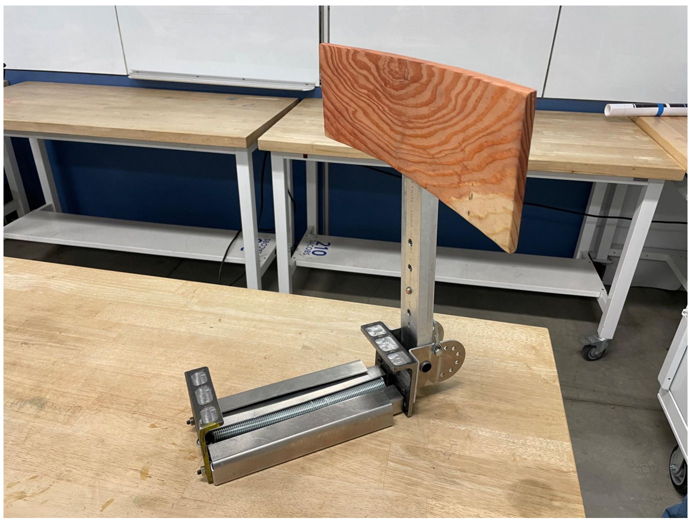
Recline

Group 1034



Ezenbaatar Batjargal, Kylie Bell, Ricardo Cano, Nolan Herbert, Vic May, Jackson Zilles

Comprehensive Description:

Lab 7:
Ezenbaatar - Contributed to the problem decision, created 15 sketches, discussed and brainsotrmed ideas with group members.
Kylie - discussed choice of problem, contributed ideas and sketches, helped moderate decisions of problem and solution, assisted with early component design
Ricardo - contributed 10 quick sketches with concept of adjustable components. Discussed and compared ideas with group members until final designs.
Nolan - Discussed problem to be solved, provided 10 sketches, communicated with group members to agree on a particular design and what features should be included
Vic - Contributed to the problem decision discussion, and created 10 quick sketches aimed towards the chosen problem (including designs with height adjustability). Reiterated ideas amongst group members until a final design was decided upon.
Jackson - problem decision discussion, 10 quick sketches, favorite concepts discussion, comparing idea to current solutions, final product design drawing

Lab 8:
Ezenbaatar - Identified Components, created a thorough description drawing of the items to show which number corresponds to which component of the item using Adobe Illustrator. Named the charts on our document. Presented the components to the lab class.
Kylie - Was absent/sick on lab day, so I completed the supplementary portion outlined in Thena's announcement. Commented on 2 different parts for each engine and discussed possible alternative manufacturing methods.
Ricardo - Helped with the reasoning behind our manufacturing choices with the stirling engine.
Nolan - Identified materials and manufacturing processes for parts such as the bottom plate, wheel, and O rings for the first engine as well as parts such as the many arms and wheel axle housing in the second engine and listed how good of a choice the material and manufacturing was for all of those parts.
Vic - Identified components, manufacturing processes, and materials, such as the ball bearings (15) in our first table and anti-scratch pads in our second table (4) for example, associated with our chosen stirling engines. Also created tables for our team to place our reverse-engineering and collaborative team plan data into.
Jackson - Helped identify components, materials, and manufacturing processes for all pieces of both engines. Judged components on good/bad choice for material/manufacturing. Created lab report. Collaborated to answer lab questions.

Lab 9:
Ezenbaatar - B shape and design, D vertical adjustment idea, F Housing with springs that interacts with G, made a major component identifying list with it's sketched image.
Kylie - All drawings, all note-taking, keeping members on track, refining ideas

Ricardo - Possible clamping in the bottom of the seat if needed.
Nolan - C shape of outer clips, long horizontal clamp idea. Identified fits, purpose of fits, and the types of fits #2,3,4
Vic - Double horizontal spring (H); friction pads and post-manufacturing securing hole addition if needed; G shape of stationary outer clip (C). Vertical movement of component B (backrest). Completion of fits table (7).
Jackson - Double spring tensioning and box covering, C shape of outer clips, pin hinge mechanism, manufacturing (metal bending and welding, bolting)

Lab 10:
Ezenbaatar - Measured the outer diameter of the object using digital calipers, and drop gauge. Measured the diameter of the inner circle of the object using hand calipers. Answered questions on the report, assisted in the spreadsheets.
Kylie - Measured outer diameter with plastic calipers and micrometer, measure with drop gauge, filled table out.
Ricardo - Measured the outer and inner diameters using the plastic caliper, and measured the Outer diameter using the drop gauge. Helped set up the functions for the mean and standard deviations in the spreadsheet.
Nolan - Measured diameter of the hole near the milled face, filled out stage 2 table, measured roundness answered questions 1b and 2e
Vic - Various calculations and measurements–Row 5 stage 2 (dimension A with plastic calipers), Row 3 stage 1 (distance from machined flat to opposite side with plastic calipers), Columns 8 and 9 stage 4 (roundness component E) in addition to extraneous identifier data (names and units). Formatting lab report.
Jackson - Measured overall length of component with digital calipers, measured dimension A with plastic calipers 5 times, measured part to part dimensional variability, measured drop gauge readings

Lab 11:
Ezenbaatar - Mass production table, Fit table, Fit checking
Kylie - Drawing header, notes, fit table checking
Ricardo - mass production/ fit table dimensions, CAD model
Nolan - Mass production table:3,6,5,2,4 Fits table: 2
Vic - Mass Production Table oversights + double checking; overall addition of Pivot Rod and Screw caps (as well as the addition of their respective fits).
Jackson - mass production advantages/disadvantages, fit table critical dimensions and tolerances, role discussion

Prototyping (+CAD):
Ezenbaatar - researched a better additive manufacturing resources. Using out of campus resources, 3D printed Carbon fiber reinforced print for the vertical adjustment unit. Cadded the difference size.
Kylie - Machined steel clamp pieces, revised drawings accordingly
Ricardo - attempted to update full CAD assembly as parts were updated and began detailed drawings of finished components.
Nolan - bought wood for backrest piece, cut, sanded and stained the resulting piece
Vic - Found springs for prototype, provided spring CAD file, re-tapped holes on 3-D printed component (including holes securing adjustment bracket to backrest, and bolt to change backrest height), secured vertical adjustment bracket to backrest. Provided workspace with tools for team to meet and begin prototype assembly.
Jackson - 3d printed spring housings, bent, drilled, and filed pin hinges and metal housings, cut springs, turned pivot rod, milled and tapped vertical extension and vertical support, CADed housings, clamps, vertical support, vertical extension, vertical adjustment, pivot rod

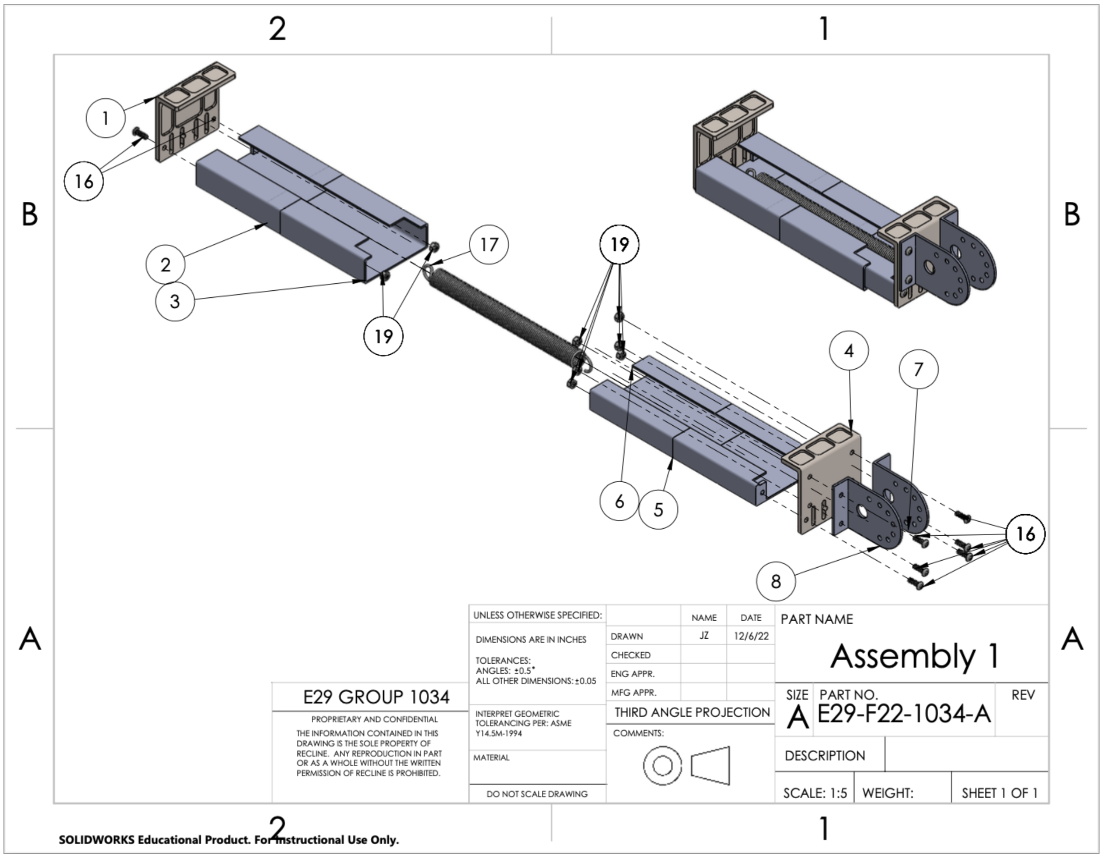
Final Report (+assembly drawings, detail drawings, Jacob's Showcase):
Ezenbaatar - Completed the contribution for previous labs, based on the old experiences advised for changes on assembly drawings. Helped to finish the showcase while presenting the idea to other students.
Kylie - Completed documentation based on the iterative manufacturing experience, analyzed process selection and scaled up production plan, materials choices
Ricardo - Made detailed drawings, added additional GD&T, and justified the decisions for the GD&T used.
Nolan - completed individual contribution for previous labs, aided in presentation of our project at the Jacob's showcase
Vic - Initiated creation of final report, completed and added mass-production table/scaled up production plan and most lab contributions for team, aided in presentation of project at Jacob's showcase.
Jackson - made assembly drawings, made and adjusted detail drawings, completed bill of materials, design for manufacturing, fits table, mass production table, exploded view assembly drawings, reflection, acknowledgements, presented project at Jacob's showcase

Market need:
Seats with no back support, such as stools and benches, are intended to promote modularity, but also promote poor posture while sitting for long periods of time which can lead to future health complications.

Description:
We have created a modular backrest for multiple seating options that currently have no back support with the benefits of aiding good posture, decreasing back pain and other health issues. The design accommodates an adjusting backrest pivoted to include multiple degrees of rotation, which is then attached by spring loaded clamps to any seat. With a removable backrest, fatigue is reduced while maintaining the structure and functionality of the original seat.

Differentiation:
Similar products are offered for stadium bleacher seats, many of which incorporate a fabric seat and seat back that attaches onto a rectangular bench. However, to accommodate a wider range of seat profiles and to offer a more secure fixture system, the design offers more degrees of freedom for the user. The spring loaded clamp system interfaces with the backrest, providing superior stability.

Exploded view assembly drawings:



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E29 GROUP 1034
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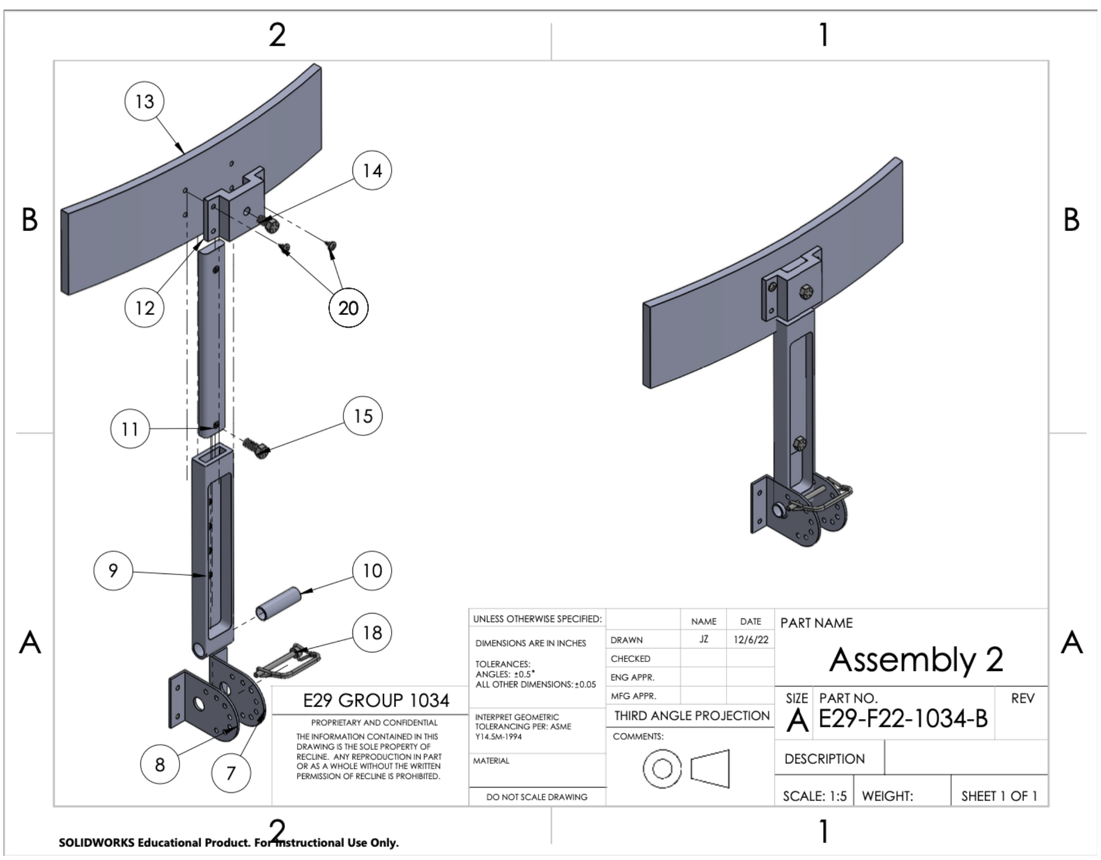

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SHEET 1 OF 1
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Fits and tolerances table:

Fit #	Component 1	Component 2	Function of fit	ANSI class of fit with description of relative forces	Component A critical dimension and tolerance	Component B critical dimension and tolerance
1	16 (¼” Bolt)	1 (Front Clamp), 2 (Outer Housing)	Permanent connection	RC6 *Medium Running Fit* pieces must slide smoothly, bolt and nut will tighten connection	Off the shelf 0.25” nominal (¼” - 20)	Holes H9, 0.25” nominal, +0.0014 to 0.000
2	2 (Outer Housing)	3 (Outer Housing B)	Permanent connection	Glued Pieces	Clearance fit so glue can be added	Clearance fit so glue can be added
3	2 (Outer Housing), 3 (Outer Housing B)	5 (Inner Housing B), 6 (Inner Housing)	Fluid sliding between parts to cover springs	RC6 *Medium Running Fit* pieces must slide smoothly, tight fit is not required	Hole H9, 4.5” nominal, +0.0022 to +0.000	Shaft e8, 4.5” nominal, -0.0030 to -0.0044
4	5 (Inner Housing B)	6 (Inner Housing)	Permanent Connection	Glued Pieces	Clearance fit so glue can be added	Clearance fit so glue can be added
5	16 (¼” Bolt)	6 (Inner Housing), 4 (Rear Clamp)	Permanent connection	RC6 *Medium Running Fit* pieces must slide smoothly, bolt and nut will tighten connection	Off the shelf 0.25” nominal (¼” - 20)	Hole H9, 0.25” nominal, +0.0014 to 0.000
6	16 (¼” Bolt)	4 (Rear Clamp), 7 (Pin Hinge A), 8 (Pin Hinge B)	Permanent Connection	RC6 *Medium Running Fit* pieces must slide smoothly, bolt and nut will tighten connection	Off the shelf 0.25” nominal (¼” - 20)	Hole H9, 0.25” nominal, +0.0014 to 0.000
7	7 (Pin Hinge A), 8 (Pin Hinge B)	10 (Pivot Rod)	Slow rotation via vertical support	RC3 *Precision running fit* piece must rotate slowly and run freely	Hole H7, 0.75” nominal, +0.0008 to +0.000	Shaft f6, 0.75” nominal, -0.0008 to -0.0013
8	7 (Pin Hinge A), 8 (Pin Hinge B)	18 (Pin)	Hold up vertical support, easy to insert	RC9 *Loose running fit* must be easy to insert, no friction necessary	Hole H11, 0.25” nominal, +0.0035 to +0.000	Shaft, 0.25” nominal, off the shelf
9	10 (Pivot Rod)	9 (Vertical Support)	Axle for support to rotate around, press fit	LN2 *medium drive fit*, pivot rod pressed into vertical support, ordinary steel part	Hole H7, 0.75” nominal, +0.0008 to +0.000	Shaft s6, 0.75” nominal, +0.0019 to +0.0014

10	9 (Vertical Support)	11 (Vertical extension)	Adjusting height of backrest	RC9 *Loose running fit* must be easy to insert, no friction necessary	Shaft, 2” nominal, -0.009 to -0.0135	Hole H11, 2” nominal, +0.007 to +0.000
11	12 (Vertical Adjustment)	13 (Backrest)	Permanent connection	Threaded (clearance and then interference)	Holes for screw	Pilot Holes
12	14 (7/16” x ¾” Bolt)	11 (Vertical Extension)	Hold backrest in place via vertical extension and vertical adjustment	Threaded (clearance and then interference)	Threaded bolt (7/16” - 20)	Matching thread for bolt (7/16” - 20)
13	14 (7/16” x ¾” Bolt)	12 (Vertical adjustment)	Hold backrest in place via vertical extension and vertical adjustment	RC6 *Medium Running Fit* pieces must slide smoothly, vertical adjustment will tighten connection	Off the shelf, 0.5” nominal	Hole H9, 0.5” nominal, +0.0016 to +0.000
14	15 (7/16” x 1” Bolt)	11 (Vertical adjustment), 9 (Vertical support)	Adjust height via optional holes in vertical support; bolt through both pieces	Threaded (clearance and then interference)	Threaded bolt (7/16” - 20)	Matching thread for bolt (7/16” - 20)
15	1 (Front Clamp), 4 (Rear Clamp)	17 (Spring)	Hold spring in place while under tension	LC11, minimal importance fit, tension holds spring in place so it only needs to be able to easily slide through	Hole H13, 1” nominal, +0.012 - 0.000	Off the shelf, 1” nominal diameter

Additional fits and tolerances:
Regarding the GD&T tolerance choices in the drawings, for parts that were bent during the machining process, perpendicularity tolerances were added with datums to ensure the bent parts were perpendicular. Cylindricity tolerances were only added to the pivot rod as it was the only cylinder in the project that needed a tolerance to allow it to fit through the vertical support, and pin hinges. The flatness tolerance was used for parts that would slide along each other such as the clamp housings and the vertical adjustment. These required a flatness tolerance to allow for smoother slide and ease of adjustment. Finally a surface tolerance was used on the backrest to keep the wood surface even and unobtrusive to the users back. A proper surface tolerance allows the backrest to optimally serve it’s only function and avoid causing the users of this backrest discomfort. This is important for our project especially for the pin hinges since they are bolted on the clamps and hold the entire backrest system in place. One additional fit not mentioned in the

table is the actual fit of the product onto a stool. The spring force creates tension that pulls the front and rear clamp together on the sides of the stool, and the top sections of the clamps with the help of gravity hold the clamps on vertically. This system sustains enough force to counter the forces of use, i.e. a user leaning back.

Process selection:
3D printing - For the backrest attachment piece, the U-shaped curve necessary to accommodate the vertical support was more feasibly achieved by an additive process such as 3D printing rather than subtractive manufacturing. 3D printing reduces weight, and since the attachment piece is not subjected to high amounts of force, offers a time efficient solution within the desired tolerance.
Machining - Specifically for the attachment between the clamps and the springs, the clamps needed to provide significant rigidity since the springs exert a large force to ensure a secure fit onto any seat. The features on most of the components were machined, and while hand machining does create variability in accuracy and tolerance, the material properties of essential parts were prioritized. It is difficult to simulate material properties of aluminum and steel with 3D printing material with our current access to resources, so while 3D printing may be more accurate, machining achieves similar outcomes.

Scaled-up production plan:
As a whole, the design is quite hefty as a result of the steel and large aluminum bars used in major parts of the backrest and clamp. While steel and aluminum offer significant structural support, these parts could be manufactured using lightweight carbon fiber or thinner profile metal pieces that provide the same rigidity. For the adjusting vertical support, the thickness of the bar could be reduced and the exterior housing of the support could also benefit from a reduction in thickness, through possible processes such as metal injection molding or die casting. With a mold, it reduces manufacturing time by accounting for holes and other features that would otherwise have to be machined. In addition, the attachment from the vertical support to the backrest would be most efficiently produced by plastic injection molding as opposed to 3D printing. More parts can be made at a time and the amount of secondary finishing processes is also reduced.

Mass Production Table – for scaled up production plan

Component #	***Component Name***	***Mass production manufacturing process***	***Material Choice(s)***	***Process advantages***	***Process Disadvantages***
9	Vertical	Extrusion	Aluminum	Creates complex	Parts need to be cut

	support	Process		shape from stock material, fast	to size, machinery is expensive
		D. O. M (Drawn over mandrel)	Aluminum	Very High quality end product, creates complex shapes	Production is bit slow compared to conventional methods
13	Backrest	Plastic injection molding	PLA	Creates complex shapes, reusable and repeatable	Higher chance of failed end products
		Blow Molding	ABS	Creates complex shape, reusable and repeatable	Limited hollow parts
1,4	Front and Rear Clamp	Die Casting	Aluminum	Quick, creates complex 3D geometry	Expensive to create molds, issues may arise with prosperity of technique
		Plastic injection molding	PLA	Creates complex shapes, reusable and repeatable	Higher chance of failed end products
12	Vertical adjustment	Permanent Mold	Aluminum	Accurate, doesn't limit thickness	Relatively long manufacturing time
		Stamping	Aluminum	Fast, accurate	Limits part thickness
7,8	Pin Hinges A and B	Stamping	Stainless Steel	Fast, creates the needed complex shape	Limits thickness of part
		Extrusion	Stainless Steel	Creates needed shape, doesn't limit thickness	Expensive, parts will need to be cut to size
2,3, 5,6	Housings	Die Casting	Aluminum	Fast, accurate, no need to cut	Expensive molds, longevity issues
		Extrusion	Aluminum	Fast, accurate	Part will need to be cut to size, expensive tools
11	Vertical extention	Die Casting	Aluminum	Fast, accurate, no need to cut	Expensive molds, longevity issues
		Blow Molding	Aluminum	Designed for high volume production,	Requires upkeep and maintenance to the

				fast, relatively cheap, no need to connect parts	cavity.
17	Springs	Off the shelf - (McMaster-Carr)	Stainless Steel (ASTM-313)	Non-corrosive and temperature resistant, common, so easy to get off the shelf.	Weaker than music wire, possibly more expensive.
		Coiling	Stainless Steel	Ability to hand select spring constants, lengths, diameters, and tolerances of springs.	Labor intensive with large room for human error.
		Cutting	Pre-manufactured spring	Can size down a large spring.	Might waste spring material; will not work for short springs (cannot add length).
18	Pin	Drawing	Carbon Steel	Fast, accurate, no need to modify	Part will need to be precise cut to size
		Extrusion	Stainless Steel	Fast, accurate	Expensive, parts will need to be cut to size
20	Screws	Off the Shelf - (McMaster-Carr)	Stainless Steel	Cheap to acquire, easily interchangeable part	Tolerancing out of our control, product differentiability diminished
		Off the Shelf - (McMaster-Carr)	Brass	Cheap to acquire, easily interchangeable part	Tolerancing out of our control, product differentiability diminished
14, 15, 16, 19	Nuts/bolts	Off the Shelf - (McMaster-Carr)	Stainless Steel	Cheap to acquire, easily interchangeable part	Tolerancing out of our control, product differentiability diminished
		Off the Shelf - (McMaster-Carr)	Carbon Steel	Cheap to acquire, easily interchangeable part	Tolerancing out of our control, product differentiability diminished

10	Pivot Rod	Drawing	Stainless Steel	Low machining time, accurate due to machine cutting	Part will need to be precisely cut to size
		Extrusion	Brass	Low machining time, accurate due to machine cutting	Part will need to be precisely cut to size

Materials choices:
In addition to revised geometries to reduce overall weight, materials initially used for the prototype such as steel and wood, would be replaced with lighter but equally strong material, only now not restricted by the means of manufacturing. A majority of the components would be most efficiently produced by die casting or extruding aluminum, which would save material in comparison to the subtractive manufacturing process we executed for the prototype. 3D printed parts such as the vertical adjustment would be replaced by aluminum, but would be equal in weight while providing stability as a result of the piece requiring a thin profile. While 3D printed parts are easily replaced by a stamping process, the backrest would transition from using subtractive methods to additive methods such as plastic injection molding.

Design for Manufacturing:
Clamps - The clamps were machined out of 4130 steel ¼" right angle bar, which while relatively thin in profile, adds a significant amount of weight to the total assembly. Milling lightening panels on the top and interior face of the clamp was intended to reduce weight without sacrificing rigidity.

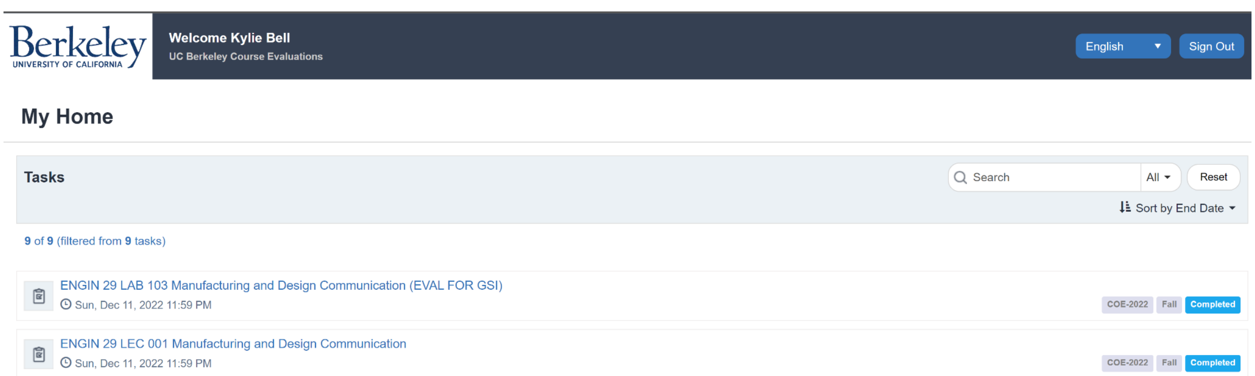
Vertical support/vertical extension - Due to the cost of metal, these two parts were made from scrap pieces found in the Etcheverry shop. Due to the lack of control over scrap piece dimensions, the designs of these pieces had to be modified to mesh with the scrap available. In the end, having the vertical extension slide through the vertical support was the solution. 7/16" threaded holes were added in both pieces to lock them in position.

Reflection:
Our biggest takeaway from this project was that dimensioning and tolerancing parts while making assemblies is not to be taken lightly. They have massive impacts on the final product, especially when being machined by hand. It is essential to find a balance between machinability and proper fitting. While prototyping and testing our design, we learned a lot about material properties. Some pieces broke, while others were too strong and therefore carried unnecessary weight. We were happy with the outcome of some pieces, such as the backrest, while we wanted more out of other pieces, such as the 3D printed housings. While assembling and watching others assemble our product, we learned that our assembly drawings were clear and understandable, but our actual product was creating trouble when getting pieces into place. We were able to use this

feedback to make adjustments. The most challenging task we faced was when we discovered our two spring system was far too strong and risked breaking the components. We were able to modify the parts to change it to a one spring system and solve the problem. The most surprising part of the project was how strong our original design ideas were. The vast majority of the changes we had to make came from material necessity, and the basic structure of our project is still very similar to our initial design. While working as a team, we learned to delegate tasks to the people who wished to take part in that portion, such as CAD or machining, and we also learned about each team member's personality and how we could all work together the best. During this project, we also learned more about CAD and machining processes, including the limitations of both. In the future, we would likely redesign many of our pieces to reduce weight and minimize machining. The clamps could be made out of aluminum to reduce weight, we could start designing with a one spring system in mind instead of two, and we could fix the housings to slide smoother. We could also decrease the size of the pin hinges and add more recline angles, revert the vertical extension and vertical support to one piece saving machining, and move the height adjustment back to the vertical adjustment. Overall, with mass manufacturing in mind, many small changes could be made, but we are proud of our idea and believe it was designed well, and that basic design we started with would still be present.

Acknowledgements:
We would like to thank Katherine, Scott, Alex, Dennis, and Eric of the Etcheverry Machine Shop for their limitless wisdom and support on this project. As our model was very machining intensive, we saved a lot of time and mistakes because of their help.

Course Evaluations



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Vic May VM

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● Completed Ends on: 2022-12-11
Update

ENGIN 29 LEC 001 Manufacturing and Design Communication
● Completed Ends on: 2022-12-11
Update

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