

# Mobile Bed Desk

Senior Design Proposal submitted to the  
Department of Mechanical and Materials Engineering  
College of Engineering and Applied Science  
University of Cincinnati

in partial fulfillment of the  
requirements for the degree of

Bachelor of Science

in Mechanical Engineering Technology

by

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May 2019

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# Table of Contents

<b>Problem Statement</b> .....	4
<b>Research</b> .....	4
<b>Quality Function Deployment</b> .....	9
<b>Concepts Drawings</b> .....	12
<b>Design</b> .....	15
<b>Drawings</b> .....	20
<b>Bill of Materials</b> .....	24
<b>Fabrication</b> .....	24
<b>Testing</b> .....	26
<b>Project Management</b> .....	27
<b>References</b> .....	29
<b>Appendices</b> .....	<b>Error! Bookmark not defined.</b>

# Table of Figures

Figure 1. Foldable Lap Desk .....	6
Figure 2. Bed Table .....	7
Figure 3. Over-bed Table .....	8
Figure 4. Concept 1.....	12
Figure 5. Concept 2.....	13
Figure 6. Concept 3 Standard .....	13
Figure 7. Concept 3 Extended .....	14
Figure 8. 200 lb. Load on a Cylindrical Leg .....	16
Figure 9. 200 lb. Load on a Rectangular Leg.....	17
Figure 10. 200 lb. Load on a Squared Leg .....	18
Figure 11. Uplift Desk Controller .....	20
Figure 12. Uplift Desk Caster Wheel .....	20
Figure 13. Design Desk Assembly (side) .....	21
Figure 14. Design Desk Assembly (front).....	21
Figure 15. Design Desk Assembly (top).....	22
Figure 16. Basic Loading Calculations.....	22
Figure 17. Final Model of Design.....	23
Figure 18. Stress Analysis of System .....	23
Figure 19. Frame Phase Components.....	25
Figure 20. Desktop Frame Components .....	25
Figure 21. Controller Holder .....	26
Figure 22. Final Assembly .....	26

## **Problem Statement**

I will be creating a product that helps solve the everlasting problem of maximizing the productivity throughout a person's day. My product will be a desk that utilizes today's technology to be used from the comfort of the user's own bed.

My product will utilize the technology from existing motorized desks that are designed to allow their user to stand while working. This will allow my user to have hard surface to work on, late at night at their desired height in their bed. My product will also have the technology to memorize certain locations (heights) based on who is in the bed. The desk will be mobile, which will allow the desk to be rolled anywhere from the head, to the foot of the bed. The desk will be easily stored away to allow the user to utilize the desk just before turning out the light and going to sleep.

## **Research**

### **Background of the Problem**

Maximizing efficiency throughout the day is something that I feel a lot of people have been aiming to do for a long time. Whether it be trying to set your alarm earlier or staying up an extra hour to complete a presentation, people as young as college students and people as old executives on the brink of retirement, see the value added.

A study conducted by Good Technology, a mobile security software company in Sunnyvale, California, showed 50% of people read or respond to work emails from bed. A similar study conducted in 2009 by Credant Technologies, a data security company out of London, found that out of 329 British workers, close to 1 in 5 employees spends anywhere from 2 to 10 hours a week, working from bed. To put that in perspective, that is anywhere between 104 to 520 hours a year working from bed. To go along with this, Martin Rawls-Meehan, the

chief executive of Reverie, a company that specializes in making adjustable beds, says that “as many as 80% of young New York City professionals work regularly from bed” (1).

As Jen Doll says in her article in *The Atlantic*, the habit of working from bed “tends to be common among those who want to get ahead, respond the most quickly, or simply never stop working”. She goes on to say while this may be something that you do not want to admit to your boss or friends, a lot more people do it than we would realize (1).

Nate Hindman highlights a quote from a legendary writer, Truman Capote in an article he wrote in the *Huffington Post*. “Truman Capote described himself as a ‘horizontal author’”. He says this because Truman Capote was unable to think unless he was “lying down, in bed or stretched on the couch”. I have witnessed a lot of people, partially because I am a college student, who are able to relate to this quote. Often times, people’s brains spark as soon as they hit the bed and their minds begin to wander. Whether it’s in regard for work they have to do, social responsibilities, or reflecting on the past day, it’s hard to argue that people do not do their most thinking just before going to bed (2).

## **State of the Art**

There are a few existing inventions that are on the market that seem to resolve the issue highlighted above. A device that will give you comfort, allow you to be productive, and allow you to be well organized. However, each of these devices seem to fall short in one area or another.

To begin, the first current state of the art is a conventional lap desk. The idea with this invention is that you are sitting in your bed, on your couch or anywhere it seems to fit. I will give them credit where it is due, it seems to be adaptable in many situations. As you can see below in Figure 1. Foldable Lap Desk, it is simply a small table that fits right over your lap that holds your laptop. However, aside from flexibility, I see this device lacking in key areas. Not only is the size somewhat limiting, it seems like it would be exhausting to lug around. Not only this, but when

the operator is doing work right before sleep, they have the pain of getting up, lifting this thing off the bed, and trying to find a place for it, all the while the operator could be sleeping (3).

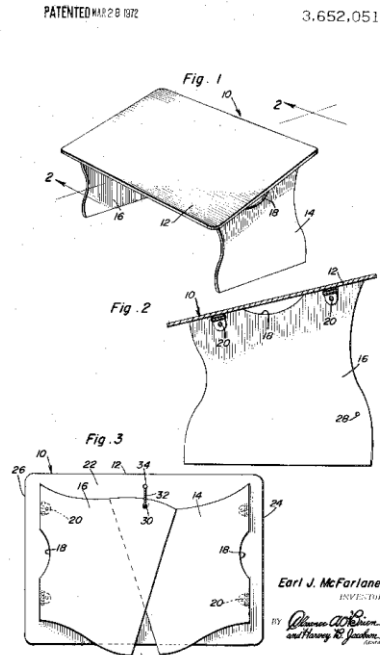


Figure 1. Foldable Lap Desk

The next product takes it a step up from a conventional lap desk. This is a table similar to something you would see next to a hospital bed. This a small desk made to go over the bed and it is extremely mobile. Its sleek design with wheels on the feet allows the user to roll it a lot of different places. Aside from its mobility, I immediately saw an issue with this design. As you can see in Figure 2. Bed Table, the table has room for a laptop and maybe small notepad. Being that mobile sacrifices the table spaces for the user. Similar to the lap desk, it seems as though the user would have to find a permanent spot for the table when it is not in use. There are definitely areas of improvement for this design with the average user in hand (4).

Dec. 27, 1927.

1,653,657

E. PRETSCH

BED TABLE

Filed Feb. 28, 1925

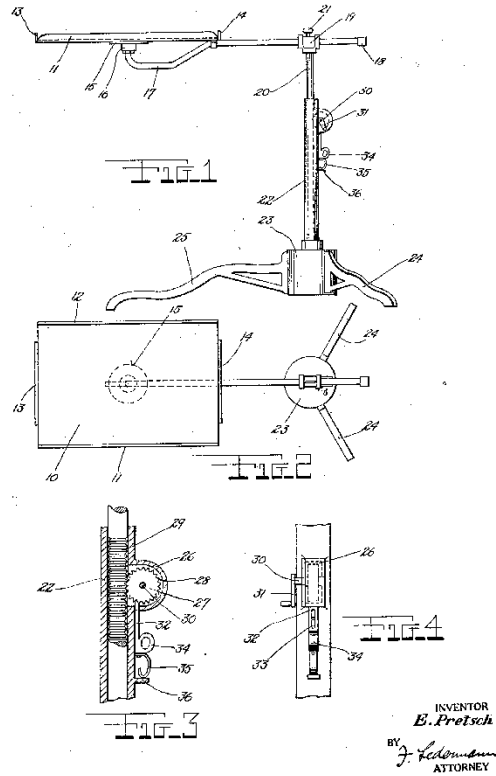


Figure 2. Bed Table

For a more permanent solution, there is another option on the market. Unlike the first product, this design is focused on the bed. This product is specifically designed as an over the bed table. While it also has a lot of advantages like increased table space and mobility with the wheels, there are still areas of improvement. As you can see in Figure 3. Over-bed Table, it seems that this frame is designed to fit the size of one bed, rendering it completely useless if the user gets a different size bed. This product also brings the question of, what is the user supposed to do with this when it is out of use? Do they stow it away until they find use for it again? Will they make a permanent space in there room for it when it is not being utilized? There are also key areas of improvement from this design (5).

Feb. 6, 1945.

B. A. DOTY  
OVER-BED TABLE

2,368,748

Filed Feb. 19, 1943

2 Sheets-Sheet 1

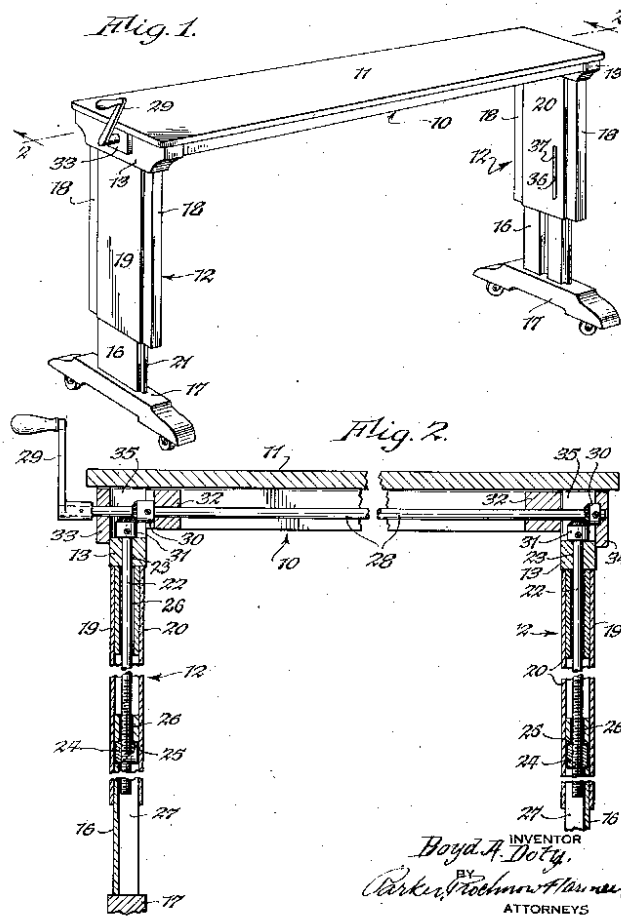


Figure 3. Over-bed Table

## End User

The primary target for this product would be anyone looking to maximize the efficiency throughout their day, specifically the “workaholics” or the 50% percent of people that respond to work emails from their bed (1). Ages can range anywhere from 21-45 years. The majority will fall towards the lower end of the range, simply due to the generation’s curiosity for “the next cool tech” and always finding new ways to incorporate technology into their everyday life. The end user will be the type of person looking to always get ahead or looking to constantly develop professionally and personally. Another end user may be a businessman away on travel. Often

times when traveling and staying in hotels, people try to make most of their time and the hotel desk is the last place they want to spend it. This product would place hotel desks and allow the user to decide where they use their desk.

## **Quality Function Deployment**

### **Customer Features**

Based on the results from targeted interviews, customer requirements for this product are as follows, ranked by order of importance based on results from targeted interviews:

1. Sturdy
2. Mobile
3. Height adjustable
4. Easily storable
5. Safe to use
6. Easy to setup
7. Doesn't slide while in use
8. Plugs into the wall easily

### **Engineering Characteristics**

Based on the customer requirements from the targeted interviews, engineering characteristics are as follows:

1. Maximum Load (lbs.)
2. Mobility (Degrees of Freedom)
3. Height Range (in.)
4. Disassembly Time (sec.)
5. Safety Sensors (y/n)
6. Assembly Time (sec.)
7. Slide (y/n)
8. 120 VAC (y/n)
9. Weight (lbs.)

# House of Quality

		Engineering Requirements (units)														Customer Satisfaction Rating (0.00 - 1.00)				
		Maximum Load (lbs.)	Mobility (Degrees of Freedom)	Height Range (in.)	Disassemble Time (min.)	Safety Sensors (yes/no)	Assembly Time (min.)	Slide (yes/no)	120 VAC (yes/no)	Weight (lbs.)										
Customer Requirements		Importance wt.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	CP	A	B	C
1	Sturdy	0.15	9								1							0.9		
2	Mobile	0.15		9	3					9								0.9		
3	Height Adjustable	0.25	1	3	9													0.7		
4	Easily Storable	0.10				9					1							0.6		
5	Safe to Use	0.10					9											1.0		
6	Easy to Setup	0.05						9		1								0.8		
7	Doesn't Slide in Use	0.15							9		3							0.9		
8	Plugs into Wall Easily	0.05								9								1.0		
9																				
10																				
Total Importance		1.00																		
Engineering requirement importance			1.6	2.1	2.7	0.9	0.9	0.5	2.7	0.5	2.1									
<b>Performance</b>																				
	Current Product																			
	competitor A: Bedchill		125	2	16	60	N	60	Y	Y	55									
	competitor B																			
	competitor C																			
	New Product Targets		225	2	30	40	Y	40	Y	Y	50									

Table 1. House of Quality

Interaction Matrix															
	Engineering Requirements	Maximum Load (lbs.)	Mobility (Degrees of Freedom)	Height Range (in.)	Disassemble Time (min.)	Safety Sensors (yes/no)	Assembly Time (min.)	Slide (yes/no)	120 VAC (yes/no)	Weight (lbs.)	0	0	0	0	0
Engineering Requirements		1	2	3	4	5	6	7	8	9	10	11	12	13	14
Maximum Load (lbs.)	1									3					
Mobility (Degrees of Freedom)	2			9				9		-3					
Height Range (in.)	3							1							
Disassemble Time (min.)	4						3								
Safety Sensors (yes/no)	5									1					
Assembly Time (min.)	6									1					
Slide (yes/no)	7									1					
120 VAC (yes/no)	8														
Weight (lbs.)	9														
0	10														
0	11														
0	12														
0	13														
0	14														

Table 2. Interaction Matrix

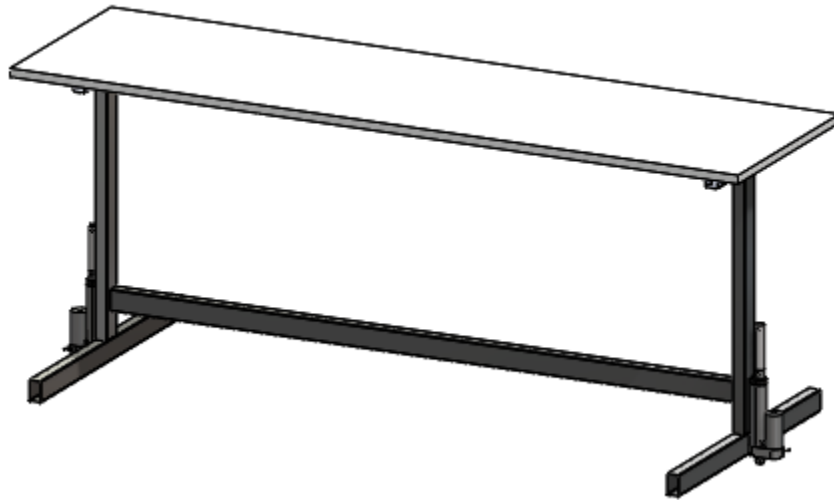
## Product Objectives

To fully meet the customer requirements there are several objectives that need to be met, listed in order of importance:

1. Create a system that utilizes actuators to maximize the height range of the desk
2. Have a frame designed to withstand the maximum load of the actuators
3. Be able to maximize the degrees of freedom of the desk with wheels without sacrificing the reliability
4. Have a reliable “quick release” function for the desktop for easy storage
5. Have a safety feature that stops the actuators if they feel resistance against them

## Concepts Drawings

Concept 1 will utilize a pair of linear actuators to mobilize the desk top in the Y-axis, maximizing the range and number of heights for the user. This concept will also use a firm frame to ensure proper stability and load maximization. Areas of concern for this design will be the lack of mobility from the head to the foot of the bed.



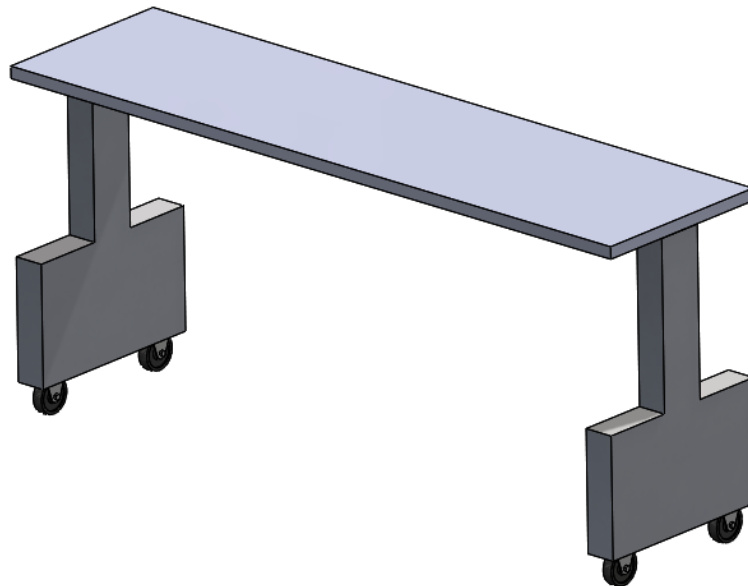
*Figure 4. Concept 1*

Concept 2 will utilize a manual hand crank to maximize the number of positions in the Y-axis. There will be a sturdy frame to maximize the load of the table top, but unlike concept 1, this concept is on wheels, making it ideal for the user to roll the desk from the head, to the foot, and even away from the bed itself. Where this concept lacks is that it requires a lot of movement from the user, taking away from the enjoyment of using it in bed (6).

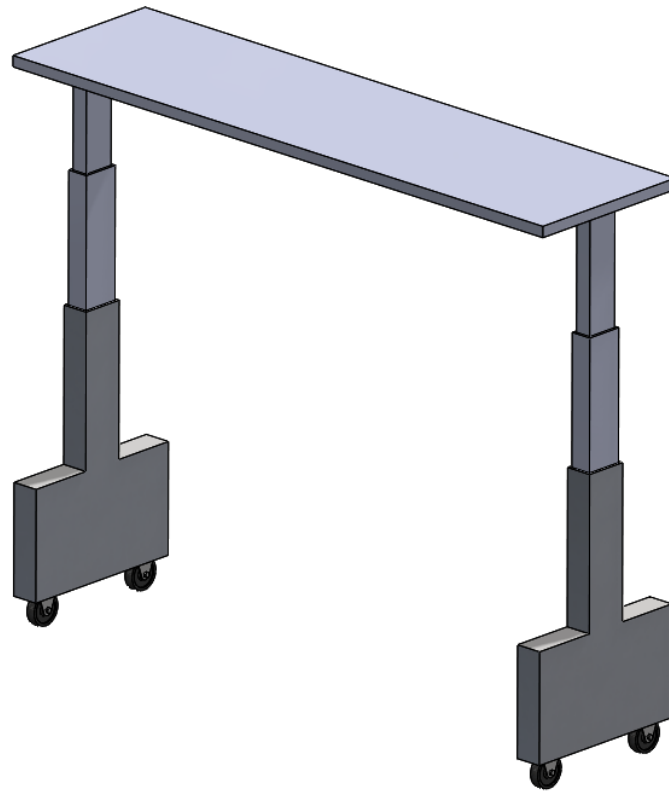


*Figure 5. Concept 2*

Concept 3 will be a mixture between concept 1 and 2. This concept will utilize both linear actuators to adjust the height of the desktop and be on caster wheels. While being the most expensive of the 3 options, this will be most ideal for the user because it allows for the maximum mobility of the desk and will be unlike anything existing on the current market.



*Figure 6. Concept 3 Standard*



*Figure 7. Concept 3 Extended*

# Design

## Minimum Design Requirements:

Height Range: 24 inches – 44 inches

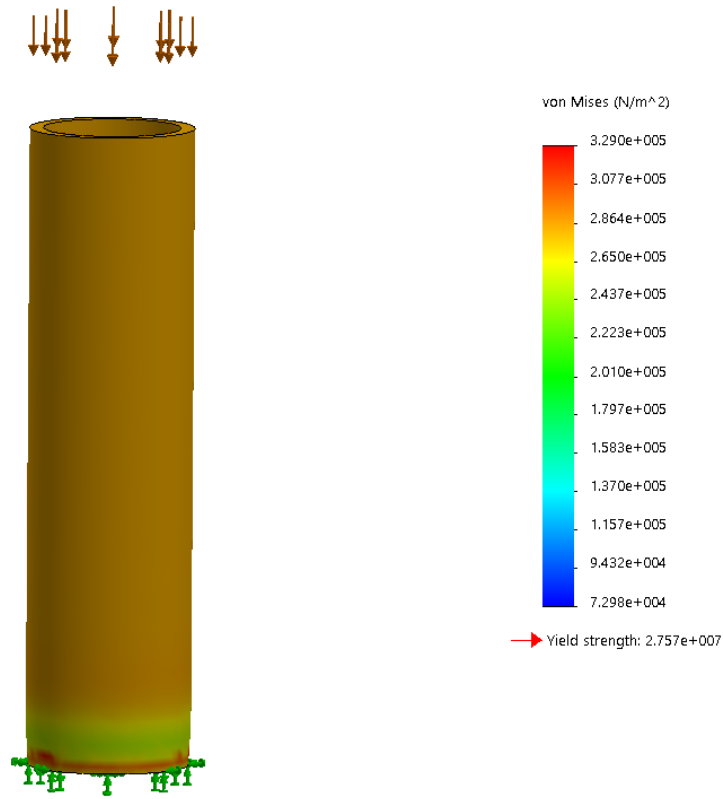
Width Range: 48 inches – 65 inches

Max Load: 150 pounds

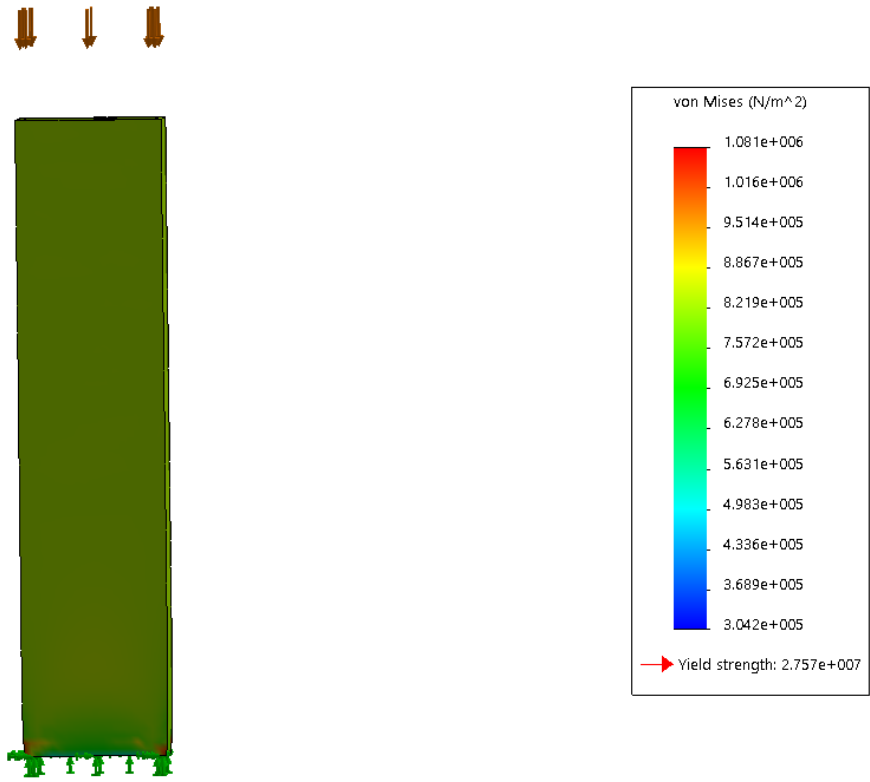
Mobility: 80 inches z-axis

## Analysis

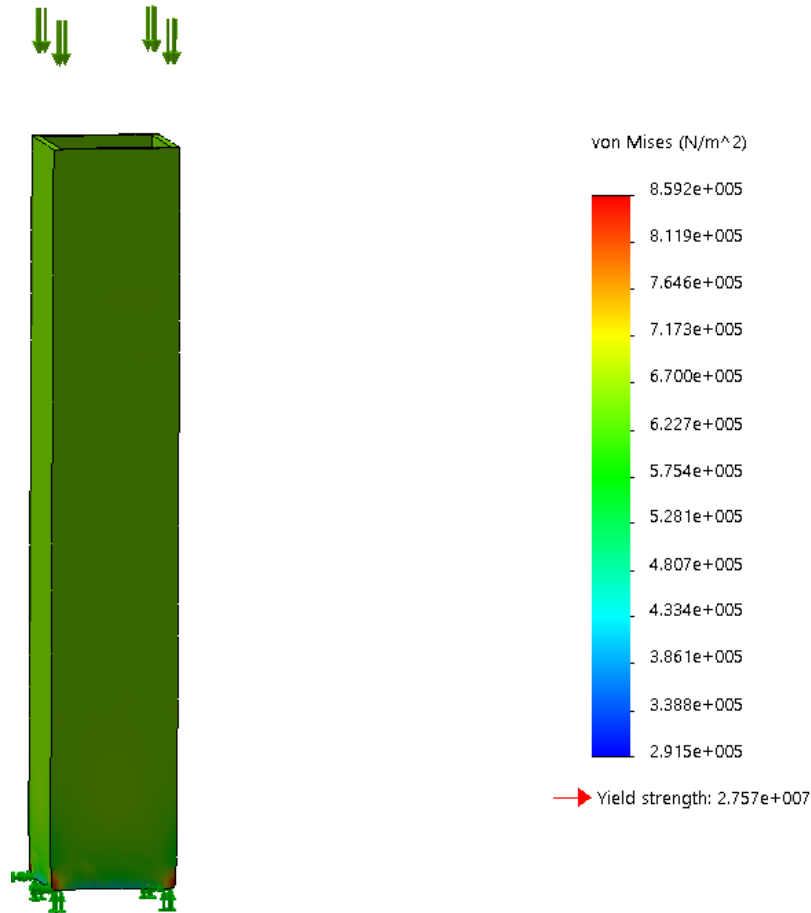
When considering the frame of the desk design, one thing that came to mind was something that seemed to vary on a lot of existing motorized desks, leg shape. Because the leg of the frame would be the part of the desk enduring the most stress, I found this important to put to the test. For this analysis, I placed set load on 3 different shapes of interest: cylindrical, square, and rectangular. I applied a two-hundred pound load to a 1060 aluminum alloy to simply test which shape would least deflect when experiencing the load. From the results show below, we can see that the shape that had to most success was the cylindrical shape. Although the cylindrical leg seemed to experience the least stress, the other two options are not terrible alternatives. With that being said, shape of the leg will not be a driving factor when selecting a leg from a manufacturer.



*Figure 8. 200 lb. Load on a Cylindrical Leg*



*Figure 9. 200 lb. Load on a Rectangular Leg*



*Figure 10. 200 lb. Load on a Squared Leg*

## Product Selection

Although there are not a lot of product like this that are on the market, there are tons of existing resources from manufacturers. A lot of the equipment needed to make my product feasible can be taking from products that are designed for similar loads, actuations, and control methods. The average sit-stand desk uses nearly all of the same product features that are required by my system, which is why I decided to research existing parts from these desks to be utilized in my design. Rather than mixing and matching different parts and pieced from different manufacturers, I found it suitable to stick with one manufacturer to supply items I can use and self-fabricate the items I cannot (7).

Desk Legs. I decided to select Uplift Desk's Two-Leg system and determined they would be best for my application. These legs are made of raw steel and aluminum feet. This design comes with two linear actuators (one in each leg), that carries a 26" range of height adjustment. These legs have a non-toxic, powder coated finish. These legs also are in accordance with ANSI/BIFMA X5.5-2008 test

standards. These legs carry a lifting force of 355 pounds, which is 205 pounds above the minimum maximum load requirement (7).

Controller. Uplift Desk also supplies two types of controller for their desk systems: Standard and Advanced. Advanced system allows the user to control the height that the desk is currently at and store up to 4 desired locations. The controller also has a display to let you know how many centimeters or inches your desktop is off of the ground. The primary reason Uplift Desk's controller stood out to be is because it comes with a safety sensor build in. If the sensor feels any resistance from the actuators when moving upwards or downwards, the controller will stop the actuators and slightly run them in the opposite direction, backing the desktop off of what was causing the resistance. This was huge due to the safety concern that comes with having a desk for the bed (7).

Desktop. The desktop for this system will need to be made custom to be tailored to the dimensions of the bed. Existing desktops on the market are nearly all designed for stand still desks and tables. However, since there are many lightweight options that would be optimal for this system, I will be trimming down an existing desktop to function for my system. The desktop will be made from particle board and have dimensions of to 70" x 16" x 1" fit a queen sized bed. Being cemented to the top of the particle board will be an 1/8" thick piece of whiteboard. The whiteboard will not be used to strengthen the system, however it will be installed to increase the efficiency of the user. Allowing the user to utilize the entire surface of the desktop is something that will promote productivity and efficiency.

Caster Wheels. Uplift Desk Provides Two different sized caster wheels to pair with their desks, as opposed to using leveling feet. I decided to choose the smaller caster wheel for my application because this design will be utilized on a hard wood surface (7).

Frame materials. Because the actuator selection supports up to 355 lbs. there needs to be a strong support around the rest of the system. The remaining portion of the frame will consist of A36 steel and cast aluminum. The pieces for the brackets will consist of A36 steel adding to the rigidity, but also adding weight. It is important to consider the weight of the system because of the concern of the product moving while in use. The feet of the system will be made from cast aluminum with ridges underneath. This makes for easier manufacturing of the shape while also making up for the weight and strength of the aluminum.

### **Design Change**

When looking at the drawings and final model of the design for the mobile bed desk, it is important to note the finalized design change. The model of the desk shows that the middle bracket support will be located at the bottom side of the desk. Upon fabrication of the desk, it became apparent

that this will be limiting its mobility. The mobility would be limited by the supports of the bed, which defeats the purpose of being able to move it with the casters. Because of this, during fabrication I decided to have the middle bracket attached at the top portion of the linear actuators, while being screwed into the underside of the bottom portion of the desk to add stability.

## Drawings

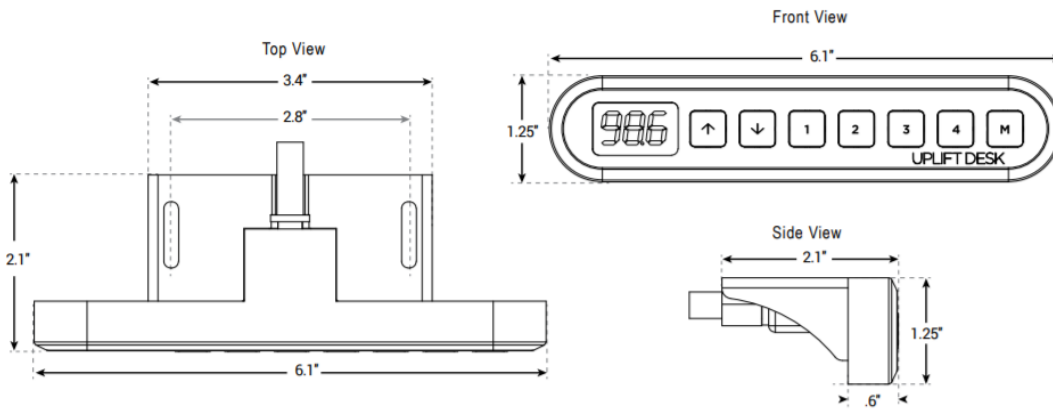


Figure 11. Uplift Desk Controller

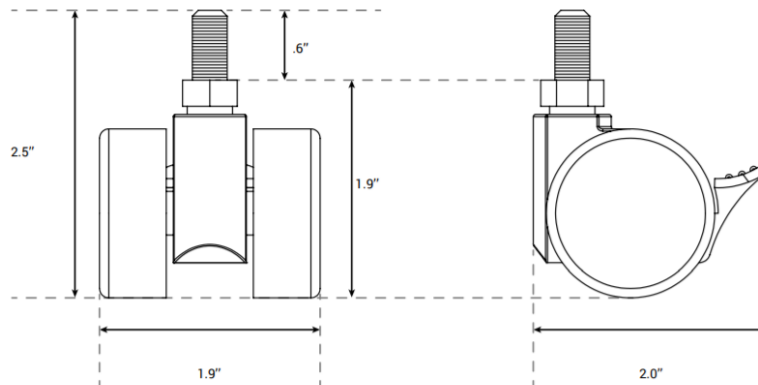


Figure 12. Uplift Desk Caster Wheel

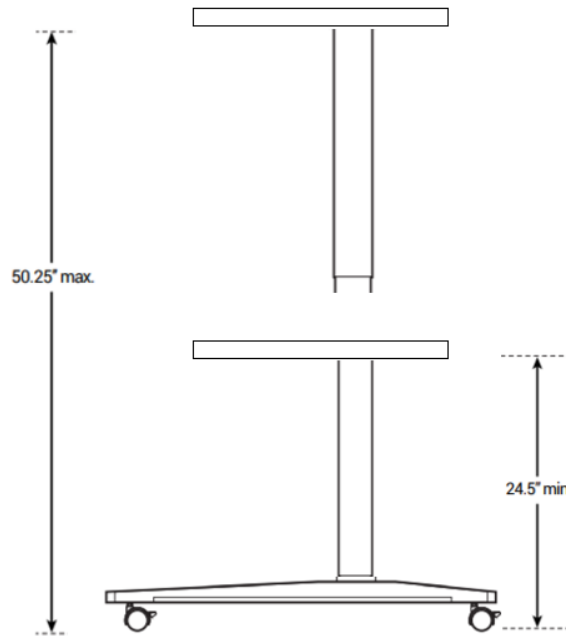


Figure 13. Design Desk Assembly (side)

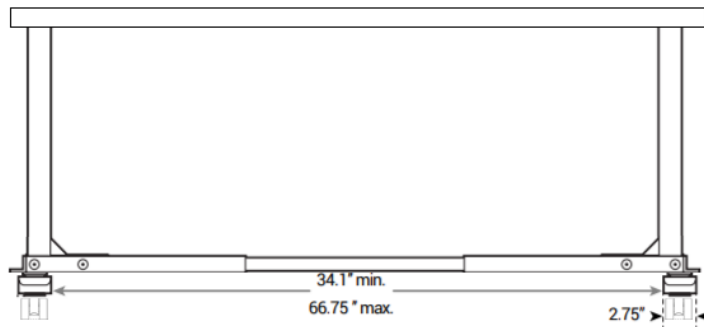


Figure 14. Design Desk Assembly (front)

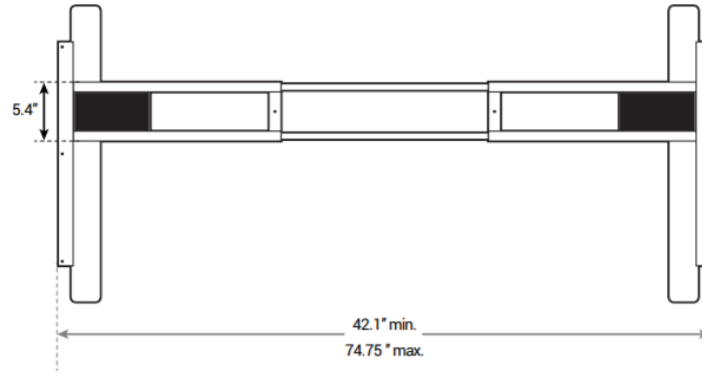
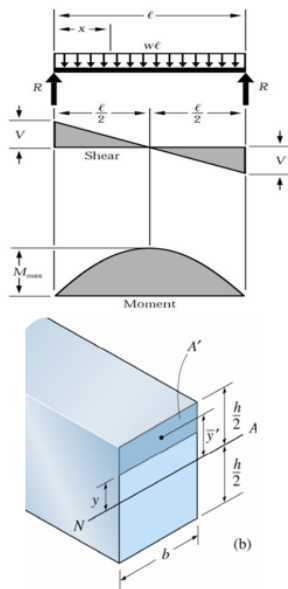


Figure 15. Design Desk Assembly (top)



$$wL = \left( 2.31 \frac{\text{lbs}}{\text{in}^2} \right) * 65 \text{ in} = 150 \text{ lbs}$$

$$R_1 = R_2 = \frac{wL}{2} = \frac{150 \text{ lbs}}{2} = 75 \text{ lbs}$$

$$M_{max} = \frac{wL^2}{8} = \frac{2.31 * (65^2)}{8} = 1,220 \text{ lb} * \text{in}$$

\*Largest moment is at the middle (Normal Stress)\*

\*Largest shear is at the supports (Shear Stress)\*

$$Q = \bar{y}' A' = [ y + [(h/2) - y] ] * \frac{1}{2} * [(h/2) - y] b$$

$$Q = \frac{1}{2} [h^2 - y^2] b$$

$$Q = .9375 \text{ in}^3$$

$$\tau = VQ / It = \frac{V \frac{1}{2} [h^2/4 - y^2] b}{(1/12 b h^3) b}$$

$$\tau = \frac{6V (h^2/4 - y^2)}{bh^3}$$

Figure 16. Basic Loading Calculations

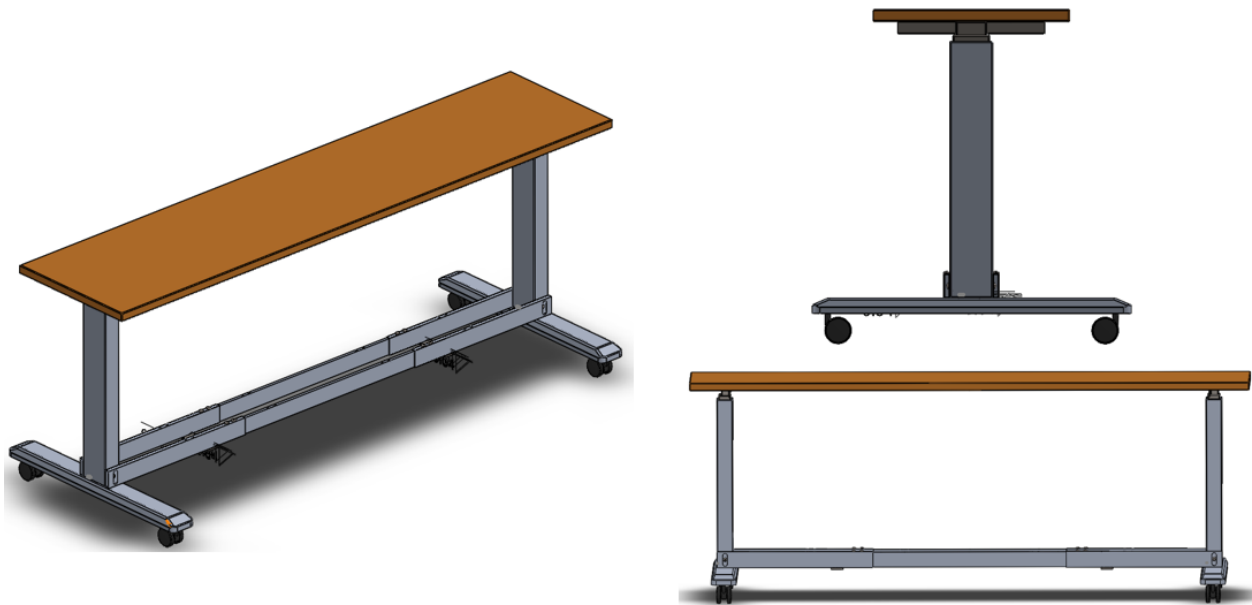


Figure 17. Final Model of Design

Name	Type	Min	Max
Stress1	VON: von Mises Stress	1.107e-01 psi Node: 40687	6.030e+03 psi Node: 7678
Factor of Safety1	Automatic	6.614e+00 Node: 7678	3.602e+05 Node: 40687

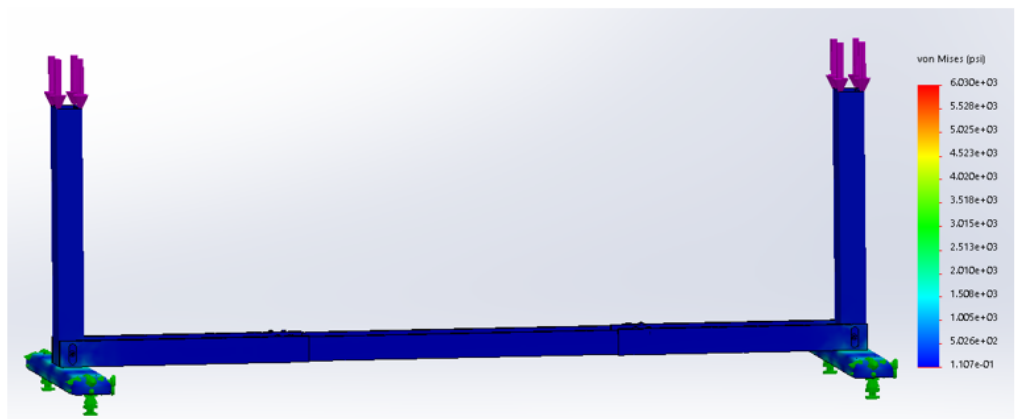


Figure 18. Stress Analysis of System

Pictured above is the stress analysis of the framed system. The load being applied is a total of 250 lb. load. The results of the FEA show that the minimum factory of safety that is being experienced is 6.614. This is right in the middle of where the expected factor of safety for this system is (6-7).

## Bill of Materials

BOM			
Item #	Part	Description	Qty.
1	Leg	Steel	2
2	Foot	Aluminum	2
3	Crossbar End	Steel	2
4	Crossbar Rail	Steel	2
5	Side Bracket	Steel	2
6	Adhesive Pads	-	10
7	Control Box	Key Pad Controller	1
8	Key Pad	Preset Buttons and Display	1
9	Cables	Connector and Power Cables	3
10	Cable Clip	Plastic	10
11	Machine Screw	M6x14	24
12	Machine Screw	M6x10	8
13	Wood Screw	#10x5/8"	12
14	Machine Screw	#10-24x5/8"	8
15	Caster Wheels	M8x15 mm	4
16	Desktop	Particle Board/Whiteboard	70" x 16" x 1"

*Table 3. Bill of Materials*

## Fabrication

For this system, the fabrication can be broken down into two separate phases: the desktop and the frame. They are separate phases because the entire fabrication process does not involve parts from either phase until the assembly portion at the end. The desktop phase, the much shorter of the two phases, consists of 3 manufacturing processes: sawing, adhering, and finishing. Sawing takes place to cut both the particle board and the whiteboard to the desired size of the desktop. Once these two pieces are cut to size, they are adhered together using contact cement. After the contact cement has been applied, the desktop assembly, as a whole, can be finished and ready for assembly. For the frame portion of fabrication, 4 manufacturing processes take place: milling, welding, tapping, and finishing. The metal pieces for the legs, bracket, and

desktop mount are milled to size, some welded together, and then finally tapped in locations for the desired screw size. After these pieces are all in their correct form, they are then finished by a powder coating technique. Once the two phases of fabrication are complete, the two pieces are fastened together using wood and machine screws. There is an additional part that was fabricated that was not included in either phase. The additional part was a 3D printed holder for the controller. The piece was added to eliminate the permanent position of the controller. The piece will be mounted on both sides of the desktop (both ends of the bed) so the user can easily move the controller to either side.



*Figure 19. Frame Phase Components*



*Figure 20. Desktop Frame Components*

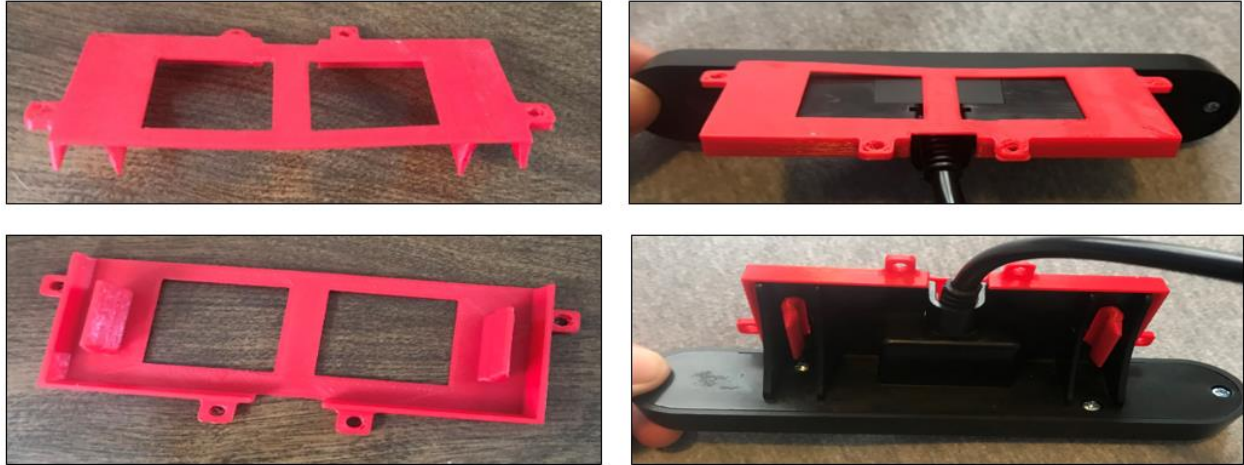


Figure 21. Controller Holder



Figure 22. Final Assembly

## Testing

The testing for the mobile bed desk was completed using 3 tests: concentrated load testing, distributed load testing, and ergonomics testing. The first two tests are an easy, quantifiable, pass/fail test. The desk should simply continue to operate while under the given loading conditions. The concentrated load was using 15, 10 lb. weights, all concentrated in one spot in different areas of the desktop. For the distributed load, the 10 lb. weights are distributed throughout the entirety of the desktop. For the ergonomic testing, a user will be asked to utilize the desk until he/she is not able to focus due to comfortability. The desk passed all tests, with a stipulation on the last test. The user was able to utilize the desk for two hours without feeling uncomfortable because they were able to sit in any position they wanted, while moving the desktop upward or downward. The user stopped using the desk due to other obligations and not due to being uncomfortable.

Test Type	Requirement	Pass/Fail
Concentrated Functional Load	Unit should not lose function	Pass
Distributed Functional Load	Unit should not lose function	Pass
User Testing	Duration of comfort	Pass

*Table 4. Product Testing*

## **Project Management**

### **Project Budget Limit**

Current Budget	
Materials	\$ 550.00
Labor	\$ 50.00
Total	\$ 600.00

*Table 5. Target Budget*

Item	Part	Description	Quantity	Price	Actual	
1	Standard Frame Actuators and 16" feet	Aluminum/ Steel	2	\$ 399.00	\$ 399.00	
2	Adjustable Bracket	Steel	2			
3	Memory Height Controller	-		\$ 34.00	\$ 34.00	
4	Caster Wheels	150 lb. capacity	4	\$ 39.00	\$ 39.00	
5	Desktop	Partical/White Board		\$ 50.00	\$ 30.00	
6	Miscellaneous Fab Expenses	Contact Cement, Paint etc.	-	-	\$ 100.00	
				Total =	\$ 522.00	\$ 602.00

Table 6. Material Cost

## Project Schedule

Task Description		October			November				December					January				February				March					April					
		14	21	28	4	11	18	25	2	9	16	23	30	6	13	20	27	3	10	17	24	3	10	17	24	31	7	14	21	28		
Senior Design II	Concept Selection	█																														
	Finalize Timeline and Select Product Specifications		█																													
	Actuator Selection			█																												
	Foot Wheel System Selection				█																											
	Adjustable Slide Slection					█																										
	Model Leg and Actuator						█																									
	Model Desktop Setup							█																								
	Hand Calculations				█	█	█	█	█	█	█																					
Senior Design III	Order Parts												█	█	█	█	█															
	Design Presentation																	█														
	Assembly																	█	█	█	█	█	█	█	█	█	█	█	█	█	█	
	Testing																									█	█	█	█	█	█	
	Tech Expo																													█		
	Final Presentaiton																														█	

Table 7. Current Schedule

## References

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