



Ladders and Lifelines

How to safely use ladders and lifelines
A Wessex Cave Club Presentation



Course Contents

- The course will cover:-
 - Hardware
 - Ropes, Belts and Harness, Karabiners, Slings, Ladders, etc
 - Rigging
 - Fall Factors, knots, belay points, Handlines and Lifelines
 - Lifelining
 - Methods, Positioning, Climbing Calls, Rope Handling, Double Lining and Self Lining
 - Practical Session
 - Putting all this into practice on the tower
- Once complete you should be confident and capable of safely rigging and lifelining cavers up and down ladders.



Basic Hardware

- The basic hardware needed to progress safely through a vertical section of a cave consists of:-
 - Ropes
 - Belts and Harness
 - Karabiners
 - Slings
 - Ladders
 - Misc. bits and pieces





Ropes

- The Wessex kit store contains two type of rope:-
 - Life Lines
 - 10mm Dynamic Kernmantle(stretchy 7% at 80Kgs)
 - Generally blue in colour
 - Labelled “Life Line” followed by a letter (i.e. “LifeLine F”)
 - Lengths 15 to 30 metres
 - SRT Ropes
 - 10mm Static Kernmantle (not stretchy 2% at 80Kgs)
 - Generally white in colours
 - Labelled “R” followed by a number (i.e. “R3”)
 - Lengths 15 to 80 metres
- **ONLY use Life Line ropes for Life Lining!**
 - Static ropes are not suitable as they do not absorb any shock and thus may break or transfer dangerous shock loads to the climber.



Ropes





Belts and Harnesses

- All ladder users must wear a caving belt or harness
- This is used to connect the life line to the caver
- The line can be directly tied to into the belt, using a suitable knot (re-threaded figure of 8 recommended) or connected by a karabiner (recommended for speed).
- In an emergency the life line can be tied directly to the climber but:-
 - The knot loop used MUST NOT slip and contract the chest
 - Injury is likely in the event of a moderate fall
 - Anytime spent hanging on the rope will be very uncomfortable



Belts and Harnesses



- Standard Caving Belt
- Petzl Avanti Harness
- Improvised harness made from knotted sling



Karabiners

- Karabiners, or “Krabs”, allow very quick, simple and safe connections to be made between different elements of hardware (ropes, belts, ladders, anchors, etc).
- Two basic types:-
 - Snap links
 - Light, cheap but no safety sleeve on gate. Not recommended.
 - Screw gate
 - Gate can be secured shut by screwing up sleeve. Many shapes available.
 - Quick Lock gates with some form a tri-action locking mechanism are also available.
- Manufactured from Steel or Alloy
 - Steel – wear resistant but heavy and may corrode
 - Alloy – lightweight, wears quickly, corrosion resistant



Karabiners



- Offset screw gate karabiner suitable for general use
- Oval screw gate karabiner suitable for general use and also a pair can be used to make a “Garda Knot” (see Self Lining)
- Pear or HMS screw gate karabiner. The best option for using an Italian Hitch as it allows the knot to easily flip between ascent and descent.
- Snap link karabiner. Only use for cowstails or in non-safety situations (clipping a tackle sack to belt etc).



Karabiners

- Only load along the long axis
- Never load three-ways or across the gate
- Avoid screwing gate up too tightly – tighten and back-off a quarter turn
- Retire a karabiner if:-
 - more that 10% of material is worn away
 - subjected to shock load (caught a heavy fall, dropped down a pitch, etc.)
 - Excessive corrosion or other visible damaged
 - Gate mechanism no longer functions (spring damaged, sleeve doesn't screw up etc.)



Karabiners





Maillons

- Cheaper than Karabiners but do the same job
- Can be safely loaded in any direction
- No gate to worry about loading
- Spanner often needed to undo
- Slower and heavier than karabiners
- Must be fully done up





Slings

- Tape Slings
 - Available pre-sewn into loops or else knotted by the user (must use correct “tape knot”)
 - Variety of lengths available (0.5m, 1m and 2m are the most useful)
 - Wide surface area makes it resistant to abrasion
 - Used to connect to anchor points (natural or otherwise)
 - Can used as an improvised harness or to provide a useful foot loop or hand-hold on awkward pitch heads
- Caution:-
 - Tapes have a very low stretch and thus low shock absorbency (do not use as a cowtail!).



Slings





Ladders

- The Wessex kit store contains:-
 - Numerous 7.5m ladders with C-links on both ends, 25mm rung spacing
 - Swildon's ladders – built-in top tether, 20 foot long, 25mm rung spacing
 - Misc. ladder extensions 1 to 3m lengths
 - Standard spreaders – single connection eyelet and C-links
 - Tethers – various length steel tethers with C-links
- Ladder Handling:-
 - Inspect carefully before use
 - Ideally transport coiled in a tackle sack
 - Always use a spreader or tether
 - Unroll carefully down a pitch
 - Clean before returning to tackle store
 - Ladders are inherently weak, always use a life line.





Misc. Equipment

- Other equipment that may be useful includes:-
 - Tackle Sacks – Ropes MUST be transported through the cave in tackle sacks. This prevents them from being damaged, as well as stops them from becoming tangled and muddied. Ideally ladders should also be transported in sacks for much the same reasons.
 - Pulley – a pulley can be useful to reduce friction when double-lifeline (see later), when assisting a tired caver or hauling tackle sacks.
 - If the cave is equipped with “spits” or “through-bolts” then the rigger will require bolts, hanger plates, spanner etc. in order to equip the belay points. Most Mendip caves are equipped with P-Bolts or have abundant natural belay points but not all! Ensure you research your trip and take appropriate hardware.
 - Pack a spare sling and few spare karabiners. These can be loaned to the caver who has forgot their belt or own karabiner, they can be used to improvise a harness to haul out a tired caver, etc.



Rigging

- What is good rigging?
- Two main aims:-
 - Promote Safety
 - Select well positioned and sound anchors.
 - Evaluate and reduce shock loads resulting from anchor failure
 - Rig away from hazards (falling water, loose rocks, etc.)
 - Operate an effective lifeline system for every member of the party
 - Reduce Difficulty
 - Ensure easy access to the pitch head
 - Use techniques to assist tired or inexperienced cavers
 - Select anchors for easier progress (hang ladder down widest part of pitch, split long pitches into shorter ones, etc)
- Good rigging is 10% Theory and 90% practice.



Fall Factors

- Safe rigging involves the avoidance of shock loading.
 - Shock loading generates enormous stresses. These may cause:-
 - The rope to break
 - The anchors to fail
 - The caver to be severely injured (both from the shock transferred through their belt /harness and any resultant impact with the floor or walls).
 - Fall Factors provide a way to evaluate the degree of shock loading for a given situation.
 - Simply put the Fall Factor is:-
 - The Length of Fall divided by Length of Rope
 - This gives a value between 0 and 2
 - ✓ ○ 0 = No shock load
 - ⚠ ○ 1 = Significant shock load – possible injury to caver but nothing should break!
 - 🚫 ○ 2 = Extreme shock load – rope and / or anchors may well fail, caver will be injured



Fall Factors



Rope=15m
Fall=6m
Fall Factor = 0.4

Rope=10m
Fall=5m
Fall Factor=0.5

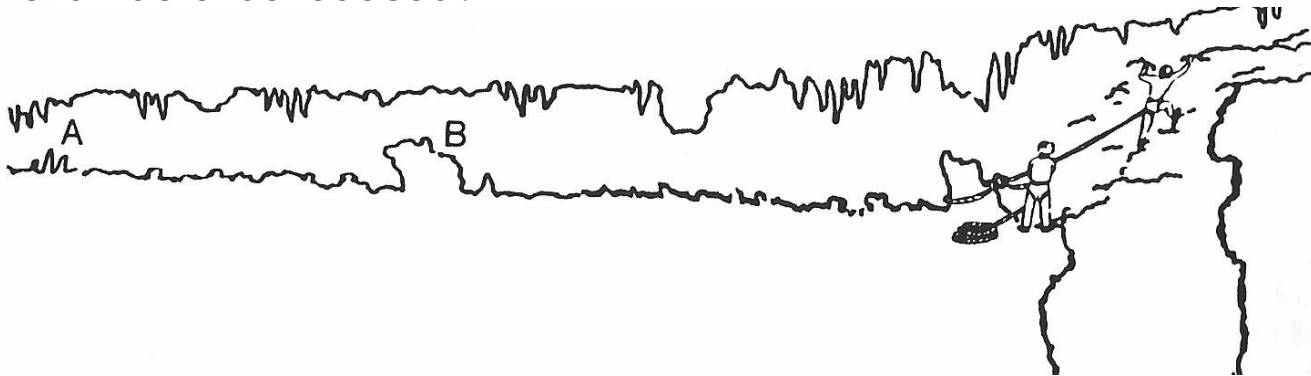
Rope=10m
Fall=20m
Fall Factor=2.0 !



Fall Factors

- Consider the below

To progress the cavers must effect an upward traverse. If the leader falls, he will fall nearly 10m with only 5m rope available. The fall factor will be approaching 2 and either the rope may break or such a shock load will be transferred to the lead climber that he will be injured. How can the fall factor be reduced?



Assuming sufficient rope, the lifeline can move back to up the passage to point A. The fall remains as 10m but now there is 35m of rope. The fall factor is reduced to 0.29. Alternatively the same effect can be achieved by running the rope through a karabiner or pulley safely anchored at point B.



Fall Factors

- Here is another situation:-

If bolt A fails a shock load results – the actual fall factor depends upon the position of the caver attached to the rope in relation to the bolt; the nearer he is to the belay the higher the fall factor.

The situation is easily rectified by adjusting the knot to create a Y-hang and thus reducing the fall factor to virtually zero.





Knots

- There are a wide variety of knots that can be used in caving.
- For our purposes only four are required:-
 - The Figure of Eight
 - Used to connect the climber to the rope and may also be used as an end knot to tie into an anchor
 - The Bowline
 - Used as an end knot to attach to an anchor point and may also be used to tie around a climber (if they haven't a belt or harness)
 - The Butterfly Knot
 - Used to create a clip-in or connection point in the middle of a rope
 - The Italian Hitch
 - Used as a reversible belay knot



Figure of Eight

Figure 8 Loop

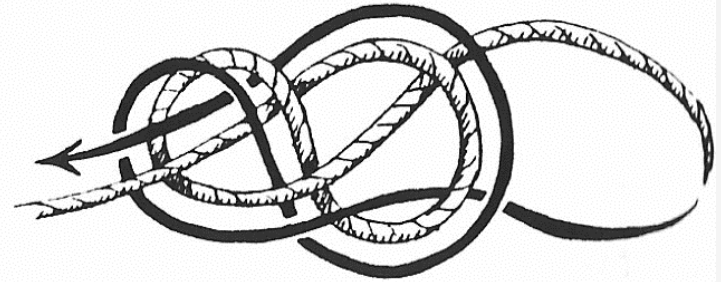
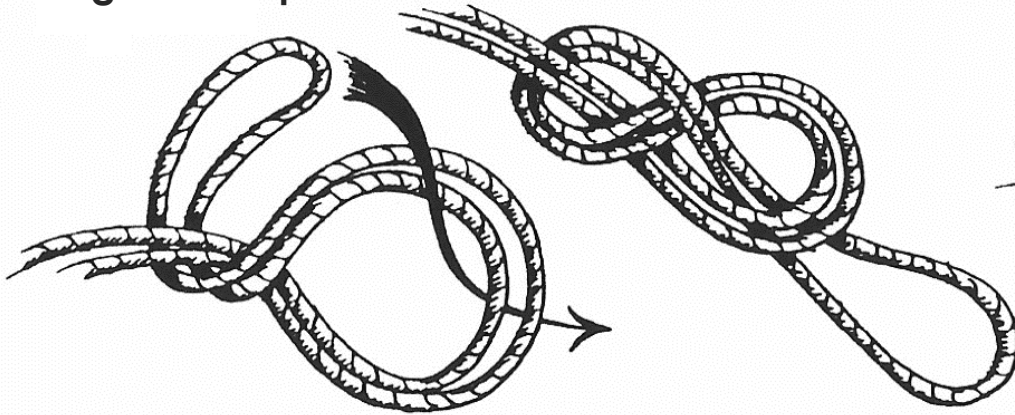


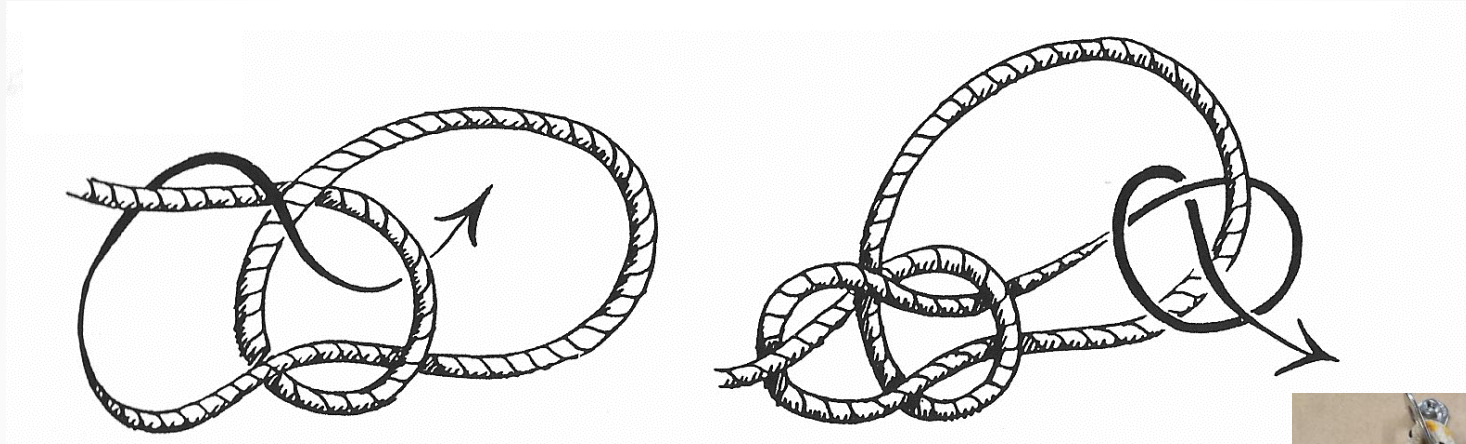
Figure 8 Rethreaded

- The Figure of Eight
 - Strong and easy to tie.
 - Can be used mid-rope
 - Always leave a 6inch tail
 - Used to connect the climber's belt or harness to the rope (via a karabiner)
 - May also be used as an end knot to tie into an anchor (rethreaded to avoid using a karabiner).





Bowline

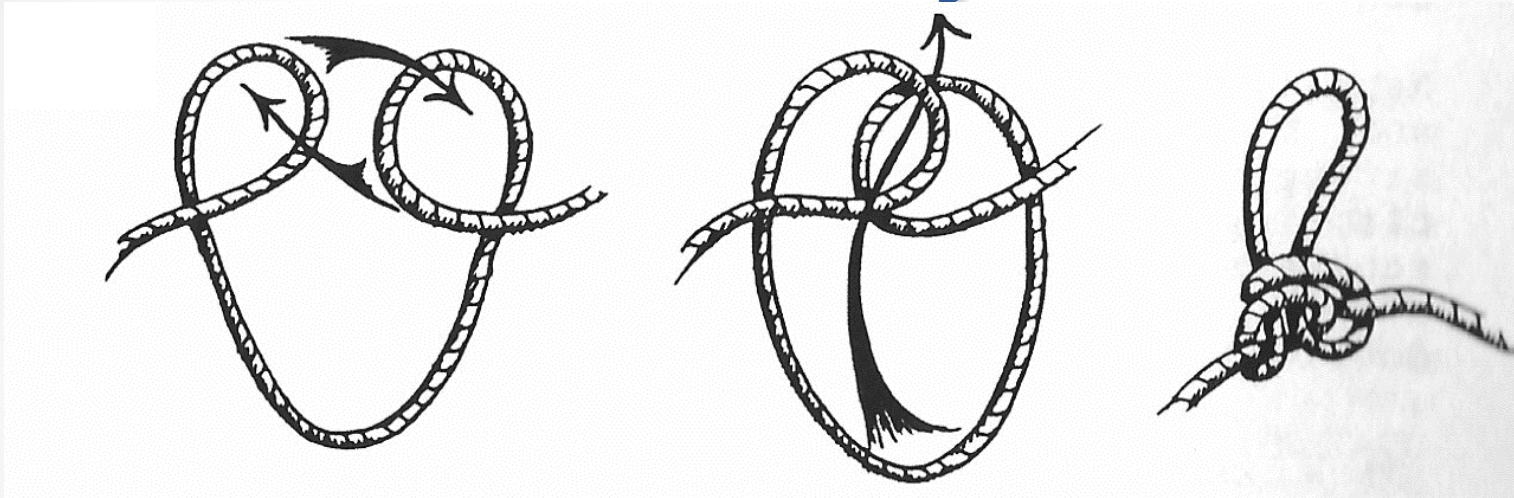


- The Bowline
 - Very quick to tie
 - Undoes easily after loading
 - Used as an end knot to attach to an anchor point
 - May also be used to tie around a climber (if they haven't a belt or harness)
 - Must have a stopper knot tied in the tail





Butterfly

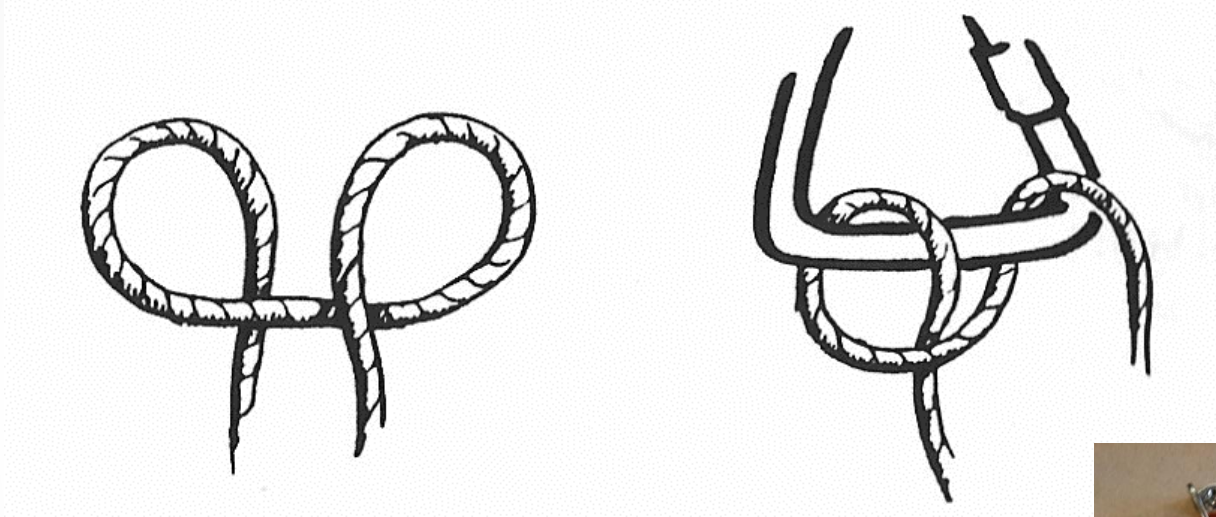


- The Butterfly Knot
 - Very easy to tie
 - Economical on rope
 - Ideal for 3-way loading
 - Good as part of Y-Hang
 - Easy to untie and adjust
 - Used to create a clip-in or connection point in the middle of a rope





Italian Hitch



- The Italian Hitch
 - Used as a reversible belay knot
 - Excellent for lifelining and abseiling





Belay Points

- Selection of safe belay points is crucial and requires careful consideration
- The selected anchors **MUST** leave absolutely no doubt about their safety.
- Every regularly used pitch under Mendip has sound anchors, ether natural or artificial – you just need to find them!
- Anchors are either Natural or Artificial

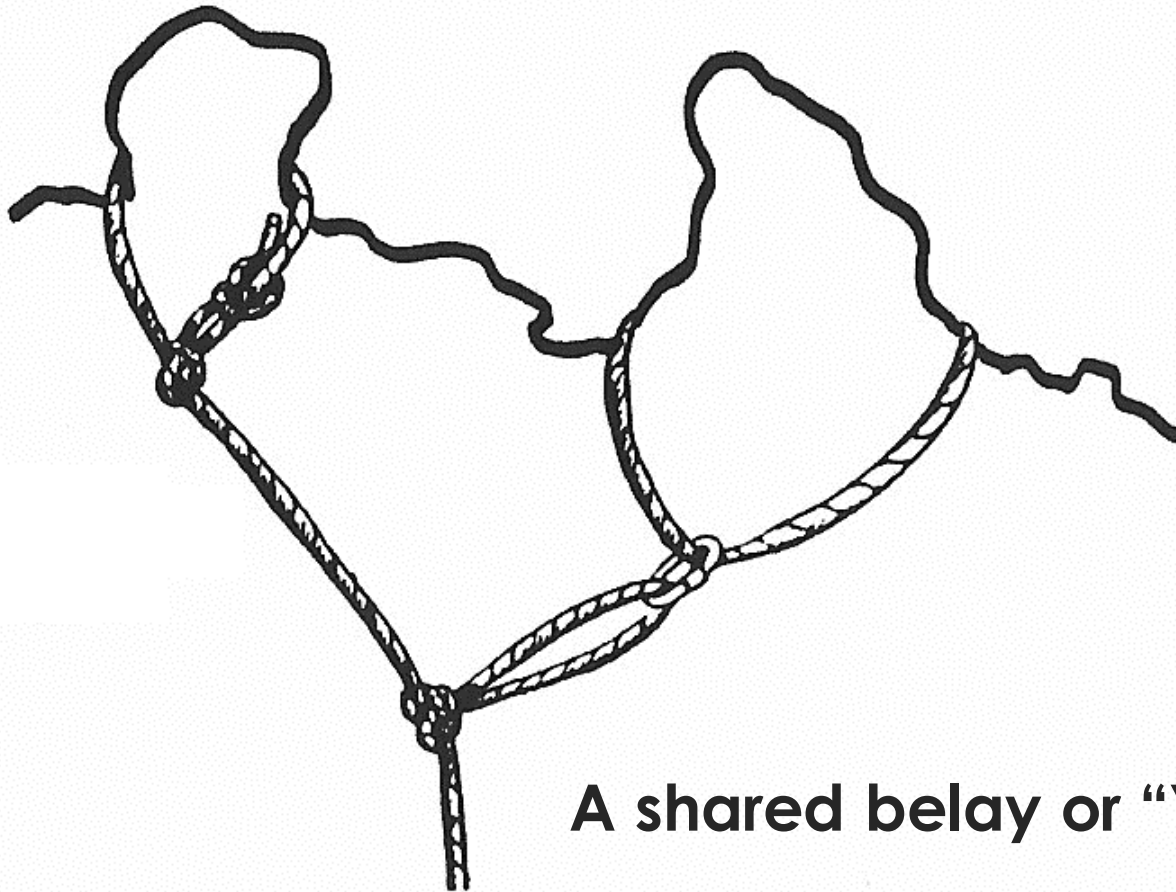


Natural Belay Points

- Sound natural anchors will “ring” when tapped with a steel karabiner. Broken or shattered rocks will give a dull, hollow note.
- Boulders
 - Make sure the boulder won't pivot when loaded
 - Make sure the attaching sling won't pull through under the boulder when loaded
 - Give them a good kick to make sure they are stable
- Stalagmite Belays
 - Use with caution
 - They must be formed on solid rock not rooted in mud or sand
 - They should have ideally a minimum diameter of 15 centimetres
 - Secure rope or sling at or near the base
- Thread belays
 - If through solid rock then provide the highest security
 - Can be difficult to locate or thread around
- For the best security use two separate and sound belays
 - Connect using bowlines, butterfly knots, slings etc. to share the load
 - Reduce shock loading by having a 90 degree angle between the two points.



Natural Belay Points



A shared belay or “Y Hang”



Artificial Belay Points

- Artificial belay points fall into two types:-
 - P-Bolts
 - Stainless steel anchors
 - Held in place by resin
 - For example the three at the “Twenty” in Swildon’s
 - Rope can be tied in directly or attached via a karabiner
 - Check not loose before using (in and out, plus rotation)
 - Spits and Through bolts
 - Spits are:-
 - Metal threads embedded in the rock
 - Into which a bolt and plate hanger are screwed
 - Through bolts are:-
 - Metal bolt sticking out of rock
 - A plate hanger is attached using a nut (may or may not be present).



Artificial Belay Points

- Never trust a single artificial belay (whatever the type).
- Always backup to a natural (or another artificial belay if no natural available)
- If installing a plate hanger make sure a suitable type is used
- Unless using a “Clown” or “Ring” style hanger, always connect the rope via karabiner or maillon. Never tie directly into a plate hanger



- Through Bolt with plate hanger (Eastwater 2nd Vertical)



- “Ring”, “Bend”, “Twist” and “Clown” spit hangers



Simple Handline

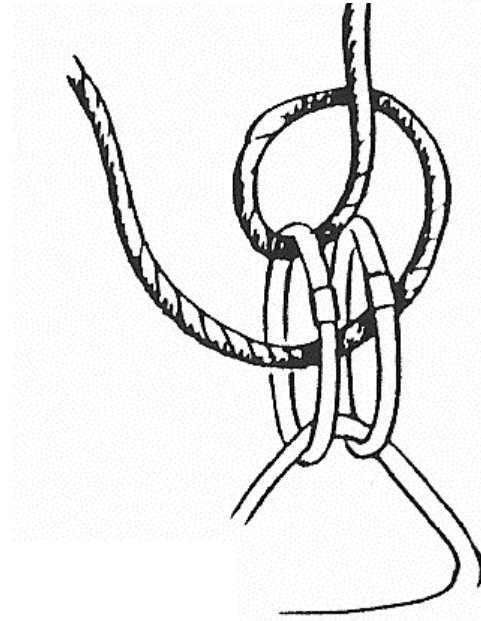
- Anchor securely at head of pitch
- Hang on to it for dear life as you descend and ascend
- Descent can be by:-
 - Hand-over-hand
 - Abseil using Italian Hitch attached to belt, or better, a harness
 - Classic “Flying Angel”
- Ascent can be by:-
 - Hand-over-hand (can be strenuous)
 - Self-locking knot such as the Garda-knot
 - Jammer connected to belt or harness
 - Warning Garda knots and Jammers can't be released under load. Never use if it is possible to swing into free space and not be able to release tension.



Simple Handline



Flying Angel

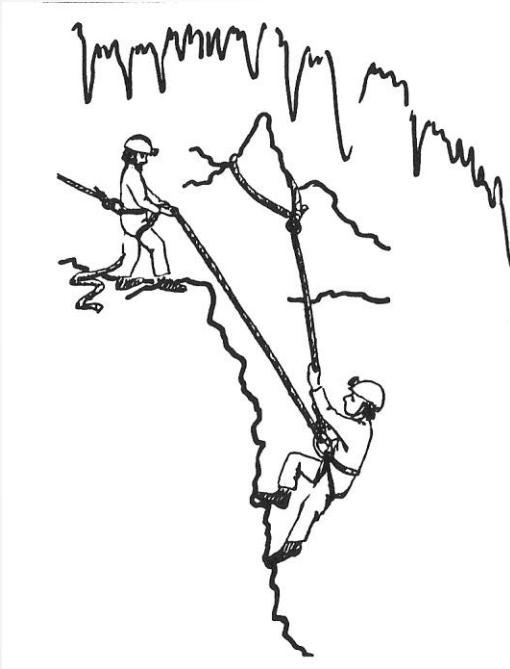


Garda Knot



Assisted Handline

- If a rope of twice the length of the climb is available then an “Assisted Handline” can be used



- Simple and effective
 - Handline
 - Lifeline and
 - Hauling system all in one
- Climber uses belayed side as handline
- Lifeliner keeps tension on the other side
- If climber tires then Lifeliner can haul on the lifeline side

Rigging Ladders and Lifelines



- Simple Rigs

- Most Mendip pitches are general short, dry and thus straight forward to rig
- Identify a suitable “bomb-proof” belay anchor (large natural or a pair of bolts)
- Rig using slings or rope to create attachment point for:-
 - Ladder (or connect directly to a bolt)
 - Lifeline belay point
 - Lifeline's safety clip-in point
- For example Swildon's Twenty, Dolphin Pitch Eastwater, Suldge Pit Entrance

- Technical Rigs

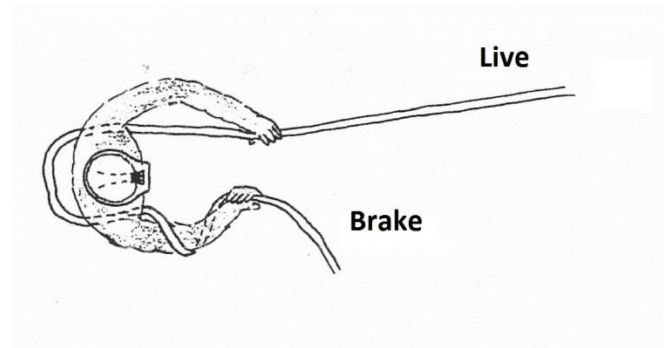
- Occasionally things are more complicated and may involve:-
 - Rigging a traverse line (to safely reach the ladder) – For example Spider Hole Hazelnut Pitch, Right Hand Route Hunter's Hole
 - Adding an additional sling to help climbers on and off the ladder
 - Rigging a handline to help climbers access the ladder



Lifelining Systems

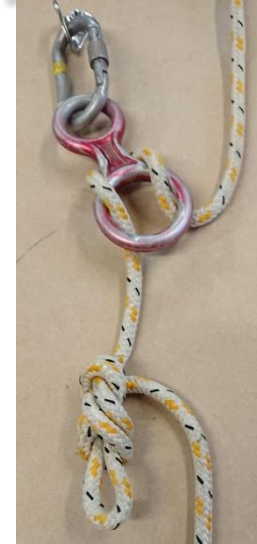
- The main aims of the selected lifelining system are:-
 - Simple and quick to operate
 - Must be reversible (i.e. easy to change from raising to lowering and vice-versa)
 - Hold and lower climber regardless of the strength of the operator
 - Ideally remove the lifeliner from the system
 - Allow the system to be “locked off” and lifeliner to go “hands-free”
 - Load taken directly from the lifeline device to the belay
- Additionally the lifeliner should be clipped in:-
 - directly to the belay using a cowstail or
 - using part of the lifeline rope
- Four of the most common systems are discussed on the following slides:-
 - Body Belay
 - Belay plates
 - Italian Hitch
 - Petzl Stop

Lifeline System– Body Belay



- Advantages
 - No additional kit required
 - Doesn't necessarily need a “bomb-proof” belay (the lifeliner is the belay)
 - Simplicity
- Disadvantages
 - Lifeliner is very much part of the system!
 - Impossible for lifeliner to go “hands-free”
 - Weight differences between climber and lifeliner needs to be considered
 - If climber heavy in comparison then lifeliner should be clipped into something solid
 - Potential for lifeliner injury if heavy fall occurs:-
 - Rope burns
 - Broken Forearm

Lifeline System – Belay Plate



- This includes devices such as:-
 - Stich Plates
 - Belay Brakes
 - Figure of 8's
- Advantages
 - Mechanically simple
 - Lightweight
 - Good braking and smooth operation
- Disadvantages
 - Need to be able to pull "brake" rope behind /above device (never mount above waist height)
 - Easy to drop down the pitch
 - Wears out fairly quickly

Lifelining System - Petzl Stop



- Ideally belay the Stop at head height
- Be careful to thread correctly
- If thick and / or wet rope then only one capstan needs threading
- Advantages
 - Doesn't twist the rope
 - Has an auto-lock (but make sure it operates)
 - Good braking and smooth operation
- Disadvantages
 - Relatively heavy, expensive and complex

Lifeline System – Italian Hitch



- Normal system of choice
- Ideally rigged at head height
- Advantages
 - Simple and effective
 - Requires a single karabiner (ideally a HMS or Pear shaped one to allow the knot to reverse through)
 - Relatively easy to lock-off (see later)
- Disadvantages
 - Twists the rope – may be an issue on longer pitches > 15m)
 - Fairly high friction so rope needs feeding through



Lifeline's Position

- The rigger should select a suitable position for the lifeline. This should ideally:-
 - Keep the lifeline safe (ideally with a clip-in point)
 - Allow the lifeline to see all the way down the pitch
 - Keep the lifeline out of the way of the climbers
 - Allow sufficient room for the lifeline to operate the lifeline system
 - Keep the lifeline away from the base of the pitch (if lifelining from below):-
 - out of the way of falling rocks, climbers or equipment!



Climbing Calls

- Clear communication is essential between climber and lifeliner
- The standard lifelining calls are:-

Climber clips into lifeline.

CLIMBER: **"TAKE IN"**

Lifeline takes in all slack rope until rope is taut.

CLIMBER: **"THAT'S ME!"**

LIFELINER: **"CLIMB WHEN READY!"**

CLIMBER: **"CLIMBING!"** but waits for confirmation

LIFELINER **"OK!"** climber starts



Climbing Calls

- Other calls are:-
 - CLIMBER: **"TAKE IN"** – there is too much slack
 - CLIMBER: **"SLACK"** – the climber needs some slack
 - CLIMBER: **"ROPE FREE"** – the climber is safe and disconnected from the rope
 - CLIMBER or LIFELINER: **"BELOW!"** – rocks are dislodged and falling down the pitch
 - LIFELINER: **"ROPE BELOW!"** – the lifeline is returning down the pitch
- If communication is difficult, say due to the distance or the noise of falling water then a whistle can be used as follows:-
 - ONE BLAST: **STOP**
 - TWO BLASTS: **UP**
 - THREE BLASTS: **DOWN**
 - Easily remembered as SUD (Stop, Up, Down).



Rope Handling

- When operating a lifeline system:-
 - **NEVER** let go of the brake rope – ever!
 - Always keep the braking hand on the rope
 - Use the free hand to help reposition the braking hand
 - Practice and practice again!
 - If a novice climber keep the lifeline taut
 - More experienced climbers will appreciate more slack
 - Ideally position the lifeline around the back or to the side of the climber
 - Keep the climber on the line until they have moved to a safe location away from the pitch head
 - Watch the rope and avoid it tangling around the ladder or other obstacles
 - Tie a knot in end of the rope to act as a warning that it is running out
 - Tie a knot to mark the length when the first person is down
 - Know how to “Lock of” the lifeline so you can go “hands free” if necessary



Locking Off

- Occasionally it will be necessary for the lifeliner to “Lock off” the line and go “hands free”:-
 - May be necessary to offer advice or assistance to the climber
 - Untangle a rope
 - Rig an alternative means of ascent or descent
 - Re-rig some part of the system if unhappy with it's operation (but not the lifeline if someone is on it!).
- Each lifeline system has a different method to lock off:-
 - Body Belay – very few options – best have someone else available.
 - Belay Plate – feed a bight of rope through the connecting karabiner and tie in a mule knot
 - Petzl Stop – don't rely on the auto-brake – feed a bight of rope through the connecting karabiner and pull tight over the top of the Stop
 - Italian hitch – use a mule knot and clip in a locking karabiner if it is to left unattended.



Locking Off



Locked off Belay
Plate



Locked off Petzl
Stop



Italian Hitch Mule
Knot



Italian Hitch Mule
Know with Safety
Krab



Lifeline Pullback

- As a party climbs up a pitch the lifeline must routinely be returned to the bottom of the pitch for those waiting below.
- This may not be as simple as shouting “**ROPE BELOW!**” and tossing the rope down the pitch.
- Some pitches are not straight or vertical or the line may snag on a flake or ledge.
- One simple solution is to use a rope twice the length of the pitch with a figure 8 knot tied halfway. Those waiting below can then use the spare rope below the knot to pull it back down for the next climber.
- This method also prevents the lifeline threading through the ladder.
- Hauling kit bags is also easier as those below can pull the bags away from the ladder or wall.

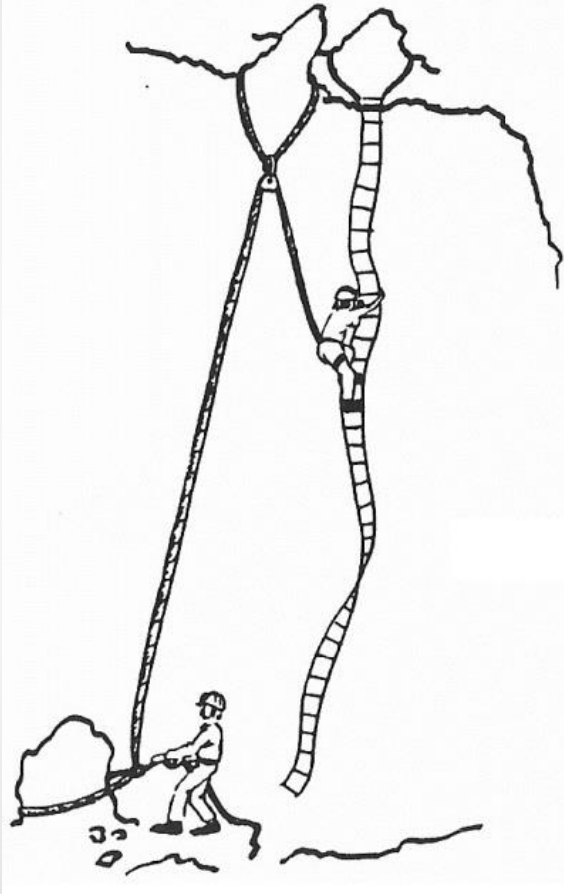


Last Man

- So you have lifelined everyone up or down a pitch. How do you get up or down safely?
- There are three techniques:-
 - Climb the ladder without a lifeline
 - Not recommended – ladders breaks
 - Re-rig as a “Doubled Lifeline”
 - Needs the lifeline to be double the length of the pitch
 - Needs a competent operator at the other end of the pitch
 - May not be possible if lifeline also forms part of the belay
 - Self Line
 - Needs something to abseil with / protect the ascent
 - Shouldn't require any re-rigging, just “Locking off” the lifeline



Double Lifeline



- A pulley can be used at the pitch head or
- the lifeline can be set to run free through a karabiner
- Ideally the lifeline should be belayed to a suitable anchor at the base of the pitch
- If there is no suitable belay then the lifeliner can use their belt
- Needs a rope twice the length of the pitch
- Once the first man is up they can re-rig the lifeline in the conventional manner



Self Lining

- Self lining reduces the amount of rope required and does not need the pitch to be re-rigged.
- The lifeline is “Locked off”
- The lifeliner abseils down the lifeline using their preferred system (Italian Hitch, Petzl Stop or Figure of 8)
- It is not recommended to abseil on a stitch plate or belay brake.
- The ascent is protected using a jammer or garda knot (though this is fiddly).
- The jammer is best connected by a cowstail and positioned over the shoulder
- Be cautious of how you will get off the rope if the ladder breaks or falls (may be you will need a full SRT kit).



Practical Example

- Dolphin Pitch - Eastwater



- Ladder rigged from two bolts using a sling as a Y-hang
- Note extra twist around karabiner in case one bolt fails



Practical Example

- Dolphin Pitch - Eastwater



- Lifeline rigged from “rescue” bolts
- Using a knotted sling to form a Y-hang

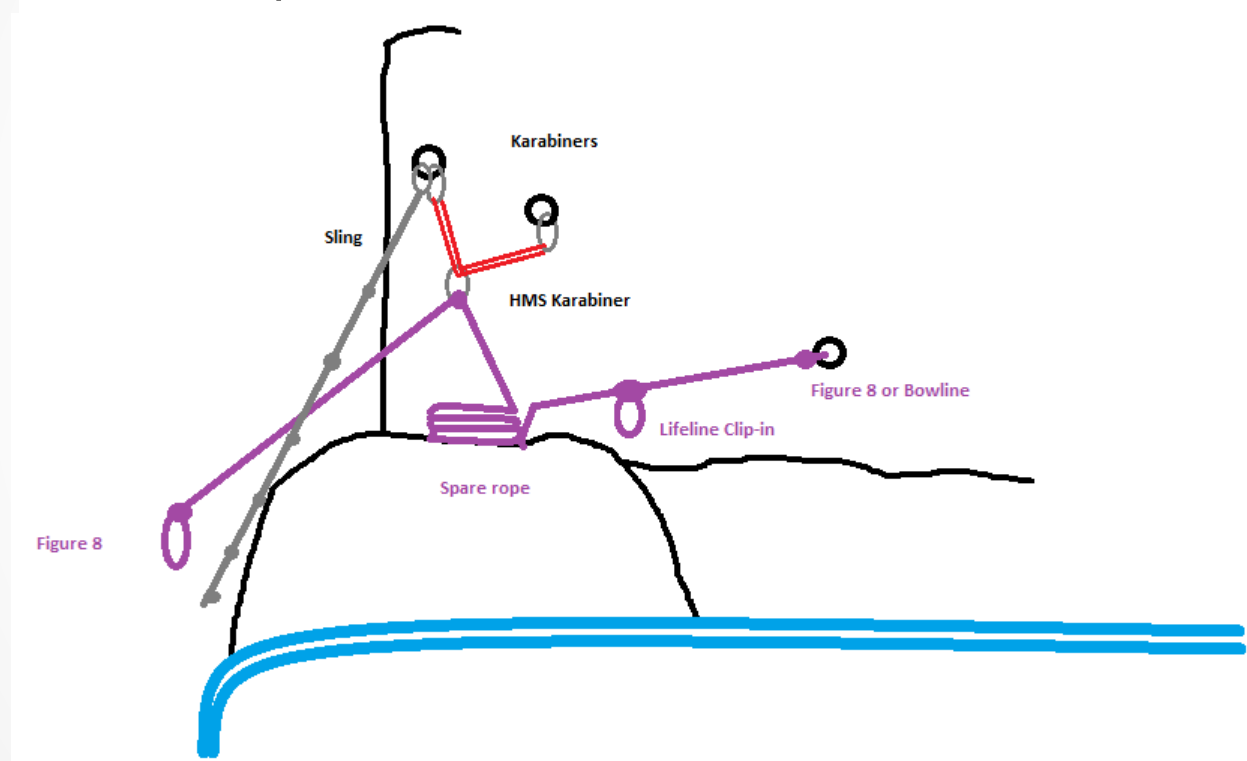
- Lifeliner clipped into lifeline belay and ideally positioned:-
 - Can see the whole pitch
 - Is not in the way of the climber
 - Lifeline system at head height





Practical Example

- The Twenty - Swlidos





Practical Example

- The Twenty – Swildon's





Summary

- Key points to remember
 - Ladders break – always use a lifeline
 - Lifeline anchors must be “bomb-proof”
 - Plan each pitch before hand and ensure you have the right equipment available
 - Don't forget the Last Man (use a double-line or self lining)
 - Know your knots and rigging kit, where and how to use them
 - When life lining **NEVER** let go of the braking rope
 - Finally – Practice makes perfect



Practical Session

- Rigging Ladders
- Rigging Lifelines
- Operating the different Lifeline systems
- Locking off
- Catching falls / lowering off
- See separate worksheet