### Objective
- Current prosthetic devices offer little capability in allowing the user to generate the twisting motion necessary to turn doorknobs.
- 250,000 upper limb amputees currently live in the United States.

### Customer Requirements
- Lightweight, Fits Amputee Range of Motion, Attachable to Prosthetic, Doesn’t Impede Current Claw Functions, Fits Variety of Doorknob Sizes, Portable, Single Arm Operation.

### Engineering Characteristics
- Actuating Force, Weight, Minimum Rotation to Open Door, Fits Grasp Range, Storage Volume, Grip Force on Knob, Compatibility with Prosthetic, Simplicity of Actuation, Ease of Attachment/Removal.

### Constraints
- Compatible with split hook prosthesis, Fits standard sizes of doorknobs [2” - 2.75”].
- Actuating force to operate doesn’t exceed 5lbs, Rotates doorknob minimum of 90°.

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### Design

**Functionality**
- Device allows for simple operation within amputee’s ROM.
- Device is portable and lightweight.
- Device fits all standard doorknobs.
- Easily attachable and removable.
- Single arm operation and movement.

**Tradeoff made:** sacrificing small size for increased contact area with knob surface.

**Prototype and Testing**

**Field Test of Early Prototype:**
- Double amputee of 30 years tested device.
- Simplicity of operation was rated highly.
- Easy actuation of doorknob, low force needed.
- Ease of attachment to doorknob rated poorly.
- Final design allows for improved dexterity.

**Testing Calculations:**
- Using the average force of 29.4 N on the device strap, the maximum stress inside the device material is 14.58 MPa.
- Safety factor of two: 29 MPa yield strength and low weight lead to High-Density Polyethylene as ideal material.

**Test Results and Future Work**

**Product Design Process**
- Customer needs determined through market research and direct contact with double amputee.
- Identified Customer Needs → Product Specifications
- Identified → Various Concepts Generated
- Final Design utilizes best methods of maintaining portability, method of achieving grip force, and mode of actuation.

**Most Helpful Parts of Process**
- Identification of Customer Needs: directly through end user.
- Testing and Modification of the Prototype: Consistent feedback available with interviewee gave ideas to make changes in design.

**Future Work and Design Challenges**
- Device aesthetics.
- Determine manufacturing cost and retail price.
- This device is currently the only portable device that can be used by double arm amputees to turn doorknobs.
- Potential for patent.