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Automatic Tail-Cutter

Miles Hardesty
Olivet Nazarene University, gmhardesty31@gmail.com

David Hutton
Olivet Nazarene University, david4hutton@gmail.com

Kevin Vroman
Olivet Nazarene University, kechev99@yahoo.com

ITW Deltar Universal Guiding System

By: David Hutton, Kevin Vroman, Miles Hardesty

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Agenda

- Acknowledgements
- Background
- Problem Statement
- Design Alternatives and Selection Criteria
- Proposed Design
- Prototyping and Final Design
- Final Design Validation
- Deliverables
- Conclusion

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Acknowledgements

Dr. Schroeder

- Setting up and offering guidance on design process

ITW Deltar & Jarrod LeSage

- Providing clear guidance on requirements for design

Mentor Dr. Giraldo

- Keeping project organized and on schedule, inspiring ideas

James Legrand & Sam Goin

- Assistance in Tech Center during prototyping

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Sponsor Background

- ITW Deltar Fasteners is a division of the larger Fortune 200 company, Illinois Tool Works
- Focus mainly on manufacturing of automotive fasteners
- The primary method of production is plastic injection molding

DELTAR®

ITW

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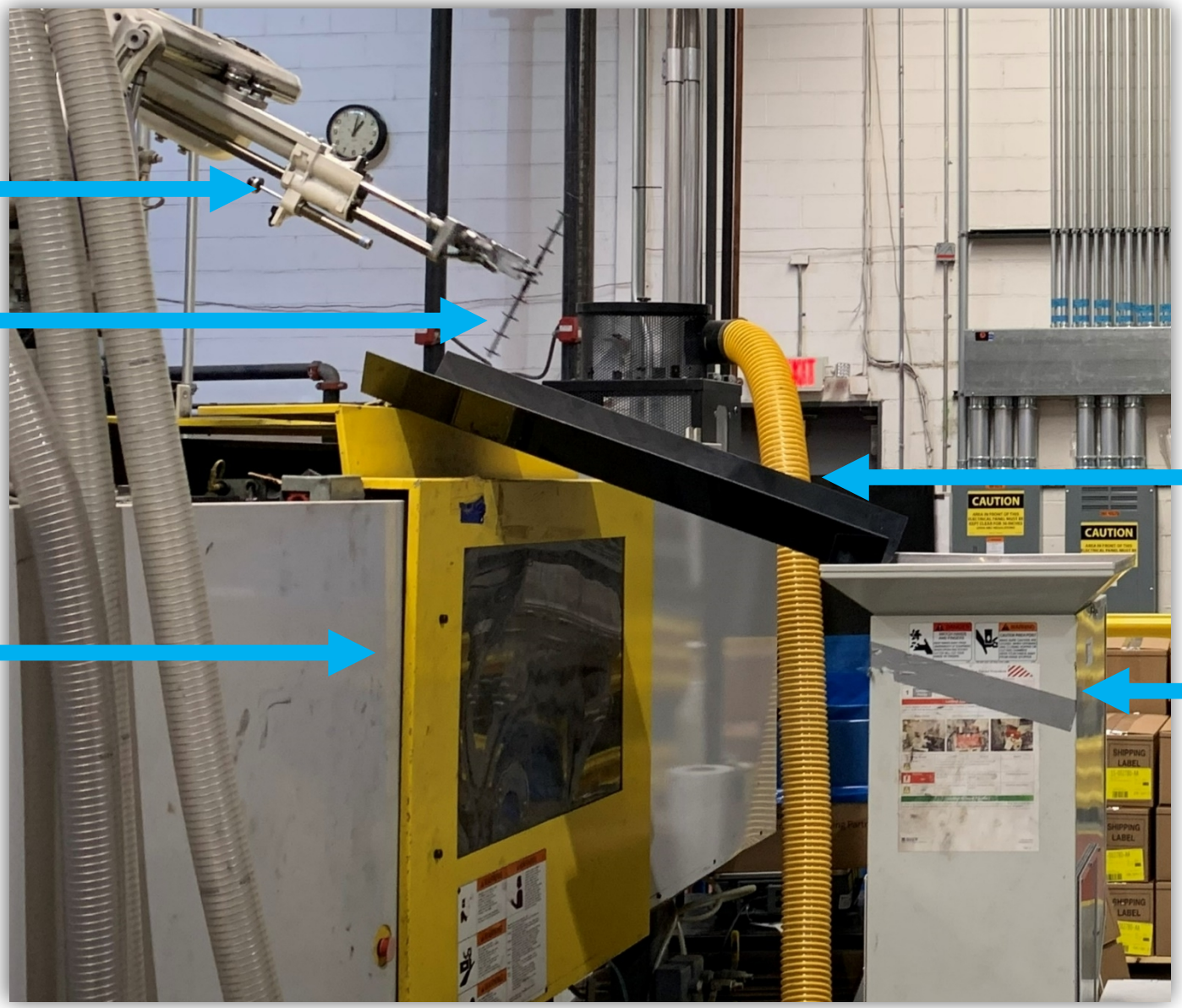
Background Terminology

- **Runners:** Hold parts together until molding is complete, then runners are placed into grinder to be recycled
- **Ramp:** guidance system for runners in the form of an inclined plane
- **Grinder:** Shreds runners to be used again on future parts
- **Mold:** Outline to format plastic into the desired shape
- **Molding Machine/Press:** Machine that fills molds to create parts
- **Degree of Freedom (DOF):** Variables affecting the range and direction in which the universal system can move

Robotic Arm

Runners

Molding Machine/ Press



Ramp

Grinder

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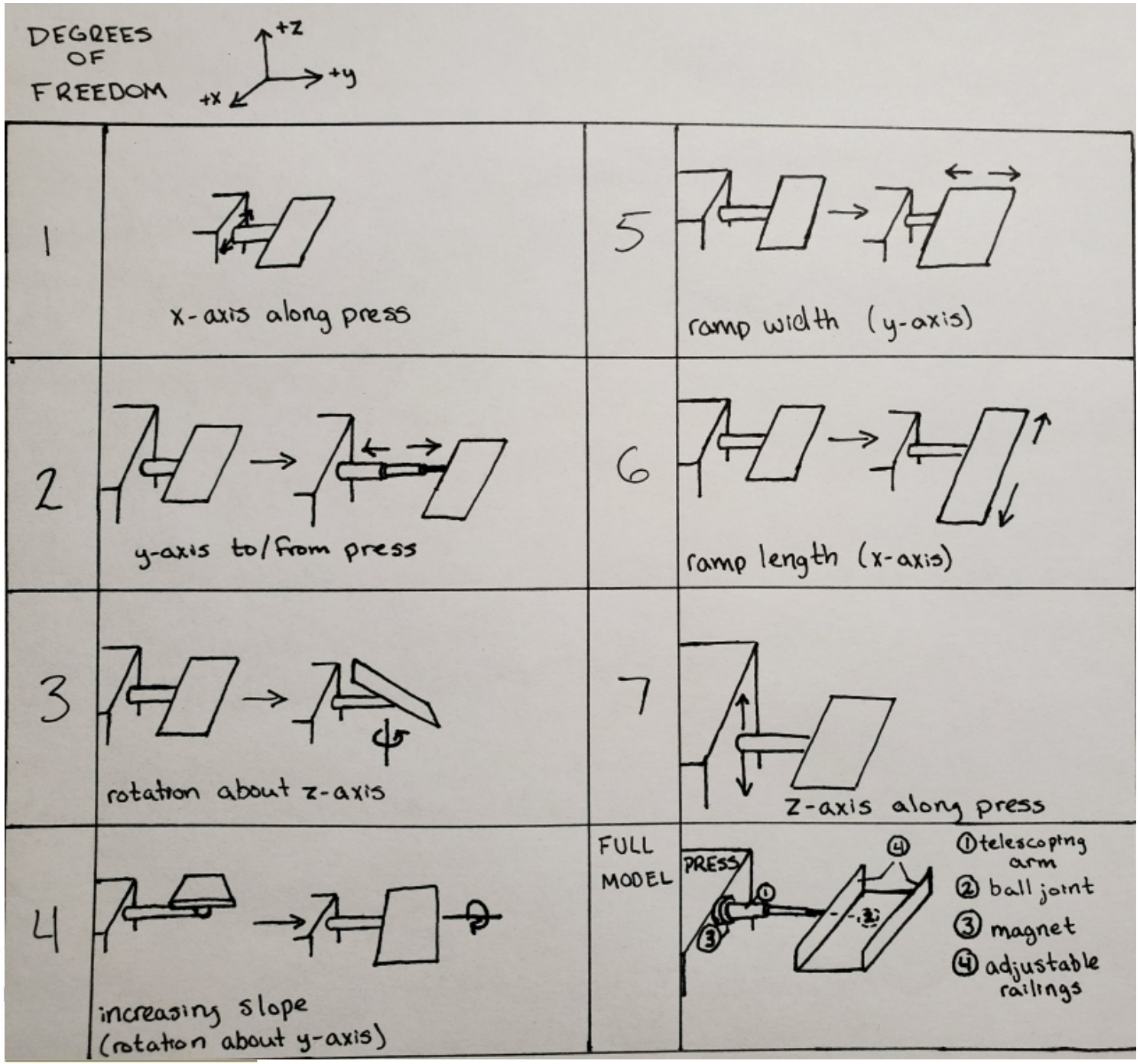
Problem Statement

Need Statement

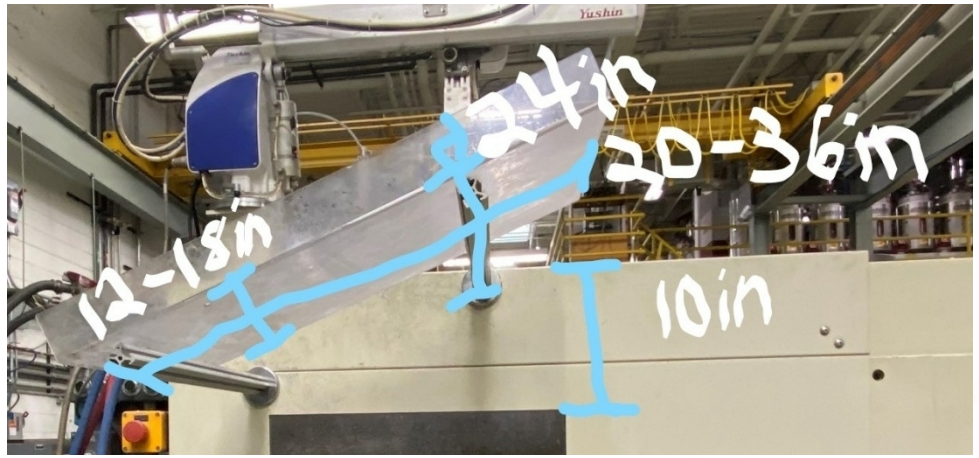
- Around 30 different presses, unique grinder orientations
- Currently custom built and fitted
- This leads to non-desired hours and potential safety hazards
- Need a universal solution that can be mass produced and easily integrated

Design Objectives & Functional Requirements

- **Lightweight:** stable & easily moveable between machines
- **User Friendly:** both machining and setup
- **Direct Connection:** between the ramp and press
- **Adjustable:** degrees of freedom to ranges set
- **Universal:** any press & grinder orientation
- **Arm Clearance:** robot arm
- **Runner Accuracy:** doesn't miss grinder
- **Longevity:** resistant to continuous dropping of runners



Degree of Freedom	Range
2: Arm Length	9 to 24 in.
3: Direction	0° to 90°
4: Slope	0° to 30°
5: Width	12 to 18 in.
6: Ramp Length	20 to 36 in.



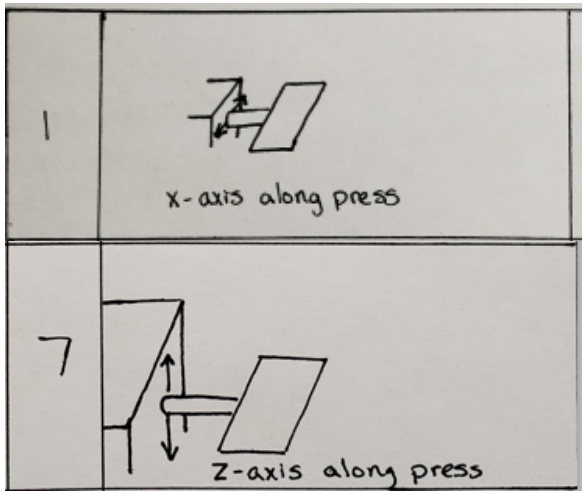
Design Constraints

- **Cost Effective:** less than $200
- **Use of Space:** fit in alley between machines
- **OSHA Codes:** 1910.22

Design Alternatives

Design Alternatives – DOF 1 & 7

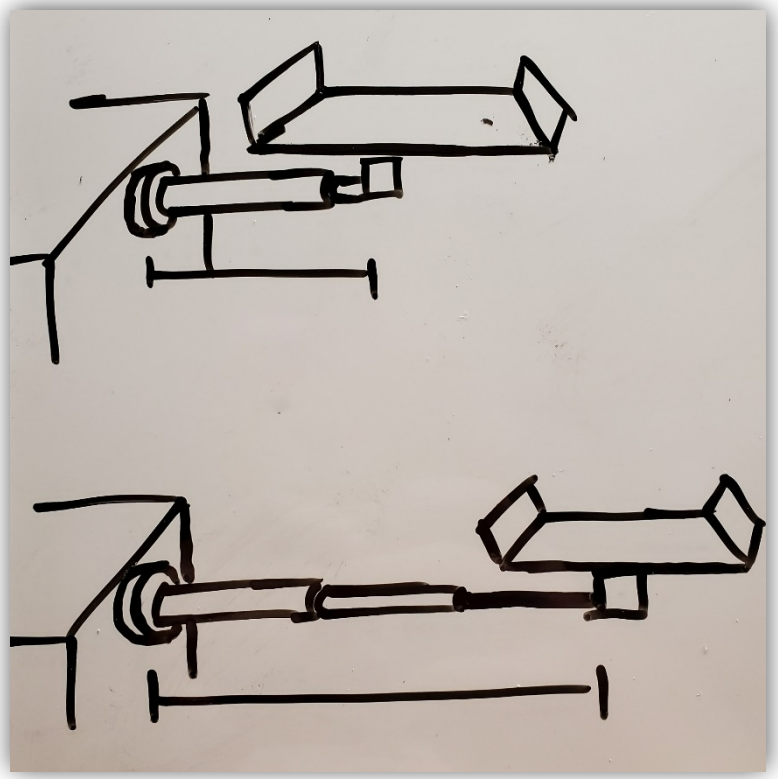
- **Angle Iron vs. Magnet**
- **DOF 1:** Ability to move ramp system in x axis
- **DOF 7:** movement in z axis
- Different mounting methods to press would allow/restrict this movement



Design Choice	Design Elements					
	Permanent Damage	Adjustability	Strength	Price	Familiarity	Total
Angle Iron	0	0	1	1	0	2
Magnet	1	1	0	0	1	3

Design Alternatives – DOF 2

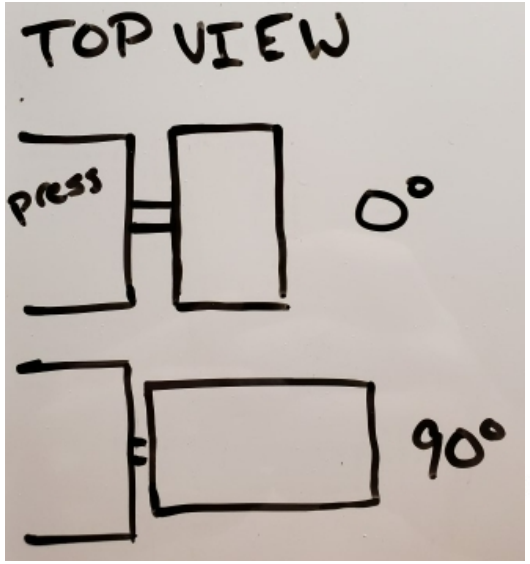
- **One vs. Two Arms**
- **DOF 2:** Ability for the ramp to move closer or further from the press
- While two arms would provide more support to the ramp, they would interfere with the ability of DOF 3



Design Alternatives – DOF 3

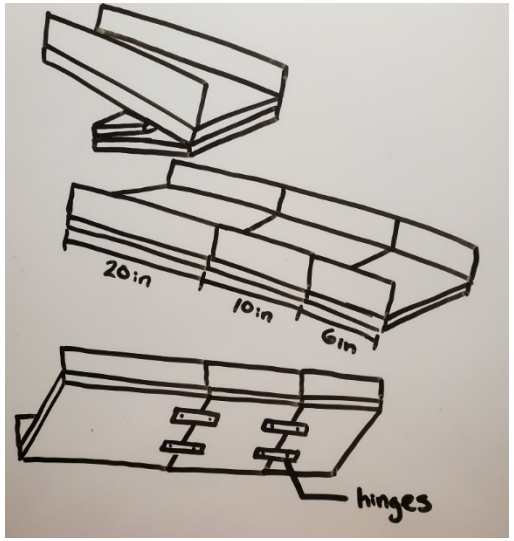
- **Ball Joint vs. Expanding Part**
- **DOF 3:** ability to rotate its direction 90 degree to be set perpendicular to press
- **Expanding Part:** pizza-like style part in the ramp to cover space as the ramp rotates
- Ball joint underneath ramp to allow for rotation

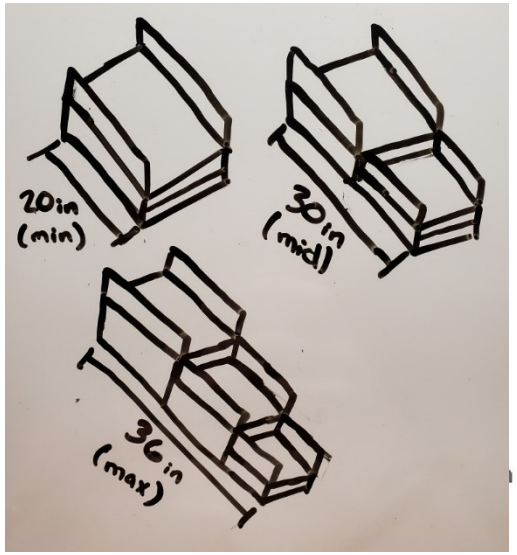
Design Choice	Design Elements					
	Machining Difficulty	Adjustability	Strength	User Difficulty	Price	Total
Pizza Style	0	0	1	1	0	2
Ball Joint	1	1	1	0	1	4



Design Alternatives – DOF 5 & 6

- Ability for ramp to change in both width (5) and length (6)
- 5 & 6 work together, some solutions caused problems for other
- DOF 6, use notch system to place guide rails at different widths
- DOF 5, fold out and extendable drawer ideas

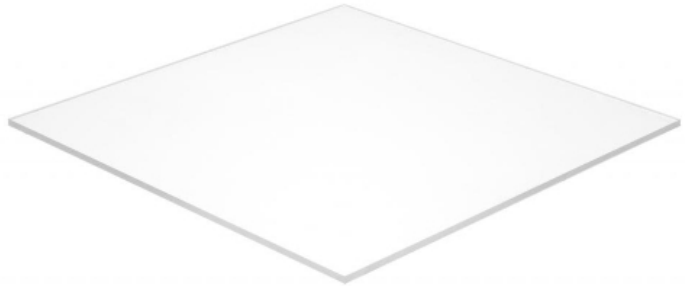




Design Choice	Design Elements						
	Weight	Angle	Width	Length	Fabrication	Cost	Total
Design 1 (Fold-Out)	1	1	1	1	1	1	6
Design 2 (Extendable)	0	1	1	1	0	0	4

Design Alternatives – Plastic Type

- **HDPE vs. Plexiglass**
- **Considerations:**
  - Cost
  - Strength/Weight
  - Ease to machine
  - Deflection



Design Choice	Design Elements					
	Weight	Strength	Cost	Deflection	Fabrication	Total
HDPE	1	0	1	0	1	3
Plexiglass	0	1	0	1	0	2

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Selection Criteria

- Meets the 7 DOF
- Lightest weight possible
- Ease of fabrication & setup
- Cost
- Durability
- Longevity

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Proposed Design

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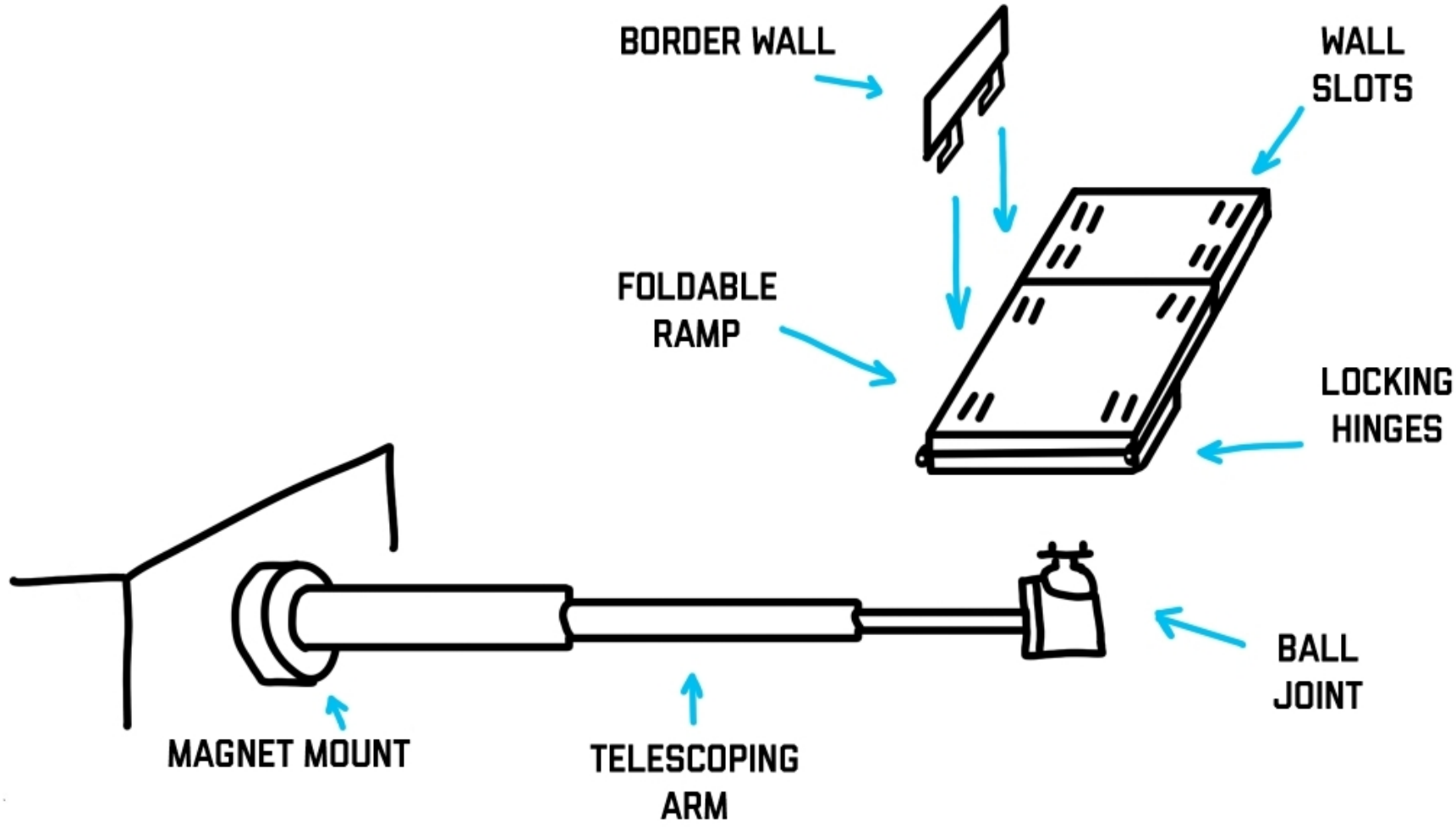
Proposed Design



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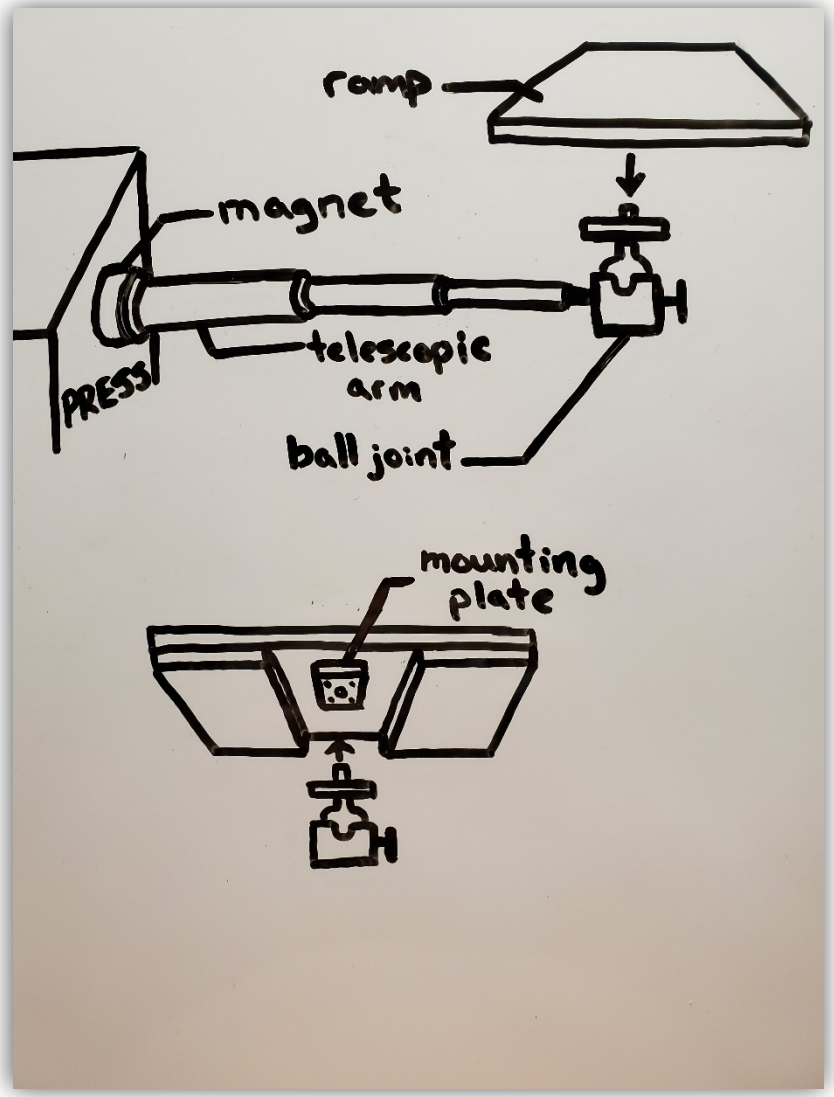
Proposed Design - Arm

- **Magnetic Mount**
- **Telescoping Arm**
- **Ball Joint:** underneath center of the ramp, 360° of motion



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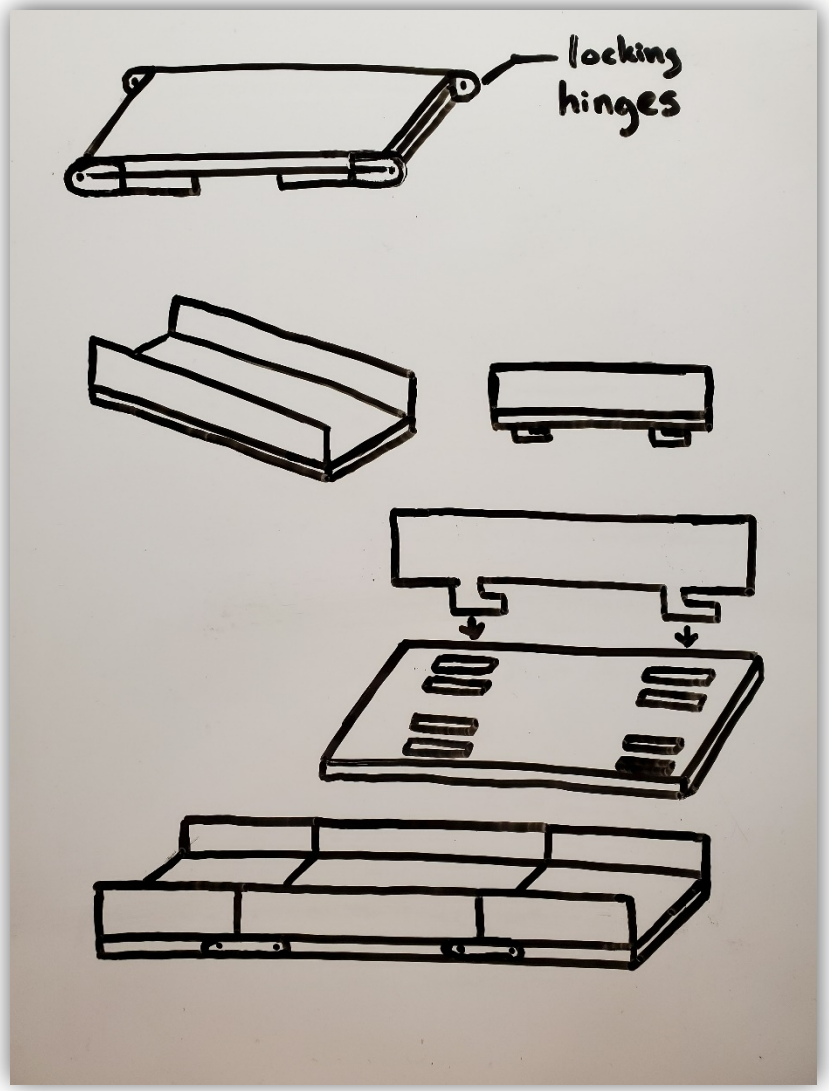
Proposed Design - Ramp

- Dual direction folding to adjust ramp length
- Locking hinges for ramp extension
- Guide rails with series of notches, adjust for different widths, slide to lock into place



Prototyping & Final Design

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"I never failed at making a light bulb. I just found out 99 ways not to make one."

- Thomas Edison

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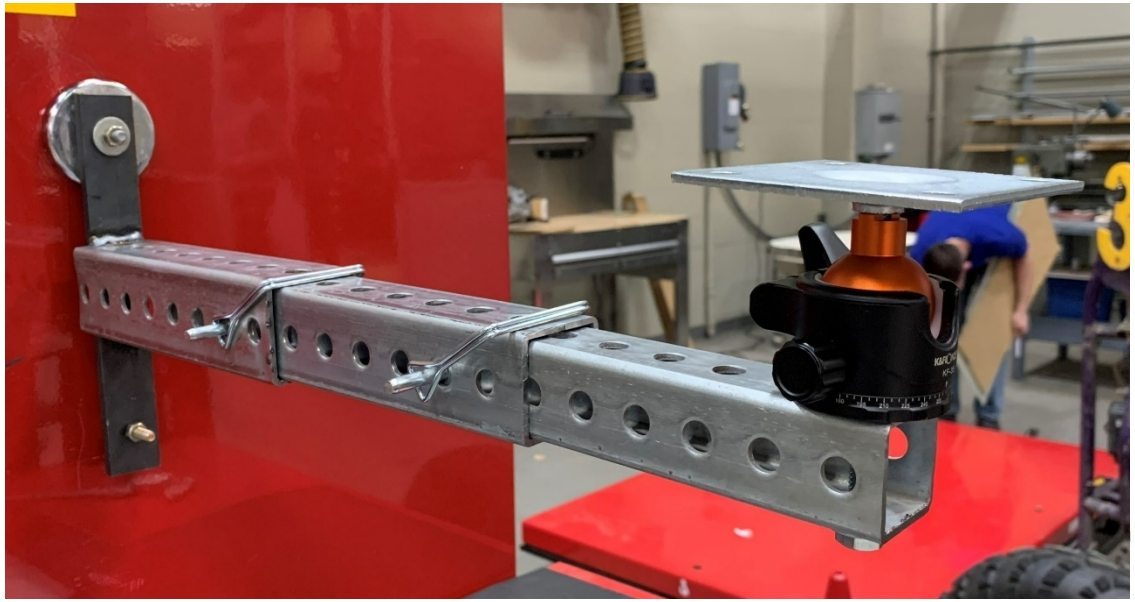
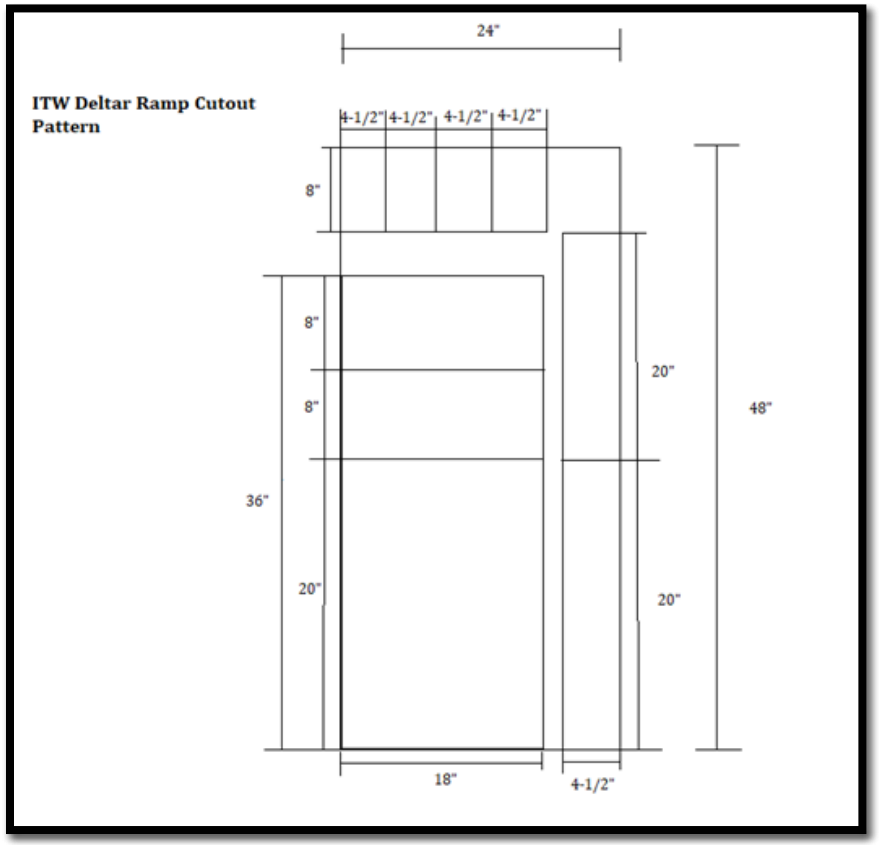
Prototyping - Arm

- Welding & magnet integrity issues
- Moment created for magnet at end of arm → structural brace for magnet
- Telescoping arm → square tubing



Prototyping - Ramp

- Locking hinges → removable pin hinges: side walls load-bearing
- Epoxy → bolts for connecting hinges & mounting plate



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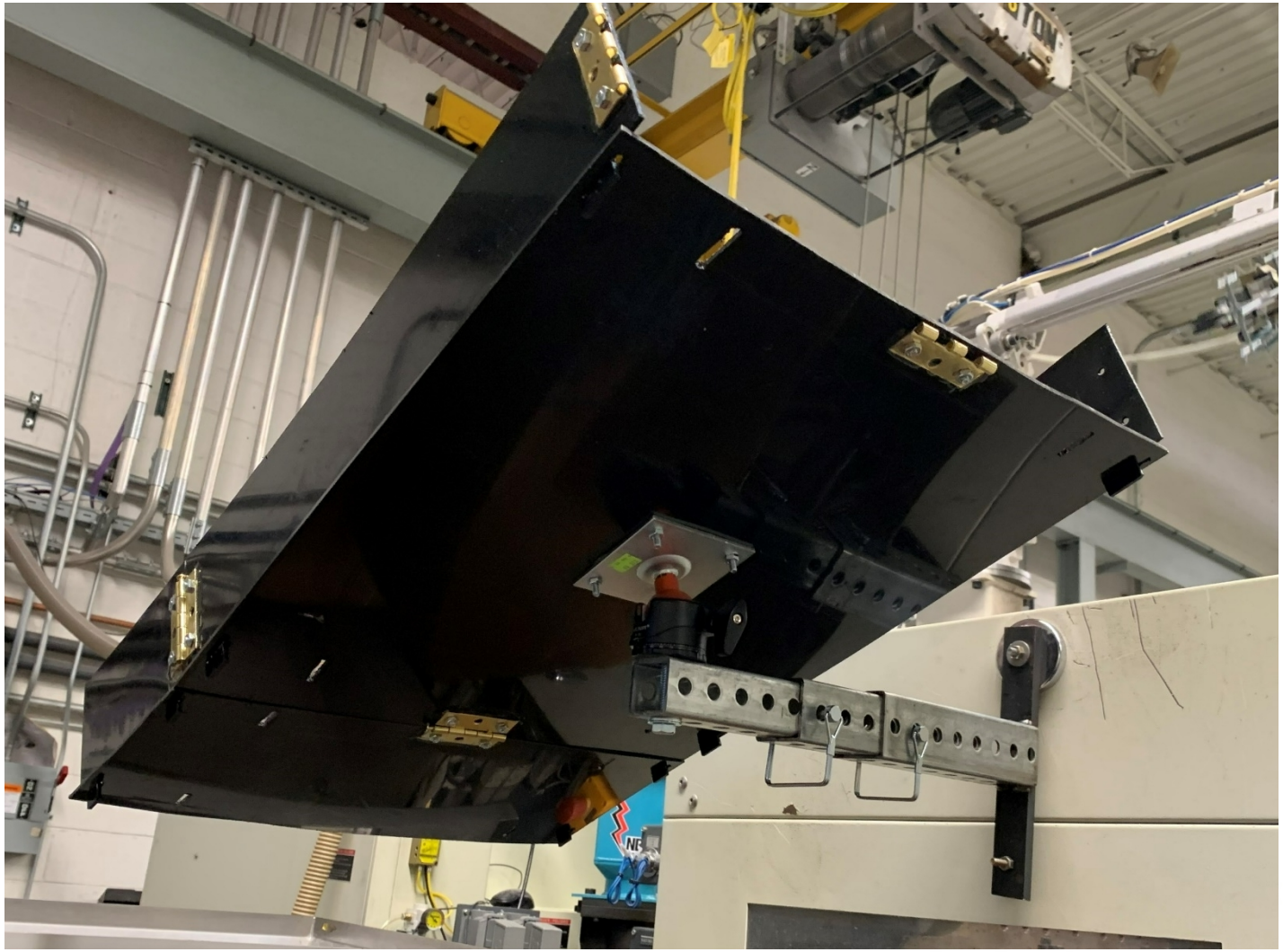
Final Design

- Pin Hinges
- Bolt Connections
- Square Arm
- Magnet Structural Brace



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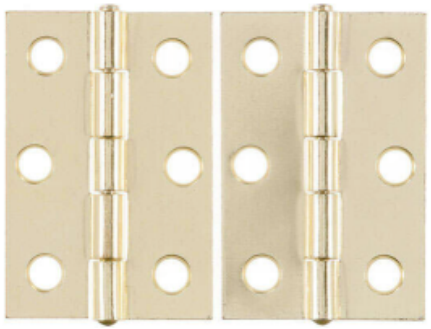
Bill of Materials & Parts

ITW Deltar Universal Guidance System Bill of Materials

Product	Provider	Size	Qty.	Unit Cost	Cost
RAMP COMPONENTS					
HDPE Sheet	ePlastics	24x48 in	1	$32.08	$32.08
Hinges	Ace Hardware	N/A	6	$2.12	$12.72
Phillips Flat Head Bolts	Ace Hardware	10-32, 1/2"	24	$0.15	$3.60
Phillips Flat Head Bolts	Ace Hardware	10-32, 3/4"	4	$0.16	$0.64
10-32 Nuts	Ace Hardware	10-32.	28	$0.14	$3.92
TELESCOPING ARM COMPONENTS					
Neodymium Magnet, C	McMaster-Carr	2.65" OD, 220lb.	1	$69.25	$69.25
Mounting Plate	Component Hardware	3-1/2"x3-1/2"	1	$12.56	$12.56
Telescoping Tube 1	Coremark Metals	1-1/2"x1-1/2"x8", 12 ga	1	$9.34	$9.34
Telescoping Tube 2	Coremark Metals	1-3/4x1-3/4"x8", 12 ga	1	$9.96	$9.96
Telescoping Tube 3	Coremark Metals	2"x2"x8", 12 ga	1	$10.16	$10.16
Safety Pin	Home Depot	1/4"x2-3/4"	2	$1.34	$2.68
Arm to Ball Joint Bolt	Ace Hardware	3/8"-16x2"	1	$0.75	$0.75
Magnet to Arm Bolt	Ace Hardware	1/4"-20x1"	2	$0.15	$0.30
Ball Joint	K&F (Amazon)	N/A	1	$49.99	$49.99
				Arm Cost	$164.99
				Ramp Cost	$52.96
				Total Cost	$217.95

Magnets used by ITW Deltar

Telescoping Tube



Hinges

Ball Joint

Safety Pin

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Bulk Order Pricing

Product	Size	Qty.	Cost
HDPE	24x48	10	$ 271.50
Hinges	N/A	60	$ 127.20
Phillips Flat Head	10-32, 1/2"	240	$ 36.00
Phillips Flat Head	10-32, 3/4"	40	$ 6.40
Nuts	10-32,	280	$ 39.20
Magnet	2.65" OD, 220 lb	10	$ 692.50
Mounting Plate	3-1/2" x 3-1/2"	10	$ 125.60
Telescoping Tube 1	1-1/2"x1-1/2"x7', 12 ga	1	$ 50.61
Telescoping Tube 2	1-3/4x1-3/4"x7', 12 ga	1	$ 57.11
Telescoping Tube 3	2"x2"x7', 12 ga	1	$ 59.22
Safety Pin	1/4"x2-3/4"	20	$ 26.80
Arm to Ball Joint Bolt	3/8"-16x2"	10	$ 7.50
Magnet to Arm Bolt	1/4"-20x1"	20	$ 3.00
Ball Joint	N/A	10	$ 499.90
*10 unit bulk order		**Total Cost**	$ 2,002.54
		Per Unit Cost	$ 200.25

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Validation & Testing

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Design Validation

Analysis

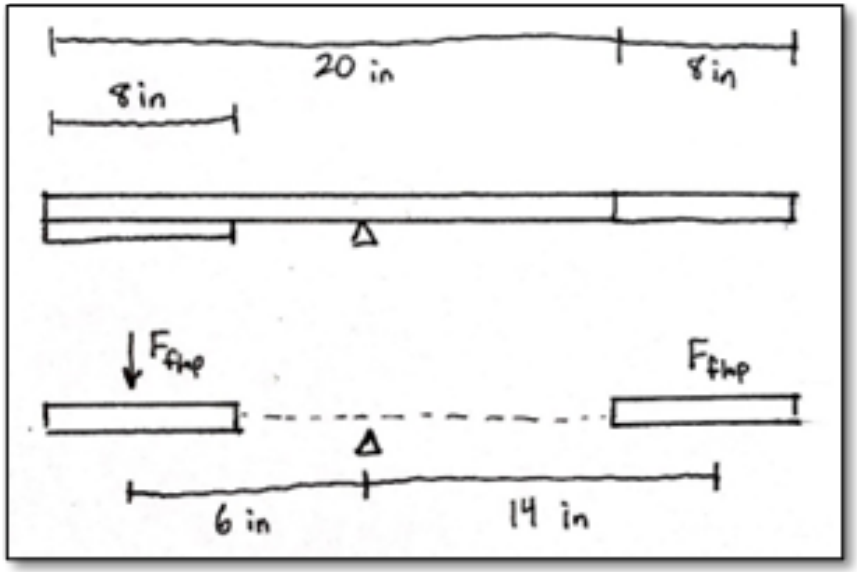
- Ball Joint Moment
- Magnet Moment
- Telescoping Arm Moment

Testing

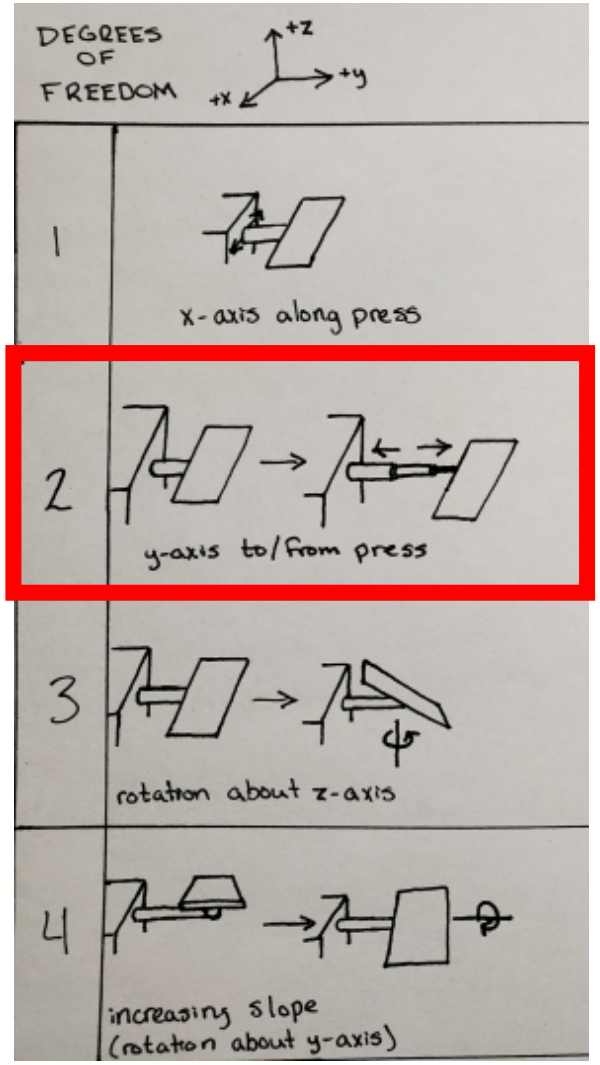
- Ball Joint Rotational Strength Test
- On-site Prototype Test

Cost Constraints

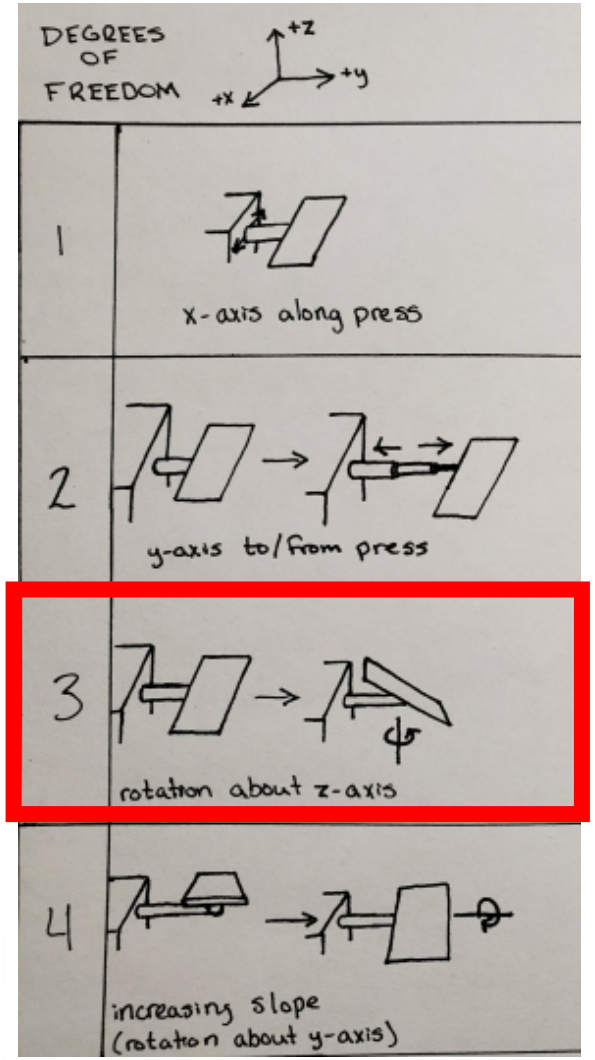
- Initial prototype estimated cost: $182.14
- Current cost estimation: $217.95



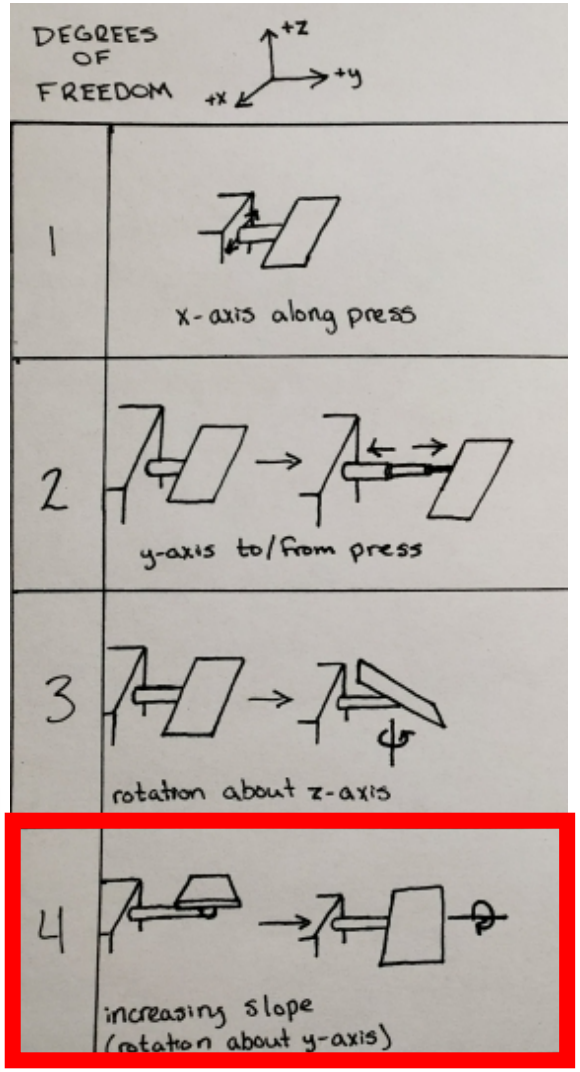
DOF 2- Movement to/ from Press



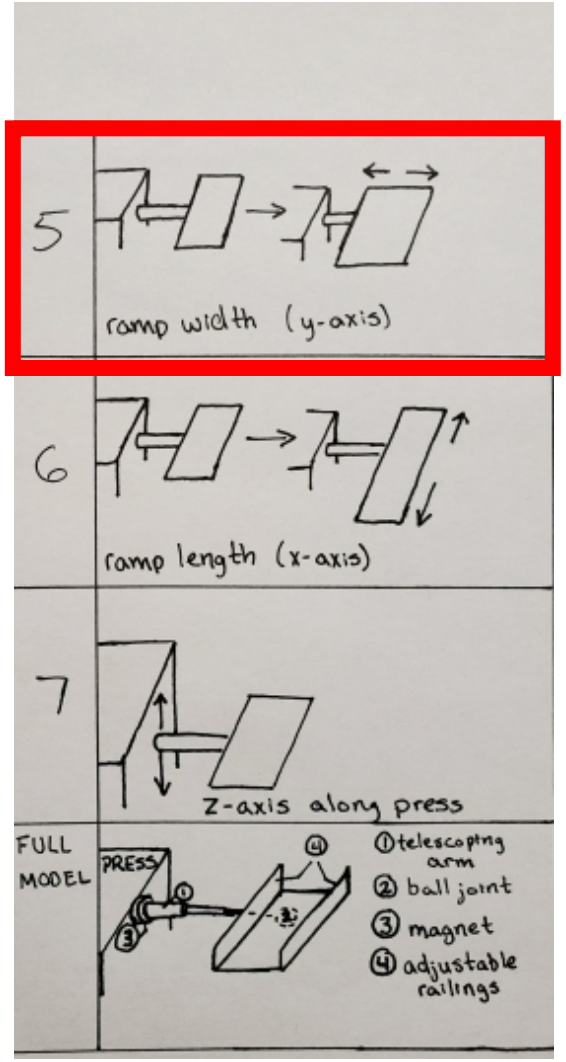
DOF 3- Rotation



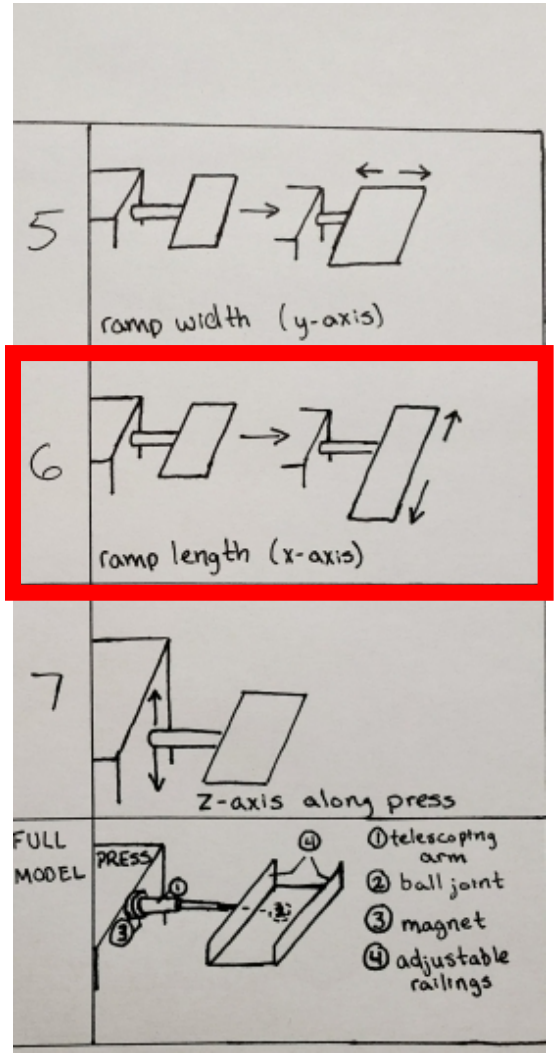
DOF 4-Changing Slope



DOF 5-Ramp Width



DOF 6- Ramp Length



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Validation Summary

Requirement	Inspection	Test	Analysis	Pass/Fail
Ball Joint Rotational Strength		x		PASS
Magnet Pull Strength			x	PASS
System Moment Analysis			x	PASS
DOF 2: Motion To/From Press (9-24 in)	x			PASS
DOF 3:Ramp Rotation (0-90 degrees)	x			PASS
DOF 4: Slope of Ramp (0 to 30 degrees)	x			PASS
DOF 5: Ramp Width (12-18 in)	x			PASS
DOF 6: Ramp Length (20-36 in)	x			PASS
On-Site Functional Prototype Test		x		PASS

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Deliverables

1. **Completed Prototype**
2. **Final Design Report**
   - Includes testing and analysis as well as further recommendations
3. **Manufacturing Document**
   - Includes Bill of Materials and Manufacturing Instructions

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Conclusion

Benefits to ITW

- Increased productivity with a standardized guidance system
- Higher reusability for universal ramps means lower costs long-term

Recommendations

- Cost cutting considerations (slightly weaker magnet, bulk ordering parts etc.)
- Additional slots would provide greater freedom when setting width
- Utilization of just arm design if DOF 5 & 6 are of low priority

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QUESTIONS?

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