Bed Adjustment Project

OneNote Summary

ME 641

Sponsored by Dr. Barbara J. Polivka, PhD, RN, FAAN, Associate Dean of Research at KUMC

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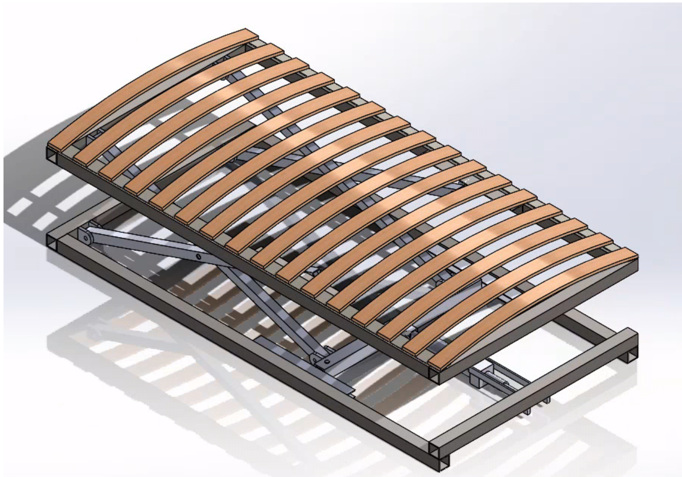
Overall Specs and Goals

Specifications:
Overall Length: 74 7/8"
Overall Width: 38 7/8"
Overall Height (collapsed): 10"
Overall Height (fully raised): 25 ¾"
Weight: 137 lbs

Goals:
Able to replace an existing box spring on a bed. - Met Goal
Able to raise and lower a patient by at least 14" - Exceeded Goal
Able to support up to 500lbs – Met Goal
Able to be assembled within 30 minutes by at least 2 individuals. - Met Goal
No forces greater than that experienced in a barber chair when raising and lowering – Exceeded Goal
As stable when fully raised as fully lowered. - Mixed Results



CAD model of final design


Fully assembled device in both the raised and lowered positions. Note the bed frame used was for a full sized bed, rather than a twin.

Manufacturing and Testing Schedule

Phase I (Prep, April 7 - April 24)
-Measure all features to be cut and mark with sharpie
-Cut all beams to size
-Drill out holes
-Shape features
-Weld beam extensions
-De-burr edges

Phase II (Production, April 24 - May 20)
-Press fit bronze tubing
-Weld caps and L bars
-Weld hinges into place
-Clean up welds
-Assemble frame + arms
-Install hydraulic cylinder

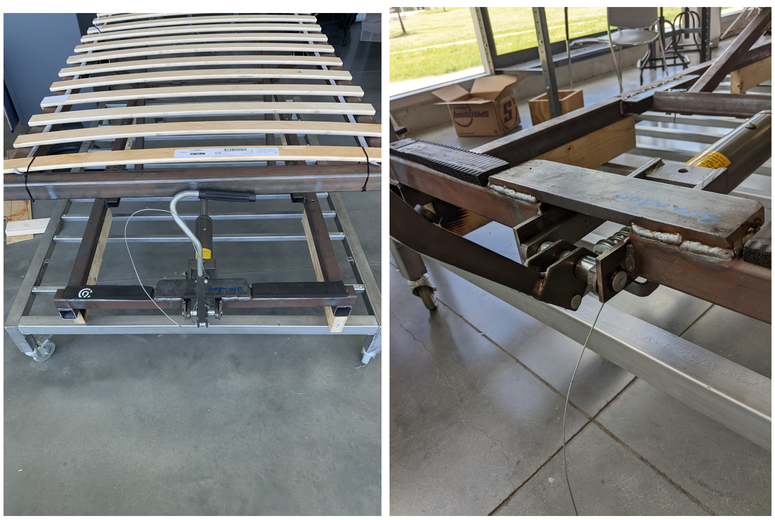
Phase III (Testing, May 20 - June 3)
-Basic Operation (ensure target height is reached)
-Bed Frame fit test
-Weight test (sand bags/concrete, ask facilities?)
-Vertical Forces testing
-Stability Testing

Phase IV (Redesign, May 25 - June 3)
-Address any faults found in testing
-Recommend design changes for future manufacturing.

Changes to Design

Hydraulic-Pushbar Junction Box - The length of the box connecting the hydraulic cylinder to the push bar needed to be increased to around 4.5" to ensure the hydraulic would be fully retracted when the device was at rest at its lowest setting.

Hydraulic Housing - The housing brackets for the hydraulic cylinder needed to be completely redone do its unusual size. A section of the bottom frame at the foot of the device was cut away and the hinges welded to the cut ends to allow for the hydraulic to lay perfectly horizontal. A small strip of 1/8" thick scrap metal was welded between the top of the cut ends to prevent bending, however during initial testing, forces from the hydraulic proved this to be inefficient, with the metal strip bending the hard way. The strip was cut off and a larger stock of ½" thick steel was welded in its place. This new weld sufficiently held up to maximum loads.



Images showing the required modifications to the back of the device to accommodate the hydraulic.

Frame Spacing and Cushioning – In order to ensure the device would remain horizontal at its lowest setting, 2" spacers were welded to the head of the bottom frame which would match the spacing found at the head of the bed. Wooden supports were also added to the bottom of the frame to accommodate the extra space needed for the hydraulic. Additionally, foam padding was added between the top and bottom frame to cushion the landing when lowered.

Side view of the device lowered and fully raised, note the aforementioned spacers, supports, and padding present on the bottom frame.

Dimensional Testing

Goal 1: Able to replace an existing box spring on a bed. - Met Goal
Goal 2: Able to raise and lower a patient by at least 14" - Exceeded Goal

Methods: The device must have the dimensions of a standard box spring for its size (Twin: 75"L x 38"W x 8-10"H). As it was discovered late that the bed frame previously acquired was a full size rather than a twin, overall measurements of the device were taken and compared with the standard box spring size. The length and width of the device were measured after assembly. The height was measured at the lowered position, and the change in height measured in its fully raised position

Results: Length: 74 7/8"
Width: 37 7"8"
Height: 10" lowered
Raised Height Change: 15 ¾"

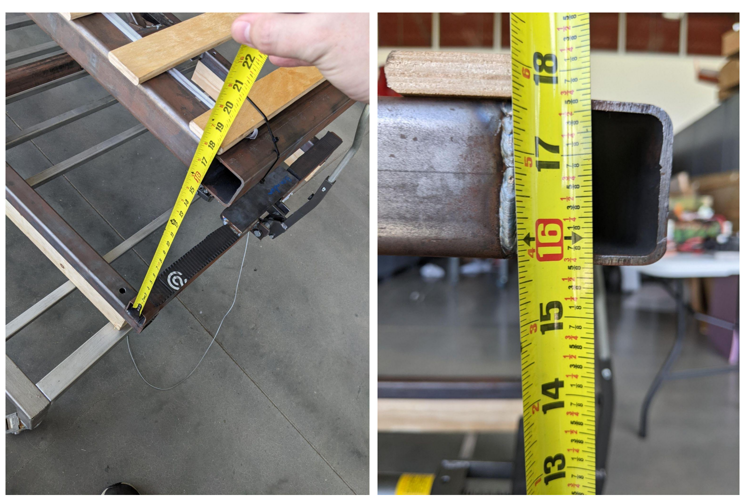
Conclusion: The device is close enough to standard box spring sizes to easily be able to integrate on most existing bed frames. When fully collapsed, the device is within the range of standard box spring thicknesses. This height could be further reduced by shortening the wooden feet of the device. The change in height between fully lowered and fully raised was measured to be 15 ¾", exceeding our goal.

Data:

Length measurement of device

Width measurement of device

Height measurement of device



Raised distance measurement

Experienced Forces Testing

Goal: To ensure patient safety and comfort, forces experienced by the patient during operation should not exceed those experienced when using a standard barber chair. - Exceeded Goal

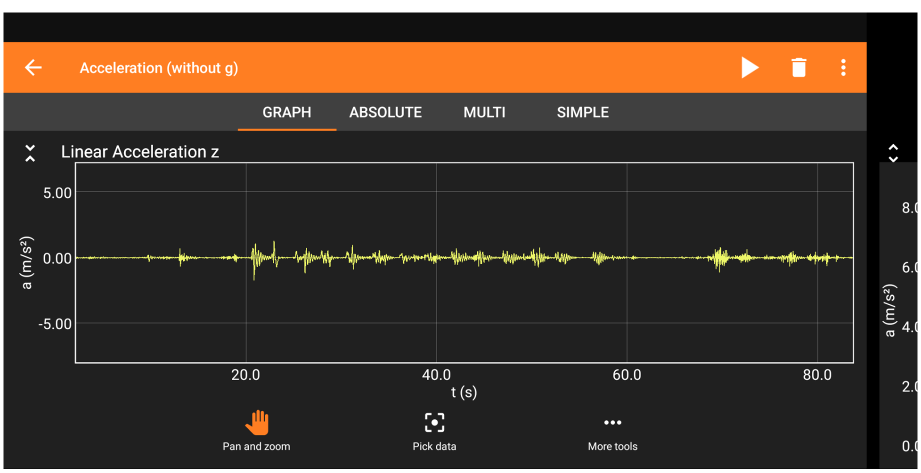
Methods: The Phyphox Android App was used to access the sensor data in a smartphone. Acceleration data was recorded with the phone placed face-up on a standard barber chair while it was fully raised and lowered. This set-up was repeated on the assembled bed lifting device and the results compared. The axis corresponding to vertical acceleration in this set-up was the z-axis, with data from the other two axis being negligible.

Results: Maximum acceleration on the lifting device was 1.77 m/s^2 experienced near the beginning of the lifting phase. Maximum acceleration on the barber chair was 4.33 m/s^2 experienced during the end of the lifting phase.

Conclusion: Vertical acceleration experienced on the bed lifting device was found to be significantly less than that found on the barber chair. As the vertical acceleration directly relates to the forces that would be experienced by the patient, we can conclude that the device will exert less forces on the patient than a barber chair while raising and lowering.

Data:

Vertical Acceleration on Barber Chair During Raising and Lowering



Vertical Acceleration on Bed Lifting Device During Raising and Lowering

Stability Testing

Goal: Have the device be as stable when fully raised as fully lowered. - Mixed Results

Methods: Forces were applied to the top of the fully raised device both laterally and horizontally and the results observed.

Results: Almost no movement in the device was observed with lateral forces, however horizontal forces did produce some shaking. However, upon examination, the majority of the movement was coming from the bedframe itself, with the movement from the device contributing only a small fraction of the overall.

Conclusion: While the device did not fully meet the goal of being as stable when raised as when lowered, the overall stability was quite good at all levels. As the majority of the observed movement came from the bedframe itself, we can presume that our device would not contribute enough to cause a negative impact to patient safety.

Data:
See attached video in email or OneNote

Weight Testing

Goal: Able to support up to 500lbs - Met Goal

Methods: Members of the team volunteered to be raised and lowered while laying on the bed. Only one person was used for the first round of testing. After the device had been reinforced, two team members laid on the bed at the same time with a total weight of ~500 lbs.

Results: While the device was able to raise and lower one team member during the first round of testing, it caused a bending and deformation of the back end of the device. This required the design to be reevaluated and eventually reinforced with a ½" thick steel plate to prevent future bending (See: Changes to Design). During the second round of testing, first one, then two team members were able to be easily raised and lowered with no observable deformation.

Conclusions: The two members on the device had a combined weight of ~500lbs. As they were able to be easily raised and lowered, the device successfully met the initial goal. Concern over the lack of specifications on the hydraulic prevented testing to failure.

Data:
See attached video in email or OneNote for full weight testing.

First image shows team member Paxton Neff supported by the assembled device during initial testing. Second image shows the 1/8" piece of steel that was originally welded over the gap in the bottom frame along with the noticeable bend and deformation after testing concluded. This part was cut off and a larger, ½” thick plate was welded in its place.

Future Recommendations

A different hydraulic or lifting mechanism should be used. Our biggest constraint was the unusual size and limited data we had on the hydraulic we removed from the lift cart. This forced us to make some impractical design choices in order to fit it in. A future team using their own sourced hydraulic should redo the entire housing to accommodate its size without having to cut away a portion of the frame.

The hydraulic-push bar junction box should be made of a thicker material, or have support material welded around it. During operation, part of the junction box became bent due to initial forces. While this did not impact the operation of the device, it represents a potential failure point that should be corrected moving forward.

The entire frame should be remade with corrugated aluminum to save weight. Our analysis showed that the forces experienced in our design could be supported by aluminum instead of steel. This may reduce the factor of safety some, but not to a unacceptable degree. Reducing the weight will make the device easier to set up and break down, as well as reduce the additional load that would be placed on a patient's bedframe.

While the device was relatively stable at its maximum height, with more movement coming from the bedframe itself rather than the device, additional stability could be created with the installation of support beams between the scissor arms. While unnecessary for the twin sized model, they may be more important if the device were to be scaled up.