



# Basic Vertical Training Student Manual

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Inside front cover

# Basic Vertical Training Student's Manual

Published by the Vertical Section of the  
National Speleological Society, Inc.

Special Edition edited by On Rope 1, Inc.  
June 2012

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Courtesy of On Rope 1, Inc. and On Rope, 1<sup>st</sup> and 2<sup>nd</sup> Editions

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Printed in the USA

## Liability Disclaimer

Warning: Serious injury or death could result from the use of the techniques and equipment described in this manual.

The Executive Board of the Vertical Section of the NSS Inc. provides this manual as a guide to Internal Organizations of the NSS for teaching safe vertical practices. All instructors and persons practicing vertical rope work should use sound judgment and a lot of common sense. Under no conditions does the Vertical Section sanction use of this material by anyone not under the direct supervision of a qualified vertical instructor.

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# Safety

## Section I

This course will not teach you everything you need to know about vertical work. It will, however, provide a basic understanding of the concepts and equipment you'll need to properly execute Single Rope Techniques (SRT). Your Instructors will cover the necessary skills. They will also provide examples drawn from their experiences and provide information about other sources of information you can use to expand the basic skills you'll gain from this course.

First and foremost, you must understand that your life will literally hang in the balance between the never resting forces of gravity and your good judgement. No perfect test scores or Instructor kudos will compensate for a fatal mistake. The ultimate responsibility for your safety lies with YOU! If you're not comfortable with a procedure, DO NOT DO IT! If in doubt, ask questions. Make every effort to completely understand what anyone asks you to do, before you step off the edge of any drop.

Your Instructors have planned their routines carefully. They have and will examine your equipment and theirs. The planned exercises in this course are designed to safely demonstrate the skills. But, you must exercise every caution to ensure your own safety. If in doubt, ASK any questions you have. Don't be afraid you'll seem stupid. There are no stupid questions, especially in any activity with deadly consequences.

Search for the “**WHY**” of all that you are taught. Understand fully and seek deeper knowledge about ascending and descending. Knowledge is the ultimate difference between a fatal mistake and a long and fulfilled life.

### **The Course Rules are:**

1. No horseplay at any time!
2. Be alert at all times. Stay focused. Be prepared for the unexpected.
3. Listen carefully to your Instructors. Do as they say!
4. Double check all rigging and equipment before climbing.
5. Use the buddy system. You check him, he checks you.
6. Proceed with caution!
7. Always wear your helmet at the practice site. Stay clear of the Drop Zone.
8. Clip in whenever you're within one body-length (6 feet / two meters) from the drop.
9. If there is an urgent moment, let the Instructors talk the troubled climber out of their predicament.

# Ropes, Webbing, and Padding

## Section II

### Rope

#### Construction

Climbing rope falls primarily into two categories - **Dynamic and Static**. Both fall within a construction design known as **kernmantle**. Other common construction designs include **laid rope**. This twisted rope is no longer used for climbing. Laid rope is generally exposed to view and to damage by light or abrasion. However, because it's open to view, you can see any physical damage to the fibers. **Kernmantle** on the other hand, which includes **both** dynamic and static rope, consists of a central fiber core (solid or stranded), surrounded by a woven sheath. Because of the exposure to abrasion of the fibers of laid rope, the UIAA sanctions only the use of kernmantle rope for climbing.



#### Stretch

Static rope (rope that stretches less than 6% while tensioned with 10% of its advertised breaking strength) is primarily used for caving. It generally has a high breaking strength coupled with a good abrasion resistance. It is preferable to find rope that actually stretches less than 2% for SRT work. Experience will bear out the brands that fall within the 2% stretch parameter.

Low-Stretch is rope that stretches 6% to 10% while high-stretch ropes stretch more than 10% when impacted with a body weight. Under high impact, these climbing ropes can stretch up to 50% before breaking. Rock and mountain climbers prefer these. During a lead-climber fall, the falling person's mass can be slowed to a point where the possibilities of injury are minimized.

#### Materials

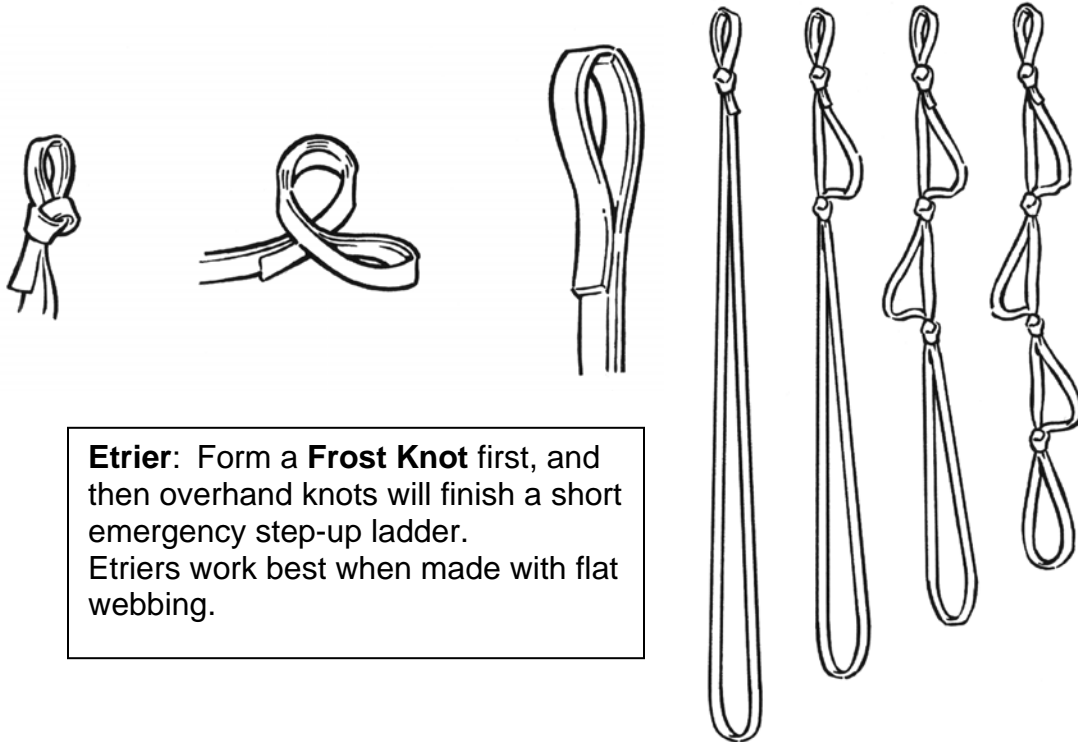
Nylon is the primary material for climbing ropes. Nylon extrudes easily into long strands, has good elongation properties, and absorbs shock well. Some industrial applications prefer polyester rope. Many cavers have recently enjoyed the virtues of polyester rope, because of its very low stretch. Nylon and polyester both have similar breaking strengths. Materials not to be used for climbing ropes include natural fibers (cotton, manila, sisal, or hemp), as they will rot, or polypropylene or polyethylene, as they have much lower abrasion and heat resistance.

## Webbing

Nylon or polyester is the only acceptable material for climbing webbing.

Tubular webbing is often more flexible than flat. Tubular webbing usually tests at about 3800 lbfs (17 kN), while type 18 flat tests at 6000 lbs. The needle loom structure and the shuttle loom are very comparable. They perform the same, break the same and are interchangeable for most all applications.

Flat webbing is often used in belts, harnesses, etriers, foot loops, and seat belts.

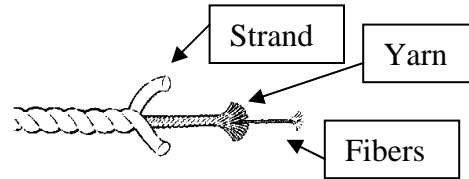


Webbing comes in a vast array of sizes.

- Less than 1" is best used for pack straps, tie-downs, and other non-life support use.
- 1" is routinely used for slings and life support straps and climbing system components. A harness should not be made with webbing smaller than 1 inch.
- Greater than 1" is used in seat belts and harnesses. There exists a harness requirement that states harnesses should be made with 1 $\frac{3}{4}$ " material or greater.

**Safety Considerations:**

- Seal all cut ends by melting to prevent unraveling.
- Use only metal buckles, designed for life support, never plastic.
- Use buckles in the manner described by the instructions provided by the manufacturer. Using buckles in any other manner or assuming you know a better way is inviting tragedy, as well as the possibility of a lawsuit. Tying knots in two inch webbing or double passing buckles on non-double pass buckles would be inappropriate.



**Care of Nylon Rope and Webbing**

**Dangers:** Sharp edges are dangerous, especially when the rope is under tension. Sunlight or other sources of Ultraviolet light will deteriorate nylon. Solvents can stiffen and weaken the fibers. Acids will deteriorate nylon.

**Storage and Transport:** Use a suitable bag to avoid damage and abrasion. Keep rope clean to reduce abrasion. Avoid contact with any corrosive materials. Store away from hazards and avoid crushing.

**Inspection:** Inspect the rope before every use. (From the Cordage Institute 781-749-1016)

Working conditions	Discard
• Bulk of surface yarns or strands reduce by 50% or more for a linear distance equal to four or more rope diameters.	X
• Cut strands	X
• Cut yarns or filaments.	X
• Rope suspected of being shock loaded	X
• Diameter reduced by 5% over new	X
• Exposure to excess temperature as specified for type of fiber	X
• Burns or melting visible for a length of over four rope diameters	X
• Abrasion on inside radius of an eye, with the bulk of surface yarns or strands reduced by 50% or more.	X
• Rust on nylon should be cleaned	
• Oil and grease wash in mild detergent	
• Heavy surface fuzz (progressive)	X
• Rope used on or with pulleys, bollards, chocks, or fairleads at a D/d* ratio less than recommended by manufacturer.	X
• More than four consecutive pulled cover strands (which cannot be reincorporated into the cover braid).	X
• Core visible through cover, because of sheath damage (except single braids).	X
• Core damage—pulled, cut, abraded, powdered, or melted strands.	X
• Damage to female side of an eye	
• Rope Hardened and reduced in diameter by 5% over new @200 D2 (sometimes called necking down).	X

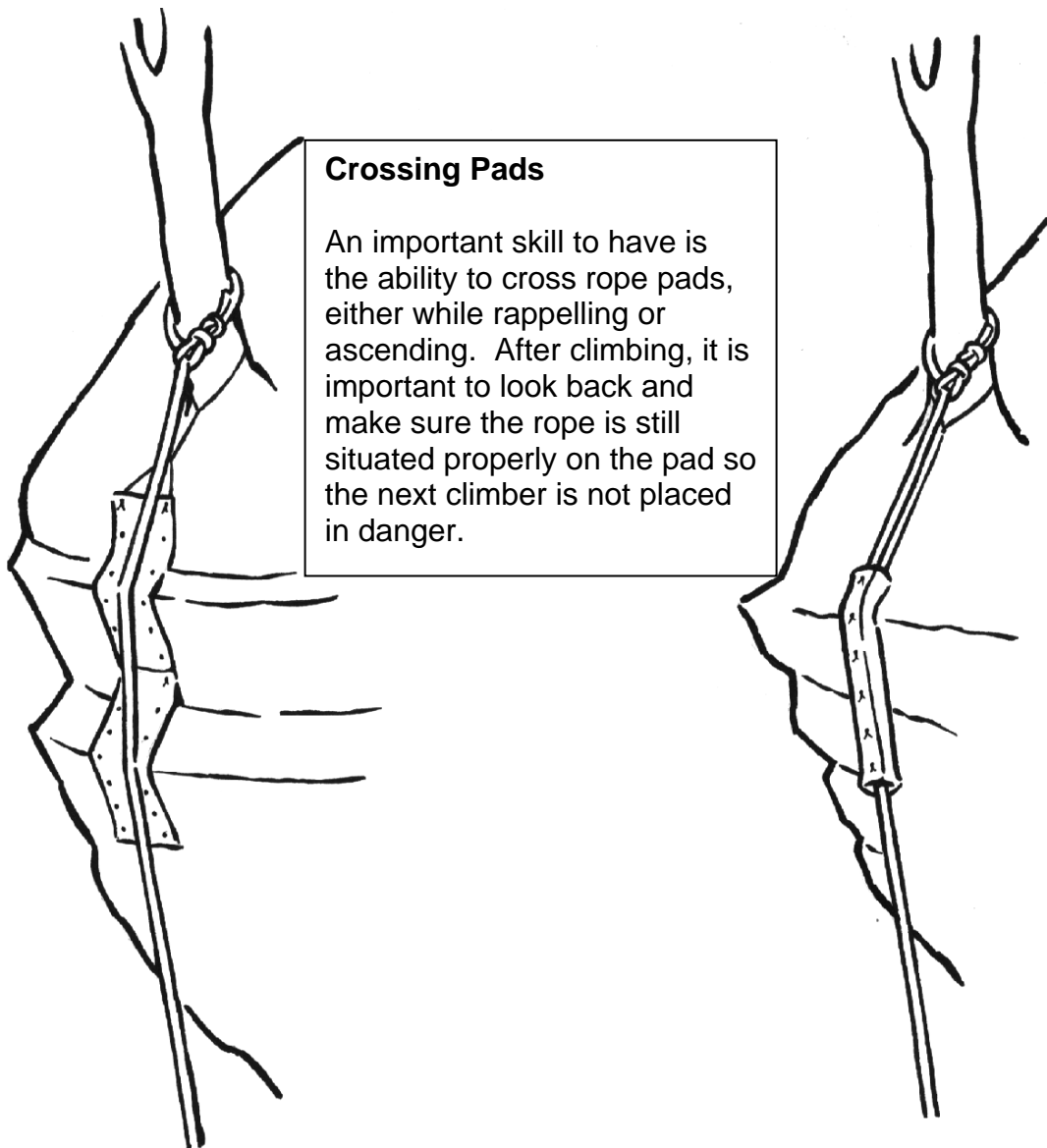
\*D/d is the comparison or ratio of two diameters. Typically the diameter of an eye compared to the diameter of the rope



## Padding

Padding is used to protect rope from abrasion, because it's usually easier than reanchoring (rebelaying). Pads may be flat or tubular canvas. Edge rollers are effective, but expensive, for long drops and rescue work. Pads should be made from natural fibers, i.e. wool or cotton. Avoid moving-nylon on stationary-nylon, as the friction can cause overheating resulting in a glazed rope. It may even cause melting and fusing of the pad material.

**Note:** Nylon's sticky point or the temperature that it begins melting is 250°F. Older carpets were manufactured with a jute (hemp or natural fiber) backing. When using older carpets like this, interface the rope with the back of the carpet. Newer carpets are all made with a nylon back as well as a nylon front, rendering newer carpets less than perfect for rope pads.



# Rigging

## Section III

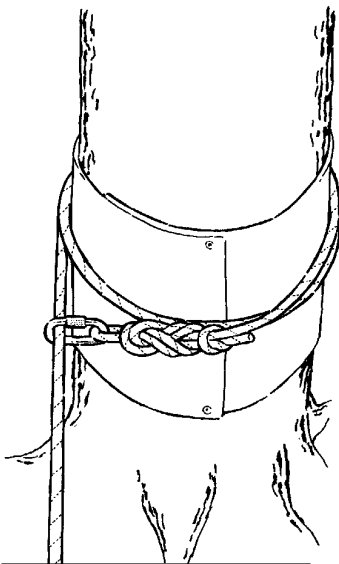
### Rigging a Main Line

When rigging a rope attempt to maintain the strength of the rope (typically 6500 lbs) through the use of knots, hardware, the anchor, and rigging configurations.

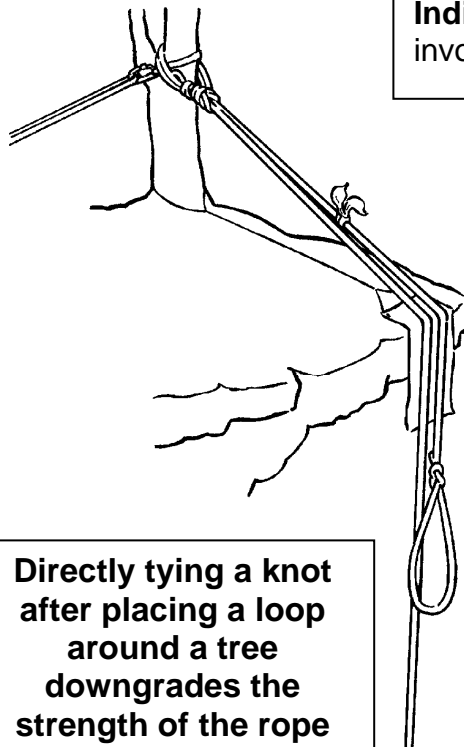
There are two general categories of tying off -- **Direct** and **Indirect**.

#### Direct Tie Off

Wrap the rope around a suitable tree or very strong anchor a couple of times (3 is usually unnecessary). Place a Figure Eight on a Bight on the end, and with a locking carabiner secure the eye of the Figure Eight to the standing line of the rope. Wrapped components should experience no droop, no deviation, a standing line that's tangent to the object, and a small hole in the eye of the Figure Eight.

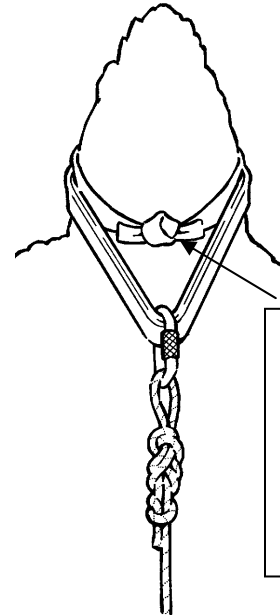


Tying off in this manner insures almost full strength rope will be available for use. Sometimes it's called a Tensionless Wrap



Directly tying a knot after placing a loop around a tree downgrades the strength of the rope and rigging by approximately 1/3.

Indirect methods of rigging usually involve a Wrap-Pull configuration.



Wrap 3-Pull 2 Notice the important position of the Ring Bend.

## Safety Considerations in Rigging

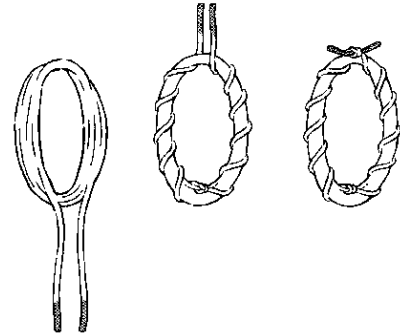
1. Strength of the anchor point in rock.
  - a. Rig only to solid rock, not formations on mud or sand.
  - b. Check that the rock has no fractures or cracks.
  - c. Check the rope doesn't contact sharp edges.
2. Sharp angles can cause failure.
  - a. Ropes/Webbing under tension should form angles less than 90°.
  - b. 120° is okay, but shoot for 90°. Use thumb and forefinger to check.
  - c. Sharp bends in rope will down grade the overall anchor strength.  
Example: A girth hitched tree will be less than 75% efficient.  
Compare this to 100% with a high strength tie-off.
  - d. Pad sharp edges.
  - e. Avoid rope crossing over other ropes. Moving nylon across stationary nylon will cause friction, heating, and melting. Avoid this condition.
3. Tie a Stopper knot at the bottom of the rope.
  - a. This knot prevents the rappeller from sliding off the end of the rope in the event the rope is short.
  - b. This knot should always be untied before ascending, so the rope doesn't snag when being hauled up.
  - c. A large loop is preferred, so the climber can step into it, in case the rope is too short. The user can simply step into the loop and expedite a changeover.
4. Rigging strength.
  - a. Choose knots that provide the greatest efficiency while minimizing rope strength loss.
5. Test the rigged rope before someone rappels or climbs.
  - a. Tension the rope from the bottom if possible.
  - b. Apply force in the direction of the expected tension.
6. Protect the rigged rope.
  - a. Dress the knots maximizing their strength and the strength of the rigging overall.
  - b. Take steps to prevent sabotage.
    - By people—if problems are anticipated, someone should guard the rope.
    - By animals—wrapping the main line with canvas or sections of hose.
7. Back-up knots.
  - a. Overall they are rarely needed. Primary knots like Figure Eight's have never, in the history of knots, come undone. A lot of valuable rigging time is often wasted tying redundant knots that are unnecessary and is a duplication of effort. If you are not convinced refer to the hundreds of published knot books in the world. None of them recommend back-up knots. Knots, from the beginning of time, have been developed to stand alone without tying other knots to make them work.

# Storage and Transport of Ropes

Coiling techniques make the rope easier to store and to carry.

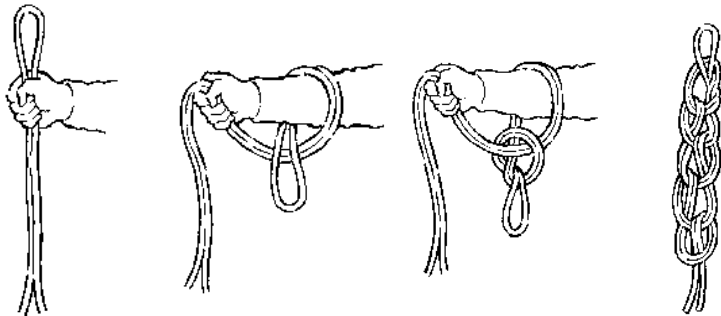
## Mountain coil/Caver coil

- Tie a wrapped coil to allow the rope to be carried over the shoulder as a bandoleer. The wrappings keep the coil tight and reduce snagging of those coils while the rope is carried.
- Wrap a tight coil around feet and knees, unwrap 1 ½ to 2 ½ coils, tie a square knot, wrap loose tails around coil members, secure with a second square knot.



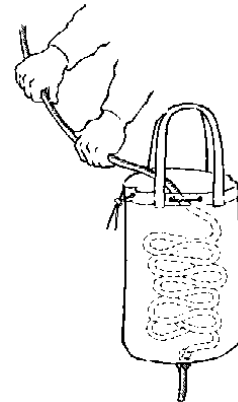
## Chaining or braiding

- This is one option that allows the rope to be carried by several people.



## Rope bags

- These are gaining in popularity. Keeps the rope dry in the dark and eliminates the kinking problem that occurs during coiling.
- Use bags with shoulder straps for long hikes.



**Butterfly coils** are dynamic rope specific. Stiffer static ropes do not deploy well nor do they remain untangled when Butterfly coiled.

## Deploying rope into a pit or over a drop safely

- Feed the rope hand-over-hand over the edge. Avoid the possibilities of the rope hanging up on a ledge or rock protrusion.
- Carefully lower coils for multi-drops, so they're not damaged.
- Yell "Rope Down" or "Rock."
- Have one end tied off so it all won't accidentally fall into the pit.
- Pull rope from the center of a coil.
- Never send a tangled rope into the pit.
- Tie a knot at the bottom of the rope so no one rappels off the end.

## Teamwork in Rigging and Transport

- Do your share of the work. If someone carries the rope to the site you carry it back.
- During coiling, usually someone pulls while someone coils. Practice doing both at the same speed—together—working as a team.
- Check the rigging before you get on the rope. It's your life!
- Have your gear prepared in advance, so others don't have to wait on you.
- Assist others in preparing to climb to help speed the process.
- When it is your turn on the rope, climb quickly so others don't remain below in a chilled hypothermic environment.
- Experienced climbers should climb and descend first and last. On the other hand the scenery only changes for the lead dog. Do what is safe. This is easy if you have two experienced vertical people. How can someone be first and last if they are the only experienced member when teaching a friend? One option would be to rig two ropes side-by-side and tether the two rappellers together and descend together maintaining consistent speed.

# Harnesses and Equipment

## Section IV

### Seat Harnesses

#### Design Parameters

- Strength: It must be able to endure multi-directional loading. Many recreational standards look for a 3500 lb. breaking strength.
- Redundancy: If a strap breaks or is cut, the harness should not fall apart, and the user must remain secure.
- Comfort: The user should not lose circulation after long periods of suspension. Harnesses should not restrict breathing

**"The essential element [in a seat harness] is the strap under the buttocks. It rests, in fact, on the pelvis, the most rigid and solid element of the human frame and is cushioned by larger areas of flesh."  
Amphoux 1982 Paris study**

#### 5 Types of Harnesses

- 1. Belts**-as primary life support harnesses, these have been unapproved for years.
  - **Thoracic belts** suspend from the armpits
  - **Waist belts** suspend from the waist.

Using a belt as a harness is a bad option. An Air force study in 1988 by James Brinkley suspended 13 extremely fit cadets from waist belts. Their toleration of the physical stresses lasted an average of 1 minute and 38 seconds until they experienced intolerable pain, numbness, nausea, extreme parenthesis, abdominal distress, severe breathing distress, and symptoms of suffocation.

**"No element of the harness must be allowed to interfere with breathing or create painful pressure on any part of the body."**

Amphoux 1982

- 2. Class I Harnesses**

Class I seat harnesses are labeled as a one-person load seat harnesses. They are sewn and labeled by a manufacturer.



### 3. **Class II Harnesses**

Class II harnesses are designed for the weight of two people. They are sewn, labeled and often padded. This heavy padding helps extend the suspension time that a user can tolerate.



### 4. **Class III Harnesses**

Class III harnesses are more commonly referred to as full body harnesses.

Post fall suspension in a full body harness should be an immediate concern about the user's ability to remain suspended in such a harness after a fall. In the 1988 Brinkley study, 10 tests of 4 different full-body harnesses were conducted. The average median tolerance of suspension in the four full-body harnesses was 22.6 minutes. It was found that prolonged suspension in the harnesses caused painful groin pressures and the chest straps compress the ribs and lung cavity. The user tires and inhaling becomes labored. Each breath becomes shallower until progressive suffocation causes blackout—with death following quickly.

## **Harness Hang Problems**

Passive suspension in a harness gives rise to many medical concerns. These include: lightheadedness, head/body flush, drowsiness, numbness, tingling, extreme paresthesia, pressure and pain from straps, abdominal pain, nausea, severe breathing distress, anxiety, and potentially death in a relatively short period of time.

Besides respiratory problems, passive suspension can cause severe circulatory problems. Death can be harness-induced when a person has been forced to sit motionless in a harness as few as 6 minutes. Blood gets pumped into the legs but cannot return if the person is not using his legs. As more blood gets trapped in the legs, you have less to circulate to your brain, kidneys, etc. As cells in the legs get deprived of oxygen there can be leakage of toxins. Once released, potassium can be bad for the heart and myoglobin is bad for the kidneys. The first priority is to get the person down quickly. Waiting for medical supplies will only increase the risk. Lay the patient down and take off the harness if convenient. Treat as would any trauma patient. Obviously, it is important to have and use a padded comfortable harness. Rope and small webbing harnesses should be used for short durations only. Know your ropework and practice it so you're never stuck on rope.

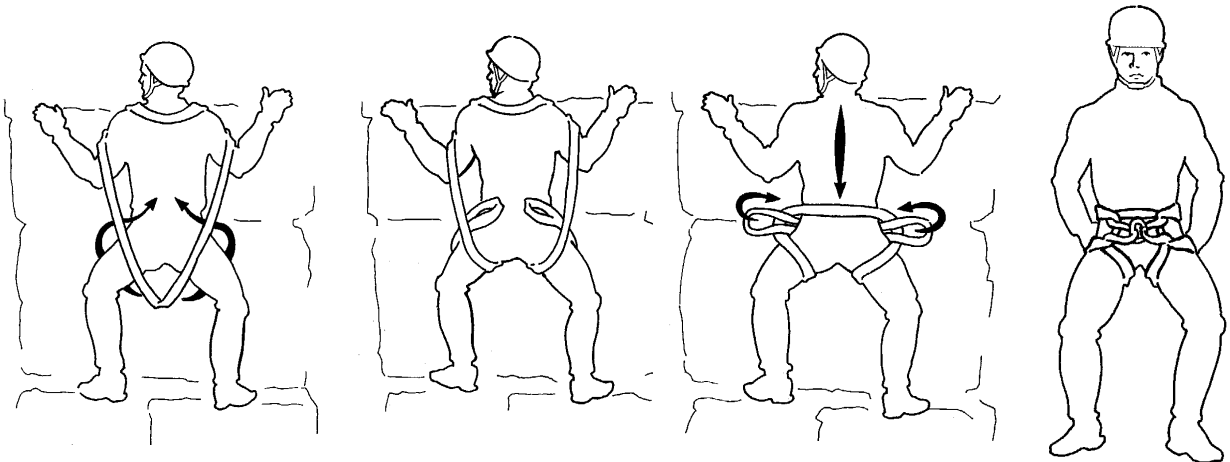
## 5. Non-Labeled (tied) Harnesses

The last style or type of harness is the emergency harness. It is often tied and should be used for short periods only and even then only under emergency conditions.

These include such well known and often used harnesses with names like: Swiss Seat, Diaper Seat, Studebaker Wrap, Swami Seat (implies leg loops are integrated with a Swami belt), Mountaineer Harness, Quick Fit Harness, GI Rig (using rope), Homemade seat Harness, Tied Webbing Harness, and Field Expedient Harness. They are probably more commonly used than any other. They are meant for the suspension and load of one person. They are often lightweight in nature, have little padding, uncomfortable, and cheap.

Realize that because they are *non-labeled*, there is no standard by which they are made or used.

### Emergency Rescue Harness



A rescuer can easily put this emergency harness on someone as shown in less than 30 seconds using a 15 foot piece of webbing.

**A respected caver** is one who knows and understands all the vintages and kinds of gear. Being able to use and troubleshoot other people's gear makes them highly desired. Make a personal goal to know all that you can about your gear. Be an expert with your gear. An intermediately skilled person is one who knows the ins and outs of not just their gear, but other's.



## Chest Harnesses

### Design parameters of a Chest Harness.

- Its purpose is to hold the climber erect. It keeps the climber's chest close to the main rope for efficient climbing.
- It reduces friction.
- It provides redundancy to a climber's system.
- It enhances comfort by establishing more places where the user is suspended.

They can be made from a **simple tied loop** of webbing. These are often uncomfortable. They usually cut into the neck and can be very painful.

**Chest Boxes and Rollers.** When coupled with a sewn chest harness, this combination is superior when used with a ropewalking system.

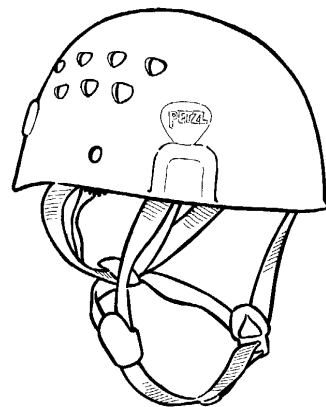
### Types of Chest Boxes (a few of the many)

Bluewater, Gossett, Simmons, Bloom, Fritzke, Bassett, On Rope 1 and PMI. PMI currently is the only chest roller manufactured in the United States.

## Helmets

### Construction and Design Parameters

- Shell should be one piece and of rugged construction.
- Climbers generally prefer no bill, for better visibility. (Note: Industry sites require a bill (per OSHA) on all helmets.)
- The suspension must be adjustable, so it fits well.
- A 3 or 4-point chinstrap with a quick-release buckle is required.
- Vents provide ventilation, while non-vented helmets are necessary for industry.
- Must be able to withstand impact from the sides, top, front, and back.
- Must stay on the head during a tumbling fall.
- Chinstrap cannot be elastic and must quick-release to avoid a choking scenario.



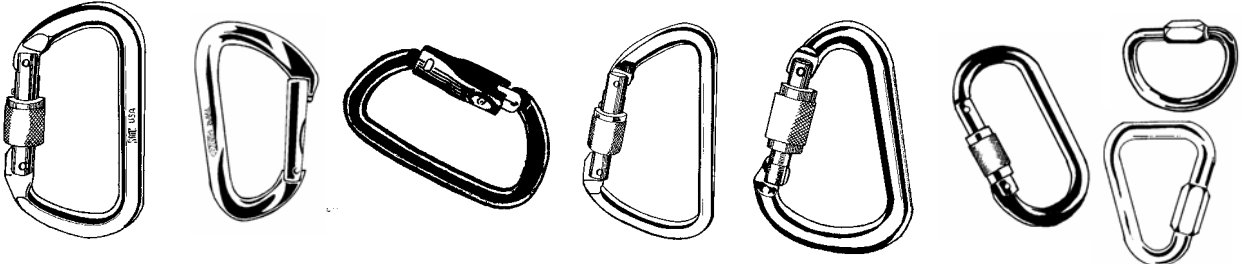
# Carabiners

**Carabiners are the basic yet most misunderstood and misused of all the basic essential gear we use. Pause! Use carabiners carefully and ensure that they are properly oriented every single time they are loaded.**

## Types and Their Uses

Locking vs. Non-locking vs. Auto-lock

- Locking types prevent the gate from opening inadvertently while a climber is maneuvering.
- Non-locking are not used in caving or rescue situations unless someone wishes a place to clip gloves. Europeans use them on their Cow's Tails.
- Auto-locks automatically spring closed and lock without assistance from the operator.
- "D" is the work horse of the carabiners. It is able to support heavy loads along its spine.
- Pear shape is best for Munter Hitches.
- Ovals deform less with an end-to-end pull, but are used less and less.
- Maillon Rapide Links (oval, delta, and 1/2 round). Replacing carabiners for many uses. Stronger and smaller.



Locking    Non-locking    Auto-locking    D-Shape    Pear shape    Oval    Maillons

## Carabiner materials

- Aluminum                      Lighter, lowest strength, cheapest.
- Steel                              Heavy, strong, moderate cost.
- Titanium                        Light, brittle, expensive, quality is suspect.

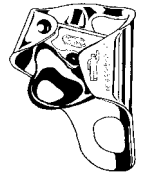
**Usage:** Always make sure the gate is closed and locked. Orient the connected lines so the carabiner is tensioned end to end only. Where possible, always position in use so the hinge of the gate is up. Suspended from webbing will reduce the strength by 1/3. Keep items within the carabiner tight against the spine during use.

# Ascenders and Climbing Systems

## Types and Uses:

(Note: Hard linking of ascenders to carabiners is potentially dangerous, as stresses generated by twisting can fracture the devices.)

- **Petzl Basic:** Right handed easy to use ascender has aggressive teeth
- **Petzl Croll:** Easy to use, compact size left-handed or chest operation.
- **Petzl Ascension Handled:** Easy to use, workhorse handled ascender.
- **ABC** ascender series have aggressive teeth
- **PMI** ascender series have aggressive teeth
- **CMI** ascender series have straight teeth.
- **Kong** ascender series have aggressive teeth
- **Gibbs** use cams and require two hands



## Ease of Use and Safety Issues

Ask and know these things about ascenders you buy and use:

- Is it strong?
- Does it grip the rope well under muddy and wet conditions?
- Is it secure on the rope (doesn't come off)?
- Does it go on and off the rope easily?
- Will it down climb conveniently?
- Does it work on multiple sizes of ropes?

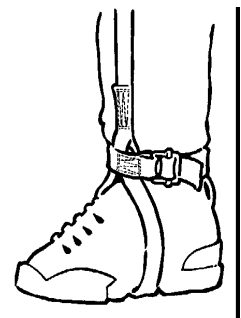


The cams should be made of durable products that will hold up over time. Aluminum cams wear quickly. Steel last considerably longer.

## Climbing System Parameters

**Chicken loops** (strap around the ankle that keeps the foot loop on).

- If the climber should invert and fall upside down, chicken loop must be strong enough to hold the user's weight.
- Required on all ascender foot stirrup systems.
- Cinch buckled are best. Tied are not as good.
- A sewn webbing loop around the ankle may not provide adequate security.



**There are 5 critical criteria that all climbing systems should meet.**

1. If there is a failure, the climber should never be allowed to fall.
2. If there is a failure, the climber should never be allowed to fall upside down.
3. If there is a failure, there should be a third ready-to-use ascender that can be placed into service.

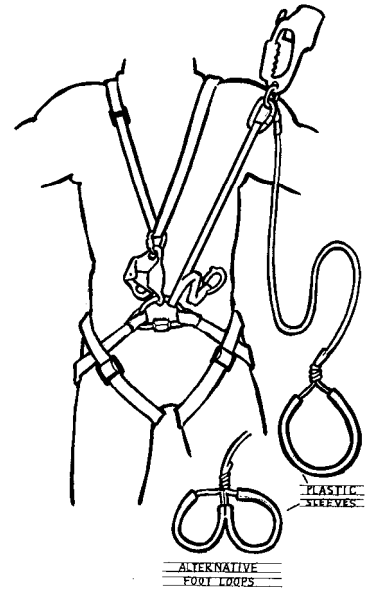
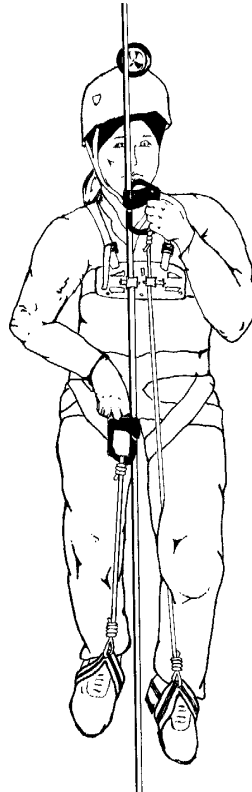
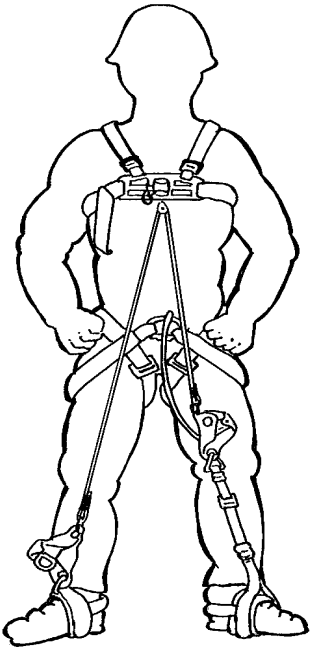
4. A climbing system should have two points of contact on the rope at all times.
5. Establish a regular system of inspection and replacement of worn components.

### Choosing and Evaluating Your System

Needs Assessment: What climbing do you do? How durable must it be?

Advantages and Weaknesses: Weight vs. Size, Speed, and Security.

Usage: Ease-of-use, strength, quick-release, and safety in reattaching.



#### Double Bungee

Works for everyone, hands free operation, long free drops are best. Cannot wear in a cave between drops, fastest system on rope. ~\$350 (For comparison only)

#### Mitchell System

A little slower than Double Bungee. Down climbs as well as it up-climbs, Hands occupied. Thinner people best. ~\$350

#### Frog System

Sit stand system  
Can wear all the time.  
Tiring to use. Takes two hands to operate.  
Easy on and off the rope.  
Better with slim tall people. Light weight.  
~\$250

# Knots, Hitches, Bends, and Splices

## Section V

### 1. Nomenclature:

#### Rope Terms:

- Working end (where the knot is)
- Standing line (middle part, hanging free)
- Running end (free end of the rope)

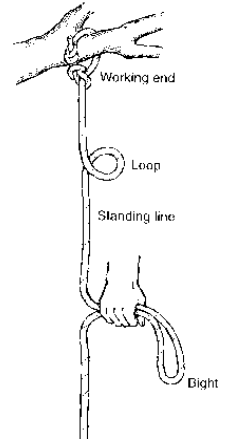
#### Knot types:

- Knot Tied configuration that doesn't move or slip.
- Hitches Tied configuration that ties around an object or a rope. When the object or rope is removed, the tie falls apart.
- Bends Tied configuration between two ends of a rope(s).
- Splices Interwoven strands (decorative macramé is also here).
- Stopper A knot that is affixed to a rope that causes no slippage.

#### Knot Terms:

- Body (main part of the knot)
- Loop (turn of rope that crosses itself)
- Bight (doubled loop, doesn't cross itself)
- Tail (free end of the rope after the knot) (4 X the rope diameter)

2. Friction Makes the knot hold.
3. Dressing Aligning the rope through the knot (increases friction).
4. Alignment Keeping the knot in the direction of forces.
5. Procedure **Tie it, Dress it, Stress it.**



## Strength of Knots

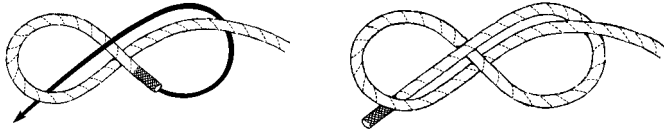
1. Sharp bends weaken the rope (A bend of 4 times the rope diameter causes minimal loss of strength).
2. Constriction or girthing (like a barrel knot) holds the rope.
3. "Backing up" a knot (keeps free end from loosening the tie).
4. Efficiency Table (approximate retention of rope's strength).

<b>Ties to Learn</b>	<b>(Efficiency)</b>
Figure Eight	75-80%
Figure Nine	80-85%
Overhand Bend	50%
Double Overhand Bend	65-70%
Triple Overhand Bend	80+%
Ring Bend (Water Knot)	55%
Bowline	70-75%
Butterfly knot	60-65%

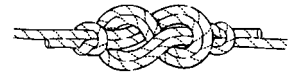
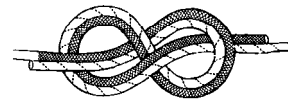
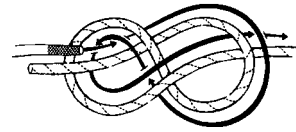
# How to Tie Knots

## Figure Eight Series

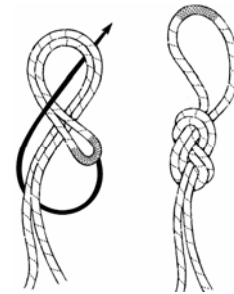
**Straight** (Stopper or first part of a follow-through)



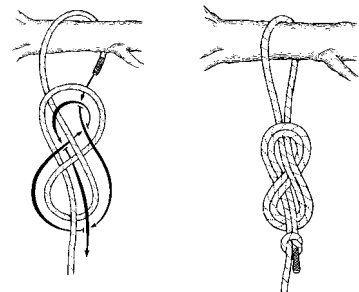
**Bend** (tie 2 ropes together) (rarely used)



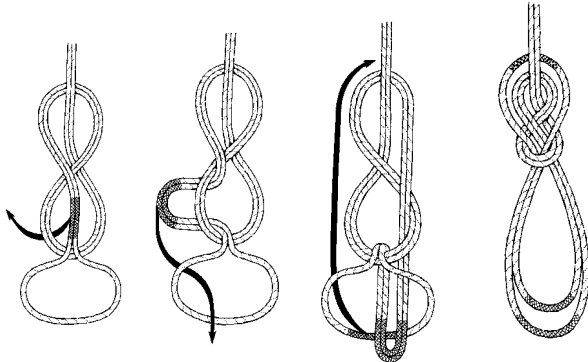
**On-A-Bight** (workhorse—loop on bottom end of rope)



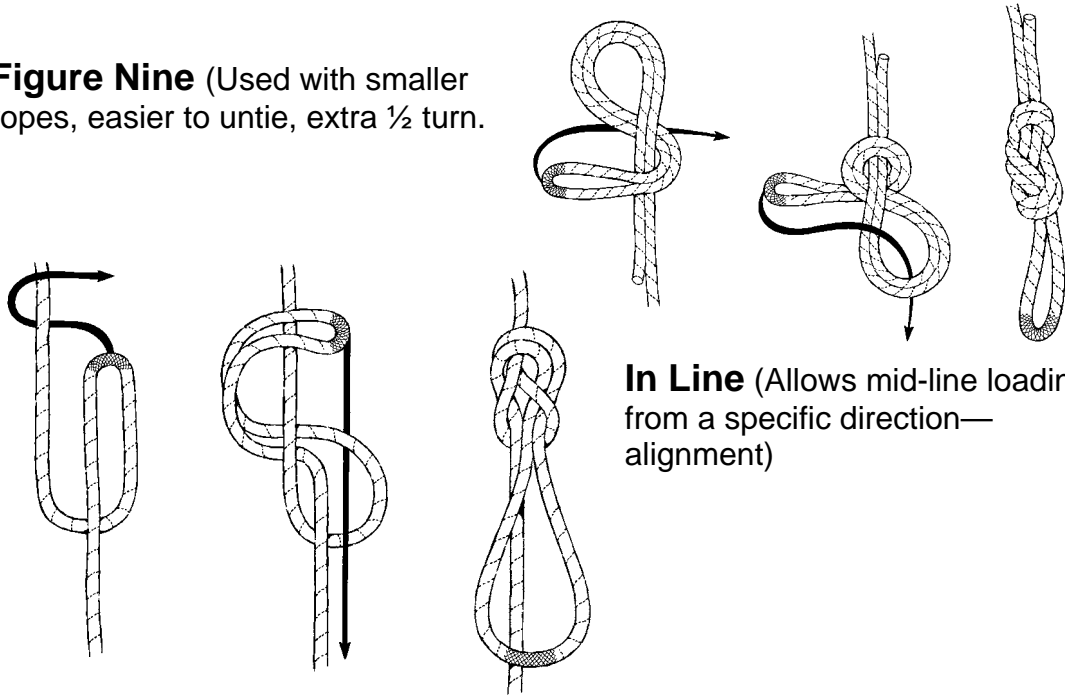
**Follow-Through** (Forms a loop for tie-offs)



**Double Figure Eight** (emergency seat harness, twin rigging)

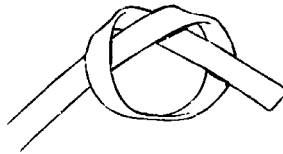


**Figure Nine** (Used with smaller ropes, easier to untie, extra ½ turn.)

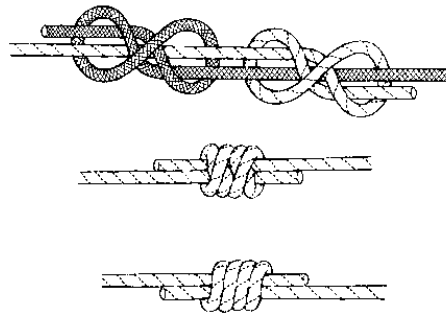


**Other useful knots**

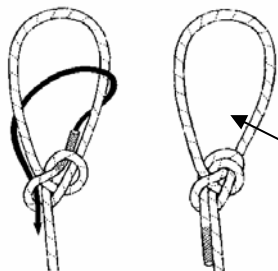
**Overhand**



**Double Overhand Bend**  
(Grapevine, Double Fisherman's)



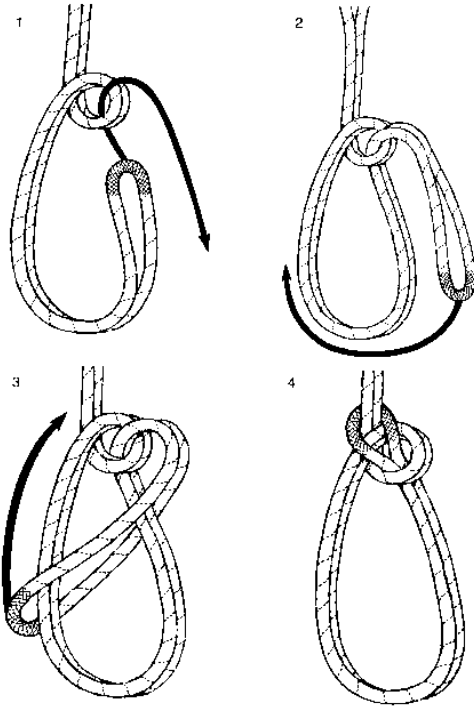
**Bowline**



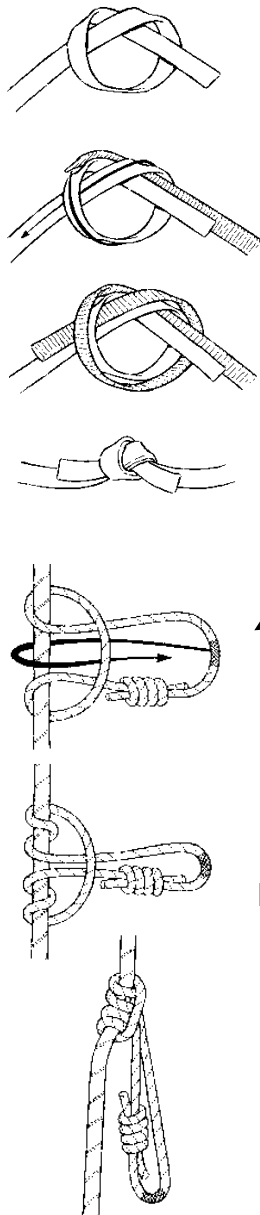
Bowline with a Yosemite back up is 8% stronger

## Bowline-on-a-Bight

85% efficiency, easier to untie than a Figure Eight-on-a-Bight



**Ring Bend** (Water knot) Use to attach ends of webbing. Has a 50% reduction in strength.



## Prusik Hitch (For climbing and as a belay)

The number of wraps depends on the mass to be supported and how slippery the main rope is.

2-wrap (four coils) is for personal use and climbing systems.

3-wrap (six coils) is for all other applications except...

Tandem 3-wrap is for belaying (shock load may occur) and tightening high lines.

## Key points to "Knot Climbing" are:

- Adjustment of the chest harness.
- Proper position and smoothness
- Proper hand positions
- Long reach with high steps
- Attention to details, as inches do count.



# Safety and Communications

## Section VI

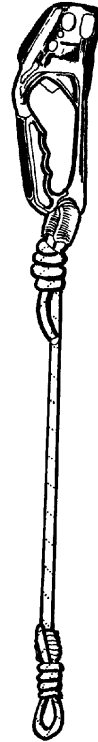
### Quick Attachment Safety (QAS)

A tethered "Handled Ascender" that can quickly be clipped-in as an additional point of security.

When attached to the seat harness, the bottom of the ascender should be approximately just about eye level (forehead).

#### A QAS is used for:

- Edge safety
- Texas climbing rig component
- Change-over
- Resting
- Floating safety
- Emergencies
- Hauling
- Partner rescue (pick-off)



### Standard Communication Methods

Deep pits or those containing waterfalls make normal methods of communication difficult or impossible. The following standard communication commands are used to improve communications under those circumstances:

#### 1) **Voice commands:**

You should: Shout words, loudly and clearly. Separate your words carefully. Use as few words as possible. Use radios.

- On Rope/Off Rope                      When approaching a rope/After leaving A drop zone.
- On Belay/Off Belay                      Add/Remove it
- Tension                                      Take up slack
- Rock                                         Something is falling
- Received/OK                              Confirms a given command

#### 2) Whistles: (International Whistle Code)

- 1 blast                                      Stop whatever you're doing.
- 2 blasts                                      Up-Tension or I am climbing.
- 3 blasts                                      Down—Lower, Slack or I'm rappelling.
- 4 blasts                                      Line is free or come on.
- Long                                         Help!!!

# Belaying

## Section VII

### 1. Belaying Mechanics

**Definition:** Belaying is the securing a climber/rappeller with an additional safety procedure.

**Direction of the belay:**

- Position the belay in the direction the climber may fall.
- Position belayer toward the fall.
- Align belay rope to reduce the pendulum.

**Friction Methods:**

- Using body wraps around the belayer is a bad idea.
- Use a two-way friction device that is anchored.
- Bottom belays are best achieved with the rope around the belayer's butt and is an exception to the no body belay rule.

**Commands:**

- |                       |                            |
|-----------------------|----------------------------|
| • Belay On/Belay Off. | Belay's On/Belay's Off.    |
| • Slack/Tension.      | Let rope out/Take rope up. |

<p><b>Never say, "Take up slack" People tend to only hear the last word. Say, "Tension"</b></p>
---

### 2. Bottom Belay

- Stand clear of drop-zone. Your own safety should be first.
- Wear leather gloves while controlling the belay.
- Anchor securely in direction of force of a fall.
- Pay attention to the climber's needs at all times.
- Prepare yourself for the need to tension the rappel line quickly
- Climb the rope hand over hand if you have to.
- Anyone out of control falling over 200 feet may be impossible to stop if they do not have enough friction on their descent device to start with.

### 3. Self-Belay Methods: French Wrap or Sliding Prusik

- Constant attention to a Prusik belay device is required to avoid jamming.
- Sliding up a Prusik Hitch while climbing requires constant attention and multi-tasking.
- Gibbs attached while climbing is pseudo belay and may or may not work.

<p><b>Any belay that does not work every time is an ineffective safety and should be reconsidered as something that will save your life.</b></p>
--

# Rappelling

## Section VIII

**Rappelling is the Most Dangerous thing we do**

## Rappel Devices

### Rappel Rack

**Safety:** Bars are supported on both sides for added strength.  
Tensioned roped holds bars closed.  
Can be easily locked off

**Controlled descent** is controlled by:

- Bar distance apart
- Bar size
- Bar type
- Number of bars engaged
- Bar offset
- Size, condition, and type of rope
- Method of brake hand control
- Environment, i.e. rain, mud, clean
- Amount of mass being controlled

**Rack length** and what it means:

Standard is 14 inches.

The longer the rack, the more gently the rope will pass over the bars, allowing for smooth control.

**Heat dissipation:** As the rope serpentine back and forth through the bars and rubs against the bars, heat builds up.

- Aluminum heats up quickly, but cools off and dissipates the heat quickly. (Note: sticky point of nylon is 250°)
- Steel heats up slowly and cools slowly as well.
- The more metal mass, the more efficient the rack will be in removing heat from the rope, thus decreasing the chance of the heat building to a rope damaging temperature.



### Materials

- Aluminum bars wear out the fastest, and leave grey aluminum particles on the rope.
- Steel lasts longer. Hollow bars remain cooler during a rappel.
- Titanium is strong and light, but brittle and more expensive.

### Rack Alternatives

- Figure 8 descender can be used for short drops and light loads.
- Bobbins are for short drops and for crossing rebelay.
- Whaletails and spools are used outside the U.S.

## A) Rappel Techniques:

### 1) Primary objectives when rappelling:

- Do no harm to yourself (i.e. safely descend the rope).
- Do no harm to anyone below you.
- Do no harm to the rope.
- Do no harm to the environment.

### 2) Basic Considerations:

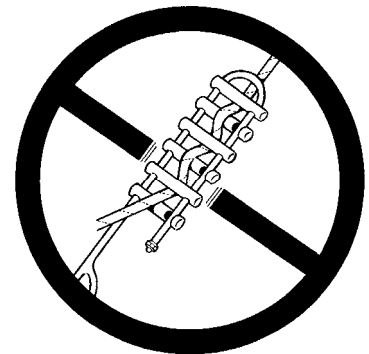
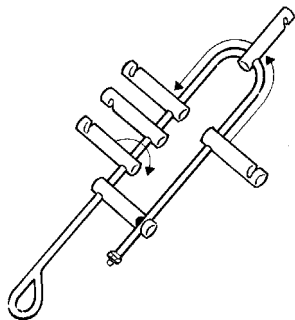
- Check all equipment before moving to the edge.
- Slow to moderate speed to avoid loss of control and overheating of the rack and the rope. Less than **one (1) meter per second descent**.
- Brake hand position. Keep the rope smoothly feeding into the rack to maintain control.
- Keep your back straight and face/hair away from the rack and rope.
- If against a wall, maintain stable feet position.
- Keep equipment, clothes, and body parts out of the rappel device.
- **Stay alert** at all times; it's your life!!!

### 3) Determine the Environment. Each descent is different:

- Rope size and condition influences friction.
- Weather conditions (wet, dry, deep, free-drop, wall, etc.).
- Equipment carried by climber affects the descent speed.
- Strength, stamina, and alertness affect your reflexes.
- Adjust rack friction (# of bars) accordingly.

### 4) Configuring the Rack:

- Length--the rack must suit the expected running load.
- Bars must be aligned for right- or left-handed use.
- Nuts on the rack must be secure.



### 5) Using the rack:

- Maintain the proper numbers of bars. Add more bars before they are needed.
- **Rack Rappellers should be ambidextrous.**

- The following technique is critical to the safe use of a rappel rack.

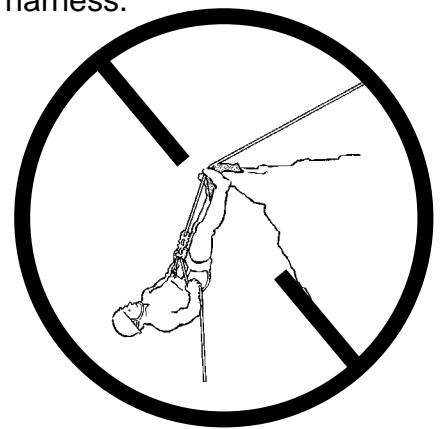
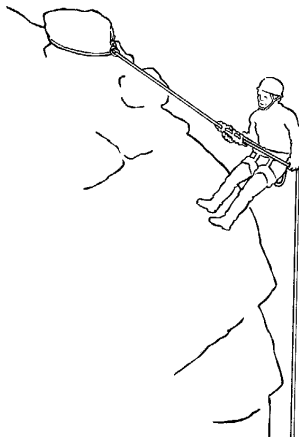
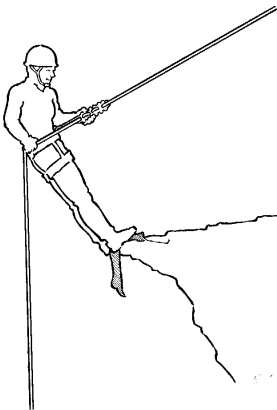
- The bottom bar that has rope reeved across it should remain captured (called “**Capture position**”) and pressed against the rack frame. This is achieved by holding the rope with your brake hand against the appropriate hip. When reducing the number of bars being used to rappel with on your rack make sure this “hip switch” of the brake hand takes place first. This move is critical to the rappeller’s safety. Failure to do this could cause a sudden reduction of friction with the loss of possibly two brake bars resulting in an out of control rappel and possible demise. Always keep the bottom bar in “Capture Position”.

- Bars are added or removed while descending.
- The rope can be tied-off to hold position on the rope.

## B) Body Positions:

### 1) Negotiating the Lip:

- Shout "**On Rope**" as you approach the rope.
- Listen for "**OK**" from proper source(s).
- Attach QAS.
- Rig the rack with as little slack as possible.
- Check all equipment before moving to the edge.
- Kneel down, if necessary, to safely pass over the lip.
- Make certain the rack will clear the edge.
- Keep feet positioned below level of the seat harness.



### 2) Control during descent:

- Slow speed. Less than 1 meter per second.

- Pay constant attention to keeping body parts, hair, clothes, and gear clear of the rack.

3) **Wall-walking:**

- Maintain a smooth rhythm--do not bounce.
- Maintain a wide stance for stability.
- Stay close to the wall.

4) **Landing techniques:**

- Check the surface before landing.
- Squat to relieve rope tension, and then stand up.
- Quickly de-rig the rope from rack.
- Clear the landing zone.
- Signal "**Off Rope**" only when you're clear.
- Listen for "**OK**" from proper source(s).

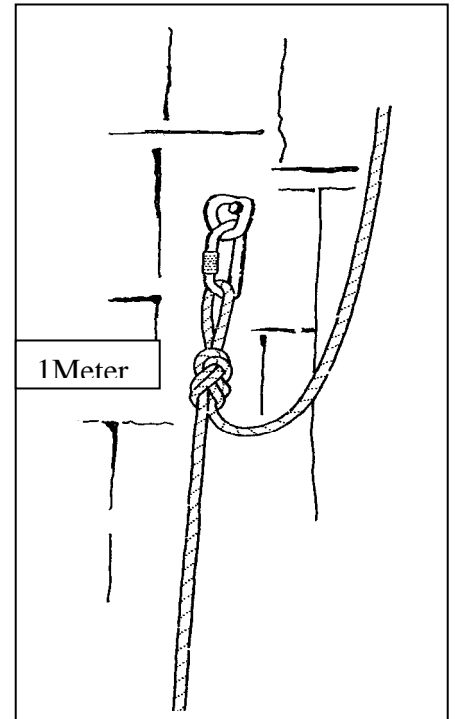
# Crossing Rebelays

## Section IX

- A. Crossing Rebelays requires special skills.
- B. A rebelay is an anchor station. Its origins come from Europe and cater to those who use a Frog Climbing system.
- C. Crossing a rebelay while descending is pretty easy.
- D. From the top of loop of the Figure 8 on bight to the bottom of the step in loop should be about a meter long. The knot should have a very small hole in it.

### Rappelling past a Rebelay Using a Frog System

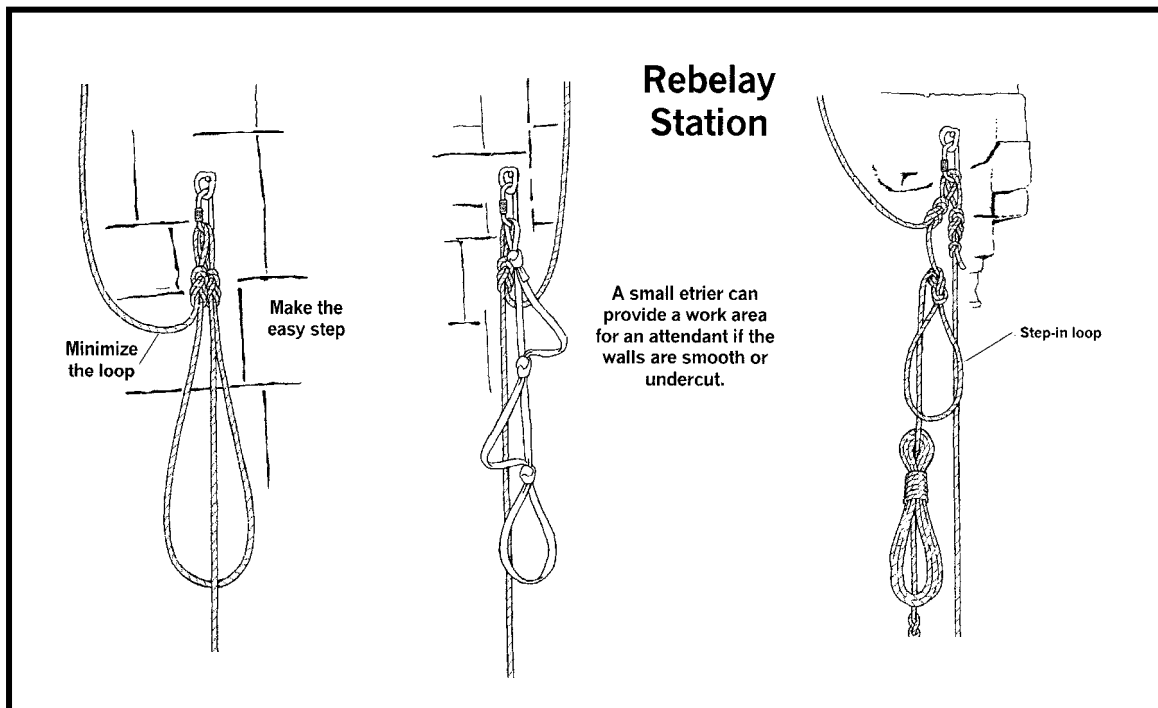
1. Rappel to a point even with the anchor.
2. Clip the short Cow's tail into the carabiner in the wall anchor.
3. Rappel your weight onto the short Cow's tail.
4. Clip your long Cow's tail into the step-in loop for redundancy or attach your QAS right underneath the Figure 8 knot on the "down" rope.
5. Unlace your descender and re-lace it below the Figure Eight on a bight with no slack. Lock it in place.
6. With your foot or knee, step up into the one meter loop and remove the cow's tail from the rebelay point.
7. Slowly ease your weight onto the rope making sure that carabiners are locked, and the rope is attached properly.
8. Unlock your rappel device.
9. Unhook your QAS or long cow's tail and continue rappelling.



### Ascending past a Rebelay point using a Frog System

1. Climb to the rebelay point and attach the long cow's tail to the anchor point on the wall.
2. Stand up and remove your chest Croll and transfer it to the rope above the anchor point.
3. Sit down, thus transferring your weight to the upper rope.
4. Remove the handled foot cord from the lower rope and transfer it to the upper foot rope.
5. Unclip the Long Cow's tail and ascend.

**Other Rebelay crossings include:** Ropewalker crossings, Deviation crossings, Tensioned traverse crossings. A good user of rebelays knows them all.



## Changeover and Self-Rescue

### Section X

In this section, you will practice problem-solving situations to develop a basic proficiency in self-rescue from common emergencies. You should focus on careful analysis with deliberate actions. Minimize wasted energy.

#### A) Changeover from Rappel to Ascent:

1) The basic steps of the method are:

- Tie-off rappel device (rack).
- Attach a QAS above the rack.
- Attach other ascender below the rack.
- Un-tension the rack by transferring the load to the QAS ascender.
- Remove the rack from the rope and climb.

#### B) Changeover from Ascent to Rappel:

1) The basic steps of the method are:

- Attach a QAS from seat harness to the rope.
- Attach a rack to seat harness with a second carabiner.



- Attach the rack to the rope below the QAS minimizing slack from the QAS ascender and the nose of the rack.
- Secure the rack.
- Remove chest rollers and all ascenders except the QAS and an easy to reach ascender on your ascent system.
- Un-tension safeties (QAS). Lower it to the nose of the rack. Do not remove it from the rope.
- While hanging from the rack remove your easy-to-reach ascenders.
- Check everything. Especially possible cross-loaded carabiners before removing the QAS. Remove the QAS
- Untie the rack and begin your rappel.

**C) Clearing an obstruction in the Rack:**

1) The options and methods available to you include:

- Pulling the stuck item out of the rack.
- Use an ascender to take force off the rack.
- Get help from another climber.
- NEVER use a knife when you're "on rope."

2) Students should practice using an ascender:

- Keep rack close to ascender, so rack can be put back into service more easily.
- A foot loop can assist and makes it easier.
- Use technique rather than brute strength!!!

**D) Recovery from a failed ascender:**

1) The basic steps of the method are:

- Attach QAS if available.
- Retie broken strap, if possible.
- Use webbing or sling to make new strap.
- Modify system, if necessary, to a Texas System.
- Continue climbing.

2) Student should practice.

You should:

- Describe your problem solving methods.
- Calmly assess the problem. Do not blow it out of proportion in your mind.
- Take inventory of what you have that is functional and works.
- Almost every climbing configuration can be reduced to a basic Texas climbing rig.
- Move cautiously.

Single Rope Users should be able to correct problems while on rope without panicking. During class each student should be tossed a problem and asked to correct it while on rope and other students watch:

(If it is man made, it will fail. Know your system and all the resources you have available to you.)  
Suggested problems listed below

### **Double Bungee Systems**

Bungee cord broken  
Chest roller broken-gone  
QAS forgotten  
Right arm broken (tie it to belt)  
Right ankle-severe sprain  
Left ascender failed-gone  
Blind folded-- find gear, get out  
Rodents ate rope- chg. ropes  
Tandem by accident--Mantle top  
(suspend a person below)  
Down climb  
Tandem climb  
Replace harness with a tied one  
Hypothermia-tape fingers straight  
Climb past another person  
Rappel past another person  
Jam bungee into knee ascender

### **Mitchell Systems**

Short ascender lost  
Broken left shoulder  
Down climb the whole way  
Rodents ate rope--chg. ropes  
Blind folded--find gear, climb out  
Long ascender failure-gone  
Right arm broken

### **Frog Systems**

Foot cord broken  
Long Cow's tail broken  
Foot cord gone  
Blind folded-find gear, get out  
Change ropes  
Descend past another person  
Pass a rebelay w/o a Cow's tail

## **Additional Notes**

