Open-Source 3D Printed Foot Prosthesis

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Team 18F04
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Project Description

- **Team goal:**
- Our team goal is to create and design an 3D printed foot prosthesis leg for below-knee amputees that easy to install and remove, inexpensive, and reachable.

- **Stakeholder:**
- E-nable Company.

- **Sponsor**
- Northern Arizona University.

Figure 1: Below-knee amputee

Figure 2: NAU

CAD Model of Design

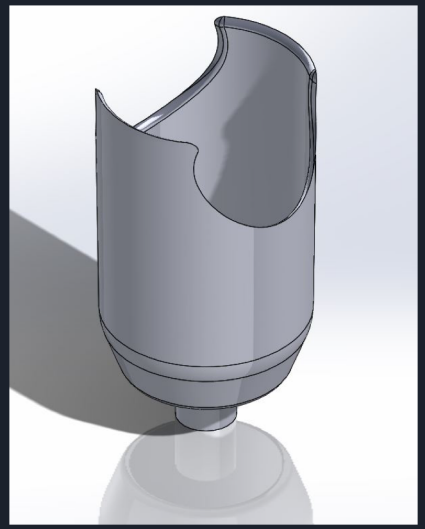


Figure 3: Supporting channel in CAD

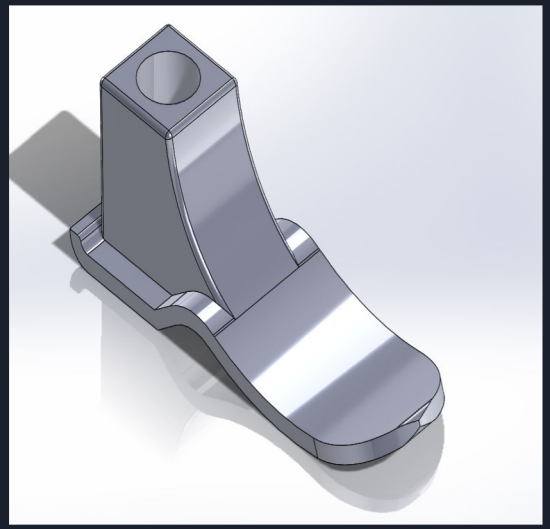


Figure 4: Foot in CAD

Salman Malallah

How does the design work?

Figure 5: Liner

Figure 6: 3D printed supporting channel

Figure 7: Aluminum pipes

Figure 8: 3D printed foot

Figure 9: Air valve

Figure 10: PVC pipes

Abdulwahab Zaidan

Bill of Materials

Table 1: BOM

Part #	Name #	Quantity	Description#	Material#	Dimension#	Cost#	Link to the cost estimate#
1	Foot	1	3D printed foot	PLA	8.29*3.00*3.00 in	30 $	Maker lab
2	Socket	1	Supporting channel	PLA	7.00*4.5*10.00 in	95$	Maker lab
3	sealing wrap	1	Wrap to hold the clamps			18.88	NAPA auto parts
4	Aluminum pipe #1	1	Aluminum pipe attached to the foot	aluminum	6*1-1/4 in	26.38	NAPA auto parts
5	Aluminum pipe #2	1	Aluminum pipe attached to the socket	aluminum	6*1 in	18.82	NAPA auto parts
6	PVC #1	1	PVC pipe attached to the socket	PVC	6*1 in	1.62 $	Home Depot
7	PVC #2	1	PVC pipe attached to the foot	PVC	6*1-1/4 in	1.17	Home Depot
8	Liner	1	Helping the socket to hold the below knee		Depends on the person	150-350 $	amputeestore.com
9	Air valve	1	Remove any intruder air while putting the liner inside the socket	Plastic		10$	Amazon.com

Ali Abdullah

Customer Requirements

Table 2: CRs

Old	New
Below knee	Below knee
Hold up to 200 lb. adult male	Hold up to 215 lb.
Must be printed from 3D printer	At least one part 3D printed
Weights 7 lb. at most	Weights 8 lb. at most
Limited filament materials	Worldwide filament material
Fits different height sizes	Fit different height sizes
Comfortable	Comfortable
Safety	Safety

Changes to design

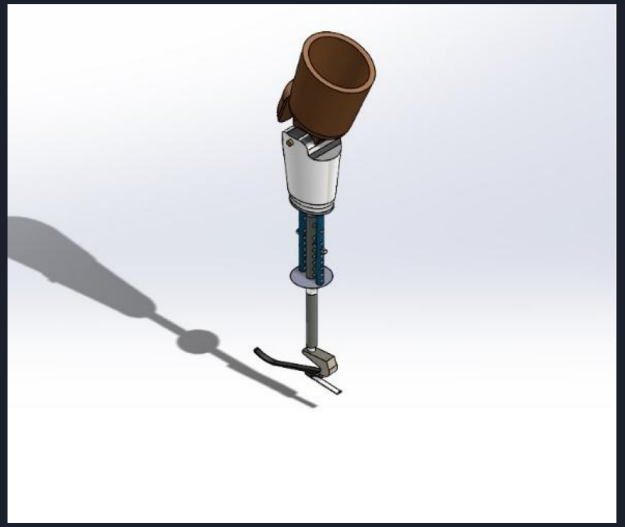


Figure 11: Old CAD design

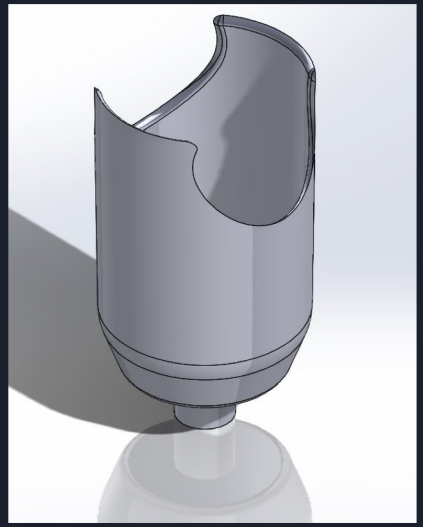


Figure 12: Supporting channel in CAD

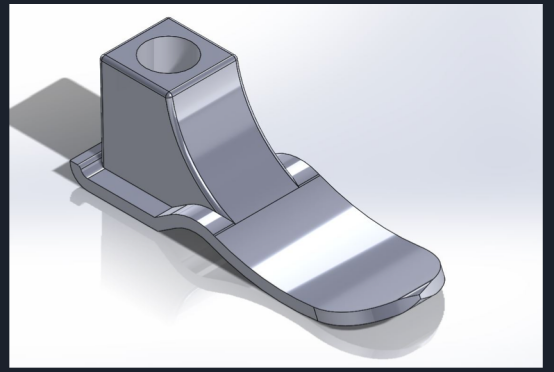


Figure 13: Foot in CAD

Ali Abdullah

Visual evidence of differences in prototype

Figure 14: Old prototype

Figure 15: Foot shell

Figure 16: PVC pipes

Figure 17: Aluminum pipes

Figure 18: 3D printed supporting channel

Figure 19: 3D printed foot

Ali Abdullah

Analytical Analyses

Three new changes analysis:

a. Aluminum pipes
b. Foot
c. Supporting channel

Figure 20: Supporting channel in CAD

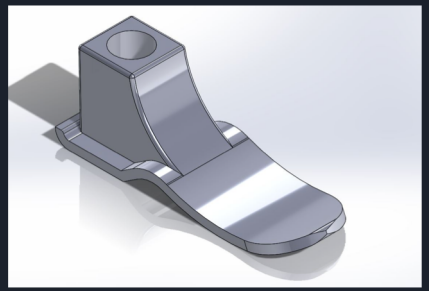


Figure 21: Foot in CAD

Figure 22: Aluminum pipes

Aluminum Analysis

1. Comparing between PVC pipes and Aluminum pipes
2. Using the Factor of safety:
    - Aluminum FS=23.8
    - PVC FS= 4.1
3. Aluminum is the one to choose :
    - Lighter weight
    - Higher Factor of safety
    - More accurate adjusting the height

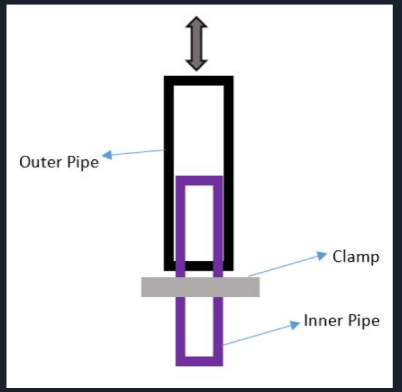


Figure 23: Force applied in the aluminum pipes

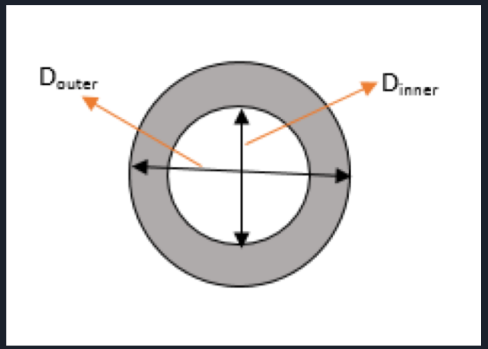


Figure 24: Inner and outer diameter of Aluminum pipes

Foot Analysis

- The Forces applied on the foot.
- Using Tensile Stress equation
- Maximum weight applied is = 5685.479 lbs
- Can withstand the Customer requirements which is 200-215 lbs

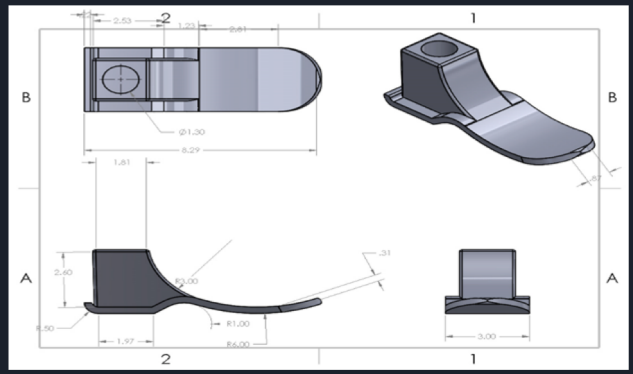


Figure 25: Foot drawing in CAD

Supporting Channel Analysis

- Difference between using ABS and PLA material to withstand the maximum forces.
- PLA = 5946 lb
- ABS = 4334.5 lb
- PLA is better than the ABS filament material

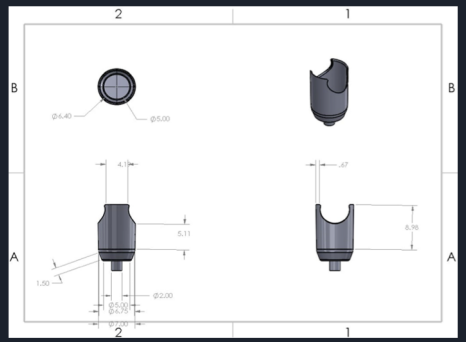


Figure 26: Supporting channel drawing in CAD

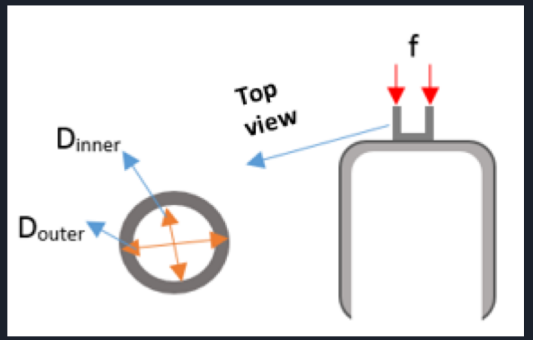


Figure 27: Inner and outer diameter of the lower part of the supporting channel

Manufacturing left of design

- 3D print the new supporting channel with hole for air valve. One for aluminum pipe and another one for PVC pipe.
- 3D print the new design of the foot for the aluminum pipe and another one for PVC pipe.

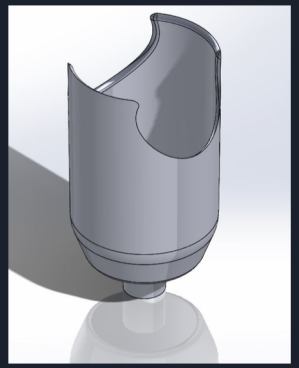


Figure 28: Supporting channel in CAD

Figure 29: 3D printed foot

Figure 30: Air valve

Plans of manufacturing

- Order the new designs of the supporting channel and the foot to be printed from NAU Cline Library

Figure 31: Cline library 3D printers

Plans for testing the design

- Test 1:
  - Add bricks on top of the design in the supporting channel and leave it for one day and then change the height .
- Test 2:
  - Letting Jenn wear the whole design for two hours first to see if the design holds her well or not. After that Jenn will try each design (Aluminum design and PVC design) for a whole week and give us the feedback.

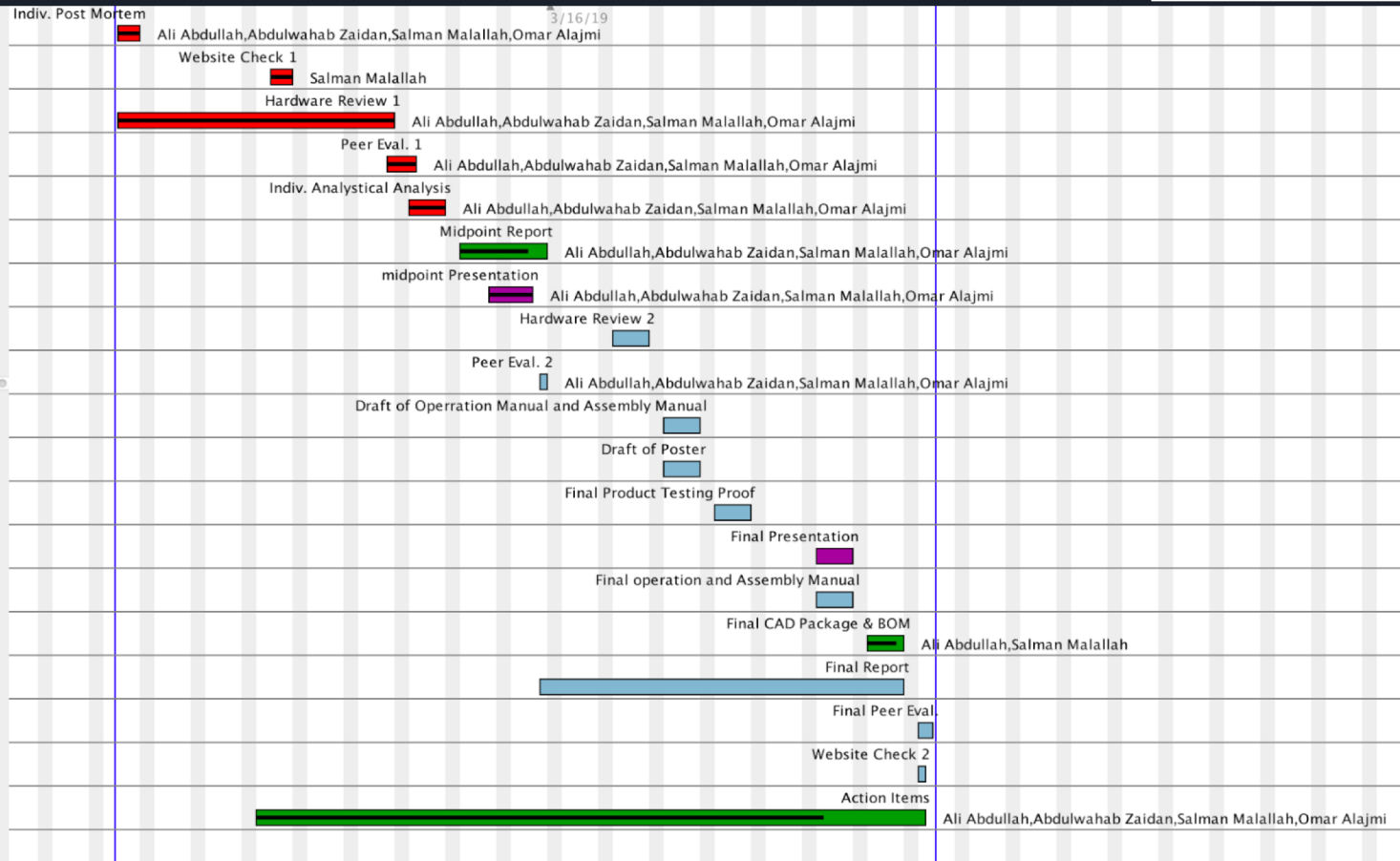
Figure 32: Bricks

Omar Alajmi

Schedule

Table 3: Gantt Chart

Name	Begin date	End date
Indiv. Post Mortem	1/16/19	1/18/19
Website Check 1	2/6/19	2/8/19
Hardware Review 1	1/16/19	2/22/19
Peer Eval. 1	2/22/19	2/25/19
Indiv. Analystical An...	2/25/19	3/1/19
Midpoint Report	3/4/19	3/15/19
midpoint Presentation	3/8/19	3/13/19
Hardware Review 2	3/25/19	3/29/19
Peer Eval. 2	3/15/19	3/15/19
Draft of Operration ...	4/1/19	4/5/19
Draft of Poster	4/1/19	4/5/19
Final Product Testin...	4/8/19	4/12/19
Final Presentation	4/22/19	4/26/19
Final operation and...	4/22/19	4/26/19
Final CAD Package ...	4/29/19	5/3/19
Final Report	3/15/19	5/3/19
Final Peer Eval.	5/6/19	5/7/19
Website Check 2	5/6/19	5/6/19
Action Items	2/4/19	5/6/19



Budget

. Project budget: 1500 $

. Total spent to date: 376.93 $

. Total available: 1,123 $

. The total cost of the project: (PVC 436 - Aluminium 486)

Omar Alajmi

References:

- Figure [1] Amputee Supplies Inc, “Knit-Rite 4-Way Stretch BK Prosthetic Shrinker, Silicone Band, Soft,” *Amputee Store*. [Online]. Available: https://amputeestore.com/products/knit-rite-4-way-stretch-shrinker-bka?variant=4114776705&gclid=EAIaIQobChMIlrD66cz44AIVBL7ACh1wPwzpEAQYByABEgIwlvD_BwE. [Accessed: 11-Mar-2019].
- Figure [2] Witt, M. (2018, August 29). In with the new: NAU welcomes two new deans. Retrieved from http://www.jackcentral.org/news/in-with-the-new-nau-welcomes-two-new-deans/article_3bc2e738-c5ea-59e0-bc98-7cdc5162d216.html
- Figure [31] : Dude Solutions, h. (2019). *Introduction to 3D Printing and Design*. [online] Events.nau.edu. Available at: https://events.nau.edu/event/introduction-to-3d-printing-and-design/ [Accessed 11 Mar. 2019].
- Figure [32]: Sandshifters.co.za. (2019). *How to Preserve your Building Bricks by Storing Them Properly | Sandshifters*. [online] Available at: https://sandshifters.co.za/how-preserve-your-building-bricks-storing-them-properly [Accessed 11 Mar. 2019].