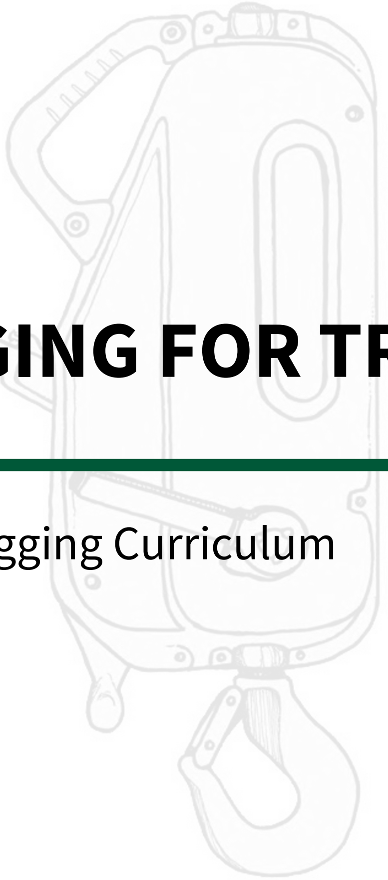
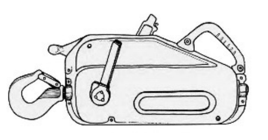
Forest Service
U.S. DEPARTMENT OF AGRICULTURE



RIGGING FOR TRAIL WORK

USFS Rigging Curriculum

What is Rigging?



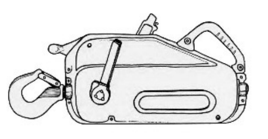
“Rigging is the use of specialized tools to safely move heavy objects from one location to another.”

Rigging for Trail Work:

Principles, Techniques, and Lessons from the Backcountry

August 2024

When is a qualified rigger required?



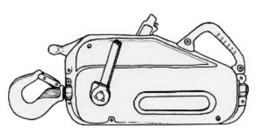
"Employers must use qualified riggers during hoisting activities for assembly and disassembly work (1926.1404(r)(1)).

Additionally, qualified riggers are required whenever workers are within the fall zone and hooking, unhooking, or guiding a load, or doing the initial connection of a load to a component or structure (1926.1425(c))."

OSHA FactSheet:

Subpart CC – Cranes and Derricks in Construction: Qualified Rigger

Who is a Qualified Rigger?



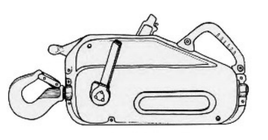
“A qualified rigger is a rigger who meets the criteria for a qualified person.

Employers must determine whether a person is qualified to perform specific rigging tasks. Each qualified rigger may have different credentials or experience.

OSHA FactSheet:

Subpart CC – Cranes and Derricks in Construction: Qualified Rigger

Who is (are you) a Qualified Rigger?



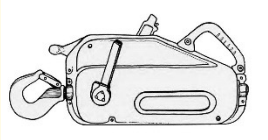
A qualified rigger is a person that:

- *Possesses a recognized degree, certificate, or professional standing, or*
- ***Has extensive knowledge, training, and experience, and***
- ***Can successfully demonstrate the ability to solve problems related to rigging loads.”***

OSHA FactSheet:

Subpart CC – Cranes and Derricks in Construction: Qualified Rigger

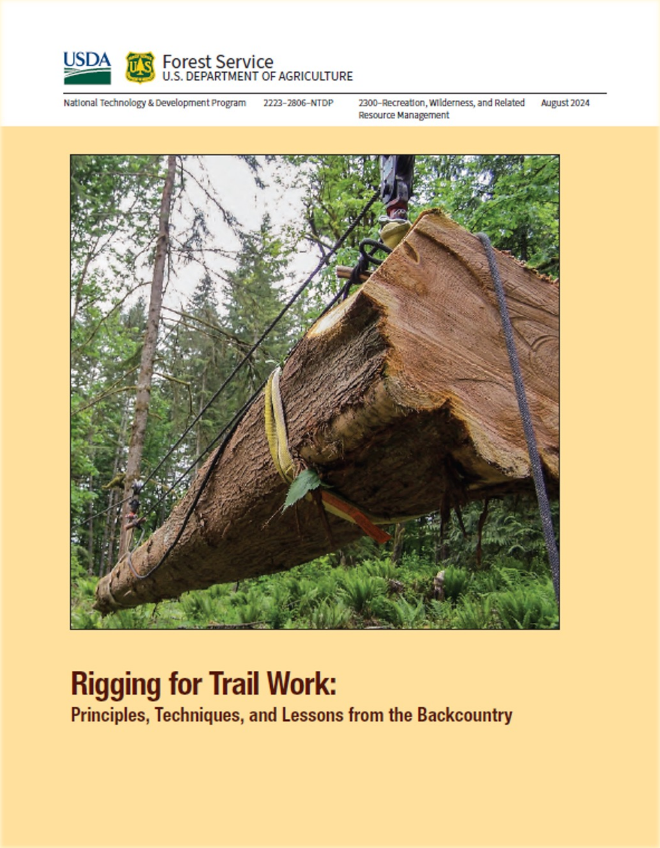
What is this class?



This Class Is:

An introduction to the rigging tools and techniques commonly used in trail work.

A chance to share knowledge and experience in a safe hands-on environment.

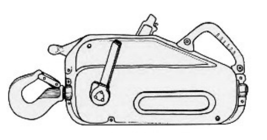


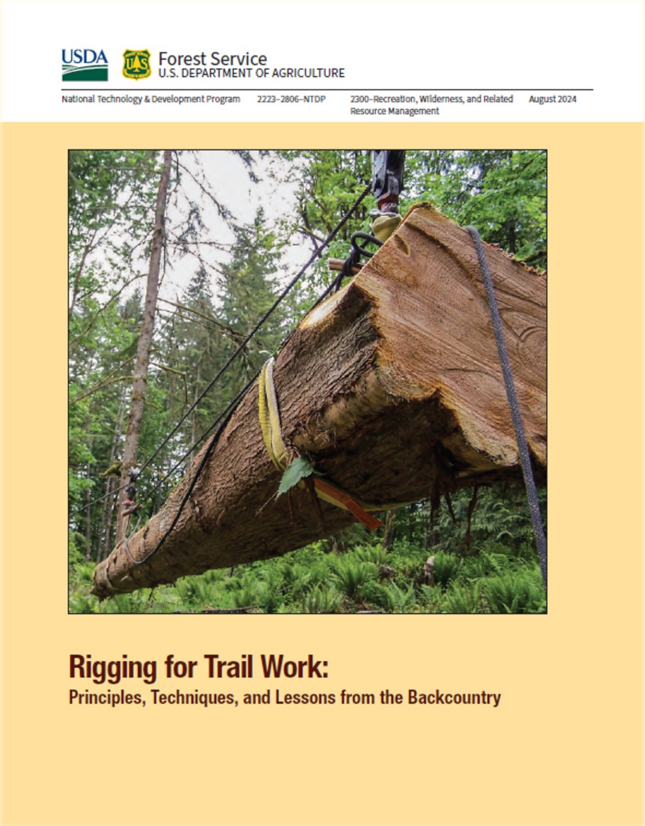
USDA Forest Service
U.S. DEPARTMENT OF AGRICULTURE

National Technology & Development Program | 2223-2806-NTDP | 2300-Recreation, Wilderness, and Related Resource Management | August 2024

Rigging for Trail Work:
Principles, Techniques, and Lessons from the Backcountry

What is this class?





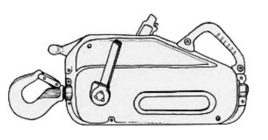
This Class Is Not:

A certification or professional qualification.

A math or physics class.

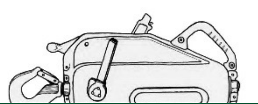
Everything you need to learn to be a rigger for the Forest Service.

Course Objectives



- Successfully and safely assemble, disassemble and operate rigging systems
- Gain experience with different types of rigging systems
- Demonstrate the ability to solve problems related to rigging loads

Rigging Safety Topics



Rigging comes with inherent risks. By understanding the rigging system, the forces at play, and paying attention to safety, we can safely lift and move heavy loads to do amazing things in remote places.

Before Operations:

- Training
- Rigging system Forces calculated and understood
- PPE
- RA/JHA's
- First Aid Supplies
- Equipment Inspection
- Evacuation Plan
- Communication Plan

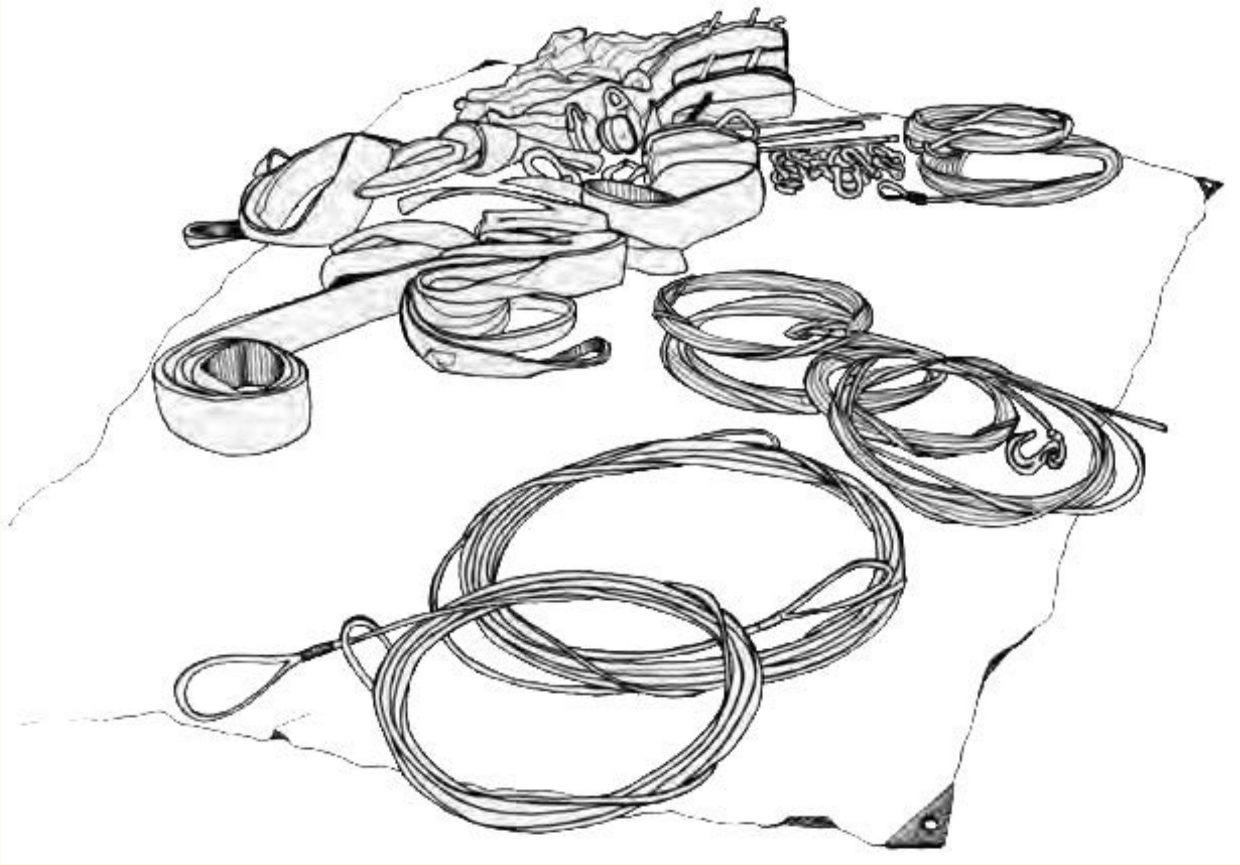
During Operations:

- Safe Project Management
- Tailgate Safety Sessions
- Crew Communication (Chain of Command)
- Voice, Radio, or Hand Signals
- Safe Working Positions
- Attaching Loads

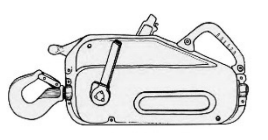
After Operations:

- End of Day operations
- After Action Reviews
- Equipment cleaning and inspection

Rigging Equipment – Equipment Inspection



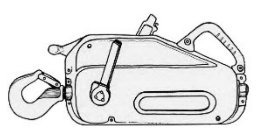
ABS and MBS



Average Breaking Strength (ABS) – is the “usual” force at which a piece of equipment will fail.

Minimum Breaking Strength (MBS) – is a statistically calculated rating, below which a piece of equipment will not fail (99.8% of the time, if using a 3σ calculation).

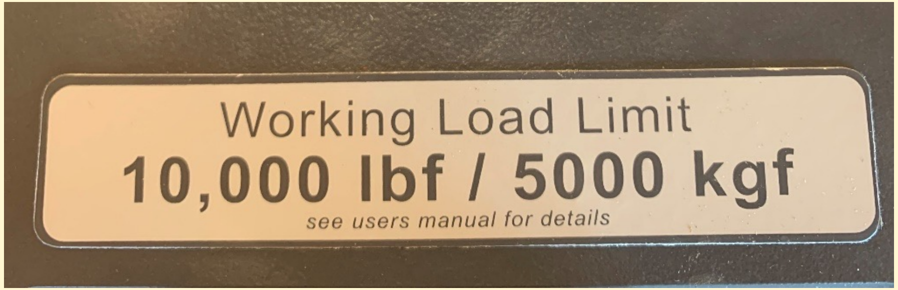
MBS, WLL/SWL



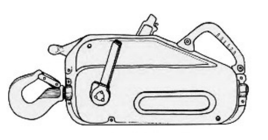
Minimum Breaking Strength (MBS) – simply is the load rating when a piece of equipment is expected to fail.

Working Load Limit (WLL) and **Safe Working Load (SWL)** are the maximum that a piece of equipment should be loaded in normal operations. Calculated by dividing the MBS by a Safety Factor (typically 5 for rigging, 10 for human life-support).

WLL = MBS / SF



Calculating Working Load Limit (WLL)



Working Load Limit =

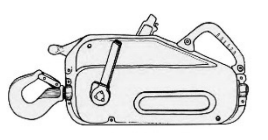
Minimum Break Strength / Safety Factor

Standard rigging operations use a 5:1 safety factor. For human life support rigging operations (typically not done) a 10:1 safety factor is used.

Questions:

- If a piece of gear has an MBS of 5000 pounds what is the WLL?
- What is the MBS of the shackle that is stamped WLL2T?
- What is the WLL of the shackle that is stamped WLL2T if used for human life support?

Fiber Rope Strength



Samson 1/2" Stable Braid Double Braid Bull Rope

SPECIFICATIONS REVIEWS

Rope Construction Double Braid (Class 1)

Diameter 1/2" (13.5mm)

Weight 8.2 lbs/100' (12.2 kg/100 m)

Specific Gravity 1.38

Average Breaking Strength 10,400 lbs (4,700 kg)

Elongation 1.1% at 10% ABS

$0.99

Per Foot

Samson 1/2" AmSteel Blue 12-Strand Rope

SPECIFICATIONS REVIEWS

Color Blue

Rope Type Winch Line

Rope Construction 12-Strand Single Braid

Diameter 1/2" (13mm)

Weight 5.9 lbs/100'

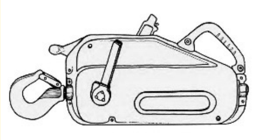
Minimum Breaking Strength (MBS) 30,600 lbs (13,900 kg)

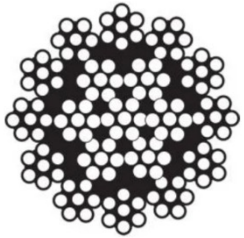
Average Breaking Strength (ABS) 34,000 lbs (15,400 kg)

$4.39

Shipping Weight 0.1 lbs.

Wire Rope Strength



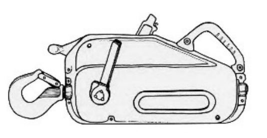


7/16" 19x7 Rotation-Resistant Wire Rope - Per Foot

Diameter	3/8" 7x19 construction
Minimum Breaking Strength (MBS):	12,300 lbs
Working Load Limit	2,460 lbs
Weight/100'	25
Price/foot	$1.06

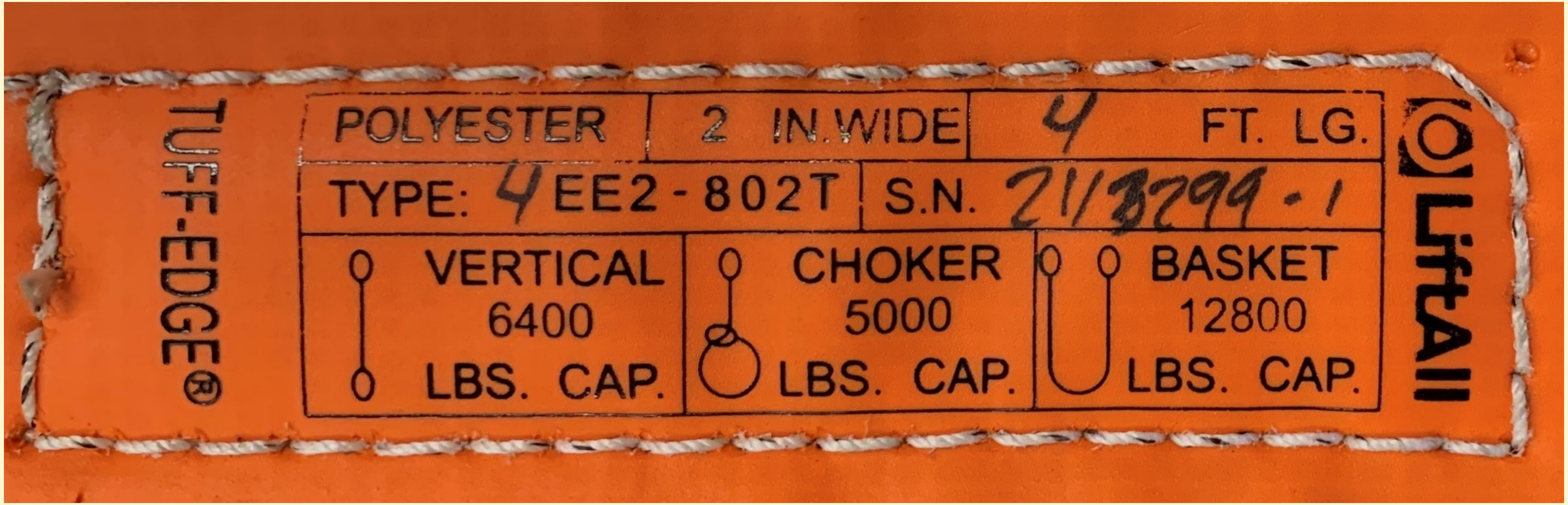
Diameter	7/16" 7x19 construction
Minimum Breaking Strength (MBS):	16,660 lbs
Working Load Limit	3,332 lbs
Weight/100'	35
Price/foot	$1.23

Sling Ratings

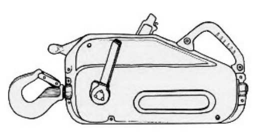


Some pieces of equipment will have different Working Load Limits depending on the configuration they are used.

This is common for slings, which often have a WLL for “Vertical”, “Basket”, and “Choker” configurations.



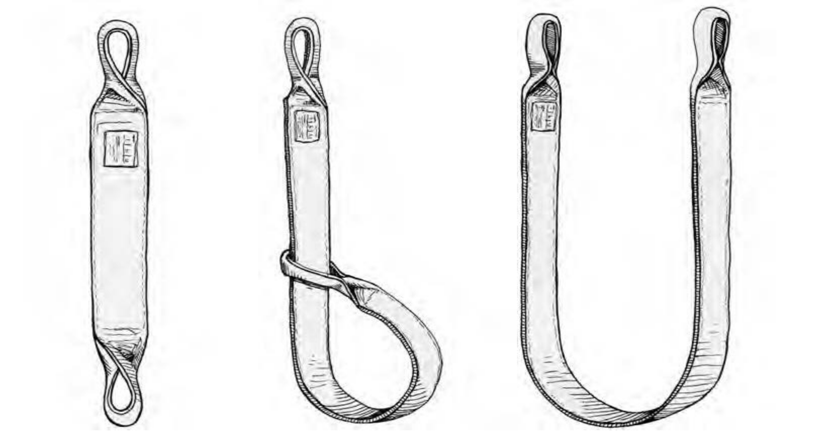
Sling Ratings - Continued

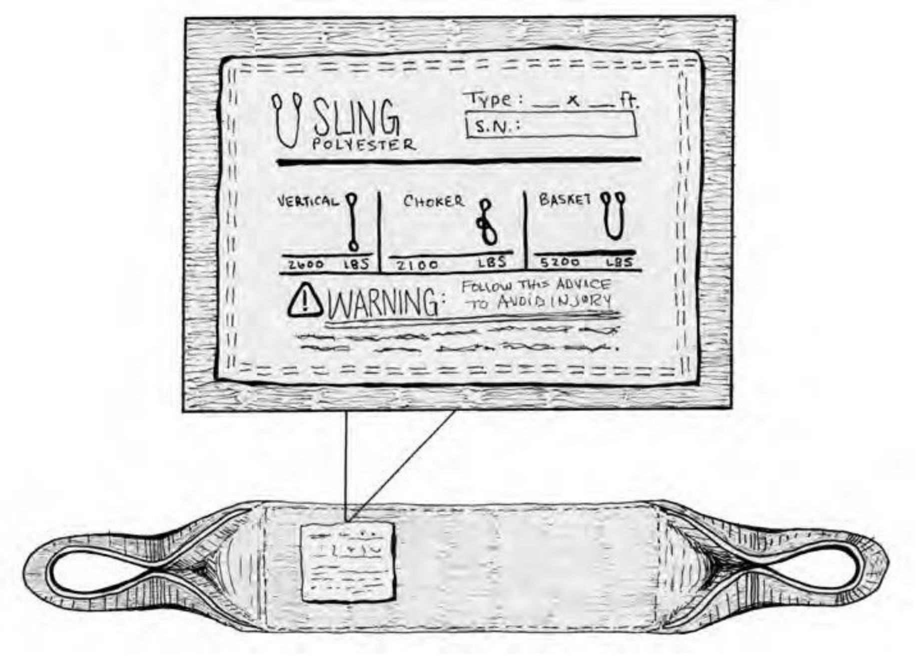


See illustrations and tags on nylon slings. Most slings will have this type of sewn on tag marking the WLL of the sling in various configurations.

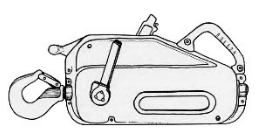
Below sling configurations:

Vertical Choker Basket





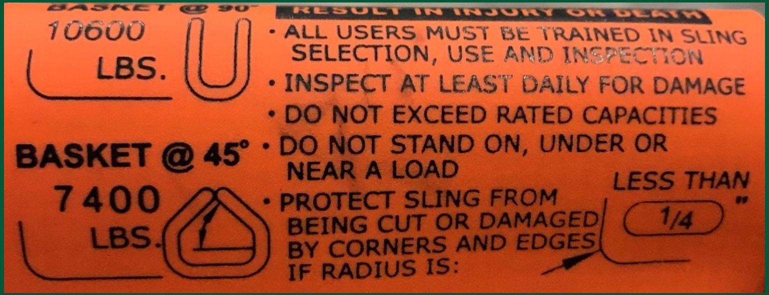
Reduced WLL Ratings

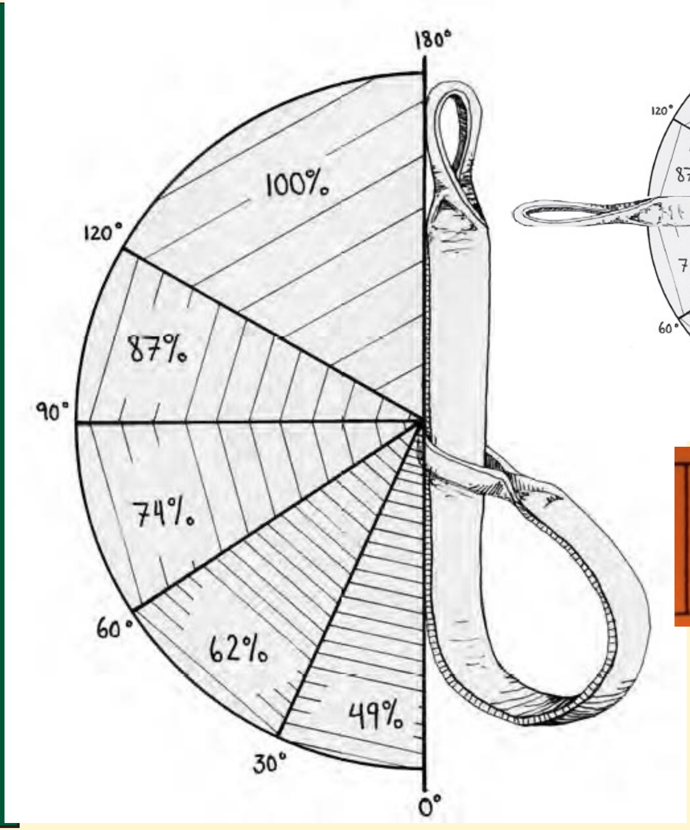


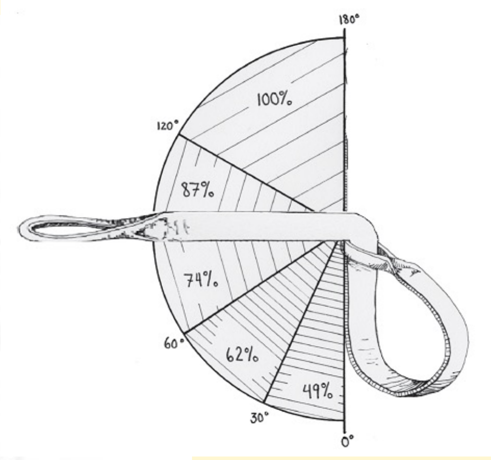
In certain configurations, it may be necessary to reduce the marked WLL ratings.

Examples include:

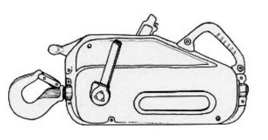
- Slings in a choker configuration, when the “choke angle” is less than 120°
- Slings in a tight basket
- Wire rope run in a small pulley







Quality Versus Sub Par Rigging Gear



ISC Medium Aluminum Arborist Rigging Block (3/4" Rope) RP055A

SKU#: RP055A

The ISC Medium Aluminum Arborist Rigging Block (3/4" Rope) is designed to work to absorb the huge forces which are created by the harsh dynamics of heavy Arborist work. The rope-friendly edges, large sheave, and retained upper sheave which opens quickly with the twist and push pin are the same as the popular small ISC block, but with beefed up strength. Eliminates the chance of dropping a sheave. The lightweight and strong sides are now made with Hot Forged Technology. The side plates are thick aluminum with a powder coating to enhance the life of the block. These blocks are rope friendly, durable and extremely robust.

$259.99

Shipping Weight 3.5 lbs.

SPECIFICATIONS WARRANTY REVIEWS

Color Blue

Height 9.5" (1825mm)

Width 4.87" (100mm)

Thickness 2.75" (70mm)

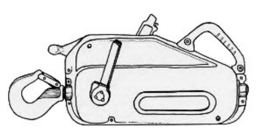
Weight 4.9 lbs

MBS 33,271 lbs (150kN)

Work Load Limit (5:1 ratio) 6,600 lbs (30kN)

Maximum Rope Diameter 3/4" (20mm)

Quality Versus Sub Par Rigging Gear



12-Stage Coating Process

Steel Fully Forged

99-Year Hassle Free

WINCH PULLEY SNATCH BLOCK - 39600 LBS, 18 TON

$41.99 USD ~~$51.99 USD~~

SAVE $10.00 USD

Shipping calculated at checkout

★★★★★ 5.0 / 5.0 based on 1 review

Available Now!

– 1 +

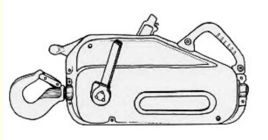
Add to Cart | Buy it now

This order qualifies for **FREE** shipping!

ABOUT THIS ITEM

- 【Extreme Snatch Block】Proudly Introducing our Extreme Series Snatch Block which is made of Ultra-Strong Fully Forged Steel to provide 79,300 LBS Break Strength to work with most Winch Ropes with diameter under 5/8in. With ALL-TOP's exclusive 12-Stage Coating process including E-coating and Powdered Coats, these Extreme-Series products are extremely Impact-Resist and have a much longer Wear Cycle against Wear & Abrasion.

Non-Rated Components of Rigging Systems



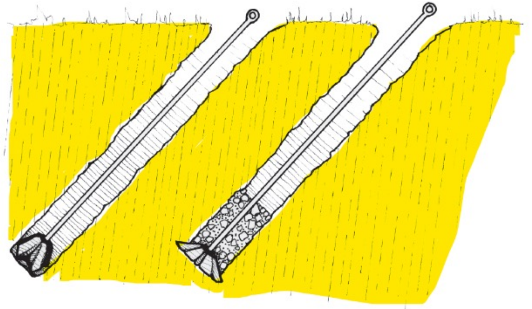


Figure 7-6—An expanding soil anchor in a drilled hole.

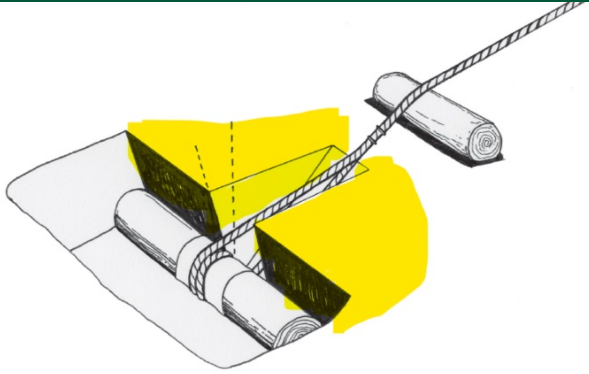
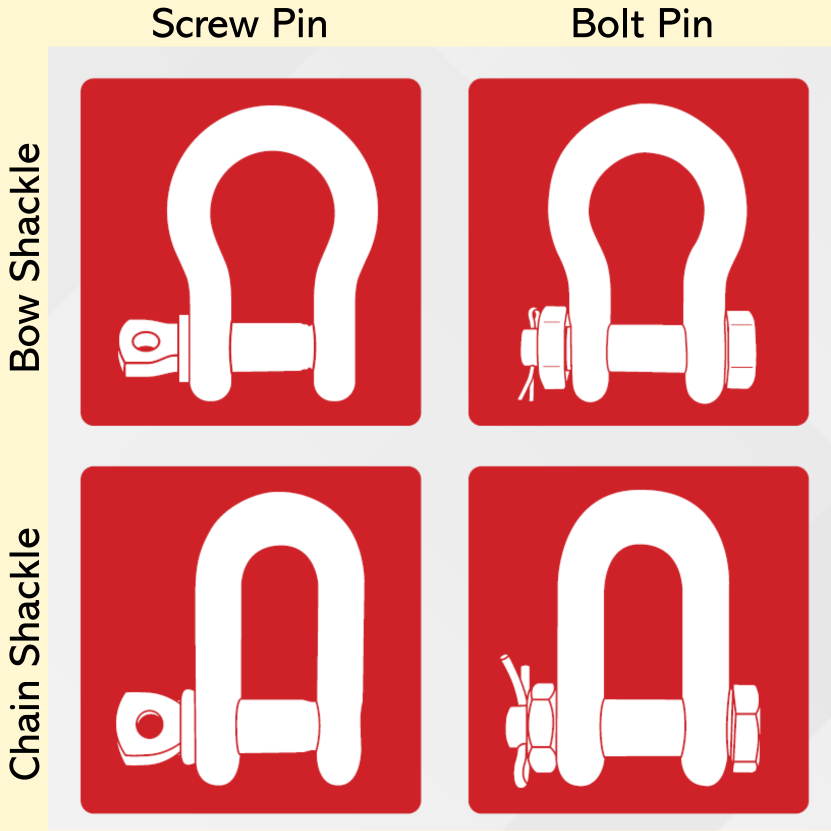
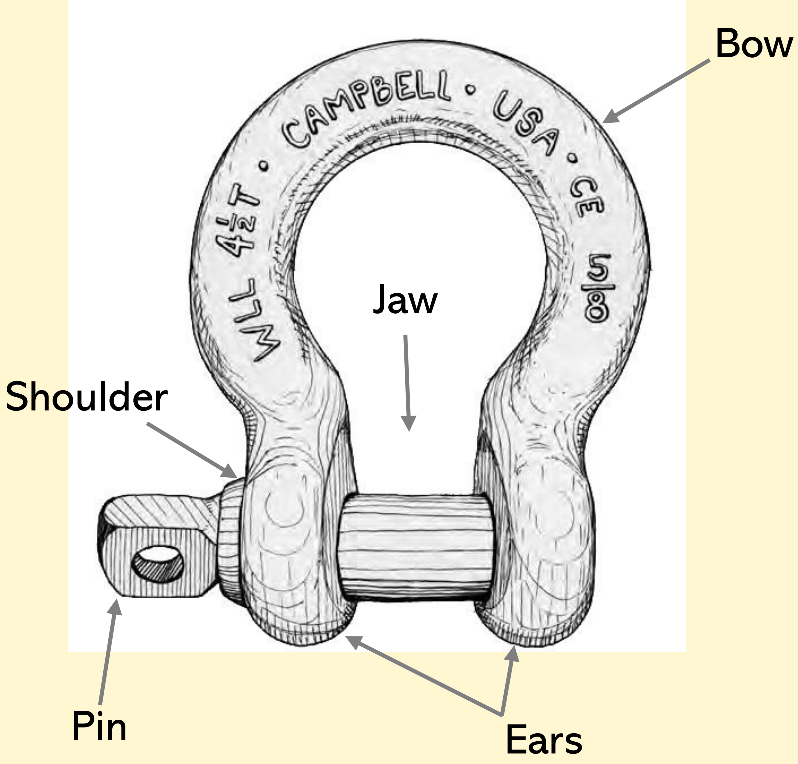


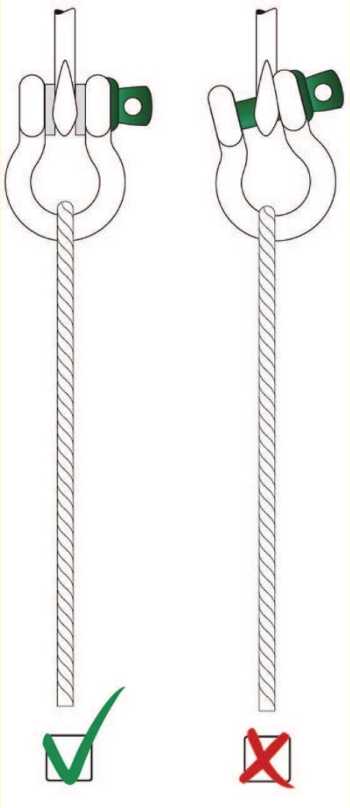
Figure 7-7—A deadman anchor (buried log).

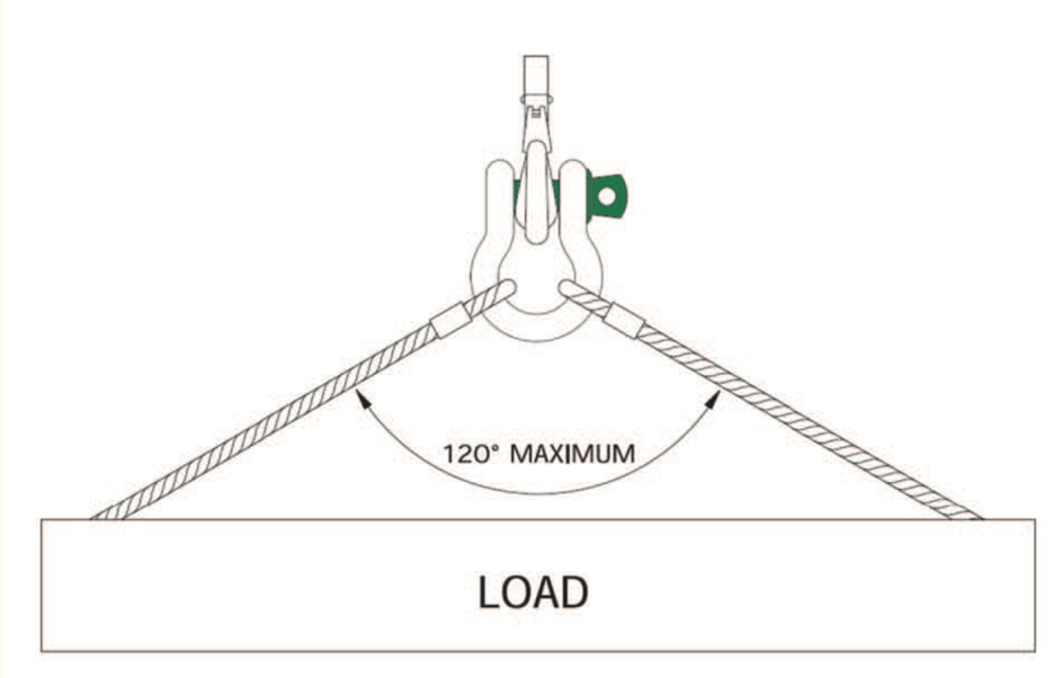
Rigging Equipment – Shackles



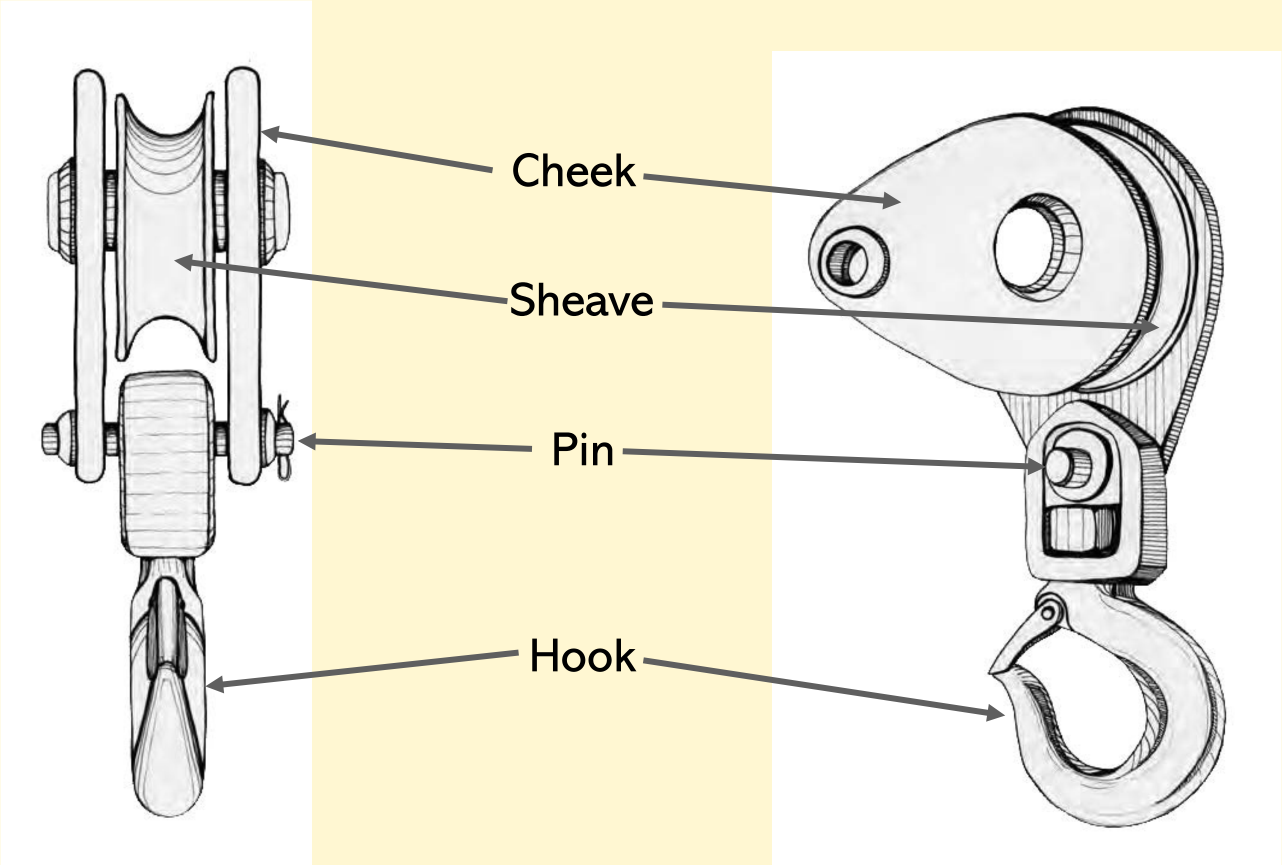


Rigging Equipment – Shackles

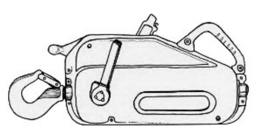




Rigging Equipment – Blocks



Blocks – D/d Ratio – Strength Reduction



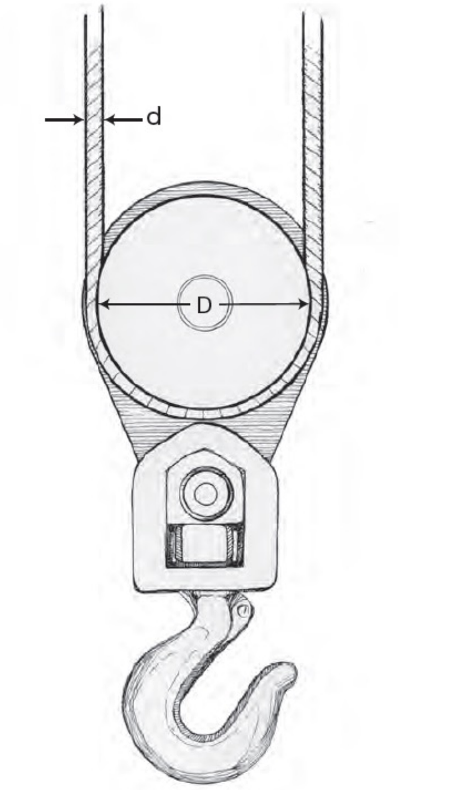
The Sheave Diameter divided by the Rope Diameter is referred to as the D/d ratio.

D is the diameter of the sheave measured to the inside of the groove, sometimes called “Pitch Diameter”.

When selecting a block, it is important to consider the D/d ratio and any strength reductions.

For wire rope a D/d of 16 to 20 is recommended.

For fiber ropes a D/d of 5 to 10 is recommended.



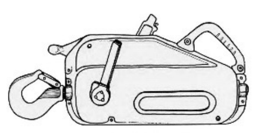
$$\text{D/d Ratio} = \frac{\text{Sheave Diameter}}{\text{Rope Diameter}}$$

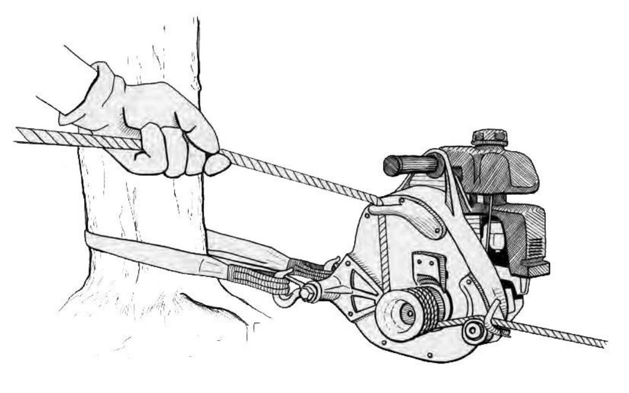
The smaller this ratio, the weaker the rope becomes and in the case of wire rope smaller than 16:1 can kink and/or distort the wire rope

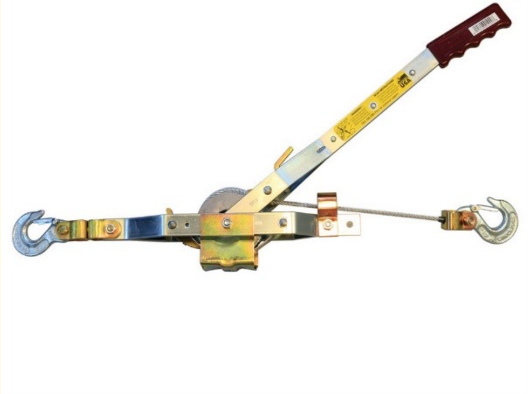
D/d Ratio Strength of rope	%
1	50%
10	86%
15	89%
20	91%

Tractel recommends a 16:1 D/d ratio for their wire rope so a minimum of a 5" sheave for TU17 5/16" and 7" TU28 7/16" wire rope. This will result in the wire rope maintaining approximately 90% of rated strength.

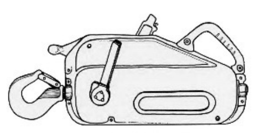
Rigging Equipment – Power Sources







Safety Equipment



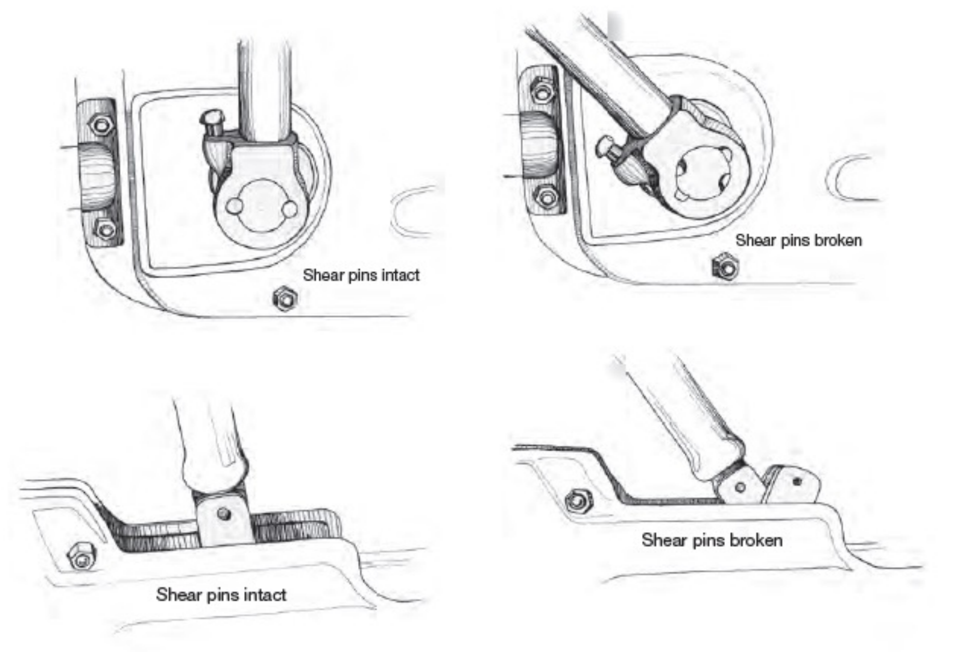
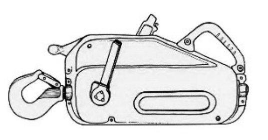


Figure 6–1 —Typical shear pin placement (intact and broken) in handles of two different types of griphoist.

SPECIAL SAFETY FEATURES:

1. Hook starts to open when device exceeds weight limit.
2. Latch "Pops" when weight is exceeded. At this point remove the load from unit.
3. Handle bends to side when unit is overloaded

Knots and hitches in rigging operations



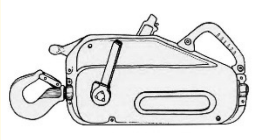




Knot	Percent Strength Retained	Typical use in rigging
No Knot	100%	Connecting a rope through a spliced eye
Tensionless Hitch:	90-100%	Anchoring a rope to a tree
Bowline:	65-70%	Terminating a rigging line at end point
Bowline on a bight:	70-75%	Terminating a rigging line somewhere other than end point
Alpine Butterfly:	70-75%	Adding an attachment point to a line mid rope
Double Fishermen's:	60-70%	Connecting two ropes or building a prusik loop
Prusik:	See double fishermen's.	Attaching pull lines to your main line or Z drag and other types of pully force multipliers
Figure-8:	70-75%	Not often used, very difficult to untie after rope is weighted
Timber Hitch:	70-75%	Connecting a rope to a tree or log
Water Knot:	60-70%	Creating slings out of webbing



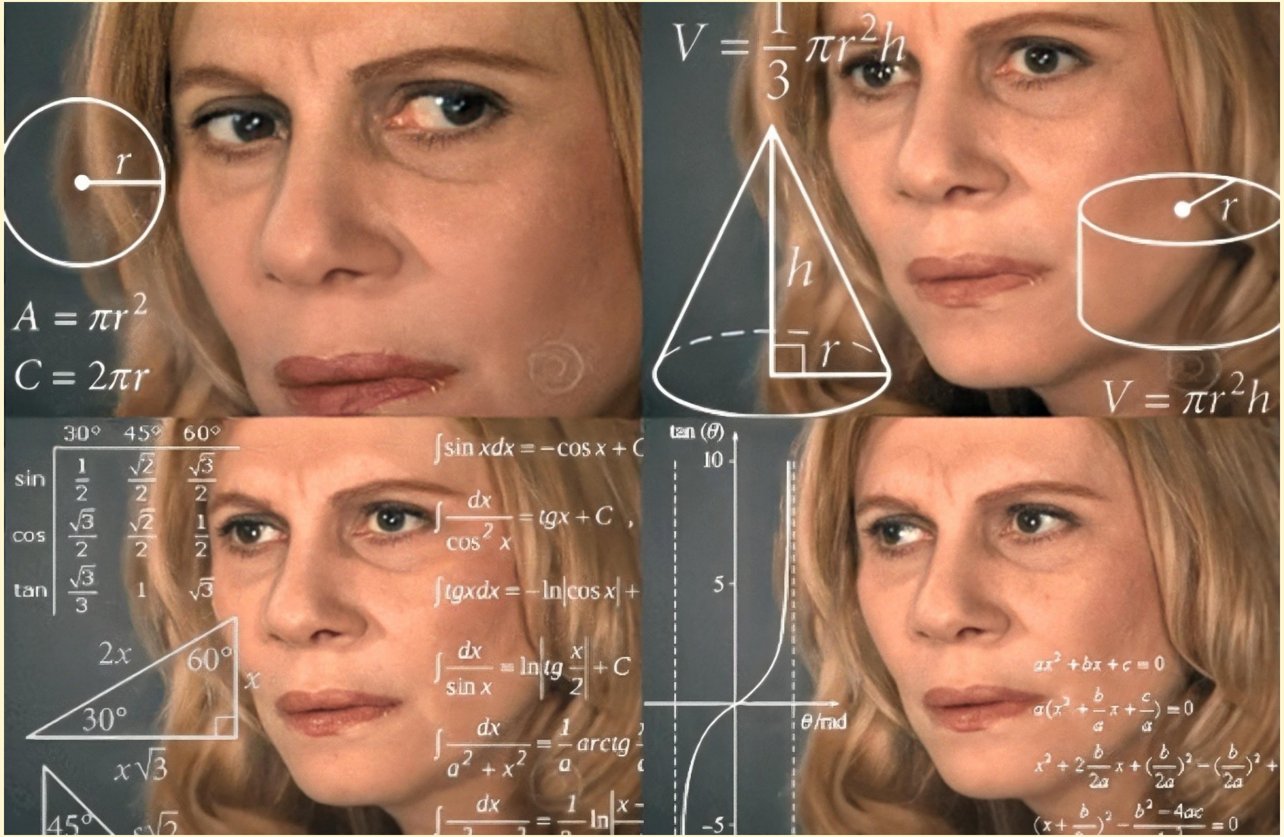

Knots and Hitches – Strength Reduction

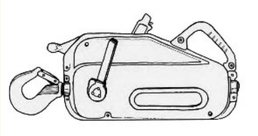


Knot	Percent Strength Retained
No Knot	100%
Tensionless Hitch:	90-100%
Bowline:	65-70%
Bowline on a bight:	70-75%
Alpine Butterfly:	
Double Fishermen's:	60-70%
Prusik:	See double fishermen's.
Figure-8:	70-75%
Timber Hitch:	70-75%
Water Knot:	60-70%

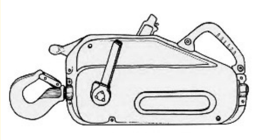
- What is the WLL of a 11mm static line, MBS of 10,000 pounds, that terminates in a bowline?
- What is the WLL of ½" Amsteel, MBS 30,600 pounds, when a spliced eye is hooked to the griphoist and the other end is tied off with a timber hitch?
- What is the WLL of ½" Amsteel, MBS 30,600 pounds, when a spliced eye is hooked to the griphoist and the other end is tied off with a tensionless hitch?
- What is the WLL for a sling made of 1" tubular webbing, MBS 4,000 pounds, tied with a water knot? (2 possible answers)

The Math and Physics of Rigging



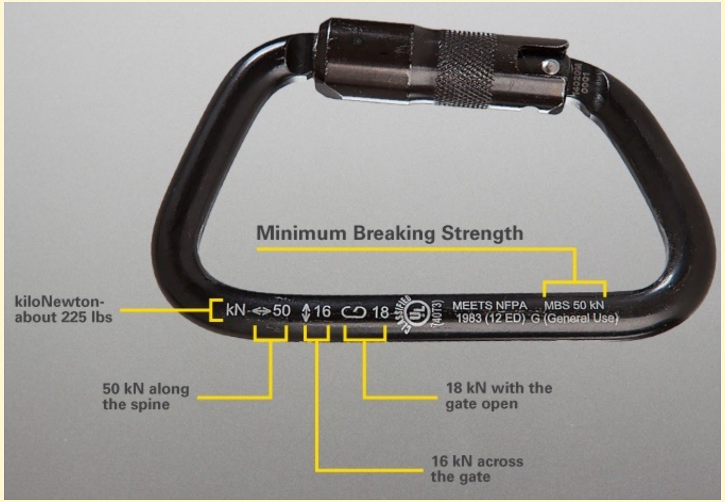


Developing intuition and tools for understanding forces generated in rigging scenarios.



Physics for Rigging – Force

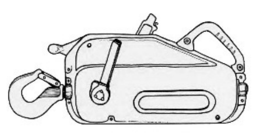
A **force** is a push or pull on an object that can change the object’s motion.



Units of force include:

- kilonewton (kN) –often used on lightweight gear like carabiners
  - 1 Newton is 1 $kg{\cdot}m/s^2$
  - kN is 1000 Newtons
  - 1 kN = about 225 pounds of force
- Pound Force (lbf)
  - The force exerted by gravity on a one pound mass on the surface of the earth.
  - Rigging gear and WLL are typically quantified in Pounds of Force

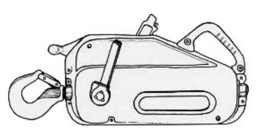
Physics for Rigging – Effect of Angle on Forces



To start with the basics, if we imagine a load of 100kg suspended equally from two slings then each sling would equally share half of the loads weight.

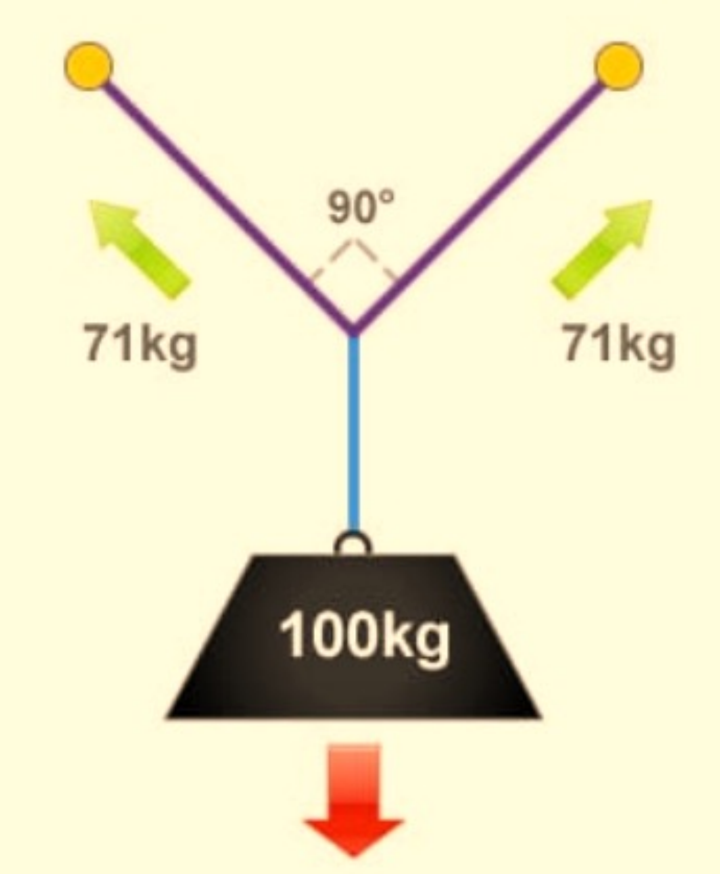
In the situation illustrated to the right, the weight of the load = 100kg. The load is supported by two slings of equal configuration with no internal angle, so 100kg / 2 = 50kg. This means that each sling and anchor point is being subject to 50kg or 50% of the loads weight.

Physics for Rigging – Effect of Angle on Forces

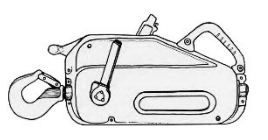


Given an internal angle of 90° between ropes and rigging components 71% of the loads weight will be distributed to each anchor component, so in this example that will be 71kg.

It is often easier to roughly estimate a 90° or right-angle when undertaking rigging tasks. By staying at or below this angle ensures that we don't load our anchor components with excessive forces.



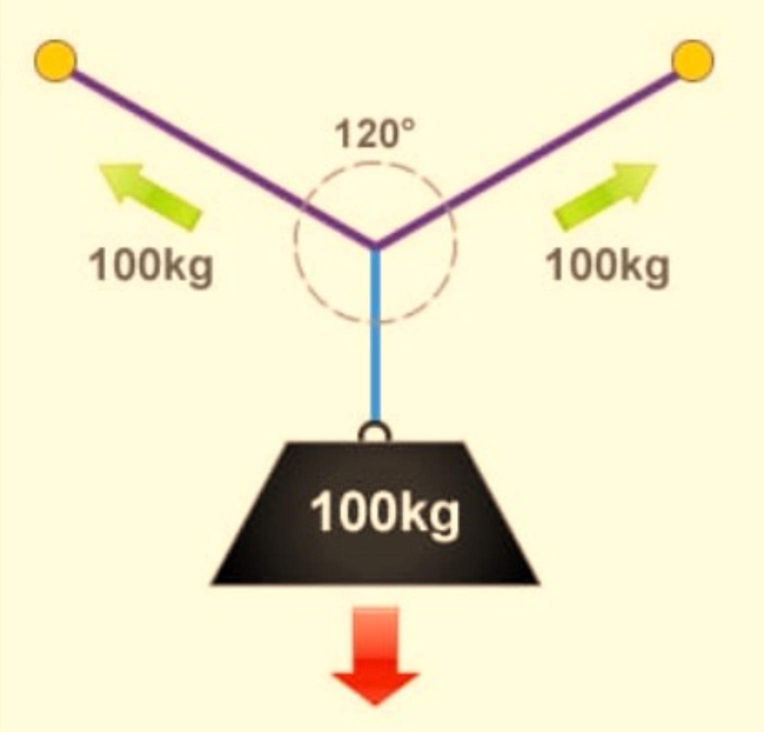
Physics for Rigging – Effect of Angle on Forces



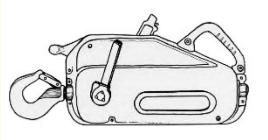
Given an internal angle of 120° between ropes and rigging components 100% of the loads weight will be distributed to each anchor component, so in this example that will be 100kg.

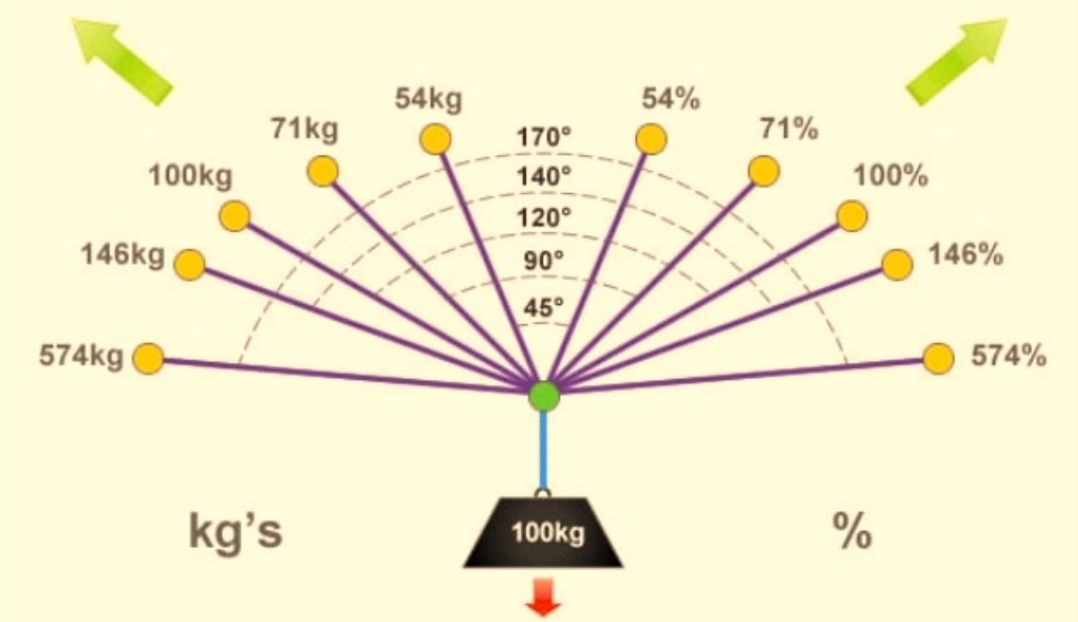
An internal angle of 120° is also defined as the 'critical angle'.

Because everything is in equilibrium at the critical angle of 120°, whatever the load weighs is what we have being exerted to each anchor point and each item of rigging equipment. So in this example it is 100kg or 100% of the loads weight.



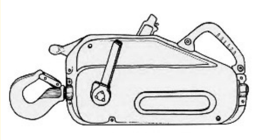
Physics for Rigging – Effect of Angle on Forces

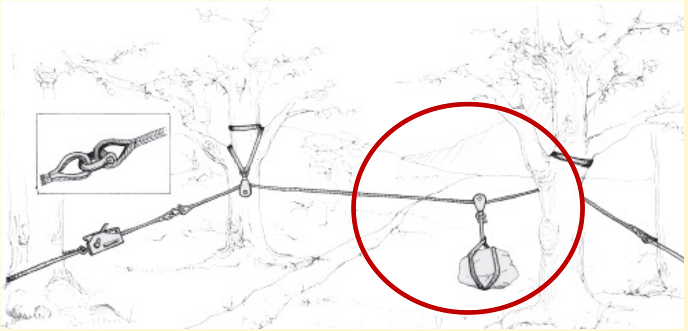




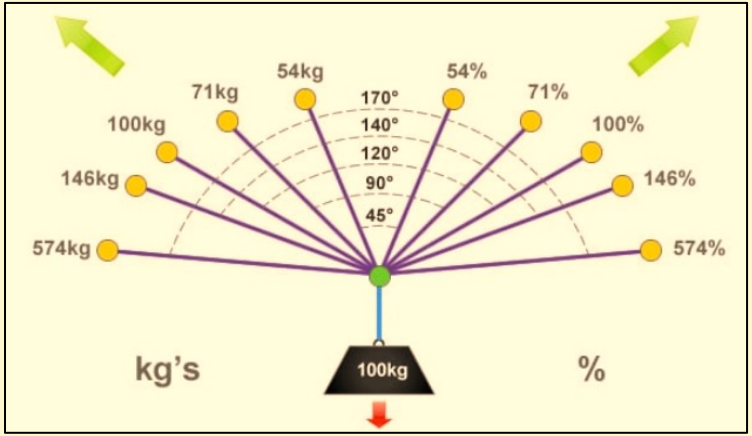
Take an estimate of the interior angle of the moving block here and calculate line tension given the rocks weight to be 500 pounds.

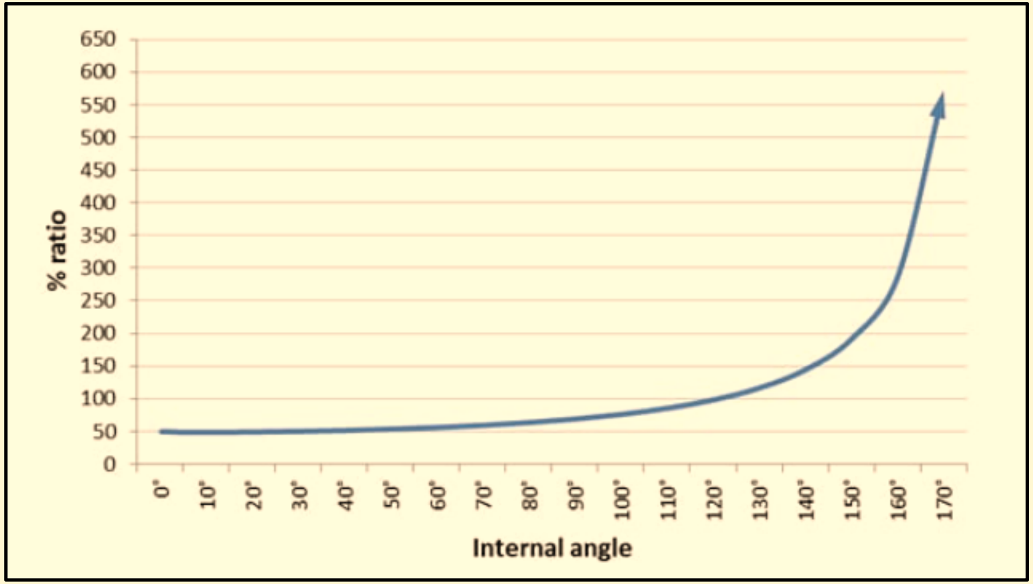
Physics for Rigging – Effect of Angle on Forces



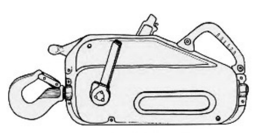


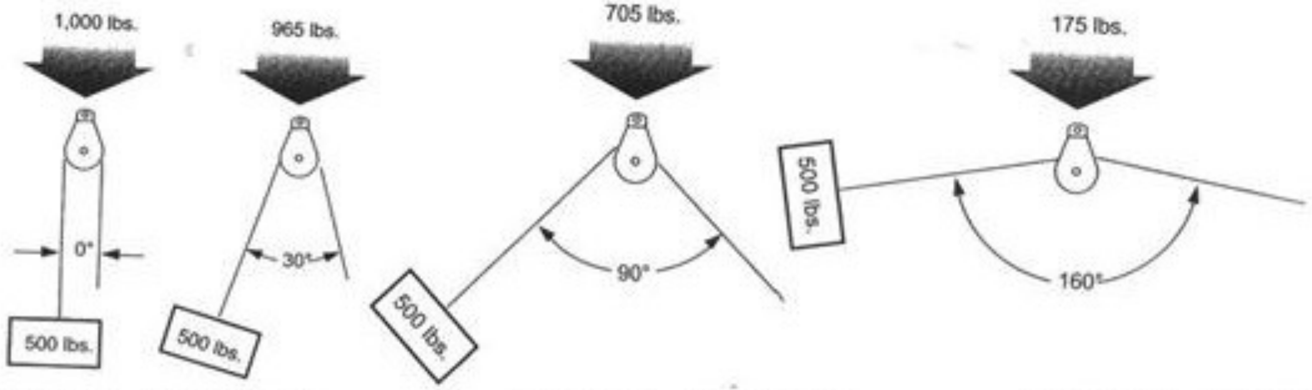
Take an estimate of the interior angle here and calculate line tension for a 500-pound rock.





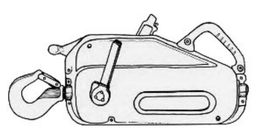
Physics for Rigging – Effect of Angle on Forces

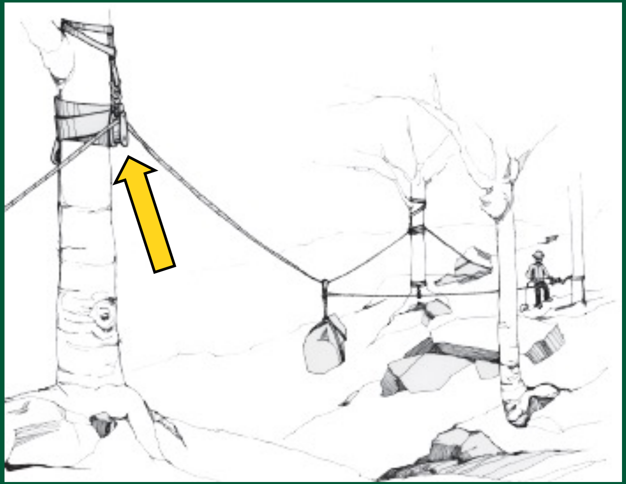


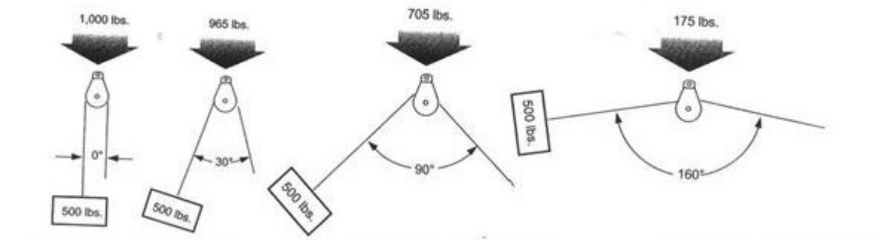


ANGLE	FACTOR	ANGLE	FACTOR	ANGLE	FACTOR
0°	2.0	70°	1.64	140°	.680
10°	1.98	80°	1.53	150°	.520
20°	1.97	90°	1.41	160°	.350
30°	1.93	100°	1.29	170°	.170
40°	1.87	110°	1.15	180°	.000
50°	1.81	120°	1.00		
60°	1.73	130°	0.84		

Physics for Rigging – Effect of Angle on Forces



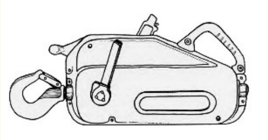


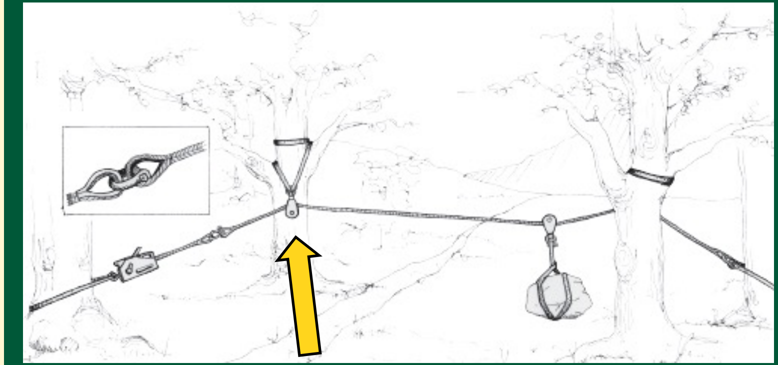


ANGLE	FACTOR	ANGLE	FACTOR	ANGLE	FACTOR
0°	2.0	70°	1.64	140°	.680
10°	1.98	80°	1.53	150°	.520
20°	1.97	90°	1.41	160°	.350
30°	1.93	100°	1.29	170°	.170
40°	1.87	110°	1.15	180°	.000
50°	1.81	120°	1.00		
60°	1.73	130°	0.84		

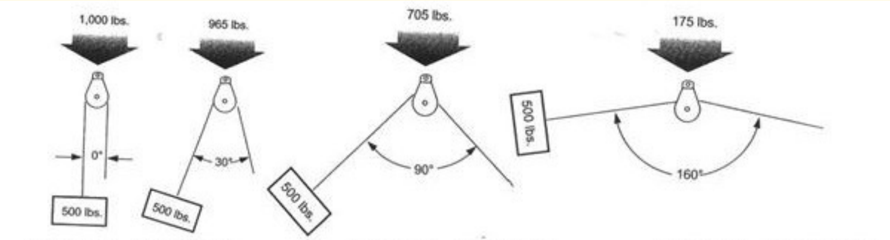
Take an estimate of the interior angle here and calculate tension on the block and sling given 500 pounds of line tension.

Physics for Rigging – Effect of Angle on Forces



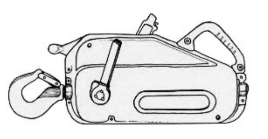


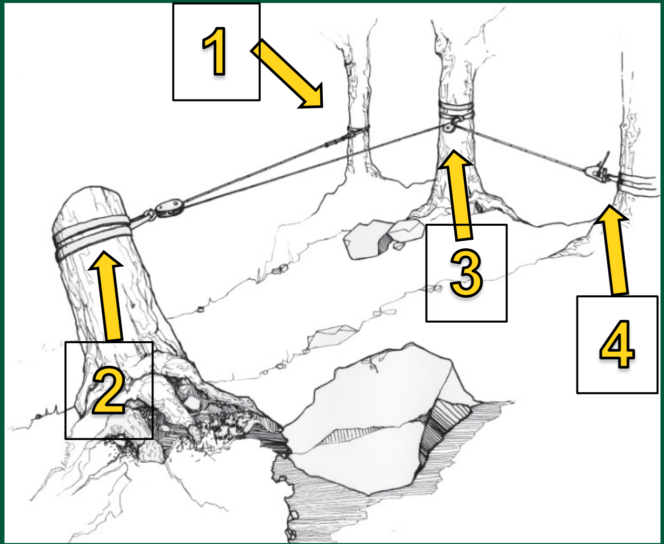
Take an estimate of the interior angle here and calculate tension on the block and sling given 1500 pounds of line tension.



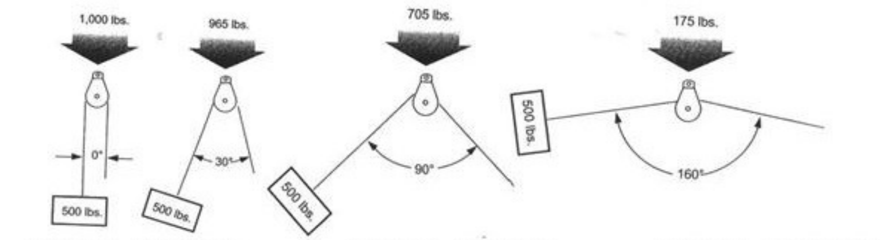
ANGLE	FACTOR	ANGLE	FACTOR	ANGLE	FACTOR
0°	2.0	70°	1.64	140°	.680
10°	1.98	80°	1.53	150°	.520
20°	1.97	90°	1.41	160°	.350
30°	1.93	100°	1.29	170°	.170
40°	1.87	110°	1.15	180°	.000
50°	1.81	120°	1.00		
60°	1.73	130°	0.84		

Physics for Rigging – Effect of Angle on Forces





Take an estimate of the interior angles here and calculate tension at each specific point given 4000 pounds of line pull.



ANGLE	FACTOR	ANGLE	FACTOR	ANGLE	FACTOR
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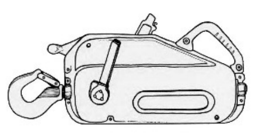
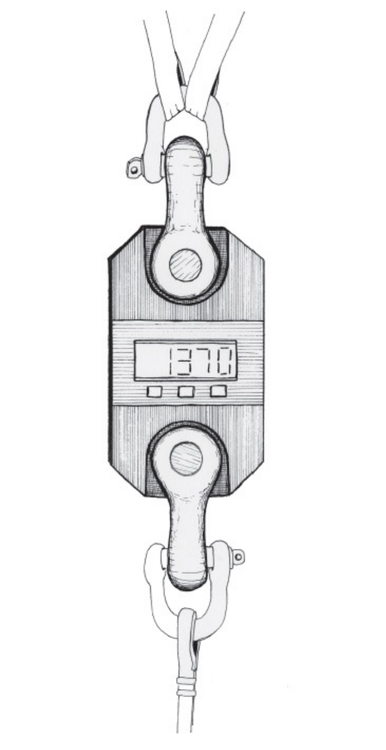
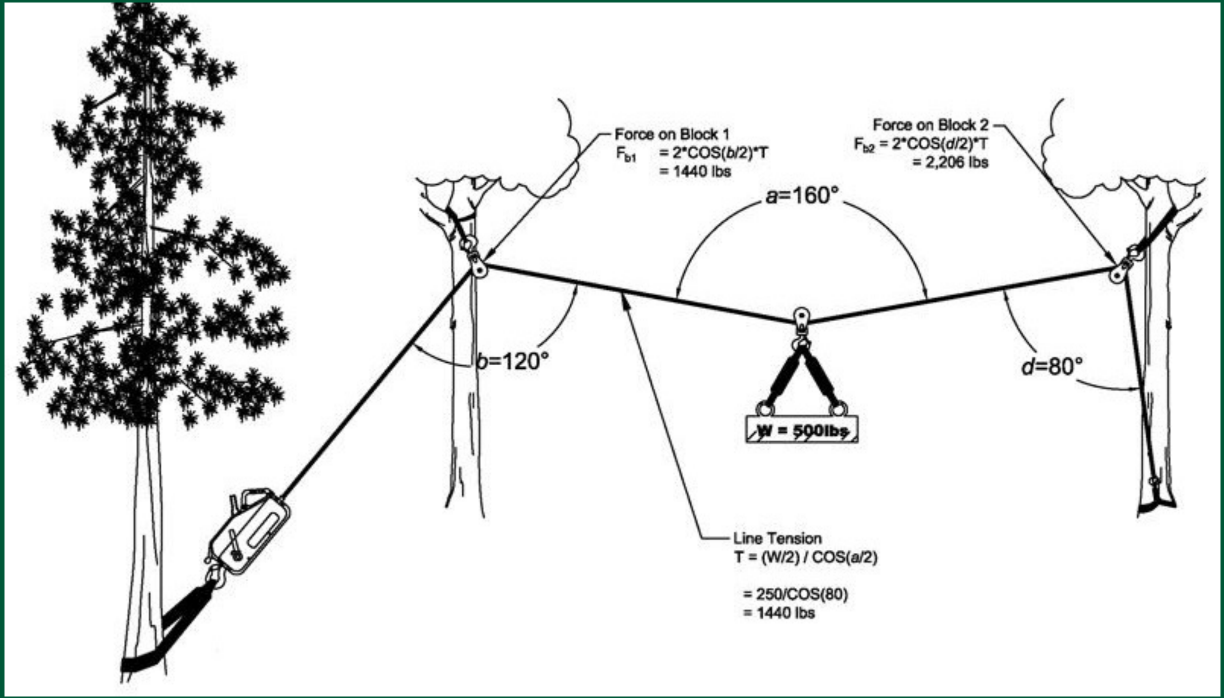
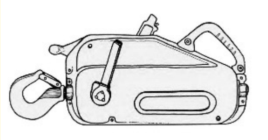
30°	1.93	100°	1.29	170°	.170
40°	1.87	110°	1.15	180°	.000
50°	1.81	120°	1.00		
60°	1.73	130°	0.84		

Physics for Rigging – What is a dynamometer?



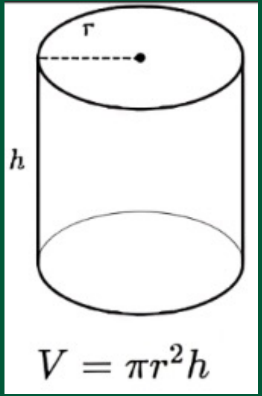


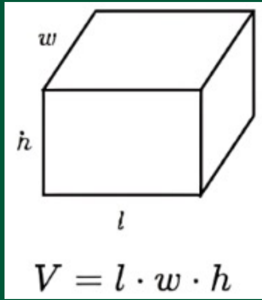




Estimating Weight by Volume

Material	Weight/ CF Dry	Weight/ CF Wet
Granite	160	160
Limestone	150	150
Gravel	105	125
Sand	100	125
Aspen	26	43
Douglas Fir	32	37
Red Oak	44	60
Western Larch	36	48

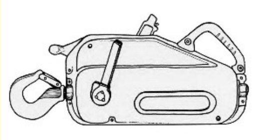




- Estimate the weight of a recently harvested 30’ Western Larch stringer that has a diameter of 20” on one end and 16” on the other.

- Estimate the weight of a piece of granite that is roughly 2’x2’x3’.

Estimating Weight by Volume



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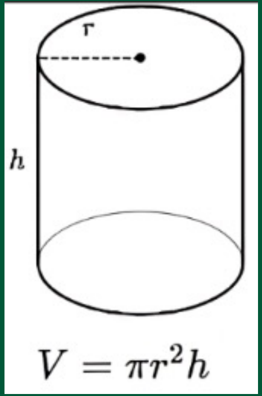
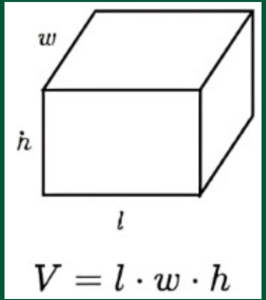




- Estimate the weight of a recently harvested 30’ Western Larch stringer that has a diameter of 20” on one end and 16” on the other.

Average diameter is 18”, average radius is 9”, 9”/12” = .75 foot average radius for stringer.

V = 3.14 x .75’^2 x 30 = 53 square feet of wood.
53 square feet x 48 pounds/ftsq = 2544 pounds

- Estimate the weight of a piece of granite that is roughly 2’x2’x3’.

V = 2’x2’x3’ =12 square feet
12 square feet x 160 pounds/sqft = 1920 pounds

Skyline math, premade table (Weight and Length)

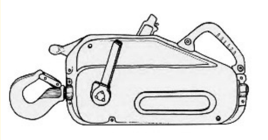


Table for determining tension given belly, distance between cable supports (Length) and Weight (load).

Determine tension based on the weight of the object and length of the skyline.

Weight= 1700

length= 70

t=w/2*CosDegree

Belly	Length	(L/2)/B	Rad	Degree	Weight	Tension	Interior angle
1	70	35.00	1.54	88.36	1700	29762	177
2	70	17.50	1.51	86.73	1700	14899	173
3	70	11.67	1.49	85.10	1700	9953	170
4	70	8.75	1.46	83.48	1700	7486	167
5	70	7.00	1.43	81.87	1700	6010	164
6	70	5.83	1.40	80.27	1700	5031	161
7	70	5.00	1.37	78.69	1700	4334	157
8	70	4.38	1.35	77.12	1700	3815	154
9	70	3.89	1.32	75.58	1700	3413	151
10	70	3.50	1.29	74.05	1700	3094	148
11	70	3.18	1.27	72.55	1700	2835	145
12	70	2.92	1.24	71.08	1700	2621	142
13	70	2.69	1.22	69.62	1700	2441	139
14	70	2.50	1.19	68.20	1700	2289	136
15	70	2.33	1.17	66.80	1700	2158	134
16	70	2.19	1.14	65.43	1700	2044	131
17	70	2.06	1.12	64.09	1700	1946	128
18	70	1.94	1.10	62.78	1700	1859	126
19	70	1.84	1.07	61.50	1700	1782	123
20	70	1.75	1.05	60.26	1700	1713	121
21	70	1.67	1.03	59.04	1700	1652	118
22	70	1.59	1.01	57.85	1700	1597	116
23	70	1.52	0.99	56.69	1700	1548	113
24	70	1.46	0.97	55.56	1700	1503	111
25	70	1.40	0.95	54.46	1700	1462	109
30	70	1.17	0.86	49.40	1700	1306	99
35	70	1.00	0.79	45.00	1700	1202	90
40	70	0.88	0.72	41.19	1700	1129	82
45	70	0.78	0.66	37.87	1700	1077	76
50	70	0.70	0.61	34.99	1700	1038	70

By entering the weight of the object (1,700#'s) and the length of the skyline (70') this table will calculate line tension given the relative height of the suspended object.

- In the top photo the oak log was about 30' below (belly) the height of the blocks. What do we expect the line tension to be?

- In the bottom photo the oak log was about 20' below (belly) the height of the blocks. What do we expect the line tension to be?

Skyline math, premade table (Tension and Length)

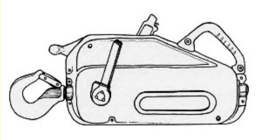


Table for determining load capability given cable tension, belly
and distance between cable supports
Determine weights of the objects based on max tension and length of skyline

Tension= 2000
Length= 70 w=t2cosDegree

Belly	Length	(L/2)/B	Rad	Degree	Tension	Weight	Interior Angle
1	70	35.00	1.54	88.36	2000	114	177
2	70	17.50	1.51	86.73	2000	228	173
3	70	11.67	1.49	85.10	2000	342	170
4	70	8.75	1.46	83.48	2000	454	167
5	70	7.00	1.43	81.87	2000	566	164
6	70	5.83	1.40	80.27	2000	676	161
7	70	5.00	1.37	78.69	2000	784	157
8	70	4.38	1.35	77.12	2000	891	154
9	70	3.89	1.32	75.58	2000	996	151
10	70	3.50	1.29	74.05	2000	1099	148
11	70	3.18	1.27	72.55	2000	1199	145
12	70	2.92	1.24	71.08	2000	1297	142
13	70	2.69	1.22	69.62	2000	1393	139
14	70	2.50	1.19	68.20	2000	1486	136
15	70	2.33	1.17	66.80	2000	1576	134
16	70	2.19	1.14	65.43	2000	1663	131
17	70	2.06	1.12	64.09	2000	1748	128
18	70	1.94	1.10	62.78	2000	1829	126
19	70	1.84	1.07	61.50	2000	1908	123
20	70	1.75	1.05	60.26	2000	1985	121
21	70	1.67	1.03	59.04	2000	2058	118
22	70	1.59	1.01	57.85	2000	2129	116
23	70	1.52	0.99	56.69	2000	2197	113
24	70	1.46	0.97	55.56	2000	2262	111
25	70	1.40	0.95	54.46	2000	2325	109
30	70	1.17	0.86	49.40	2000	2603	99
35	70	1.00	0.79	45.00	2000	2828	90
40	70	0.88	0.72	41.19	2000	3010	82
45	70	0.78	0.66	37.87	2000	3157	76
50	70	0.70	0.61	34.99	2000	3277	70

By entering the max tension of the power source (2,000#'s) and the length of the skyline (70') this table will calculate the max weight of suspended object with your power source at max power in relation to the height.

- Given a 30' belly what is the weight of an object you could lift at 2000 pounds of line tension?

- Given a 20' belly what is the weight of an object you could lift at 2000 pounds of line tension?

Skyline math, premade table

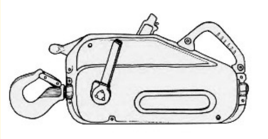


Table for determining load capability given cable tension, belly
and distance between cable supports
Determine weights of the objects based on max tension and length of skyline

Tension= 2000
Length= 70
w=t2cosDegree

Belly	Length	(L/2)/B	Rad	Degree	Tension	Weight	Interior Angle
1	70	35.00	1.54	88.36	2000	114	177
2	70	17.50	1.51	86.73	2000	228	173
3	70	11.67	1.49	85.10	2000	342	170
4	70	8.75	1.46	83.48	2000	454	167
5	70	7.00	1.43	81.87	2000	566	164
6	70	5.83	1.40	80.27	2000	676	161
7	70	5.00	1.37	78.69	2000	784	157
8	70	4.38	1.35	77.12	2000	891	154
9	70	3.89	1.32	75.58	2000	996	151
10	70	3.50	1.29	74.05	2000	1099	148
11	70	3.18	1.27	72.55	2000	1199	145
12	70	2.92	1.24	71.08	2000	1297	142
13	70	2.69	1.22	69.62	2000	1393	139
14	70	2.50	1.19	68.20	2000	1486	136
15	70	2.33	1.17	66.80	2000	1576	134
16	70	2.19	1.14	65.43	2000	1663	131
17	70	2.06	1.12	64.09	2000	1748	128
18	70	1.94	1.10	62.78	2000	1829	126
19	70	1.84	1.07	61.50	2000	1908	123
20	70	1.75	1.05	60.26	2000	1985	121
21	70	1.67	1.03	59.04	2000	2058	118
22	70	1.59	1.01	57.85	2000	2129	116
23	70	1.52	0.99	56.69	2000	2197	113
24	70	1.46	0.97	55.56	2000	2262	111
25	70	1.40	0.95	54.46	2000	2325	109
30	70	1.17	0.86	49.40	2000	2603	99
35	70	1.00	0.79	45.00	2000	2828	90
40	70	0.88	0.72	41.19	2000	3010	82
45	70	0.78	0.66	37.87	2000	3157	76
50	70	0.70	0.61	34.99	2000	3277	70

Instructor leave PowerPoint and pull up the Excel File "Skyline Math" to demonstrate the functionality of it in preplanning a rigging operation.

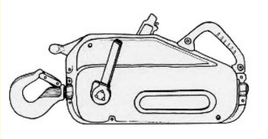
A good scenario to discuss is listed below more talking points in "Notes" section of this slide:

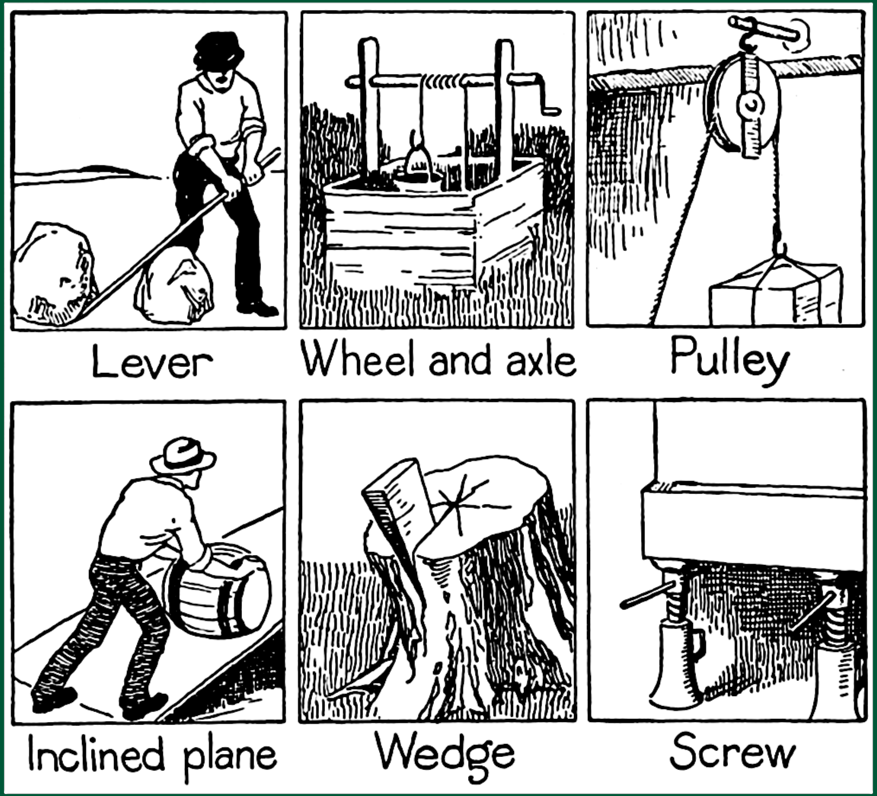
A cedar stringer weighs 1,800 #'s and there are no trees available to use so you will set up tripods to rig off. The height of the tripods is 10' you expect the belly to be about 7 feet when the stringer is lifted. You have a 4000# power source, and the tripods will be 50' apart, do you have the power to lift the stringers into place?

The Math and Physics of Rigging

Remember when I said this wasn’t a math or physics class?

Physics for Rigging – Mechanical Advantage

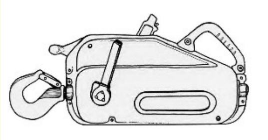


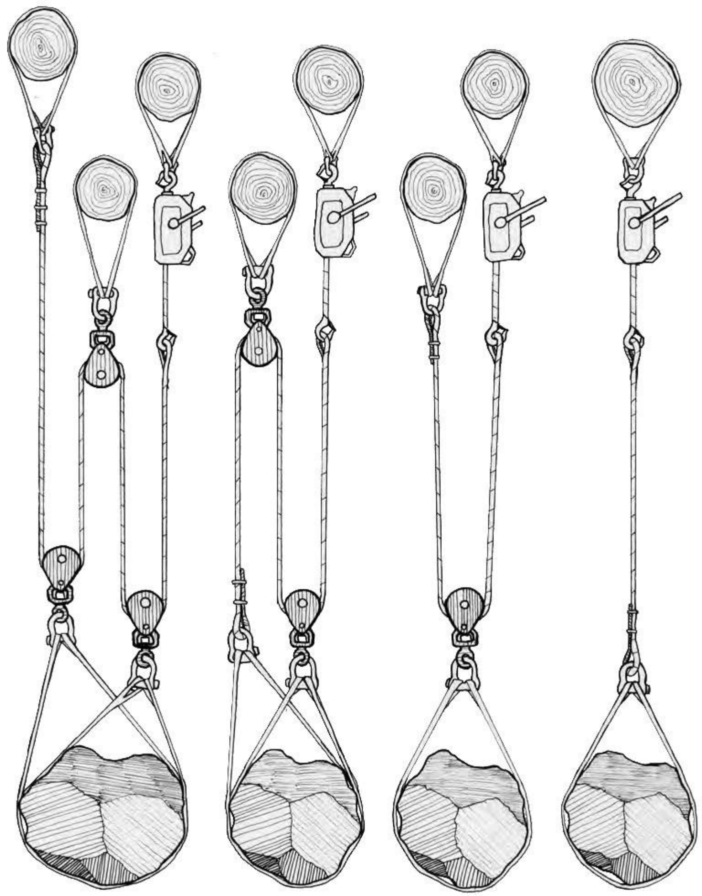


Six Classic Simple Machines:

A **simple machine** is a mechanical device that changes the direction or magnitude of a force.[1]

Physics for Rigging – Mechanical Advantage

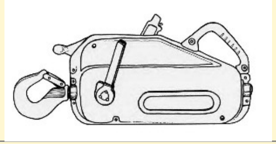


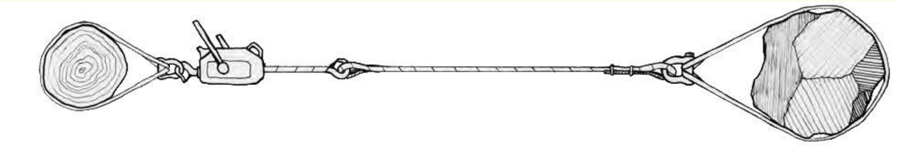


If energy is neither created; nor destroyed, how can we move larger objects using rigging?

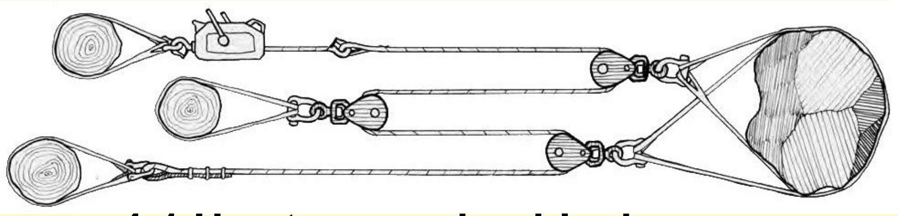
Mechanical advantage increases the output force by trading a lower input force for a larger distance that input moves.

Physics for Rigging – Mechanical Advantage



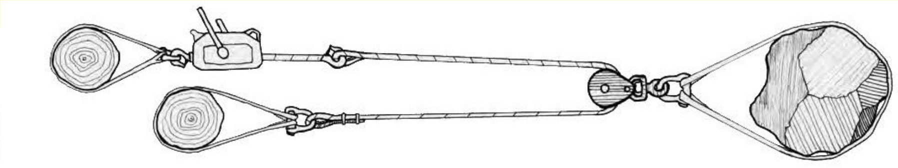


1:1 – Straight Pull



4:1 Has two moving blocks.

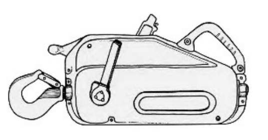
Generates 4x as much force, but for the load to move 1 foot, 4 feet of rope must be pulled through the system



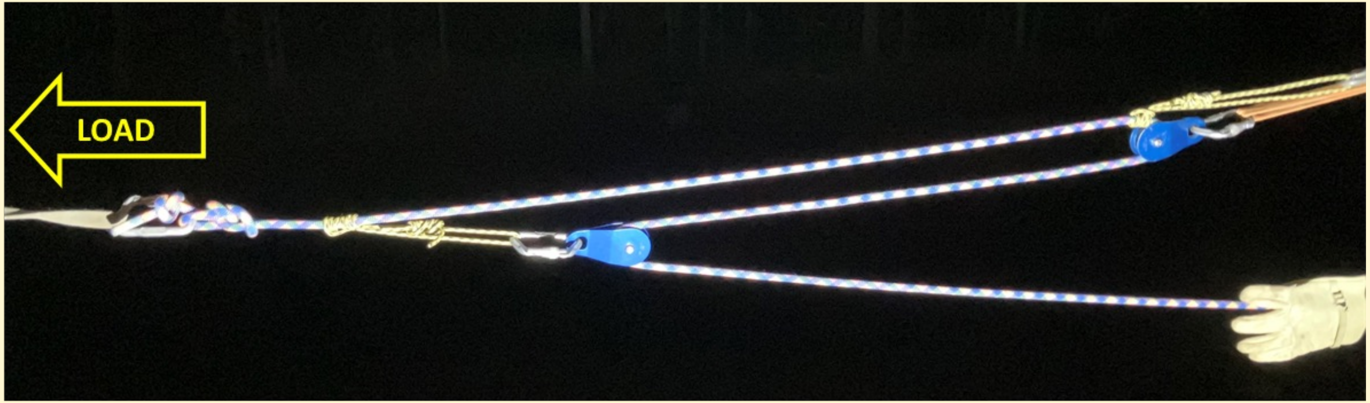
2:1 Has one moving block.

Generates 2x as much force, but for the load to move 1 foot, 2 feet of rope must be pulled through the system

Physics for Rigging – Mechanical Advantage

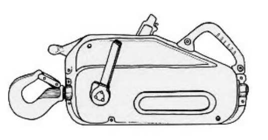


- Z Drag – 3:1

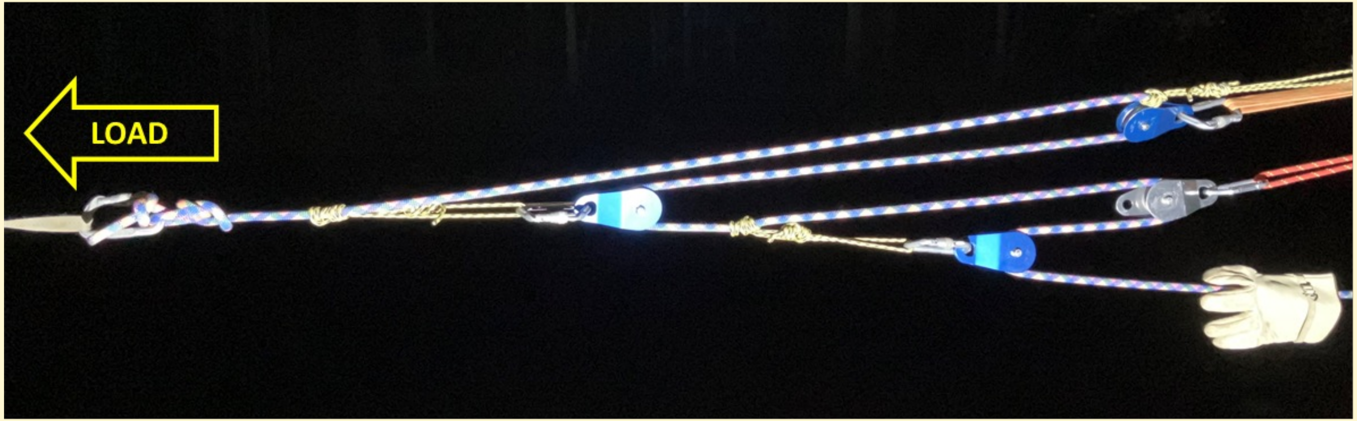


Let's look at the mechanical advantage system to the left and count the force multiplication.

Physics for Rigging – Mechanical Advantage

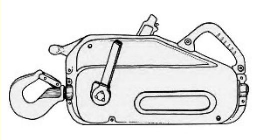


- Double Z – 9:1

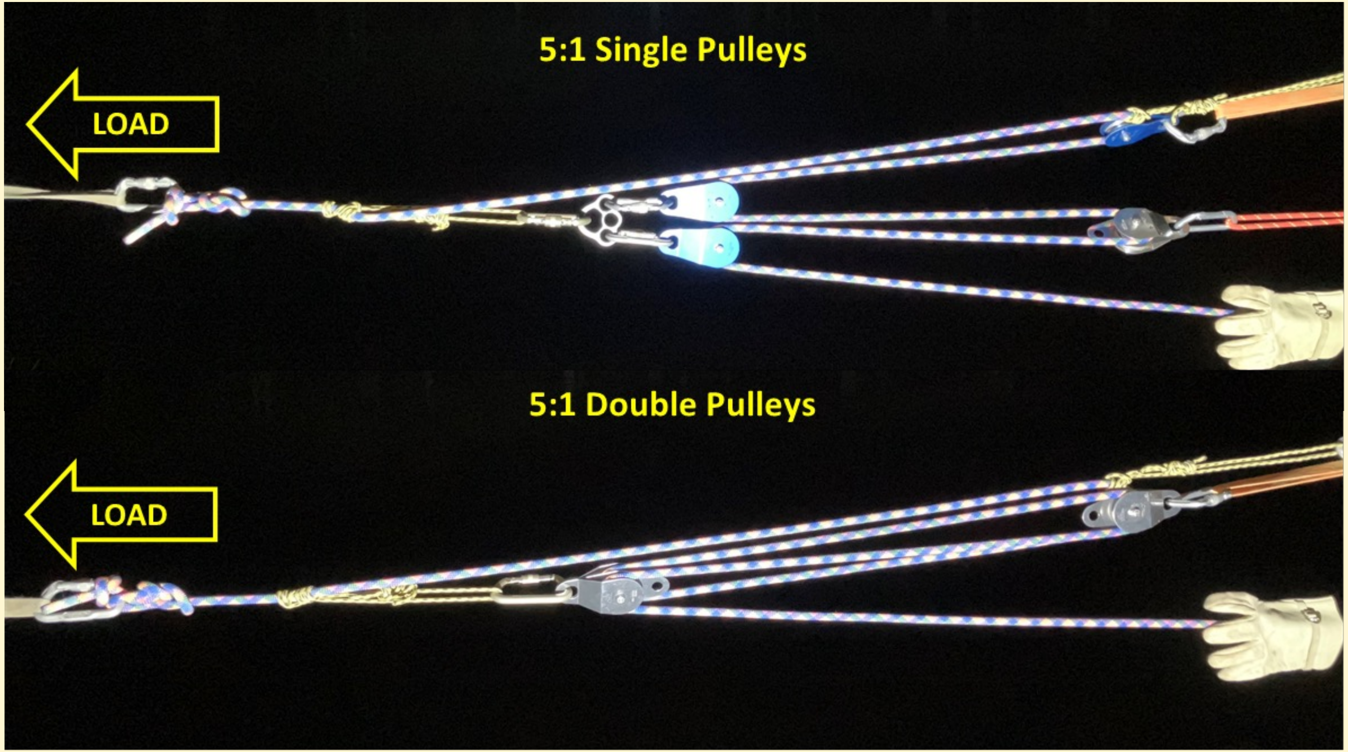


Let's look at the mechanical advantage system to the left and count the force multiplication.

Physics for Rigging – Mechanical Advantage

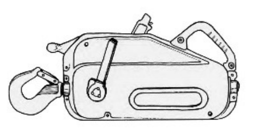


- 5:1



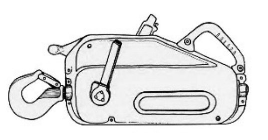
Let's look at the mechanical advantage systems to the left and count the force multiplication of each one.

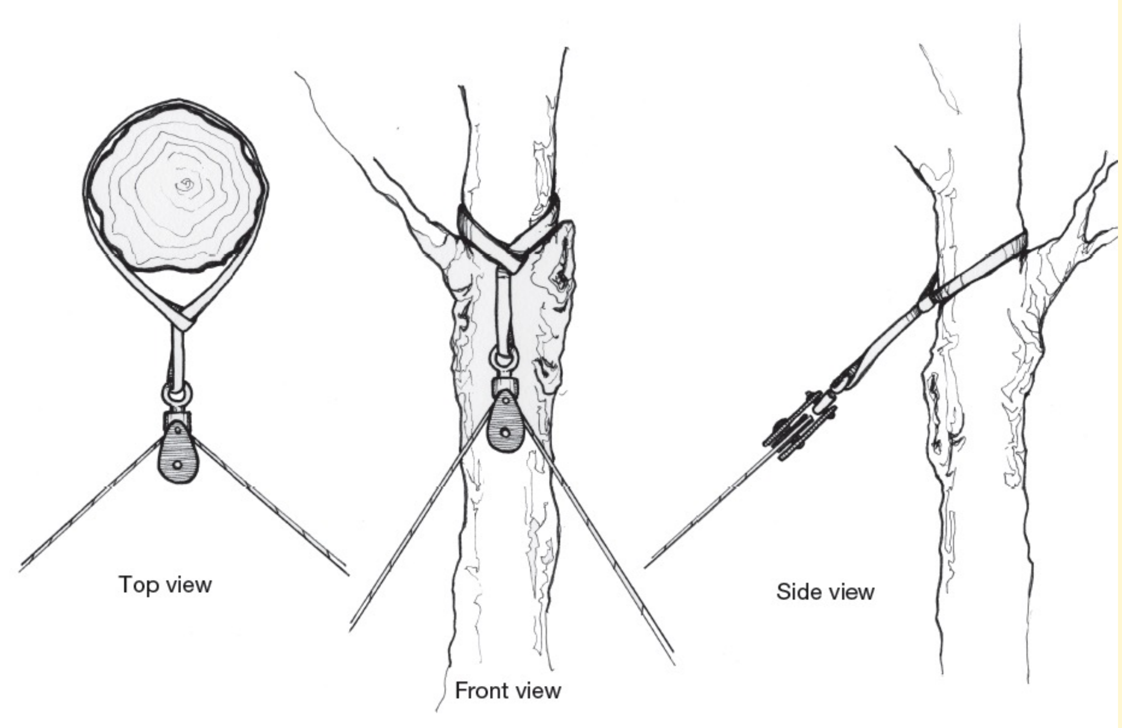
Inspecting Rigging Systems



- A Qualified Rigger will inspect each system component before fully tensioning
  - Check corridor for obstructions
- Perform complete visual inspection before moving or lifting loads
  - Walk the entire system from the power source to the anchor back
  - On first pass focus on big picture, environmental and human hazards, system requirements, working areas, corridor of travel, loads to move, and communication
  - On second pass focus on specific working zones, individual components and the forces exerted upon them, and the delineation of fly zones
- What are potential hazards?
- Have you sufficiently engineered the system to move the heaviest load?

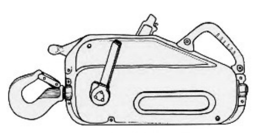
Rigging Set-ups: Spar Blocks

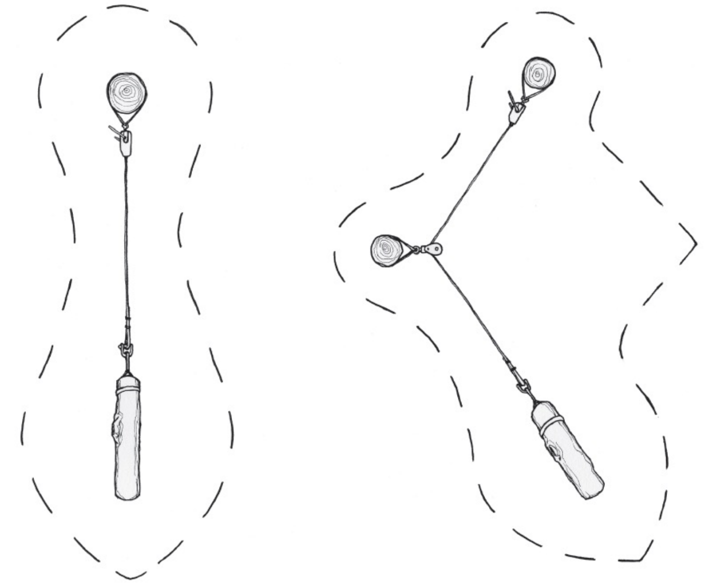




- Most ariel systems require spars, a frames, or tripods to gain vertical height to lift.
- Configuring systems in a straight line is important.
- Spar tree selection
  - Proximity of tree to intended skyline
  - Height and width of trees
  - Tree species
  - Deflection caused by system (alignment)
  - Overall tree condition
  - Maximum weight and size of loads to be lifted

Rigging Set-ups: Fly Zones and Safety



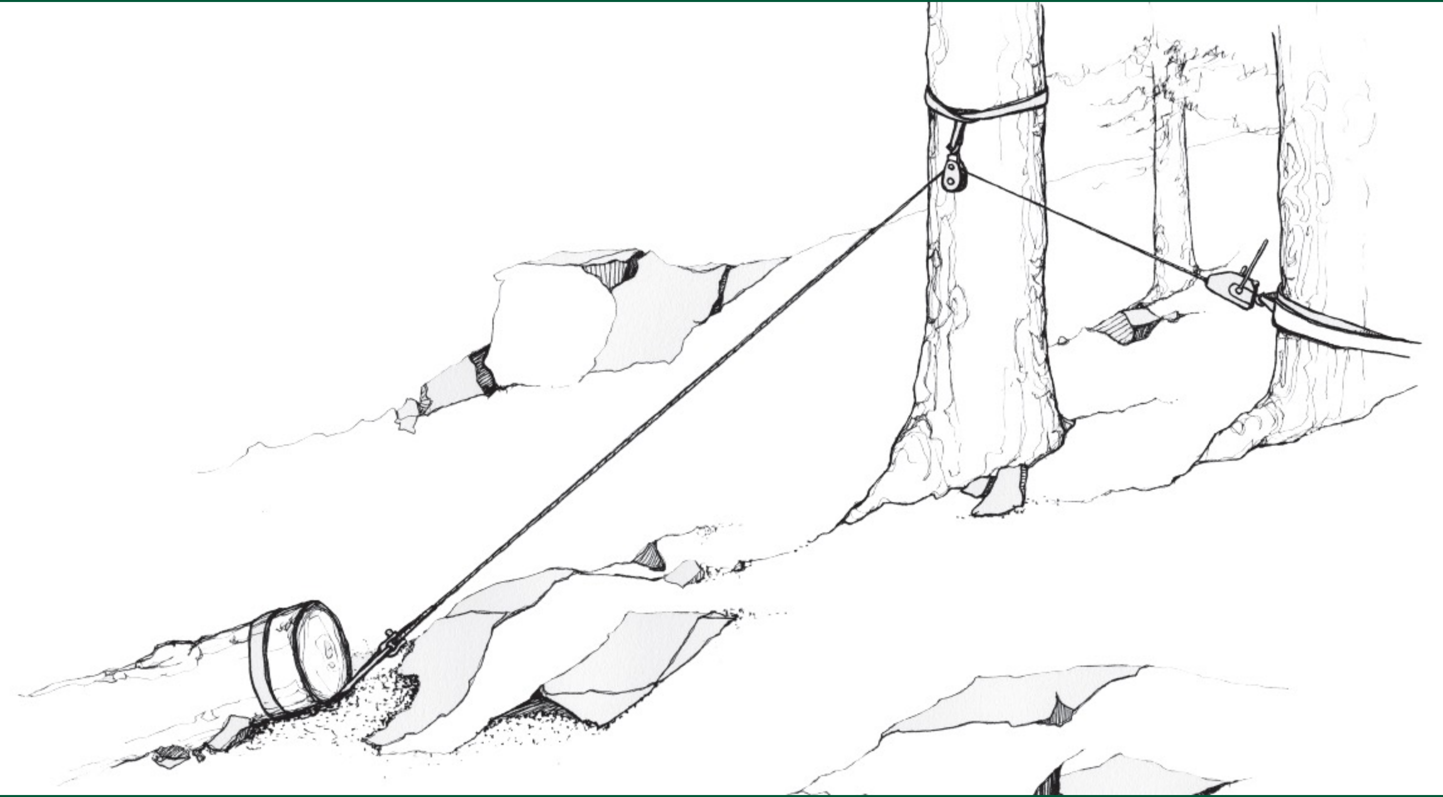


Where are the fly zones if a component fails?

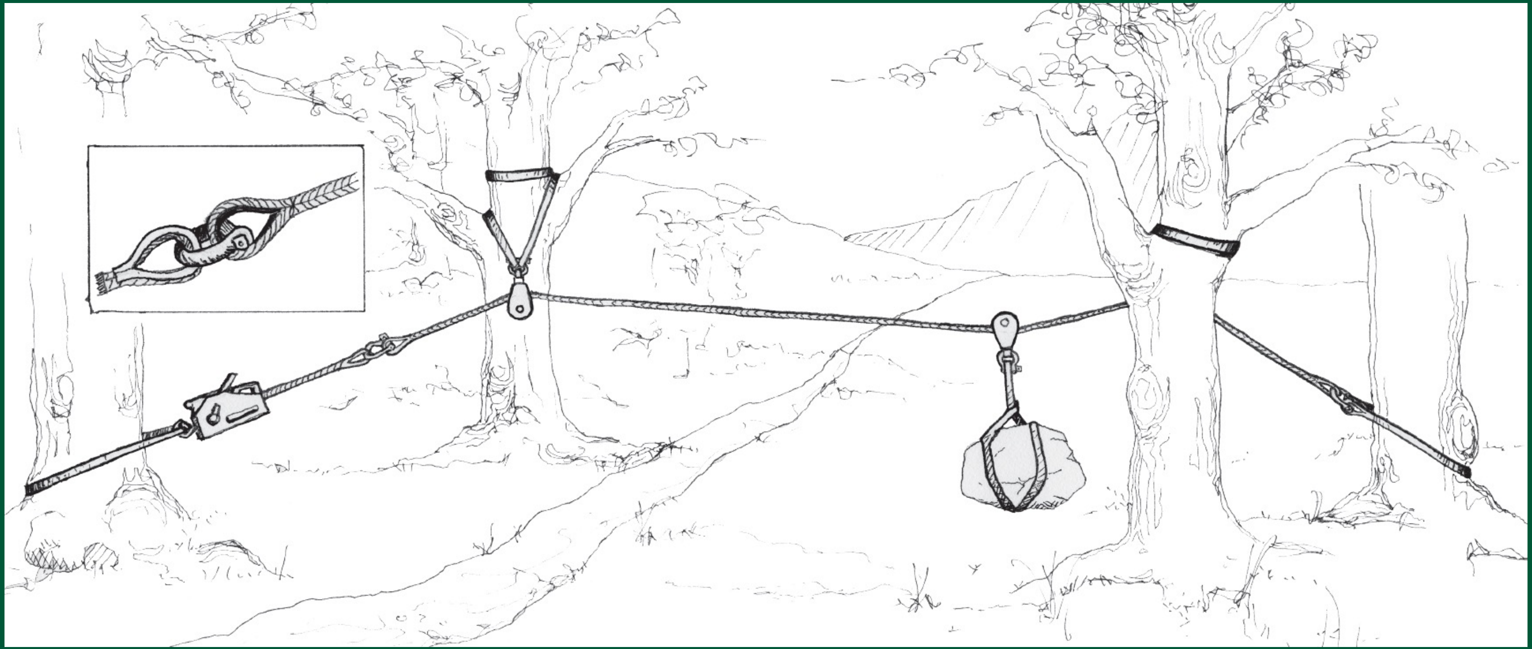
- A component will fly in the direction of the force applied to it. Assume that the component will fly a long way, unless it is clear that it will hit an obstacle, such as a tree or boulder.
- The fly zone, also known as “the angle of death” (for good reason), is much wider than the direction of force and usually has a teardrop shape, emanating outward from the component. This teardrop-shaped fly zone is a result of the components connecting together.
- For example, if a sling holding a spar block breaks, the block will fly along the direction of force, but the line that runs through the block will also be carried with it. For this reason, the fly zone is the entire area that falls between any angle created by a line running through a block.
- Also, the wire rope usually pulls toward the power source, so in the event of a component line failure, the line will most likely fly quickly toward the hoist operator.

Rigging Systems – Straight Pull

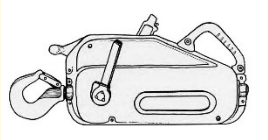
Rigging Systems – High Lead

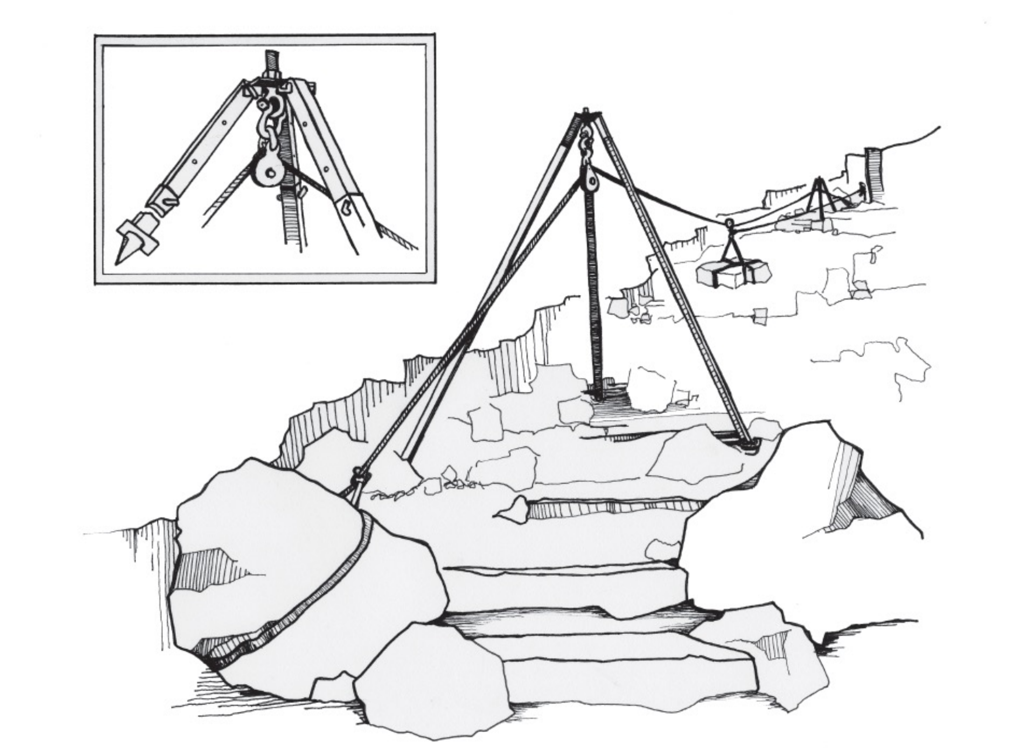


Rigging Systems – Basic Skyline



Rigging Systems – Basic Skyline On Tripods





Anchor Options

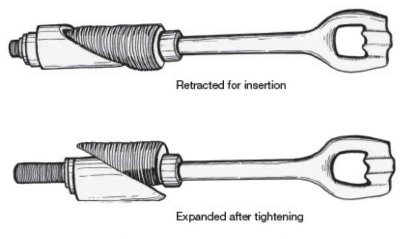
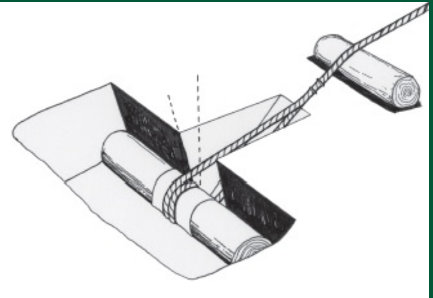
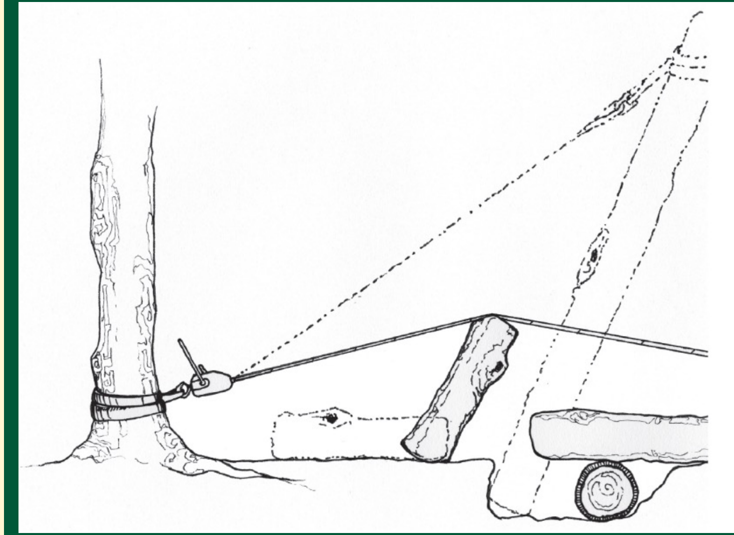


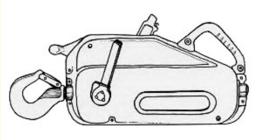
Figure 7–3—An expansion rock anchor.

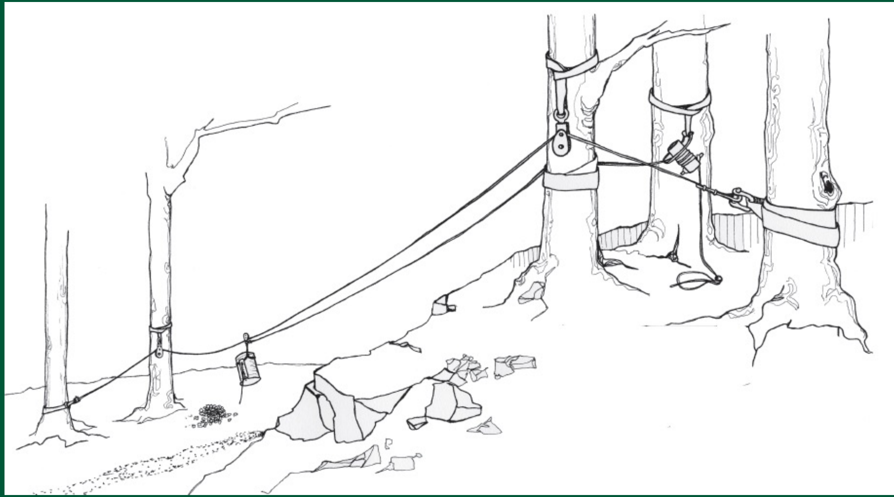


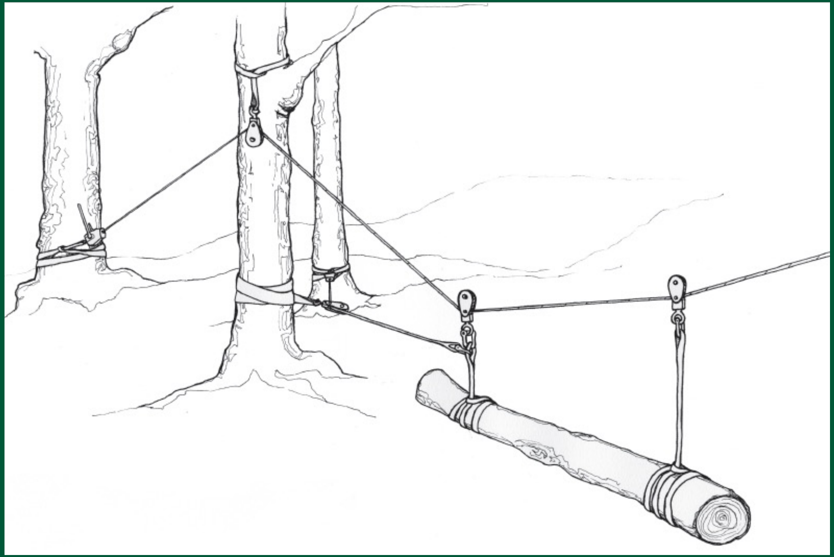
Rigging Systems – Basic Skyline using a Spar Pole



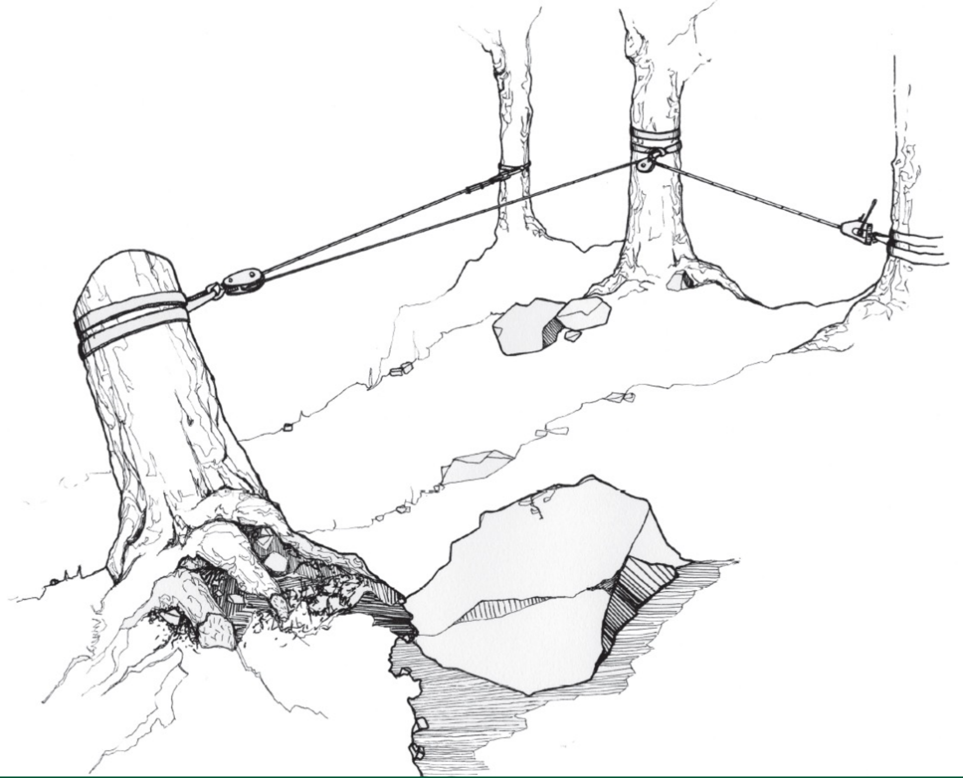
Rigging Systems – Basic Skyline with belay or power source added



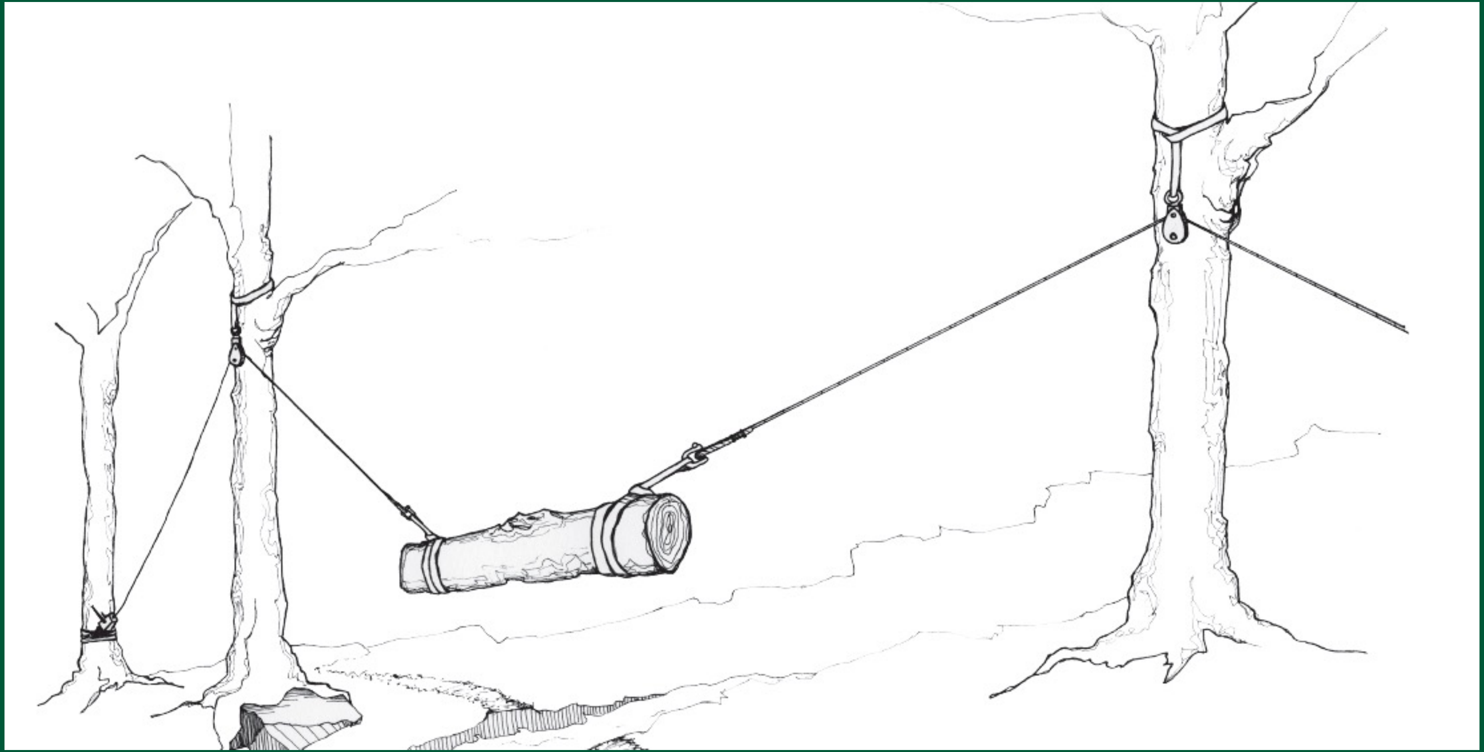




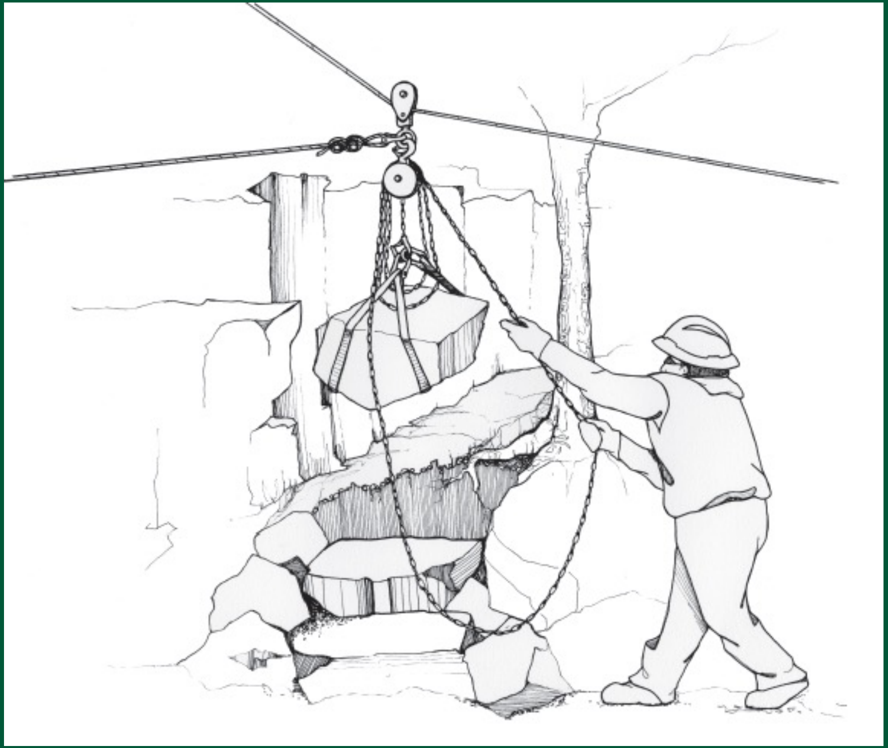
Rigging Systems – Pulling Stumps



Rigging Systems – Double High Lead



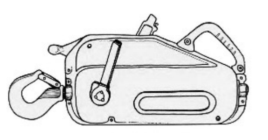
Rigging Systems – Skyline with a hoist

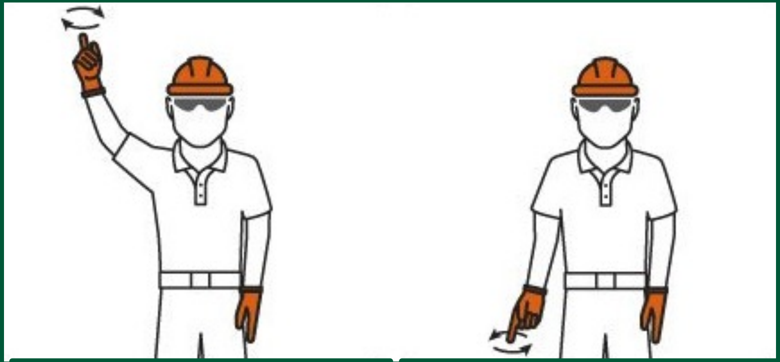


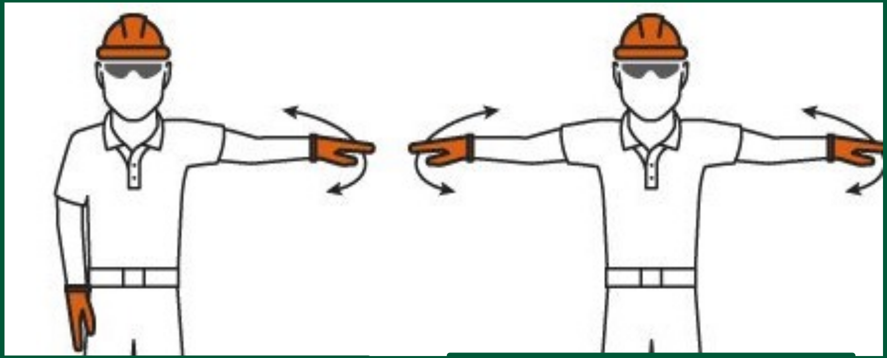
Rigging Systems –Shocking a rigging system

Gelrum's "Stage Rigging Handbook" provides a telling example: A 75-foot, ¼-inch diameter galvanized cable sling subjected to a shock load from a suddenly dropped 500-pound load (6-inch drop) experiences a shock force of 2,296 pounds – over four times the weight of the load!

Rigging Communication – Same Language and clear hand signals





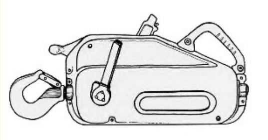


Tension / Hoist | Slack / Lower | Stop / Hold | Emergency Stop

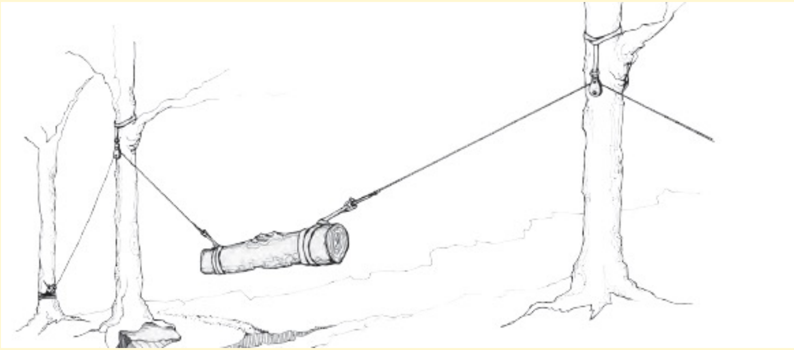
The lead rigger will set up communications as the project needs, this can be by voice, radio, hand signals, or all of the above. Some jobsites need a human repeater to get from the lead rigger to the hoist operator.

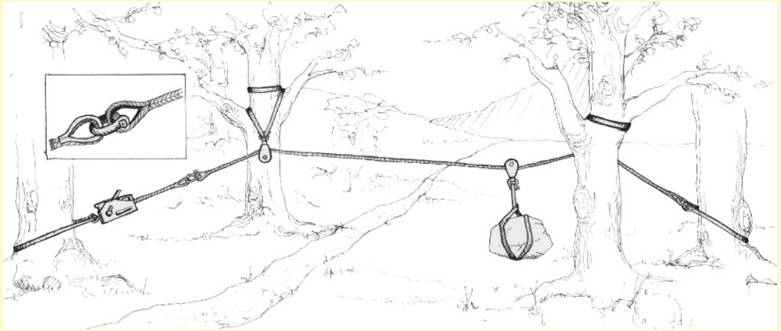
No matter how the communication is delivered it needs to be repeated back to the lead rigger to ensure that it was understood, and directions are being followed.

Knowledge Check

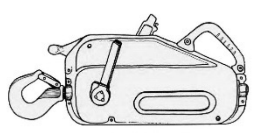


Given the interior angle in these two systems which system do you think would have higher line tension? (if we assume the rock and log have similar weights)





Knowledge Check



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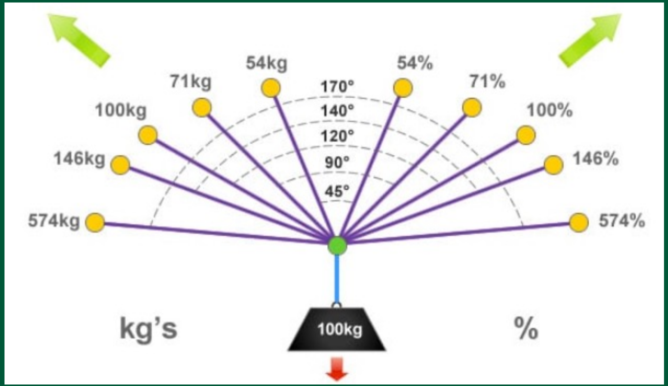
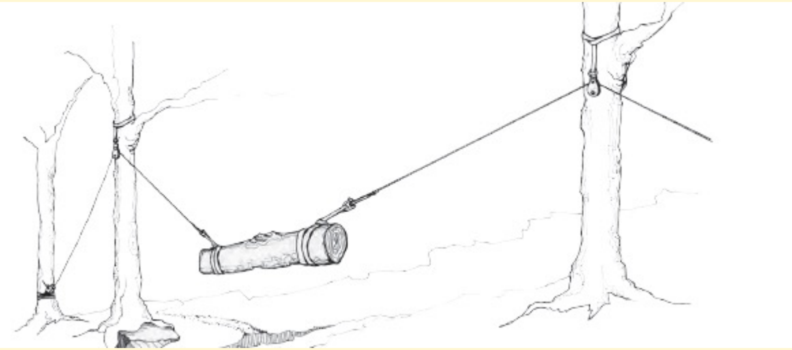
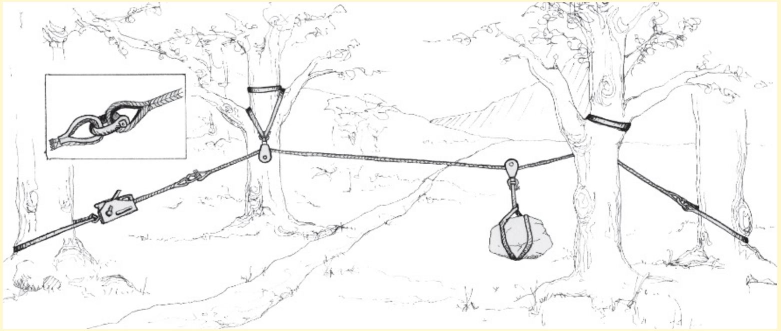
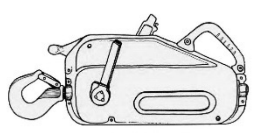


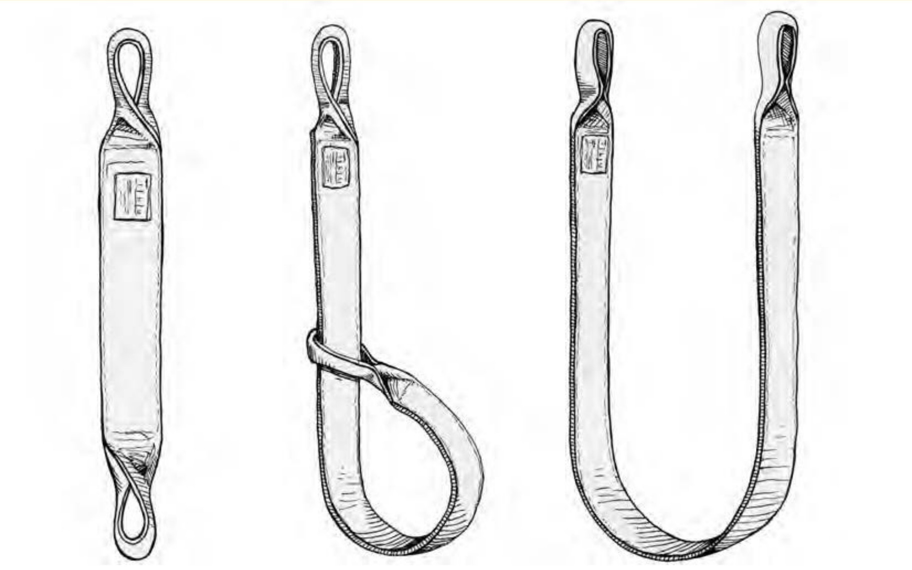




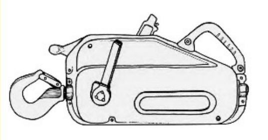
Knowledge Check



What are these sling orientations called, and which has the highest and lowest WLL?



Knowledge Check



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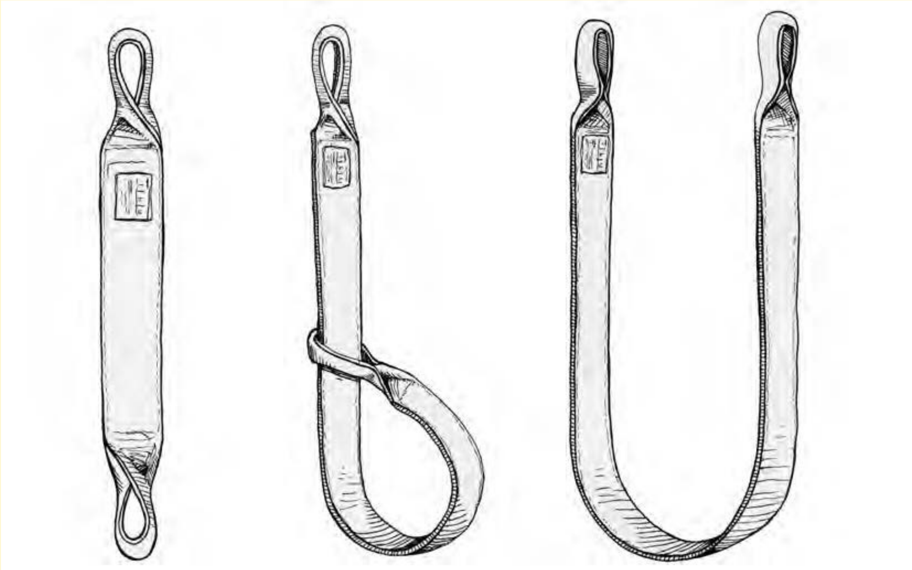
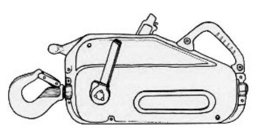


Knowledge Check

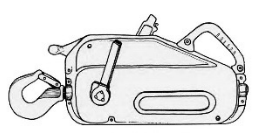


What is the WLL of this rope if the MBS is 10,000 pounds and it is tied off with a bowline on a bight?

Note 15 extra points awarded if you can tie a bowline on a bight.

Knot	Percent Strength Retained
Bowline on a bight:	70-75%

Knowledge Check



What is the WLL of this rope if the MBS is 10,000 pounds and it is tied off with a bowline on a bight?

10,000MBS/ safety factor of 5 = 2,000 pound WLL

Strength retained for a bowline on a bight 70 – 75%

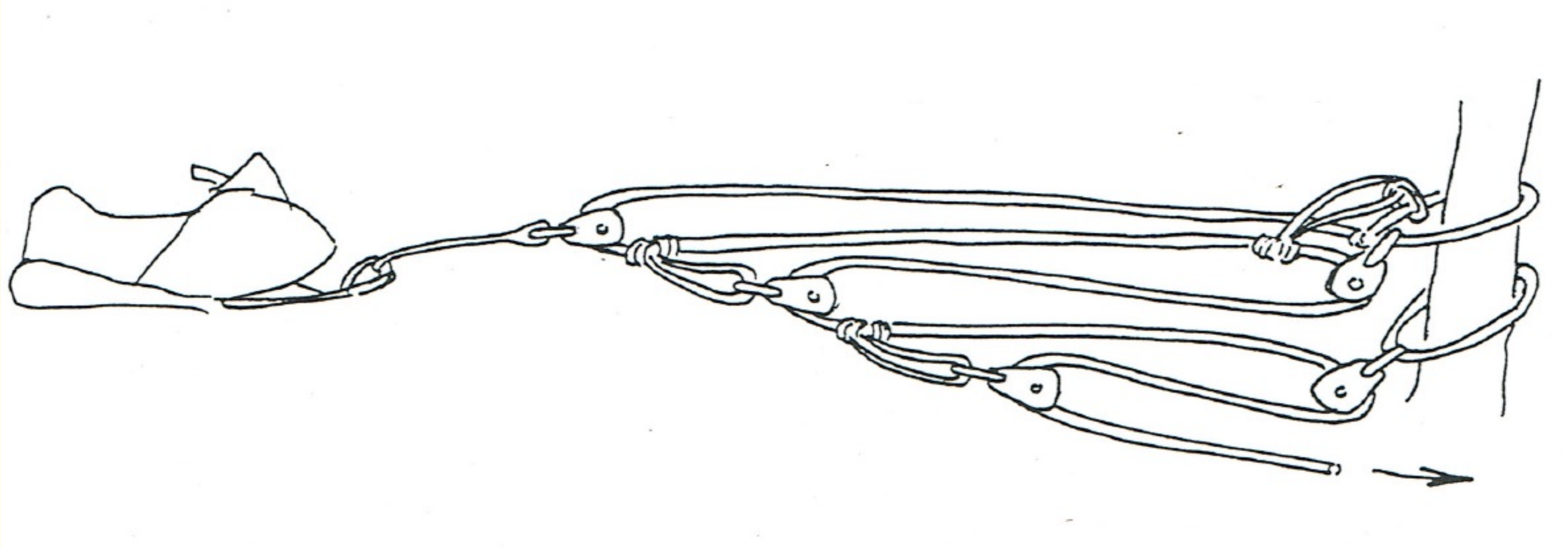
2000 x 70% = 1,400 pound WLL

2000 x 75% = 1,500 pound WLL

Knot	Percent Strength Retained
Bowline on a bight:	70-75%

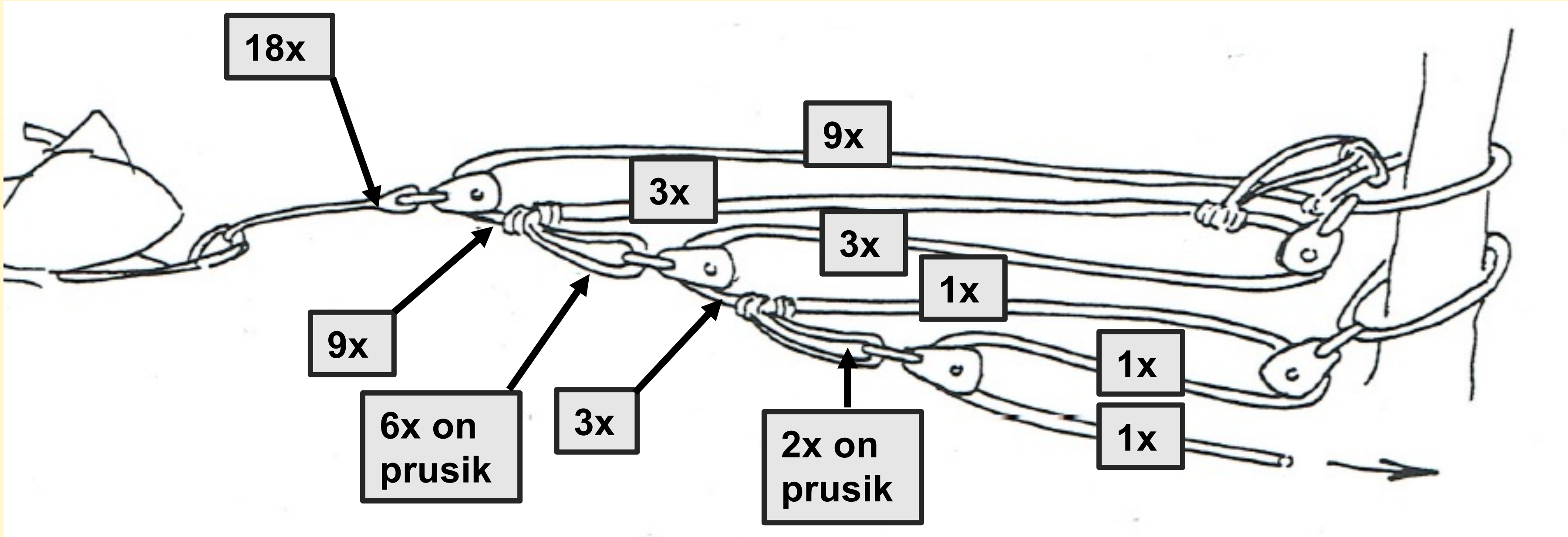
Knowledge Check

What is the mechanical advantage in this system?

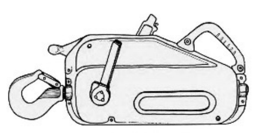


Knowledge Check

What is the mechanical advantage in this system?



~~Who is a~~ Are you (getting closer) a Qualified Rigger?



"A qualified rigger is a rigger who meets the criteria for a qualified person.

Employers must determine whether a person is qualified to perform specific rigging tasks. Each qualified rigger may have different credentials or experience.

A qualified rigger is a person that:

- *Possesses a recognized degree, certificate, or professional standing, or*
- ***Has extensive knowledge, training, and experience, and***
- ***Can successfully demonstrate the ability to solve problems related to rigging loads."***

OSHA FactSheet:

Subpart CC – Cranes and Derricks in Construction: Qualified Rigger

Forest Service
U.S. DEPARTMENT OF AGRICULTURE

RIGGING FOR TRAIL WORK – QUESTIONS?

USFS Rigging Curriculum

The End

Forest Service
U.S. DEPARTMENT OF AGRICULTURE

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