Rigging ICARUS

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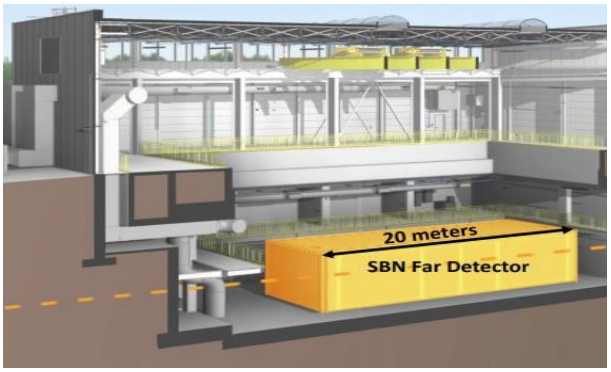
Abstract

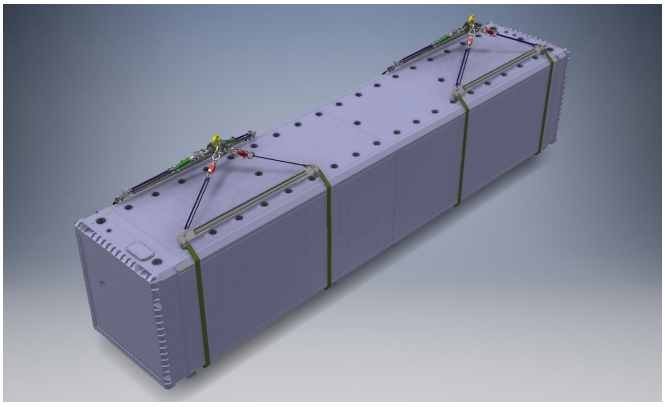
In the Neutrino Division , our mission for our research is to understand the role that neutrinos play in our universe . Before we can answer this question , we need to understand how neutrinos interact with our universes . The experiments at Fermilab contribute greatly to this cause including NOva , MicroBooNE , MINERva , and LArIAT. Scientist are still trying to find the “sterile neutrino” and with the help of ICARUS and the other detectors at Fermilab could give us the key to finding the 4th type of neutrino. My contribution to this project is to create a rigging cart that will be able to mobilize and store the crane equipment to help Fermilab with its biggest challenge of moving ICARUS into its new home in the SBN-FD building.

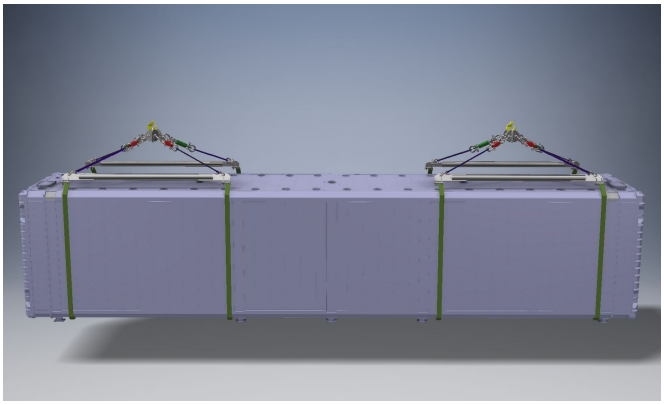
Introduction

This project is an important part of the lab because with the inclusion of ICARUS and the other two neutrino detectors already on site including MicroBooNe and Short Baseline Detector will help guide us to gain evidence of the 4th type of neutrino that is yet to be discovered. We have so far uncovered the muon , electron , and the tau neutrino but now hope to discover the “sterile” neutrino. Sterile neutrinos are a hypothetical particle that is said to only interact with gravity itself and no other interaction of the standard model. As the data stands today , the MiniBooNe experiment detected a stronger neutrino oscillation than is currently on record which hints that there may be a possible sterile neutrino. ICARUS’s operation is so important to the field because it is currently the world’s largest liquid-argon neutrino detector and could be the key to the sterile neutrino. The biggest challenge is to move this approximately 130 ton detector from the outside into its new home inside of the SBN-FD building.



The difficulty for this task is that the detector is broken up into two 66 ton pieces which is right at capacity of the cranes located inside the building. In order to ensure the safe landing of the detector, the team has drawn up schematics for the equipment that will be placed on the detector for its safe delivery.





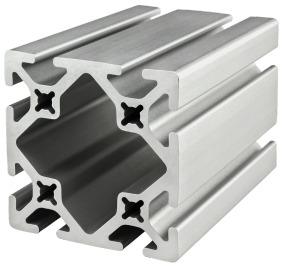
Strain gauges will be placed on both ends of the detector to detect the amount of tilt on either end of the detector to make adjustments to the side with the most tilt. Strain gauges measure the amount of deformation divided by unit length and the higher ratio of strain means that there is more tilt , and we want to avoid going over the maximum tilt angle which would cause the one side to snap. There will also be cameras placed in the box to ensure the proper

placement of the feet of the detector. My part of the project is to create an A-frame cart that is mobile to carry the crane equipment to and from different locations of the neutrino division as well as be used for storage purposes. The equipment can range from harnesses and hard harts to hooks for the crane which can be very heavy so this cart will be very useful for current and future projects to be able to access equipment at ease.

Design Process

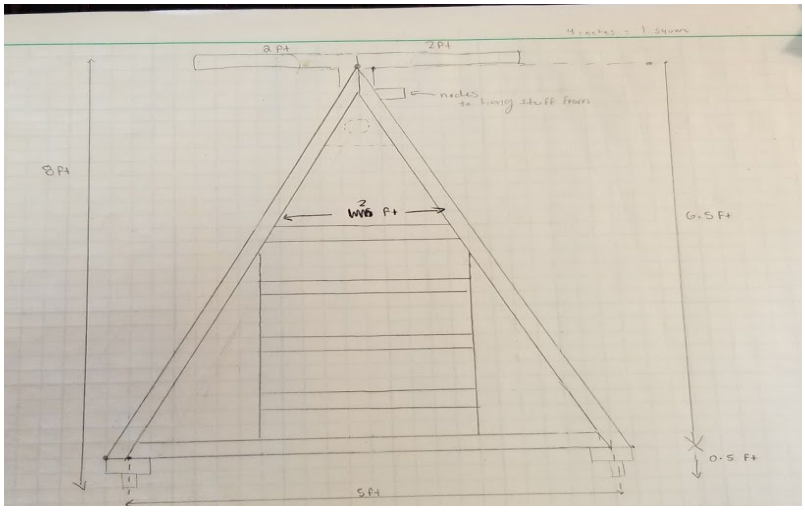
My rigging cart must be an A-frame structure to provide stability , and it would allow for more open space to place heavier items on the floor of the cart that are accessible from the side. I was asked to design this cart keeping in mind of the following design requirements and constraints:

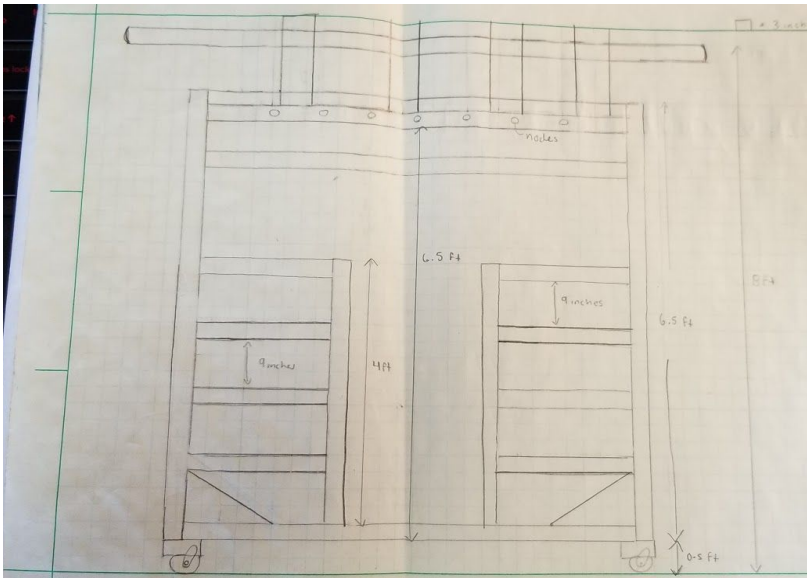
- Must hold a minimum of a 1000 pounds
- It must be at least 8 ft tall
- Maximum width of 5 ft
- It must contain two shelving units to organize equipment on
- It must be on wheels to mobilize it
- Must use 80-20 to construct the frame with a 3030-S profile (picture shown to the right)
- Minimum safety factor of 3



The reasoning behind using 80-20 are the slots that are extruded across the whole bar make this type of material very adjustable and can change easily be taken apart to use for something else. It is also very lightweight but durable enough to handle heavy loads. This material is easy to assemble without having to take out a screw gun including the cheaper cost in comparison to using steel.

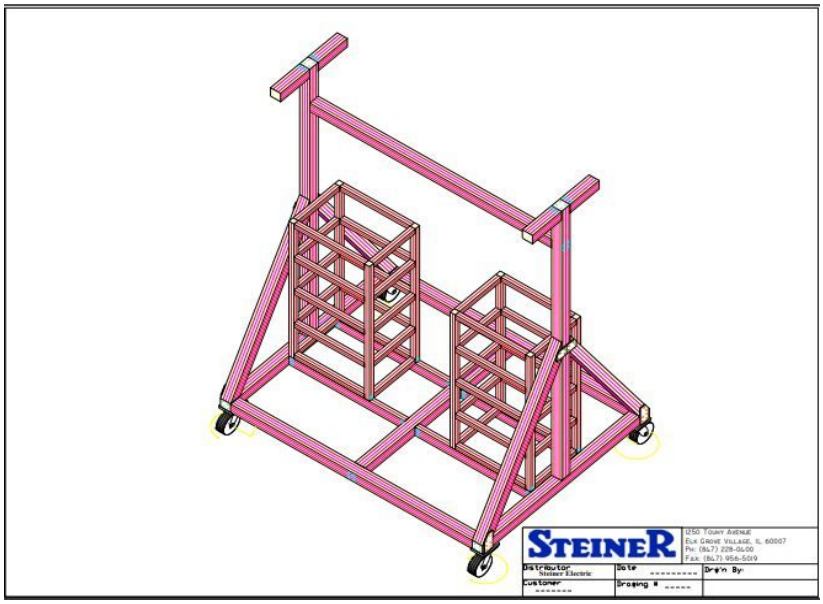
Initial Design



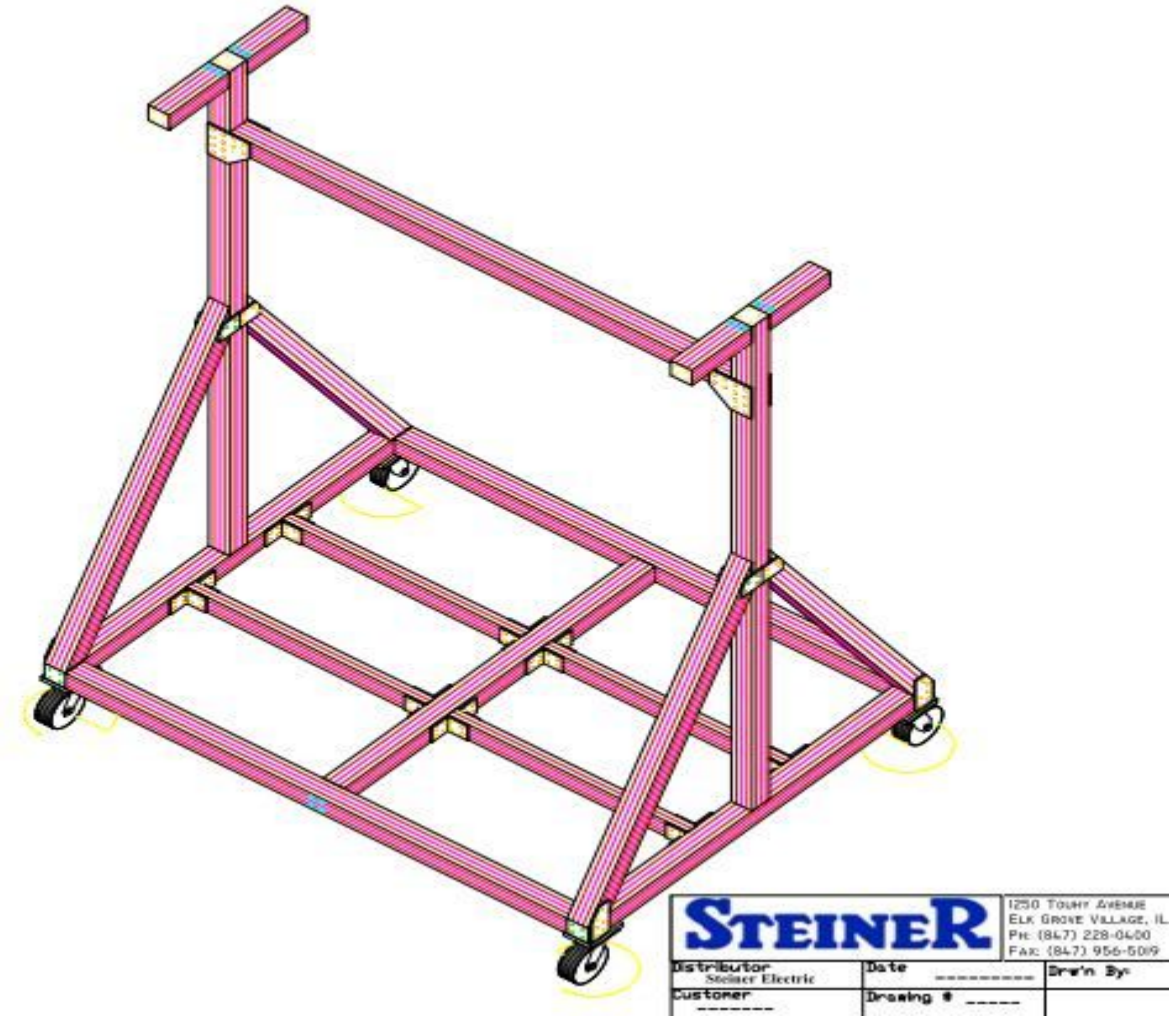


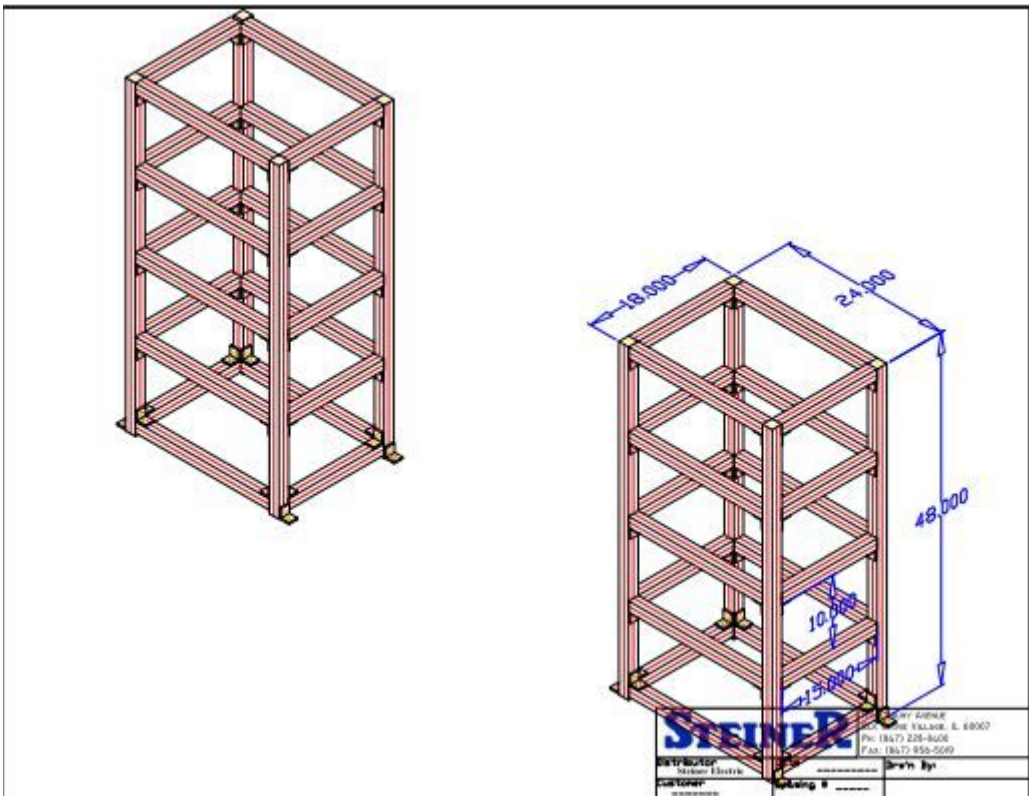
My initial design had a extender bar that would stretch across the whole cart to hang 16 ft rigging straps over the top , so they do not drag while the cart is motion . The bar can also be used to hang anything from full body harnesses for the workers to hard hats and other equipment that can be hung. I added two shelving units in the cart for organizational reasons and easy accessibility. The small circles that are right below the extender are nodules that would be welded on to hang pieces of equipment from which can include crane hooks.

After collaborating with Steiner Electric which is a local distributor of 80-20 , I realized that the angles of the triangle that I had drawn out would not be appropriate for the job. I had a 70 degree angle , and the maximum angle that the company would be able to cut the bars to is 60 degrees. After doing some calculations , I decided to decrease the height of the angled supports in order to decrease the angle to a 30-60 triangle as shown below. My design will be using I also removed the nodules because it became clear that the pieces would not be able to be welded on and the weight capacity of anything I could have connected to the slots would have not supported the weight without it having a big cost . The extender bar was replaced with 4 bars that protrude out from the top that will be connected together using a steel pole and holder that will be attached in the slots . This will be easier for assembly and manufacturing purposes.



After showing my supervisor , the finished product. She wanted me to optimize the adjustability of the cart meaning that I would change the way that pieces were connected so that they could be more adjustable. Instead of drilling holes into the bars as originally planned, we would use slotted L-brackets and plating to connect the pieces together. This not only allows for movement of the bars but also saves money on the labor fees to drill the holes. My final and complete design is shown below. The flooring will be made of steel grid paneling and the shelving for the units will be made of thick aluminum pieces.

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5 ft

My design can hold a total of 3500 pounds which is a safety factor of 3.5 which is above the required safety factor. The total weight of the material used to make the cart itself is 500 pounds since 80-20 is so lightweight. The load capacity of the shelving is 120 lbs so assuming that all 8 shelves are at capacity with a total of 960 pounds it means that 2540 lbs can still be placed on the rest of the cart. The quotes for the rigging cart will be displayed below with the shelving units separated from the framing quote. The total cost of the cart will be a total of approximately 3852 dollars.

Shelving

Contact #1:
Email:
Contact #2:
Email:
Company Email:

Contact #1:
Email:
Contact #2:
Email:
Company Email:

Notes: Bill Of Materials creates 1 kits.
Please tag all extrusions and panels

Fermilab253HD_rev1_Shelves

Tag	Part #	Qty	Length Each (or area)	Units	Total Wgt (lbs)	Description Note:all extrusion dimensions start at the left end	Each $	Price $
A	1515-LS	8	48.000	IN	33.70	1.5" X 1.5" LITE SMOOTH T-SLOTTED EXTRUSION	21.60	172.80
B	1515-LS	20	21.000	IN	36.86	1.5" X 1.5" LITE SMOOTH T-SLOTTED EXTRUSION	9.45	189.00
C	1515-LS	20	15.000	IN	26.33	1.5" X 1.5" LITE SMOOTH T-SLOTTED EXTRUSION	6.75	135.00
	7010	48		EA		Cut to Length 1.5" x 1.5" T-Slot and Tube	1.95	93.60
D	4302	88		EA	7.48	15 S 2 HOLE INSIDE CORNER BRACKET	2.95	259.60
	3320	176		EA	7.04	5/16-18 X 11/16" FBHSCS & ECON T-NUT	0.60	105.60
E	UP-7413	1		EA		Tag all Panels and Extrusions, manufactured by 8020	0.00	0.00

Total weight for 1 kits: 111.40

Total amount for 1 kits: 955.60

Drawing Filename: \\stnrelknsn1\users-groups\GroupRoot\8020\Fermilab\Fermilab253HD_Angled Cart\Fermilab253HD_rev1_Shelves.dwg
AutoQuoterX II Version-D19: 2.10.27.12

Rigging Cart

Fermilab253HD_rev1_Angled Cart

Tag	Part #	Qty	Length Each (or area)	Units	Total Wgt (lbs)	Description Note:all extrusion dimensions start at the left end	Each $	Price $
A	1530-S	4	34.500	IN	28.28	1.5" X 3" T-SLOTTED EXTRUSION SMOOTH	32.09	128.36
B	3030-S	2	96.000	IN	63.20	7055 Left	144.00	288.00
D	3030-S	2	72.000	IN	47.40	7055 Left; 7055 Right; 7257 in M @ 35.250; 7257 in N @ 35.250; 7257 in M @ 36.750; 7257 in N @ 36.750	108.00	216.00
C	3030-S	1	72.000	IN	23.70	3" X 3" T-SLOTTED EXTRUSION SMOOTH	108.00	108.00
E	3030-S	2	60.000	IN	39.50	7050 style B in X Left; 7050 style B in W Left; 7050 style B in X Right; 7050 style B in W Right; 7257 in Q @ 29.250; 7257 in R @ 29.250; 7257 in Q @ 30.750; 7257 in R @ 30.750	90.00	180.00
F	3030-S	4	57.000	IN	75.05	7085 -30 degree X Miter Left; **PER DRAWING**; 7085 60 degree X Miter Right; **PER DRAWING**	85.50	342.00
G	3030-S	1	54.000	IN	17.77	7055 Left; 7055 Right	81.00	81.00
H	3030-S	4	10.500	IN	13.82	7040 in N Left; 7040 in M Left; 7040 in Q Left; 7040 in R Left	15.75	63.00
	7020	4		EA		Cut to Length 1.5" x 3" T-Slot and Tube	2.45	9.80
	7030	16		EA		Cut to Length 3" x 3" T-Slot and Tube	2.60	41.60
	7040	16		EA		Anchor Fastener Counterbore for 15S	2.60	41.60
	7050	16		EA		Access hole for 15S	1.95	31.20
	7055	8		EA		5/16-18 Tap For 3" x 3" Extrusions	7.65	61.20
	7085	8		EA		Miter Cut 3" x 3" extrusion per drawing	4.10	32.80
	7257	16		EA		Drill Thru & Counterbore for 15S	2.95	47.20
I	2147	4		EA	5.84	HEAVY DUTY FLANGE MOUNT CASTER PLATE	29.15	116.60
J	2712	4		EA	22.78	6" HEAVY DUTY FLANGE MOUNT SWIVEL CASTER	60.90	243.60
K	4304	16		EA	6.00	15 S 8 HOLE INSIDE CORNER BRACKET	6.55	104.80
L	4328	4		EA	2.92	15 S 12 HOLE 90 DEGREE JOINING PLATE	12.90	51.60

Tag	Part #	Qty	Length Each (or area)	Units	Total Wgt (lbs)	Description Note:all extrusion dimensions start at the left end	Each $	Price $
M	4331	8		EA	1.88	15 S 4 HOLE 30 DEGREE ANGLE JOINING PLATE	6.00	48.00
N	4362	4		EA	1.56	15 S 6 HOLE 60 DEGREE ANGLE JOINING PLATE	7.10	28.40
O	5500	4		EA	21.32	2" DIAMETER SINGLE SHAFT BLANK MOUNTING PLATE	67.50	270.00
	3098	8		EA	1.68	15 S 5/16-18 DOUBLE ANCHOR T- NUT SHORT ASSEMBLY	5.80	46.40
	3125	16		EA	0.59	3/8-16 X 3/4" SHCS	0.32	5.12
	3140	24		EA		5/16-18 X 3.25 SHCS	1.60	38.40
	3344	8		EA	0.72	15 S DOUBLE END FASTENER W 5/16-18 SCREW	2.90	23.20
	3355	116		EA	13.18	5/16-18 DOUBLE ECONOMY T-NUT & TWO 11/16" FBHSCS	1.50	174.00
	3360	16		EA	1.60	15 S ANCHOR FASTENER ASSEMBLY	3.15	50.40
	3458	16		EA	0.74	5/16-18 X 7/8" SHCS, ECON T-NUT	0.53	8.48
	3458	32		EA	1.47	5/16-18 X 7/8" SHCS, ECON T-NUT	0.53	16.96
P	UP-7413	1		EA		Tag all Panels and Extrusions, manufactured by 8020	0.00	0.00

Total weight for 1 kits: 391.00

Total amount for 1 kits: 2897.72

Conclusion

My future work will involve the full assembly of the rigging cart with the help with my fellow technicians that I have also collaborated with throughout the summer to come up with the design. I have realised how important it is for an engineer to work alongside their technicians who can tell if a design can realistically be built or be able to mention the flaws of the design that cannot be initially seen from the software used to make these designs. Also , a stress analysis will be done on the rigging cart to check for the weakest spots of the cart to avoid putting heavy objects that will fracture the cart . The analysis will show the proper weight distribution for the rigging cart and will lead to the duplication of the same cart to be placed in another building on the neutrino site. For further work , I suggest looking to other types of design structures or material use to lower down the price of the cart.