Personal Fire Escape Preliminary Design

March 24, 2020

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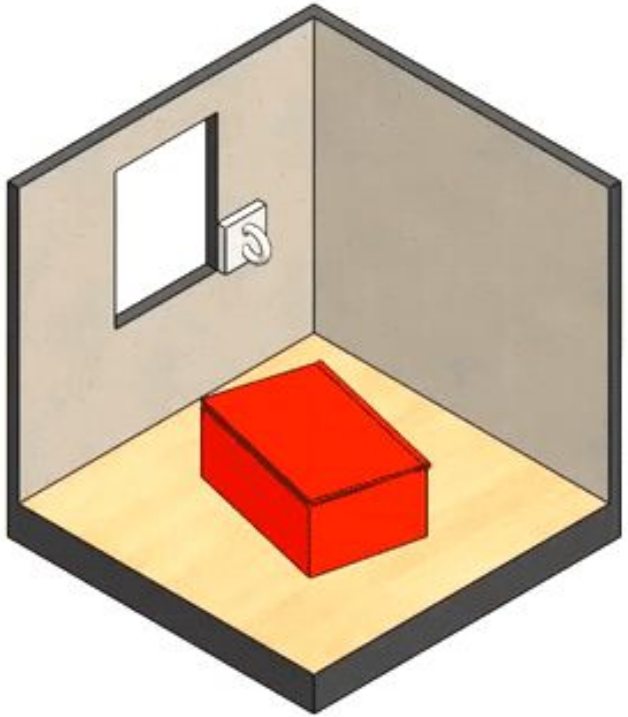
Agenda

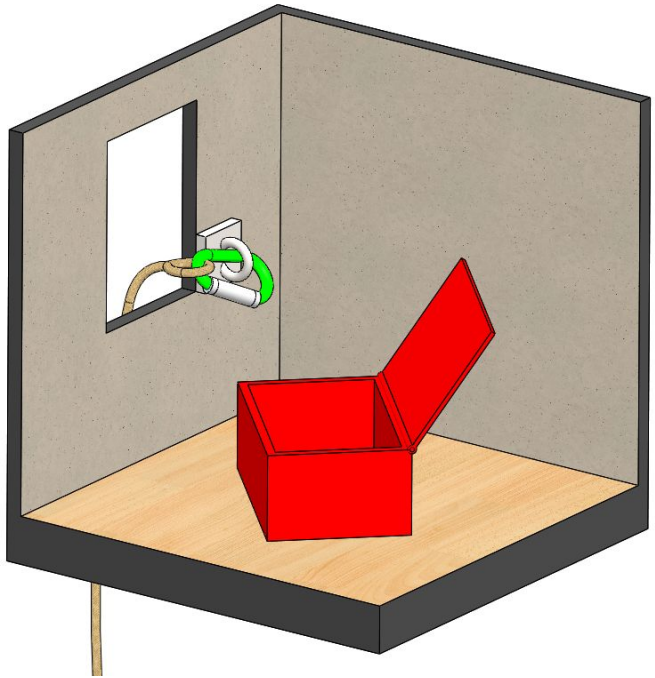
	Personal Fire Escape System
	List of Components
	Clasp
	Rope
	Harness
	Two Scenarios
	Braking System
	Conclusion

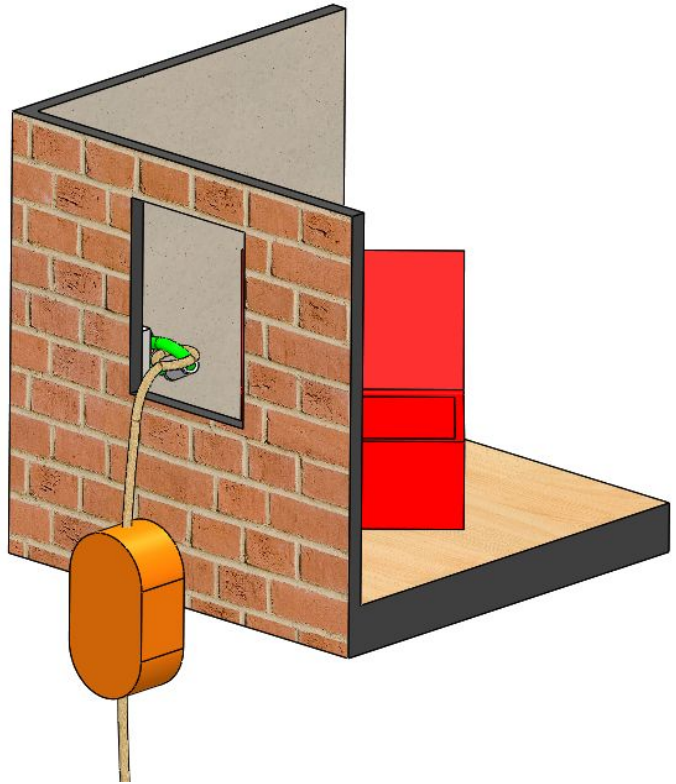
Personal Fire Escape System



Quick, portable fire escape system through a window

Components





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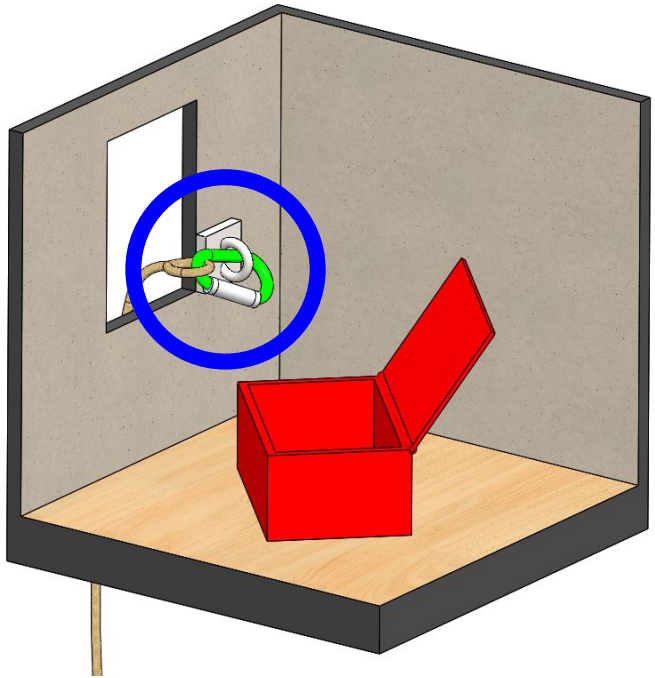

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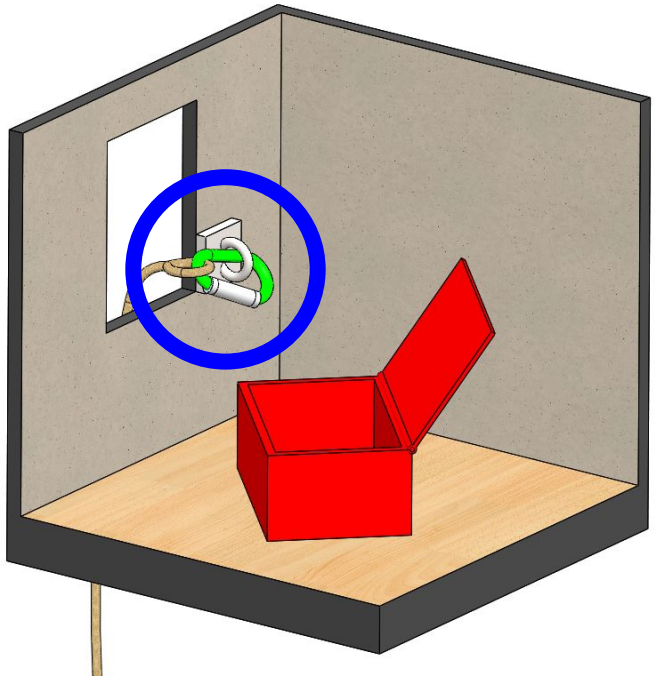
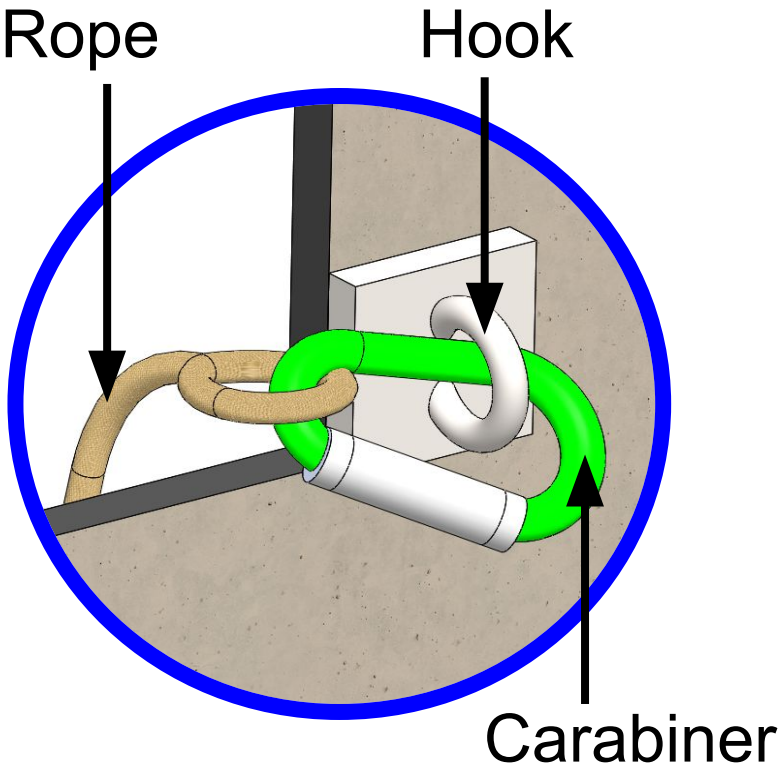
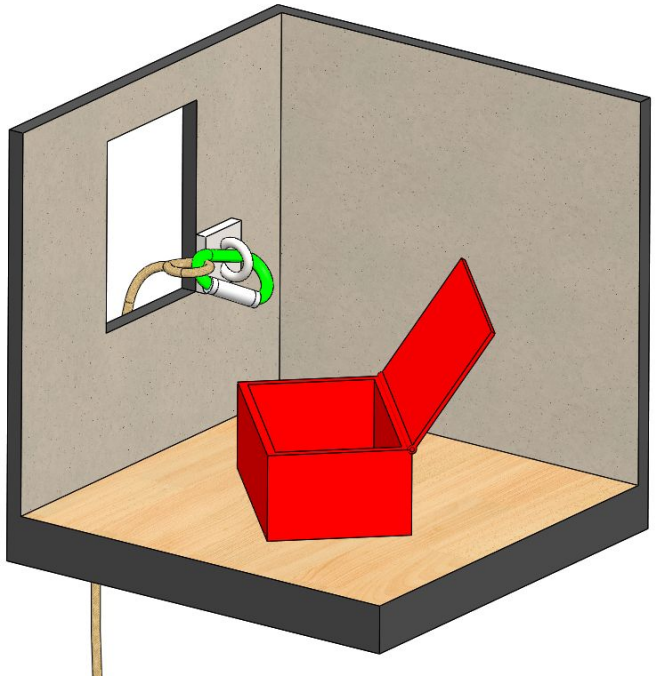




Components



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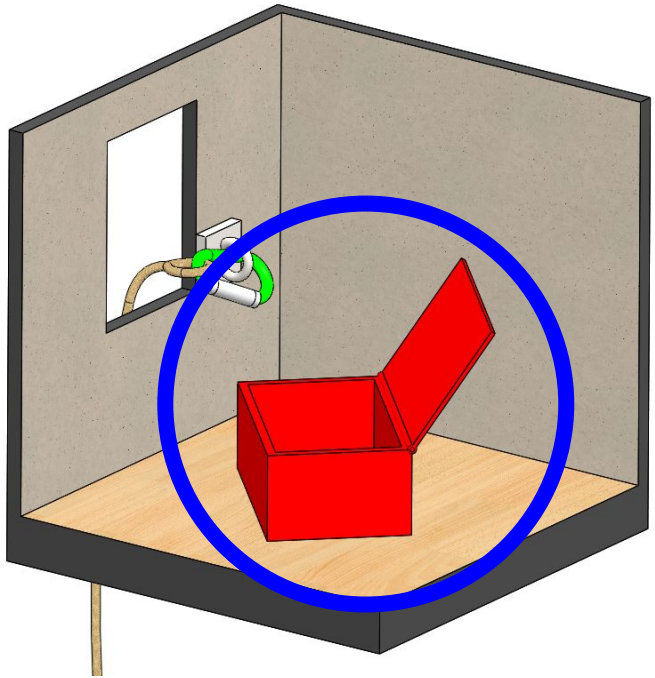
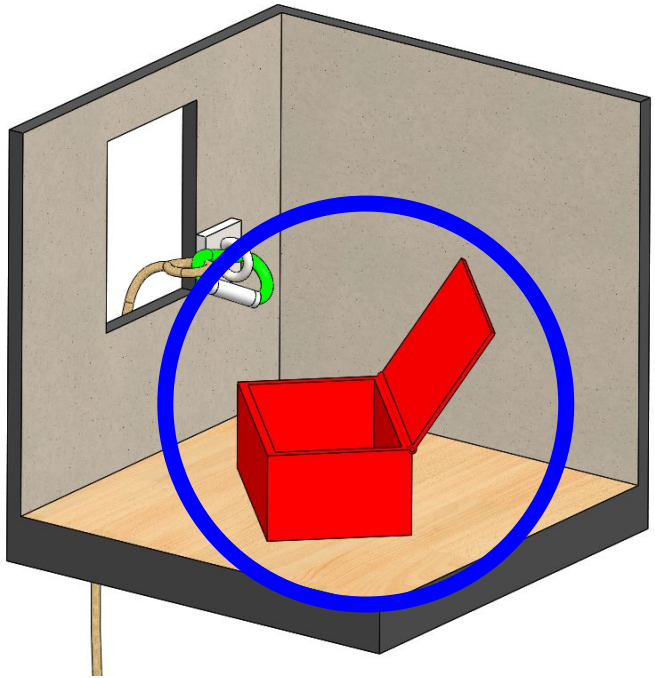
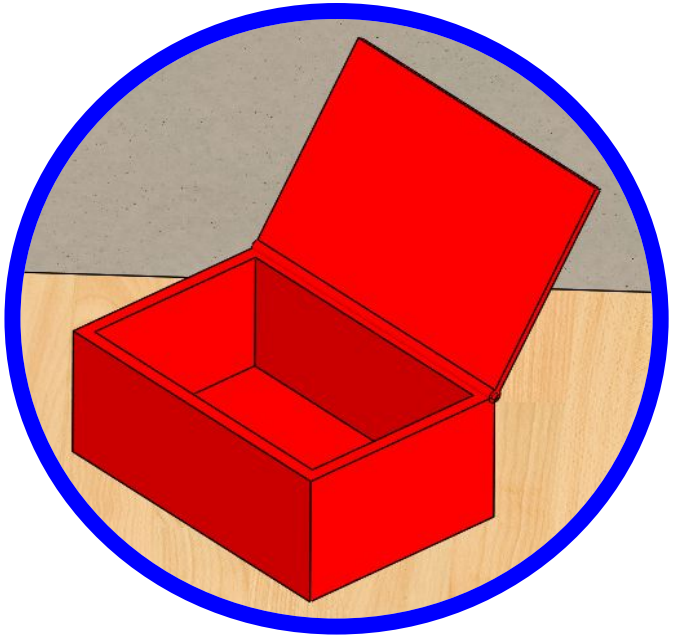


Components



Hermitic box



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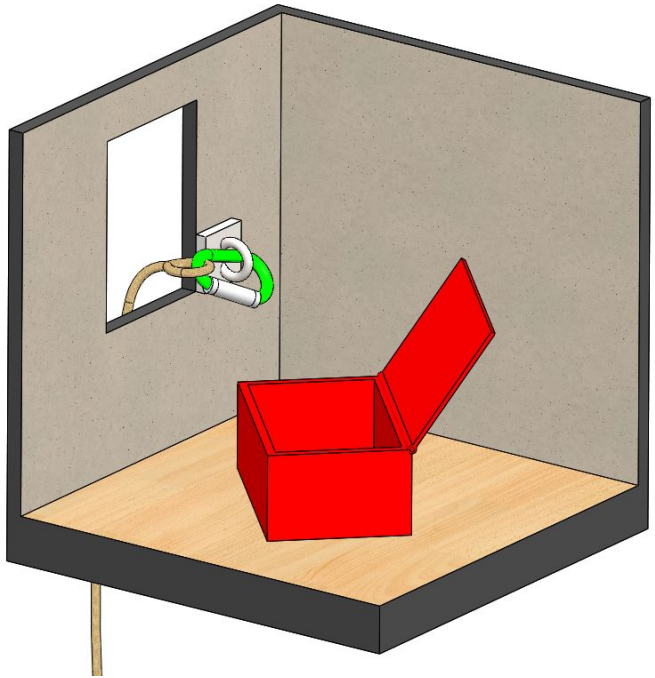

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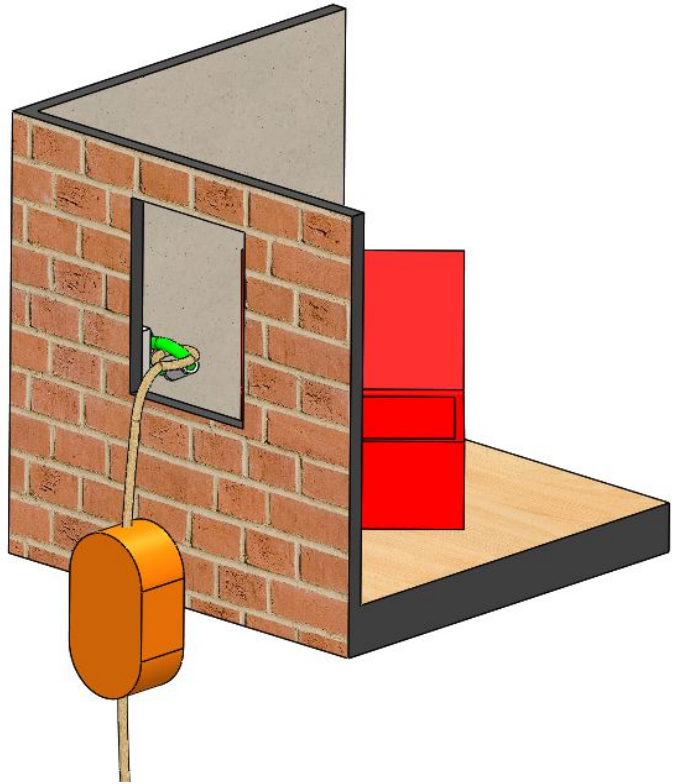

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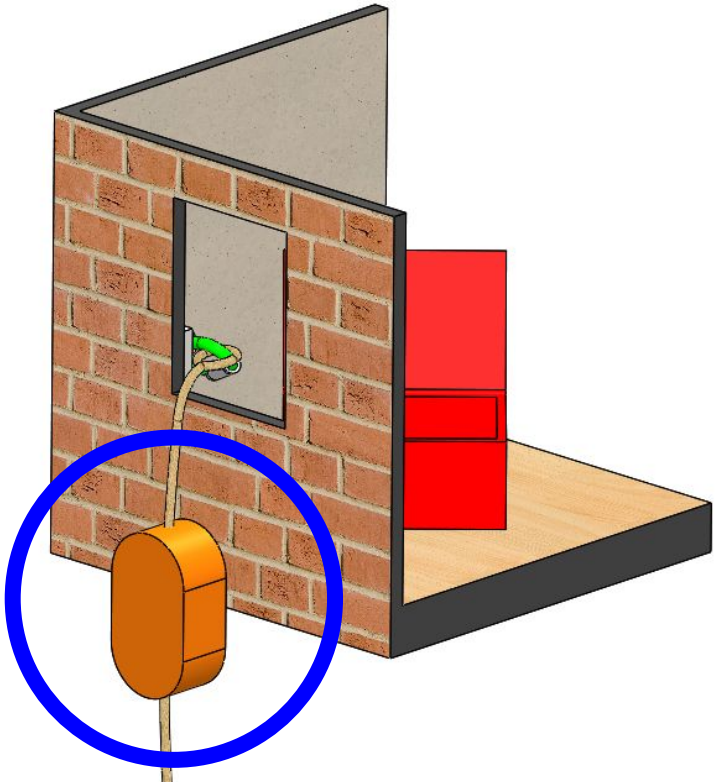
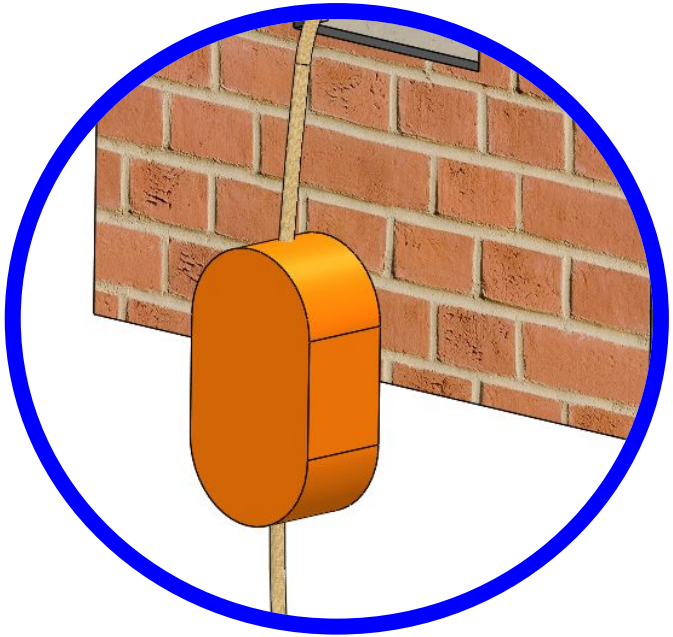
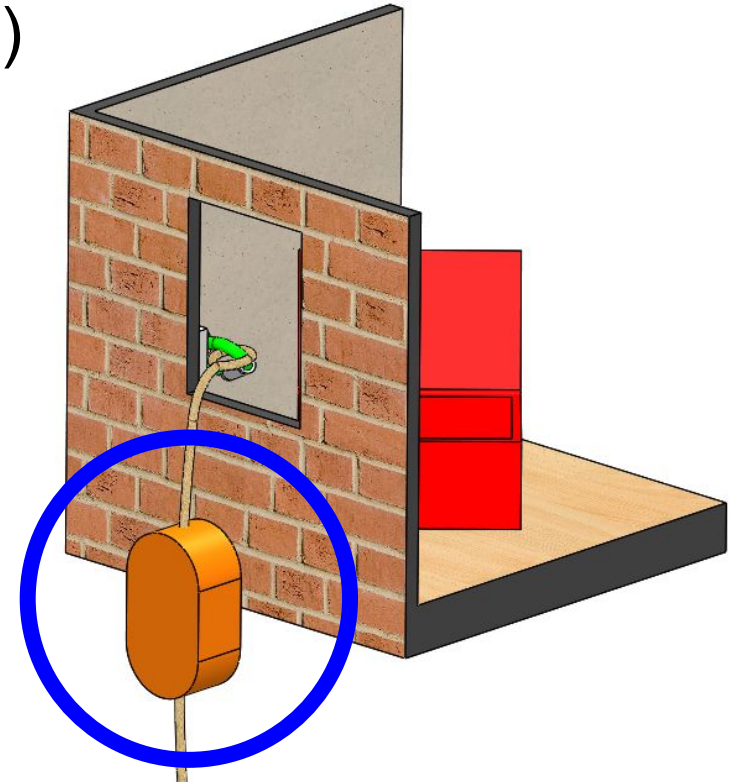


Components

Braking System (Design TBD)

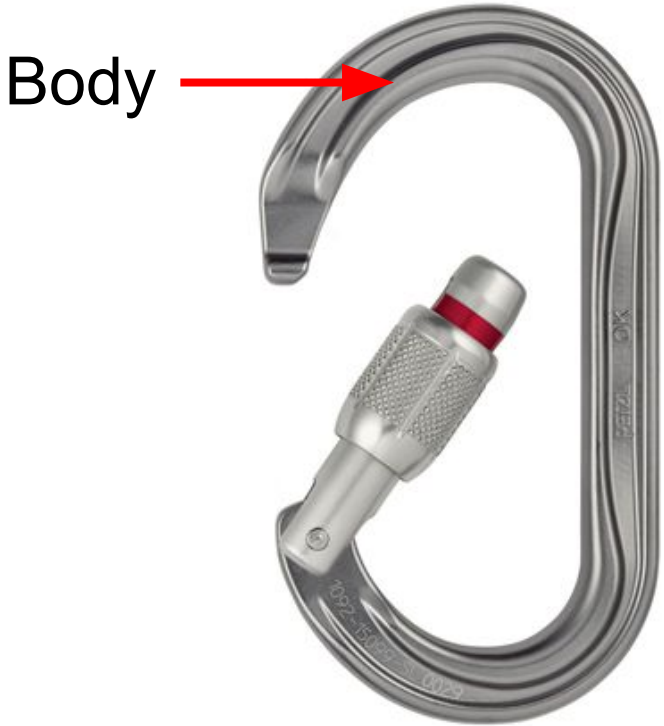




Clasp of choice: Carabiner

- Common
- Simple
- Used in high-risk activities (rock climbing, hang gliding, bungee jumping)

Clasp of choice: Carabiner



- Common
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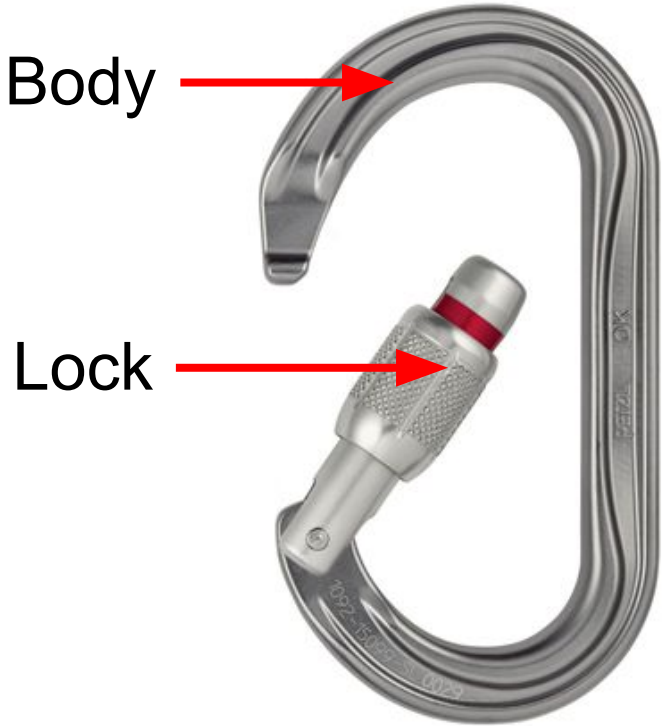
Clasp of choice: Carabiner



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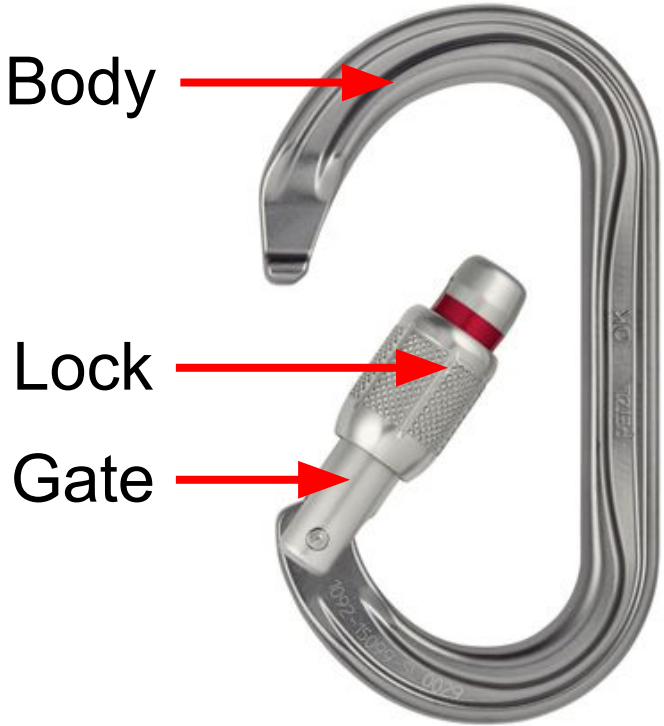
- Used in high-risk activities (rock climbing, hang gliding, bungee jumping)

Clasp of choice: Carabiner



- Common
- Simple
- Used in high-risk activities (rock climbing, hang gliding, bungee jumping)

Carabiner Requirements

Availability	No custom order necessary
Cost	Less than $10
Strength	Withstands 1000 lbf
Weight	Less than 0.1 lbf
Ease of clipping	Wide opening
Ease of opening	One-handed, takes less than one second to open
Ease of locking	One-handed, takes less than one second to lock
Safety	Will not fail or open under 1000 lbf

Carabiner Shapes

Oval

D-Shape

Modified D-Shape

Pear

Carabiner Shapes

Oval

D-Shape

Modified D-Shape

Pear

Carabiner Shapes

Oval

D-Shape

Modified D-Shape

Pear

Carabiner Shapes

Oval

D-Shape

Modified D-Shape

Pear

Carabiner Shapes

Oval

D-Shape

Modified D-Shape

Pear

	Oval	D	Modified D	Pear
Availability 1 = hard to find, 4 = easy to find				
Cost 1 = expensive, 4 = cheap				
Strength 1 = weak, 4 = strong				
Weight 1 = heavy, 4 = light				
Ease of clipping 1 = hard to clip, 4 = easy to clip				
Total /20				

	Oval	D	Modified D	Pear
Availability 1 = hard to find, 4 = easy to find	4	2	3	1
Cost 1 = expensive, 4 = cheap				
Strength 1 = weak, 4 = strong				
Weight 1 = heavy, 4 = light				
Ease of clipping 1 = hard to clip, 4 = easy to clip				
Total /20				

	Oval	D	Modified D	Pear
Availability 1 = hard to find, 4 = easy to find	4	2	3	1
Cost 1 = expensive, 4 = cheap	Cheapest on REI (outdoor store)			
Strength 1 = weak, 4 = strong				
Weight 1 = heavy, 4 = light				
Ease of clipping 1 = hard to clip, 4 = easy to clip				
Total /20				

	Oval	D	Modified D	Pear
Availability 1 = hard to find, 4 = easy to find	4	2	3	1
Cost 1 = expensive, 4 = cheap	$3.68	$6.25	$4.39	$8.73
Strength 1 = weak, 4 = strong				
Weight 1 = heavy, 4 = light				
Ease of clipping 1 = hard to clip, 4 = easy to clip				
Total /20				

	Oval	D	Modified D	Pear
Availability 1 = hard to find, 4 = easy to find	4	2	3	1
Cost 1 = expensive, 4 = cheap	4	2	3	1
Strength 1 = weak, 4 = strong				
Weight 1 = heavy, 4 = light				
Ease of clipping 1 = hard to clip, 4 = easy to clip				
Total /20				

	Oval	D	Modified D	Pear
Availability 1 = hard to find, 4 = easy to find	4	2	3	1
Cost 1 = expensive, 4 = cheap	4	2	3	1
Strength 1 = weak, 4 = strong	1	4	3	2
Weight 1 = heavy, 4 = light				
Ease of clipping 1 = hard to clip, 4 = easy to clip				
Total /20				

	Oval	D	Modified D	Pear
Availability 1 = hard to find, 4 = easy to find	4	2	3	1
Cost 1 = expensive, 4 = cheap	4	2	3	1
Strength 1 = weak, 4 = strong	1	4	3	2
Weight 1 = heavy, 4 = light	3	1	4	2
Ease of clipping 1 = hard to clip, 4 = easy to clip				
Total /20				

	Oval	D	Modified D	Pear
Availability 1 = hard to find, 4 = easy to find	4	2	3	1
Cost 1 = expensive, 4 = cheap	4	2	3	1
Strength 1 = weak, 4 = strong	1	4	3	2
Weight 1 = heavy, 4 = light	3	1	4	2
Ease of clipping 1 = hard to clip, 4 = easy to clip	2	1	3	4
Total /20				

	Oval	D	Modified D	Pear
Availability 1 = hard to find, 4 = easy to find	4	2	3	1
Cost 1 = expensive, 4 = cheap	4	2	3	1
Strength 1 = weak, 4 = strong	1	4	3	2
Weight 1 = heavy, 4 = light	3	1	4	2
Ease of clipping 1 = hard to clip, 4 = easy to clip	2	1	3	4
Total /20	14	10	16	10

	Oval	D	Modified D	Pear
Availability 1 = hard to find, 4 = easy to find	4	2	3	1
Cost 1 = expensive, 4 = cheap	4	2	3	1
Strength 1 = weak, 4 = strong	1	4	3	2
Weight 1 = heavy, 4 = light	3	1	4	2
Ease of clipping 1 = hard to clip, 4 = easy to clip	2	1	3	4
Total /20	14	10	16	10

Carabiner Gates

Straight

Wire

Screw lock

Auto-lock

Carabiner Gates

Straight

Wire

Screw lock

Auto-lock

Carabiner Gates

Straight

Wire

Screw lock

Auto-lock

Carabiner Gates

Straight

Wire

Screw lock

Auto-lock

Carabiner Gates

Straight

Wire

Screw lock

Auto-lock

	Straight	Wire	Screw	Auto-lock
Availability 1 = hard to find, 4 = easy to find				
Cost 1 = expensive, 4 = cheap				
Safety (x3 weight) 1 = not safe, 4 = safe				
Ease of opening 1 = hard to open, 4 = easy to open				
Ease of locking 1 = hard to lock, 4 = easy to lock				
Total /28				

	Straight	Wire	Screw	Auto-lock
Availability 1 = hard to find, 4 = easy to find	Number available on REI			
Cost 1 = expensive, 4 = cheap				
Safety (x3 weight) 1 = not safe, 4 = safe				
Ease of opening 1 = hard to open, 4 = easy to open				
Ease of locking 1 = hard to lock, 4 = easy to lock				
Total /28				

	Straight	Wire	Screw	Auto-lock
Availability 1 = hard to find, 4 = easy to find	10	22	48	23
Cost 1 = expensive, 4 = cheap				
Safety (x3 weight) 1 = not safe, 4 = safe				
Ease of opening 1 = hard to open, 4 = easy to open				
Ease of locking 1 = hard to lock, 4 = easy to lock				
Total /28				

	Straight	Wire	Screw	Auto-lock
Availability 1 = hard to find, 4 = easy to find	1	2	4	3
Cost 1 = expensive, 4 = cheap				
Safety (x3 weight) 1 = not safe, 4 = safe				
Ease of opening 1 = hard to open, 4 = easy to open				
Ease of locking 1 = hard to lock, 4 = easy to lock				
Total /28				

	Straight	Wire	Screw	Auto-lock
Availability 1 = hard to find, 4 = easy to find	1	2	4	3
Cost 1 = expensive, 4 = cheap	Cheapest on REI			
Safety (x3 weight) 1 = not safe, 4 = safe				
Ease of opening 1 = hard to open, 4 = easy to open				
Ease of locking 1 = hard to lock, 4 = easy to lock				
Total /28				

	Straight	Wire	Screw	Auto-lock
Availability 1 = hard to find, 4 = easy to find	1	2	4	3
Cost 1 = expensive, 4 = cheap	$6.25	$4.39	$3.69	$11.89
Safety (x3 weight) 1 = not safe, 4 = safe				
Ease of opening 1 = hard to open, 4 = easy to open				
Ease of locking 1 = hard to lock, 4 = easy to lock				
Total /28				

	Straight	Wire	Screw	Auto-lock
Availability 1 = hard to find, 4 = easy to find	1	2	4	3
Cost 1 = expensive, 4 = cheap	2	3	4	1
Safety (x3 weight) 1 = not safe, 4 = safe				
Ease of opening 1 = hard to open, 4 = easy to open				
Ease of locking 1 = hard to lock, 4 = easy to lock				
Total /28				

	Straight	Wire	Screw	Auto-lock
Availability 1 = hard to find, 4 = easy to find	1	2	4	3
Cost 1 = expensive, 4 = cheap	2	3	4	1
Safety (x3 weight) 1 = not safe, 4 = safe	2 x 3	1 x 3	3 x 3	4 x 3
Ease of opening 1 = hard to open, 4 = easy to open				
Ease of locking 1 = hard to lock, 4 = easy to lock				
Total /28				

	Straight	Wire	Screw	Auto-lock
Availability 1 = hard to find, 4 = easy to find	1	2	4	3
Cost 1 = expensive, 4 = cheap	2	3	4	1
Safety (x3 weight) 1 = not safe, 4 = safe	2 x 3	1 x 3	3 x 3	4 x 3
Ease of opening 1 = hard to open, 4 = easy to open				
Ease of locking 1 = hard to lock, 4 = easy to lock				
Total /28				

	Straight	Wire	Screw	Auto-lock
Availability 1 = hard to find, 4 = easy to find	1	2	4	3
Cost 1 = expensive, 4 = cheap	2	3	4	1
Safety (x3 weight) 1 = not safe, 4 = safe	2 x 3	1 x 3	3 x 3	4 x 3
Ease of opening 1 = hard to open, 4 = easy to open	4	3	1	2
Ease of locking 1 = hard to lock, 4 = easy to lock				
Total /28				

	Straight	Wire	Screw	Auto-lock
Availability 1 = hard to find, 4 = easy to find	1	2	4	3
Cost 1 = expensive, 4 = cheap	2	3	4	1
Safety (x3 weight) 1 = not safe, 4 = safe	2 x 3	1 x 3	3 x 3	4 x 3
Ease of opening 1 = hard to open, 4 = easy to open	4	3	1	2
Ease of locking 1 = hard to lock, 4 = easy to lock	N/A	N/A	3	4
Total /28				

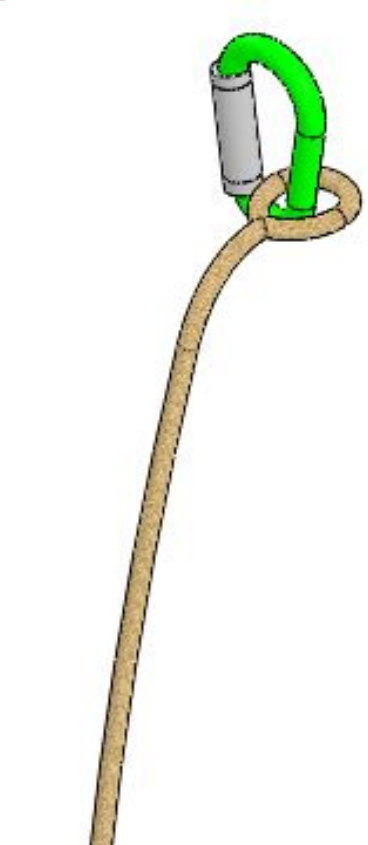
	Straight	Wire	Screw	Auto-lock
Availability 1 = hard to find, 4 = easy to find	1	2	4	3
Cost 1 = expensive, 4 = cheap	2	3	4	1
Safety (x3 weight) 1 = not safe, 4 = safe	2 x 3	1 x 3	3 x 3	4 x 3
Ease of opening 1 = hard to open, 4 = easy to open	4	3	1	2
Ease of locking 1 = hard to lock, 4 = easy to lock	N/A	N/A	3	4
Total /28	13	11	21	22

	Straight	Wire	Screw	Auto-lock
Availability 1 = hard to find, 4 = easy to find	1	2	4	3
Cost 1 = expensive, 4 = cheap	2	3	4	1
Safety (x3 weight) 1 = not safe, 4 = safe	2 x 3	1 x 3	3 x 3	4 x 3
Ease of opening 1 = hard to open, 4 = easy to open	4	3	1	2
Ease of locking 1 = hard to lock, 4 = easy to lock	N/A	N/A	3	4
Total /28	13	11	21	22

Carabiner Summary

- Modified D-Shape
- Auto-lock

Escape Rope Preliminary Selection



- 100 feet length
- Can withstand a dynamic load of up to 1000 lbf
- Flame resistant

Escape Rope Material

Nylon

Technora

Galvanized Steel

Escape Rope Material

Nylon

Technora

Galvanized Steel

Escape Rope Material

Nylon

Technora

Galvanized Steel

Escape Rope Material

Nylon

Technora

Galvanized Steel

¾” Diameter:	Nylon 6	Teijin Technora	Galv. Steel
Availability 1 = hard to find, 3 = easy to find			
Elastic Modulus 1 = weak, 3 = strong			
Cost 1 = expensive, 3 = cheap			
Weight 1 = heavy, 3 = light			
Heat Resistance 1 = low , 3 = high resistance			
Ease of Attachment 1 = hard , 3 = easy			
Total /18			

¾” Diameter:	Nylon 6	Teijin Technora	Galv. Steel
Availability 1 = hard to find, 3 = easy to find	3	1	2
Elastic Modulus 1 = weak, 3 = strong			
Cost 1 = expensive, 3 = cheap			
Weight 1 = heavy, 3 = light			
Heat Resistance 1 = low , 3 = high resistance			
Ease of Attachment 1 = hard , 3 = easy			
Total /18			

¾” Diameter:	Nylon 6	Teijin Technora	Galv. Steel
Availability 1 = hard to find, 3 = easy to find	3	1	2
Elastic Modulus 1 = weak, 3 = strong	18900 ksi	10200 ksi	29000 ksi
Cost 1 = expensive, 3 = cheap			
Weight 1 = heavy, 3 = light			
Heat Resistance 1 = low , 3 = high resistance			
Ease of Attachment 1 = hard , 3 = easy			
Total /18			

¾” Diameter:	Nylon 6	Teijin Technora	Galv. Steel
Availability 1 = hard to find, 3 = easy to find	3	1	2
Elastic Modulus 1 = weak, 3 = strong	2	1	3
Cost 1 = expensive, 3 = cheap			
Weight 1 = heavy, 3 = light			
Heat Resistance 1 = low , 3 = high resistance			
Ease of Attachment 1 = hard , 3 = easy			
Total /18			

¾” Diameter:	Nylon 6	Teijin Technora	Galv. Steel
Availability 1 = hard to find, 3 = easy to find	3	1	2
Elastic Modulus 1 = weak, 3 = strong	2	1	3
Cost 1 = expensive, 3 = cheap	$1.35/ft	$4.61/ft	$3.19/ft
Weight 1 = heavy, 3 = light			
Heat Resistance 1 = low , 3 = high resistance			
Ease of Attachment 1 = hard , 3 = easy			
Total /18			

¾” Diameter:	Nylon 6	Teijin Technora	Galv. Steel
Availability 1 = hard to find, 3 = easy to find	3	1	2
Elastic Modulus 1 = weak, 3 = strong	2	1	3
Cost 1 = expensive, 3 = cheap	3	1	2
Weight 1 = heavy, 3 = light			
Heat Resistance 1 = low , 3 = high resistance			
Ease of Attachment 1 = hard , 3 = easy			
Total /18			

¾” Diameter:	Nylon 6	Teijin Technora	Galv. Steel
Availability 1 = hard to find, 3 = easy to find	3	1	2
Elastic Modulus 1 = weak, 3 = strong	2	1	3
Cost 1 = expensive, 3 = cheap	3	1	2
Weight 1 = heavy, 3 = light	0.0423 lb/in³	0.0502 lb/in³	0.282 lb/in³
Heat Resistance 1 = low , 3 = high resistance			
Ease of Attachment 1 = hard , 3 = easy			
Total /18			

¾” Diameter:	Nylon 6	Teijin Technora	Galv. Steel
Availability 1 = hard to find, 3 = easy to find	3	1	2
Elastic Modulus 1 = weak, 3 = strong	2	1	3
Cost 1 = expensive, 3 = cheap	3	1	2
Weight 1 = heavy, 3 = light	3	2	1
Heat Resistance 1 = low , 3 = high resistance			
Ease of Attachment 1 = hard , 3 = easy			
Total /18			

¾” Diameter:	Nylon 6	Teijin Technora	Galv. Steel
Availability 1 = hard to find, 3 = easy to find	3	1	2
Elastic Modulus 1 = weak, 3 = strong	2	1	3
Cost 1 = expensive, 3 = cheap	3	1	2
Weight 1 = heavy, 3 = light	3	2	1
Heat Resistance 1 = low , 3 = high resistance	460 °F	500 °F	392 °F
Ease of Attachment 1 = hard , 3 = easy			
Total /18			

¾” Diameter:	Nylon 6	Teijin Technora	Galv. Steel
Availability 1 = hard to find, 3 = easy to find	3	1	2
Elastic Modulus 1 = weak, 3 = strong	2	1	3
Cost 1 = expensive, 3 = cheap	3	1	2
Weight 1 = heavy, 3 = light	3	2	1
Heat Resistance 1 = low , 3 = high resistance	2	3	1
Ease of Attachment 1 = hard , 3 = easy			
Total /18			

¾” Diameter:	Nylon 6	Teijin Technora	Galv. Steel
Availability 1 = hard to find, 3 = easy to find	3	1	2
Elastic Modulus 1 = weak, 3 = strong	2	1	3
Cost 1 = expensive, 3 = cheap	3	1	2
Weight 1 = heavy, 3 = light	3	2	1
Heat Resistance 1 = low , 3 = high resistance	2	3	1
Ease of Attachment 1 = hard , 3 = easy	3	2	1
Total /18			

¾” Diameter:	Nylon 6	Teijin Technora	Galv. Steel
Availability 1 = hard to find, 3 = easy to find	3	1	2
Elastic Modulus 1 = weak, 3 = strong	2	1	3
Cost 1 = expensive, 3 = cheap	3	1	2
Weight 1 = heavy, 3 = light	3	2	1
Heat Resistance 1 = low , 3 = high resistance	2	3	1
Ease of Attachment 1 = hard , 3 = easy	3	2	1
Total /18	16	10	10

¾” Diameter:	Nylon 6	Teijin Technora	Galv. Steel
Availability 1 = hard to find, 3 = easy to find	3	1	2
Elastic Modulus 1 = weak, 3 = strong	2	1	3
Cost 1 = expensive, 3 = cheap	3	1	2
Weight 1 = heavy, 3 = light	3	2	1
Heat Resistance 1 = low , 3 = high resistance	2	3	1
Ease of Attachment 1 = hard , 3 = easy	3	2	1
Total /18	16	10	10

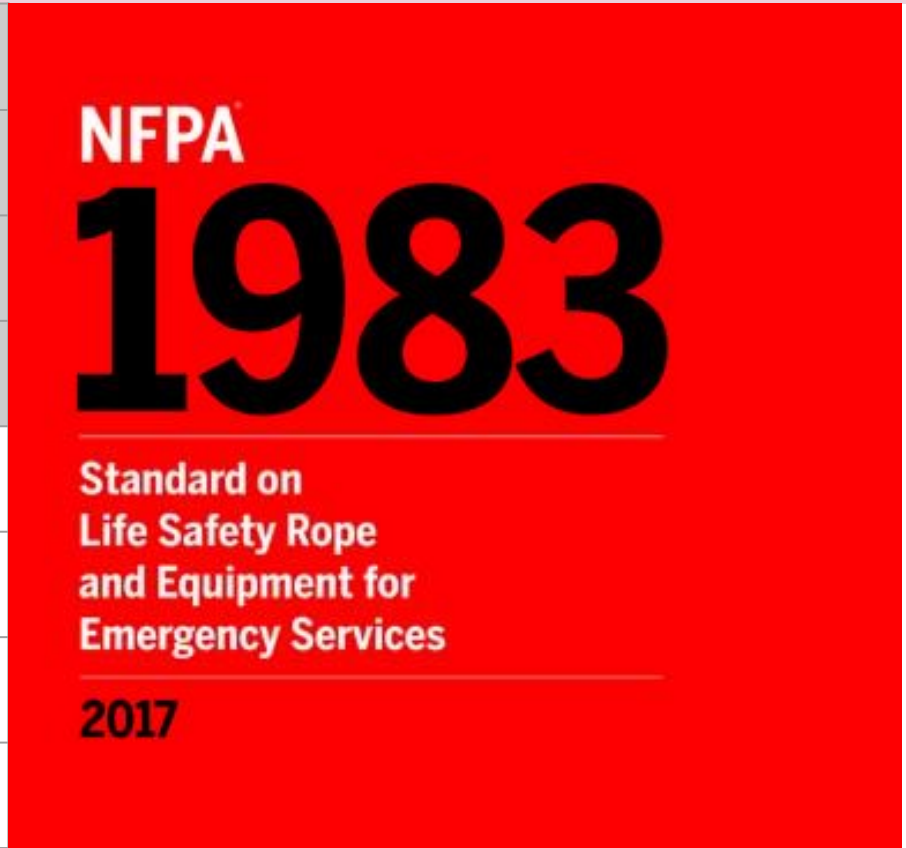
Rope of Choice: Nylon

- Good elasticity and resilience
- Robust with attachments when descending
- Cheap

Rope of Choice: ¾” Nylon 6

Availability	Commonly manufactured and available
Tensile Strength	428 ksi
Cost	As low as 40 cents per foot
Minimum Breaking Strength	12780 lbf
Safety Load	1073 lbf
Weight | Density	0.0423 lb/in^3

National Fire Protection Association (NFPA)



Standard on

Life Safety Rope

and Equipment for
Emergency Services

Nylon Rope NFPA Standards

- Breaking strength > 3034 lbf
- Elongation between 1 - 10%
  at 10% breaking strength
- Virgin Fiber
- Flame Resistant

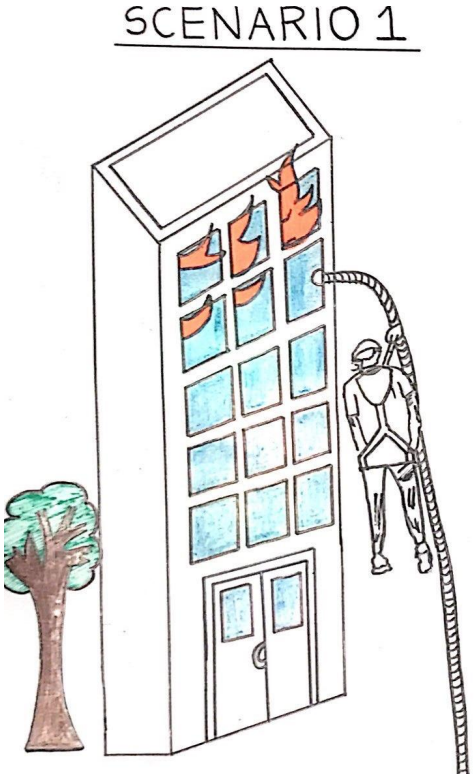
Rope Summary

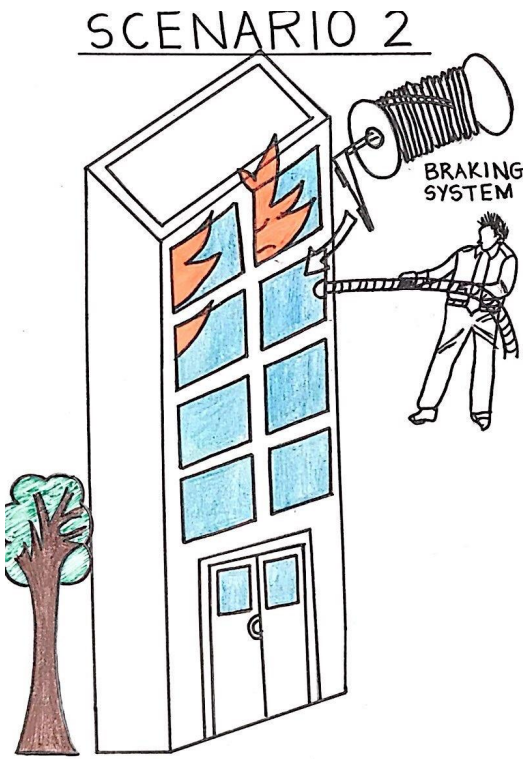
- Nylon
- ¾” Diameter
- Follows NFPA Standards

Harness Belt Summary

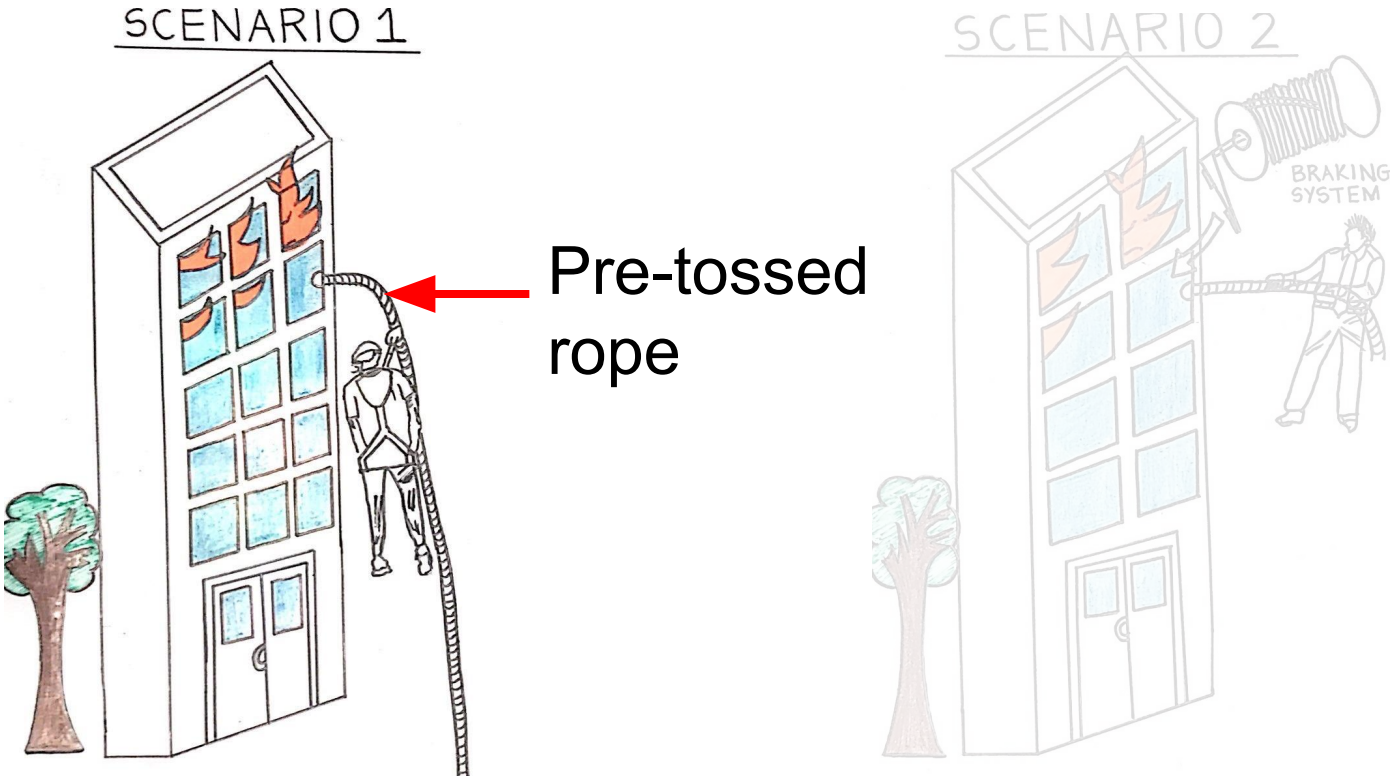
- Breaking strength > 1000 lbf
- Shoulder harness
- Flame resistant

How is our system going to work?

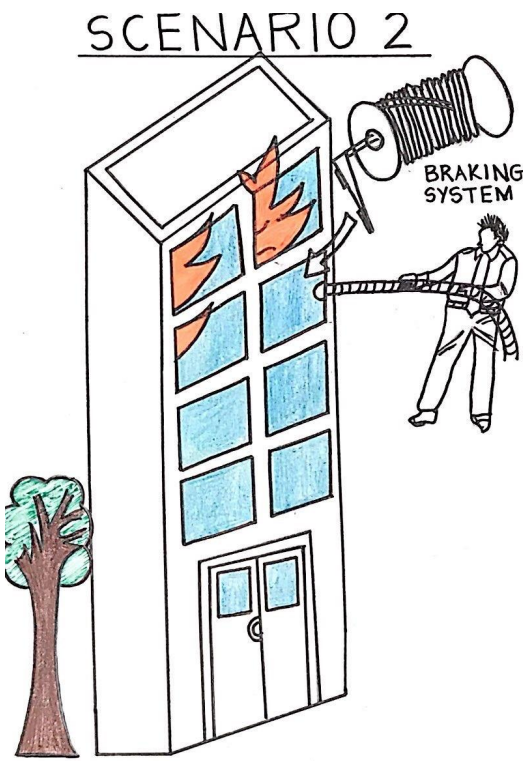




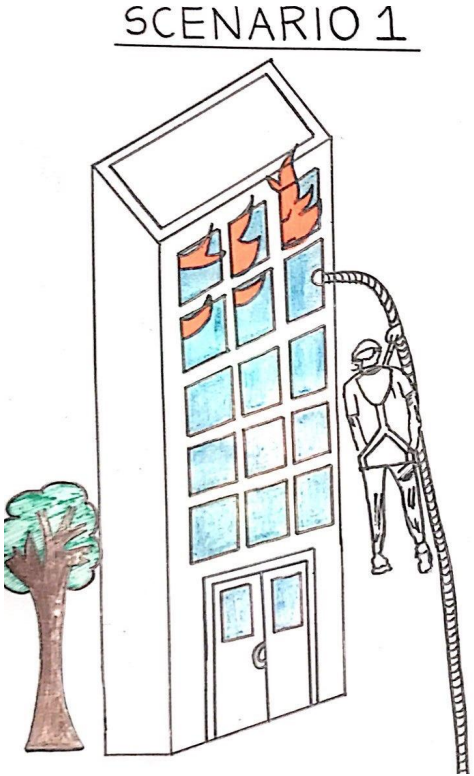
How is our system going to work?



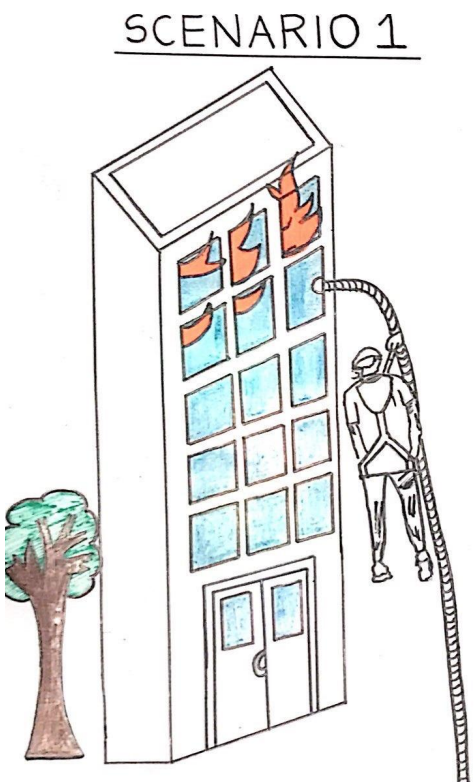
How is our system going to work?



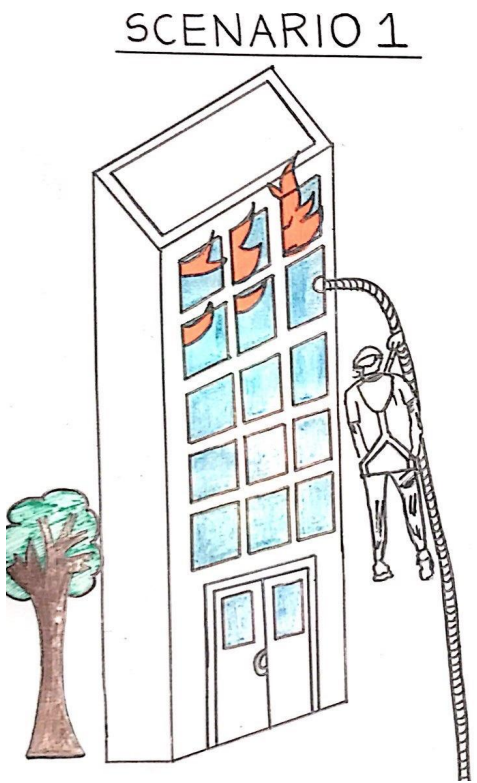
Case 1: Rappelling on a Stationary Rope



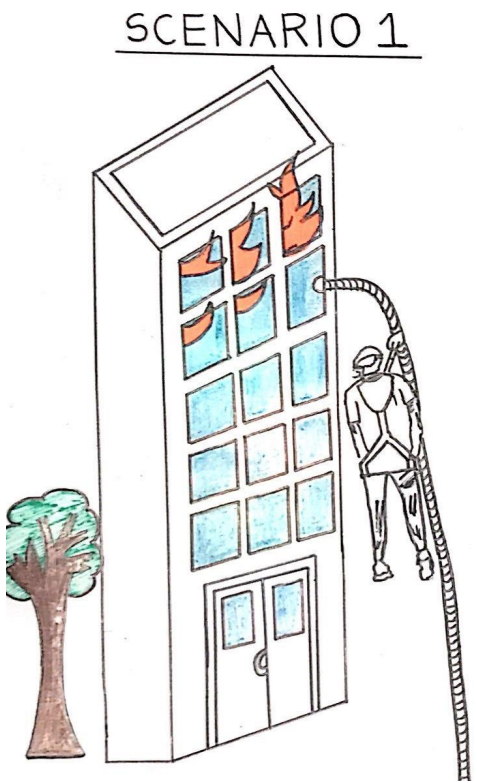
Rappelling for Firefighters



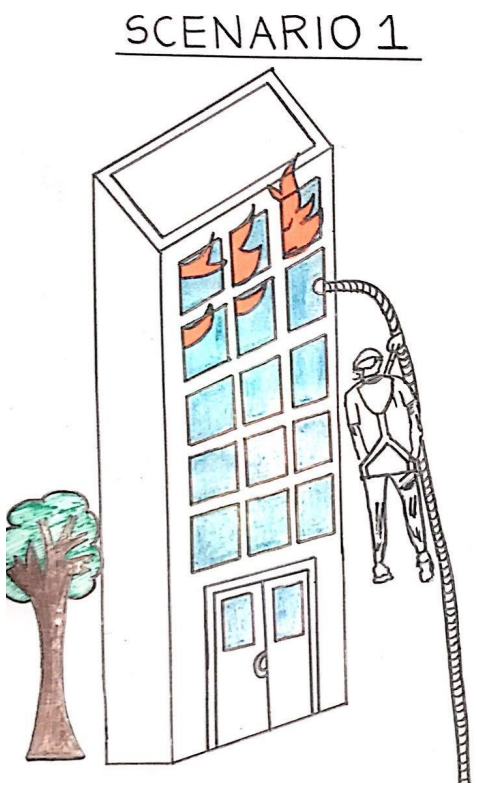
Rappelling for Firefighters



Rappelling for Rock Climbers



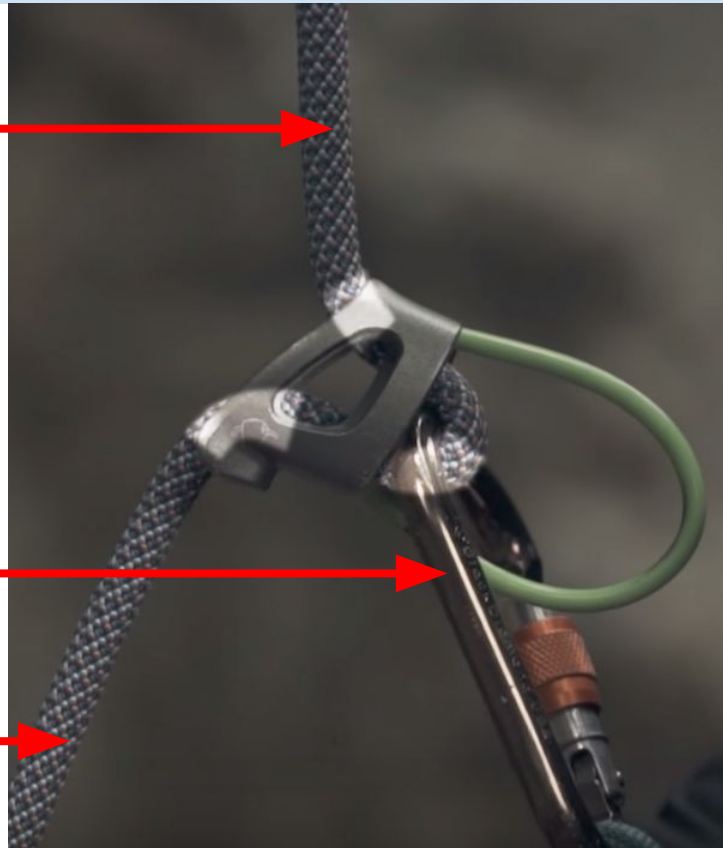
Rappelling for Rock Climbers



Support End

Carabiner attached to user

Brake End

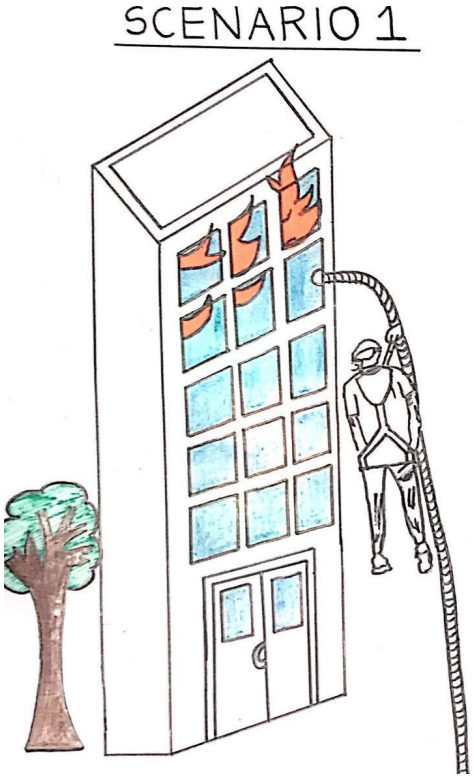


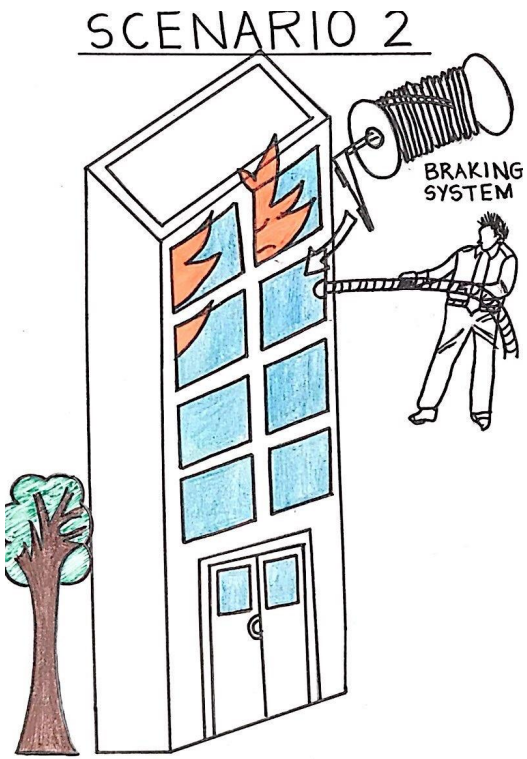
Problems & Concerns

Automatic Braking

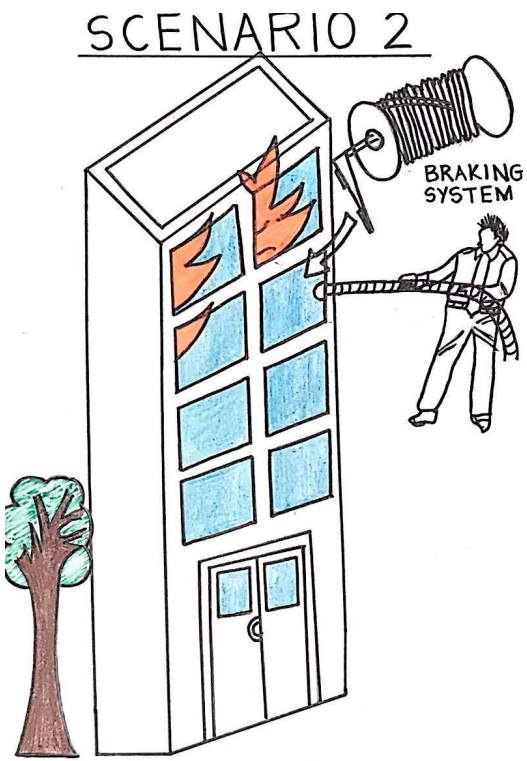
- How do we redesign this to brake at a constant rate independent of user’s weight?

How is our system going to work?

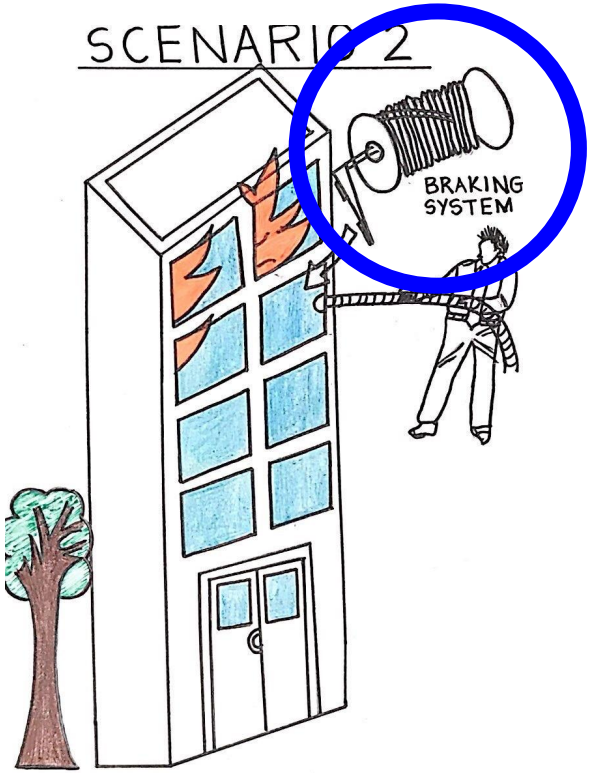




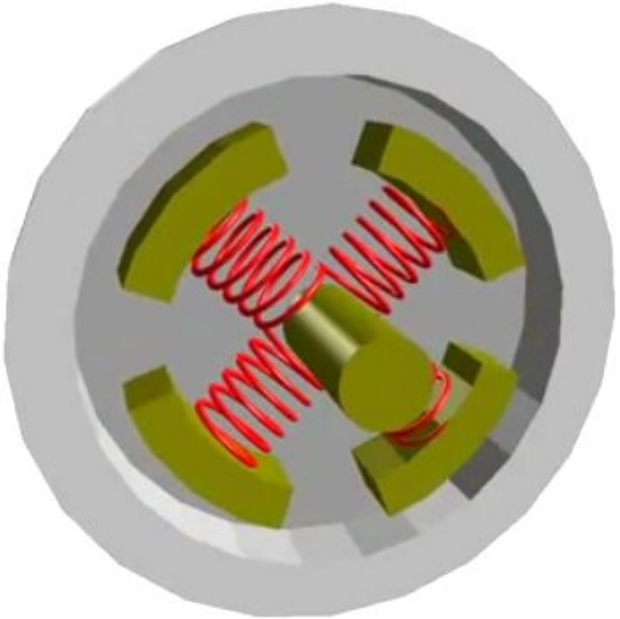
How is our system going to work?



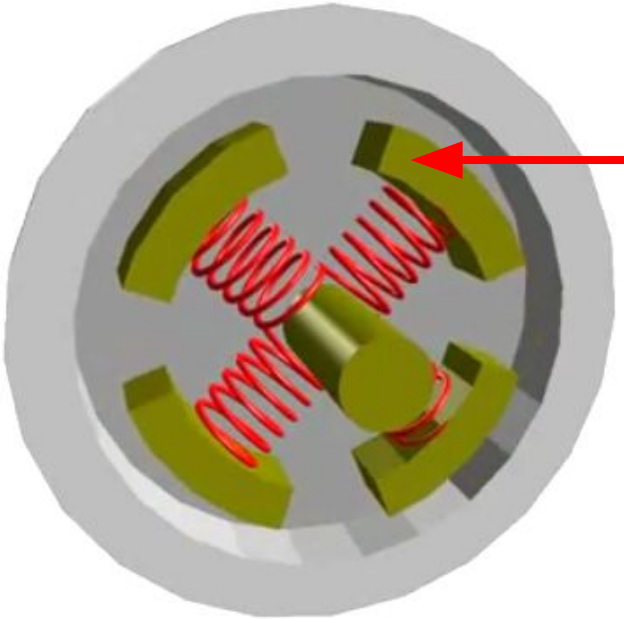
How is our system going to work?



Case 2: Centrifugal Braking

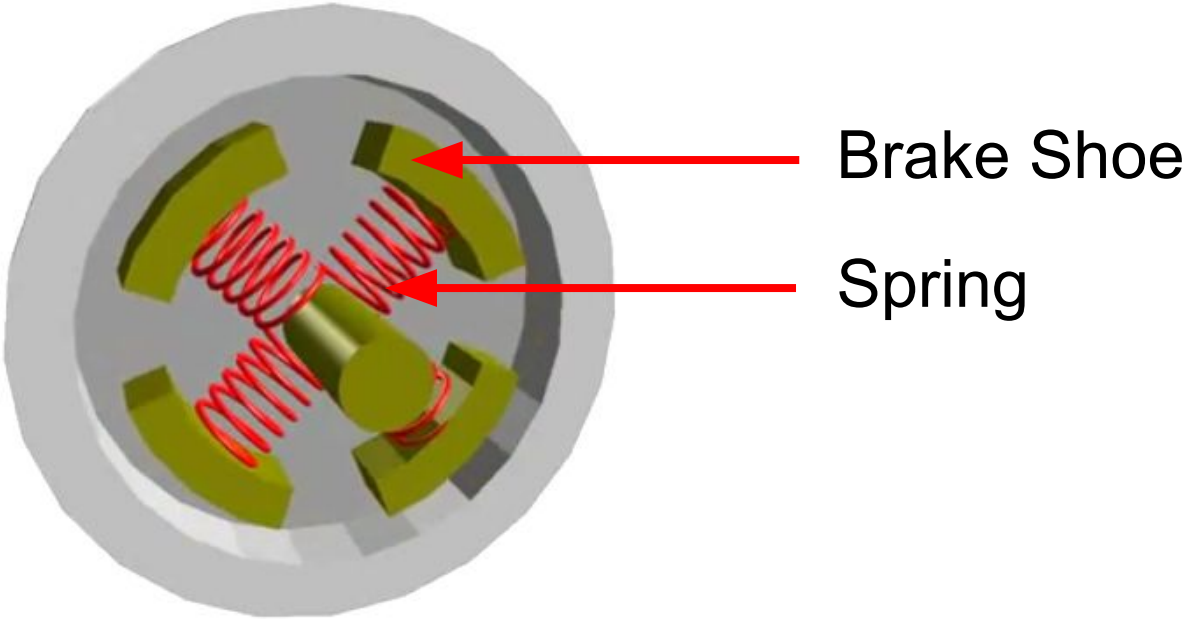


Case 2: Centrifugal Braking

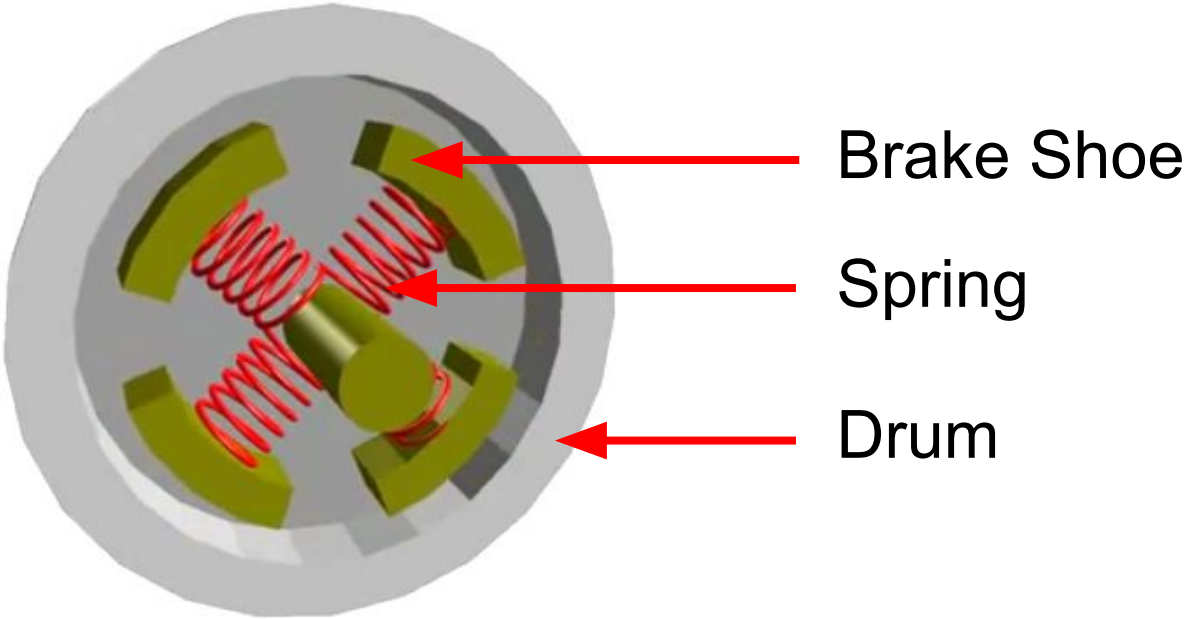


Brake Shoe

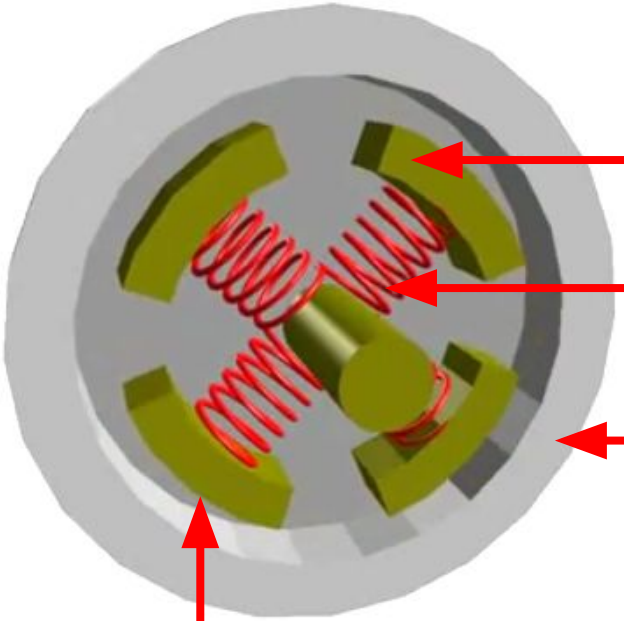
Case 2: Centrifugal Braking



Case 2: Centrifugal Braking



Case 2: Centrifugal Braking



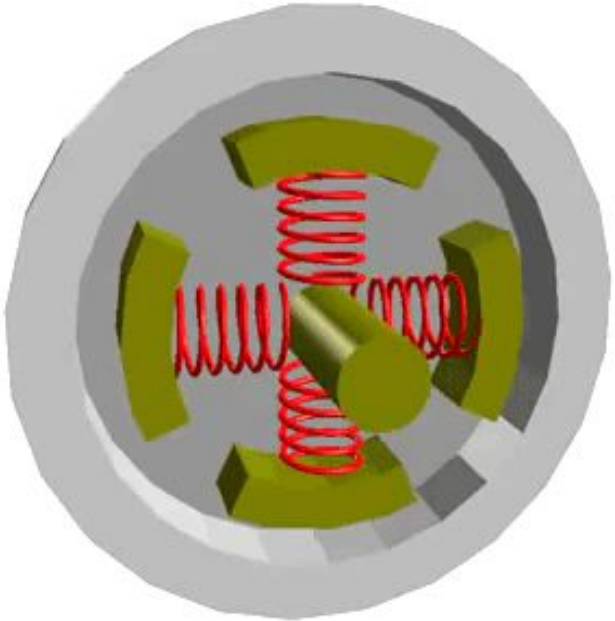
Brake Shoe

Spring

Drum

Friction Lining
(outside of the brake shoe)

Case 2: Centrifugal Braking



- Rope causes inner mechanism to rotate, producing a centrifugal force on the brake shoes
- As descent speed increases, centrifugal force increases to brake

Problems & Concerns

Calculations:

- How do we make sure the system does not brake hard enough and stall the rotation?

Size & Weight

- Will the system have to be large to bring a 1000 lbf weight from free fall to 3 ft/s?
- Will the system be too large and heavy to carry?
- Will we have to account for this weight in addition to user weight?

Design Summary

Carabiner

- Modified D
- Auto-lock

Rope

- Nylon
- ¾” Dia

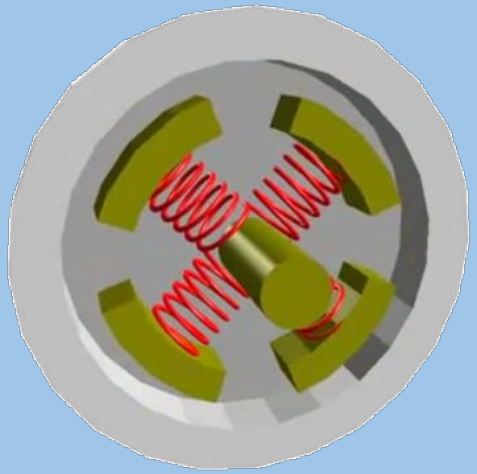
Harness

- Shoulder type

Design Summary

Rappelling

- Descend with device



Centrifugal Brake

- Spool system

Next Steps

Design of hook: size, strength

Design of hermitic box: size, fire-resistancy

Continue design of braking system:
Case 1: Automating the braking
Case 2: Determining required calculations

Questions?

References

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