TR GENERAL ROPE; ANCHORS

Objectives:

- Identify, construct, and demonstrate:
- Tensionless anchor.
- Two bight anchor (sometimes referred to as a three bight anchor).
- Multi-wrap anchors.
- Artificial anchors
- Steadfast picket systems

Objectives:

- Identify, construct, and demonstrate:
- Anchor Systems:
  - Single point anchors
  - Tie Backs
  - Multi-point Anchors
    - Load Sharing
      - 2 & 3 points
    - Load Distributing
      - 2 & 3 points
  - Natural & Artificial Anchors
    - Cams, Bolts, Screws, Pitons
    - Picket systems

Anchors:

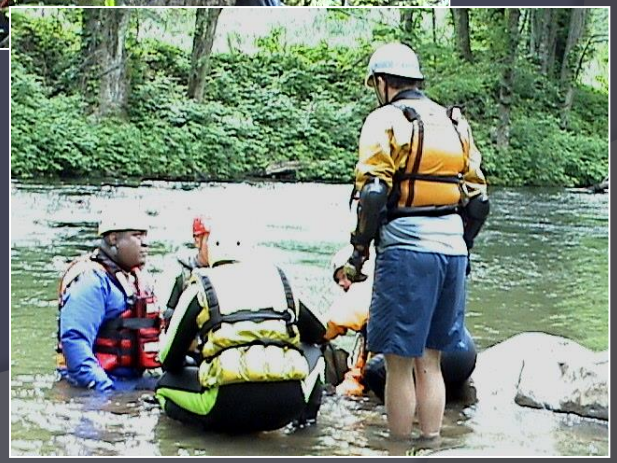
- Secure ropes, hardware and or software to a solid object.
- An anchor in the high angle system is like a foundation in a structure.
- Anchor points are the object to which anchors are secured.
  - Single Point
  - Two-Point
  - Three-Point or more
  - Natural or artificial materials

Anchors:

- Take many forms:
  - Natural
    - Most common natural anchors include trees and rocks.
      Both have potential for failure.
  - Portable
    - Timber A Frames, Timber tripods
  - Commercial artificial anchors.
    - Tripods; Larkin Frames; Arizona Vortex' High directional

Natural Anchors

- Examine trees for weakness (BFT)
  - Greater than 4” in diameter
  - Rotting
  - Exposed or shallow root system
  - Soft or saturated soil.
- Check boulders for stability and solidity.
  - Sharp edges need padding
  - Wrap as low to ground as possible



Structural Anchors:

- Select:
  - Anchors that are inherently part of the structure or specifically designed to support rescue loads.
  - Inherent anchor points include:
    - Structural columns
    - Beams or projections off structural beams
    - Supports for large industrial machinery
    - Stairwell supported beams
    - Anchors for window cleaning equipment

Inappropriate anchors:

- Corroded metal
- Weathered stonework
- Deteriorated mortar
- Sheet metal vents
- Flashing, gutters and downspouts, small chimneys and fire hydrants.
- Dead /Rotten Trees
- Loose railings

Less Obvious Anchors:

- Elevator and machine housings
- Roof drain holes (scuppers)
  - Tiebacks, using timbers or pipes, can be secured through the scupper hole on parapet walls to create anchor points.
- Wall sections between windows and doors.
- Stairwell beams.

Artificial Anchors

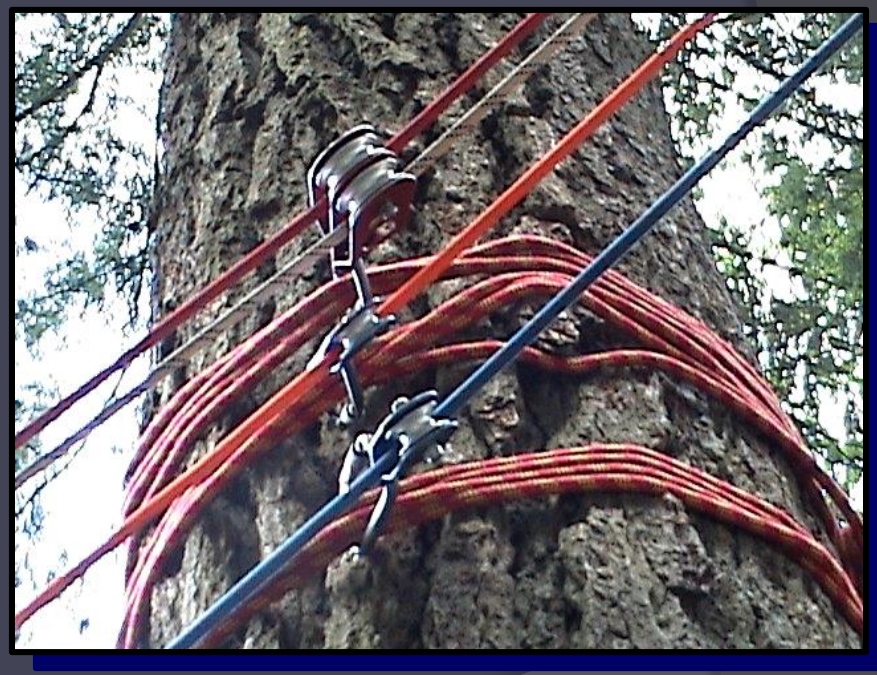
- Specifically designed for creating anchor points in places where natural anchors are unavailable,
- Used primarily in a wilderness setting.
  - Nuts, chocks, hexcentrics, and cams
  - Bolts
    - Time consuming to set
    - Not the first choice for rescue operations.
  - Artificial anchors should be constructed by someone with a great deal of skill and practice in their use. (who?)

Anchor Placement

- Criteria for placing anchors.
  - Placing secured anchors is dependent on:
    - Training
    - Practice
    - Experience
    - Judgment
  - Anchors must be able to withstand the greatest anticipated force of the rescue system.
  - An anchor's capability ability to withstand the forces put upon it depends on:
    - Condition of the anchor
    - Integrity of the anchor
    - Direction of the force upon the anchor point.

Direction pulled upon an anchor can affect the force applied.

- Set anchors that align with the direction of pull.
- Effects of the direction of pull changes.
- Some anchors are rigged so they are strong in one direction only.
- A change the direction and the anchor system may be compromised or may fail.



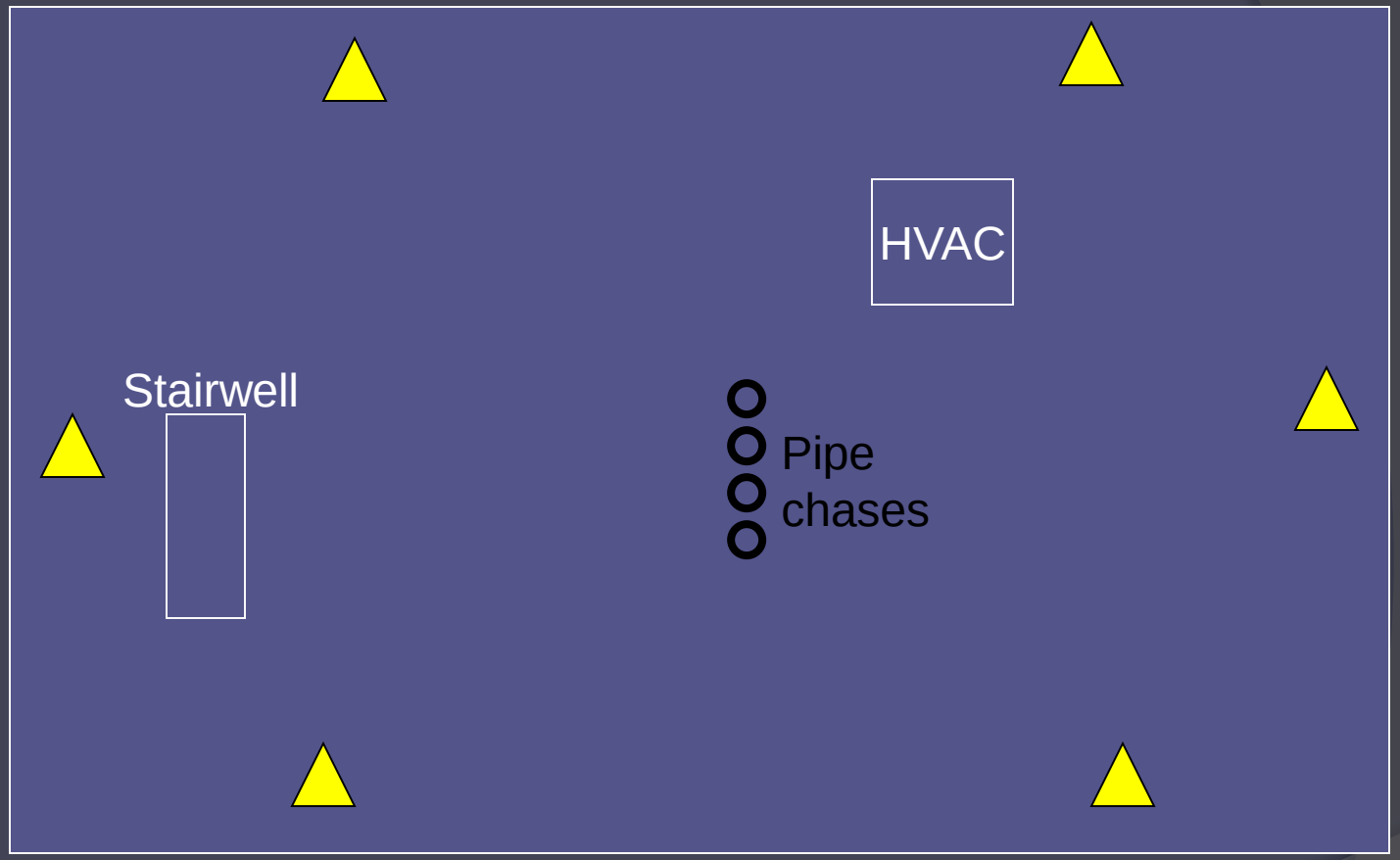
Back-up anchor systems

- Suggested for all questionable single anchor points.
  - Is called a back-tie.
  - Select a strong anchor located behind the primary anchor.

Selecting A Suitable Anchor Point

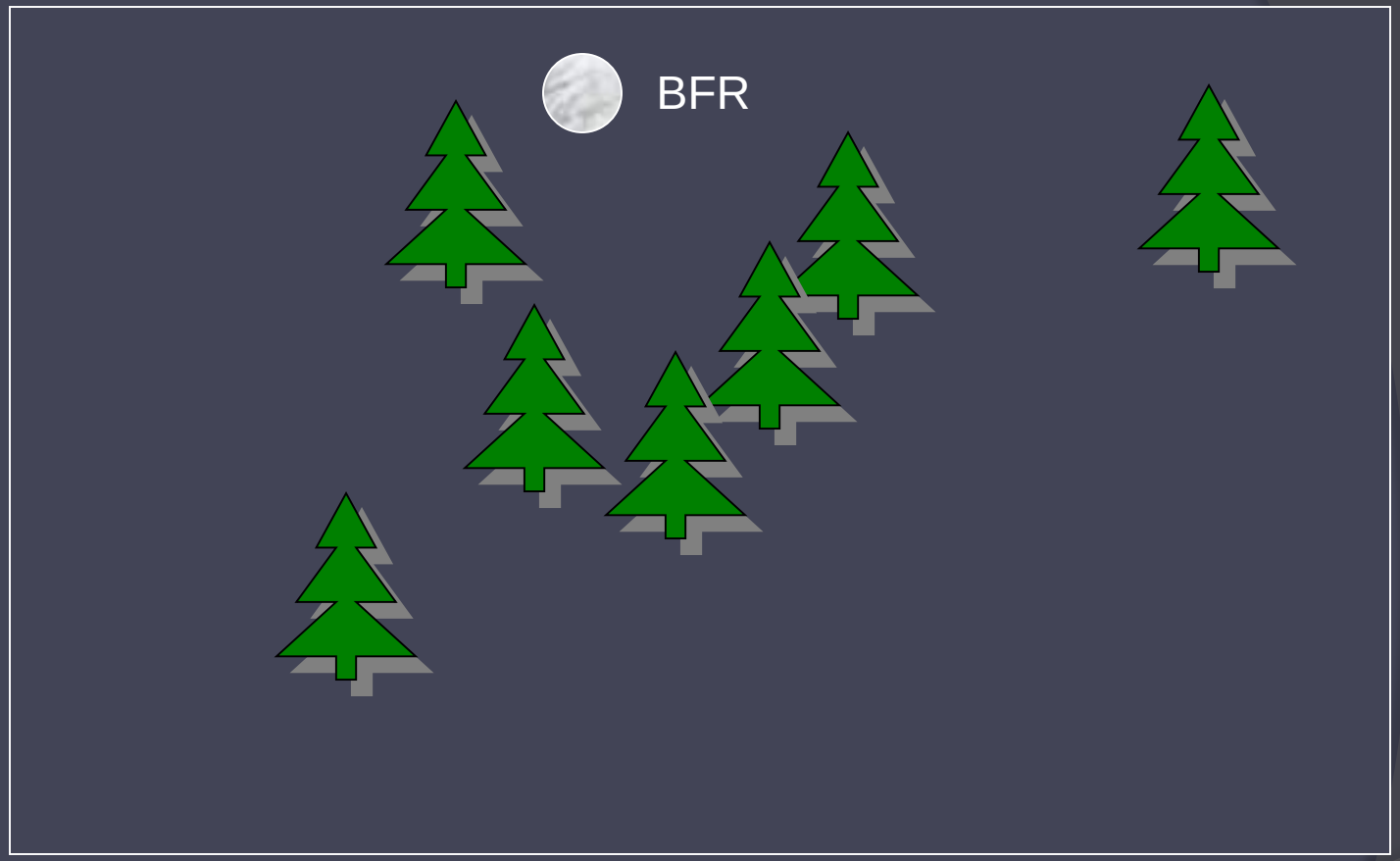
- Anchor points should be close to and directly above the victim.
- Location of adjacent suitable anchors
- Assess for hazards to rescuer & victim
  - Loose rocks or other objects falling on the rescuers or victim.
  - Wildlife *(bees, snakes, pets, vegetation…)*
  - "Widowmakers" or Debris
  - Flame impingement.
  - There may not be suitable anchor points directly above the load.
  - Ground conditions
  - Access to anchors

X Target

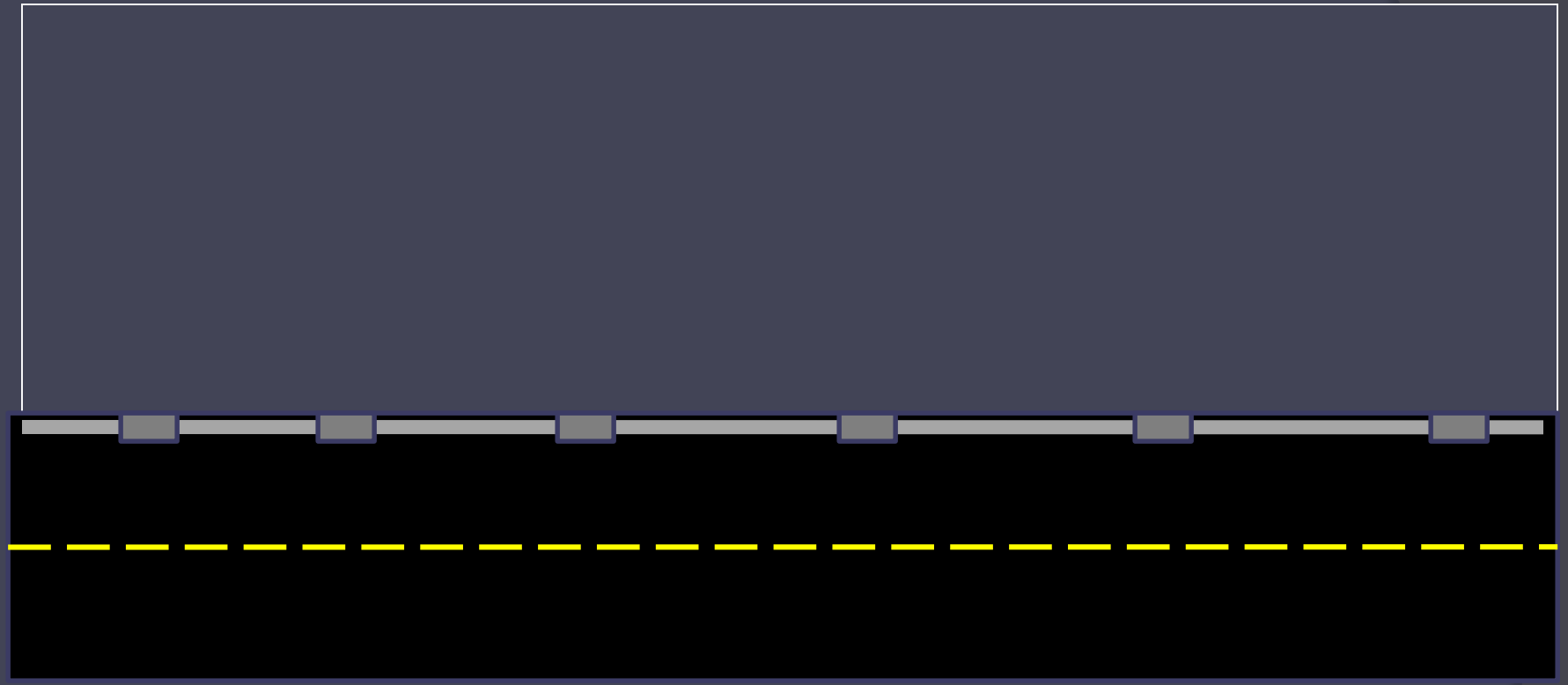


Roof view of 35 story high rise:

X Target



Overhead view of 250 cliff



Anchoring To A Vehicle:

- Potential anchors:
- Axles, cross members, and secure towing points on a vehicle.
- Large amount of material may be required
- Remove keys from the ignition
- Set the emergency brake
- Chock the wheels.
- Protect from abrasion and fluids.

Directional Anchors

- Directs a rope into a more favorable position.
- Used to:
  - Avoid abrasion
  - Elevate ropes
  - Make sharp turns
  - Re-direct a hauling system pull
  - Make sure the same amount of attention used to select a primary anchor point is used to select the anchor point for the directional line.

Back-up Anchors

- Backing up a primary anchor creates redundant anchors for the purpose of safety.
- Employed when there is an uncertainty of the strength of an anchor.
- Type of back-up anchor is based on the condition of the anchor points, the nature of the high angle experience, and the loads.

Ropes Used as Anchors

- Life Safety Ropes must be used!!
- 30’ Body Cords
- Static Anchors
- Abrasion Protection
- Strength (General use)
- More expensive
- Single Point Anchors
- Multiple Point Anchors

Webbing For Anchors

- Less expensive than rope
- Fewer knots to be learned.
- Cannot be tied using as many knots as rope.
- Less Strength.
- Do not absorb shock loading as well as ropes.
- Easier to carry in hasty packs
- Can be extended readily
- Conforms to anchor
- Less abrasion protection

Webbing For Anchors

- Is Bigger really Better?
  - *In reality the larger webbing inserted through a standard size locking carabiner and then loaded can reduce the load strength of the carabiner up to 50 % of its rated capacity.*
  - 2” is required whenever webbing comes into contact with a human being.
  - 1” inch tubular webbing tensile strength is between 4000-4500 pounds.
  - One inch of flat webbing, although a little frustrating when dressing down knots, is rated at 6000 pounds which is the same rating for most 2” webbing.

Pre-sewn Web Slings:

- To pre-tie or not to pre tie that is the question…
  - As a general rule, do not leave knots tied in webbing after using them, unless each sling is carefully inspected before returning it to the equipment box and inspected prior to its next use.
  - Deploy quicker
  - Less errors in knots
  - Quick attachment
  - Verify tensile strength for life safety. How?

Anchor straps:

- Webbing lengths with metal “D” rings sewn into each end to accommodate an appropriate size carabiner.
- Heavy-duty strap with the NFPA “G” for general use designation has an end to end breaking strength of 8,000 pounds.
- Light duty strap with the NFPA “L” for light use designation has an end-to-end breaking strength of 4,900 pounds.
- Under heavy loads adjustment buckles can slip.

When attaching locking carabiners to any system, make sure the locking nut is facing towards the load.

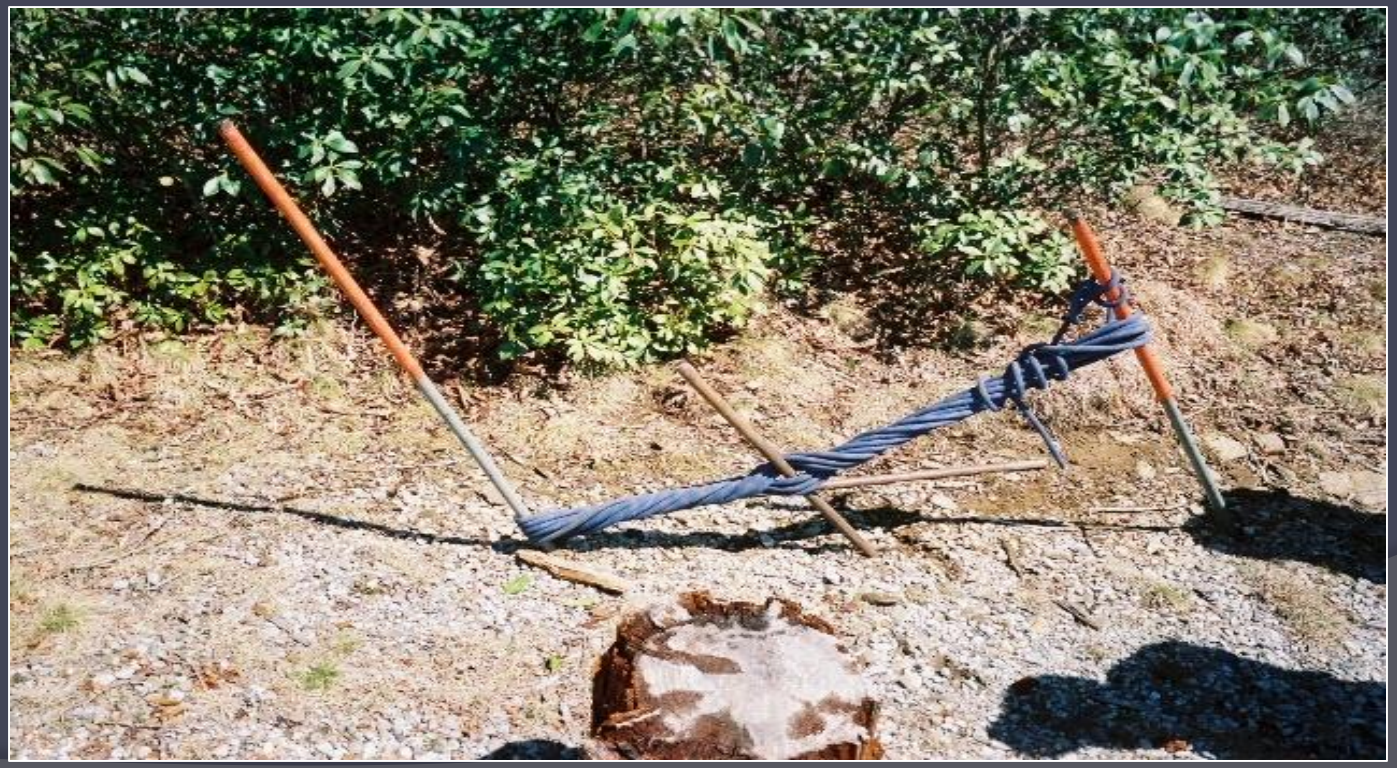
This reduces the chance of the gate accidentally opening as a result of vibration.

Steadfast Pickett Anchors

- Used in a natural setting such a soil when no other anchors are available.
- Soft soils do not accommodate a picket system well.
- Should be driven into the ground approximately two-thirds their length at an angle of 15 degrees away from the object to be moved.
- Should be driven into the ground at a distance apart equal to their length. Pickets should never be less than three feet apart.
- Lashed together with a 1/2” x 25-50’ rope.
- Spinner rod (minimum 2 foot by 3/8” diameter) use a PVC pipe as a buffer.

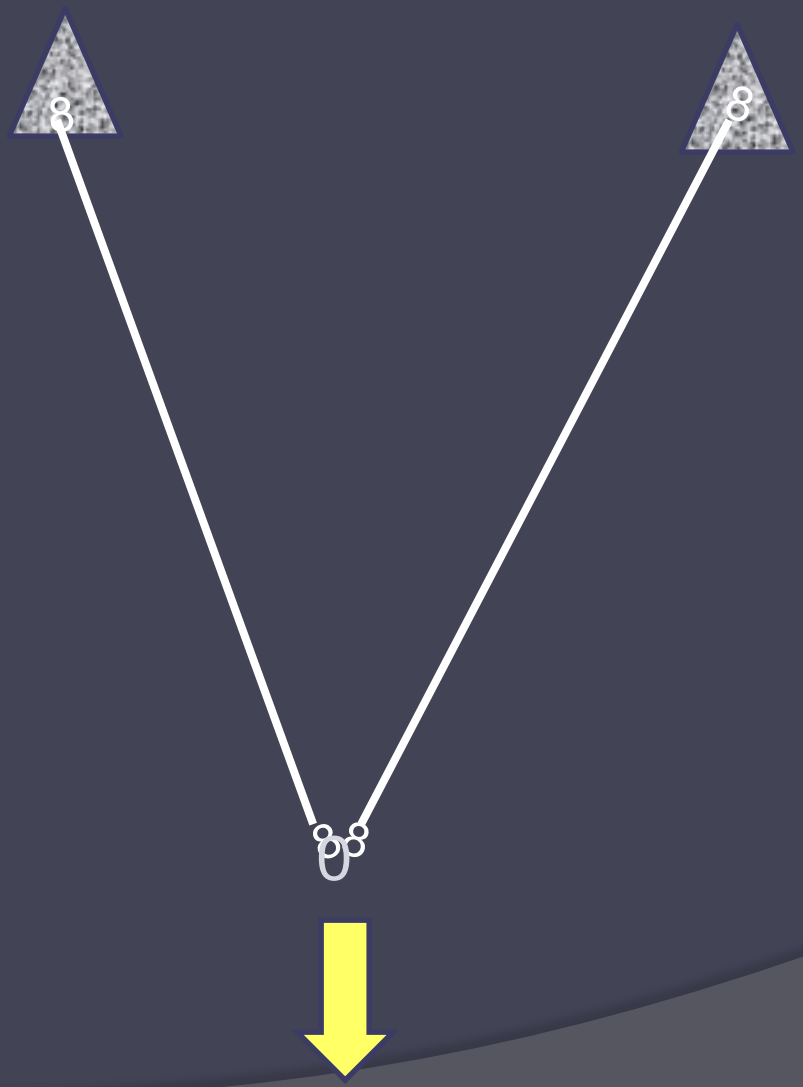
Steadfast Pickett Anchors

- Load capacities when constructed in average soil.
- Single Picket System- 700 pounds.
- 1:1 Combination- 1400 pounds.
- 1:1:1 Combination- 2000 pounds.

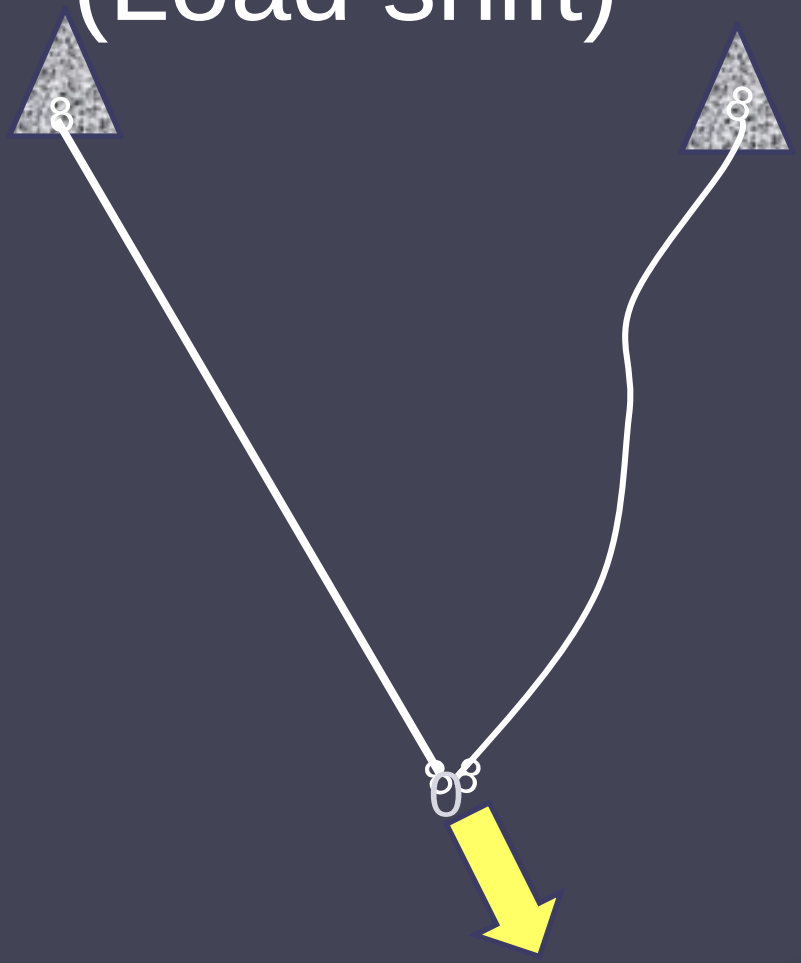


Multi-Point Anchors

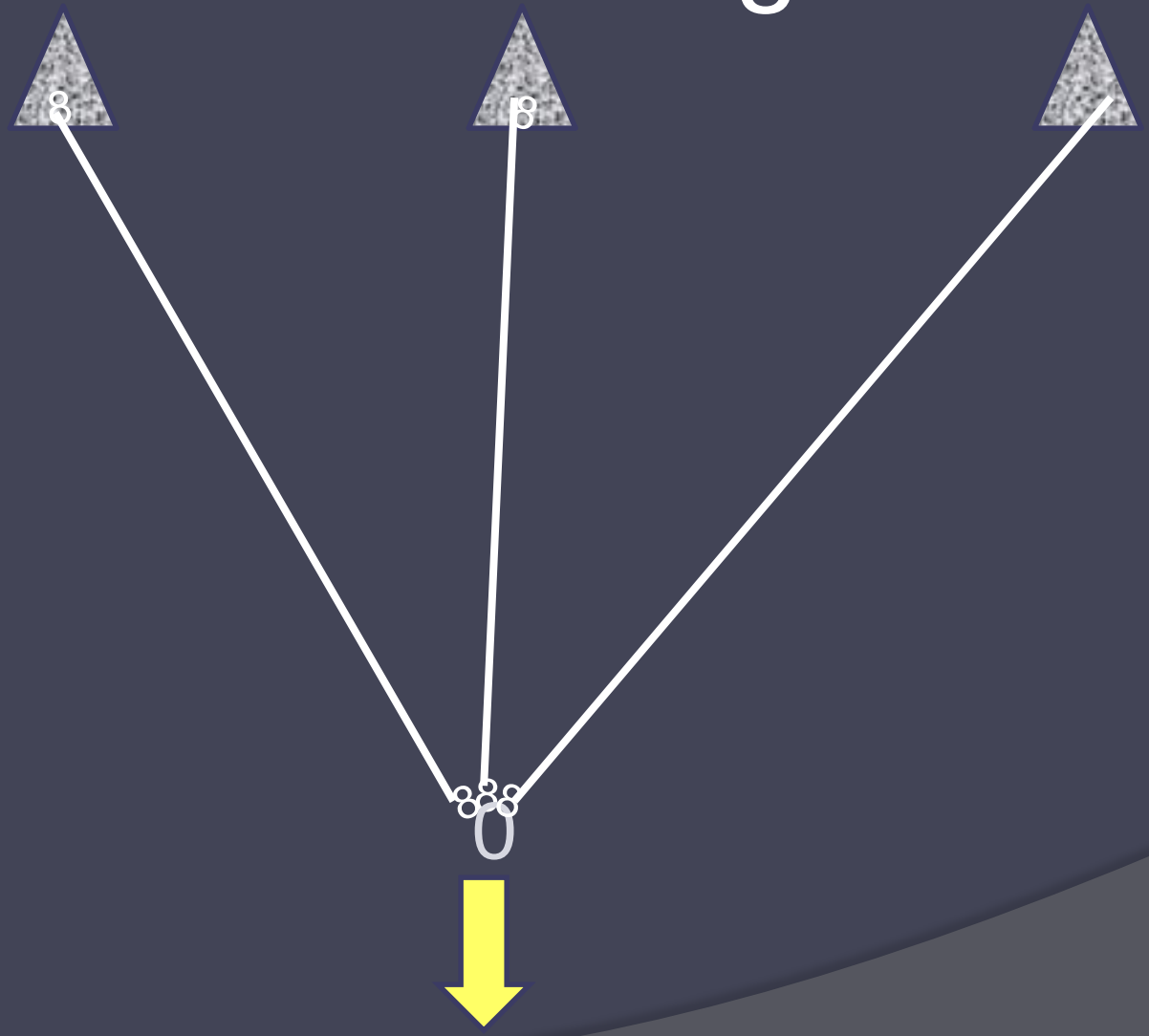
2-Point Load Sharing



2-Point Load Sharing (Load shift)



3-Point Load Sharing



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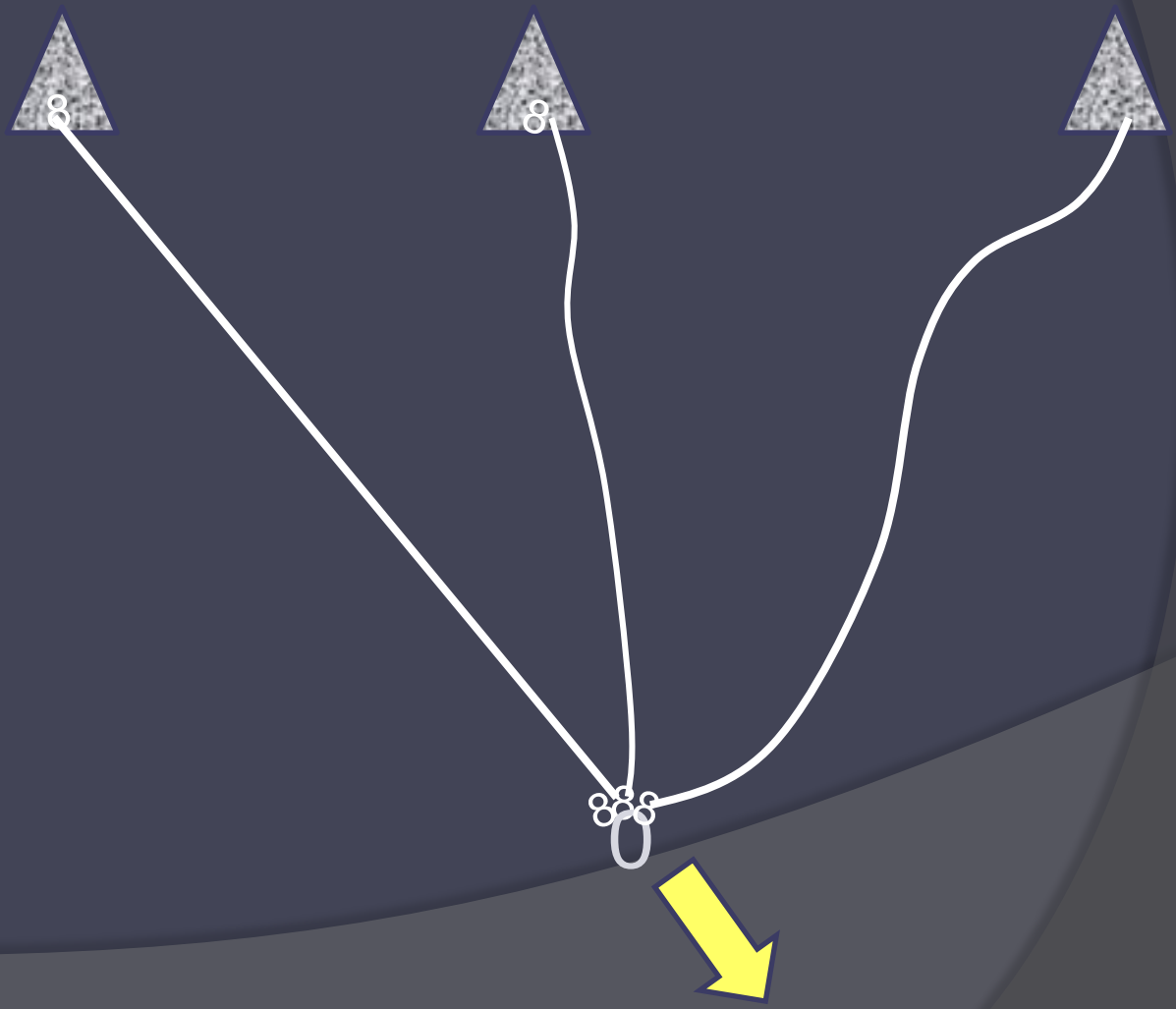
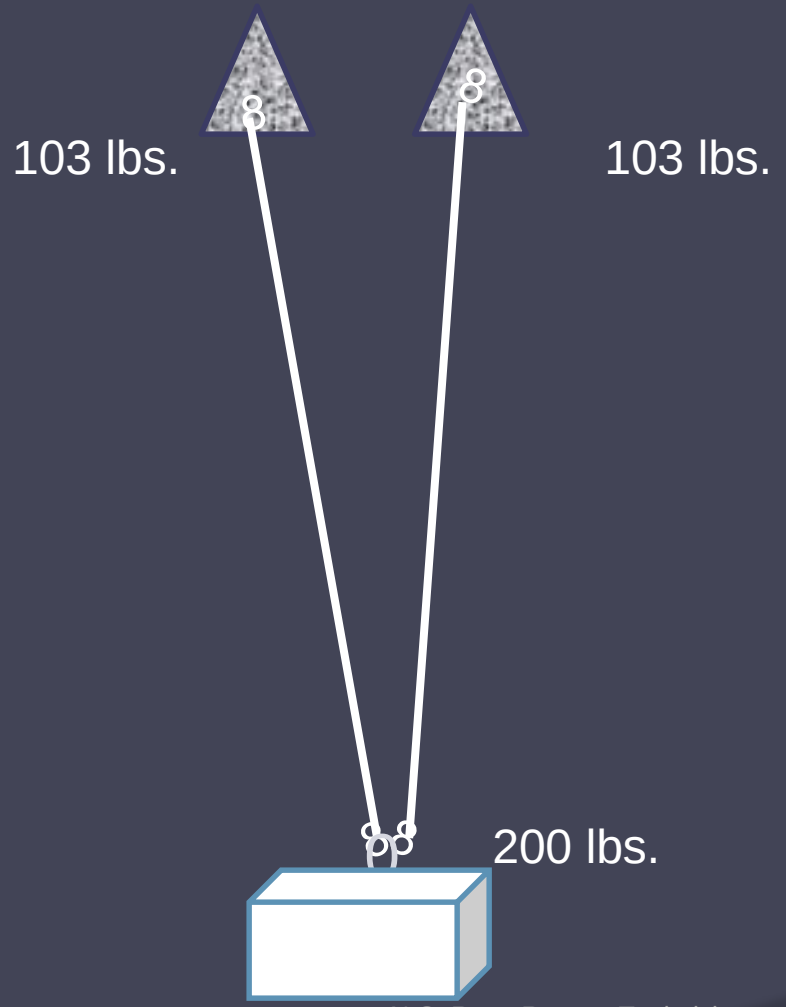


Angles Affect Integrity



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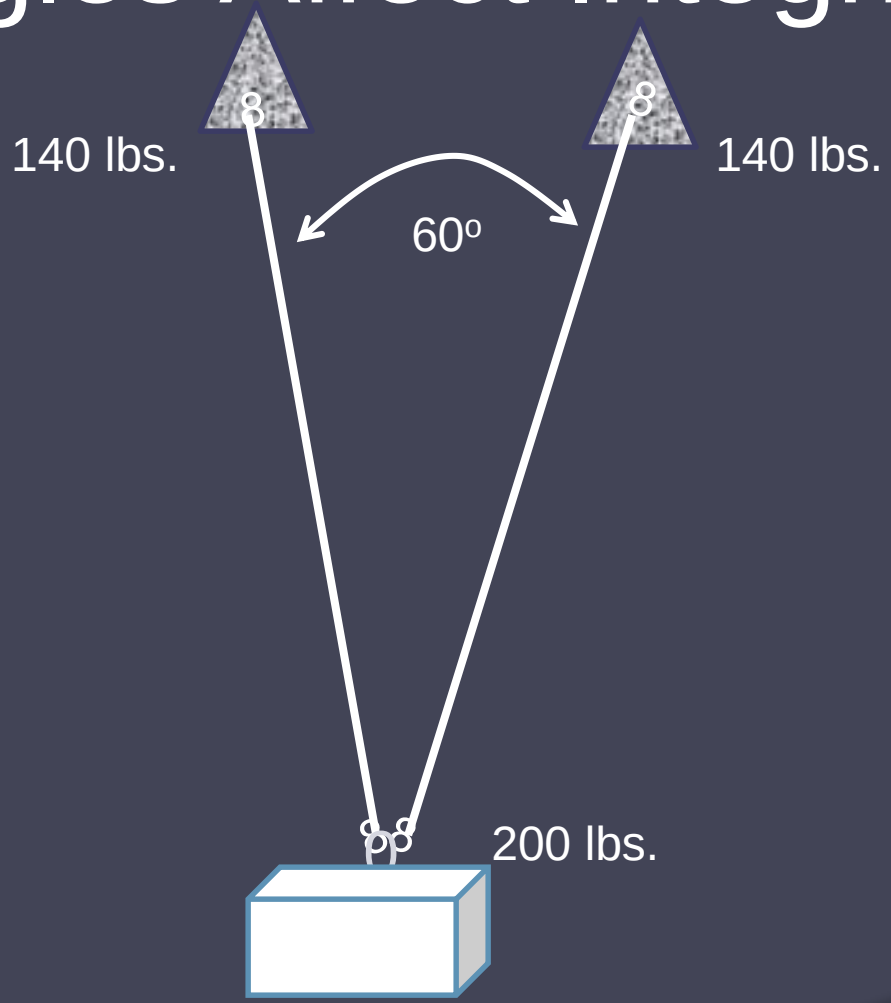

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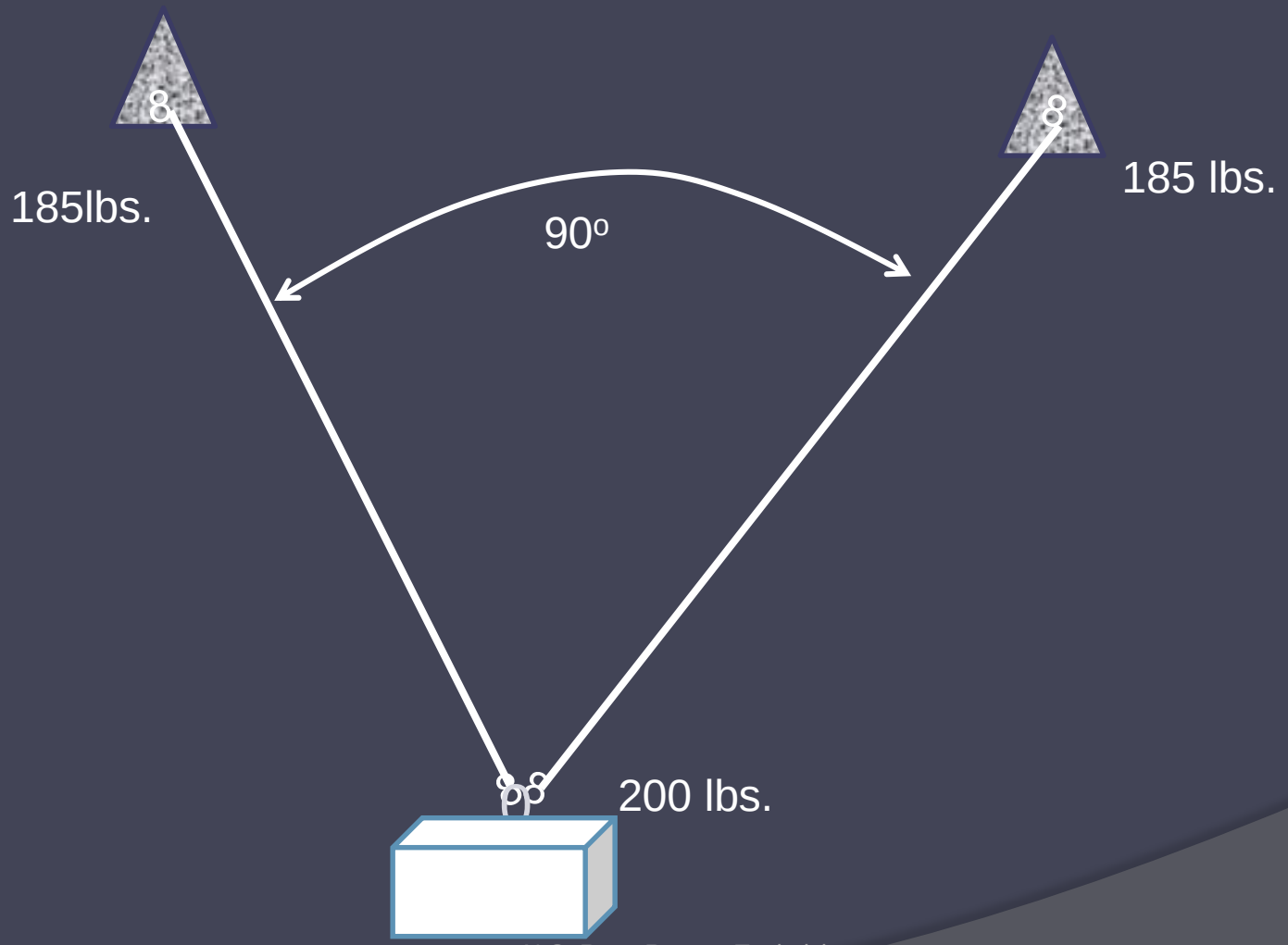

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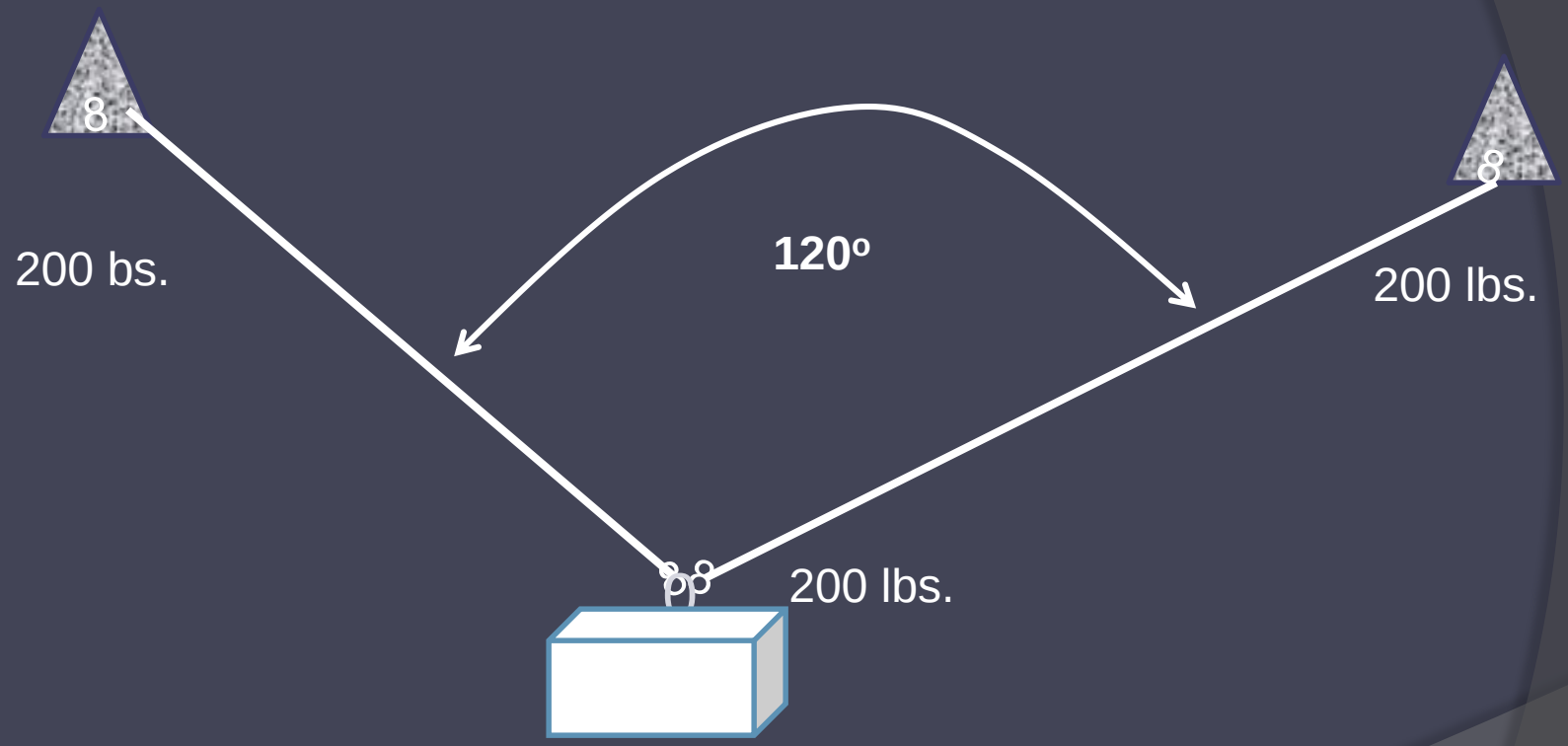

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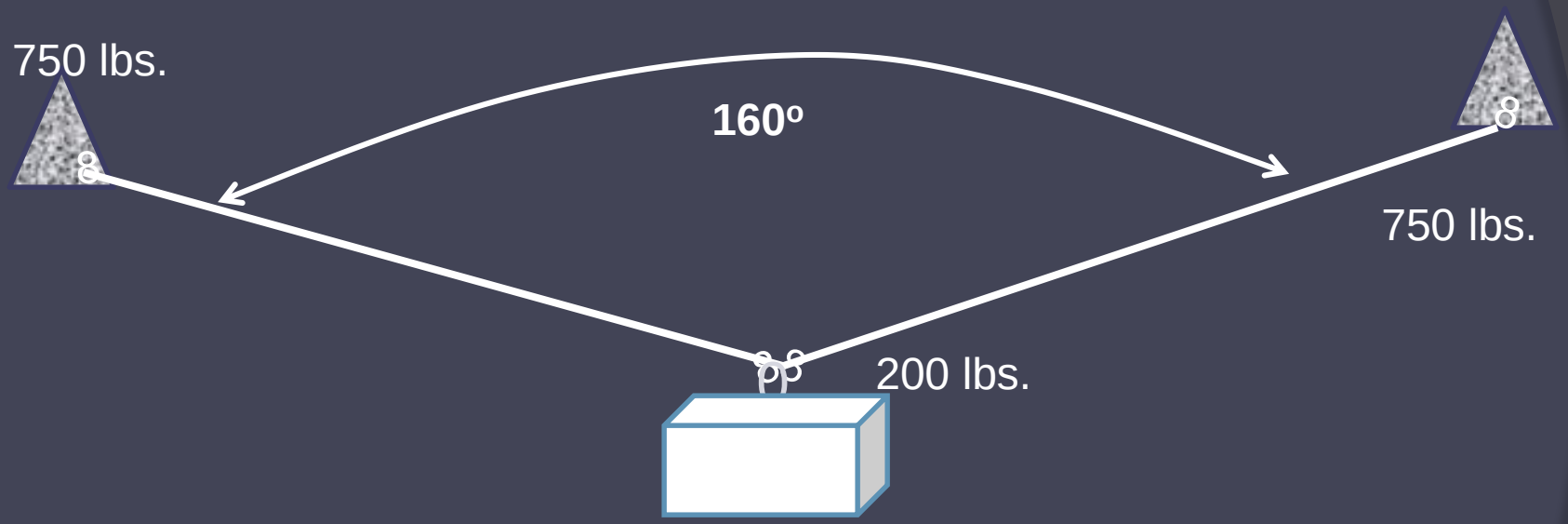
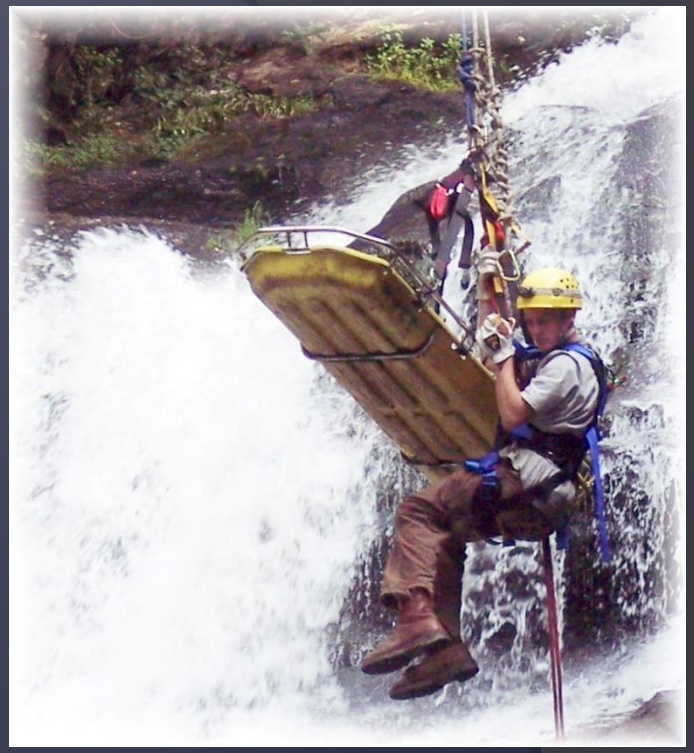


MECHANICAL ADVANTAGES



Some Principles To Consider

- “Every Object Resting On Earth Is “At Rest” Or A State Of Equilibrium.
- “The Greater The Weight Of An Object, The Greater The Friction Force.”
- “The Smoother The Contact Surfaces, The Less Friction Between Those Surfaces”
- “Materials With Rounded Surfaces That Break Contact Between Objects Will Generally Reduce Friction.”
- Energy: “The Property That Gives Something The Ability To Do Work.”

Some Principles To Consider

- Types Of Energy:
  - Kinetic- Energy Possessed By A Body Or Object In Motion.
  - Potential: Stored Energy

Some Principles To Consider

- Work:
  - The Rate At Which Something Produces Energy.
- Need Power To Do Work And Overcome:
  - Friction
  - Gravity
  - Inertia
  - Weight
  - Air Resistance.

Mechanical Advantage

"Applied to the relationship between the weight of a load being lifted and the power of force required to lift, push, or hold a load."

Mechanical Advantage

- Examples of ways to reduce friction include:
  - Pulleys
  - Cams
  - Incline Planes
  - Screws…
  - Levers

Mechanical Advantage:

- Ratio between the output of force a machine exerts to the input force that is furnished to that machine to do work.
- Defines how efficient and effective a machine is.
- M/A less than 1 means:
  - The output force delivered to the machine is smaller than the input force supplied to the machine.
- M/A greater than 1 means:
  - The output force delivered to the machine exceeds the input force (energy)

Mechanical Advantage Systems

- A non-mechanical advantage hauling system is one in which the required pulling force exerted by the rescuers is equal to the load.
  - 1:1 MAS;
    - The load is 100 pounds
    - Pulling force is 100 pounds of force (lbf),
    - No mechanical advantage

Mechanical Advantage Systems

- A mechanical advantage system is one in which the pulling force exerted by the rescuers is less than the load. It is called theoretical mechanical advantage.
- 2:1 MAS
  - The load is 100 pounds
  - Pulling force is approximately 50 pounds of force (lbf)
  - This calculation does not address
    - Size of pulleys,
    - Ropes
    - Friction created by rope making contact with various objects
    - Number of bends in the rope.

Mechanical Advantage Systems

- Used for low/ medium/high angle rescue missions.
- Consists of:
  - Simple
  - Compound
  - Complex Systems.

Why would we use M/A?

- Excessive Loads
- Minimal Manpower To Move Load
- Unanticipated Loads During The Lift.
- For Rigging Support Systems Such As Gantries, Derricks, Tripods, A-frames…
- Stabilization Systems

Mechanical Advantage Systems

- Hardware & Software should be rated for the load being moved.
- The haul line should be pulled in a steady rhythmic fashion by walking not pulling.
- Never stand under the load being hauled.
- Whenever possible the pull should be a “Counter-balance pull” or downhill.

But which M/A do we use?

- Too many people pulling on the haul line can cause catastrophic failure by exceeding the tensile strength.
- Exceeding the 15:1 Safety Ratio when building M/A's.
- Manpower to move victim.
  - Less manpower means more M/A.
- KISS
  - (20 mules: 1 victim)
- Rule of 18's for ½"rope
  (# of rescuers x M/A= less than 18)
  - No more than 6 people pulling on a 3:1
  - No more than 4 people pulling on a 4:1
  - No more than 2 person pulling on a 9:1

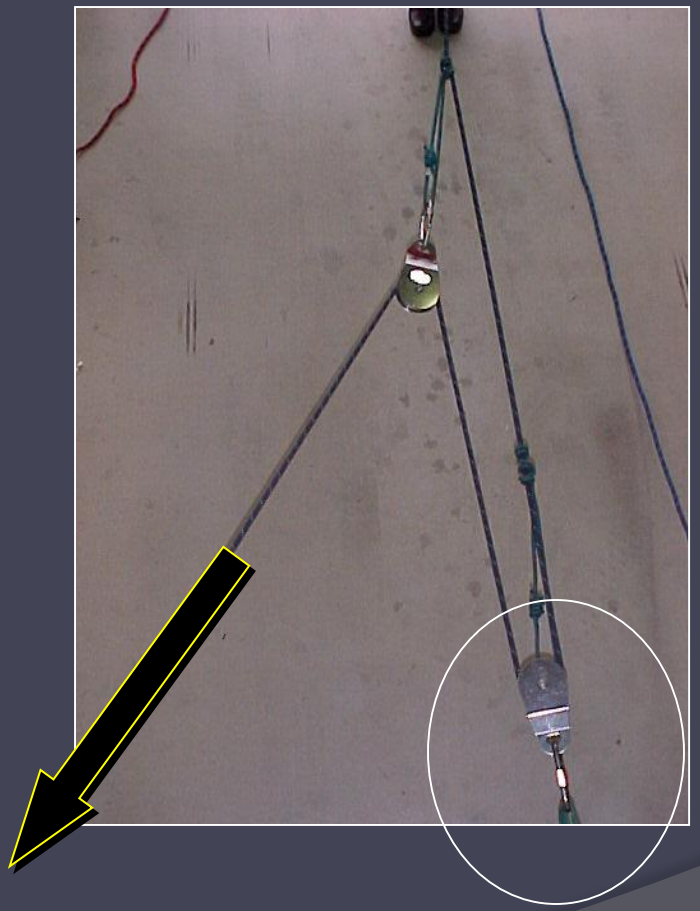
RULES OF MECHANICAL ADVANTAGE

Rule #1 :

"If The Rope You Are Pulling <u>Begins At The Load</u>, The Mechanical Advantage Will Always Be Odd." i.e. 1:1

Rule #2:

If a turn in the rope or pulley doesn't move, then it is nothing more than a "change of direction", with no mechanical advantage.



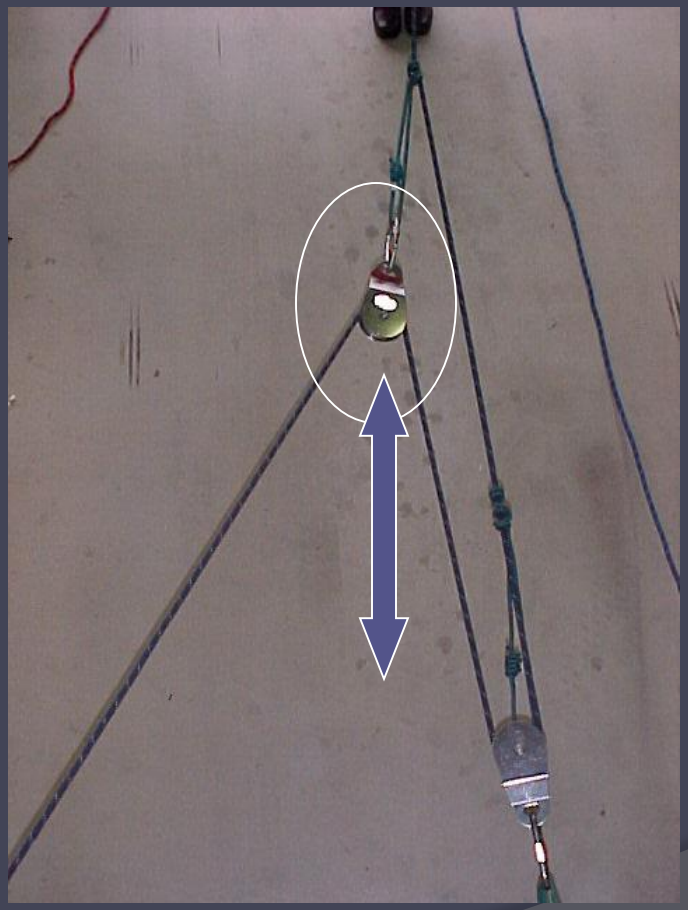
Stationary Pulleys are Change of Direction

Rule #3:

"If the rope you are pulling begins at the anchor, the mechanical advantage will always be even." i.e. 2:1

Rule #4:

"If the pulley (or a turn in the rope) moves or travels within the system, it will create a mechanical advantage."

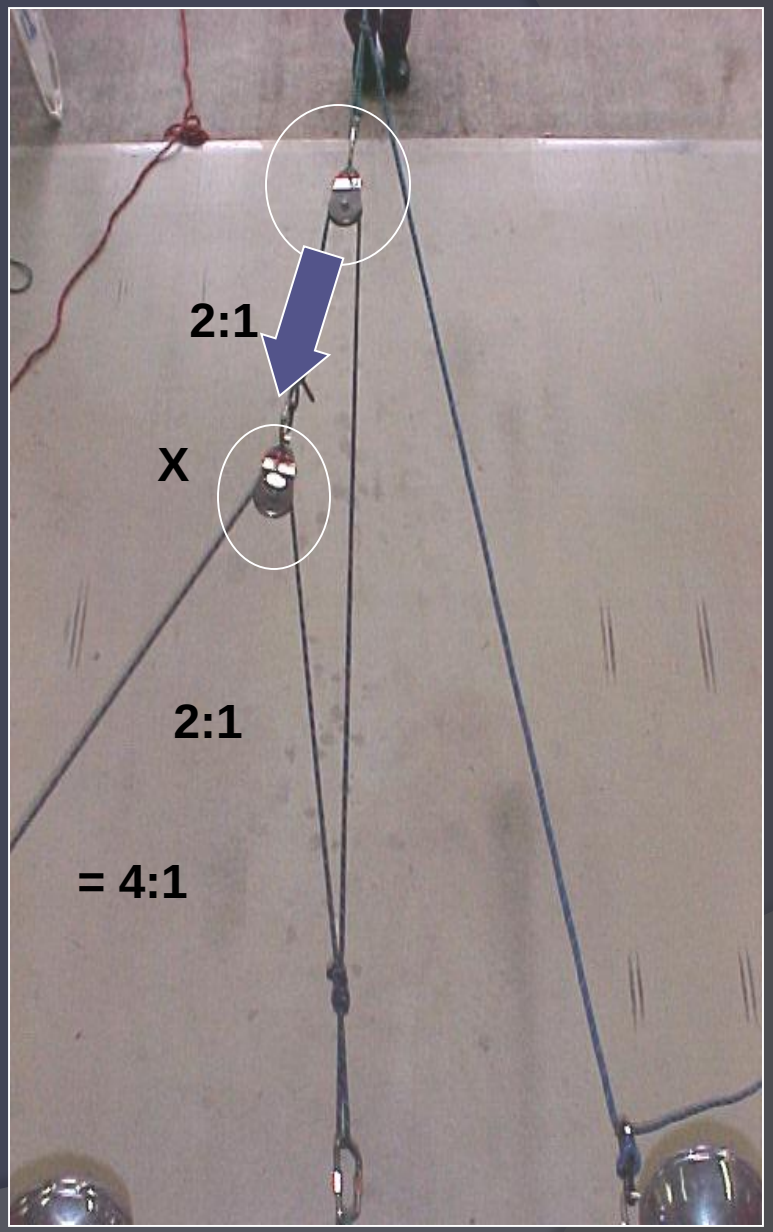


Rule #5:

"When stacking pulleys into a system, a traveling pulley, placed on top of another traveling pulley <u>MULTIPLIES</u> the mechanical advantage." This is known as Compounding the Mech. Advantage.

So, if we have one system pulling on another M.A., we multiply.

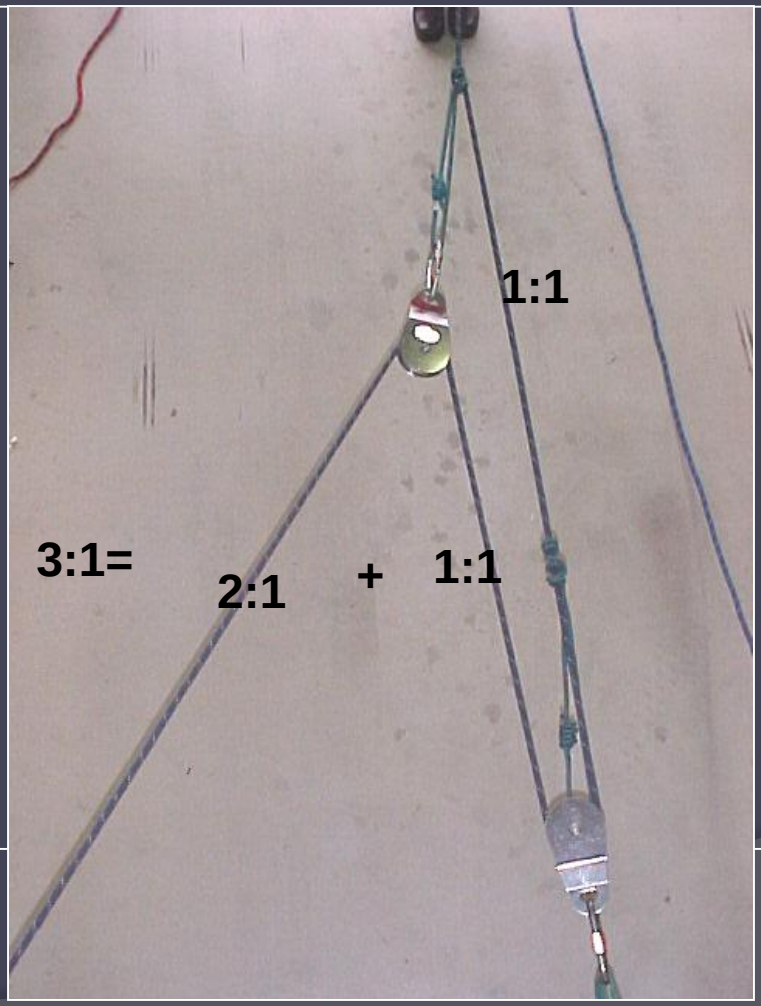
- COMPOUND M/A
- 2:1 x 2:1= 4:1



Rule #6:

"If we stack a pulley on a non-traveling pulley, we ADD the mechanical advantage."

2:1 + 1:1= 3:1



Prussik Hitches

- A prussik sling at the recommended pre-tied lengths of 53" and 65" is constructed from
  6 - 8mm prussik cord and tied using a double fisherman knot.
- Creates a man made rope grab/ clutching system.
  - A **pulling prussik** hitch seizes the rope and pulls it into motion.
  - A **braking prussik** hitch seizes the rope and prevents it from moving.
  - A **ratchet prussik** hitch allows mechanical advantage pulley systems to be reset for repeated multiple pulls.

Prussik Hitches

- Prussik hitches are used in tandem.
- Tandem double-wrapped prussik system can be used for loads up to 300 pounds
- A tandem triple-wrap prussik system can be used for loads exceeding 300 pounds.
- DO NOT USE CAM SYSTEMS!!!

Number Of People Pulling On MAS.

- Too many people pulling on the haul line can cause catastrophic failure by exceeding the tensile strength.
- Rule of 18’s for ½”rope.
- No more than 6 rescuers pulling on a 3:1 MAS with 1/2" rope – 6 x 3 = 18

Elements to the Block & Tackle

- Block - wooden or metal shell.
- Sheaves - metal roller inside the shell.
- Tackle - system incorporating 2 blocks and rope

Calculate The Amount Rope For Block & Tackle

- Lifting a load 20‘
- Multiply distance to be raised x the number of returns (reeves) through the tackle and 1 haul line, for a total of five, (+) add an additional 4' for room for the chock-a-block.
- Example: 20' distance to be raised x 5 returns. 100' + 4'. chock-a-block = 104'. of rope needed.

Calculate The Load Capacity For Block & Tackle

- Multiply the safe working load of the rope x the number of returns x 2/3.
- Example: 600 pound load x 5 returns x 2/3 (.66) = 1,980 pound load capacity.

Chock-a-block

- Term used to describe the minimum distance between the anchor and the tackle at which the mechanical advantage is no longer efficient. Some texts use 4' and some texts use 3' when referencing chock-a-block.