

Design 1: Screw It

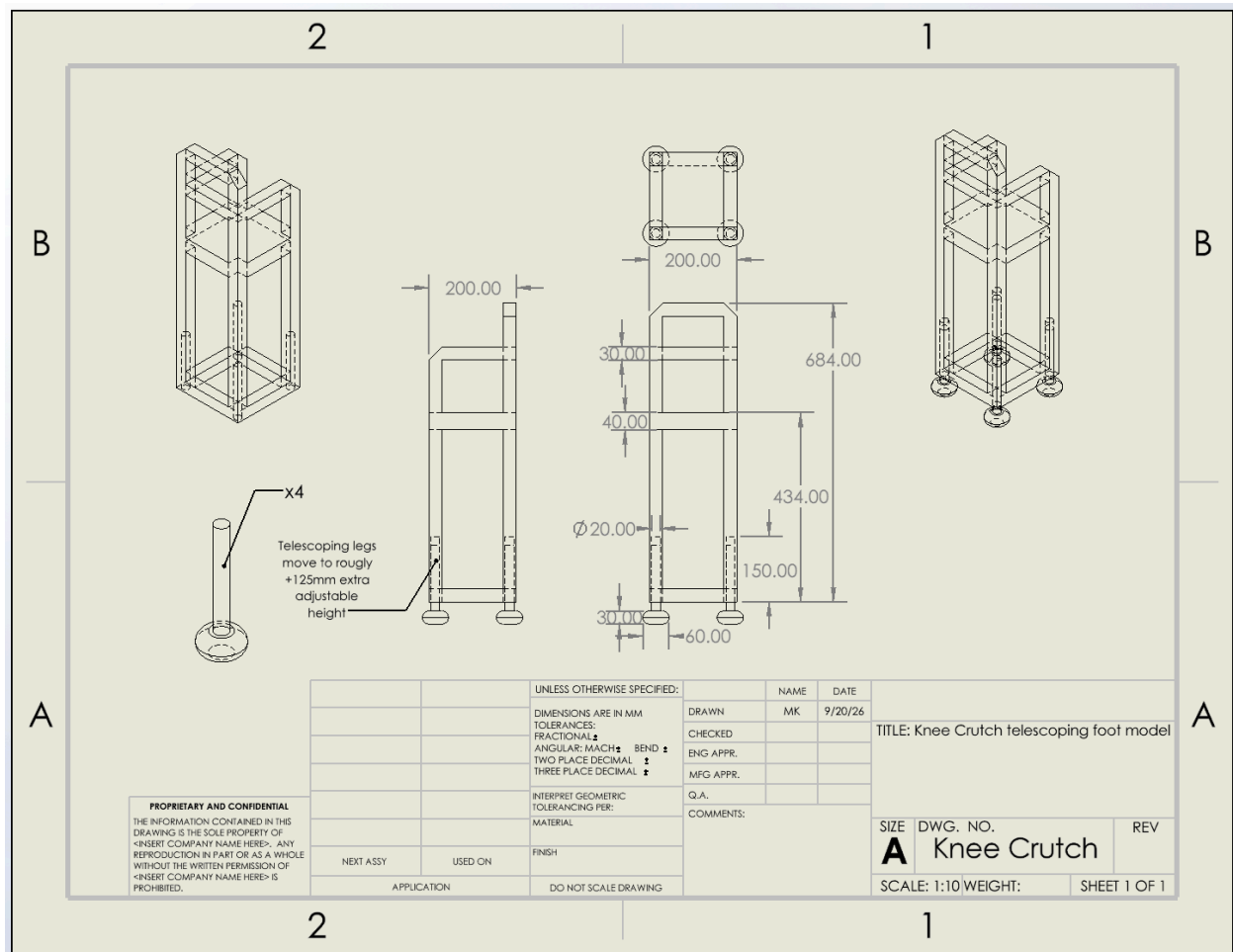


Figure 1: SolidWorks Drawing of Knee Crutch Telescoping Foot Model

The design consists of 5 major parts, a main body composed of 30mmx30mm aluminum bars with a 200mmx200mmx40mm plate in the center for resting the knee, a cushion will be added on top of this plate for added patient comfort. The main structure is 4 columns of aluminum which connect together with a square set of bars at the top and bottom respectively the top portion of connectors has an open face to allow the knee and thigh to freely be placed within the design. There is a handle built into the design on the front of the main structure for the patient to grab and maneuver while in use. On the bottom of the structure there are 4 drilled holes of 20mm diameter and 150mm depth to make room for the 4 legs which comprise the rest of the parts. The legs are 200mm tall with a rubberized foot structure for added grip. The feet and the holes are threaded to allow the whole design to be adjusted in height for up to about 125mm of extra height from fully extending the legs.

Design 2: Light Step

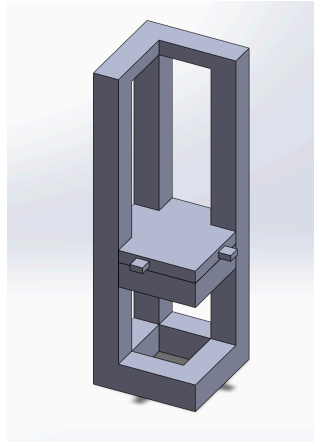


Figure 2: Isometric View of the Removable Stacking Plates Knee Crutch

This design consists of 2in x 2in aluminum bars that form a 9in x 9in horizontal square. From three vertices of the base square extends vertical 2in x 2in aluminum bars. The bars extend 23 inches from the floor and terminate with two connecting horizontal bars that provide structural support and function as handles for ease of movement. Foam casings will be added to these bars for comfort. A permanent 9in x 9in plate is placed 10.5in from the ground to act as a starting point for the adjustable height component of the product. A cushion is attached to the top of the plate, and during use, the knee is placed on top of the cushion. To adjust the height of the plate and its cushion, additional 9in x 9in x 1in plates may be added on top of the permanent plate. The plates include small tabs for ease of removal.

Design 3: Bolt Step

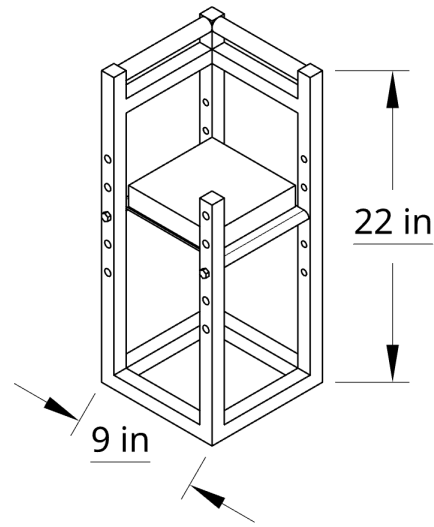
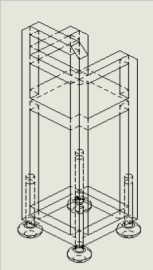
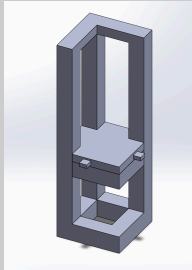
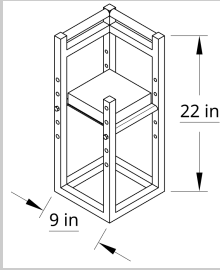


Figure 3: Isometric view of the Bolt Supported Knee Pad design

The base of the design consists of four 1 in x 1 in aluminum bars that form a 9 in x 9 in horizontal square. From each vertex of the base square extends a vertical 1 in x 1 in aluminum bars, one of which is shorter than the others. The longer bars extend 22 inches from the floor and terminate with four connecting horizontal bars that provide structural support and function as handles for ease of movement. In each of the four vertical bars, there are five $\frac{1}{2}$ in diameter horizontal holes spaced two inches apart, starting eight inches from the floor. The direction of the holes is such that each hole can be matched with another hole on another vertical bar. In each pair of holes, one is tapped. Two 9 in long bolts are inserted through one hole and screwed into its pair. These bolts occupy holes of the same height, and an aluminum plate is placed across the bolts. The plate is bent at two ends to better grip the bolts and avoid sliding off. A cushion is attached to the top of the plate, and during use, the knee is placed on top of the cushion. To adjust the height of the plate and its cushion, the bolts are moved to a different set of holes at a different height.

Design Criteria	Weight	Screw it		Light Step		Bolt Step	
							
Weight	20	4/5	16	4/5	16	5/5	20
Adjustability	20	5/5	20	4/5	16	4/5	16
Sterility	20	5/5	20	5/5	20	4/5	16
Ease of Use	20	3/5	12	4/5	16	4/5	16
Comfort	10	5/5	10	5/5	10	3/5	6
Ease of Fabrication	10	2/5	4	5/5	10	3/5	6
Total Score	100	82/100		88/100		80/100	

Criteria:

Weight: Weight refers to how light and easy the device is to lift and transport. The Knee Crutch should weigh approximately 4 lb or less while maintaining enough stability and strength to safely support users up to 400 lb. The weight should be distributed evenly to prevent tipping and allow users to easily move the device while navigating stairs or transferring to a wheelchair.

Adjustability: Adjustability refers to how easily the device can be modified to accommodate different users. The Knee Crutch should have a simple adjustment mechanism that accommodates users ranging from 5'0"–6'0". The device should have approximately three height settings and should not require stacking components or complicated tools to adjust.

Sterility: Sterility refers to the ability to clean and sanitize the device between uses. The Knee Crutch should be made from materials that can withstand appropriate hospital cleaning and sanitization procedures. Surfaces that come into contact with the user should be easy to wipe down, and the knee padding should be either cleanable or easily replaceable.

Ease of Use: Ease of use refers to how simple and intuitive the device is to operate. The Knee Crutch should require minimal steps to adjust, position, and use when navigating stairs. The height adjustment should be quick and easy for users ranging from 5'0"–6'0", without requiring complicated tools. The device should also be easy to lift and reposition between stairs and a wheelchair.

Comfort: Comfort refers to how comfortably the device supports the user during stair navigation. The knee padding should remain securely in place during use, while the base should provide adequate cushioning and traction to improve comfort and stability.

Ease of Fabrication: Ease of fabrication refers to how simple the device is to fabricate. The device should be relatively straightforward to fabricate to ensure the success of this project.

Cost: Cost refers to how much the device costs to fabricate. The device should be cost effective so that it can be mass produced and easily distributed.

Evaluation Criteria:

Weight (20%): The final design must be light and easy to lift and transport weighing approximately 4 lb or less while maintaining enough stability and strength to safely support users up to 400 lb. Using aluminum metal in the design will be the most reliable for durability but also lightweight. The design has four legs to evenly distribute the weight to prevent tipping and allow users to easily move the device while navigating stairs.

Adjustability (20%): The final design will have a simple adjustment mechanism that accommodates users ranging from 5'0"–6'0". The design chosen has approximately three height settings along with two tabs on the edge of the square plates to allow for easy access to remove and adjust the height.

Sterility (20%): The final design must be suitable for use in hospital and rehabilitation settings and allow for easy cleaning between users. The entire frame and handlebar will be constructed from aluminum, providing smooth surfaces that can be easily wiped and sanitized. The knee cushion will be covered with a leather-like material that is also resistant to moisture and can be wiped down between uses. The design will minimize areas where dirt, moisture, or contaminants can accumulate, allowing the device to be cleaned efficiently and reused between patients.

Ease of Use (20%): The final design must be user friendly and intuitive for individuals with limited lower-limb mobility and varying levels of strength and balance. This criterion considers the number and complexity of steps required to use the device, the number of moving or removable components, and how easily the device can be adapted to different users. The proposed Knee Crutch is designed to require minimal user interaction once properly adjusted. The user will place their knee onto the padded support, use the handlebar for stability, and advance the device while navigating stairs. The aluminum handlebar will be oriented to accommodate both left- and right-limb injuries, eliminating the need for separate left- and right-sided designs. The removable plates will include tabs to allow for quick removal and adjustment without requiring complex tools or procedures. Additionally, rubber on the bottom of the device will provide increased traction and reduce the likelihood of slipping during use. The lightweight aluminum construction is also intended to make the device easier to move between stairs compared to the client's current heavier design. Overall, the design minimizes the number of steps and adjustments required from the user while incorporating features that improve stability, adaptability, and ease of handling.

Comfort (10%): The final design must have the patient's knee comfortably fit into the cushion and provide support so the patient does not have to put additional strain on the lower back. The criteria for comfort is assessed by how secure the patient's knee is on the cushion. Additionally, comfort is determined based on how easily the plate with the knee cushion may be adjusted and removed based on users needs. The handles for the knee crutch are also a factor for comfort. The criteria for comfort on the handles is determined based on how much strain is put on the palm and wrists. Also the cushion material used on the handle is determined by how much force the handles will have acted on them, therefore analyzing the comfortability of the handles.

Ease of Fabrication (10%): The ease of fabrication is an essential factor when determining the most effective final design. The criteria is determined by resources available, as well as availability of materials. The client has provided a charitable budget for this project therefore finances are not a significant constraint for fabrication.