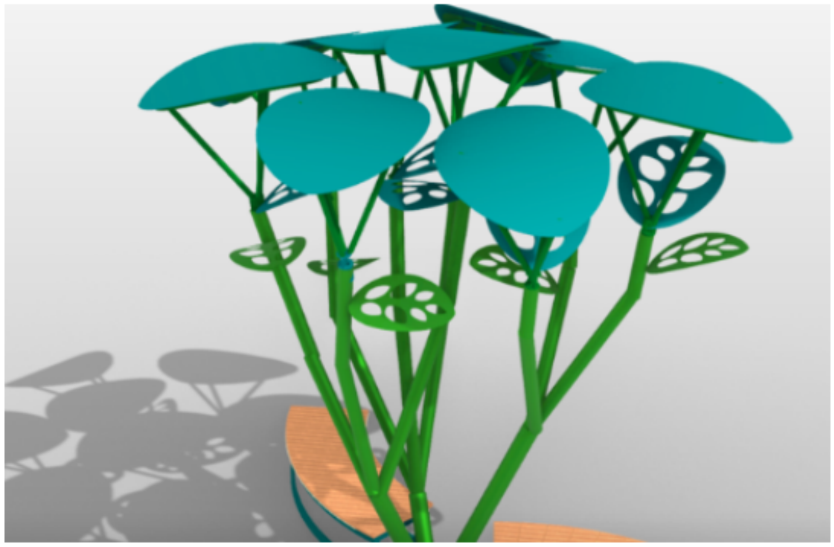
Solar Tree Project at the University of Connecticut



Diamond Builders Company

Executive Summary

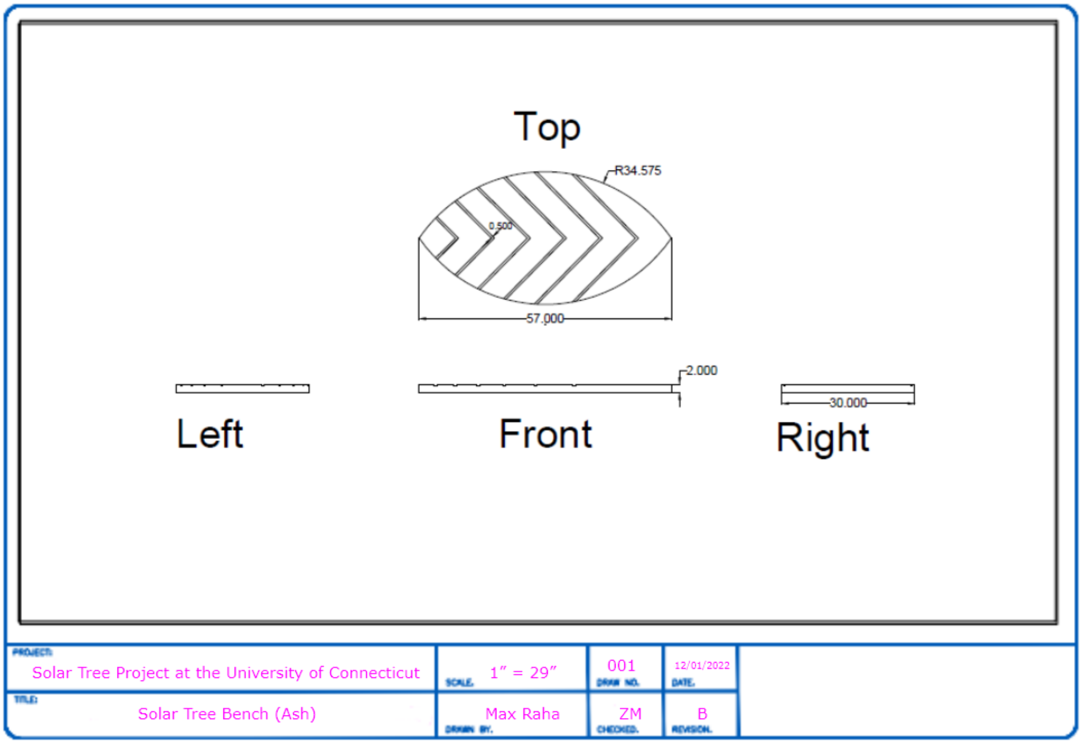
The purpose of this project was to look through the whole process of designing, planning, building, and finishishing the solar tree at University of Connecticut. To start off the project we had to design it. We utilized AutoCAD to complete these designs and created CAD drawings from different views to show exactly how our tree should look. We worked together on the basis of this design and our CAD specialist, Max, was able to create very accurate drawing documents. With the desired design in hand, we then had to come together to brainstorm the best locations to place the trees on campus. We wanted it to be in an open area where students could relax and this desire led us to our chosen locations. Before we got to the scheduling and planning of our project we needed to get our bid price. Our pricing specialist, Ahmed, worked hard to research different prices for the necessary materials of the solar tree and performed calculations to get an estimated price that was as precise as possible.

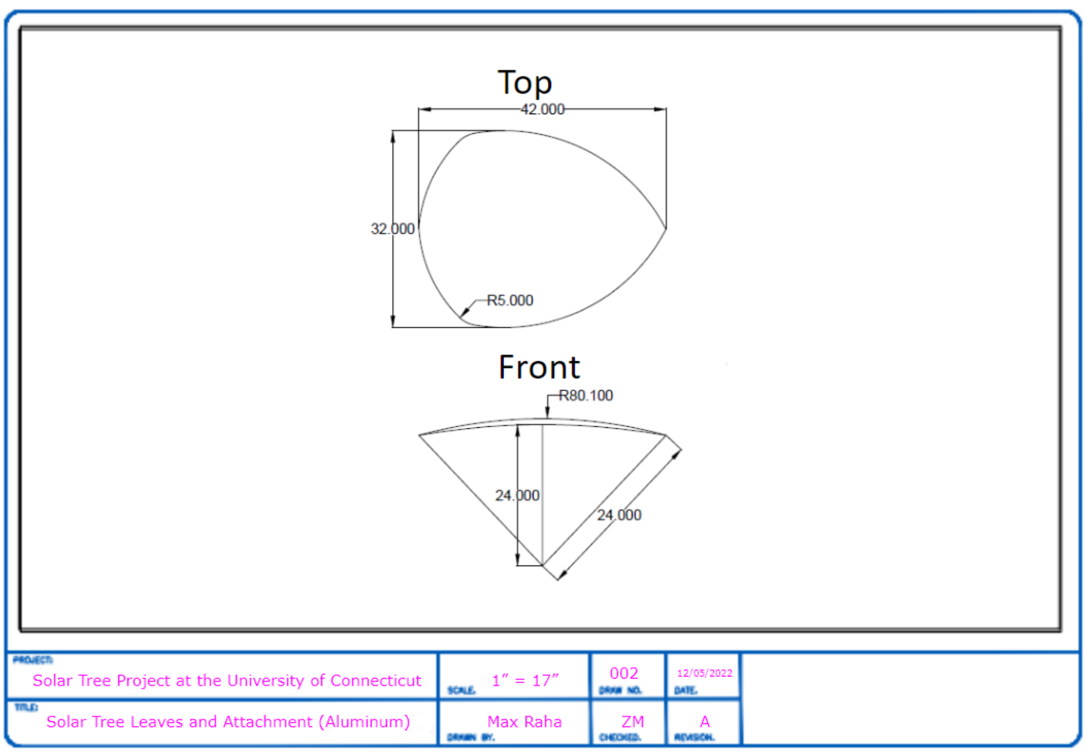
With the whole design, location, and bid price in hand, we were then able to start doing the construction planning. The construction planning and scheduling was done by our scheduler, Zach. He worked on creating a precedence table based on Work Breakdown Structures. This table showed all of the activities necessary to complete the solar tree project in a reasonable amount of time. From this we were able to create a Gantt Chart schedule on Microsoft Projects. This schedule gave an overview of the whole project and its deliverables. From the precedence table we were also able to create Activity on Node and Activity on Arrow diagrams to get the total project time. With all of this done, we would be able to proceed to the procurement and construction phases of the project.

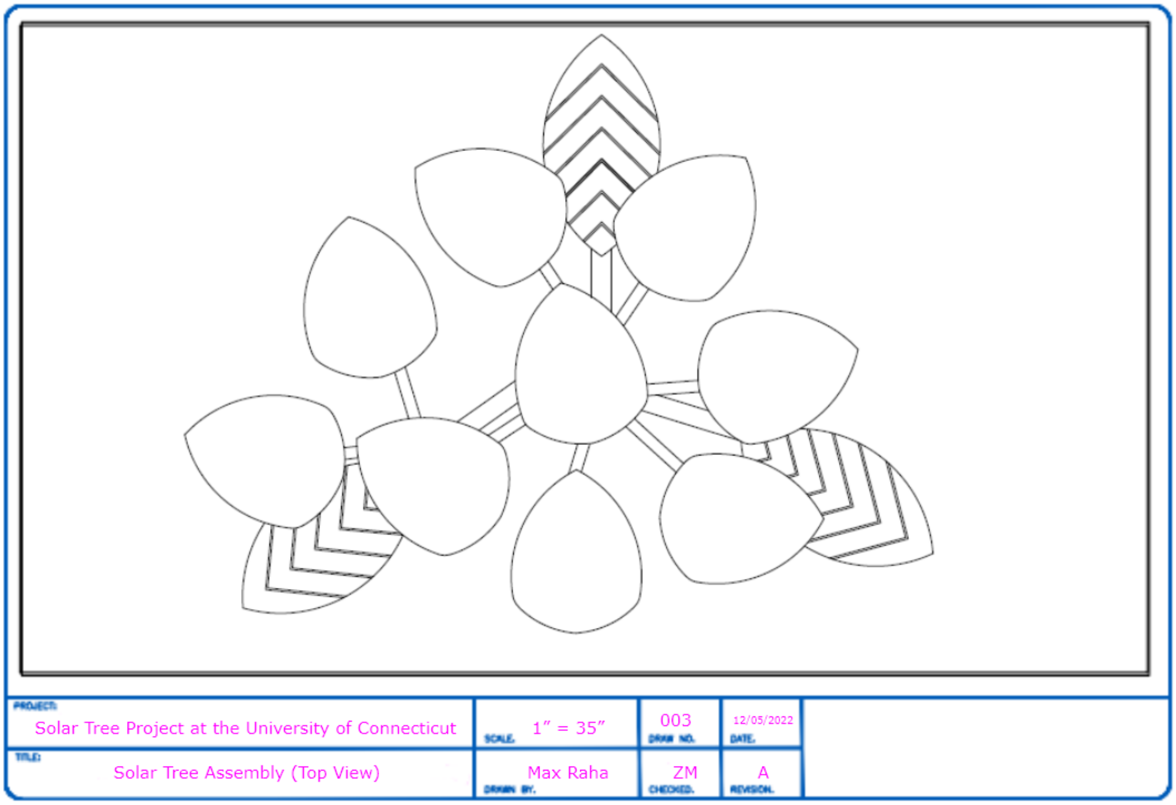
The final portions of this project that we achieved were safety and sustainability. These portions are just as important as all the previous, due to the fact that without these the project could not be considered successful. We went about learning about safety concerns and sustainability by using the Principles of Construction course lectures and further online research. This made our proposals about the two subjects significant to the project.

During this solar tree project we achieved our goal of working through and planning the whole construction process of the solar tree project. We made use of a lot of the skills we learned in class and felt that we made an efficient plan to make a very successful project.

Engineering Drawings



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Solar Tree Project at the University of Connecticut
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DRAW NO. 003
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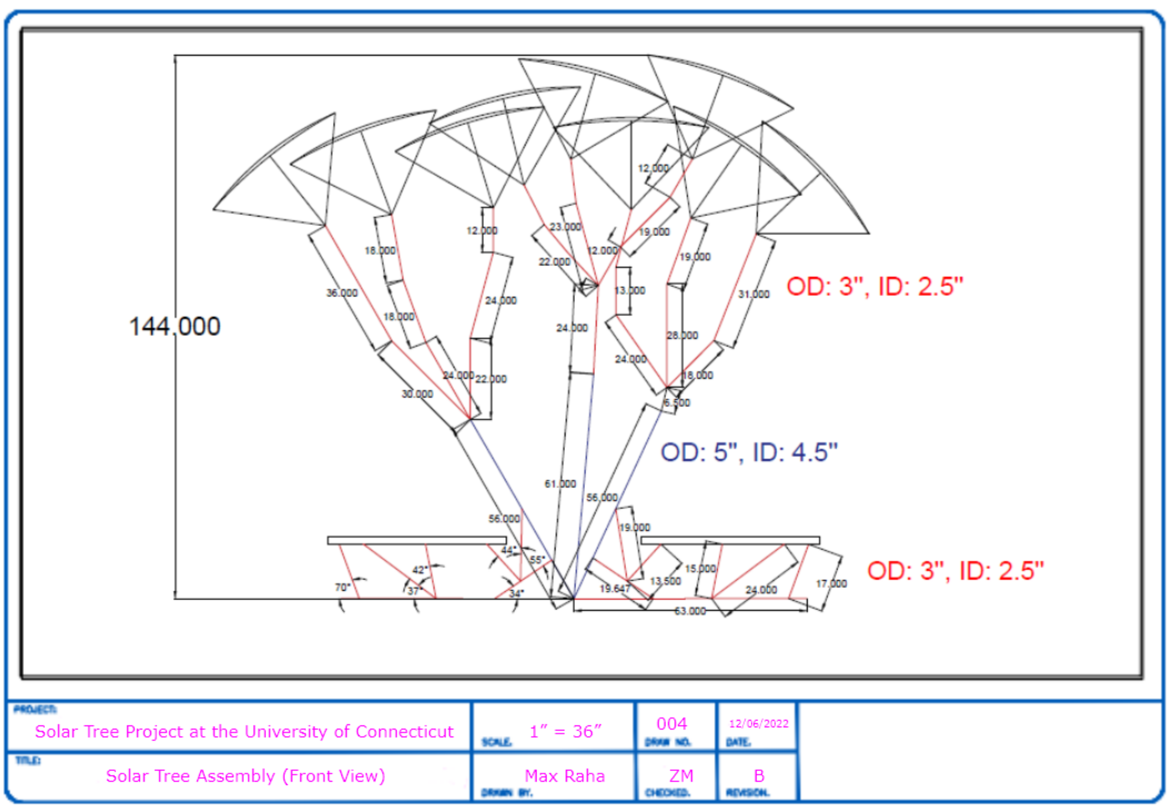
TITLE:
Solar Tree Assembly (Top View)
DRAWN BY: Max Raha
CHECKED: ZM
REVISION: A


144.000
OD: 3", ID: 2.5"
OD: 5", ID: 4.5"
OD: 3", ID: 2.5"
PROJECT:
Solar Tree Project at the University of Connecticut
SCALE: 1″ = 36″
DRAW NO. 004
DATE: 12/06/2022
TITLE:
Solar Tree Assembly (Front View)
DRAWN BY: Max Raha
CHECKED: ZM
REVISION: B

Site Selection

UConn is a very diverse campus with a variety of aesthetically pleasing locations ranging from Horsebarn Hill for its beautiful sunsets/sunrises, to behind the student union where you'll regularly see students playing spikeball if the weather is warm enough. Nevertheless, in regards to our interests the two most important factors for choosing a site to build upon are site popularity, and access to light.

A location I believe would serve well in regards to both is the UConn dairy bar! The UConn dairy bar doesn't only have floods of people going there whenever it's actually open, but also has a field area that meshes into the farms/agricultural center of UConn. With these two points in mind, I believe that it'd serve to be a huge improvement aesthetically, and it wouldn't restrict use of the land. People tend to be looking for more seating outside the dairy bar, and the solar tree could act as that! Shown below is the seating arrangement outside the dairy bar, specifically the open fields available to house the solar tree!

My second recommendation is the rock behind Monteith that cycles through different graffiti every now and then. My primary support for this point is that it would promote more gathering in this area, and further give students a chance to talk about whatever matter is being promoted on the rock. The solar tree could be the epicenter of social activity before and between classes on days where the weather permits. On top of that, there is a section of flat ground, as shown in the photo below, where no taller buildings or trees surround and take the brunt of the incoming sunlight.

<u>Construction Cost/Bid Price</u>

<u>Material cost of Aluminum 6061 T6:</u>

The first thing we did was calculate the volume of metal used

I.e Bottom section/Thicker pipes: $\pi(1.5^2*30-1.25^2*30)+\pi(1.5^2*16-1.25^2*16)+2*\pi(1.5^2*19-1.25^2*19)+2*\pi(1.5^2*17-1.25^2*17)+\pi(1.5^2*13.5-1.25^2*13.5)+\pi(1.5^2*24-1.25^2*24)+\pi(1.5^2*15.5-1.25^2*15.5) = 369.333\ in^3$

Repeat for remaining pipe sections, and convert from in^3 to cm^3 ($1\ in^3 = 16.3871\ cm^3$) then multiply by the density of aluminum 6061 T6 ($2.7 g/cm^3$) to find weight in grams, then convert to lbs (0.00220462 lb/g). The total weight including the metal leaves on top results in 1,383.224 lbs. After finding a real cost estimate from a work package which includes sales of aluminum 6061 T6, we were able to estimate the price per pound of our desired material.

A 1/2x48x96 aluminum 6061 plate costs $1,547.40. Converting from volume to weight as done previously:

$2304\ in^3 * 16.3871 cm^3/in^3 = 37755.8784 cm^3$. $37755.8784 cm^3 * 2.7 g/cm^3 = 101{,}940.8716$ g of alum per sheet.

101,940.8716g / 453.592g/lb = 224.7413lbs. 1,547.4 / 224.7413 = $6.88/lb of alum 6061 T6

$6.88/lb * 1383.2241lbs =$ 9,516.58 Cost for all framing

6061 T6 Screws:

Small screws: 8-32x ¼, comes in packs of 50 @ 12.14$ a pack. 120 Small screws required for fabrication, can't order half a pack, so 12.14 * 3 = $36.42

Large screws: ¼-20 x 1 ⅜, comes in pack of 10 @ $20.90 a pack. 78 Large screws required for fabrication, 8*20.90 = $167.20

Metal work/Welding costs:

The number of hours worked by each trade varies depending on the importance of the trade. To ensure there's minimal time wasted and that the workers of different trades don't conflict during their work hours, the hours won't overlap with more than 2 trades present at a time.

$95/hr. 13 days of work* 6 hrs/day = 78hrs* 95 =$7,410

Total aluminum 6061 T6 costs = $17,130.2

Material cost of electrical

Waterproof touch screen computer: $125

50 watt solar panels: $30 per panel, 9 required for project = $270

Installation cost of electrical

$93.13/hr. Estimated work hours towards electrical: 10 days* 6hr/day = 60hrs*93.13 = $5587.80

Total costs of electrical: $5,857.80

Material cost of wood

Assuming that we are ordering plywood sheets, and then forming them into the required shapes: the cost per wooden panel is 42.97 for a 4x8 ½ in thick oak plywood option, and we'll need one for each of the three leaf shaped benches. 3 * 42.97 = $128.91

Carpentry costs:

$56/hr. Estimated work hours towards carpentry/woodwork: 5 days* 4hr/day = 20hrs* 56 = $1120

Total costs of woodwork and materials: $1248.91

Sum total:

1248.91 + 5,857.80 + 17,130.2 = $**24,236.91**

Location/Time Factor influence

If this project were developed in New Haven it would be more expensive, as the location index is 119.7, or if it were built in Bristol the index would be 119.2, compared to 118.8 the location index in Willimantic (our closest reference point to Storrs). Furthermore, after doing the calculations, we find that it'd be $10321.52 in New Haven, and $10278.40 in Bristol; being a $77.60 upcharge or $34.49.

(119.7/118.8) * 24,236.91 = $**24,420.52** & (119.2/118.8) * 24,236.91 = $**24,318.52**

These location factors were from the RS means in 2021, not too far of a comparison to 2022, but time of development is also an interesting factor to take into account. If the historical cost index of 2022 is 261.6, using the cost indices during 1975 (17.5) as well as 199 9(48.6) we can find out the cost of development during that time period, in the locations we previously calculated for.

24,420.52* (17.5/261.6) = $**1,633.64** in 1975 & 24318.52 * (48.6/261.6) =$ **4,517.89** in 1999

Activity Duration and Precedence Table

To make the precedence table and figure out the activity durations we had to do some research. To get the activity order we spoke to Professor Sancomb, a University of Connecticut professor who worked on making a solar tree. This gave us a plan on how to start the project from the designing and planning stage and move onto the beginning of construction until the end. For the durations, we worked on making the time allotted to each activity as accurate as possible. To do this, we used our course notes and online sources. With all of this information and using the information of work breakdown structures in class we were able to make a full precedence table to be used for the project.

Precedence Table for Solar Tree Project

Code	Activity	Description	Time in Days	Predecessor(s)
A	Design	Creation of construction documents for the solar tree with accurate dimensions	8	-
B	Planning	Determine the proper location for the solar tree and speak to the University to confirm the location. Confirm a location for workshop before it is planted	10	-
C	Estimating	Making cost estimates for project and determining materials needed	5	A
D	Purchasing	Purchasing all materials needed and having them delivered	25	B,C
E	Metal Work	Cutting metal material to proper sizes. Making stems, trunks, and leaves out of aluminum	5	D
F	Woodworking	Wooden benches to be carved out to proper dimensions	5	D
G	Solar Panel	Attach Solar Panels to leaves prior to them getting elevated to the top of the tree	1	E
H	Welding	Weld all of the cut metal material together	8	E

I	Assembly	Assembling all finished material into one tree	20	F,G,H
J	Electrical	Wiring the solar Panels to the charging station and installing the touch system tablet screen	10	I
K	Decoration	Paint the final designed solar tree and add final touches	12	J
L	Transport and Place	Transport final designed solar tree to desired location and place for use	1	L

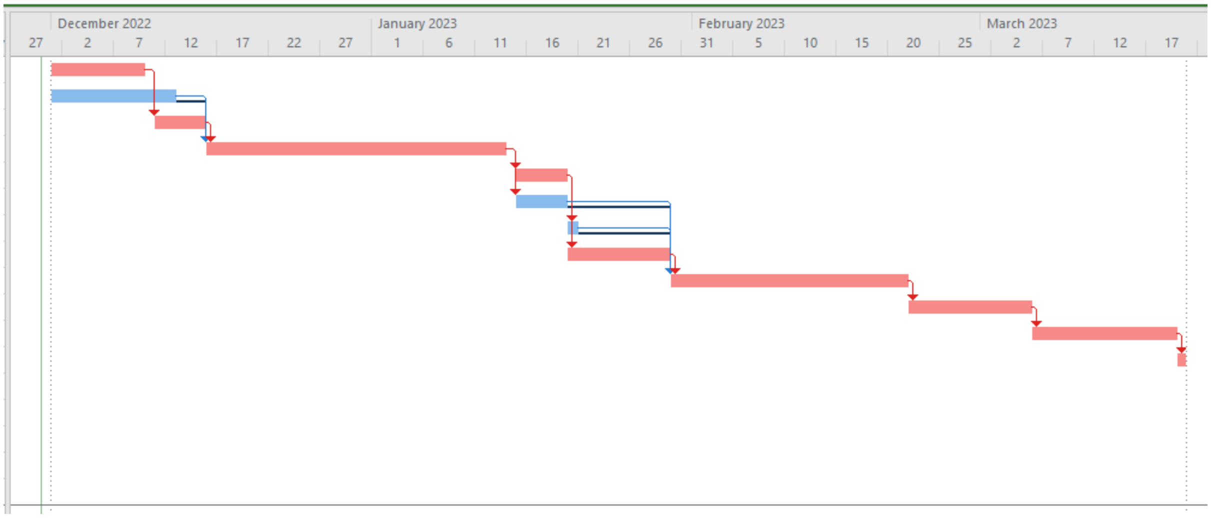
Bar Chart

We used the software Microsoft Projects to make our bar chart/Gantt chart. This Gantt chart schedule was based off of our constructed precedence table with the predecessors and durations. When we input all of the information, the software creates the bar chart schedule and highlights the critical tasks. The critical tasks are in yellow in the first image and in red on the actual chart. It also shows the slack time for the non-critical activities.

Information on Bar Chart:

	Task Mode	Task Name	Start	Finish	Late Start	Late Finish	Free Slack	Total Slack	A
1		A	Thu 12/1/22	Fri 12/9/22	Thu 12/1/22	Fri 12/9/22	0 days	0 days	
2		B	Thu 12/1/22	Mon 12/12/22	Mon 12/5/22	Thu 12/15/22	3 days	3 days	
3		C	Sun 12/11/22	Thu 12/15/22	Sun 12/11/22	Thu 12/15/22	0 days	0 days	
4		D	Fri 12/16/22	Fri 1/13/23	Fri 12/16/22	Fri 1/13/23	0 days	0 days	
5		E	Sun 1/15/23	Thu 1/19/23	Sun 1/15/23	Thu 1/19/23	0 days	0 days	
6		F	Sun 1/15/23	Thu 1/19/23	Tue 1/24/23	Sun 1/29/23	8 days	8 days	
7		G	Fri 1/20/23	Fri 1/20/23	Sun 1/29/23	Sun 1/29/23	7 days	7 days	
8		H	Fri 1/20/23	Sun 1/29/23	Fri 1/20/23	Sun 1/29/23	0 days	0 days	
9		I	Mon 1/30/23	Tue 2/21/23	Mon 1/30/23	Tue 2/21/23	0 days	0 days	
10		J	Wed 2/22/23	Sun 3/5/23	Wed 2/22/23	Sun 3/5/23	0 days	0 days	
11		K	Mon 3/6/23	Sun 3/19/23	Mon 3/6/23	Sun 3/19/23	0 days	0 days	
12		L	Mon 3/20/23	Mon 3/20/23	Mon 3/20/23	Mon 3/20/23	0 days	0 days	

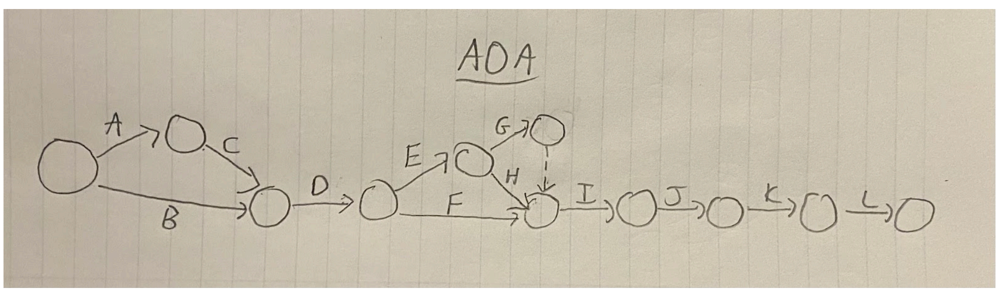
Bar Chart



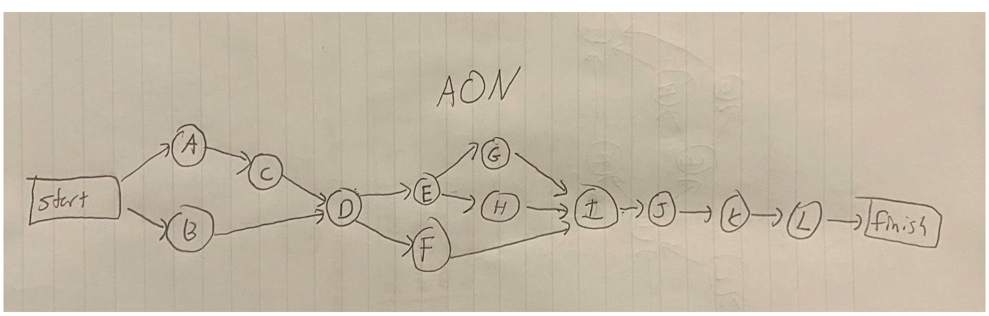
Project Completion Time

After creating our precedence table and bar chart, we are now able to make the network diagrams. The two types of network diagrams that we will make are Activity on Arrow (AOA) and Activity on Node (AON). Through these two diagrams we are able to find our critical path and determine the total duration of the project. Below are our two diagrams and then the calculations to find duration.

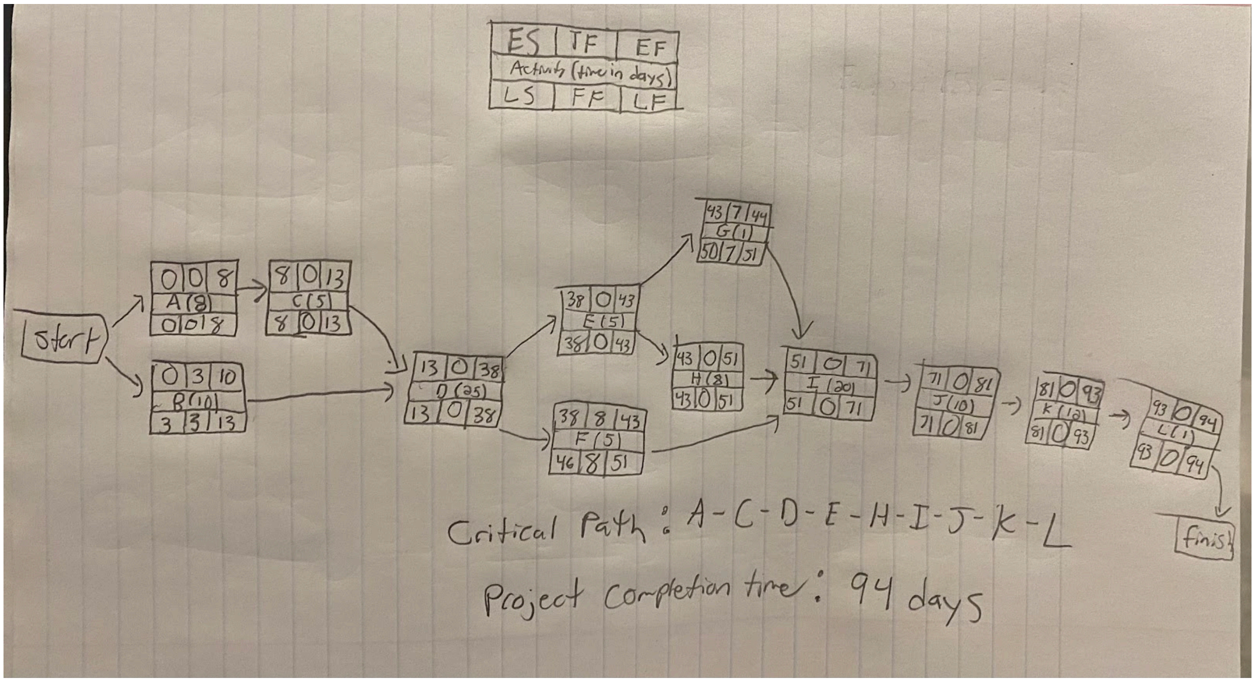
Activity on Arrow Diagram:



Activity on Node Diagram:



Calculation of Critical Path and Total Project Duration:



Here we were able to use the critical path method on the AON diagram to find the early start and finish, late start and finish, total float/slack time, and free float. All of the activities with a slack time of 0 are critical path activities. The critical path, as seen above is A-C-D-E-H-I-J-K-L. This critical path gives a total project completion time of 94 days.

Safety and Health Concerns

As with all projects, it is imperative to make sure to point out all of the safety and health concerns. While this is a small project compared to constructing a building or a bridge, it still has a lot of safety hazards that everybody has to be aware of. According to the Principles of Construction I lecture slides the four types of fatal construction accidents are falling, struck by something, caught “in-between” something, and struck by electricity. All four of these, known as the “fatal four” by OSHA, can happen on the solar tree project. Falling can occur during the assembly phase when connecting the leaves to the trees about 12 feet in the air. Struck by something and caught “in-between” something could occur during the assembly phase as well when attaching all of the aluminum together. Finally struck by electricity could happen when completing the wiring for the solar panels and tablet.

Not only is there the possibility for the “fatal four” accidents on this project, the safety precautions while welding needs to be looked at. According to research, it is important to make sure that the welder is properly installed and grounded, so that it does not move. Also, the person conducting the welding should make sure to protect their entire body with fire retardant clothing, shoes, gloves, and eye protection. Finally, welding needs to occur in a location that is completely firesafe so nothing spreads.

To prevent these types of accidents such as welding and the “fatal four”, it is necessary to hold meetings such as toolbox talks. By conducting safety meetings like this, the workers will be knowledgeable about all of the precautions they should be taking and this can hopefully reduce the risk of injury to a minimum.

Sustainability

This solar tree project will most definitely help in addressing some of the sustainability issues. One of the most valuable resources is energy and the whole entire purpose of the solar tree is to use the solar panels to conserve energy. Solar panels collect sunlight and convert it into energy which is a much more natural and efficient way of producing electricity. Using solar panels is definitely under the title of “building green” and that is the direction that all construction projects should be moving.

According to the UConn STEAM Tree website online, they go into detail on how this project fits well with sustainable systems enabling food security in extreme environments. While this project is only a nice place for students to sit down and charge up their electronic devices, it really shows the capabilities of solar panels and how it can use sustainable energy to solve many problems. This energy from solar panels can be strong enough to grow food in harsh climates and so much more. The solar tree project is a step in the right direction to a future with much more sustainable construction.

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