VANCOUVER SECTION

ALPINE CLUB OF CANADA

BASIC MOUNTAINEERING COURSE

LEVEL 1

SYLLABUS & COURSE NOTES

This course is a basic level, introductory course. On completion, students should be equipped with the knowledge that will enable them to safely attend Vancouver Section trips that include snow travel. It is not intended to be an advanced climbing course. While some complex topics will be demonstrated such as crevasse rescue, the focus of the course is on basic skills to allow safe travel on snow and ice.

The attached manual provides notes and information on the topics that this course will cover. Please keep in mind that this is not intended as a comprehensive manual for alpine climbing.

Mountaineering techniques and equipment are constantly changing. However the content shows what is currently accepted as best practice.

The following topics will be covered:

Moving on Snow and Ice

- Assessing snow and ice conditions
- Walking with and without crampons in a range of appropriate conditions
- Use of an ice axe
- Step cutting practice
- Self arrest practice, with and without an ice axe.
- Rhythm, balance and secure footing

Rope Work and Belaying

- A session on rope work and knots including how to select and tie the appropriate knot for common situations - Figure 8 on a bight, Figure 8 on a trace, Clove Hitch, Italian (Alpine or Munter) Hitch, prussik knots, Alpine Butterfly, Tape knot.
- Demonstrations and practice of creating belay stances
- Pitching practice on moderate terrain
- The pitching calls and the importance of clarity of communication

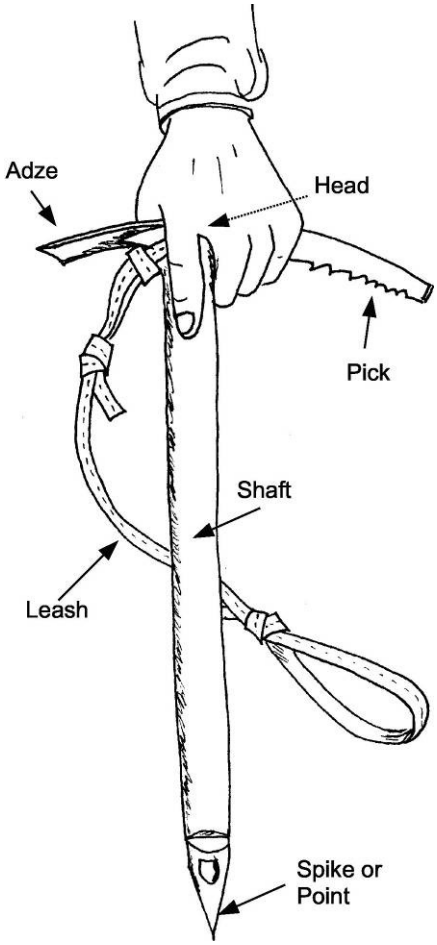
Snow and ice Anchors

- Demonstrations and practice for setting up the different types of snow anchors:
- Pickets
- T-Slot anchors
- Ice axe belays
- Snow bollards
- Ice screws (dependent on finding suitable ice conditions)

Glacier travel

- Discussion on glacier theory
- How to rope up including use of prussiks
- Crevasse extraction techniques (this will be covered depending on time constraints – a demonstration will be done, students will get to practice this if time allows.)

THE ICE AXE

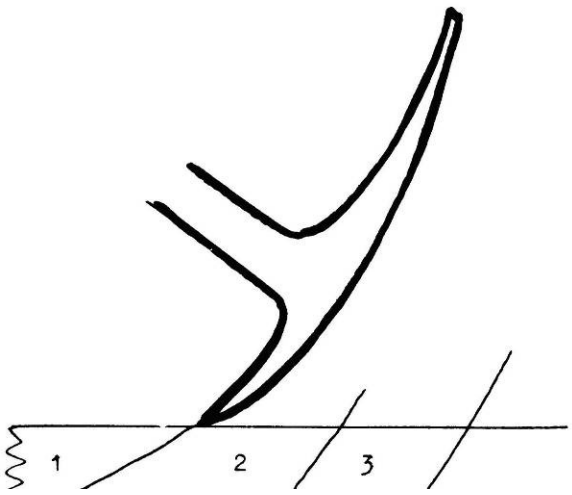


- Why carry an ice axe? It's a combination tool; a walking stick, used for self arrest, for step cutting, as an aid on steeper ground and as a snow anchor.
- Naming the bits - head, adze, pick, shaft, point, sling, teeth, pick shapes.
- Attaching the axe to your pack. Don't transport axe attached to your pack in cars or aircraft; carry it/them separately.
- How to hold it. For walking, carry the axe as shown in the drawing with the pick pointing behind.
- How to use it. Should always be carried in uphill hand.
- Different axe sizes, styles and pick shapes will be discussed during the course.
- Care. Although built tough, axes should be treated with care. Clean and dry before storing, clean off any rust. Replace sling when worn. Don't sharpen with power tools (heat can damage temper of the steel).

STEP CUTTING

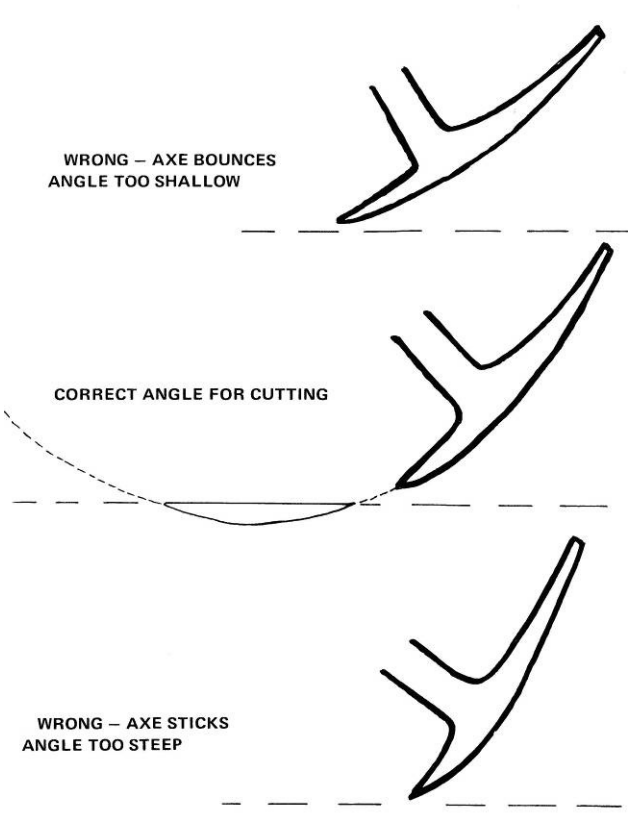
In the modern world one might have thought step cutting was becoming obsolete. BUT step cutting still has its part in our climbing careers. What happens if your crampons fail, or are lost, or you've got to guide some inexperienced people out of trouble. Also, the skills learnt here will bide you well for cutting belay stances.

- Use the leash so you don't loose axe.
- Rhythm, Balance And Secure Footing are essential.
- First cut close to you, then cut away, so spoils will break into spare space.
- Angle of incident very important on hard conditions otherwise axe will bounce off, or the adze will get caught in ice.
- Ideal axe is longer, has a heavy head, and has flat profile adze.



Up

- Start 2 handed, 2/3 blows to make platform
- Drop shoulder, place axe before swinging (just like addressing a golf ball before you swing)
- Maintain a RHYTHM, conserve energy
- Cut in a swinging motion
- Cut with purpose, but not aggression (conserve energy)
- Try one handed, one slash steps
- Step should be level and at right angles to fall line.
- Step should be big enough to accommodate whole foot.
- Do not cut them too far appart. Test by walking down them.

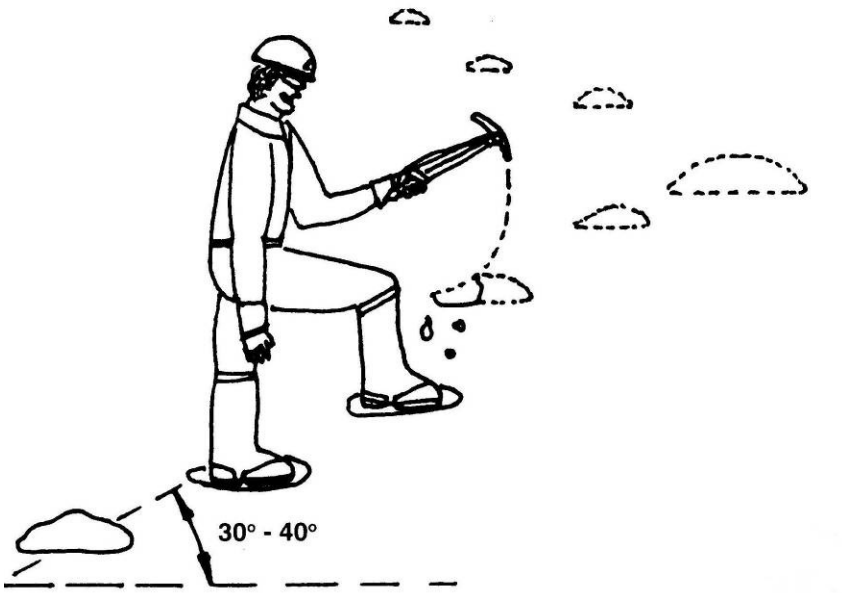


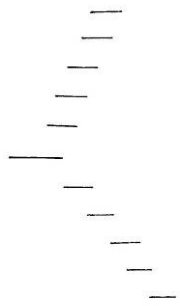
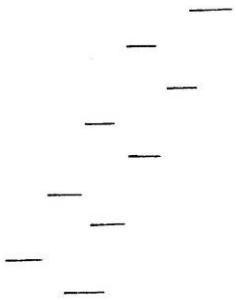
Down

- Try to cut in a direct line
- Shuffle rather than cross feet

Options.

- Cutting single line
- Cutting in pairs
- Different for cutting pigeon holes
- Try seeing how your technique changes with different angle slopes.
- Cut an extra big step at turning points.
- Make belay platforms large enough to put both feet in easily



Step Cutting Patterns		
		
Cutting single steps at a time Used on moderate ground.	Cutting steps in pairs. Used on steeper ground.	Cutting hand and toe steps on very steep ground, like pigeon holing.

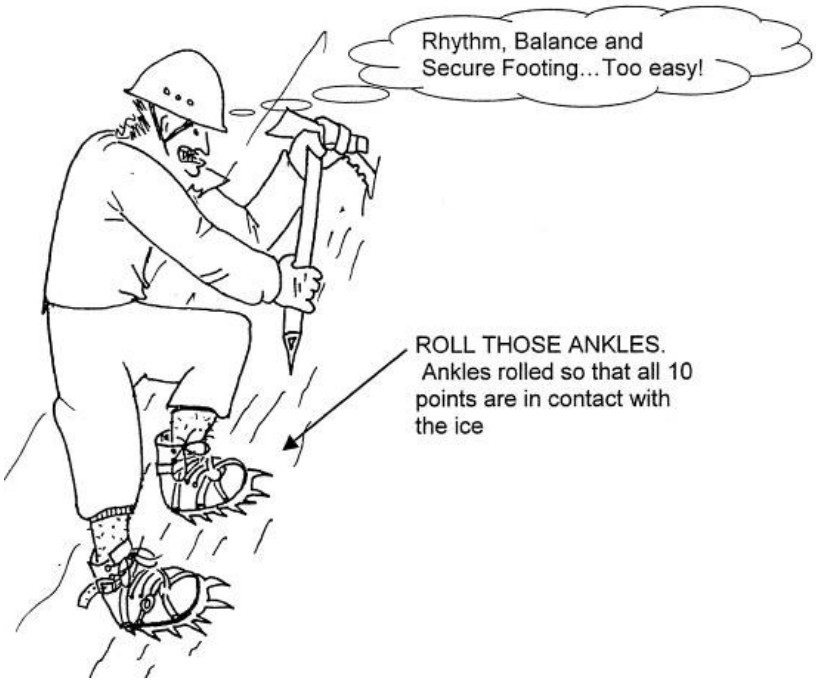
When the ice is too hard for the adze to penetrate, try cutting out the steps outline with the pick. Then use the adze to break up and remove the balance of the spoil.

CRAMPONING

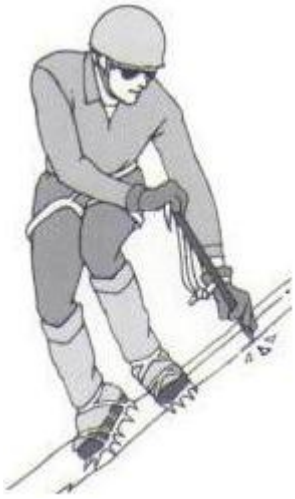
There is nothing like walking on ice with crampons. After your step cutting session you will quickly appreciate the merits of crampons.

Unfortunately crampons bring a new series of risks with them. They are sharp and seem to spend their time looking for the unready water bottle or expensive gore-text coat to puncture. They also lengthen your legs making it easier to trip up on them. Getting them caught on the other foot is very common, either on a crampon strap, boot lace, or loose clothing. So it pays to keep your pants or overtrousers tucked away in tight fitting gaiters, and walk with your legs a bit further apart in a “John Wayne” fashion.

The other problem where you can get into trouble with crampons is not getting the fit right. This is best done at home, before you reach the mountain for it can become very difficult adjusting crampons on the mountain, in the middle of the night in a blizzard. They should fit snugly and be easy to put on and take off. Practice at home is a worthwhile investment.



Watch for changing snow conditions, particularly late in the day when the sun has softened up the snow and it starts sticking (balling up) to your crampons. This is very disconcerting, and potentially dangerous. A well timed tap with the base of the ice axe will cause this snow to drop off. You should probably be reviewing the need to be wearing crampons if you’re experiencing this problem.

Technique	In use	Comments
Pied a plat (flat footed)aka the French Technique		Using as many points in the ice at once in a flat footed technique. Involves rotating the ankles to make this happen. Elegant looking technique which requires considerable mastery. Not as stressful on the body as one may imagine, but may feel disconcerting at times.
German Technique aka Front Pointing		Using the front points only either the two sticking directly out of the front, or the four (2 horizontal & 2 vertical) front points. Very strenuous and best used only on the steepest ground.
American Technique *(**Please note** that drawing to right is incorrect. A foot should be horizontal to be a true representation of the American Technique)*		This is a combination of the two, where one foot is placed facing directly into the slope using the front points in the German style, while the other is at right angles to the slope and the ankle is rolled in the French style. Used on long moderate angle faces. You can alternate the styles on the legs to rest a leg (French technique leg) at a time.

The French Technique developed further

There are several subsets of the French technique which are dependant upon the angle of the slope, the direction of travel up/down the slope, and your own confidence level. It is worthwhile practicing all these techniques without the assistance of your iceaxe, as this forces you to learn how to use your balance, and develops trust in the crampons holding ability.

Flat Ground. Yes you will sometimes find crampons of great assistance on flat ground. They will give you the missing traction. But remember to keep your feet further apart than usual, and to step higher than usual to compensate for the length of the spikes. And watch out for tripping on the front points if you lose concentration. Don't be tempted to bend your soles when walking, your rigid boots/crampons might not allow it. Try walking flat footed instead.

Achilles Ground. As you transition from the flat ground, at first you will be able to keep your feet parallel, which works fine to the point that your Achilles tendons are stretched to their full extent. This point varies considerably with people, subject often to their fitness and flexibility.

Herring Bone Ground. As the ground steepens you should splay out your feet, a little at first, but even more as the angle increases. You will end up climbing in a herring bone fashion. You will probably have to start rolling your ankles a little so to keep as many of the vertical points in the ground as possible.

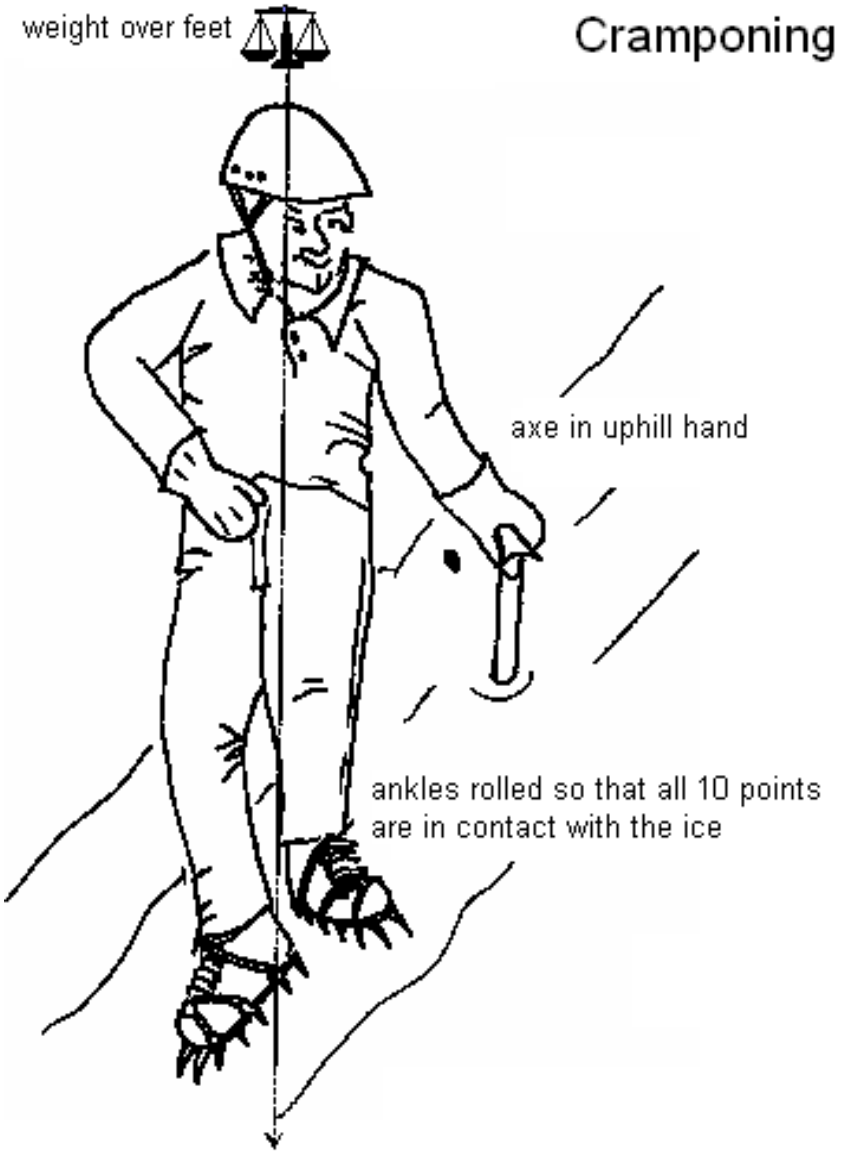
Push those hips out to get the balance over your feet.

Crab Ground. When the herring bone is no longer doing it for you, and the achilles are starting to complain just a little you move into the next technique, where you turn side onto the face and start making a zigzag route up the slope at a 45° angle. Both the feet will be at right angles to the fall line, but you will start rolling your ankles significantly to maximise the number of points in the ground. It is important to make sure that you are upright in a balanced stance. Leaning into the slope will make you feel very uncomfortable, plus put an undue strain on the crampon adherence with the ice. You walk in a crab like fashion crossing over your feet. Do not be tempted to edge on the top edges of the boot/crampon. This is dangerous and increases the risk of failure as all the force is being concentrated on a small section of ice. Enjoy the ankle rolls.

The Broken Footed Crab. You'll understand why it's called that. As you are probably guessing, by now, you can even climb steeper ground. As the ground steepens the bottom foot starts to point down the slope, eventually pointing directly down the fall-line at the

extreme. Remember to continue rolling the ankles particularly on the top foot, and avoid edging it. Any steeper and you'll probably be considering either the American technique or using the front points.

Constipated Duck Technique. Just when you thought you'd mastered it all, we now have the issue of descending using the French Technique. Face directly down the slope, toes point directly down, with legs well splayed. Then as you walk straight down the slope you bend the knees so that your bum is directly over your heels enabling you to retain your balance. All crampon points, except the front ones, will be in the ice. You will be surprised by how steep a slope you can descend in relative comfort. Unfortunately because you are facing out you might find it rather disconcerting, but the answer is to TRUST your crampons.

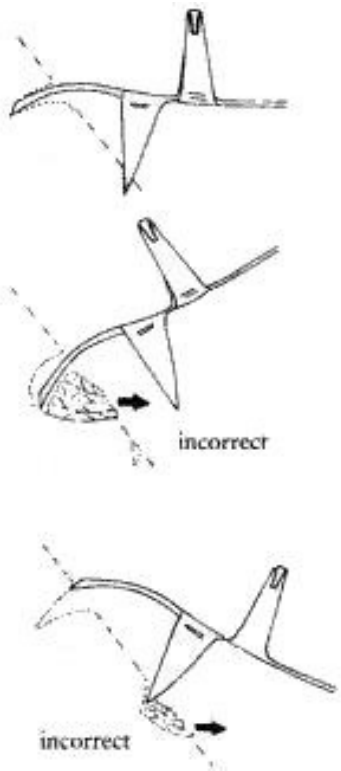


Front Pointing

The steeper the better. It is surprising what you can climb when you get on your front points. Good technique is essential for it to be enjoyable. Bad technique is reflected in the dreaded leg shakes, complaining Achilles', and aching arms. The key thing is getting your feet right. The feet should be 400mm apart. The soles of the feet should be horizontal, or the heels slightly dropped. Do not lift the heels above horizontal, as this will change the angle on the front points, meaning that they'll fracture the ice easier. We do not walk up stairs on tip toes, so you do not need to tip toe when climbing ice.

The feet are placed with a firm swing from the knee. Do not be tempted to kick into the ice hard. Arrange your body in a balancing position directly above your feet. Do not lean into the mountain, and avoid leaning out from the slope. Do not extend the arms above the head unless it's required.

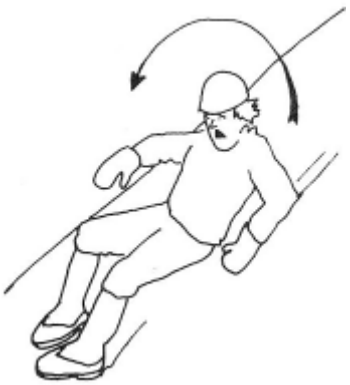
The photo below shows the perfect position on near vertical ground.



SELF ARREST

Self arrest is one of the most essential skills you should learn for travelling on snow. It is the back-up plan if you slip and start careering down the slope at an ever increasing speed. The best idea is to ensure that you never fall. But in the unlikely event ……., this section gives you some skills. Falls generally occur with a lapse of concentration, so the more alert you stay…

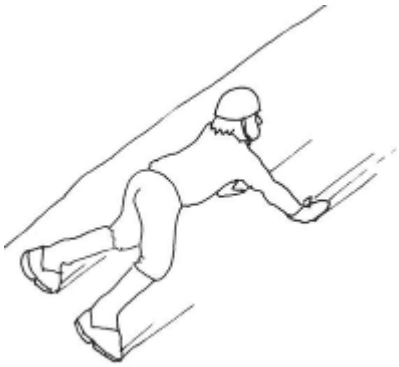
Arresting without an axe



Compose yourself.

Roll over until face down.

Spread legs for stability.



Spread arms and legs into star pattern.

Lift body off snow, maintaining contact with hands and feet only.

Keep hands and feet well appart for stability.

Point your toes into the slope.

Never never give up.

You will appreciate that there will be a great deal of friction on the snow because all you weight is distributed over the four points of contact. Having gloves on will save you a great deal of pain, if not cold hands.

In soft snow you can get some excellent results. In extremely soft snow you could form a large scopping shape with your arms which will enable you to gather as much snow as possible.

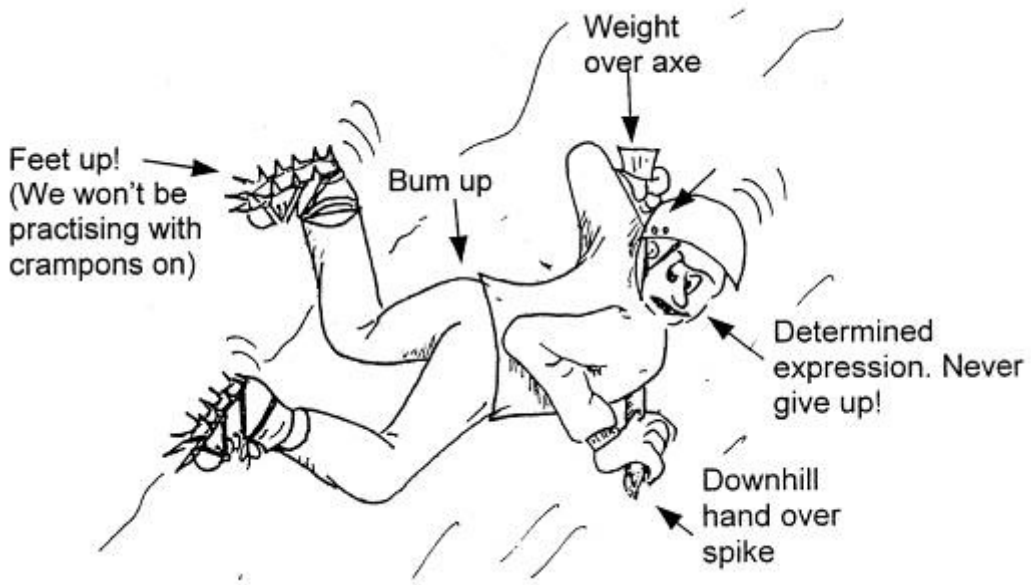
It this is failing to work, and you are wearing a pack, you can roll onto your back and try to get the pack to dig into the snow.

Ice axe Plunge

The ice axe comes into its own for self arrest. It is even more useful if you know how to use it, and have the

composure to use it correctly. The time between you losing your footing, and full flight in a down hill direction is only a fraction of a second. So be alert at all times, and regularly work through the actions in your head as to what you'd do if you slipped.

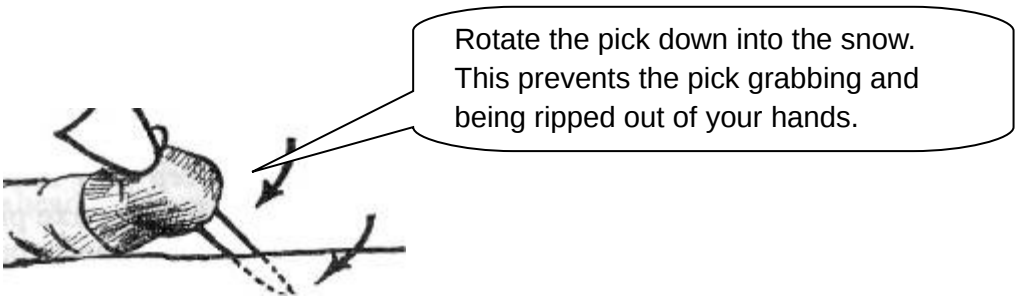
The best technique is to plunge your iceaxe into the snow, holding tightly onto its head (with both hands if possible). This has to be an instinctive movement. The key aspect of this technique is that you get a secure purchase of the mountain with your axe before you have achieved too much ground speed. The big disadvantage is that you might not be able to hold onto the axe during the fall, thereby leaving the axe behind.



Try the technique going straight downhill. The key is to have your hand right over the head of the axe and plunge it into the snow beside your hip.

Some basic safety rules

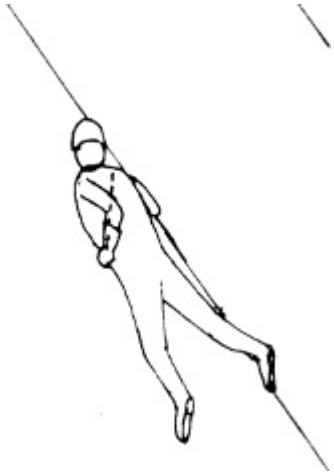
Yes I know its hard to remember everything when you're taking a big skid. First, crampon points (the front ones) can dig into the snow which will either result in a cartwheel, or a twisted ankle. Do NOT practice self arrest with crampons on, but practice as if wearing them. So bend the knees to raise you feet off the ground. Please be carefull falling onto your ice axe. We do not want chins cut with the adze. Keep an eye on the base of the shaft and don't let it dig into the snow, or impail you in the guts. Hold onto your ice axe, we don't need it acting like a javelin. Keep an eye on your runout area.



Self Arrest

Put top hand over top of head of adze. Adze head should be positioned under same side shoulder as the hand over the adze head. The other hand is holding shaft base firmly. When lying face to snow, the head of the axe should be sitting flat on the slope. The pick should be pointing across your chest. The diagram to the left is misleading on this aspect.

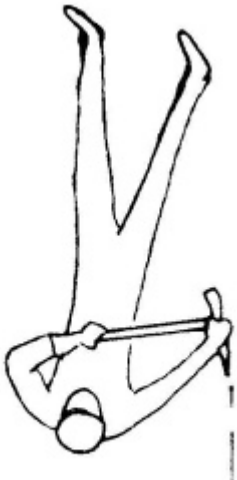
Roll the head of the axe into the snow. So if the axe was under your right shoulder, then the rotation of axe is clockwise. Anticlockwise for the left shoulder. Slowly rotate the pick into the snow, making sure that you keep the end of the shaft up, which will prevent it from catching in the snow. If you had started on your back you will have to roll onto your front.



Keep legs apart to increase stability. Force down with all your might onto the axe. It's position would have migrated to the centre of your chest by now. Arch the back to increase the force being applied to the adze head. If you are wearing crampons, bend the knees to keep the front spikes from catching.

Keep at it. Never give up.

Head First on your back Self Arrest

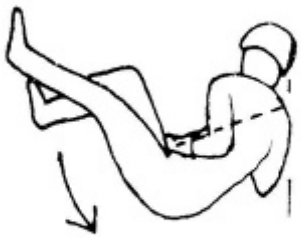


Compose yourself. It may feel a little uncomfortable at first.

Place iceaxe across your body, placing the pick into the snow, lightly at first.

Remember that the other hand should be at the shaft base.

The friction from the pick will start a rotation of your body around the pick.



As rotation occurs roll onto the head of the axe.

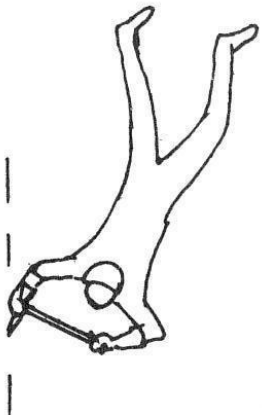
This is easier than you expect.

Lift the base of the shaft into the correct position as you learnt in the first example.

Move into full self arrest position.

Keep at it. Never give up.

Head First on Front Self Arrest



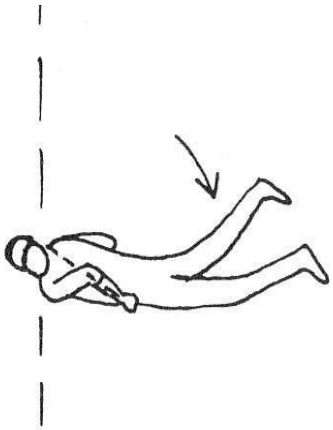
Very difficult to commit yourself to it. It's not natural to slide down the hill like this.

Get somebody to hold your feet while you get into position.

Holding iceaxe with one hand over head, and other at the base of the shaft.

Hold axe at full arms length in front of you.

Slowly create friction with pick.



The friction will create a rotating movement.

Let you body rotate around the pick.

Keep pressure on pick.

As you rotate move your body weight over the adze.

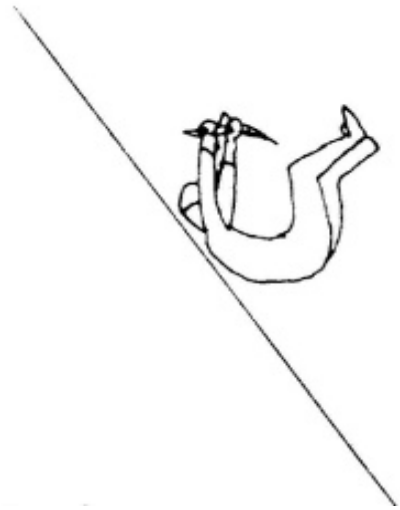
Finally resulting with the adze head under your shoulder and into the self arrest position.

Forward Roll Self Arrest.

Very difficult to commit yourself to it. Doing forward rolls down a hill with an ice axe is not a natural activity.

First cut a platform to start from (unless you're falling off the mountain of course)

Forward roll



As you roll open out your legs. Like opening a clenched fist.

This flattens out the body and stops the roll.

It has to be done early before too much momentum is gained.

Once you've flattened out, compose yourself.

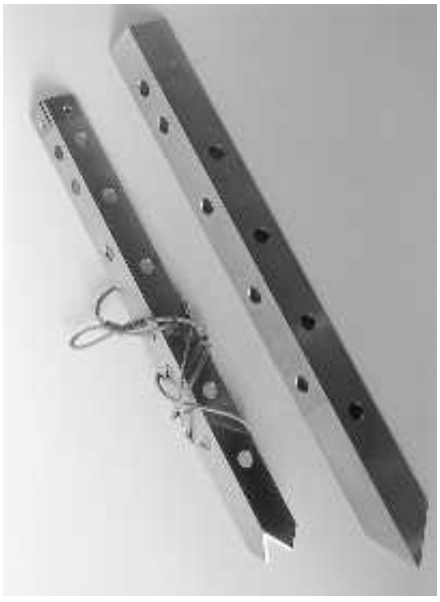
Place the ice axe across your chest, with one hand over the head and the other at the shaft base.

Start rolling into the self arrest position.

SNOW and ICE ANCHORS

The subject of snow anchors is one of great change particularly over the recent years. Development is still going on as climbers better understand the attributes and merits of the various types of anchors and the snow. The critical rule here is to use the best anchor for the prevailing snow conditions. This means that one must have a good understanding of snow structures, and the snows relative strength for each type encountered prior to selecting your anchor.
Most of the belaying principles already learnt apply to snow anchors, namely:

- Belay as low as possible below the anchor (at least 1.5mtrs below)
- Use the body to absorb load as part of the system
- Use as many anchor points as justifiably possible
- Ensure load is evenly distributed over your anchors
- Arrange so that load is not distributed over an angle greater than $60^{o,}$
- Design anchor to best handle direction of load



Snow pickets are the first tool in the arsenal of the climber for snow. Generally they are T section aluminium alloy, usually 60cm in length. You can get “V” section alternatives. A strop of either climbing rope, climbing tape or wire rope is attached to the picket’s head. Ideally the attachment point of the strop can be relocated from the picket’s top to the middle (balancing) point. You can improvise a picket in some situations by using a number of other tools, like avalanche probes, ice axes, skis, ski poles, pack, packed tent, your climbing companion (not wise). One has to be aware of the relative merits of each of the picket’s placement options.
When working with snow anchors try to consider the snow conditions in order to create the greatest holding power possible. It is desirable to achieve 10kN, or more, bolding force from the snow. The strength of an anchor is hard to judge. Testing has shown that the picket will fail (bend) at around 13Kn. By

introducing a belayers body into the system one can potentially remove 3Kns of force from the anchor. By the way, climbing ropes are designed to take 12kNs, which is about the maximum the human body can handle.

As a rule of thumb, hard snow (almost ice) will give you over 10kNs, while soft unconsolidated snow with the best anchor available will provide a holding power as low as 3kN. A climber falling on a 45^{o} slope will generate between 4kN to 8kN of force. Top roping falls, or an abseil is equal to between 2kN to 3kNs. You can subtract 2kNs off the anchor desired strength by putting a belayer (firmly placed on a stance) into the system. The problem that we have is to balance the holding power of our anchor against its possible loading.

It has been shown that by compacting snow in front of an anchor will almost double its holding power, but this is subject to the type of snow you're working with.

Please remember that the placements as described here are only designed to take a downward load. An upwards load will result in the picket popping out like a champagne cork. We have two methods of assessing the snows holding ability for anchors.

Remember that the holding power may be improved if the snow is compressed around the anchor.

The following technique enables you to access the ability of the snow to be compressed.

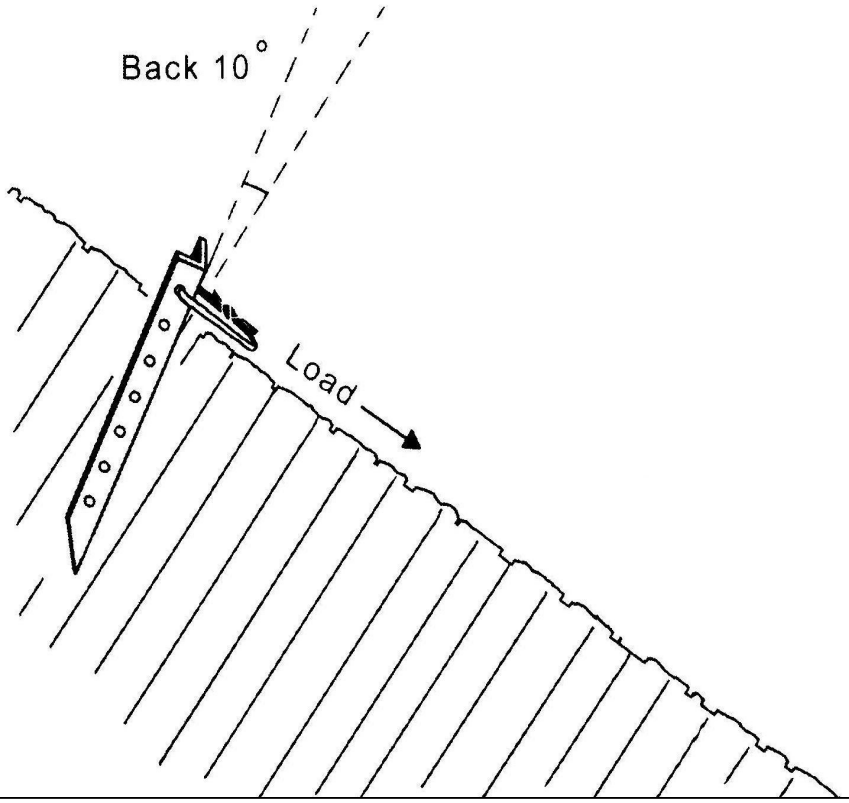
Assessing the snow conditions, and therefore its holding power, can be achieved by taking a generous handful of snow, and compressing it, then destroying it. The following table summarises these two tests, and gives some useful names for the different snow types.

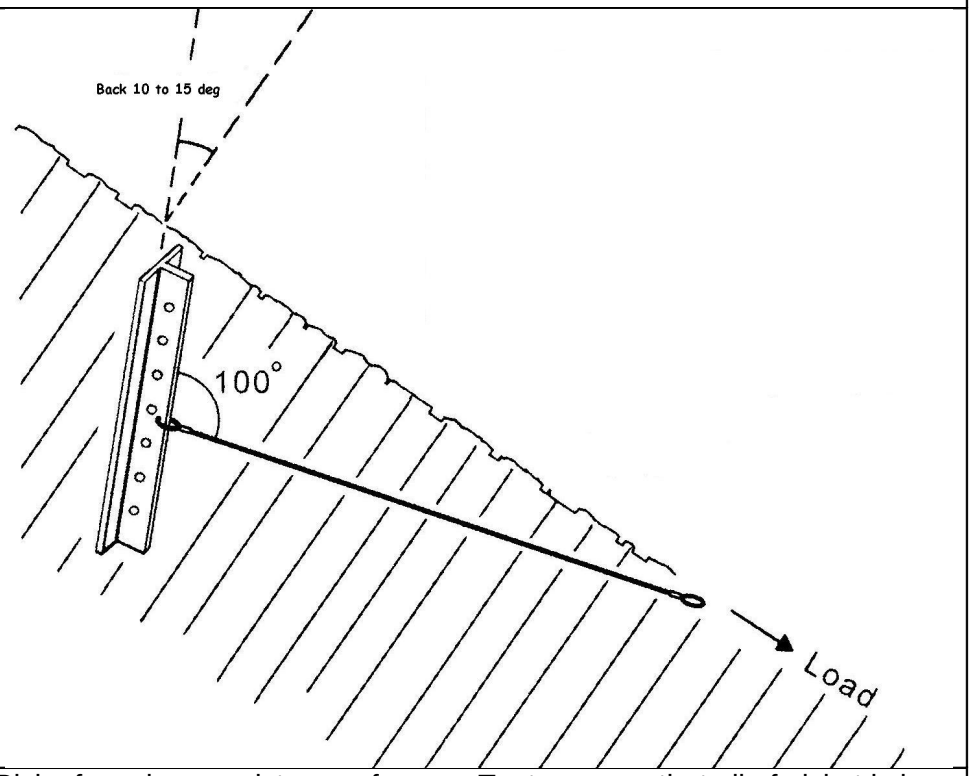
Hardness	kN range	Suggested Anchor
Knife	40kN	Top Clip
Pencil	4kN to 40kN	Centre Clip, T- Slot, Snow Pig
1 finger	1kN to 4kN	T- Slot, Snow Pig
4 finger	< 1kN	Snow Pig (poor)
Fist	Insignificant	less than poor, don't bother

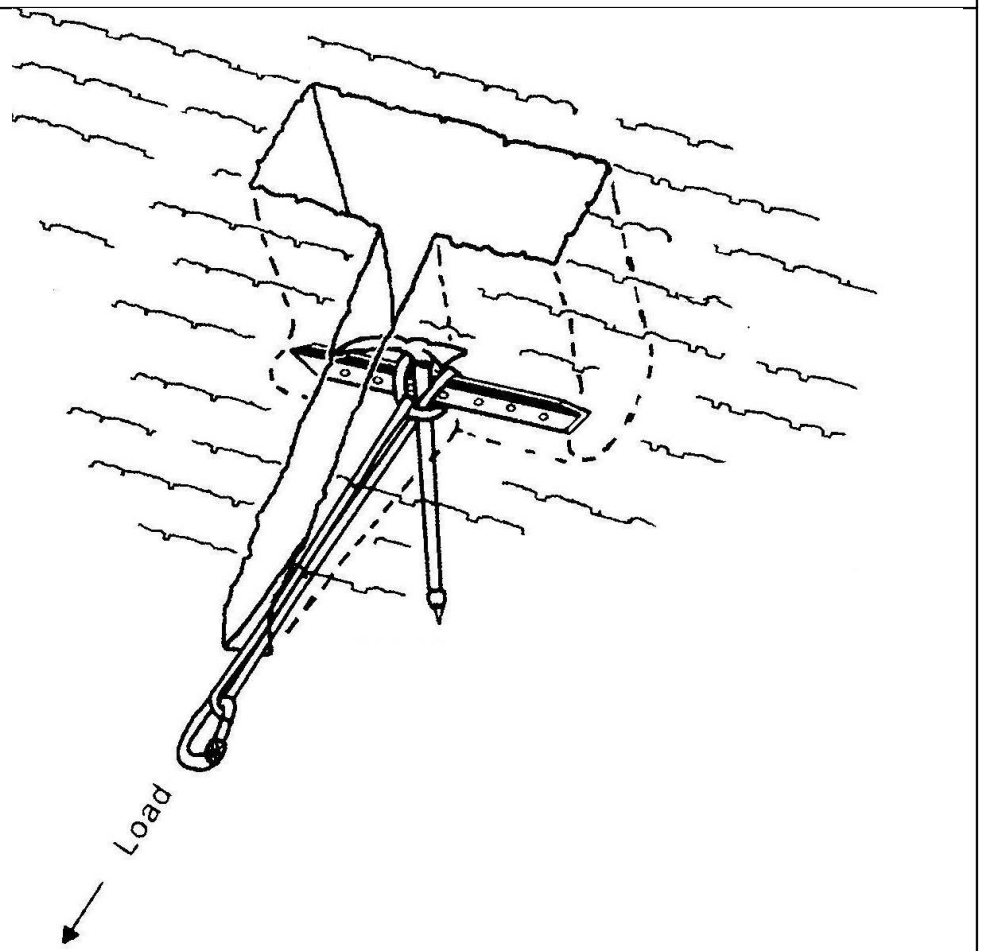
One final point. Do not get blinkered by pickets. Remember that there maybe other alternatives to belay from, like the rock face which is only meters away. If conditions are marginal, use any of the soft snow anchors as your last alternative.

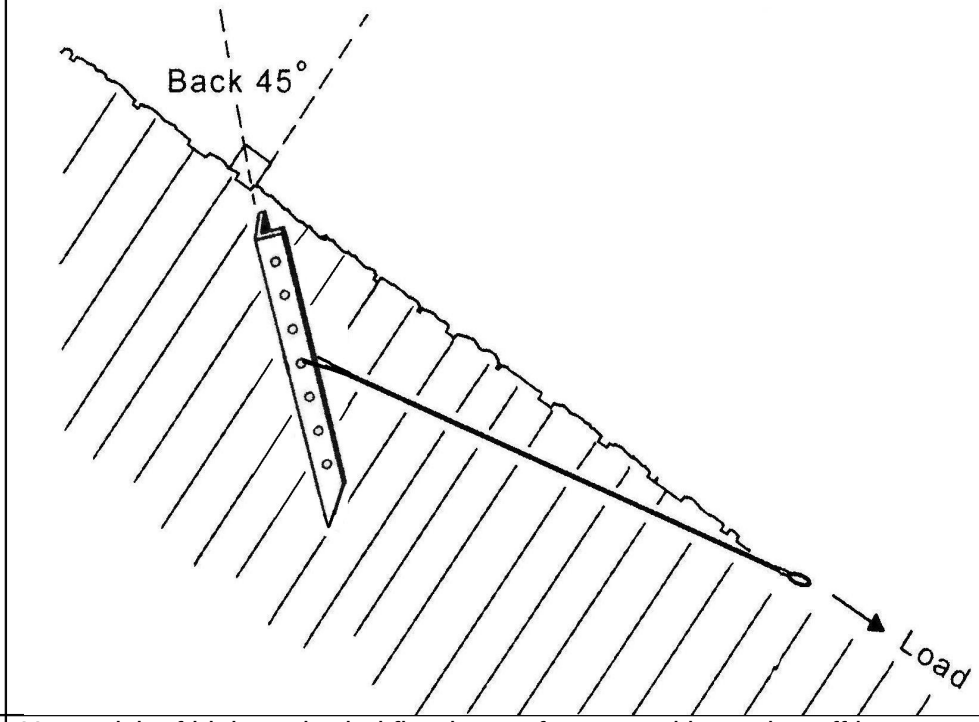
Compression/Destruction Tests

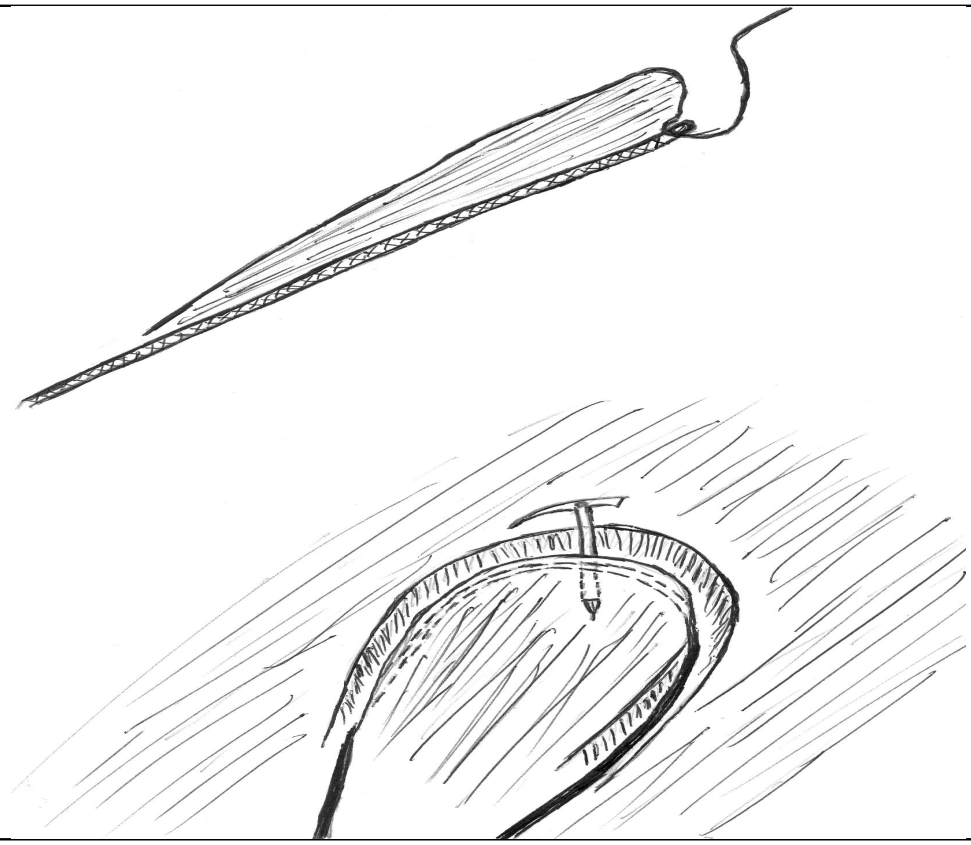
Snow Type	Collection Test	Compression Test	Destruction Test	Merits
Ice	Ice axe to chip out blocks.	No way can you compress it.	Broken with your ice axe only.	Bloody good if used correctly.
Hard & Fast	You'll probably need an iceaxe to chop out a sample.	This will be too hard to change its shape.	You'll be lucky to break it. You'll probably end up with a sore hand trying.	This is good.
Firm & shatters	Some quick cuts with the pick of the iceaxe will enable you to have a block.	You'll have something that looks like a slab and will not compress.	A karate chop will cause it to shatter, often fracturing between its strata.	This is OK, but you may have to choose your anchor according to the underlying conditions.
Hard snowball	You will be able to collect a sample with some scraping of your gloved hand.	Pressing it together will produce a solid snowball. The snowball is darker in colour, and the volume of the snow is reduced.	Hitting it with your hand will hurt your hand, or cause the snowball to deform, or even fracture.	This is good "compactable" snow, and it is recommended snow should be compacted.
Soft snowball	This is relatively easy to mine the snow	When compressed it forms a good round shape. The colour of the snow does not change.	The snow ball will shatter easily. In some cases it may have started to self destruct.	It is possible to have an effective anchor, but requires planning and care in its construction. Have a go at compressing it first.
Wet warm slush	This is yucky to scrape up and blobs in the hand. It has the consistency of wet sugar.	Squeezing it will produce water and a wet glove.	The resulting mass will destruct with little encouragement	Hard to establish an anchor with a large deeply buried T-slot.
Fresh	Easy to harvest, and sits on the hand like an impressive sand castle. It's probably snowing while you're conducting the tests.	It may be compressed, but retains its original colour.	If a snowball is created, it is easily destroyable; otherwise it may self -destruct.	Ideal for throwing, and can be used for some types of anchors. Using a deeply buried T-Slot
Cold & Fluffy	You'll find that the snow falls through your fingers as you pick it up. It's probably cold and you're standing up to your knees in it.	Impossible to compress. it has no substance.	If hit with the other hand it will probably fly away in the wind.	Any anchor is token only.

Anchor Type	**Top Clip**
Conditions	Hard & Fast & maybe firm & shatters
Placement	Strop is at top of picket. Picket is 10^{O} to 15^{O} back from perpendicular to slope. It will take a dozen good blows of the hammer to drive it home. V is placed pointing downhill. Belay at least 1.5 metres below picket.
	
Risks	Underlying snow may not have the same consistency. Watch for layering. This will be noticed when hammering in. Most force is on top layer of snow and point end of picket. Essential that they are in the best snow possible.

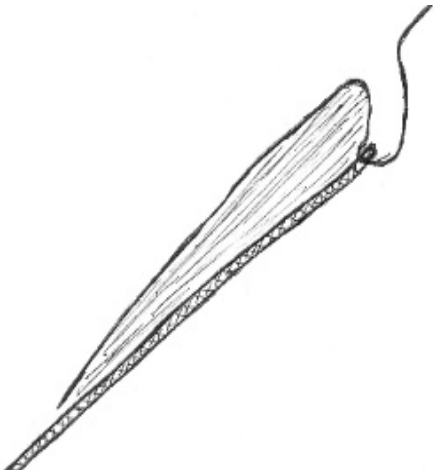
Anchor Type	**Mid Clip**
Conditions	Firm & shatters. Difficult to place in Hard & Fast as considerable digging maybe required.
Placement	Strop is at top of picket. Picket is 10^{O} to 15^{O} back from perpendicular to slope. It will take a dozen good blows of the hammer to drive it home. V is placed pointing downhill. Belay at least 1.5 metres below picket.
	
Risks	Risk of varying consistency of snow. Try to ensure that all of picket is in firm and consistent snow. The greatest holding power is at the centre of the picket. Snow may need to be compacted. Make sure that the trench for the strop causes minimal disturbance to the snow.

Anchor Type	**T-Slot**
Conditions	Most universal of all the techniques. This could be considered for most snow conditions except the softest.
Placement	Dig a trench at right angles to the slope. It should be deep enough to find a firm layer of snow if possible, or at least 50cms. Dig deeper if the conditions are poor. Dig a slot for the strop to form the “T”. The strop should be placed in centre of picket. Place the picket in the slot, V pointing uphill. Belay at least 1.5 metres below picket.
	
Risks	The snow may need to be compacted below the slot to increase its integrity. Watch for buried soft snow layers. Additional holding power maybe gained by pinning the picket in place with iceaxes. Alternatively you could replace the picket with a pack.

Anchor Type	**Snow Pig**
Conditions	Soft Snowball to Fresh
Placement	Place strop at centre of picket. Place/bury at 45^{O} back right angle to slope. This works on the same principles as a ships sea anchor. The pig will dig its way into the snow when a load is applied. It should be seated with a tug. V should be pointing uphill. Belay well (metres) below picket.
	
Risks	Has a risk of hitting a buried firm layer of snow and bouncing off it to softer snow. The system is dynamic which may be disconcerting. Picket may move a metre or two under shock loading, so belay to compensate. Its strength is that it digs in under load.

Anchor Type	**Bollard**
Conditions	Hard & Fast to soft snowball
Placement	Cut a horseshoe (open end down) in snow. Size is subject to snow conditions, but could be between 300mm to 2 metres. Place rope around bollard, ensuring that the load will be evenly placed on full extent to top curve.
	
Risks	Not recommended for anchors for belaying, as the bollard will not handle shock loading well except in the ultimate of conditions. Generally used as rappel anchor. It is recommended to use with a backup.

More on Bollards



Bollards are an effective method of getting off the mountain quickly (rappelling). They can be quick to build, and flexible as to their positioning. The critical issue is that you must build enough structural integrity into the bollard to prevent it from failing under loading. When rappelling the loading you are using is considerably less that the shock loading which an anchor receives from arresting a fall. Theoretically you should construct one to take a 100 kilos (bodyweight with pack), but it is prudent to build in a substantial safety margin. The quality of the material is critical to deciding on the bollard's girth. In good quality ice it will be possible to dig one as small as 20cm to 30cms in width. But in soft

conditions 2m or even 3m may be required. Compacting the snow inside the bollard is advisable if conditions permit.

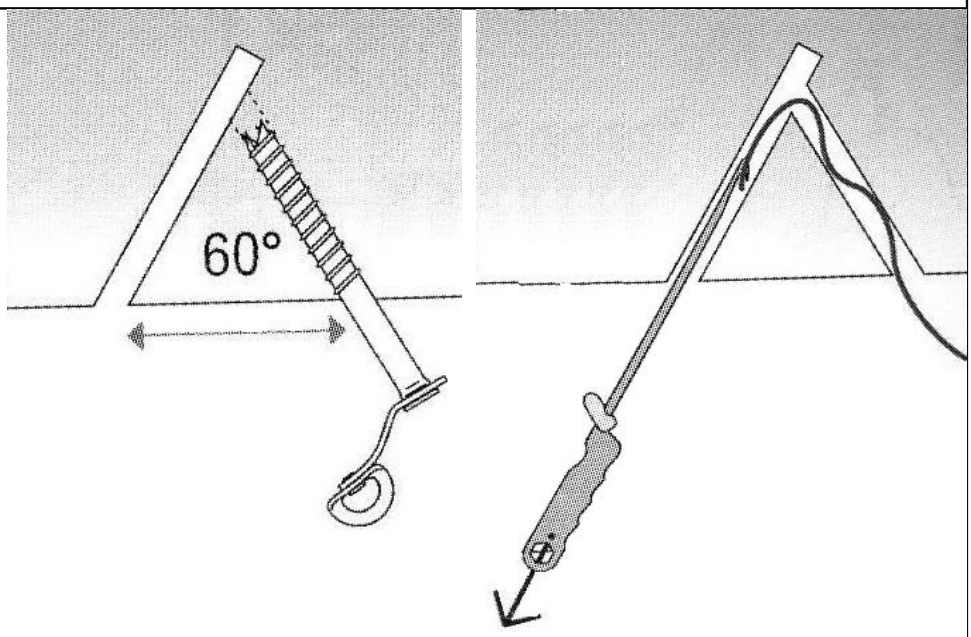
The curve of the horseshoe should be consistent so when weight is applied to the rope, it will be distributed evenly throughout the circumference of the curve. The bollards shoulders are generally the part where the rope cuts, hence reducing the holding power of the crown, which will eventually lead to failure. The depth of the bollard is dependent upon the strength of the snow layers. It is desirable to use any firm/hard layers that you uncover when forming the bollard.

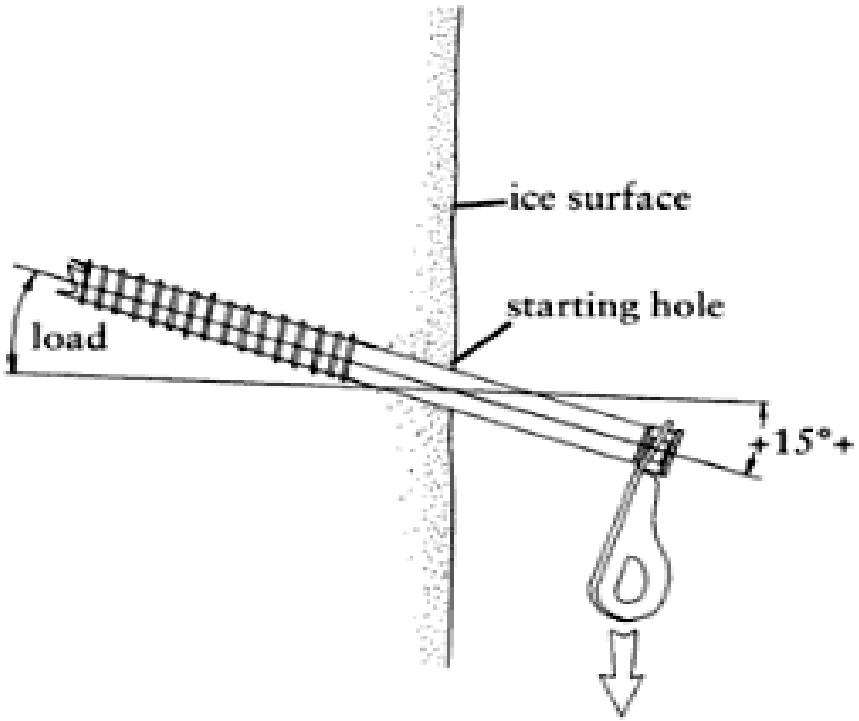
Use your fingers to form a groove around the top arc of the bollard for the rope to sit in. Place the rope around the bollard, checking that it is sitting evenly. With a gentle sawing motion of the rope cut a small slot into the bollard. This will melt the snow with the friction of the rope, which will immediately freezes into an icy lenses, thereby adding more strength to the bollard.

It is advisable to backup bollard with an ice axe or alternatively karabiner, sling, and snow picket.

Standing well below the bollard you can commence the abseil.

The last person down may wish to remove the bollard's backup if the bollard has proven itself as safe.

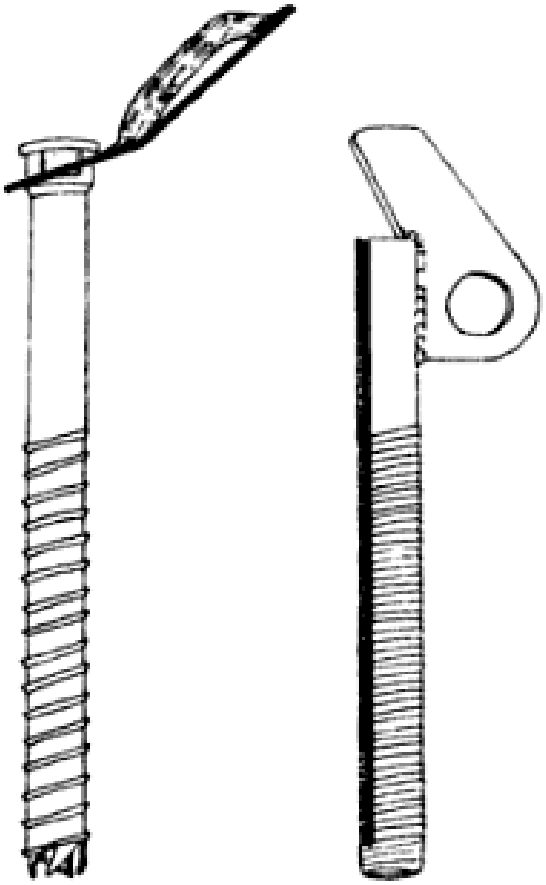
Anchor Type	**Abalokov Thread ("V" Thread)**
Conditions	Good quality Ice. Holes drilled 15cms apart have a strength as much as 10kN in good conditions. Ideal for abseiling off a mountain. Only used for belay anchors in conjunction with other anchors.
Placement	Using your longest ice screw, drill two holes at 60° angles so they intersect. This takes some skill to get you holes to line up. The holes should be 150mm to 200mm apart. Threat a 7mm cord (or 12mm tape) into the back of one hole. Use a hooking tool to grab the cord from the other hole, and pull through. Tie the cord securely about 350mm out from the ice 
Risks	The ice is surprisingly strong, but the strength is dependant upon the ice's temperature, and the weaknesses in the ice. It is recommended to back up the thread with other anchors.

Anchor Type	**Ice Screw**
Conditions	Good Quality Ice
Placement	Chip a small starter hole with axe pick. Screw in at a 15° inclined angle Screw in to hilt.
	
Risks	The depth of the ice. Ensure that the screw is driven fully home to optimise holding power. Hollowness of the ice. It is not uncommon for the ice to be just a top layer, and under it is either snow, or air. Solidity of the ice. When placing a screw there should be plenty of resistance and you have to work to screw. The ice may not be adequately attached to the mountain, like in the case of an ice pillar.

More on Ice Screws

There is a great deal of pleasure in a well placed ice screw. They can be very secure, and very versatile, plus can add significantly to what would have been an otherwise frightening climb. They can be easily poorly placed so some care is required. The quality of the ice is paramount to the holding power.

There are two types of ice screw: Screw in type and the Hammer in, Screw out type. Both provide excellent holding capabilities in good quality ice well in excess of our 10kN benchmark.



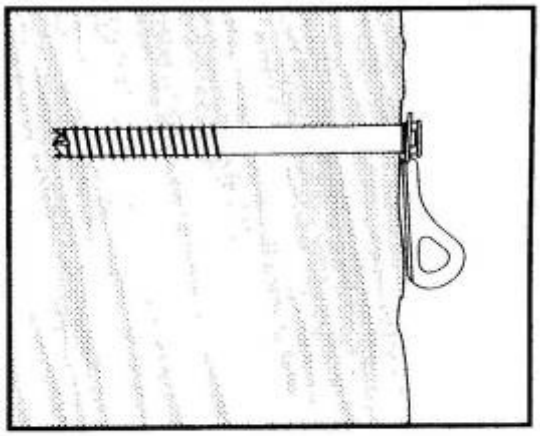
Screw in & Hammer in, Screw out Ice Screws

When you first arrive at the spot where you want to place the screw, first secure yourself, by either cutting a stance, or clipping yourself onto a firmly placed axe. You may require one or both hands free to do this exercise. Retaining balance can be hard on the steepest of ground. You should aim to place the screw at waist to chest height to your right (if right handed). Usually novices are tempted to try to place the screw above ones head, which can be difficult. It is advisable to place multiple screws, following the basic belay anchor rules.

When first placing a screw you should scrape away all the top layer of snow or weak ice to expose the quality ice. Chip a small hole in the ice into which to start the screw. Screw carefully at right angles to the ice (or tweaked slightly down sloping 15^{o}). You may need to use your ice axe, or a karabiner to help give more leverage while screwing.

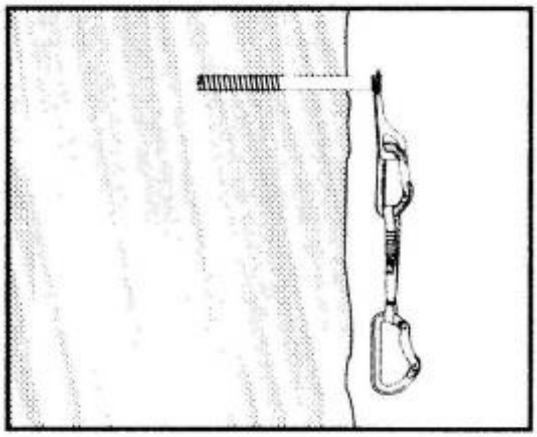
If you cannot get the screw right in, eg a rock, or exceptionally hard ice, then you should tie it off, as close as possible to the ice surface. Any further out will cause unnecessary leverage on the screw. Tie off the screw if more than 5cms is protruding.

If placing multiple screws, then place one higher than the other and slightly to the side if possible, rather than having them both on the same plane. Ice tends to shatter horizontally rather than vertically. This also makes it easier to obtain the less that 60^{o} angle requirement.



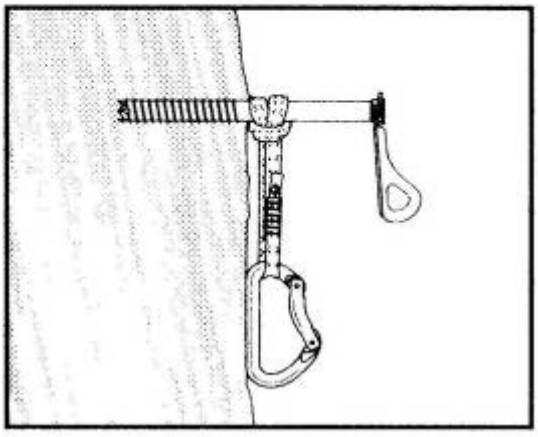
When removing a screw the process is reversed. The screw will freeze into the ice, so just give the screw a tap with the hammer to fracture the freeze. Then you'll be able to unscrew it with your hand, or use the karabiner for additional leverage.

The 15^{o} inclined placement needs some explanation. There is additional strength arising from an ice screw's chunky thread which produces additional holding power. Additionally with the downward pull there is less stress being placed upon ice. Tests indicate an additional 20% to 25% holding power can be obtained.



But if the ice is a little dodgy, then angling the screw 10^{o} to 15^{o} in the opposite direction, which may produce a slight hooking effect.

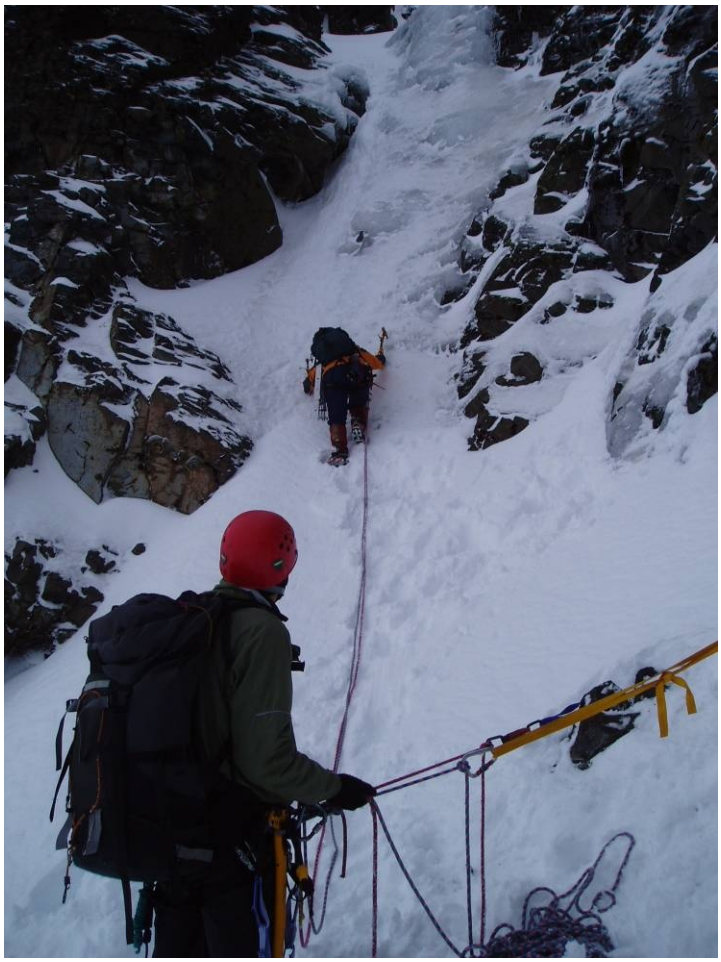
Do NOT incline the hammer in, screw out type, or the older less chunky threaded screws. The threat on these is so fine that it adds little marginal holding power. Place then at 90^{o} to the ice's surface.



Do not tie off inclined screws for obvious reasons.

BELAYING

Belaying is when the rope is used to protect the climbers on sections of the climb where the consequences of a fall are serious. Only one climber will be moving at a time – with their harness tied on to the rope. The other climber (the belayer) remains attached to the mountain using whatever anchors are appropriate for the conditions. The belayer pays out or takes in the rope through a belay device, which, if required, is capable of applying sufficient friction to stop a fall.



How to attach you to various anchors will be demonstrated on the mountain.

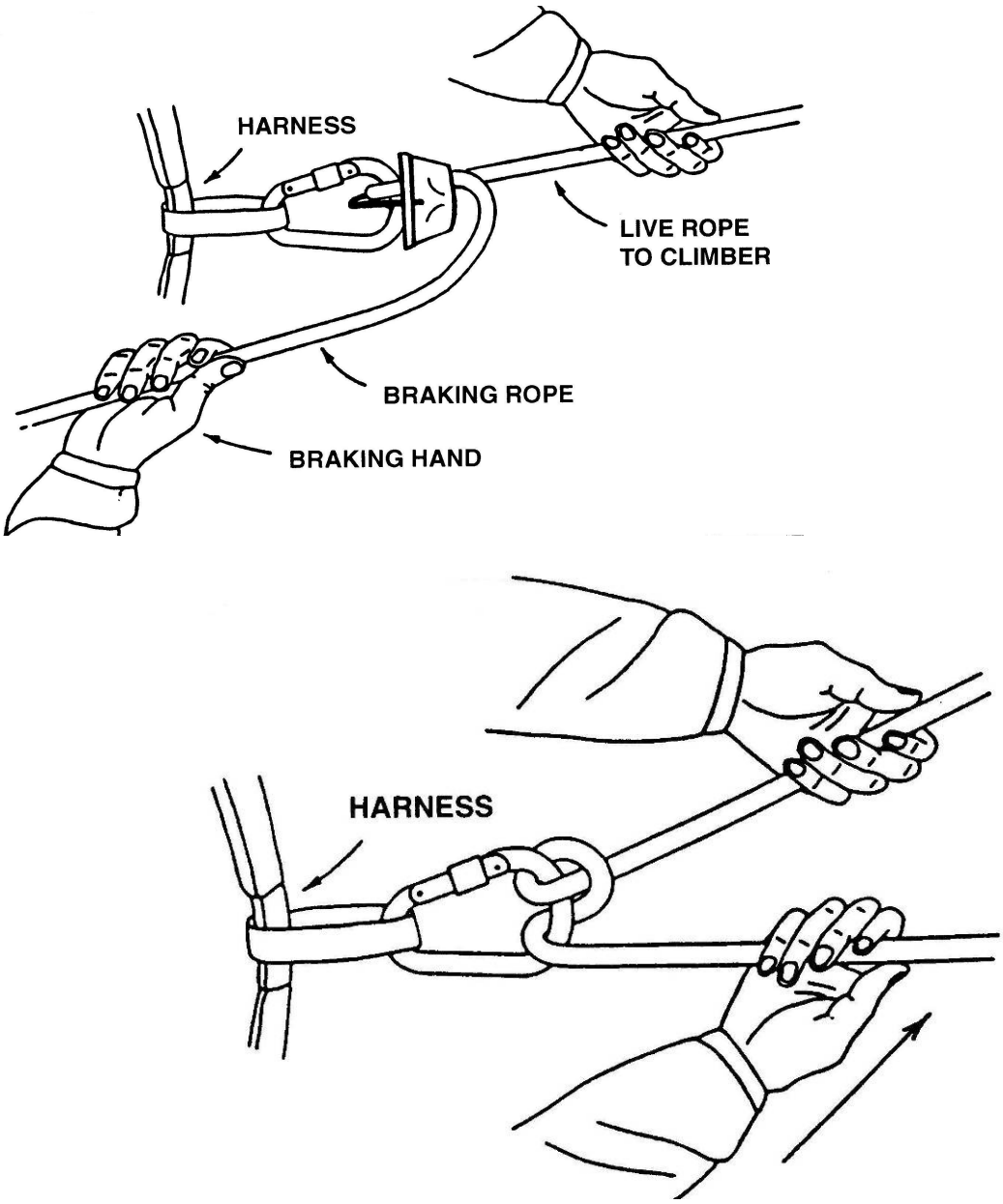
The two most types of common belay devices are the Figure-8, and the ATC (Air Traffic Controller). There are alternative versions of the ATC.

These types of belay devices can also be used for rappelling. In the case of the ATC, the way the rope threads through it when rappelling is exactly the same as when it is used for belaying.

Belays on snow and ice are usually “indirect belays”. This means that the belay device is attached to the belayer’s harness, not directly to the anchors. The belayer is then attached to the anchors. Part of the shock loading from a falling climber can be absorbed by the belayer’s body, and through their feet which should be firmly planted on their belay stance. The remaining load is transmitted via the belayer’s harness to the anchor(s). This reduces the shock-loading on the anchors, which are often more marginal in the alpine environment than is normal for rockclimbing anchors.

A direct belay would be one where the belay device connects directly to the anchor(s), with the belayer standing next to it (although still attached to the mountain somehow).

The key to safe belaying is to always have one hand on the brake rope. Your instructor will show you the sequence of hand movements used on the rope to achieve this. It is far easier to see this demonstrated than to illustrate it here.



Using an Italian hitch (Munter) to belay

Belaying Safely

- Prior to climbing, discuss the plan of attack with your climbing partner. Describe what you intend to do.
- Discuss any alternative backup plans you may have, in case the primary plan turns out to be unfeasible.
- Use a locking karabiner on your harness, and check that it is locked.
- Use locking karabiners to connect you to your anchors, and check that they are locked.
- Set up bombproof anchors and attach yourself to them properly.
- Prepare a good belay stance.
- Ensure both the climber and belayer have tied into either end of the rope. Both will remain tied into the rope until the end of the climb.
- Perform buddy checks before the actual climb begins.
- Use standard calls to your climbing partner, to ensure both of you know what is going on.
- Keep calls short and concise, to avoid confusion.
- Be aware that in all probability verbal communication will be rendered useless due to weather and terrain.

- If possible, at first, climb with your partner in a controlled environment to familiarise yourself with your climbing partner's climbing style.
- Never detach yourself from the anchors at your belay stance until you are sure you are "On Belay" from your partner.
- When you are the belayer, **KEEP ONE HAND ON THE BRAKE ROPE AT ALL TIMES**
- Manage the rope efficiently to avoid tangles.
- Don't stand on the rope. Especially if you are wearing crampons.
- Be alert at all times.
- Keep the correct amount of tension in the rope at all times. This is a (delicate) balance between short-roping your climber and having too much slack in the system. This dictates how your climber views your belay ability and hence their confidence in you. This in turn will directly affect how much effort they will expend on climbing and how much effort they will expend in not falling.

BELAY STANCES

There are two variations on a theme. In one situation the belayer will be belaying the climber from below, in the other, from above. There are points of commonality as well as differences.

In both cases:

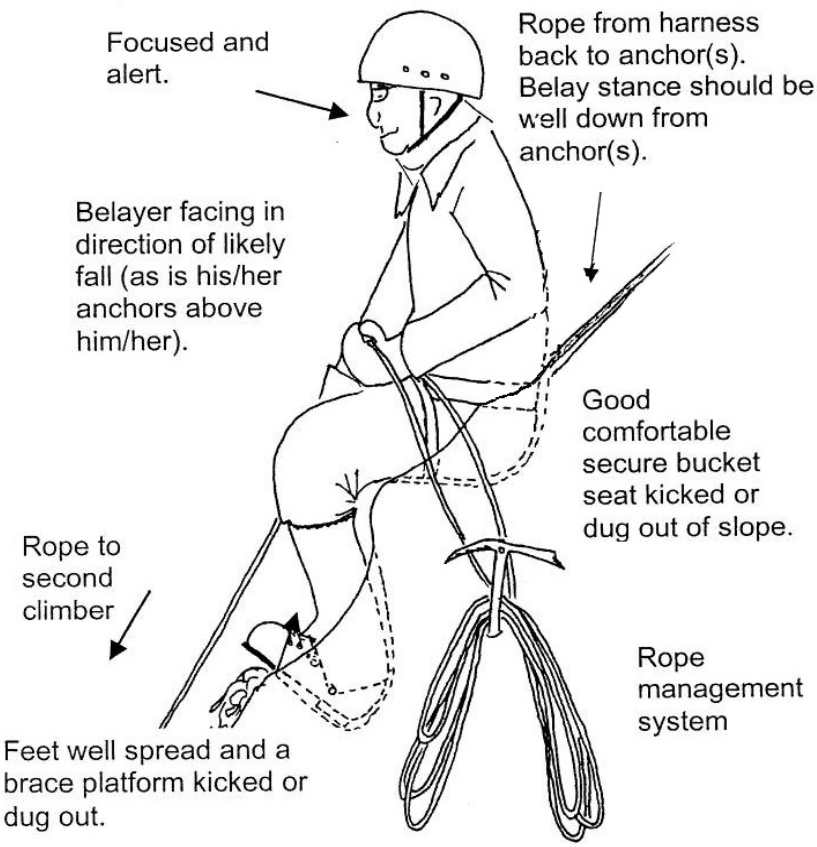
- Put some thought into the location of a belay station. If possible choose a location that affords shelter, both from the elements and falling debris etc. Consider also the pitch above.
- Stance is to be positioned well downhill from the anchors, at least 1½ metres below.
- The belayer needs to be comfortable and alert. As the belay will in all likelihood be an indirect belay, the belay stance is as important as the anchor(s). This is because in the event that the climber falls, the intent is that the majority of the energy of the fall is absorbed by the belayer him/herself, especially by belayer's legs.
- Arrange for efficient rope management.
- Remember that you might be there for a while, so try to build some comfort into your stance.

For belaying from above:

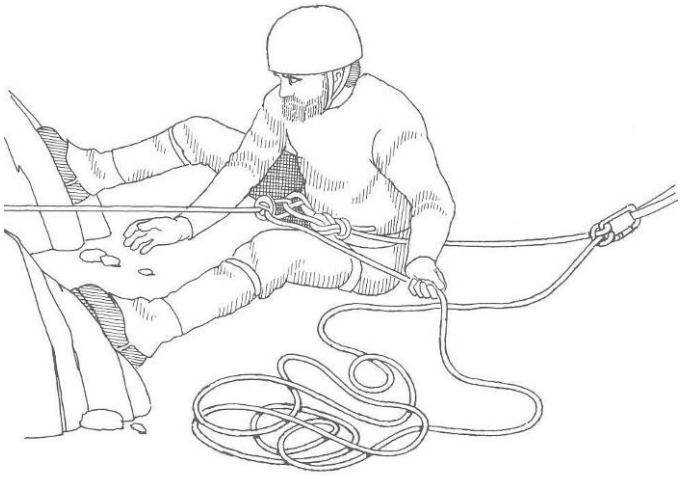
- In snow on moderate slopes, dig or kick out a deep bucket seat and dig or kick positive foot placements. Legs bent at knees to absorb energy of fall.

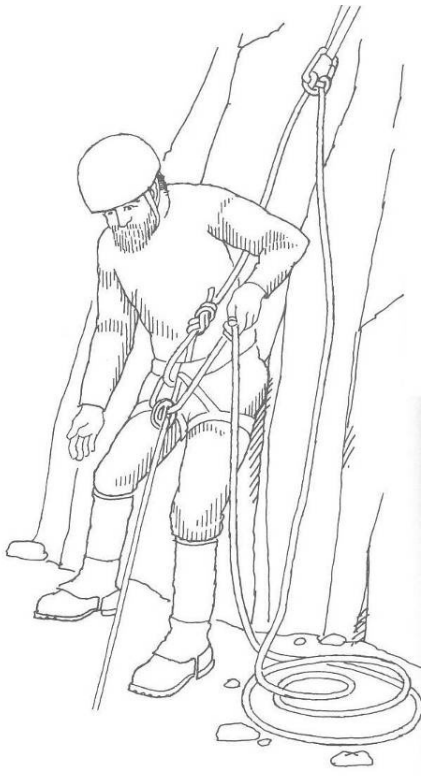
For belaying from below:

- In snow on moderate slopes, flatten an area large enough to comfortably stand on.
- Stance should be positioned to one side of the expected fall line. The belayer needs to consider the pitch above, when deciding where to set up the belay.
- Belay stance must be aligned in the direction of expected fall. Any climber who falls must come past on the "active" side of the belayer, not on the "rope management" side.



If you have been leading a pitch and arrive at the point where you will be belaying from, you should develop a sequence which will ensure your safety. Firstly chop a little step to stand in. Once you are in it, place the first anchor, and tie in. You are now relatively safe. Place the subsequent anchors and optimise the anchor sling tensions. Improve the belay stance. You can then set up the belay and belay your partner through.

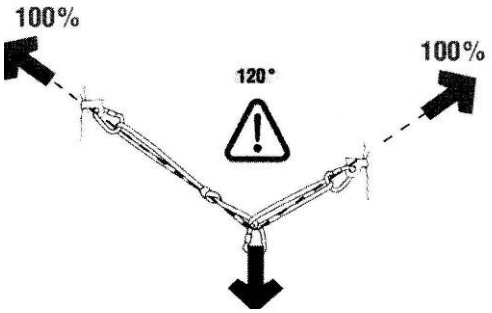
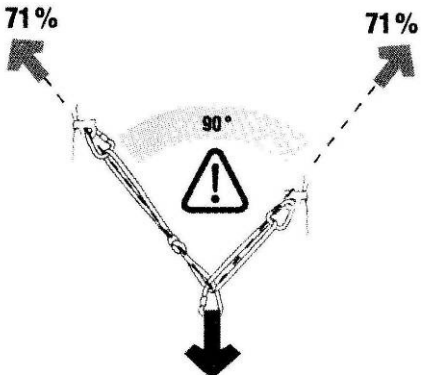


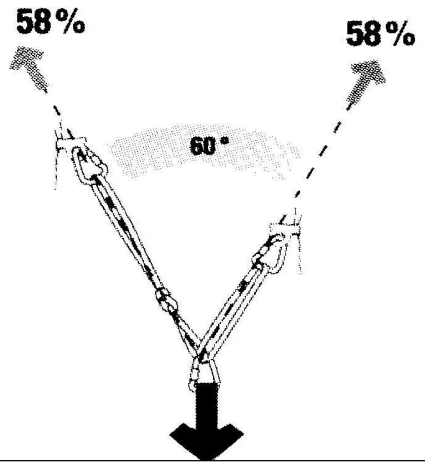


BELAY ANCHORS

There are many tomes written on this subject. As such, this guide cannot cover that much. When setting up an anchor, a good acronym to bear in mind is **EARNEST**.

- **E**qualised. Assuming that there is more that one anchor point, this refers to the fact that the load should be shared equally between the anchor points, therefore minimising the probability that one anchor point will fail.
- **A**ngles. See figure below, to see how the load transmitted to the anchor points varies with the angle between them. Essentially this is say that the greater the angle, the greater the load on the anchors. What this diagram fails to make clear, is that once the angle exceeds 120 degrees, this setup becomes a force multiplier, to the extent that once the angle reaches 170, the force on each angle is over 6 times the initial load. Always aim to keep the angles between anchors to be less than 60^{o}.
- **R**edundant. If some part of an anchor should fail, it should be a minor inconvenience, not a catastrophe. Look toward multiple primary placements.
- **N**on **E**xtending. If one of the placements should fail, the system as a whole should not drop. If it does, there is a risk that the other placements will be shock loaded and fail as the system comes up short.
- **S**olid. The individual primary anchors, and the system as a whole must be bombproof.
- **T**imely. Of great significance in the alpine environment. There is little point setting up excessively bomb proof anchors if both you and your climbing partner end up suffering from acute hypothermia in the process.

	At 120^{o} a 100% of your load will be placed on each anchor. You need exceptionally good anchors to hold this sort of stress. Avoid at all costs.
	At 90^{o} a 71% of your load will be placed on each anchor. You still need very good anchors. Avoid at all costs.



At 60° a 58% of your load will be placed on each anchor. You will need good anchors. This is the maximum angle expectable.

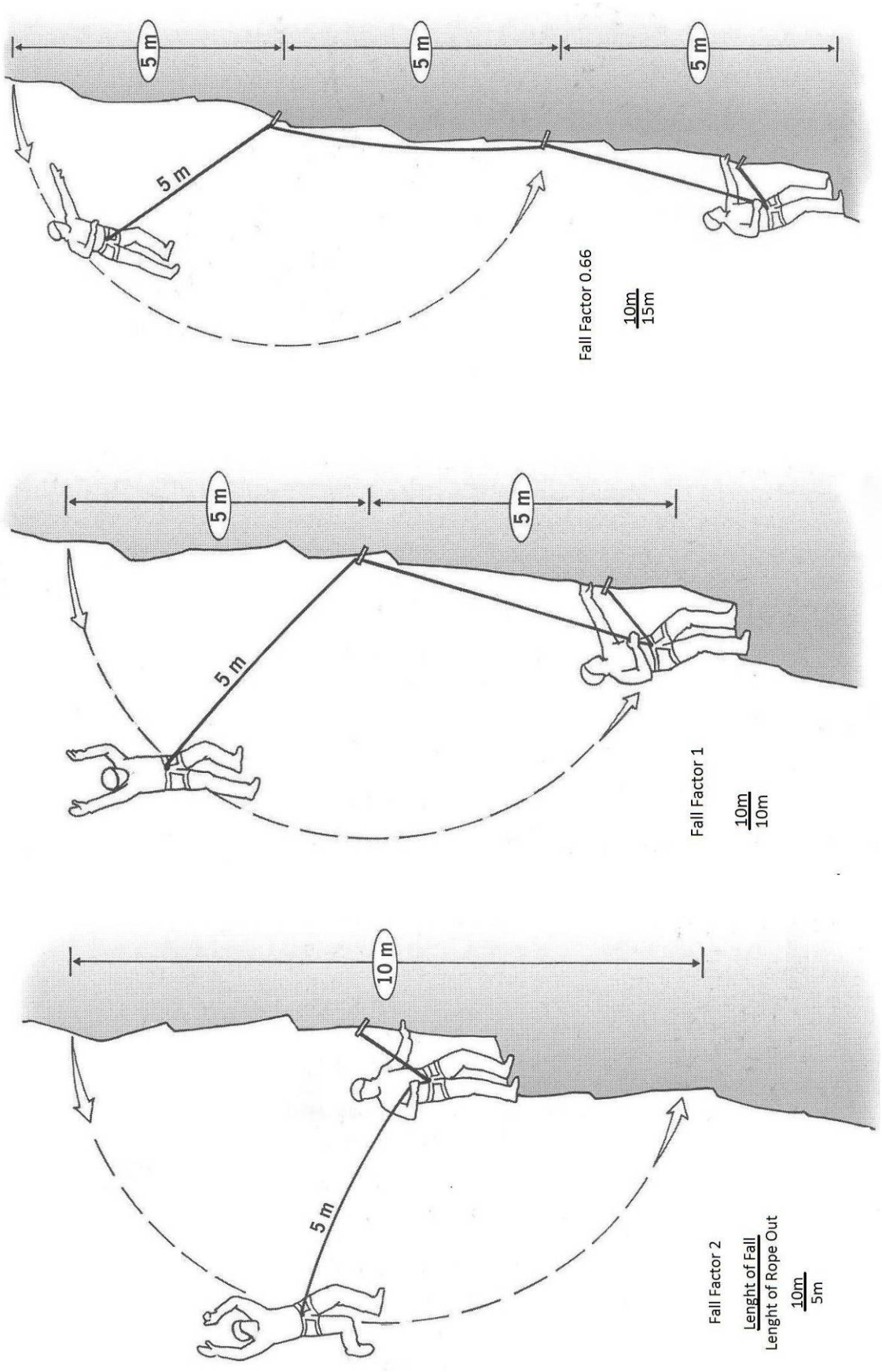
Overall, when building anchors, look for simplicity and efficiency. Exploit any existing features like using a sling over a large boulder or behind pinnacles of rock etc.

Make sure your Anchor will in fact anchor you. Some people find it useful to add the primary placements up, to get to 10 points. For example, a well placed bolt is worth 5 points. Hence two bolts are worth 10 points equals a good anchor. A dodgy nut or ice screw placement may be worth only 1 or 2 points. The following table gives an idea of what a well placed piece of each type of anchor is worth, assuming that they are perfect placements on good quality material, and the load is from the right direction.

Type	Strength in kN	Value
Bolt	**10 -> 30**	5
Piton	**10**	4
Cam	**10 -> 12**	3
Small nut	**5**	2
Large nut	**10 -> 12**	4
Hex	**10 plus**	4
Ice Screw	**10 -> 20**	5
V – thread	**10 -> 20**	5
Large boulder	**Heaps**	10
Snow bollard	**2**	2
Snow picket (Top Clip)	**10 -> 12**	5
Snow picket (Mid Clip)	**4 -> 10**	4
Snow pig	**1 -> 4**	2
T Slot	**1 -> 4**	2
Karabiner	**20 -> 30**	
Rope	**19 -> 25**	
Prussik Cord	**8**	
20mm Sling	22	

Basically the short of it, keep putting in more anchors until you feel confident that you have a “Bomb Proof” anchor. It is often more worthwhile to place several marginal anchors rather than wasting a lot of time searching for the bomb proof anchor placement. Anchor placement becomes an art form developed and honed with experience.

Fall Factors



Just when you thought the Physics was over. The force (measured in kiloNewtons kN) on the belayer and anchors is a result of three things:

The distance of the fall
The amount of rope out from the belayer
The angle of fall

Lets assume the fall is vertical for simplicity.

The fall factor is the length of fall over the length of rope out from the belayer.
A fall factor of 2, being 10m/5m is extremely undesirable. A fall factor of 2 generates forces of near 12kN, which is about the maximum the human body can handle. So it is desirable reduce the fall factor as soon as possible.

But by being intelligent with the placement of your runners you can reduce the fall factor. Spend some time looking at the following three diagrams and understand the results of the leader placing protection soon after they climb away from the belayer.

The first fall factor reducing runner is being called “The Jesus Runner” in some climbing circles.

Weight

Protection is heavy stuff. Be wary of carrying excess gear that you will never use. For example, if you and your climbing buddy have only five ice screws between you, there is little point bringing more than 5 or 6 quickdraws. The excess is simply dead weight that has to be carted around. Often a climber’s nervousness is reflected in the amount of gear they carry. Less can be more. Carry slings and using rocks or other natural protection can greatly reduce the amount of gear you need to take with you on the hill.

Multi directional anchors

Throughout this discussion, the assumption has been made that anchors will only have to contend with force downwards. As such, they will have been set so that they will not fail by being pulled downwards. However, it will generally mean that they will be removed by pulling them upwards. If there is a chance that this may happen, for example the lead climber taking a big fall after placing the Jesus runner, the anchor should be also capable of taking the force from the opposite direction.

CLIMBING CALLS

These Climbing calls are universal, and have been developed over a number of years. They are used to avoid unnecessary shouting, which often leads to confusion. They should be kept simple, concise and pitched loud enough to be heard even in strong winds. Use a consistent tone for the same call all the time, like “Belay On” which should be shouted with a singing type tone, while “Hold” is said in a desperate cadence. The tone makes understanding calls considerably easier in marginal conditions. Do NOT use unnecessary chatter, it is inevitable that it will generate confusion. Save the chatter for when you recount the climb in the pub afterwards. Sing for positive calls, while urgency calls should be short and harsh tones.

Call	Usage	Notes
Belay On	The belayer is telling the climber that the climber is protected, and the climber is free to start climbing.	
Climbing	The climber’s responds to “*Belay On”. This warns the belayer that the climber is about to move.*	This call is redundant, but it does act as an affirmation that the climber is aware that they are being belayed.
Runner On	The lead climber warns the belayer that they have the first piece of intermediate protection (runner).	To the belayer this means that if there is a fall, the force on the belayer will an upwards pull.
Safe	The lead climber has reached the belay stance and has securely anchored them self to the mountain.	The belayers belay is now effectively redundant. So they can start dismantling the belay and preparing to climb.
Belay On	The lead climber has now successfully put in a belay and it is now possible for the second to follow the pitch.	This has effectively completed the cycle.
The following calls that are only occasionally used, and said with some desperation/urgency in the callers tone.		
Hold	The climber tells the belayer they are falling or about to fall,	The belayer should lock off the belay.
Hooooooooold !!!!	The climber tells the belayer they are falling.	Often identifiable by the desperate tone of the shout. The belayer should lock off the belay instantly.
Rock	Used by anyone to alert all others in the vicinity that there is or is a risk of falling debris or equipment. This call is NOT limited to falling rocks	All below should act like a tortoise under their helmet, or get out of the path of any falling items.
Slack	The climber asks the belayer for extra rope	This is often confused with take in. Remember that the climber wants a slack rope
Take In	The climber asks the belayer to tighten (take in) the rope	The climber has either reversed a section of the climb, or they have moved into a position which means

		that the trailing rope can be straightened
Watch Me	The climber tells the belayer they may fall.	In some ways redundant, because the belayer should be always on the ready for a fall.
The following are useful, but not essential. Because they are of a positive nature they can be said in a singing tone. You may want to use a firm authoritive tone for the "5 metre" call		
5 metres	The belayer advises the climber there is 5 metres of rope left.	The climber is advised to find a belay stance and to establish a belay in less than 5 metres
That's Meeee	The second climber tells the belayer that all the surplus loose rope has been taken in.	The climber can no longer advance, or will not be able to pull up any surplus rope to their belay stance
Off Belay	The belayer tells the climber that he/she has taken him/her off the belay	The climber had better be attached to the mountain and "Safe"

As you become more proficient at understanding the sequence of events, you may want to consider becoming more economical with the calls you use. Experienced climbers can get to the point where no calls are necessary, which significantly reduces confusion on the mountain.

GLACIER TRAVEL

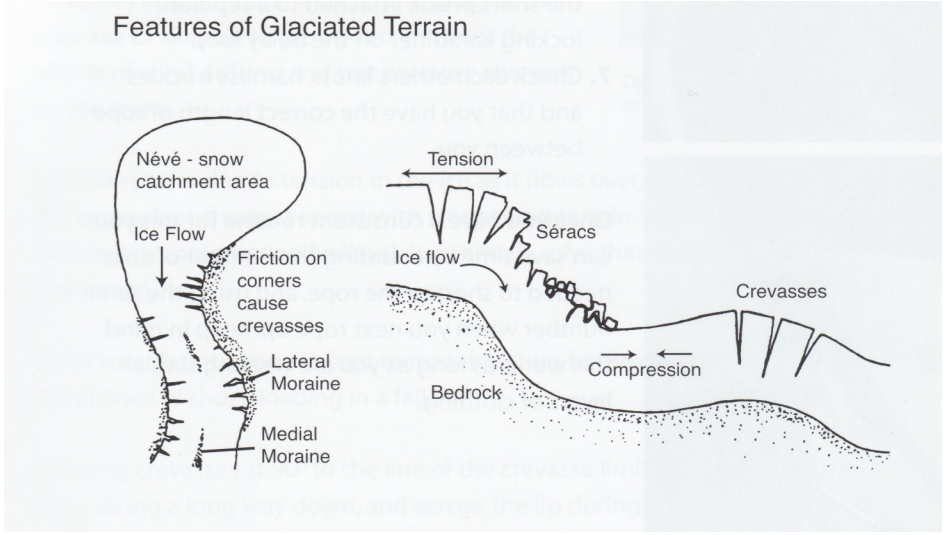
In Search of a crevasse

Safe travel

It is essential for you to be roped when travelling on any glacier with a snow covering. There are lots of hidden crevasses just waiting for the unwary climber. The consequences of an uncontrolled crevasse fall are serious. Good route finding and suitable rope technique are vital to safe travel in glaciated terrain.

Be observant and curious about the patterns of crevasses and the state of snow bridges. Use your ice axe or ski pole to probe. Consider the effects of wind drifting and temperature changes on the snow.

Crevasses form due to tension in the ice as it flows over underlying bumps in the bedrock or changes speed with steepening terrain. Travel in places where the ice is in compression (valleys) is generally safer than in areas of tension (roll-overs).



Roping Up

How the rope is distributed depends on the number of climbers on the rope. 2 is obviously the minimum but does have limitations in holding a crevasse fall. 3 is better, 4 is ok. Teams of 5 or more on a rope are generally too cumbersome and slow.

When in glacier country you would normally travel about 8 to 10metres apart with the surplus rope being taken out of the system and carried in coils by the climbers on each end.

- At the appropriate distances, climbers clip in to the rope using an figure-8 on the bite or alpine butterfly by attaching a locking biner attached on the belay loop on their harness.
- End climbers may either tie in directly to the rope ends or to a figure-8 closer to the middle.

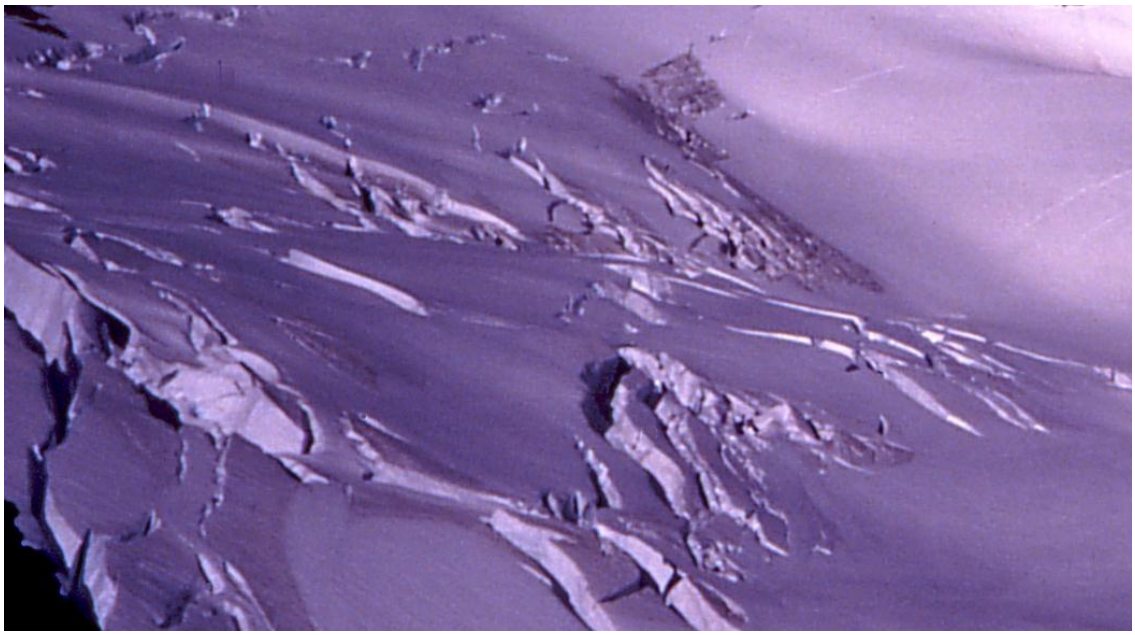
- Surplus rope should be coiled and either stowed in your pack (Canadian method) or carried in coils round the body (modified Kiwi coil – New Zealand method).
- Whatever method is chosen, it is important that the rope between climbers is connected directly to the belay loop on each climbers harness. The low attachment point reduces the chance of the climber holding the fall being pulled over forwards and “penguin” sliding to the lip of the crevasse. The original “Kiwi Coil” method where chest coils are tied to the waist harness is no longer recommended for this reason.
- Put your prussik loops onto the rope that leads to the other climber with the short prussik closer to the other climber. This prussik should then be clipped back to a separate locking biner on your harness belay loop. The long prussik can either be stuffed in a pocket or daisy chained and clipped back to a gear loop.

On the Glacier

After years of experience it is still very hard to identify hidden crevasses. You will be caught out. The key thing is vigilance.

A few basic rules for glacier travel.

- Pick your route from a distance where you can see better.
- Keep rope between you taught, this will reduce any fall distance.
- If your partner falls, tension the rope quickly, this will often result in minimising the distance of fall, even to the point that the faller will still be sitting on the edge of the crevasse on their pack.
- Keep the rope at right angles to the crevasse line at all times. A sideways fall increases the fall distances, and creates a difficut angle for your partner to hold you.
- If in doubt about the quality of a bridge, drop the coils and belay over the bridge.
- Remember that your partner may be travelling at a different pace on steeper ground, while you maybe on easier (faster) ground. It is ideal to move at a steady and appropriate pace for both of you..
- Be alert at all times, sloppiness can result in a far more serious situation than intended.
- Crevasses can be often jumped. Before making a jump, warn your partner so they can move with the jumper thereby avoiding stopping the jump in mid flight.



Typical glaciated ground

CREVASSE RESCUE

It pays to be prepared for the “unlikely event” of falling into a crevasse. Actually falling or stepping into a crevasse is quite common. Fortunately the most common crevasse fall is just putting your foot into the void, or even dropping up to your waist. Above your waist the body starts getting bigger, which reduces your chances of fitting into smaller crevasses. But when the crevasse is bigger, we can start having serious problems. Fortunately as intelligent mountaineers, we have prepared ourselves for a crevasse fall. Hence the importance of roping up for glacier travel before you fall into a crevasse. Basically crevasses are cold ugly unfriendly places and should be avoided at all costs.

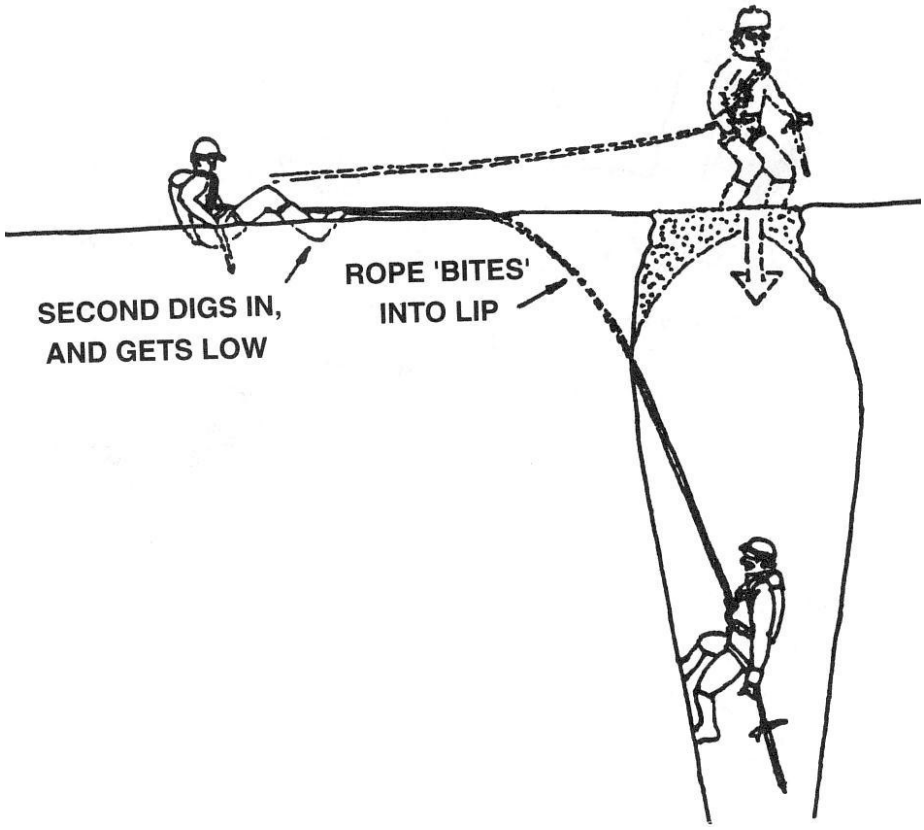
This section progressively gets more complicated, so don’t be alarmed about the complexity. It is well worth spending some time in the comfort of your lounge working through all the issues.

Let’s look at the events associated with arresting a crevasse fall.

Oh Shit!

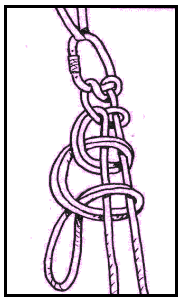
1. Hold the Fall (get down and get heavy). This has got to be instantaneous because the greater the fall, the harder it is to hold it. Lean against the pull, ram the ice axe in as a brace. Get down onto the snow levering off your solid foot placement. By getting low you increase the amount of friction being generated by the rope cutting into the crevasse lip.

2. Ram in the ice axe as an anchor and attach the active prussik to it. Transfer the load on to the anchor. By doing this you have created a temporary anchor. This will give you the freedom to improve the situation.

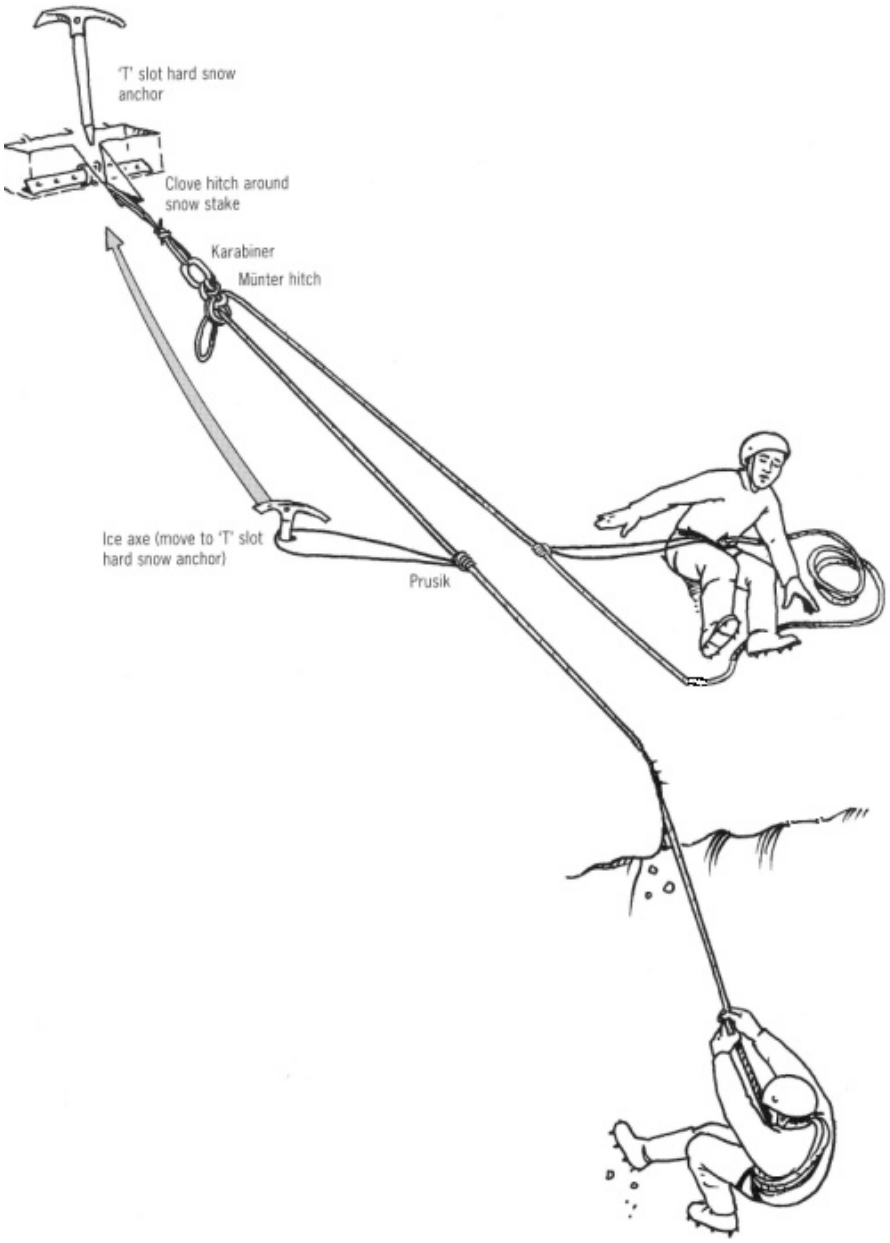


3. Drop your pack (optional) and the spare coils while keeping a foot or two on the ice axe anchor.

4. Make bomb proof anchor, like a T-slot, backing it up if conditions dictate.
5. Put an Italian hitch (Munter) onto anchor using the rope from your coils. Tie off Italian hitch with 2 half hitches.
6. Transfer weight from ice axe / prussik anchor onto the Italian Hitch anchor. How you do this will be based upon how you attached the prussik to your temporary ice axe anchor.
7. You now have the situation under control. Putting another prussik onto the rope and walk to crevasse edge to assess situation & develop strategy.



TIP. The Italian hitch is important. It gives you the option of being able to lower the victim without the complicated process of having to put it in later.



What Next!

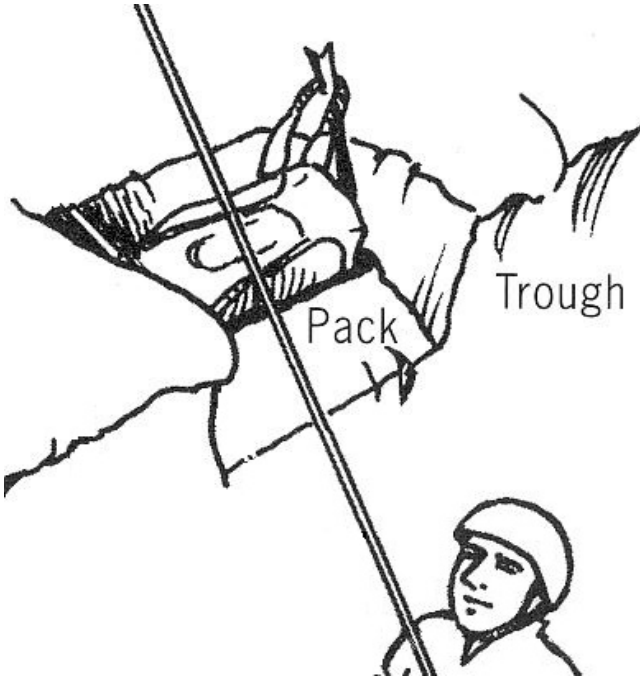
From the crevasse edge establish contact with the victim and together come up with the best plan.
You usually now have five options available. Your assessment at the crevasse edge will help you decide which is the most appropriate option.

In order of preference (the easiest order):

1 The victim can climb out
2 The victim is lowered to a point where they can climb out
3 The victim can prussik up the rope to safety
4 The victim can not prussik up, but is capable of assisting setting up a hoist
5 The victim is incapable of assisting and will require to be hosted out

Climb out!

- Agree the plan with the victim
- Go back to anchor, tie yourself into the anchor
- Undo the half hitches locking off the Italian hitch
- Belay up climber as required



Lower and Climb out!

- Agree the plan with the victim, and the distances involved
- Go back to anchor, tie yourself into the anchor
- Undo the half hitches on the Italian hitch
- Lower the victim until tension is off rope when they get to solid ground (be careful, solid ground is not always solid)
- You will then belay the climber out of crevasse.

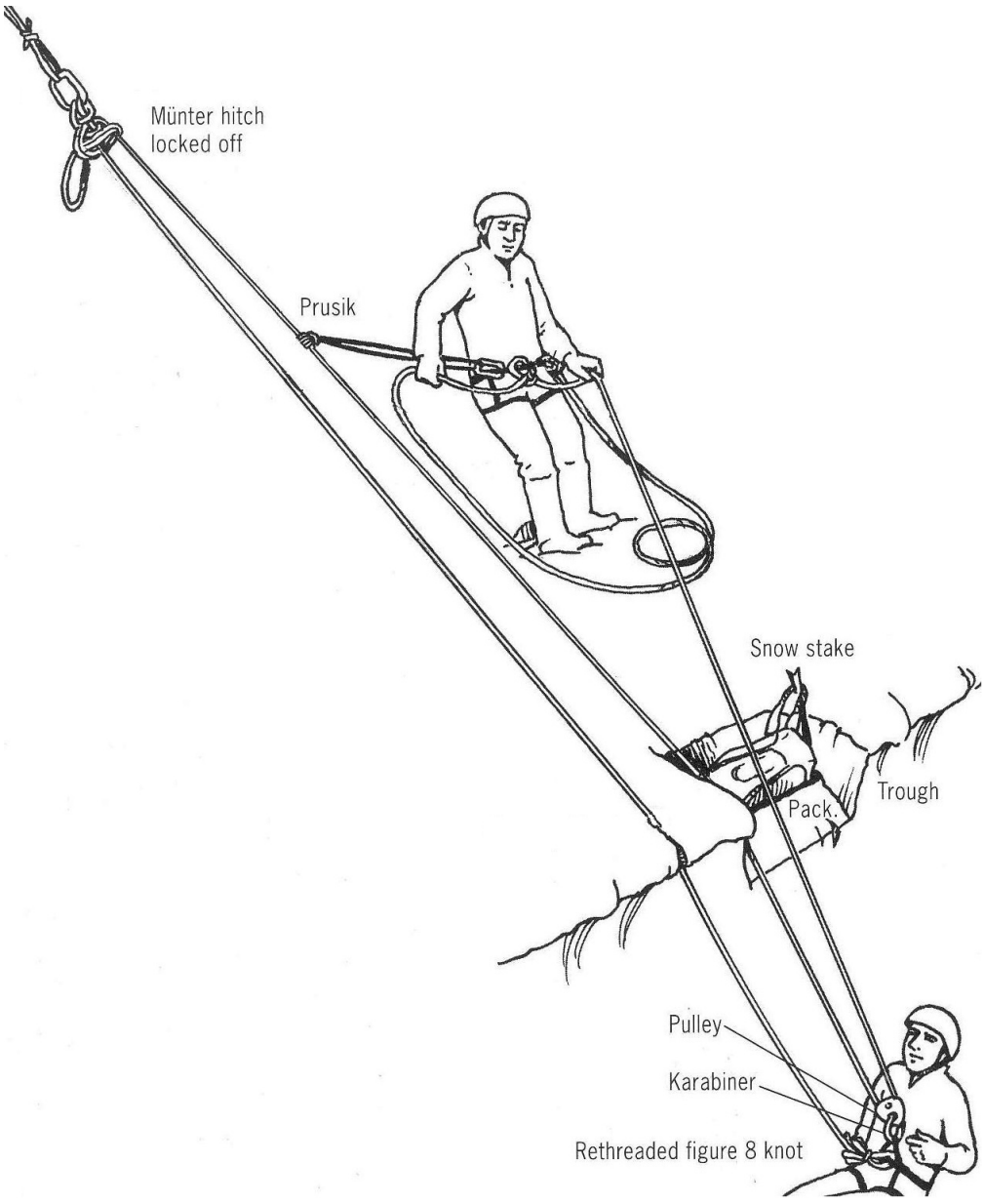
Prussik their way out of this mess!

- Agree the plan with the victim, and the distances involved.
- You will have to modify the edge of crevasse in order to make it easier for the victim to get over the lip
- Stop the rope cutting into the lip you can place a pack or ice axe
- The best modification is to create series of landing steps
- Return to anchor to strengthen it if required, and monitor it.
- Give encouragement to victim as they prussik up the rope

Hoist me up Scotty!

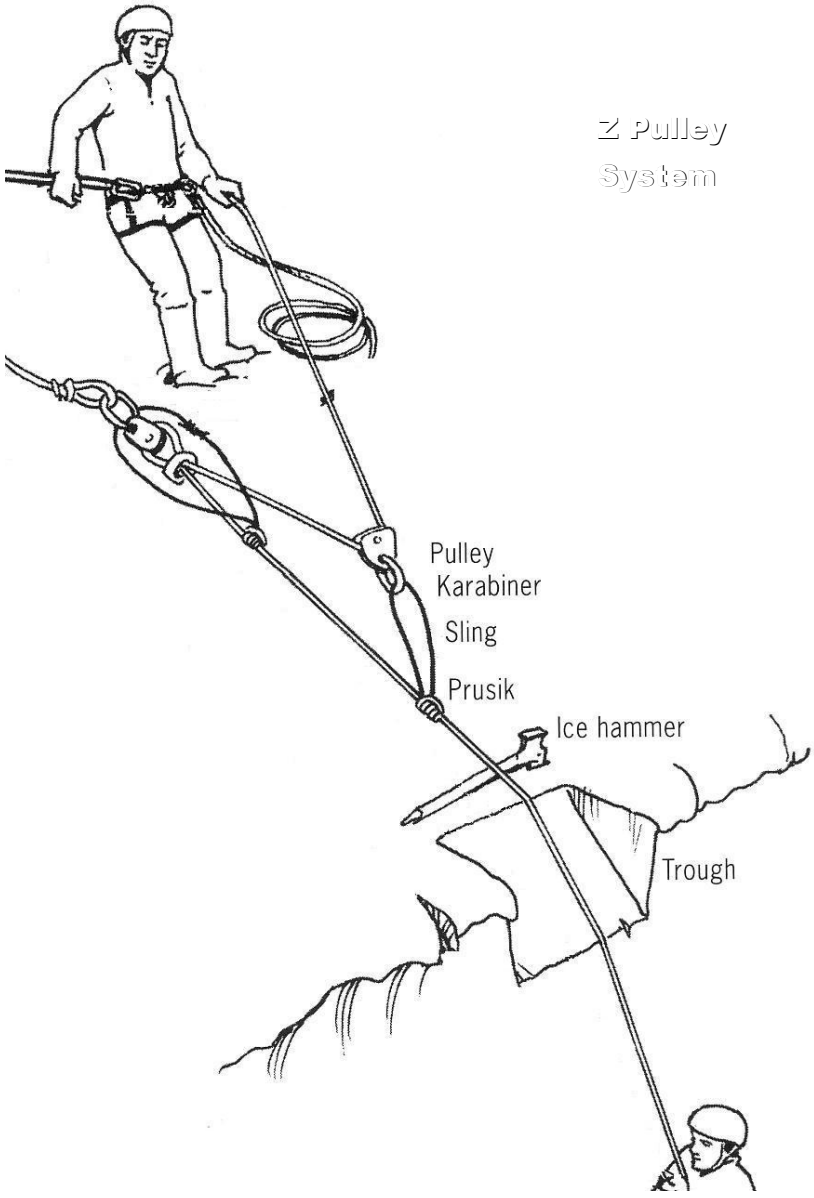
(Drop loop method)

- Modify edge of crevasse with a stepped landing pad. Also stop rope cutting deeper into snow by using a pack or ice axe
- Return to anchor and strengthen it if required
- Tie off “dead rope” to anchor. (Dead rope is rope that was previously in your coils)
- Returning to crevasse edge, and drop a bight of rope down to crevassed climber
- Having a Karabiner or two on the rope may help it drop easier to the victim
- If you have a pulley, put this on the rope with the karabiners, before you drop the rope
- Victim clips the karabiner (and Pully) into their harness
- Return to a position near the anchor, your belay device into the live rope
- Start pulling up the victim. You will be getting a 2:1 advantage
- If you have spare personnel, get them to pull also
- You can get the victim to assist by pulling up on one of the ropes tied off to the anchor



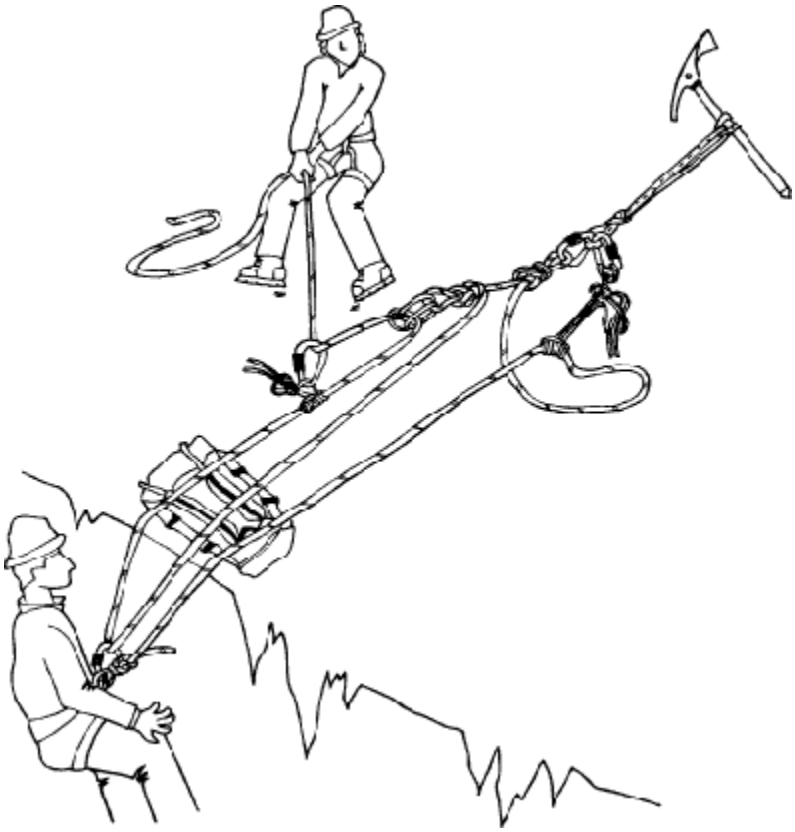
Method 2 - a “Z” pulley assisted hoist

- Used where you do not have enough spare rope to drop a loop
- Modify edge of crevasse with stepped landing pad as above
- Return to anchor. Place a “French” prussik on the live rope side of the Italian Hitch, and attach the prussik to the anchor using a karabiner
- Undo the half hitches on the Italian hitch and release pressure onto French prussik
- Undo Italian hitch and construct an auto block or ratchet – see options below
- Go down live rope as far as possible, put prussik onto live rope (short prussik) and a karabiner, then clip the dead rope into karabiner
- Return to near the anchor and start pulling trailing end of dead rope
- You may have to reposition the two prussiks a number of times to get extra lifting bits
- If lifting is difficult, try adding extra “Z” into the system
- It is possible to put a massive force on the anchor, so strengthen prior to introducing the extra “Z”



Method 3 – a drop loop plus “Z” pulley

- This is the system most used in crevasse rescue where there is only one rescuer. While it has greater mechanical advantage than the 2 previous methods, greater friction and rope stretch reduce efficiency compared to the single drop loop and it requires more spare rope than the straight “z” pulley



Ratchets

- Ratchets reverse the direction of the rope and prevent it from running back during hauling
- A variety of ratchets are available as indicated below. No one method is perfect.