Frost Step

by Human+

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Problem Statement

Over **2 million people** in the United States use **prosthetic limbs**. However, they are worn under layers of socks, which means that they get **uncomfortably hot** over time.

Engineering Goal

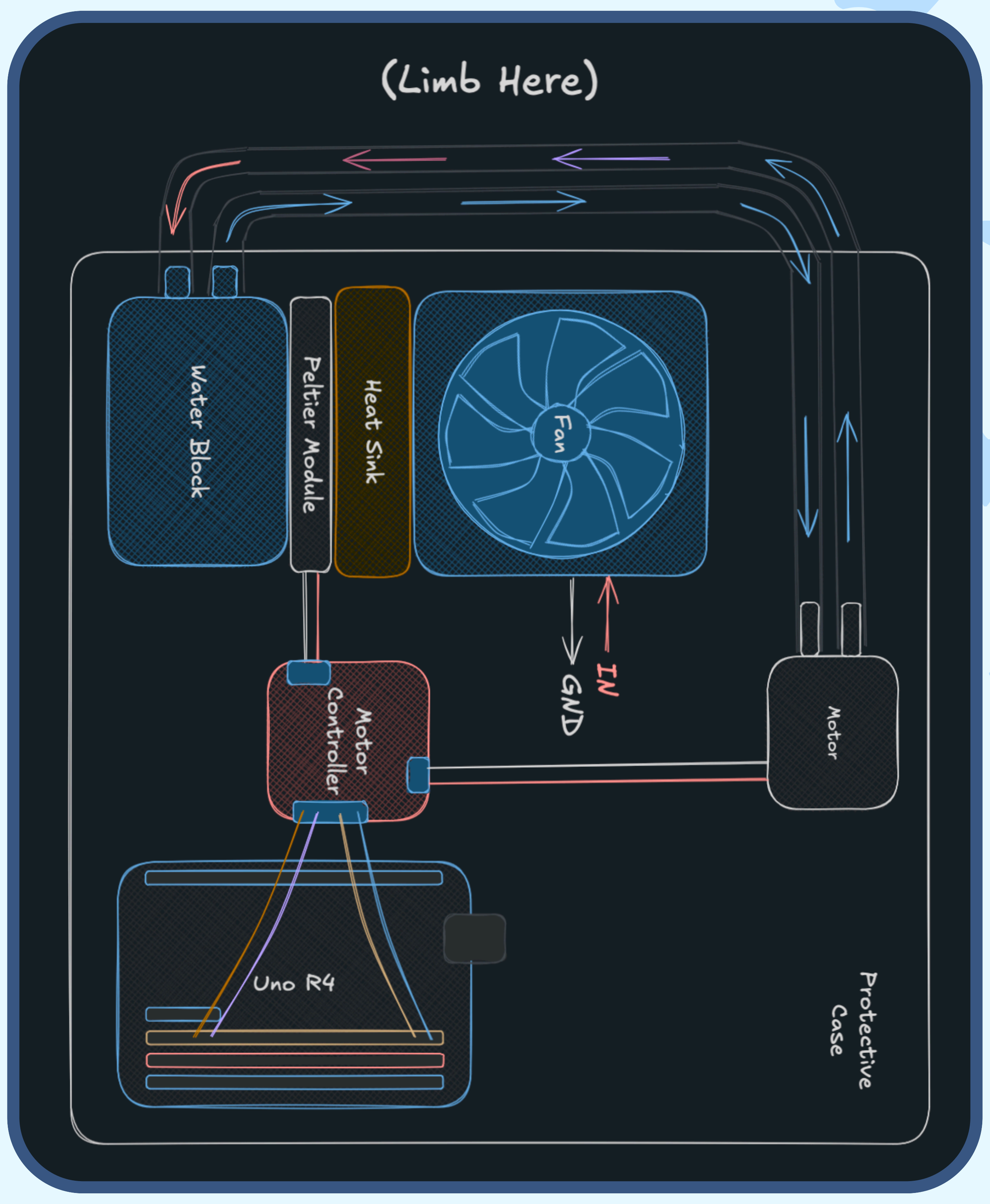
Our project aimed to engineer a product that can **actively cool** prosthetic liners in a **compact** and **lightweight** form factor that is durable enough for **daily use.**

Level 1 Requirements

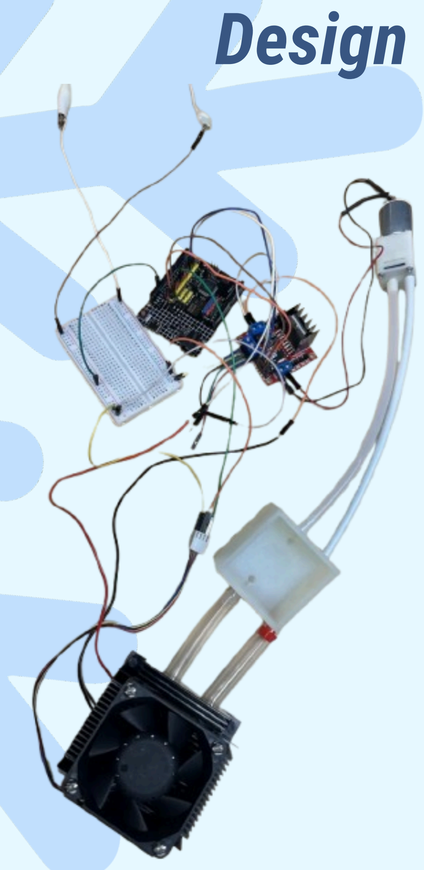
Type	Description	Met
Functional	Cools the prosthetic leg to an ambient temperature (below 70 degrees fahrenheit)	Y
Physical	Does not cause signigicant discomfort to the user (qualitative)	?
Physical	Product does not need to be carried in the clients hands	Y
Physical	Product does not break/come loose from its compartment	Y
Physical	The product should not have any toxic comopnents or parts	Y

Current Design

- **Compact**, able to fit in a fanny pack
- Cooling is **fast** and **efficient** (reaches target temperature in **<10 min**)
- Uses Peltier module for **active cooling**
- Pumps water around **residual limb** using motor
- **Heat sink** and fan cool hot side of **Peltier module**
- **Arduino** and **motor controller** control motor and Peltier module



Design #1: Fan and Peltier Cooling



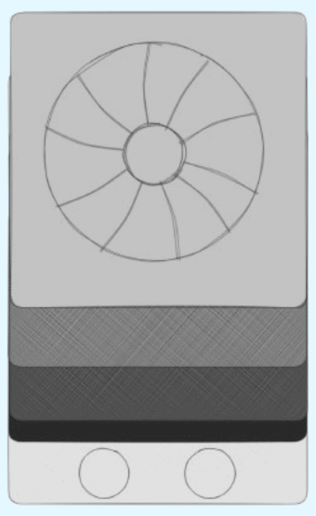
Pros

- Small and **portable**
- Reaches desired temperature in under **10 mins**
- **Cheap** components and small form factor

Cons

- Requires **high power**
- Heavier than **1** lb

Design #2: Radiator Cooling



Pros

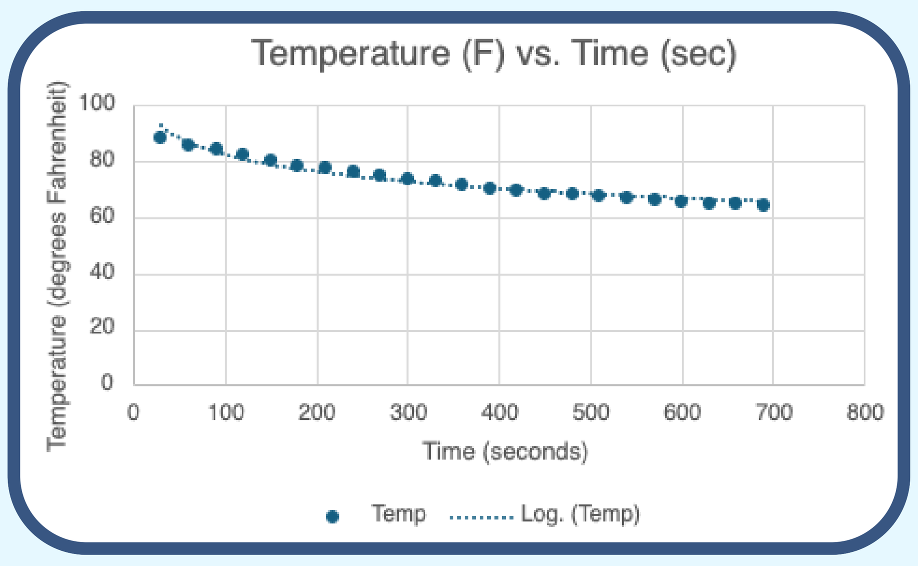
- **Effective** cooling
- Simple water tubing mechanism
- Less mechanical/electrical parts

Cons

- Large **weight**/size
- Requires **high power**

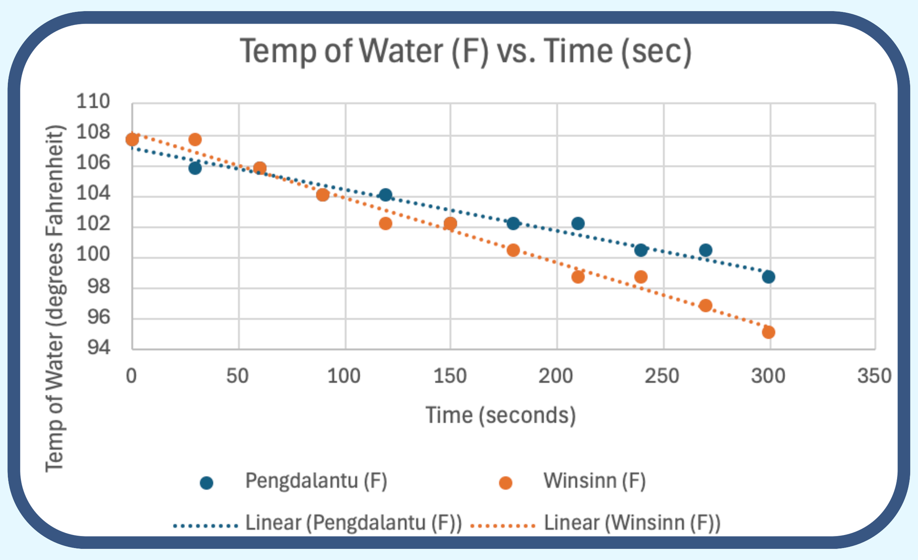
Design Study #1

Purpose: To determine the overall **cooling capability** of our first design.
Independent Variable: **Time** (sec)
Dependent Variable: **Temperature** (°F)
Results: The design was able to cool the water from 91.4°F to 64.4°F (**Δ-27°F**) in **11.5 minutes.**



Design Study #2

Purpose: To determine the differences in **cooling** between our **two fans.**
Independent Variable: **Time** (sec)
Dependent Variable: **Temperature** (°F)
Results: The **Winsinn fan** (which we are using for our current design) cooled the water more than the **Pengdalantu fan** (which we used for design #1) in the alloted time of **5 minutes**.



Conclusion

- A **prosthetic water-cooling solution** is viable in a small form factor
- Our product can fit in a **fanny pack** and can **cool water effectively**
- Cooled water can be pumped around the **residual limb** to **reduce heat**

Future Work

- Place the **cooling tube** inside an amputee's **silicone liner**
- Test directly with **amputees**
- **Reduce the size** of design until it can be **mouted on prosthetic**
- Adapt design for **arm prosthetics**
- Add **Bluetooth connectivity**