Assignment 4: Solids Models

Problem Statement

- Using the concepts made in Assignment 3, choose one concept to expand on, these expansions should make up three different modules or subassemblies. These subassemblies should meet the design parameters and criteria in the initial problem statement: The purpose of my design is to help utilize the limited space in my small kitchen, the design must be easy to use by myself and all my roommates, must be compact, made to be durable, relatively inexpensive, and easy to assemble and disassemble.

Assumptions About the Problem

- The three concepts created in Assignment 3 all carry their own pros and cons. In order to determine the most fitting concept the design must answer and withstand any problems originally stated. These problems include: 1) My kitchen has limited space, therefore the design must be compact and purely useful, 2) Design will be constantly used, so it must be durable.

Pugh/Decision Matrix

Relative Weights	Evaluation Criteria	Alternatives					
		Rotation		Vertical Translation		Horizontal Translation	
		Rating	Score	Rating	Score	Rating	Score
30%	Strength	3	0.90	3	0.90	4	1.2
30%	Surface Area/Compatibility	5	1.5	2	0.60	4	1.2
20%	Shelf Size	3	0.60	5	1.00	5	1.00
20%	Degrees of Freedom	2	0.40	5	1.00	5	1.00
100%			3.4		3.5		4.4

Based on the Decision Matrix, the best concept choice is the horizontal translation.

Explanation of Evaluation Criteria

1) Strength: Overall strength for the shelf is a very important aspect especially if it will be holding heavy objects, the strength of the shelf can be determined by analyzing their shear stress. The equation for shear stress is, shear stress is equal to force applied divided by cross-sectional area. ($\tau = F/A$)
2) Surface Area/Compatibility: For limited space, this aspect is also very important, as the design must be compact but still large enough to hold a reasonable amount. We can determine which design will allow for the most compatible size for the small kitchen while also allowing for a reasonable surface area to hold products. To solve for surface area we will use the equation, $SA=2(lw+lh+wh)$
3) Shelf Size: Similar to the previous, shelf size is important in order to maximize the kitchen's space. Rather than calculating the surface area of the entire shelf like above though we will calculate only the area of useable shelf space. Therefore, we use the equation $A=lw$
4) Degrees of Freedom: Degrees of freedom help us analyze the independent displacements or rotations that show movement of the object. DOF will allow us to see how rigid the structure is. To solve for DOF, we will use the equation, DOF=3(#links-1)-2(#joints)-h-x

Multiple Solutions

FRDPARRC Table for Horizontal Translation

FR	DP	A	R	R	C
Dove tail (figure 1)	Shelf fits into slot using dove tails	P=Tw Shear/bending of shelves Friction force $F_f = \mu N$	https://byjus.com/physics/kinematics-rotational-motion-around-fixed-axis/	Friction, dove tails grinding	Have clearance for them to slide, keep lubricated. Design with coefficient of friction in mind
Wheel bearing on shelf (figure 2)	Shelf has rollers that slide in a slot on the stucture	P=Tw Shear/Bending of shelves Friction force $F_f = \mu N$	https://byjus.com/physics/sliding-friction/	Friction, wheels jamming	Keeps shelf light, design with coefficient of friction in mind.
Wheel bearings on structure (figure 3)	Structure has two sets of parallel rollers	P=Tw Shear/Bending of shelves Friction force $F_f = \mu N$	http://www.animations.physics.unsw.edu.au/jw/rolling.htm	Friction, wheels jamming	Keeps shelf light, design with coefficient of friction in mind.

3D models: These are shown without the shelf, as the shelf will be the same for each of the subassemblies, therefore only the structure is shown.

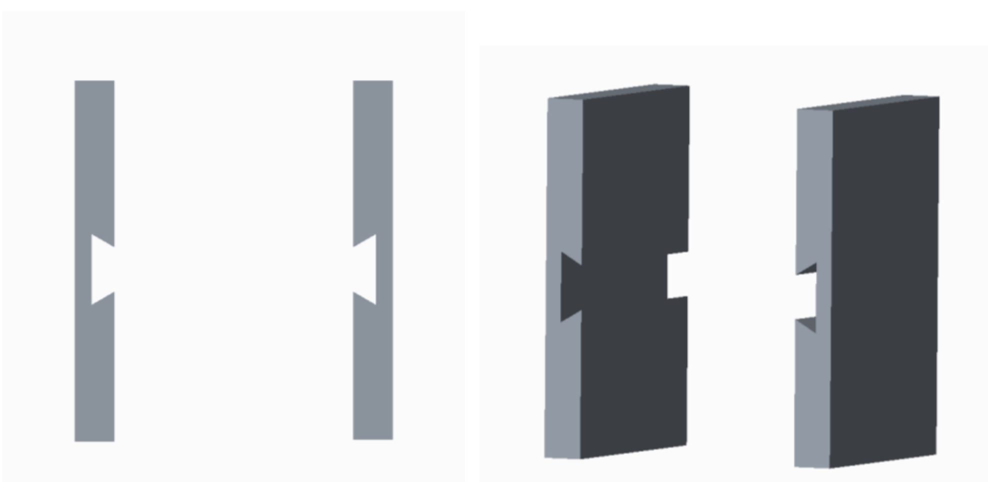


Figure 1: Dove tails

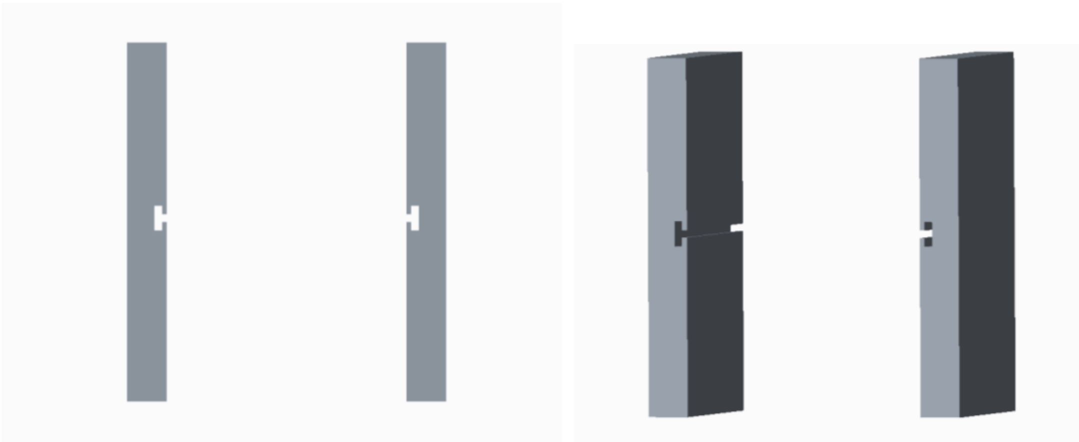


Figure 2: Track for rollers

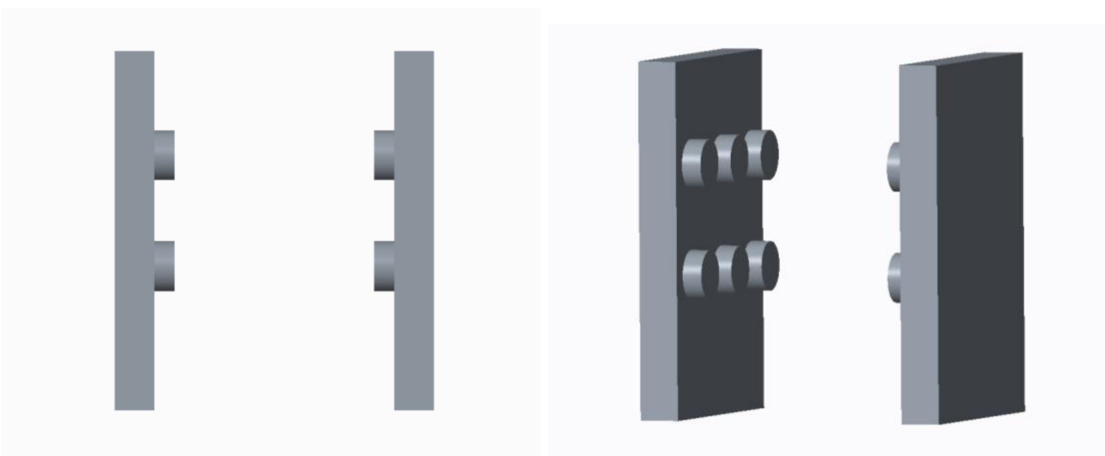
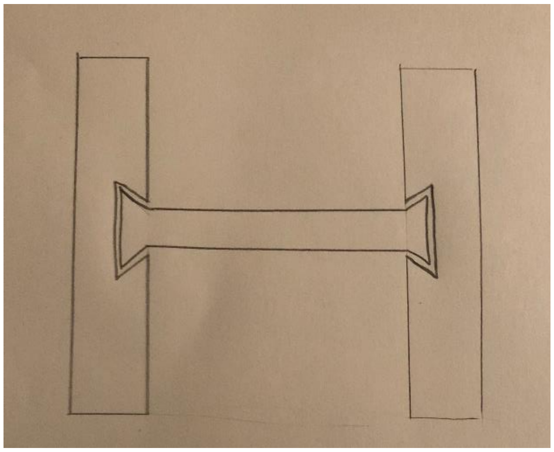


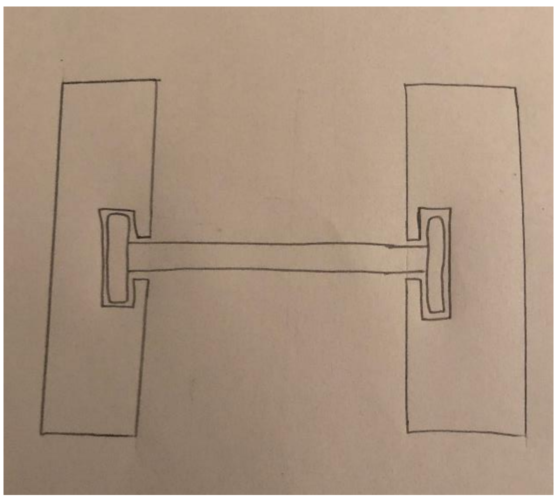
Figure 3: Wheels on structure

Degrees of Freedom and 2D Models



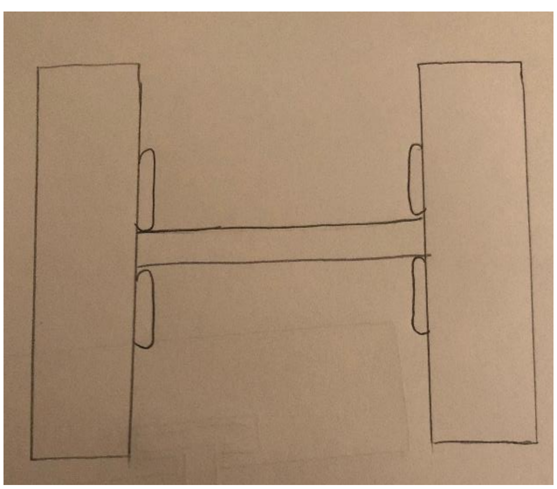
Dove Tails:

There is a single horizontal translations, therefore there is only one degree of freedom.



Rollers with Bearings

There is a horizontal translation, which makes up for one degree of freedom. The wheels can roll forward and backward making up two DOF each, with 6 wheels that is 12 DOF. Therefore there are thirteen degrees of freedom.



Two sets of Rollers with no bearing

There are 12 wheels, each with two DOF and a horizontal translation. Therefore there are twenty-five degrees of freedom.

Lessons Learned

- How to apply degrees of freedom to structures
- How frictional force can apply to horizontal translations
- How shear stress can affect the strength of a beam

Comments to Advisee

- Jake Weber, Cameron Klovstand
- Make tables labeled more clearly and elaborate on decision matrix
- Make modules on FRDPARRC table based on one concept, i.e. on type of movement