

# Ropes and Anchors – Kitsap 2021

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## Logistics

### When

23 March 2021, 6:30pm via Zoom

3 April 2021 (one day), 8am – 3pm Spire Rock

### Description/Leader Notes

Rock Climbing Anchors, Multi-Pitch Belay Technique, Rappel and Rope Team Techniques, and Single-Pitch Top-Roped Cragging.

The ropes and anchors lecture and field trip are prerequisite to all subsequent Intermediate field trips.

### Trip Leader

Ciara Sampaio and Mark Goodro

### Gear

Prepare as if you are going on a one-day rock climb. Bring rock shoes if you have them – definitely not essential. You can bring protection if you have it but not necessary for this FT. Bring quickdraws or alpine draws if you have them, but don't buy them for this field trip. You will be outside most of the time without too much physical activity, dress for April Spanaway weather. In addition, you will need to purchase a *cordelette*. Do not buy any other gear for this field trip. Your cordelette will be 17 to 22 feet and made from 5 to 7 mm cord. Tech cord 5 or 5.5 mm is nice. 6 and 7 mm perlon is fine also.

A cordelette is a length of cordage, 6 meters (20 feet) or so in length. Typically it's made of one of these two materials: [7mm perlon](#) or [5.5mm spectra](#). Spectra is more expensive but lighter, especially when wet. You may refer to [this document](#) produced by the Seattle Climbing Committee for further information on material selection prior to purchasing a cordelette. (From 2001, is now a little dated, but still accurate.)

### Notes on Material Terminology

- Nylon: [Nylon](#) is a general term for a family of similar materials. Nylon comes in many types. A few of them are widely used for making climbing ropes.
- Perlon: Perlon™ is a trademark of [Nylon 6](#), a type of nylon. Most accessory cords are made of Perlon. In this handout, Nylon and Perlon are sometimes used interchangeably.
- Spectra and Dyneema: they are brand names of the [same material](#) and are used interchangeably.

Dyneema vs Nylon: Dyneema's strength/weight ratio is higher than not only nylon but also steel. It has a higher resistance to cutting and lower water absorption. But its elasticity is less and its melting point is

lower. The result is higher impact forces (on you) with Dyneema. Reference:

<https://dmmclimbing.com/Knowledge/June-2010/How-to-Break-Nylon-Dyneema%C2%AE-Slings.>

Material	Unknotted strength	Appx. knot reduction	Appx. Knotted strength
6mm NLSK cord	7kN	30%	5kN
8mm NLSK cord	14kN	30%	10kN
9mm NLSK cord	16kN	30%	11kN
11mm NLSK rope	28kN	30%	20kN
12.5mm NLSK rope	40kN	30%	28kN
25mm tubular web	18kN	45%	10kN

(181)

\*NLSK = Nylon Low Stretch Kermantle

## Supplementary Reading (and watching)

Treat this handout as a starting point and hub of core information rather than a comprehensive guide. A few videos and online articles are linked to the handout. Read and watch them before the field trip. A bibliography follows. It is not necessary to buy all the books listed, but I recommend reading: "Rock Climbing Anchors: A Comprehensive Guide, 2nd Ed." (Donahue, 2019)

## Bibliography

Donahue, T. and Luebben, C. (2019). *Rock Climbing Anchors: a Comprehensive Guide*, 2<sup>nd</sup> edition. Mountaineers Books.

Florine, H., & Wright, B. (2005). *Speed Climbing - How to Climb Faster and Better*, 2nd edition. Falcon.

Houston, M., & Cosley, K. (2004). *Alpine Climbing: Techniques to Take You Higher*. Mountaineers Books.

Long, J., & Gaines, B. (2006). *Climbing Anchors*, 2nd edition. Falcon.

The American Alpine Club. (2011). *Accidents in North American Mountaineering*. The American Alpine Club.

## Climbing Dynamics

### Order of magnitude of forces and strength of climbing gear

These are rough ranges. Some data comes from [\(Donahue, 2019, p. 206\)](#)

- Tensile strength of single ropes: 18-22kN
- Carabiners (major axis): 23-25kN
- Carabiners (open gate): 7-10kN
- Carabiners (cross loaded): 7-10kN
- Belay loops of climbing harnesses: ~25kN
- Webbing sling (8-12mm Spectra/Dyneema): 22kN
- Small wired nuts: 4-7kN
- Medium wired nuts: 6-12kN
- Large wired nuts: 10-12kN
- Small cams: 3-10kN
- Cams: 12-14kN

### Other useful numbers

- Force human bodies can withstand: ~12kN
- Gravity of an average climber: ~0.8kN
- Gravity of a compact sedan: ~15kN
- Force created by bouncing on a rappel: < 2 times body weight

### Fall Force

Fall force is a complicated topic. There is a good thread on [supertopo](#) with a list of good references, if you are interested. For the rest who are not interested in the math, the take-aways are:

- Impact forces on the anchor and climber are limited by the breaking force of the belay device and significantly mitigated by the friction and rope stretch.
- Good belay technique is critical to reducing impact force in a fall.
- Gear usually doesn't break when *properly* used.

### When Do Ropes Fail/Weaken?

- Abrasion: inspect the sheath frequently. Sheath provides almost no strength but protects the core.
- Sharp flake/edge: sharp flakes cut ropes like a hot knife through butter.
- Melting: ropes and webbings don't dissipate heat as well as metal. Excessive sliding between nylon/spectra is dangerous. Reference: [\(The American Alpine Club, 2011, pp. 29-30\)](#). Spectra/dyneema has an even lower melting point than nylon.
- Knots: all knots weaken ropes and webbings. See next section for detailed explanation.

## Why Knots Weaken Ropes



Figure 1 Construction of a Kernmantle Rope

- The core of a kernmantle rope is constructed with strands braided together.
- The strength of the rope comes from the elongation of strands.
- All ropes elongate, including static ropes.



Figure 2 Force Distribution on a Straight Rope

- When the rope is straight, all strands elongate evenly.

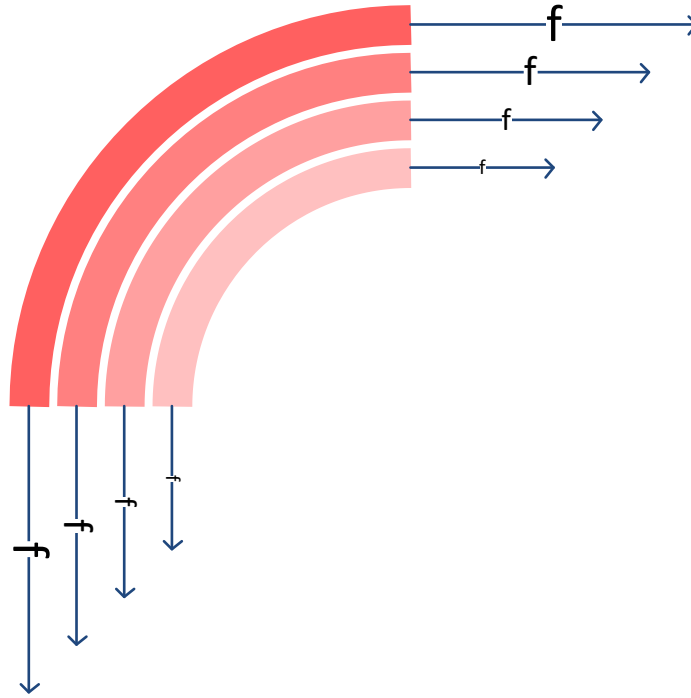


Figure 3 Force Distribution on a Bent Rope

- When the rope is bent, strands elongate unevenly, causing an uneven distribution of the force.
- The sharper the bend, the more unevenness.
- The smaller the knot, the weaker it is. Overhand < figure 8 < figure 8 on a bight.

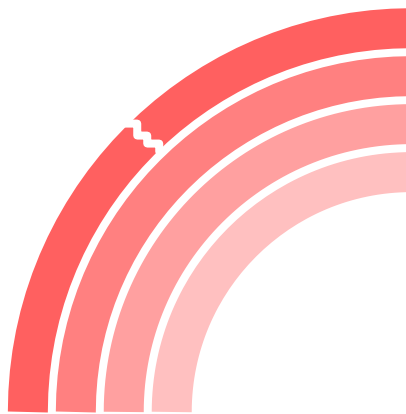


Figure 4 Individual Strands Start to Break

- When one strand breaks, the force is redistributed among other strands, which will now more likely break.
- Webbing is constructed a little differently. But it is subject to the same problem too.

- The breaking strength of a skinny spectra runner with an overhand knot is low (can be <50% of the rated strength).
- So should you avoid tying knots in a rope or webbing? It depends on lots of factors. For example:
  - How strong does it need to be?
  - Is it going to be the weakest link?
  - How hard is it to untie after being loaded?

## Static vs. Dynamic

- Static and dynamic are relative terms. Everything stretches including steel cables.
- The more the rope and other elements in the system stretch, the longer it takes to stop a fall, the less the force (remember  $f = ma$ ).
- Concrete floor: static; carpet: more dynamic; crash pad: even more dynamic.
- Climbing rope: dynamic; nylon webbing: less dynamic; spectra webbing: least dynamic.

## Personal Anchors

Personal anchors are worth mentioning because they have become popular, but they are used in unsafe manners too often.

- In general, there are two types of personal anchors: *Personal Anchor Systems* with individual loops and *daisy chains*.



Figure 5 Personal Anchor System

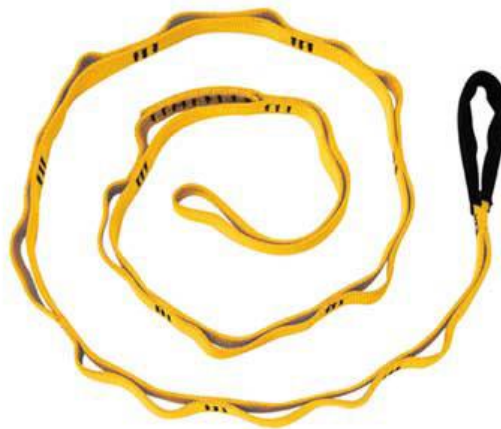


Figure 6 Daisy Chain

- Every loop of a PAS is full strength (~20 or 22kN depending upon model). Every pocket of a daisy chain is for *body weight* (<1.5kN) only.
- **Do not use daisy chains** unless you have read this [article on daisy chain dangers](#) from Black Diamond® and watching the video linked to it. Or, here is the quoted content:
  - Let's be clear: You should NOT be using a daisy chain to anchor yourself to a belay.
  - Daisy chains are designed for aid climbing only and to support body weight only. When aid climbing properly, the rope is ALWAYS in the system, and in the event of a fall, the energy absorbing capacity of the rope is used. If you use a daisy chain to anchor yourself

to a belay, you've now taken the rope out of the equation and are potentially subjecting yourself and the daisy chain to a possible shock-loading scenario. You should NEVER be impact loading a daisy chain. NEVER. Daisy chains and runners don't stretch much, which means they don't absorb much energy. This increases the load on the anchor, and you. Worse-case scenario under a severe-impact load, a daisy can snap. Best-case scenario under a severe-impact load, you'll snap your back.

- **Do not use daisy chains in free climbing. They are intended for aid climbing only.**
- Personal anchors are static and will have a severe impact in a fall.
- Correct and incorrect methods of using personal anchors.
  - Extending rappel: OK, because there is no slack in the PA, and there is a rope in the system.



- Connected to the anchor while belaying: **dangerous**. You should always be tied into the anchor with a **dynamic** rope when belaying from the harness.

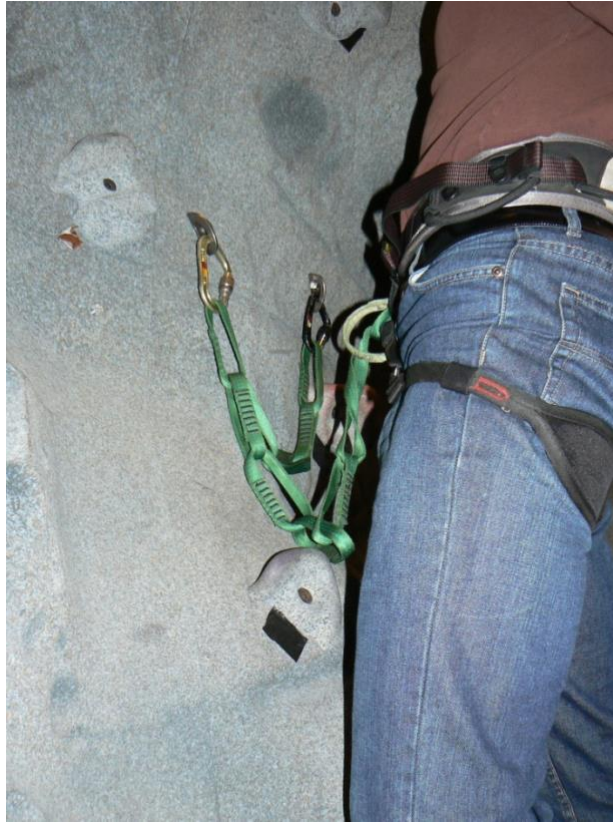


- Connecting to the anchor when standing on the ledge setting up rappel
  - Hanging on the PA: good





- Standing on ledge with slack: poor



- Standing above the anchor: **dangerous**



- General rules when using personal anchors:
  - Do not climb above your anchor. Ever.
  - Use your rope to connect to the anchor when you belay (in fact, whenever possible!)

## Anchors

### Objectives

- Understand requirements of various climbing anchors.
- Build various anchor components and evaluate them using SERENE.
- Build 2-point anchors using slings.
- Build multipoint cordelette anchors.
- Rig with rope.

### SERENE: a tool for anchor evaluation

- *Solid*: will hold the maximum forces it might encounter, also *strong* and *secure*.
- *Efficient*: does not require excess time or gear.
- *Redundant*: every component behind the master point has a backup. If any one component fails, the anchor remains intact.
- *Equalized*: load distributed across multiple components (tug-of-war analogy).
- *No Extension*: if one component fails, the anchor won't extend much.

It is hard if not impossible to satisfy all the criteria. In particular, full equalization and no extension cannot be achieved at the same time. It's important to evaluate your scenario and trade-offs.



Figure 7: Efficient anchors shouldn't look like this

### Anchor forces: direction and magnitude

- Rappel:
  - ❖ Direction: down & out.
  - ❖ Magnitude: < 2 times body weight.
- Top-rope:

- ❖ Direction: down.
- ❖ Magnitude: < 2 times body weight.
- ❖ The *pulley effect* doubles forces: force of falling climber + force of belayer catching the fall.
- Top belay (belaying a follower):
  - ❖ Direction: to top piece of pro until it is cleaned, then a pendulum to the fall line.
  - ❖ Magnitude: body weight as long as the rope is taut.
  - ❖ Do not out-climb your belayer: falling with slack significantly increases fall forces.
- Lead belay:
  - ❖ Fall factors:
    - (Length of fall) / (length of rope catching the fall).
    - For the same rope, falls of the same fall factor generate similar force.
  - ❖ Fall after first piece of pro is placed (less than factor 2):
    - Direction: upward to first piece of pro.
    - Magnitude: depends on fall factor, can be significant.
    - Pay attention to where belayer will be pulled up after a hard fall.
  - ❖ Fall before first piece of pro is placed (factor 2):
    - Direction: pendulum down past the fall line.
    - Magnitude: violent, worst case.
      - Force goes directly onto the belayer's harness.
      - Getting that first piece of pro in (the "Jesus nut") is critical.
      - This is what you design your anchor to hold.
- Multi-pitch anchors:
  - ❖ Bottom anchor: upward pull only unless belay is exposed.
  - ❖ Middle anchors: first a top belay, then a lead belay, which has a potential of getting an upward pull. Hence it must handle upward pull if the leader outweighs the belayer significantly and a big fall is possible.
  - ❖ Topmost anchor: should not get an upward pull.

## Anchor rigging methods

- How many pieces? Two good bolts or three good pieces of pro are usually good enough. When pieces are not bomber, add more and equalize.
- V-angle and force amplification [\(Donahue, 2019, p. 36; Long & Gaines, 2006, p. 149\)](#):
  - ❖ The angle formed by a sling connecting two anchors or slung around a wide anchor.
  - ❖ Wider V-angles can significantly increase forces. Refer to Figure 8 V-angle. Force on either anchor, assuming they are fully equalized:  $f' = \frac{f}{2 \cos(\alpha/2)}$ .
  - ❖ Try to keep it under 60 degrees, never exceed 90 degrees.

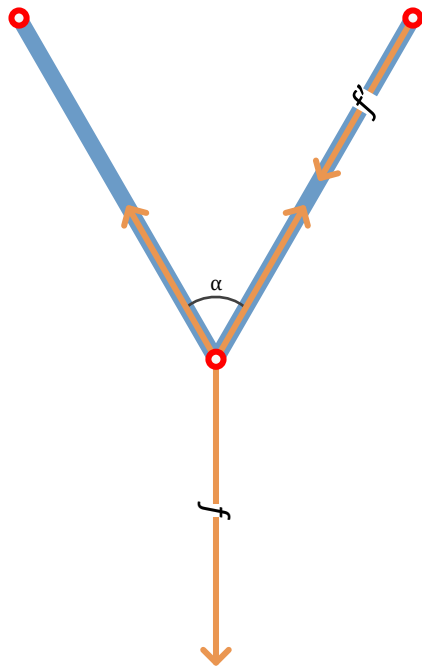


Figure 8 V-angle

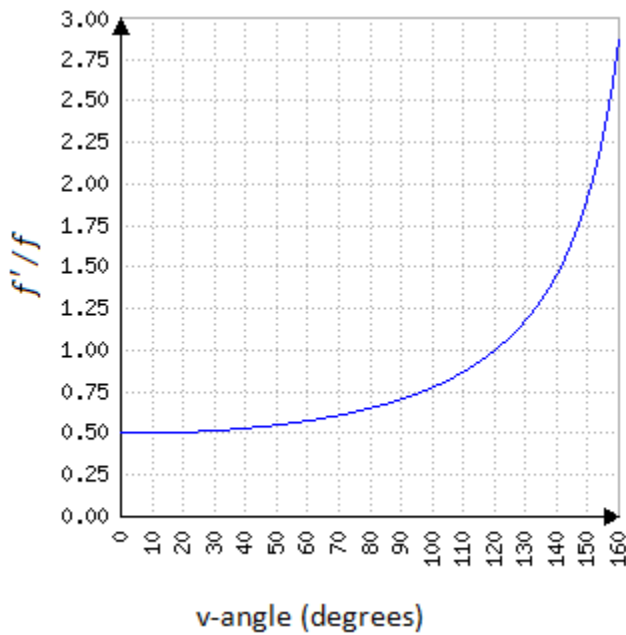


Figure 9 Force multiplication (0-160 degrees)

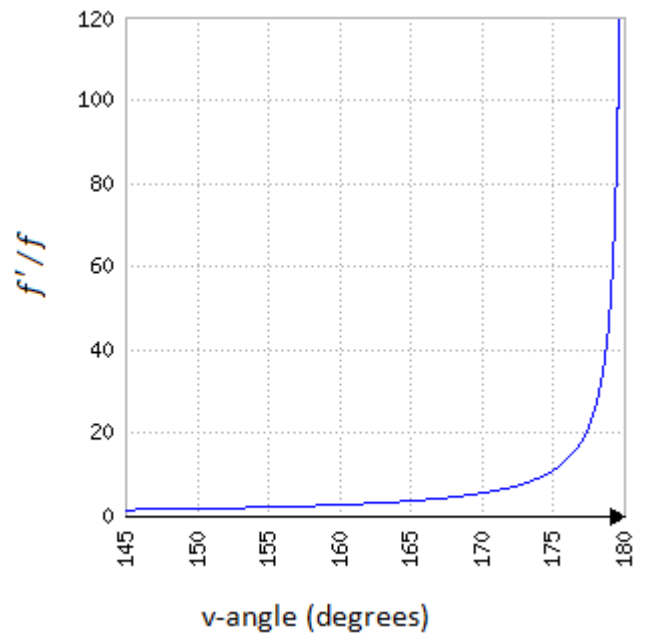


Figure 10 Force multiplication (145-180 degrees)

- Pre-equalizing techniques:
  - ❖ Two slings
  - ❖ Sling with figure-8 knot
  - ❖ Two quickdraws (sling shot top rope anchor)



Figure 11 Two slings



Figure 12 One sling with figure-8



Figure 13 Two quickdraws

- Self-equalizing techniques:
  - ❖ Sliding X (Figure 14)
  - ❖ Sliding X with two slings for redundancy (Figure 15)
  - ❖ Extension limiting knots (Figure 16)
  - ❖ 2 sliding carabiners (Figure 17)



Figure 14 Sliding X



Figure 15 Sling X with two slings



Figure 16 Sliding X with limiter knots



Figure 17 Limiter knots and two carabiners

- American death triangle (Long & Gaines, 2006, p. 206):



- ❖ No redundancy on the sling
- ❖ Allows extension
- ❖ Unnecessarily stresses the anchor

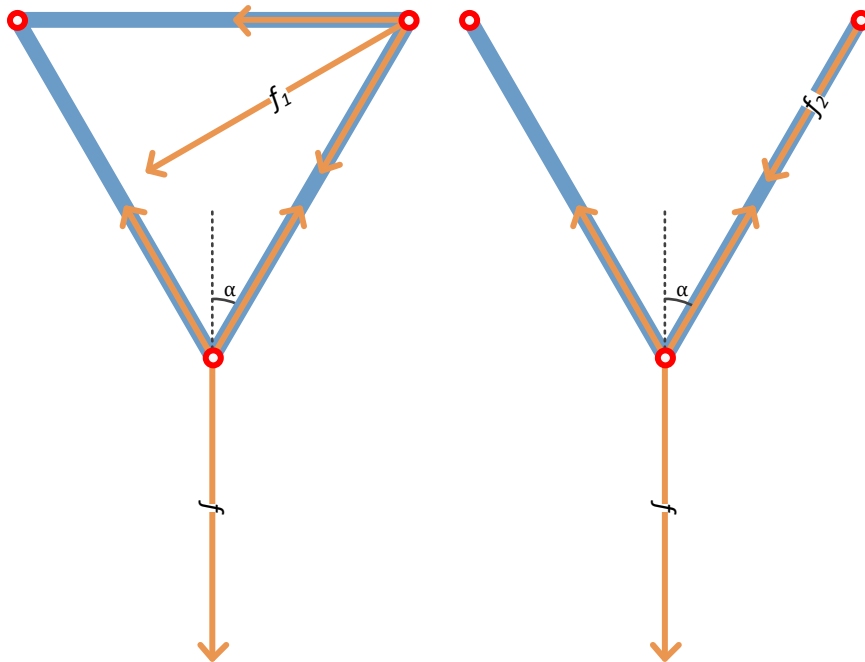


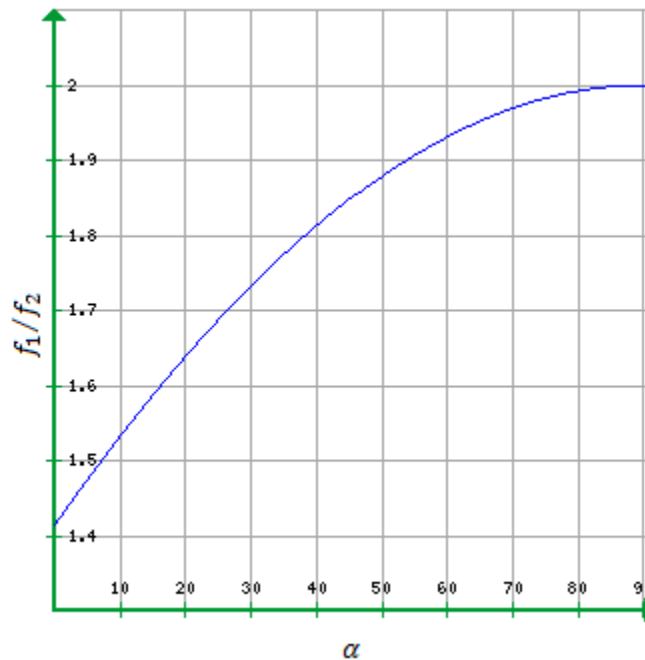
Figure 18 Left: American Death Triangle, Right: Two Equalized Slings



- ❖ Forces on the two pieces are drawn to scale in the above diagram.

$$\text{Left: } f_1 = \frac{f \sqrt{\frac{1+\sin \alpha}{2}}}{\cos \alpha} \quad \text{Right: } f_2 = \frac{f}{2 \cos \alpha}$$

Bored by the math? Remember the conclusion:  $f_1$  is 1.4-2 times  $f_2$ . It's not as deadly as its name sounds, but it's poor engineering.



## Cordelette anchors

- Material: 5.5mm spectra or 6-7mm perlon
- Length: 17-20 feet
- Building a cordelette anchor (Long & Gaines, 2006, p. 150; Donahue, 2019, p. 32):
  - ❖ Clip each anchor component with cordelette.
  - ❖ Position the knot in the cordelette close to one component (can clove hitch to that component to keep the knot out of the way).
  - ❖ Estimate the direction of pull (DOP).
  - ❖ Tie a figure-8 to create the power point.
- Nomenclature:
  - ❖ Master point or power point: the main loop created by the figure-8 knot.
  - ❖ Shelf: clip between each pair of lines above the master point knot.
    - Good for belaying from, clipping in, or hanging stuff.
    - Shelf is as strong as the master point as long as there is a carabiner clipped in the master point.

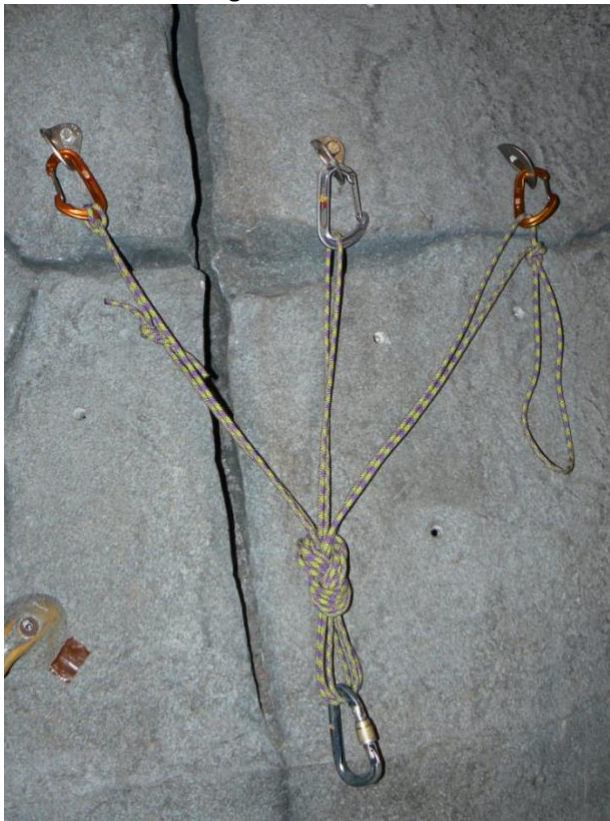
## Cordelette adjustment tricks

- Too long?
  - ❖ Tie a figure-9 instead of figure-8. A figure-9 knot is a figure-8 with one more wrap.



Figure 19 Figure-8 and figure-9 knots

- ❖ Pull out an extra bight to tie off with an overhand.



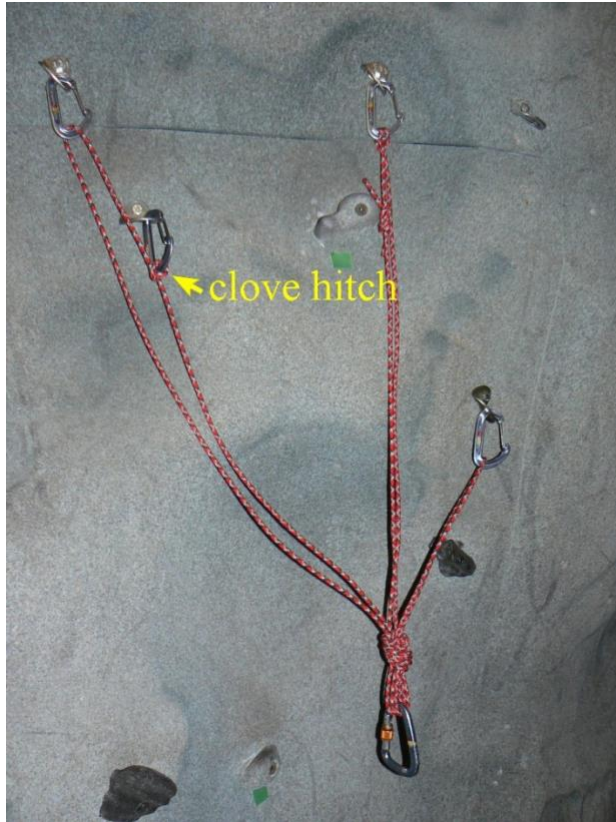
- ❖ Make a double bight and tie a figure 8 or overhand on 4 strands.



- ❖ Double clip one or more pieces, ideally the strongest ones. I.e. clip one piece twice, treating it as if it's two.
- Too short or too many pieces?
  - ❖ Overhand knot instead of figure-8.
  - ❖ Extend individual pieces with slings.



- ❖ Tie in-line pieces off serially.



- ❖ Merge pieces with slings.



- ❖ Retie cordelette as a web-o-lette (Long & Gaines, 2006, p. 156; Donahue, 2019, p. 146).  
Note: you lose the shelf!



Figure 20 Web-o-lette



Figure 21 Figure 8 on a bight on both ends

### Tie in with a clove hitch

- Easy to adjust
- Fast to tie and untie
- Pitfall: dress it well! Put body weight on it to cinch it down.

## Advanced Topics

### The “Quad”



- Self-equalizing
- Limited extension
- No need to break it down. Very efficient for bolted anchor stations.

### Equalette

- Reference: (Long & Gaines, 2006, pp. 166-172)
- Equalizes better
- Takes longer to rig
- No master point

### Rig with Rope

- Reference: (Donahue, 2019, pp. 154-161)
- Serial clove hitches
- Redirectional figure-8
- Dog-eared figure-8
- Quiz: think of one major disadvantage of rigging with the rope versus a cordelette with a power point.

# Belay Techniques and Multi-pitch Climbing Techniques

## Instructions for instructors

### Station setup

- Use bolts on the north wall for hanging belay.
- Pre-clip a carabiner and a double runner on the third row of bolts for part of the hanging belay anchor. Use a ladder to access the bolts.
- Students stand on the ledge to access the bolts and build hanging belay anchors.

### Gear

- Bring a Reverso or ATC Guide.
- Emphasize testing the self-braking mode.
- Emphasize gear management efficiency.

### Objectives

- Belay directly off the harness
- Belay with redirection through the anchor
- Belay off the anchor with a Munter hitch
- Belay off the anchor with an auto-locking belay device
- Hanging belay
- Manage ropes, anchors, and communication on multi-pitch routes

### Techniques for belaying a follower

- Directly off your harness (Houston & Cosley, 2004, p. 155; Long & Gaines, 2006, p. 178)
  - ❖ Pros: simplest, fast transition when swapping leads, your body can buffer the stress on a less-than-bomber anchor.
  - ❖ Cons: all the weight goes on your harness if second hangs, awkward position unless there's a good ledge, difficult to manage the rope if there is no place to pile it.
  - ❖ Application: easy terrain and short pitch.
- Redirected through anchor off your harness. (Long & Gaines, 2006, p. 180; Donahue, 2019, p. 46)
  - ❖ Pros: simple, fast transition when swapping leads, easy to make lap coils.
  - ❖ Cons: pulley effect increases load on the anchor when the follower falls.
  - ❖ Considerations: redirect only when the anchor is bomb proof; redirect on master point or shelf if possible; avoid redirecting on one piece unless it's absolutely bomb proof; when redirecting from one piece, avoid setting the redirection too high.
  - ❖ Quiz: under what circumstances does redirection *not* increase the load on the anchor when the follower falls?
- Directly off anchor with Munter hitch (Houston & Cosley, 2004, p. 156; Donahue, 2019, p. 45)
  - ❖ Pros: belaying is easier, no pulley effect, little stress on belayer if second hangs, belay escape is simple, plenty of friction even if the brake strand is not in the ideal direction, allows you to make lap coils, allows belayer to be far from anchor, also a good way to lower someone so they don't have to rappel.
  - ❖ Cons: can kink the rope, must convert belay to harness when swapping leads.

- ❖ Application: belay device lost; belayer needs to be far from the anchor.
- ❖ Tip on eliminating the kink: keep both strands next to each other, and run the rope loosely through the hitch.
- Directly off anchor with auto-locking device (Reverso 3, ATC Guide, or similar). [\(Houston & Cosley, 2004, p. 157; Donahue, 2019, p. 44\)](#)
  - ❖ Pros: same as with Munter, plus easier to manage the rope, belayer can multi-task while belaying, hauling assist easy to setup.
  - ❖ Cons: must convert belay to harness when swapping leads, belayer must know how to give slack when device is under load.
  - ❖ Application: long and slow pitches; when neat lap coils are critical.
  - ❖ Petzl made a [video](#) on how to use a Reverso 3. A similar [video](#) was made by Black Diamond on ATC Guide.
  - ❖ Efficiency tip: the belay carabiner never needs to leave the belay device. Pay attention to what the red climber does in [this video](#) at 6:30.

## Multi-pitch belay sequence

Multi-pitch climbing techniques on a traditional route is demonstrated in [this video](#).

- Leader arriving the belay station:
  1. Build an anchor, clip rope into the first piece you place for the anchor as protection for yourself.
  2. Connect to the anchor with a clove hitch and a figure 8 on a bight.
  3. Yell “Off belay!”
  4. Start setting up to belay the second.
- Leader belaying up the second:
  1. Second: “Belay is off!”
  2. Leader pulls up the slack in the rope and stack or lap coil it.
  3. Second: “That’s me!”
  4. Leader puts the second on belay and yells: “belay on!”
  5. Second cleans previous anchor.
  6. Second: “climbing!” Leader: “climb on!”
  7. Leader belays second up and continues stacking/coiling the rope.
  8. Second arrives at the belay station clips to the anchor.
  9. Second: “Off belay!”
- Transition to start the next pitch (new roles depend on if you are swapping leads):
  1. New leader collects all gear for next pitch.
  2. Flip rope if you are not swinging leads.
  3. New belayer sets belay off their harness (may already be there).
  4. New belayer: “Belay on!”
  5. New leader unclips from the anchor.
  6. New leader: “Climbing!”
  7. New belayer: “Climb on!”



## Multi-pitch communication

- If other rope teams are nearby, preface all commands with your partner's name.
- Use "Repeat!" when you don't hear a command.
- Use "Okay" to acknowledge a command without another immediate response to let partner know you heard them.
- Use radios.
- Use *rope signals* agreed upon before climbing. This requires that the climbers know their partners well and are familiar with the rope movement pattern. A good article describing this technique can be found [here](#).

## Multi-pitch rope management

- If ledge is big enough, stack the rope into a neat compact pile
- Otherwise, coil the rope between you and the anchor (aka "lap" or "butterfly" coils):
  - ❖ Swapping leads: start long and make each loop successively shorter.
  - ❖ Block leads: prep for flipping: start short and go longer, keep it well organized.
- Flipping the rope:
  - ❖ If stacked in a pile, carefully flip like a pancake, 1 hand on top, 1 on bottom.
  - ❖ If butterflyed for flipping, carefully flip the butterfly over to the second's lap.
  - ❖ Last resort: re-flake the rope.

## Rappel Technique/Rope Team Technique

### Objectives

- Build and evaluate rappel anchors.
- Effectively manage ropes for rappels.
- Alternative rappel methods.
- Describe situations where running belays are appropriate to use.
- Efficiently pass protection as a middle person.
- Shorten the rope as an end person.

### Rappel anchors

- Typical alpine rappel anchors:
  - ❖ Trees, blocks, horns, or fixed gear (bolts, pitons, chocks, etc.).
  - ❖ Tied webbing or perlon slings (at least 2).
  - ❖ Rappel rings:
    - Makes pulling easier.
    - Makes anchor reusable by others (friction from rope pulling can burn slings).
    - Other options: quick links or "bail 'carabiners".



Figure 22 Rappel Ring



Figure 23 Quick Link

- Existing rappel anchors:
  - ❖ Built by unknown people with unknown experience and gear.
  - ❖ Affected by the alpine environment (sun, heat, cold, rain, rock fall, animals, etc.).
  - ❖ May or may not get much use.
  - ❖ May or may not be on route (bail stations).
  - ❖ May or may not allow an easy rope pull.
- Evaluate every existing anchor carefully:
  - ❖ Location, location, location! On route or not? Is there a better station nearby? Any rope-eating features below?
  - ❖ Base anchor. Whatever it is, it must be solid.
  - ❖ Slings:
    - Check complete length: it may look good in front and be rotten in the back.
    - Look for cuts, abrasions, fading, burn marks, unraveling, crunchiness, etc..
    - Spectra wears faster than nylon.
    - Check the knots.
  - ❖ Rappel rings:
    - Lack of rings means ropes have been pulled directly on the slings.
    - Check for wear: SMC hollow aluminum rings wear especially fast.
    - Rope pull: are there potential problems pulling the rope?
- Improve anchors as needed:
  - ❖ Replace slings:
    - Tie to equalize load among all slings.
    - Remove and pack out old slings (“tat”).



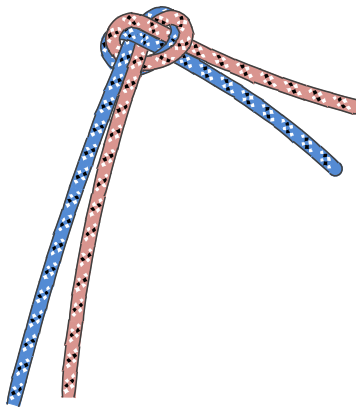
Figure 24 Tat

- ❖ Incorporate another feature or new gear into the anchor. Equalize with existing anchor.
- ❖ Add a rap ring. Tied perlon cord can back up a single ring.
- Back up a questionable anchor:
  - ❖ Place a backup that takes none of the load, but will hold if the original anchor fails.
  - ❖ Send heaviest climbers down first.
  - ❖ Last climber decides whether to take or leave the backup.
- Test pull: if you see potential problems pulling the rope. First person down pulls the rope a bit while top person observes and adjusts as needed.

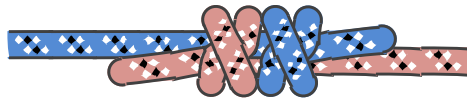
## Rappel rope management

- Setting up a rappel:
  1. Clip into rappel anchor with your personal anchor before untying from the rope or going off rappel.
  2. Thread one end of the rope through the rappel rings.
  3. Knot that end. A stopper knot (1/2 double fisherman) works best. If you knot one end, make sure you knot the other end as well. Otherwise you might as well not knot it.
  4. Pull that side of the rope through the anchor until you reach the middle mark.
  5. Make 2 separate coils: bottom half, top half.
  6. Tie a slip knot with both strands near the middle and clip a carabiner to it to prevent the rope from sliding.
  7. Throw down that side of the rope:
    - a. Yell “Rope!”
    - b. Throw it hard to where you want it to go (don’t “toss it to the breeze”).
    - c. Throw upper coil first, let it settle.
    - d. Then throw the bottom coil (the one with the end).
    - e. Try to keep the end away from the coils to reduce tangles.
  8. Repeat with the other side of the rope:
    - a. Knot the end.
    - b. Make two coils.
    - c. Yell “Rope!”
    - d. Throw upper coil, then lower coil.

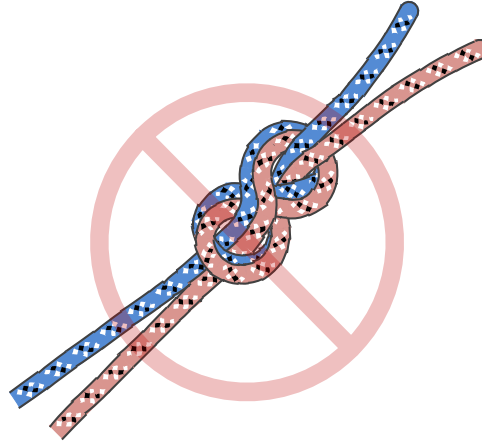
9. Unclip/untie the middle knot and proceed with rappel.
- Rappel Extension
    - ❖ Allows you to use both hands to brake, puts less stress on arms, and is easier to control.
    - ❖ Provides better visibility on the rappel device especially when you are wearing many layers of clothes.
    - ❖ Allows you to pre-rig inexperienced climbers.
    - ❖ Allows you to rig autoblock on the belay loop.
  - Autoblock – our standard method
    - ❖ Very helpful when you need to untangle the rope or otherwise free up both hands.
    - ❖ Works best with 5mm soft hero loops.
    - ❖ Easier to control with rappel extended.
    - ❖ Practice and get used to it. It does not slow you down too much but adds safety and convenience significantly!
  - Rappel with heavy packs. Heavy packs tip you off balance. Here are a few tips to mitigate the situation:
    - ❖ Use autoblock. We use it anyway.
    - ❖ Use a chest harness (clip it to the rope above the rappel device) to keep your upright.
    - ❖ Extend your rappel to your shoulder level.
    - ❖ Consider dropping your pack on your harness instead of carrying it on your back, especially on a free-hanging rappel.
  - Special cases:
    - ❖ No middle mark. Flake both ends of the rope together, with one going through the rings. Marking the middle with a [rope marker](#) is *strongly recommended*. It saves tons of time.
    - ❖ Double rope rappel:
      - Avoid if you can.
      - No need to pull the rope through the anchor on the first rappel: thread one end and tie it to the other rope.
      - Options for joining two ropes:
        - Flat overhand knot (aka European Death Knot):
          - Pros: flat profile runs over edges easily, easy to untie.
          - Cons: must be tied and dressed well with long tails, but still [strong enough](#) to hold a small car.



- Double fisherman's knot
  - Pros: bomber knot.
  - Cons: big profile can get stuck on edges and features, hard to untie.



- **Never** use a “Flat figure-8”. It’s significantly weaker than a flat overhand and can fail under rappel forces.



- Track which end to pull on each rappel.
- Pull the side with the knot.
- Say “Pulling yellow” or “Pulling blue” aloud for the team to hear.
- First rappeler down:
  - ❖ Consider using (use) an autoblock.
  - ❖ Stay above any tangles, keep coiling and throwing until you reach the next station.
  - ❖ At the bottom, clip into next rappel anchor if there is one.
  - ❖ Get off rappel quickly so next person can start. Yell “off rappel!”
  - ❖ When you’re at the next rappel anchor:
    - Thread the end of the rope that you will pull through the next anchor (knot it too).
    - Flake the other end of the rope so it’s ready to pull.
    - Be prepared to give a fireman’s belay.
    - If you’re at the bottom, get away from the base to avoid potential rock fall.
- Pulling the rope:
  - ❖ Untie the knot at the end.
  - ❖ Make sure the two strands are separated.
  - ❖ Pulling slow and steady usually works best until the rope starts coming on its own.
  - ❖ Yell “Rope!”
  - ❖ If you’re at the next rappel anchor:
    - One person pulls the rope.
    - Another feeds it through the anchor and makes coils to throw.
    - When the rope is down, the first person makes coils on that side.
  - ❖ Stuck rope strategies:
    - Move to either side or away from the wall if you can.
    - If both ends of the rope are still down, try pulling the rope back up a bit.
    - Try generating a big wave in the rope.
    - Pull harder – a prusik can help you get a better grip.
    - Be wary of rock fall.

## Alternative rappel methods

- Munter hitch rappel:
  - ❖ Gear efficient. Any locking carabiner (or two non-locking carabiners) will do.
  - ❖ Easy to check.
  - ❖ Does not rely on specific gear.
  - ❖ Works well with a wide range of rope diameters.
  - ❖ Fully compliant with recommended usage from gear manufacturers.
  - ❖ Less complicated.
  - ❖ **MUST BE CONFIGURED CORRECTLY:** Brake strand must be on spine side of carabiner, as running over gate side may release locking gate, allowing possibility of brake strand to pass through gate.
- Carabiner brake rappel:
  - ❖ Gear intensive. 1 locking carabiner and 3-4 regular carabiners are needed.
  - ❖ Has the potential to be set backwards. This fatal mistake is more prone to be made when the rappeler is facing away from the anchor.
  - ❖ Does not work well with certain carabiners.
  - ❖ Sensitive to rope diameter.
  - ❖ More complicated.

For a more comprehensive study on Munter hitch and carabiner rappel, refer to:

1. [Study on Alternatives to the Belay Device for Rappelling](#)
2. [Backup Rappel Method Proposal](#)

## Running and terrain belays

Reading: (Florine & Wright, 2005, pp. 46-55) and (Houston & Cosley, 2004, pp. 144-149)

- Running belay is a compromise between belaying pitches out (slower, safer) and no protection (faster, riskier).
- Running belay is used in places where a fall is unlikely, but would have bad consequences with no protection. Also called “simul-climbing”.
  - ❖ You have all running belayed: glacier travel.
  - ❖ Rock, ice: relatively easy but exposed terrain, “easy” depends on climbers’ capabilities.
  - ❖ Snow: steep or exposed enough so team arrest is unreliable. When team arrest won’t work, either place protection or unrope.
  - ❖ Try to keep at least 2 points of protection on the rope at all times. Coordinate placing pro in front with removing pro in back.
- It is worse for a downhill person to fall than the top person.
- The rope can be placed across a ridge or solid rock horn (terrain belay). A perfect example: West Ridge of Forbidden Peak.

## Passing protection when running belaying

- Applies to rope teams of more than two people
- Goals: never be unclipped, be fast.
- Demonstrated in [this video](#).

- One way: use a second carabiner to clip the other side of the rope to the sling before removing the first one.
- The fast way:
  1. Grab your tie-in knot, slide down and grab both the strand in front of you and the one behind you.
  2. Hold the carabiner on the protection with one hand and clip both strands of rope held by the other hand.
  3. Continue moving forward. The front strand should slip out, leaving only the back strand.

## Short roping

- Stack in the pack.
- Kiwi coil.
- Demonstrated in [this video](#).
- Applications (Houston & Cosley, 2004, p. 220):
  - On easy terrain, the higher climber is able to stop the lower climber's slip. Often used by guides.
  - Lacking a second rope, a small party needs extra rope on either end to rig a rescue system.

# Single Pitch Cragging

## Instructions for Instructors

We will use Spire Rock or another suitable location for this.

### Spire Rock setup:

- Set up hand lines on the top of the towers.
- Phantom belay is best provided by instructors from above. A GriGri is ideal for the job.
- Both ends of a rope can be used for phantom belaying, even a 30-meter rope. The tower is shorter than 15 meters.
- Graduates of the crag course or sport climbing course are allowed to lead for real without a phantom belay as long as they are comfortable.
- If possible, ask the students to setup anchors below the final big ledge. This will force them to hang on the anchor and get a more realistic feeling. You can give instructions from above.

### Instruction

- The purpose of this station is to teach single-pitch sport cragging. Please do not confuse with multi pitch alpine climbing.
- Back-clipping can be addressed but don't have to be over-emphasized. Z-clipping should however be called out if students are seen doing it because it is particularly dangerous.
- Each student needs to (mock) lead once and clean the anchor once. Whether they want to clean the quickdraws when being lowered or on top rope is up to them and the nature of the route. If a route doesn't follow the fall line, it is best cleaned on top rope.

### Objectives

- Mock-lead a bolted route and build a sling-shot top rope anchor at a bolted station.
- Clean the route when being lowered.
- Belay and lower a top roped climber.
- Clean a top rope anchor and rappel.

### Typical single pitch cragging

- First climber leads a route, builds a bolt anchor.
- Belay lowers the leader.
- Last person cleans the anchor and rappels off the chains.

### Considerations and etiquette

- Clip yourself to two bolts while building the anchor or setting up rappel.
- Bolts are not always solid: check them before trusting them.
- Do not top rope or lower someone through rappel anchors (e.g. chains) unless that is standard practice at that particular crag (a guidebook should say). Instead, create your own anchor to top rope and rappel to descend after cleaning the anchor.



## Top rope anchors using bolts

A typical single-pitch cragging anchor consists of a pair of bolt hangers and rappel chains.



- General considerations:
  - ❖ Same principles as other belay anchors.
  - ❖ Use extra caution because no one will be watching them all the time. Use locking carabiners when in doubt.
  - ❖ Use two carabiners at the power point: adds redundancy and rope will run better
  - ❖ Avoid running the rope over sharp edges
  - ❖ The power point should ideally be “in the air” so the carabiners don’t rub on the rock
  - ❖ Redirection: if the anchors are not in line with the climb, adding a directional sling can prevent pendulum falls
- Anchor options:
  - ❖ Figure 11 Two slings
  - ❖ Figure 12 One sling with figure-8
  - ❖ Figure 13 Two quickdraws
  - ❖ Figure 14 Sliding X
  - ❖ Figure 15 Sling X with two slings
  - ❖ Figure 16 Sliding X with limiter knots
  - ❖ Figure 17 Limiter knots and two carabiners

## Belaying a top roped climber

- Anchoring the belayer:
  - ❖ Fixed bottom anchors are rare.
  - ❖ You can often find boulders or trees to sling.
  - ❖ If there is no anchor, do not climb if the climber significantly outweighs the belayer.
  - ❖ Don’t position yourself too far from the base of the climb.
- Communication:
  - ❖ The usual commands apply: “on belay?”, “climbing”, “slack”, “up rope”, “falling” etc.
  - ❖ If other climbers are within earshot, preface each command with your partner’s name.
  - ❖ “Take:”
    - Climber says “Tension” or “Take” for belayer to take their weight
    - Belayer takes in slack tightly to hold the climber’s weight and then says “Gotcha!”

- Climber can then fully weight the rope.
- ❖ “Watch me:”
  - Climber says “Watch me” when feeling they might fall.
  - Belayer pays close attention, takes in any excess slack, and says “I’m with you!”
- ❖ Command sequence at the top of the climb:
  - Climber: “Take!”
  - Belayer: “Gotcha!”
  - Climber: “Lower me.”
  - Belayer: “Lowering.”
- Lowering:
  - ❖ Always use two hands on the brake strand when lowering the climber.

## Cleaning a top rope anchor and rappelling

1. Climb the route on top rope.
2. Clip yourself to both bolts:
  - a. Either using a personal anchor with two locking carabiner, one to each bolt.
  - b. Or using two personal anchors.
3. “Off belay!”
4. Disassemble and rack the top rope anchor. You can delay doing this if you like. But doing it now provides a clean workspace to setup the rappel.
5. “Belay off!”
6. Untie the tie-in knot on your harness.
7. Feed the end you just untied through the rappel rings.
8. Pull up enough rope through the rappel rings for it to get back to the ground. Go to the middle mark if you have any doubt.
9. Verify with your belayer that both ends are on the ground.
10. Set up to rappel, double check, then “On rappel!”

## Tips and considerations:

1. If there is a risk of dropping the rope, tie a keeper knot (an overhand or slipper knot will do) and clip the rope to yourself. Undo the knot when another keeper knot is tied or the rope is secured.
2. Keeper knots can also help to keep the middle in position.
3. Coil and throw the rope if the route is slabby or has rope tangling features.

## PBUS Belay Method

For further information on the PBUS (Pull, Brake, Up-Slide) Belay Method, see the following link from the American Alpine Institute - <http://blog.alpineinstitute.com/2013/10/toprope-climbing-belay-technique.html?m=1>

The PBUS Belay Method is the standard belay method being taught to new climbing students as of the 2015 Seattle Basic Alpine Climbing Course. Intermediate Students should familiarize themselves with this technique in preparation for instructing Basic Students. This method of belaying is thought to be a safer way for beginners to learn to top-rope belay.

## Grade Card

Name: \_\_\_\_\_

Phone: \_\_\_\_\_

Evaluator: Initial the Yes box only if the candidate demonstrates the skill safely and competently.

<b>Area I – Anchors</b>	<b>Evaluator:</b>	<b>Y</b>	<b>N</b>
Understand requirements of various climbing anchors			
Build various anchor components and evaluate them using SERENE			
Build 2-point anchors using slings			
Build multipoint cordelette anchors			
Rig with rope			
<b>Area II - Belay techniques &amp; multi-pitch techniques</b>	<b>Evaluator:</b>	<b>Y</b>	<b>N</b>
Belay directly off the harness			
Belay with redirection through the anchor			
Belay off the anchor with a Munter hitch			
Belay off the anchor with an auto-locking belay device			
Hanging belay			
Multi-pitch climbing: sequence, communication, rope management			
<b>Area III - Rappel &amp; rope team techniques</b>	<b>Evaluator:</b>	<b>Y</b>	<b>N</b>
Build and evaluate rappel anchors			
Effectively manage ropes for rappels			
Join two ropes for rappel			
Extended Rappel with Autoblock			
Alternative rappel methods			
Describe situations where running belays are appropriate to use			
Efficiently pass protection as a middle person			
Shorten the rope as an end person			
<b>Area IV – Top roped climbing at the crags</b>	<b>Evaluator:</b>	<b>Y</b>	<b>N</b>
Build a top rope anchor at a bolted station			
Belay and lower a top roped climber			
Use of commands			
Rope management at the anchor			
Clean a top rope anchor and rappel			
PBUS Belay Method - (Pull, Break, Up-Slide)			

Instructor Notes: