

Motivation, Goal, Impact

MOTIVATION

- 500,000+** INJURIES/YEAR
Treated in emergency rooms due to ladder accidents.
- ~300** FATALITIES ANNUALLY
Ladder-related incidents that prove to be fatal.
- 40%** OF ACCIDENTS
Involve extension ladders.

WHY IT HAPPENS

- IMPROPER SETUP**
- UNSTABLE SURFACES**
- FAILURE OF LOCKING DEVICES**

OUR SOLUTION

- IMPROVES STABILITY
- REDUCES TIPPING & SLIPPING
- ENHANCES USER SAFETY & CONFIDENCE
- SIMPLE TO USE

THE IMPACT

- FEWER FALLS & INJURIES
- REDUCED ER VISITS
- LOWER JOB SITE DOWNTIME

OUR STAKEHOLDERS

- PROFESSIONAL USERS
- CONSTRUCTION WORKERS
- HVAC TECHNICIANS
- HOMEOWNERS
- DIY USERS

Statistics from sources: americanladderinstitute.org and Kupyna, Paul at usf.edu. The rest was AI generated based on our product and stakeholder interviews/research.

Requirements

REQUIREMENTS OVERVIEW

1	STABILITY ON LEVEL / UNEVEN / SLOPED SURFACES
2	PREVENT TIPPING / SLIPPING / UNINTENDED MOVEMENT
3	COMPLY WITH OSHA / ANSI / OTHER RELEVANT REGULATORY CODES
4	QUICK / EASY SINGLE-USER SETUP, NO SPECIAL TOOLS
5	MUST NOT INTERFERE WITH NORMAL CLIMBING MOVEMENT
6	LIGHTWEIGHT / PORTABLE / COMPACT STORAGE
7	RESIST ENVIRONMENTAL DEGRADATION
8	AFFORDABLE / PRACTICAL TO MANUFACTURE AT SCALE

AI GENERATED IMAGE USING OUR DSM MATRIX

FINAL SYSTEM DESIGN

ALL COMPONENTS ATTACHED

The system clamps securely to the side rail of an extension ladder and provides a reliable anchor point using either a vacuum cup or ground stake, depending on the surface conditions.

CLAMP DETAIL (SIDE VIEW)

Rubber caps are placed over the clamp bolts (inside) to increase the friction and protect the ladder rail surface.

GROUND ANCHOR OPTIONS (ONE PER SIDE)

OPTION 1: VACUUM ANCHOR

Vevor Heavy Duty Rubber Based Vacuum Cup

OPTION 2: STAKE ANCHOR

Vigoror Stake Hooks (Drive into Ground)

SYSTEM OVERVIEW (EACH SIDE)

Use one complete system per side of the ladder for maximum stability and safety. Always ensure a secure connection and inspect all components before each use.

AI GENERATED IMAGE USING OUR PRODUCTS

Final Design

4.2 inch Per Final CAD

FINAL COST

TEAM D5 LADDER SAFETY
RETROFIT SAFETY ATTACHMENT FOR EXTENSION LADDERS

PER SIDE ASSEMBLY	TOTAL WITH 2 SIDES (COMPLETE LADDER SETUP)	CLAMP ATTACHMENT ONLY (TWO CLAMPS NEEDED ON THE LADDER)
\$67.38	\$134.77	\$21.05 EACH / \$42.10 PAIR

CLAMP COMPONENTS	COST (USD) EACH
Clamp Housing (6061 Aluminum)	\$14.86
2 Screws with Pads (Alloy Steel)	\$5.04
2 Pins (Stainless Steel)	\$0.72
2 Rubber Caps (Rubber)	\$0.43
TOTAL CLAMP COST (EACH)	\$21.05

Future Attachments

Tool Bucket

Carrying Strap

Design Calculations & Decisions

Rope Tension Required

- Slipping backwards: 340 lbf worst case scenario
- Tipping sideways: 1500 lbf worst case scenario. 45 degrees: 184 lbf

Suction Cup

- 220 lbf (max safety limit) > 184 lbf (equal and opposite rope tension): adequate.
- Safety Factor = 220 lbf / 184 lbf = 1.2

Source from: VEVOR Glass Suction Cup, 8" 615 lbs Load Capacity.

Clamp Design Optimization

- Objective: Minimize bolt tension forces required to prevent slipping
- Design Variables: height (h), thickness (L1), distance from bolt to clamp (L2)
- Best Results: tallest, medium distance hole, thinnest
- Screw 1 tension: 307 lbf
- Screw 2 tension: 196 lbf
- Screw 1 tip friction: 264 lbf
- Screw 2 tip friction: 169 lbf

Material Selections

- Clamp body: **6061 Aluminum Alloy**
- Screws: **Alloy steel** provide high tensile strength and wear resistance
- Rope: **Static climbing rope** has high strength and very low stretch
- Suction Cup: **Heavy duty rubber cup** provide better sealing and repeated use.

Manufacturing Decisions

- Clamp body: **CNC machining** for tight tolerances and complex geometries
- Screws: **Thread rolling or machining** for durable threads capable of many cycles

Prototype & Test Results

Fit Testing

Average Ladder Side Width (inches)	3
99.7% Confidence Interval	2.024334547 - 3.975665453

Our design fits all ladders within a 99.7% CI

Slip Testing

1-1 Set up; Force height 47/63"

Baseline Average (lbf)	Suction Cup Average (lbf)
22	54.9

Improvement = 2.5x higher slip resistance

Tip Testing

Ladder Height = 93"; 4-1 Set up

Baseline Average (lbf)	Suction Cup Average (lbf)
12.81666667	25.4

Improvement = 1.98x higher tip resistance

Load Testing

Average Ladder Weight (lbf)	52.745
Max Ladder Weight	102.5
Max Sustained Clamp Load	90
Ladder Load Per Clamp (Strap Case)	51.25

Our Clamp allows for Carrying Strap as well as Tool Bucket Add Ons

Load Testing

Slip Testing

Suction cup proved more limiting than stake

Tip Testing