Multi-pitch and Alpine Rock Climbing Course

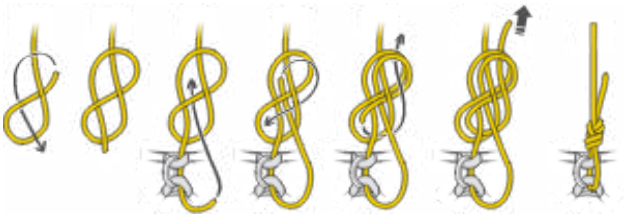
Knots and hitches

Below is a list of knots used by mountaineers and climbers and their common uses. A hitch is a type of knot that is tied around an object, most commonly a carabiner. When the object is removed the hitch collapses.

Overhand knot is the simplest knot. Can be used to join two strands of rope and is typically used when abseiling on two ropes.

Overhand knot on a bight is a simple and easy knot that is an option whenever a loop of rope (or bight) is required along a length of rope.

Rethreaded Figure-8 is most commonly used to tie into a harness. Always make sure that there is at least 10-15 cm of the tail of the rope left hanging out of the back of the knot.

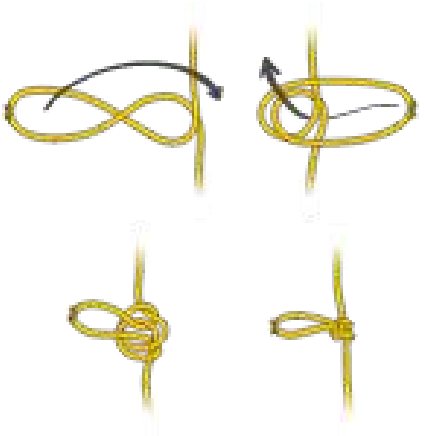


(*Petzl)*

Figure-8 on a bight is similar to an overhand on a bight with an extra twist. It Is not very stable if pulled laterally so not the best option when loops are required along a length of rope but is useful for tying loops at the end of ropes, for example at the end of abseil ropes.

(*Petzl)*

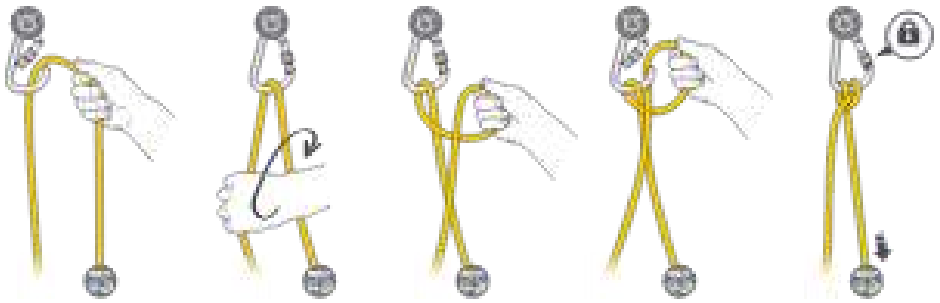
Alpine butterfly is a bight knot that can be used as an alternative to an overhand on a bight for creating loops along a length of rope. It has the advantage of being strong and stable when pulled laterally.



(*Petzl)*

Double fisherman's is used to create prusiks from loops of chord and can be used to join two ropes together - especially if of different diameters.

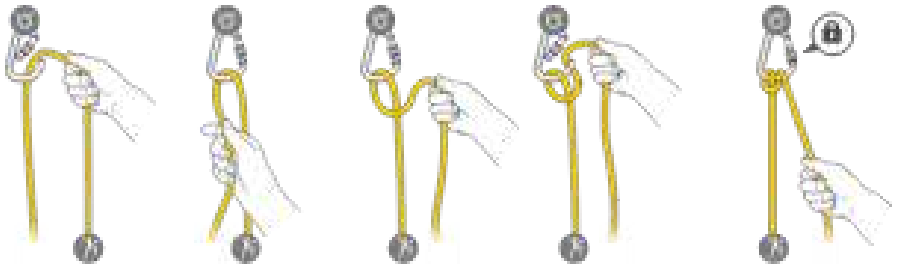
Clove hitch is used to attach the rope to a carabiner and typically used to attach a climber to an anchor. It has the advantage of being adjustable without taking it off the carabiner and is easy to undo once loaded.



(*Petzl)*

Italian hitch is a friction hitch (also known as Munter hitch) that can be used for rappelling and belaying.

Being able to lock off an Italian hitch with a *Munter mule* hitch is useful for rescue situations.



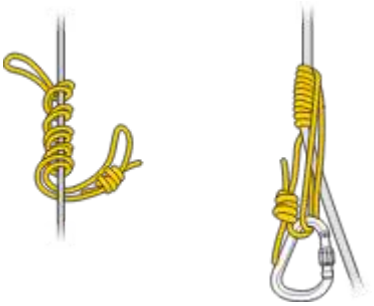
(*Petzl)*

Prusik hitches

Prusiks are loops of cord and are lightweight, inexpensive and can be useful in a variety of situations. It is usual that 2 or 3 prusiks or other mechanical ascending devices are carried when climbing or mountaineering. Prusiks are made from lengths of 6 or 7 mm diameter chords with the two ends together using a double fisherman's knot.

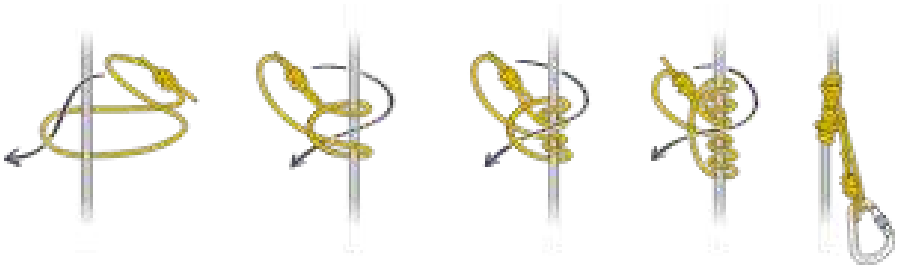
There are dedicated hitches that prusiks are used for and three types that are commonly used:

French prusik locks in both directions and is releasable under load and therefore commonly used as an abseil backup**.** It is tied by wrapping a prusik loop around the rope a number of times and clipping both ends into a carabiner. It is important that there is not too much slack to ensure it grips so the prusik loop may need to be shortened with an overhand knot if necessary.



(*Petzl)*

Classic hitch works with pulls in either direction along the rope. It is tied starting with a larks girth hitch) around the rope, with successive wraps fed through in the inside. Once tightened unc it can be loosened by wiggling the *Breaking bar* so that it can be moved up the rope.



(*Petzl)*

Klemheist hitch is quick to tie and is useful as it is the only prusik hitch that can be tied with tape sling. The disadvantage is that it becomes very difficult to release under load. It also works best when pulled in the downwards direction.

The number of wraps around the rope for all prusik knots should be a minimum of 3 but can be as many as 5 depending upon the diameter of the rope being ascended. The diameter of the prusik cord should be less than 2/3 of the diameter of the rope it is being wrapped around. Too many wraps will introduce too much internal friction within the hitch. This may prevent the prusik from working correctly and tightening around the rope when loaded. All prusik hitches must be neatly dressed to ensure they work well and correctly and always check that they grip satisfactorily before committing weight to them.

Anchors

Anchor systems principles

Two or more pieces of protection can be combined into an anchor system that can be used for pitching or abseiling. In these situations reliability is paramount as climbers will often have their entire weight on an anchor and its failure can be catastrophic.

When creating an anchor system the following 5 principles apply:

Secure - Each piece of protection used within an anchor system must be secure. This means that there is good confidence in its strength and reliability.

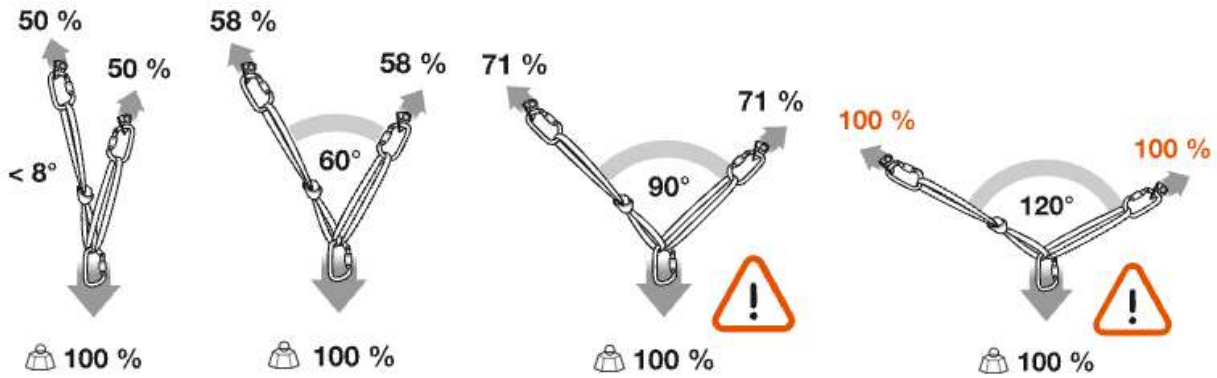
Independent - Each piece of protection must be independent.

- This means that for rock protection, each piece should be in separate cracks (ie, if the crack widens, only one piece of protection is affected).
- For snow anchors maximum strength and independence is achieved by separating each piece of protection by at least twice the depth of the deepest piece.
- On good water ice, 2 well spaced ice screws are usually sufficient to create a suitable anchor. To avoid the ice screws affecting the strength of each other and the ice fracturing around the entire anchor system, separate each screw by at least 2 screw lengths and in different horizontal and vertical planes.

Equalised - To minimise the force on individual pieces of protection and maximise the strength of an anchor system, it is important that the initial load is equalised or shared between all of the individual pieces of protection.

Redundant - If a protection piece within the anchor system fails, then there must not be a shock load on the other protection pieces of the anchor system.

Angle - The angle created at the focal point when equalising multiple pieces of protection points into an anchor system is of paramount importance because of the Magnification of Vectors. This always needs to be considered, especially if the pieces are separated.



Magnification of vectors (Petzl)

Anchor system configurations

Anchor systems can be built using slings or whilst pitching, the climbing rope. Using slings is preferred and used with a direct belay as it keeps the rope and other members of the climbing party out of the system.

Fixed anchor systems

On long multi-pitch or alpine routes, using quick and reliable protection and a simple anchor system that are quick to assemble and disassemble will maximise efficiency.

Overhand

The simplest anchor system is the Overhand. A sling is clipped through 2 (or more) anchor points and an overhand knot on a bight is tied at a point in line with the direction of pull and equalised on each of the anchor points.

This provides 3 separate attachment points which can be used to keep the anchor organised and separated. These are the Shelf that captures both loops above the overhand knot, and each individual loop below the overhand knot.

This configuration does require anchor points that are relatively close together using a long sling to ensure the angle between the strands is within the acceptable range.

Sliding X Girth Hitch

The Sliding X Girth Hitch offers greater redundancy over a standard Girth Hitch anchor and is an efficient use of sling for more widely spaced anchor points. Of particular advantage in alpine climbing is that no knots need to be untied with cold or gloved hands which speeds up the process. This requires an additional Master Carabiner (abseil ring or bears paw) in the system that should remain closed with all other elements of the anchor and belay system clipped to it.

Alpine anchors

For more alpine terrain, when using and transitioning between a range of roping techniques, the alpine anchors are quick, require minimal dismantling. A focal point is created on the primary or best piece of protection and this is backed up to further pieces using a tied off sling (or alpine quickdraw).

Floating anchor systems

Quad

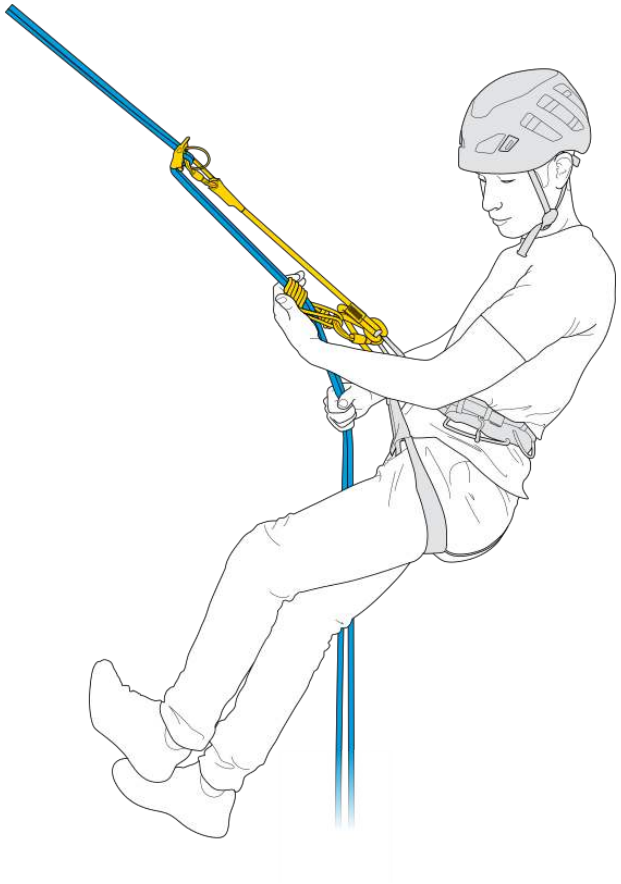
It is very difficult practically to achieve true equalisation with a knotted sling. Any change in alignment of the direction of load will impact the sharing of the load.

The Quad is useful for technical pitched climbing and can form part of an anchor module. It is especially useful if the direction of pull may change on a direct belay during a pitch.

Abseiling

Abseiling (also known as rappelling) is a fundamental technique required for climbing and mountaineering. Whether abseiling on a single or doubled rope, the principles remain the same. For pitched climbs that require steep abseiling often two 50 or 60 metre ropes are usually carried so that full pitches can be abseiled.

Abseiling systems



(Petzl)

An extended abseil system is most commonly used with the abseil device extended above the belay loop with a short, knotted sling or a Personal Anchor System (PAS) and the backup prusik attached to the harness belay loop. Although dedicated PAS are commonly used for sport climbing, for mountaineering an extended abseil is only used during the descent and for weight efficiency can easily be improvised from a 120cm sling when required.

A backup is often used when abseiling incase of inadvertently letting go of the dead rope. A backup is also useful when having to clean a route, manage rope or to construct multi-pitch anchors whilst hanging on the abseil rope. a French prusik can be placed around the rope and attached to the belay loop of the harness. French prusiks are preferable in this situation as they are releasable when loaded. It is important that the abseil device is extended sufficiently so that the backup prusik cannot interfere with the device which could result in it failing to lock.

A prusik backup can be avoided if there is someone at the bottom able to hold the rope. If this backup belayer is ready to pull down hard on the rope, the abseil device will lock. This is known as a Fireman's belay.

On all abseils where the rope doesn't reach the ground, individual knots should be tied in each end of the rope. Alternatively the first abseiler can stay tied into the end of one of the ropes, providing the ropes are secured at the abseil anchor.

Before committing to an abseil:

1. Ensure that the anchors are secure and attached correctly, you are likely already attached to the anchors so this would have been done already;
2. Check that your harness is on correctly and the buckle(s) are doubled back on non-self-locking harnesses;
3. Check your belay device is threaded correctly and the carabiner attaching your belay device to your harness is locked (squeeze the gate to test it);
4. Check that the end(s) of the rope are touching the ground or have a knot tied in it/them;
5. If you are using one, check your abseiling backup is working correctly (see below);
6. If you are using a *Personal Anchor System* (PAS) to attach to the anchor, all your weight should be on the abseil device and rope with the personal safety is slack as a check before unclipping it from the anchor.

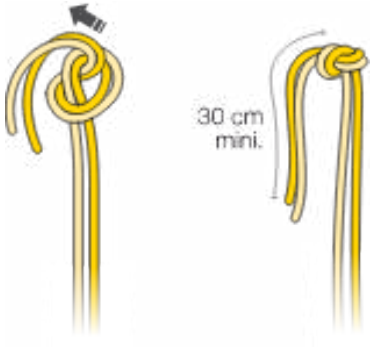
Retrievable abseils

(Petzl)

Most of the time when multi-pitch abseiling in the mountains a Retrievable abseil system is required. This allows the rope to be pulled down after use in order to continue onwards with the descent. This is done by threading the rope or ropes through an anchor that is left behind and then abseiling on two strands of rope. When the bottom of the pitch is reached, one strand can be pulled to retrieve the rope(s). If using a single rope only half its length can be descended at a time.

Once a retrievable abseil is set up, the ends of the rope can be lapped and thrown down. It is common for the rope to get caught on ledges so the first person down should backup their abseil system leaving their hands free to manage the rope if need be so as to never allow the ends of the rope to get snagged above them.

On steeper faces and in windy conditions is to lap the rope over a sling attached to the side of the harness in ‘saddle bags’ for the first abseiler to carry down.



(Petzl)

Two ropes are often carried on longer steeper and more technical routes to enable full rope length pitches to be descended. There are a number of options to join two ropes but the simplest for tow ropes of the same diameter is using an overhand knot. The knot must be neatly dressed with at least 30 cm of tail for each rope as in extreme cases it is possible for this knot to roll and undo itself. A major advantage of this knot is that it has a flat surface that rolls well over edges. The ropes must be of similar diameter or very near to it. If not, then use a double fisherman's knot.

To remember which strand of the rope to pull, the personal safety can be clipped around it. It is also important to remember to take the knots out before retrieving the ropes as they can get stuck at the anchor.

On lower angle broken ground it is best to keep abseils short to make the rope easier to manage. Many established abseil descents in NZ mountains are setup for 30m abseils.

Carrying a lightweight tagline (a thin 50m or 60m long 5.5mm diameter spectra chord or similar) allows full rope lengths to be abseiled without carrying a full second rope. The abseil is set up on the full rope and the tagline is used to pull and retrieve the rope.

Multi-pitch climbing

Once the climbing becomes more technical, mountaineers will start pitched climbing, moving from stance to stance and protecting the leader from big falls by placing protection along the route.

Single ropes are designed for use on their own and commonly for most mountaineering objectives in NZ. Diameters range between 8.9 mm and 10.5 mm and the choice will be a compromise of weight versus durability. A single rope means less rope to drag up the route and also reduces the time it takes to stack, coil and sort the rope. Using double ropes is particularly useful to reduce rope drag on more technical routes, when opportunities for placing protection are not in line or when it is planned to abseil full rope lengths.

In the mountains, verbal communication may be difficult due to distance or weather so teams can employ simple procedures to ensure everyone knows what is happening at each stage. It is essential that a lead climber and their belayer have predefined, clear and unambiguous calls to communicate when climbing.

Leading strategies

Leaders should take advantage of good pieces of protection on the route that are quick and easy to place and remove. This also means choosing appropriate lengths for pitches and taking the

opportunity to belay where there is good protection rather than having to spend time creating a mediocre anchor at a more distant stance.

Teams should keep the leader's pack light so that they can climb as comfortably, quickly and safely as possible. On technical routes, this may mean being set up to haul gear ahead of the second.

Speed and safety are important in the mountains so using protection as aid to get through difficult, time consuming moves is preferable to spending too much time working it out or falling.

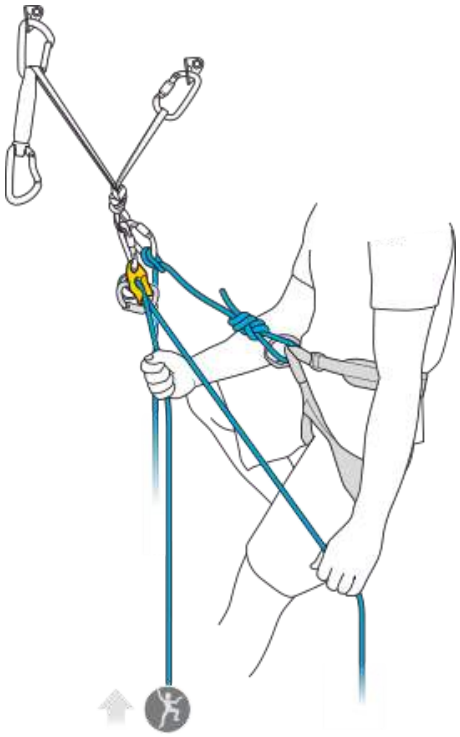
Direct belaying

On arrival at the top of the pitch, the leader should secure themselves as soon as possible. This allows them to be taken off belay and gives the second time to prepare to climb whilst the anchor is being built.

Anchors should be situational, meaning that are appropriate to the anticipated load (with a sufficient safety factor). This means that on easier ground with lower potential for big falls, a two or three piece anchor may not be required.

The leader should construct the anchor and belay system before pulling up the slack rope. An obvious focal point helps keep the stance organised and it allows other members of the team to secure themselves quickly as soon as they arrive on the stance. Each climber should have an independent attachment to the anchor by using a clove hitch on their climbing rope. This is simple, strong and adjustable. As soon as the slack rope is taken up, the second should be put on belay so that they can prepare to climb.

Once the leader is secure at the top of the pitch, the second can start dismantling their anchor down to a last (best) piece. As soon as the slack rope is taken in, the second knows that if they wait a few moments, they will be on belay and can start climbing.



(Petzl)

Direct belaying is the preferred method of a leader belaying a second at the top of a pitch. This involves the use of a belay device or hitch that attaches directly to the anchor. The belayer is secured separately to the belay system. Using an Italian hitch is simple and commonly used, especially for shorter or less vertical situations. Otherwise a self-locking Plaquette (such as Petzl Reverso or Black Diamond ATC Guide®) can be used as this makes it easier for the belayer to deal with any unforeseen issues and switching the lead climber on multi-pitch climbs.

Plaquettes are versatile devices that can either be used as a standard belay device or set as a direct belay that automatically locks if the climber falls off. A hand should always still be on dead rope at all times.

Being able to safely release a fully loaded Plaquette or transferring the load to an alternative roping system[1] is important to know if using them in this way.

Stance management

The management of climbers and the rope at stances will depend on the leading strategy for the route. If the leading is shared, the second will lead through to lead the next pitch and the leading duties are swapped back and forth. This has the advantage of the leader's end of the rope being at the top so it doesn't need to be restacked to ensure it is ready to run smoothly as the leader moves up the next pitch. When leading through, racking gear on a sling or bandolier is useful so that it can be swapped quickly when swapping leads to avoid double handling gear.

Block leading can be efficient on longer climbs and requires the same leader for a number of consecutive pitches. The leader can get in 'the zone' and all the gear does not have to be passed back and forth at each stance. If the rope is stacked on a ledge, the leader's end will be at the bottom of the pile and it will have to be re-stacked or well managed with neat lap coils to avoid tangles.

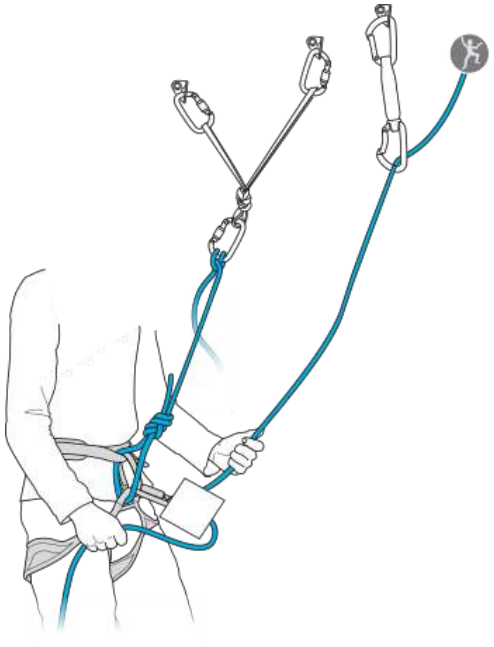
Anticipating which direction the leader will be departing stance will help planning where climbers should position themselves.

Careful management of the rope at each stance is important for efficiency. Tangled ropes are annoying and take time to sort out. If a suitable ledge is available it can be stacked in a pile. On smaller or free hanging stances the rope can be lapped over the belayer's attachment to the

[1] See Vertical Rescue: Load Transfer

anchor or over a sling. If leading through, each loop must be progressively shorter to ensure the rope pays out neatly. For block leading, loops can start small and lengthened so that the loops can be flipped over to the second to allow the leader to continue leading. On low angle terrain the loops should be kept quick short to avoid snagging but on steeper terrain or smooth snow slopes, the loops can be longer.

Lead belaying



(Petzl)

To lead the subsequent pitch, the leader needs to be put on lead belay. They should attach themselves to the anchor so that their direct belay can be swapped to a lead belay off the harness.

The leader should place a piece of protection as soon as possible to protect the belay from a factor 2 fall (see: Forces at Work During a Real Fall). This should be ideally separate to the anchor to avoid shock loading and compromising the integrity of the anchor.

If there is a difficult move directly off the belay that may be difficult to protect the belay for, then the leader of the previous pitch can complete the with a runner on the belay, place a good piece of protection above and then lower back to the belay to bring up the second. This provides a top rope initially at the start of the next pitch.

Teams of 3

Climbing as a team of three can be as quick and possibly more efficient than climbing in a pair providing that both seconds climb at the same time on a parallel roping system. This is because there is always a spare person at each stance to eat, drink, rest and deal with any issues. The leader will need to trail two ropes.

If two single rated ropes are used, they can take a belay on one strand and clip both ropes through every piece of protection. Belaying on two strands of single rated rope should be avoided as it increases the potential force on protection during a fall so in this case. If belaying on both strands, the ropes should be clipped alternatively.

At the top of pitches, there will be two ropes to manage at the stance and there is potential for the ropes to get twisted. If trailing a second rope that is not being used to belay the leader, this can be clipped onto the leader's harness with a carabiner so it is easy to unclip and remove any twists in the rope. The leader would clip into the anchor with a clove hitch on the belayed rope as well as clipping the other rope through the same carabiner to keep the rope running neatly.

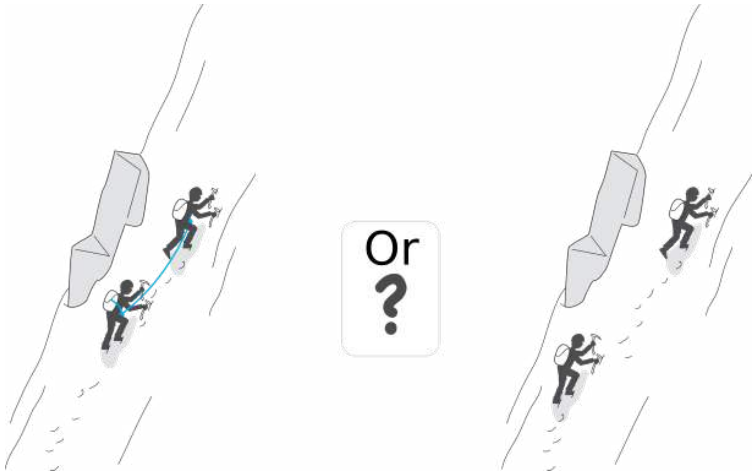
The ropes can be managed as with one rope if they are moving at the same time, either into a ‘clean’ stack or coils. This is usually the case when the leader is bringing up the slack rope before putting the seconds on belay. Once the seconds are on belay, their strands of rope will be brought in at different speeds which would result in a ‘dirty’ stack or coils. The clean and dirty sections of the stack should be separated by a knot or by separating the strands if they are coming in dirty so that this section of the rope can be restacked prior to the leader heading off up the next pitch.

Alpine roped security techniques

Travelling in the mountains will always contain some element of risk. The quickest way of moving through the mountains will always be to avoid using the rope or soloing. On the other end of the continuum, pitching offers good security but slows everything down. This is appropriate for technical climbing but can impact travel time if used on intermediate terrain. Mountaineering usually requires a lot of travel on intermediate terrain and the appropriate application of roped security techniques can offer a proportional amount of security without compromising efficiency. It does require good judgement and careful consideration of the risks to apply the most suitable technique and therefore maintain an adequate degree of safety.

Transitioning from soloing to roped security techniques

The decision to transition between soloing and roped climbing is an important decision and needs to be well timed. Deploying the rope too early will slow the team down, too late will compromise safety and it may become more awkward and slower to transition. It pays to be well prepared with harnesses on, gear racked and rope stacked in a pack. A well practised fluidity in ropework, so that it can be done quickly and efficiently, will speed up transitions greatly. Knowing that it is not going to waste valuable time transitioning will help make better decisions about when to transition to roped climbing.



(Petzl)

Many serious accidents have occurred when climbing partners have fallen whilst being roped unnecessarily. If the rope is being used it must always be adding a degree of safety through the use of runners and protection. If not, once sliding it will become impossible for either person to stop the fall. There will be two people injured and no one to get help.

Shortening the rope

For techniques other than pitching on technical terrain, using the entire length of rope is not always appropriate or efficient. For the following roped security techniques, being able to quickly shorten the live rope (the rope between two team members) speeds up any required transitions when anticipating and reacting to changing conditions. A shorter length of live rope is appropriate for glacier travel, to safeguard ridge traverses or for shorter, easier to manage pitches over less steep or broken ground.

Unblocked coils (Petzl)

Carrying excess rope in coils draped over one shoulder has the advantage of allowing the rope to be immediately accessible without taking off the pack and is a quick way to lengthen and shorten the rope between two climbers as required. Coils can either be blocked to hold them securely and neatly or unblocked, for shorter lengths of rope and having the advantage of being quicker to adjust.

If it is anticipated that the rope will be lengthened to climb pitches, it is important to tie into the end of the rope before taking coils to expedite the transition.

With both blocked or unblocked coils, an isolation knot is required to provide a low tie-off and ensure any loading comes directly onto the harness. For glacier travel, a bight knot onto a directional locking carabiner (or two opposed locking carabiners (in order to minimise the risk of the carabiner rotating and cross loading) as makes it easier to escape the system for companion crevasse rescue if the live rope is loaded. Whilst pitching or moving together, a clove hitch can also be used as it is easily adjustable, providing it is regularly checked to avoid it loosening during movement.

Hand coils are often used to shorten the rope on easy and low consequence terrain where leaving the rope run out can get in the way or snag. It is a quick alternative to temporarily untying from the rope for a short section of soloing terrain. It must be emphasised that this is not the same as the short roping technique often seen being used by professional mountain guides to

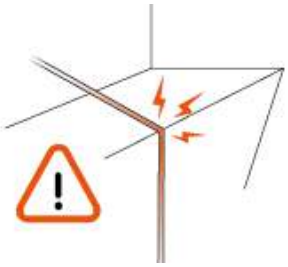
safeguard their clients and should not be used when there is any chance of slipping or falling in which case the rope will intensify the seriousness of the situation.

Moving together

Moving together with 10-15m of rope between two climbers provides a degree of security providing there is sufficient running protection on the rope. It works well on horizontal and well featured ridges where suitable options running protection exists using natural terrain features or by placing quick and easy to remove protection. If managed well, moving together can increase security over soloing without compromising speed.

Different to glacier travel, as it is not anticipated that the spare rope is required for rescue, one climber attaches to the end and the other carries the spare rope, it is easier to transition back to soloing when it becomes preferable.

Both team members should be actively involved in placing protection, communicating with each other, maintaining the route of the rope and minimising slack. If an upcoming section is looking more difficult, it may be more appropriate to belay and carry out a short pitch (without taking more rope out of storage). Climbers should be prepared to make quick adjustments of the live rope between them to the most appropriate length for the terrain.



(Petzl)

It is inherent that when moving together on rocky ridges, the rope will be threaded around natural terrain features. These provide running protection and simple belays for easier and less steep situations. Whenever the rope is running over terrain, there is always the risk of rope cutting over sharp edges, especially when the preload, or the tension in a loaded rope, exceeds more than a single person's bodyweight. The preload is the most important contributing factor affecting the cut resistance of ropes so the main consideration when moving together is limiting the potential preload.

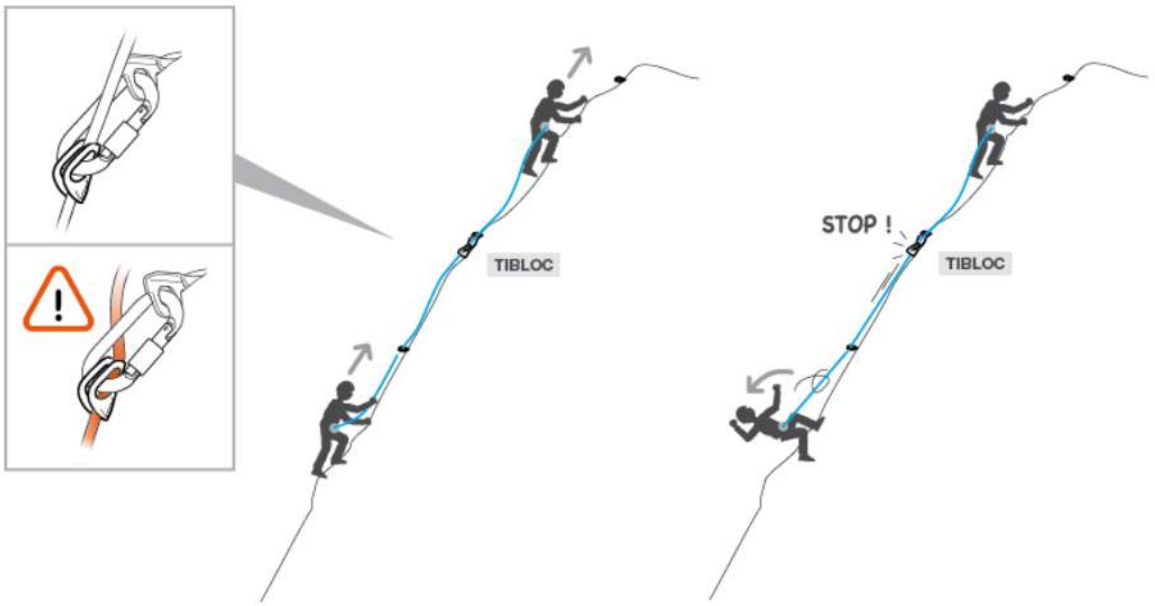
Strategies that can be applied to maximise the cut resistance of ropes include:

- Routing the rope away from edges using runners.
- Using running protection to minimise fall factors.
- Applying a dynamic belay technique to spread any abrasion of a tensioned rope longitudinally along the length of the rope rather than across the strands. This means avoiding a self-locking plaquette unless the climbing line is direct and clean.
- Minimise the interference of the rope with terrain by using short pitches.
- Doubling the rope or climbing on two strands of rope.

Simul-climbing

Simul climbing is an advanced travel technique of moving together on steeper and more technical terrain. It should only be applied by a team with a good understanding of the difficulties relative to the team's abilities and the risk. It is often used at the top of a pitch, where the leader and second are on 'easy' terrain to allow the leader to reach a better belay.

If the leader falls, the weight of the second acts as a belay. If the second falls, it can pull the leader off unless a progress capture device such as a Petzl Tibloc® is installed on protection to take the load of a falling second directly onto the anchor.



Simul-climbing using Petzl Tibloc® for security of the second (Petzl)

Vertical rescue

When the ground is no longer close enough to easily retreat to in the event of a problem, both climbers (rescuer and victim) must have the necessary equipment and should be familiar with techniques for vertical rescue. This includes lowering and raising, load transfers and ascending and descending ropes individually or as a team. It is always easier to descend than fight gravity and continue upwards.

As in all roping situations some basic principles apply. These include never relying solely on a single prusik as the only point of attachment to the rope and ensuring that the 'loop is closed' i.e. that the end of the rope cannot pass completely through the system, leading to catastrophic failure.

In most rescue and load transfers situations, **every stage should be releasable/reversible** in order to avoid any problems or complications. It is important to be systematic and organised at

every stage. This includes being able to tie-off belays leaving hands free to construct the next element in the system, backing up and adding the next element before removing anything.

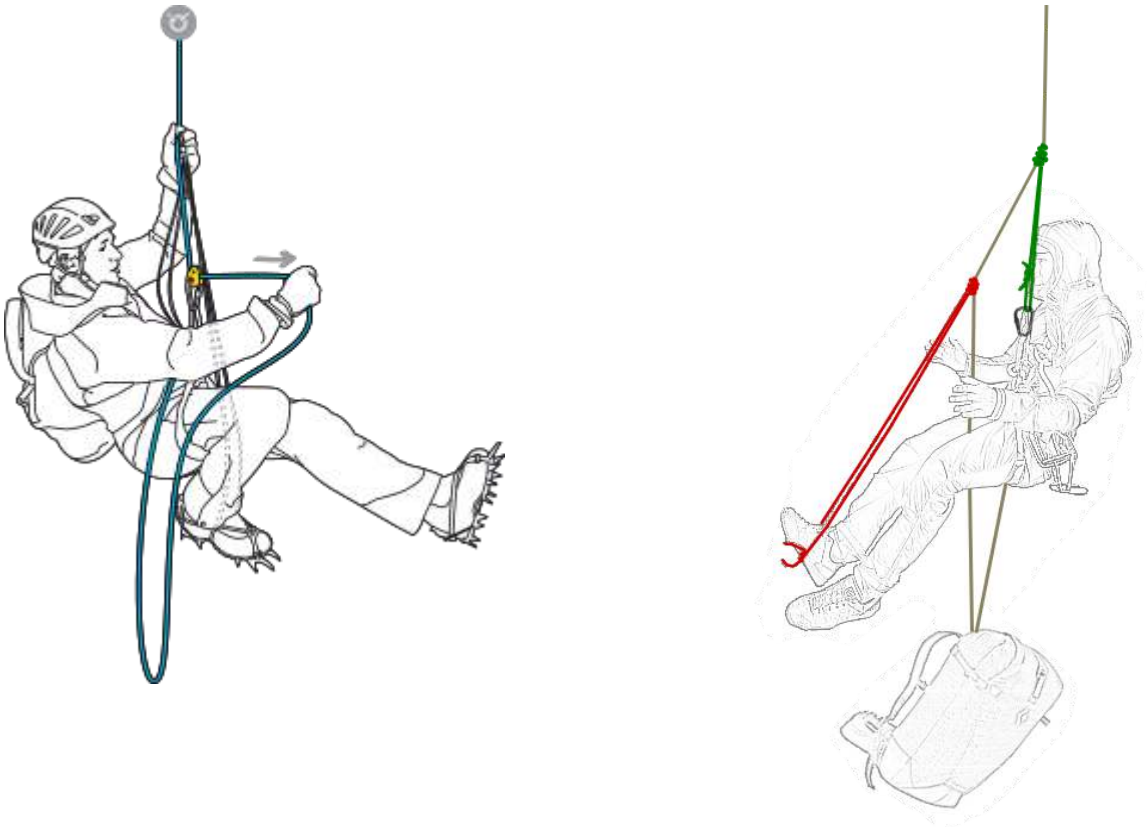
Ascending the rope

Being able to ascend a rope is useful in a number of situations such as crevasse rescue. It is most simply done using two prusiks, one for the belay loop off the harness and one for legs. Either the Klemheist or Classic are the most appropriate hitches in this situation as they cannot be released whilst loaded. Using two prusiks, the leg prusik will go on the rope below the waist prusik.

Mechanical rope ascenders (such as Petzl mircoraxion® or Tibloc®) are heavier than prusiks but can be much more efficient and easier to use as they slide up the rope freely when not loaded. If available these should be used in preference at the waist. With a mechanical ascender in this position, the leg prusik (differently to when using a prusik at the waist) goes on the rope above. Using mechanical ascenders, it is also possible to incorporate mechanical advantage into the ascending system.

To ascend the rope, alternately weight one prusik or ascender and move the other prusik or ascender upwards as far it can go without it coming under load. When stepping up in the leg prusik it is important that your weight is balanced over your leg so as not to be pulling on the arms. The length of the foot loop may need to be adjusted for this to work efficiently.

In case of the prusiks or ascenders failing, an important safety consideration is to tie into the end of the rope. It is also possible to backup using a clove hitch onto the harness that is adjusted as upwards progress is made.



Using prusiks or mechanical ascenders to climb a rope (tie-in omitted for clarity)

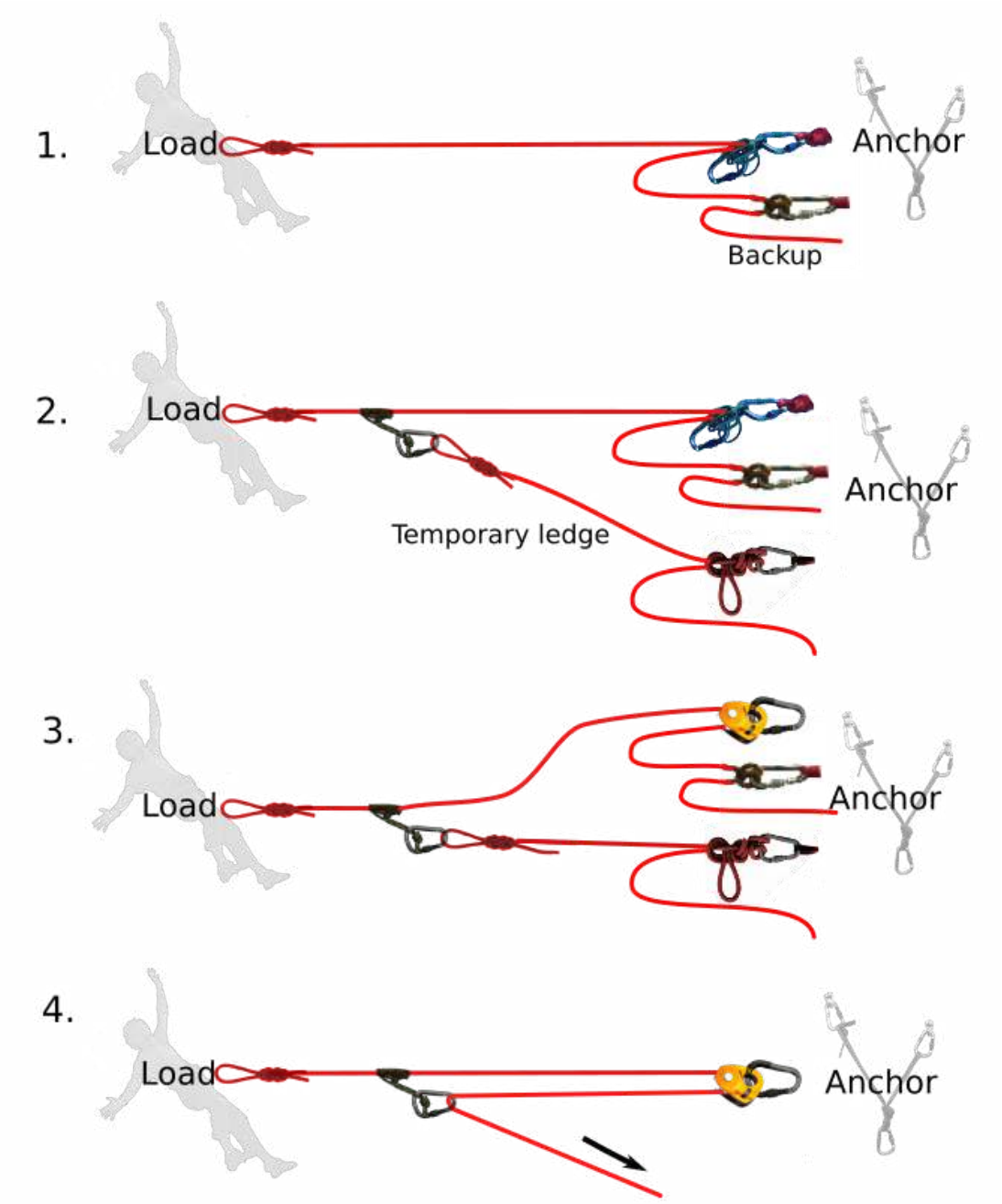
Load transfer

Techniques to force an auto-locking Plaquette to 'fail' for lowering purposes, for any lower longer than just a very short distance is not advised and it is preferable to carry out a load transfer and swap out the Plaquette for a dedicated lowering or raising system.

Transfers are straightforward providing that the live rope can be unweighted, say by the victim standing on a ledge, but in a vertical or fully weighted situation, a Temporary Ledge needs to be artificially created by the rescuer.

1. Put a Catastrophe Knot in the dead rope of the loaded Plaquette or clove hitch the dead rope into the anchor as a backup;
2. Attach a prusik onto the live rope and attach it to the anchor with a tied-off Italian hitch and the other end of the rope. Alternatively use the backside of a clove hitch attached to the anchor and construct the tied-off Italian Hitch on the prusik end. This creates the Temporary Ledge.;

3. Remove the Catastrophe Knot and ease the load onto the prusik. Replace the Plaquette with a progress capture device (eg Petzl microraxion®) for a raise or a tied-off Italian Hitch or lowering device for a lower;
4. Release the tied-off Italian Hitch of the Temporary Ledge and slowly ease the load onto the tied-off raising or lowering system.



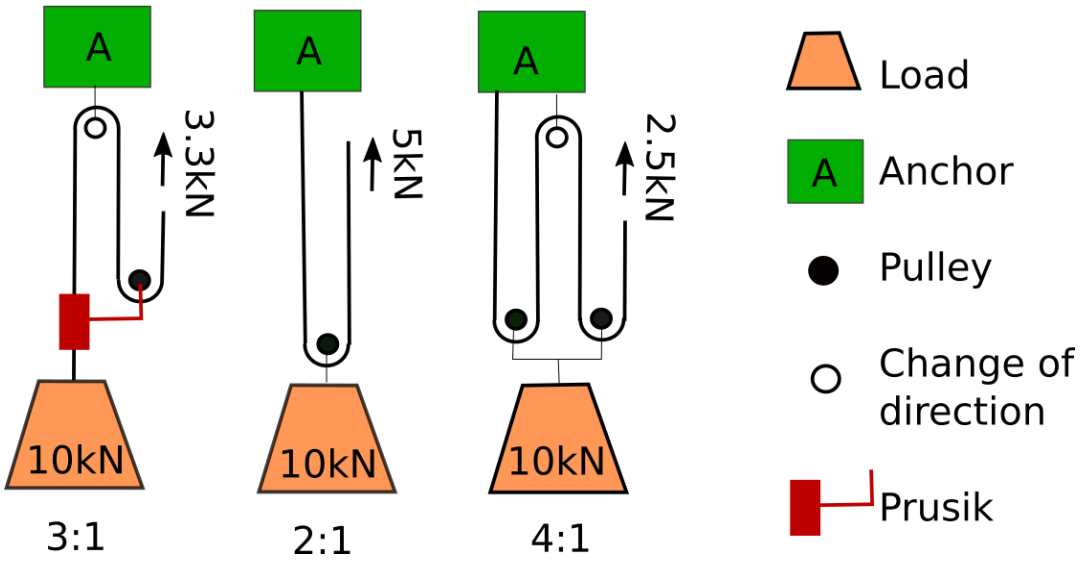
Load transfer from a Plaquette to 3:1 raise using a Temporary Ledge

Pulley systems

The aim with pulley systems is to use mechanical advantage to multiply the force of the pulling for raises. The force required to pull decreases it but increases the amount of rope that has to be pulled through the system.

This is the theoretical value and in reality, the effect of stretch and friction reduces the effective advantage significantly. Friction is introduced at any point where the rope is running through a carabiner along the surface of the snow. Friction can be avoided by making sure the strands of rope are running neatly, using pulleys on carabiners if they are available and excavating snow from under all the moving parts of the system. If pulley devices are available, they should be used in priority on any moving pulleys (those moving towards the anchor). If only one pulley device is available, this should be placed as close as possible to the hauling end of the rope so its benefit will be multiplied through the system to the load.

Pulley systems can be simple or compound. Simple systems use one continuous flow of rope.



Mechanical advantage of simple pulley systems

Mechanical advantage of simple pulley systems can be determined by:

- Measuring the distance the load moves relative to the rope being pulled through the pulley system.
- Counting the strands of rope in the pulley
- If the rope is fixed at the load end then the advantage of the pulley system will be odd (eg 1:3,5...). If the rope is fixed at the anchor end, the advantage will be even (eg 1:2,4,6..).

- Pulleys moving towards the anchor add advantage. If the rope runs through a carabiner or pulley and it doesn't move, it is referred to as a change of direction.

Progress capture

All pulley systems work best with a form of progress capture. This is a system that takes the load as progress is made, which means that the rescuer can take a break and the weight of the victim is taken directly on the anchor. Using an efficient progress capture will make the hauling easier and quicker. There are a number of different options for progress capture:

Progress Capture Device - These small devices (eg Petzl microraxion®) are the most efficient autoblock and highly recommended. A Petzl Tibloc® is a mechanical prusik that can be used for ascending a rope and can be used as an efficient and simple progress capture.

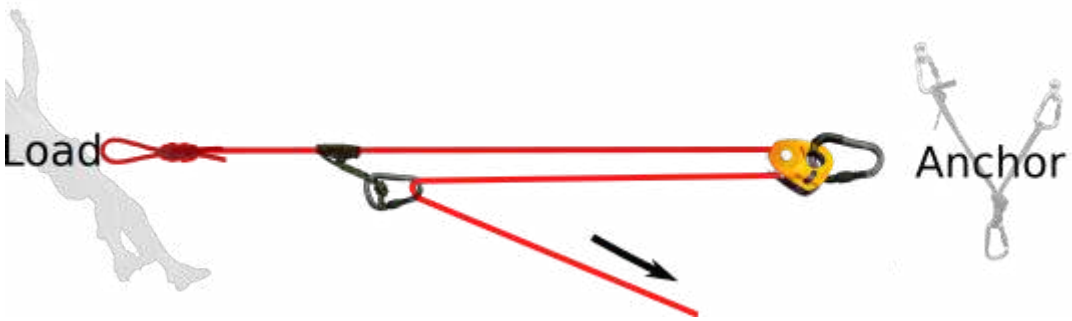
Prusik - This is a simple but effective autoblock. It is important to use a french prusik so that it can be bumped under load. Using a Prusik Minding Pulley (PMP) instead of the belay device reduces friction.

Using a Plaquette (eg Petzl Reverso® or Black Diamond ATC® Guide) as a progress capture introduces a lot of friction into the system and should only be used for smaller diameter ropes.

Simple raises

In the context of rock climbing, simple raises can be used to assist a second past a difficult section to get to easier climbing or for hauling equipment up a steep route..

If the belay is set up directly on the anchor with a Plaquette, it is easy to set up a simple 3:1 raising system. There is a lot of friction through a guide plate used in this way so if this hauling system is not sufficient then a load transfer can be used to swap out the direct belay to a more efficient progress capture or change to a more complicated hauling system.



Simple 3:1 raise

Downwards multi-pitch rescue

Whenever doing a downward rescue involving abseiling, always use a prusik backup system that places the prusik below the device. This way only one hand is required to abseil and the other one will be free to deal with the victim.

If the rescuer and victim are at the same anchor, it is possible to tandem abseil.

To conduct a tandem abseil:

1. Rope is set up as a retrievable abseil, ends are thrown with stopper knots near the ends or saddle bagged;
2. Abseil device is threaded onto rope, screwgate carabiner clipped in and done up. This carabiner becomes the Focal Point for both the rescuer and victim to attach to using their PAS. The victim's attachment to the Focal Point should be shorter than the rescuer's (half length is a good place to start) so that they sit above and can be manoeuvred by the rescuer;
3. The rescuer attaches prusik backup onto dead rope below the belay device and clips it to their harness belay loop. The abseil begins;
4. The next anchor is built (unless there is already an anchor in place and the rescuer attaches themselves and the victim so that they are hanging directly off it, with a releasable system. This can be backed up with slack PASs (care with shock loading). This way once the next abseil has been set up, the victim can be easily lowered onto the new abseil system;
5. The abseil rope is pulled and the next retrievable abseil is set up. PASs are removed and releasable attachments released onto the abseiling system.