



# Prosthetic Hand

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## Function

Losing part of a hand is an incredibly difficult obstacle to overcome considering how much a person uses their hands throughout any given day. Not only does it affect many physical aspects in a person's life, but it can cause mental hardships as well. Unfortunately, state of the art prosthetics can cost a fortune, which is not an option for many people. In this case, the patient has lost their thumb, pointer, middle finger, and much of their palm to a serious infection. They retain their ring finger and pinky finger, however movement is severely restricted. The ring finger is immobile, and the pinky finger can bend at the metacarpophalangeal joint a maximum of 10 degrees. Our team will work to help this patient restore functionality to his hand while making it look as real as possible. The goal is to create an affordable solution so that more people like our patient can regain use of their hands.

## Client requirements:

- Prosthetic must be able to stabilize and hold objects.
- Cosmetic appearance of prosthetic is more important than the function.
- Prosthetic needs to be comfortable for extended, daily wear.
- Prosthetic should include at least a thumb, preferably 2-3 additional digits.
- Prosthetic needs to be water-resistant or water-proof.

## Design requirements:

### 1. Physical and Operational Characteristics

#### a. *Performance requirements:*

The prosthetic must provide the user with the ability to stabilize and hold objects that are light to moderate in weight. The prosthetic hand should give a gripping force of between 4N and 17N before significant slipping occurs [1][3]. A gripping force of 3.8 pound-force (17N) should be achieved, as this was shown to be effective [1]. In addition, the user needs to be able to use a writing utensil.

#### b. *Safety:*

The prosthetic must be safe for continuous wear over a lifetime. All materials used must be safe for extended contact with skin, and sharp edges or pinch points must be covered.

c. *Accuracy and Reliability:*

The prosthetic hand must move in a controlled manner so the patient is able to benefit from understanding the consistent movements. Hand must be able to continuously function for 8 hours of use so the user is able to work without changes in function.

d. *Life in Service:*

The prosthetic must be functional for constant wear by the user for several years, and be durable enough to withstand common daily tasks.

e. *Shelf Life:*

The prosthetic should not have any problems being stored for several years.

f. *Operating Environment:*

The prosthetic must be functional in all environments the user encounters in daily life. This includes rain and very cold weather. It would be ideal for it to function fully submerged in water, but not necessary.

g. *Ergonomics:*

The prosthetic should be functional and not get in the way of any daily tasks. It should act as an extension of the body, and prolonged use should not cause any discomfort.

h. *Size:*

The prosthetic must blend in with the size of the user's natural hand. The team received a 3D scan of the user's affected hand and can use this to reference specific measurements.

i. *Weight:*

According to the prosthetic development community, there is no specific maximum weight of prosthetic hands. However, the general consensus is that the prosthetic hand should remain below 400 grams, which is the average weight of an adult human hand. Many current users indicated that when wearing a prosthetic hand that weighed the same as a natural hand, it felt too heavy. This is a direct result of the attachment. [1] A smaller weight would be ideal as it would be easier to stabilize.

j. *Materials:*

The materials used should not cause any adverse effects to the user after prolonged use. They should provide both structural support and grip in order to pick up and hold various objects.

k. *Aesthetics, Appearance, and Finish:*

The user desires a more cosmetic approach to this device. This means that the prosthetic hand must maintain cosmesis and blend appropriately with the rest of the body. The device should achieve the closest to a natural look as possible.

## **2. Production Characteristics**

a. *Quantity:*

The device is being made for a specific patient, so only one device is necessary to manufacture. However, the prosthetic device will be made so that others who have lost multiple digits can use the same design principles with aspects of the design tailored to the limb of the patient.

b. *Target Product Cost:*

The prosthetic device must be as economical as possible because the client did not provide a budget. All funding will be coming from an outside source.

## **3. Miscellaneous**

a. *Standards and Specifications:*

1. Grip light-medium objects with 17 N of force [1]
2. Remain under 400 grams [2]
3. Match size of the client's hand provided by .stl file
4. Must be reproducible in multiple skin tones

b. *Customer:*

The customer for this project is the client's patient. However, this project will be applicable for other users down the line. These users will be individuals who have had one or more compromised digits on their hand that has limited functionality.

c. *Competition:*

The client has reached out to other organizations for additional assistance. One company includes Enabling the Future. E-nable is a company that produces 3D printed mechanical prosthetic hands for individuals who have at least some movement of the wrist.

## Reference

[1] A. Kargov, C. Pylatiuk, J. Martin, S. Schulz, and L. Döderlein, "A comparison of the grip force distribution in natural hands and in prosthetic hands," *Disability and Rehabilitation*, vol. 26, no. 12, pp. 705–711, 2004.

[2] J. T. Belter and A. M. Dollar, "Performance characteristics of anthropomorphic prosthetic hands," *2011 IEEE International Conference on Rehabilitation Robotics*, 2011.

[3] L. Roberts, G. Singhal and R. Kaliki, "Slip detection and grip adjustment using optical tracking in prosthetic hands," *2011 Annual International Conference of the IEEE Engineering in Medicine and Biology Society*, 2011, pp. 2929-2932, doi: 10.1109/IEMBS.2011.6090806.