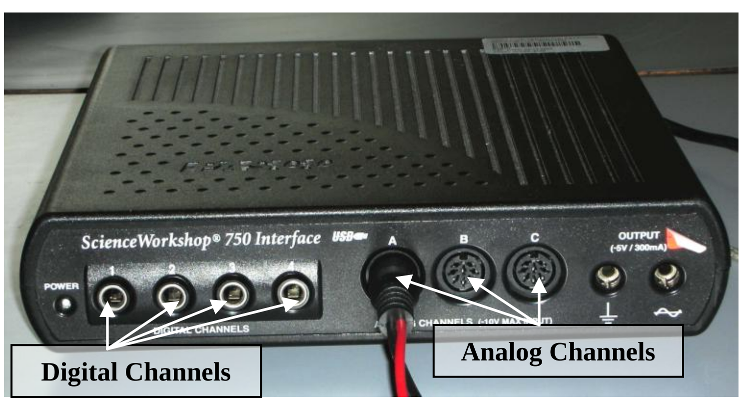

Figure 4.17: ScienceWorkshop 750 Interface from Pasco

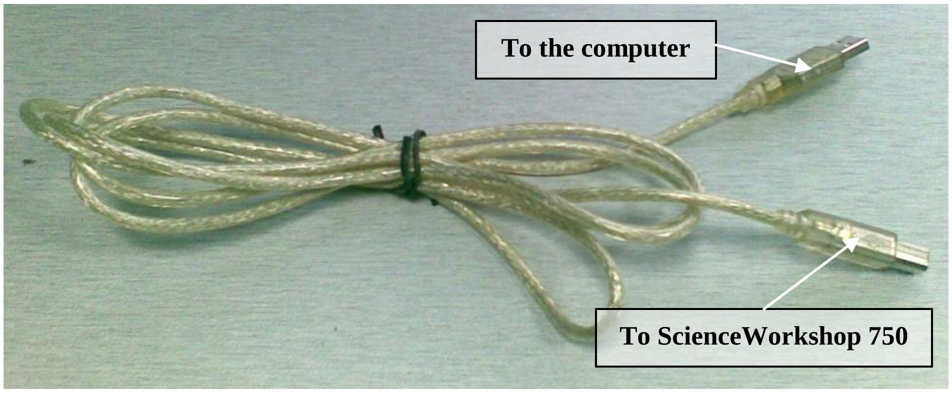

Figure 4.18: USB cable

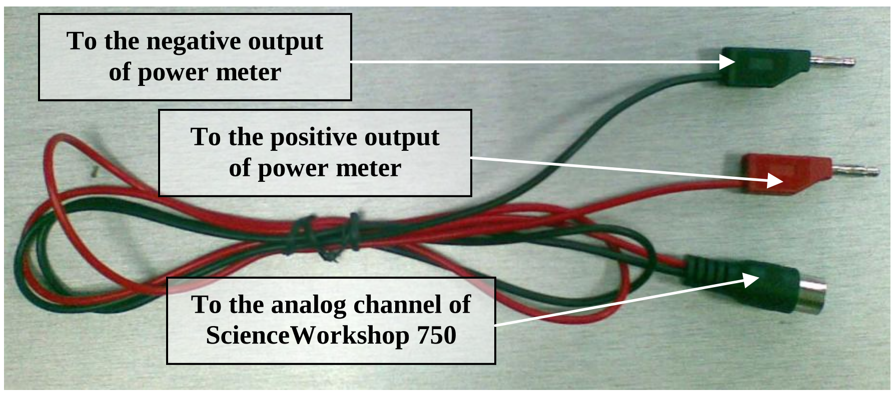

Figure 4.19: Voltage-sensor cable

4.7 Costing

Costing plays an important role for either big or small projects. It shows how much money has been spent on completing the projects and it must be controlled so that the money will not be spent on the unnecessary things. A fixed budget of RM500 is allocated for each of Final Year Project in UTP and the purchasing of items ought to be monitored and controlled to keep the cost within the budget. Table 4.2 in the next page shows the cost breakdown for the laser attenuation measurement system. The total investment for this project is RM453.70.

Table 4.2: Cost breakdown for the laser attenuation measurement system.

Component	Specification	Cost (RM)	Remark
Laser pointer	▪ Class IIIa ▪ Power output: <5mW ▪ Battery operated 5V	40.00	
Aluminum connector	▪ Material: Aluminum	0.00	Acquired from Manufacturing Workshop.
Plastic boxes		11.50	For the laser source and light intensity power meter.
Beam expander	▪ 10× ▪ 40×	160.00	2 microscope objectives.
Lens holder	▪ Material: Aluminum	0.00	Acquired from Manufacturing Workshop.
Plano-convex lens	▪ Material: Glass ▪ Focal length: 10cm and 15cm ▪ Round and square shapes	96.00	Three pairs of lenses.
Power meter circuit		50.00	Consists of LDR, resistor, digital display, veroboard, battery clips, 9V batteries, single-core wires and soldering device.
Platform	▪ Plywood ▪ Aluminum U-channel	34.30	For the prototype and finalized system.
Miscellaneous	▪ Foot pump ▪ 1”×1”×8’ Wood stick ▪ Sand papers	61.90	
Total		**453.70**	