United States Search and Rescue Task Force

Ropes & Knots

Ropes

A rope is an indispensable lifeline for a climber, rescuer, etc. It is one of the few elements in the protection system that is not backed up by other equipment, and one that absolutely must not fail. An understanding of the design and construction of ropes as well as knowledge of their selection, use and care, is crucial to reducing the risks associated with their use.

Rope Design and Construction -

Ropes used for climbing are dynamic - they are designed to stretch when fallen on, absorbing and dissipating the energy generated by the fall. Static ropes, such as those used in rescue work are designed with minimal stretch and should never be used for climbing. Although static and dynamic ropes look the same they are not interchangeable. Static ropes are not climbing ropes - never use a static rope for climbing or any application where dynamic loads may be encountered.

Cross section of a kernmantle rope showing the weave of the core and the sheath.

Climbing ropes utilize a kernmantle construction consisting of a core (kern) covered by a sheath (mantle). The core is the main load bearing element, and largely determines a rope's major characteristics, such as maximum impact force, and number of test falls held. The sheath is braided tightly around the core and its primary purpose is to protect the core against abrasion, although

the sheath also helps determine a rope's handling characteristics.

Maximum breaking strength is the load whereby a single strand of rope (free of knots or sharp bends) breaks. High breaking strengths are desirable, especially in static life support and rescue ropes.

Knots, bends, edges and falls all reduce maximum breaking strength. For example, the breaking strength of a given rope over a carabineer with a diameter of 10 millimeters is approximately 30 percent less than the maximum breaking strength. Smaller diameter carabineers or rock edges reduce the strength even further. Note that sharp edges are extremely dangerous and are the main cause of rope failure. Use of double or twin ropes reduces this danger considerably.

WARNING: SHARP EDGES ARE EXTREMELY DANGEROUS AND ARE THE MAIN CAUSE OF ROPE FAILURE.

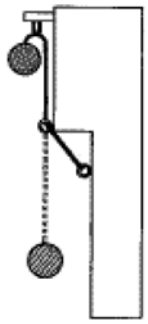
Static elongation is the stretch of a rope when weighted with a 176 pound load. A low static elongation is desirable for rappelling and hauling.

Maximum impact force is the maximum load transmitted to the climber during a fall. The UIAA specifies a maximum impact force of 2540 pounds for single ropes and 1760 pounds for double ropes.

A rope with a low maximum impact force absorbs more of the energy generated in a given fall than a rope with a high maximum impact fore, thus transmitting less energy to the protection system and to the falling climber. However, low impact force is often associated with high rope stretch, which may increase the climber's chances of hitting a ledge or the ground.

Historically, the UIAA (Union International des Associations d'Alpinisme) was the international body that certified climbing ropes. The CEN (Committee for European Normalization) now coordinates standards that are upheld throughout the European Community. The CEN adopted the UIAA rope standards, and ropes tested to CEN/UIAA standards now carry the CE mark. The US government does not require ropes to carry a CE or a UIAA label, nor does it recognize the CE standards. Therefore, standards are presently being developed through the ASTM (American Society for Testing and Materials).

The number of test falls held indicates how many UIAA certified falls a given rope can sustain before breaking. The testing procedure - dropping a 176 pound weight attached to an 8.25 foot length of rope a distance of 16.5 feet - yields a very severe fall which would be difficult to duplicate in any but the worst actual climbing situation. It is important to note that ropes lose elasticity, and their ability to absorb energy, when subjected to repeated falls.



An 80 kg/176lb. weight drops a distance of 4.8 m/15.75 ft. in the CE/UIAA

While the CE/UIAA has set standards for these tests, all of the results are pass/fail. A CE/UIAA label indicates that the rope has passed the

minimum tests only. Any other information listed on the rope label is at the manufacturer's discretion. Number of falls, impact force, etc. are all based on the manufacturer's claims, which may be based on theoretical estimation, and not necessarily on test results.

test. The rope is statically anchored and must survive five consecutive falls for single-rope certification.

Rope Attributes -

Several other attributes of a rope's design and construction are important to consider.

Flexibility - If a rope is too stiff, knots are difficult to tie and may even untie themselves. The more flexible the rope, the easier it is to tie knots and have them stay tied.

Water - Ropes absorb water, increasing the weight of the rope greatly. In cold weather absorbed water freezes, making the rope stiff and unmanageable (ice crystals also reduce rope strength). Many climbing ropes are treated with a water repellent coating to help prevent moisture absorption. "Dry" ropes will not saturate immediately when subjected to moisture; therefore, they will remain lighter and stronger than untreated ropes. Sheath weave also affects water absorption. Ropes with tightly woven sheaths absorb water slower than ropes with loose woven sheaths, and in some instances untreated ropes with tight sheaths absorb less moisture than dry treated ropes with loose sheaths.

Abrasion resistance - Abrasion resistance is the rope's ability to resist fraying. Weave patterns, flexibility, and treatments all affect a rope's abrasion resistance.

Kinking - Every rope kinks. Help prevent kinking by properly uncoiling the rope from the manufacturer's coil. Place your arms inside the main coil. Spin your arms, allowing the rope to un-wind. Do not pull the rope; let it unravel as your arms rotate. Further kinking problems are generally due to improper coiling techniques (i.e. loop coils), and rappel devices (i.e. fig. 8's and Munter hitches).

Hand - "Hand" describes how a rope feels and handles. Diameter, weave pattern, coatings/treatments, sheath tightness, sheath material, and production quality all help determine a rope's hand.

Rope Selection -

First, determine whether a dynamic or static rope is best for your intended use. Always use a dynamic rope for lead climbing. Static ropes may be used for rappelling, rescuing, caving, top roping, and hauling where there is no chance of significant impact loading.

Typically, climbing ropes sold in the United States carry a CE mark and a tag stating rope diameter, length, manufacturer's statement on number of falls held, maximum impact force, weight per meter, and classification of rope (single, double, etc.).

Single ropes are the most common and are identified by the number "1" inside a circle on the label at either end of the rope. Single ropes vary in diameter from 9.8 to 11 millimeters. Thick ropes last longer and usually hold more falls. Small diameter ropes are lighter and easier to clip into protection, making them the preferred choice for high-end lead climbing and glacier travel.

Double ropes (or half ropes) are used only in pairs. These ropes range from 8.2 to 9 millimeters in diameter and are identified by a number "1/2" within a circle on the label at the end of the rope. Double ropes may be clipped alternately through the protection, reducing rope drag and decreasing the chances of rope failure over an edge.

Twin ropes are a third classification offered by some manufacturers and are certified by the UIAA. These are delineated by a "t" symbol on the UIAA label. Both of the twin ropes are clipped through every protection point. The strands should never be separated. Twin ropes are uncommon in the United States. Double and twin ropes are designed to be used with a matching rope. Use of unmatched ropes will cause undue wear on one of the ropes, usually the one with the lowest working elongation or greatest diameter.

Bi-colored ropes change colors or sheath patterns at the midpoint. This feature allows you to easily find the center of the rope.

Inspection of Ropes -

Inspect your rope before and after each use. It is the user's responsibility to know the history of the rope and to determine when it should be retired; keep a rope log on how many times it has been used and the number of falls held. When in doubt, retire your rope. Generally, a rope should be discarded after holding a long hard fall, if it has flat or soft spots, becomes stiff, or shows sheath damage.

Retire a rope after no more than four years of occasional use, two years of weekend climbing, or one year of active use. Retiring a rope after only six months of hard use isn't uncommon; some climbing gym ropes wear out after only a few weeks of intensive use. Also, multiple short lead falls (common in sport climbing), bounding rappels, and shock-loaded top rope falls can have a cumulative negative effect on the rope's shock-absorbing capacity.

Use and Care of Ropes -

Always protect your rope at potential abrasion points. Most ropes are retired because they become frayed, not because of the number of falls held. Watch for sharp edges like rock crystals, bolt hangers, glass, and even pack grommets, which can cut a rope's sheath. Retire your rope if you can see the core at an abraded area or if the rope feels lumpy or flat in spots.

Keep your rope clean. Dirt shortens rope life by causing internal as well as external abrasion. Transport and store your rope in a protective bag or pack. Wash a dirty rope in cold water using mild, non detergent soap. Adding fabric

softener while washing improves rope flexibility by lubricating the fibers. Do not bleach your rope. Air dry your rope away from direct sunlight. Do not dry it in a dryer.

Store your rope away from heat, sunlight and chemicals. Protect your rope from all compounds containing acids, alkalis and oxidizing agents. Avoid contact with battery acid and bleach. Avoid contact with petroleum substances such as gasoline and oil which do not appreciably affect nylon ropes by themselves but may contain additives that can cause damage. These substances also attract dirt which causes the rope to wear more quickly.

Always use proper rappelling techniques. Fast rappels, bounding, or swinging can damage your rope. Some rappel devices place a sharp bend in the rope which creates excessive heat build up and stresses the rope's fibers, leading to accelerated wear.

Never use a climbing rope for any purpose other than for what it was intended. It is not for towing cars, trimming trees, working on roof, etc.

Never step on a rope. Stepping on a rope grinds dirt into the rope fibers, causing excessive wear.

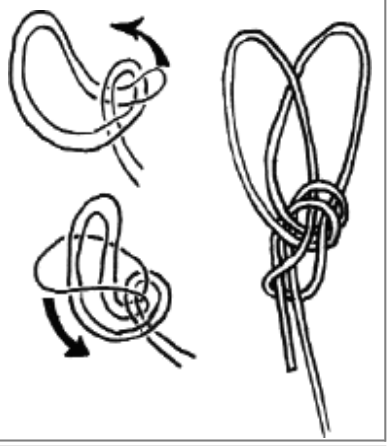
Knots

Bowline 	**An extremely sturdy, and therefore safe, fixed loop. Used by emergency personnel to loop around a victim's body, under their armpits, for rescue operations. If properly tied, it will not grow or shrink under a load.** **This can be used for tying a rope around a belay but is most often used for tying the end of a safety line rope around a person when belaying them up**

a climb or ladder.

This knot does have a tendency to loosen and can come undone so it is a good idea to used a half hitch to secure the "tail" of the knot to the loop.

Bowline on the bight

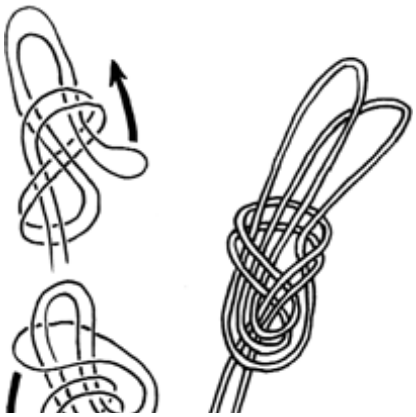


This is another double loop knot suitable for rigging Y-belays. It has the advantage that is a bit less bulky than the figure-of-eight on the bight.

Figure-of-Eight

This is a very versatile knot most commonly used for attaching ropes to anchor points. Most things that can be done with fancier knots (e.g. double loop knots for a Y-belay) can also be done with a suitable combination of figure of eights. If you only learn one knot, make it this one.

Double Figure-of-eight on the bight

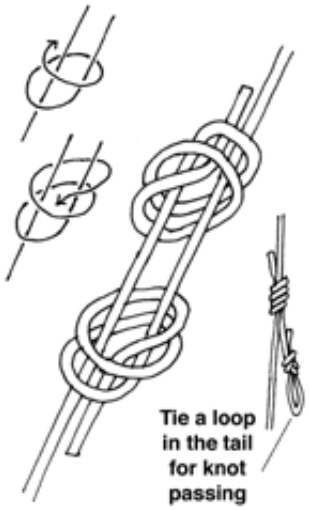


This double loop knot is most commonly used for rigging Y-belays. The nature of the knot means that it is reasonably easy to adjust the loops by moving rope from one of the loops to the other.

Fisherman's Knot

Ideal for heavy, stiff, or otherwise difficult to work with ropes, this knot is easy to tie, but once it has been tightened down, it can be very difficult to remove, especially difficult to remove if it has a load on it (for example, if used in suspension). Slippery rope, such as nylon, will require a double tie on each end to make it fast.

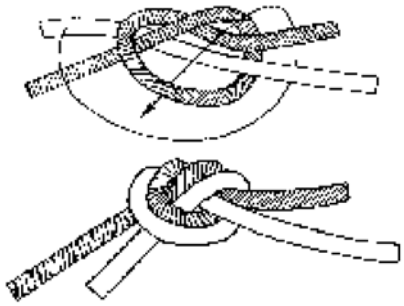
Double Fisherman's Knot



The standard knot for tying two ropes together. If used in the middle of a pitch, a loop knot such as the figure-of-eight should be tied into one of the "tails" of the knot for safety during knot passing.

The two knots that compose the double fisherman's should not be mirror images of one another (i.e. they should have the same "handedness") otherwise they won't stack properly.

Water Knot



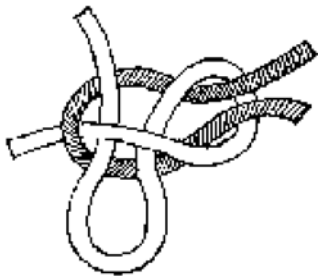
Another knot used to tie two ropes together, this is very strong but difficult to untie. It is good for tying wet rope and rubber.

Not needed for most applications, but when working with latex straps or other difficult-to-tie materials, it can really be helpful.

Sheetbend

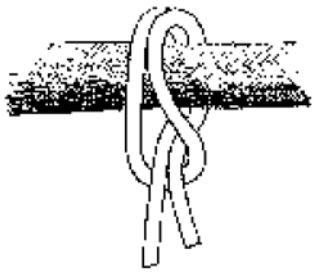
Used to tie two ropes together: notice the similarity to the Square (or Reef) Knot. Equally good for thick and thin ropes, and easy to untie.

Slipped Sheetbend



A variation of the ordinary sheetbend, but even easier to untie -- just pull the loose end.

Lark's Head/Foot

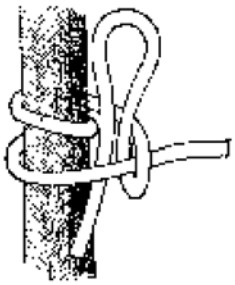


This very easy knot can be tied even if the ends are already tied down. Both ends of the rope must have the same load, or the knot could slip and become unreliable.

Use to tie into grommets or eyebolts for a neat, clean look. Also used to tie into D-rings, such as those found on a collar or on wrist restraints.

A body harness or "Web" can be started by attaching to the subject's collar with a Lark's Head. For this type of application, the knot must be made with the center of the rope, leaving two equal lengths to work symmetrically around the body.

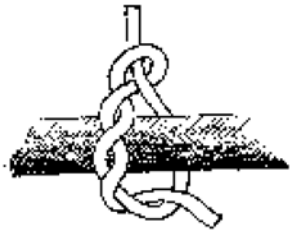
Round Turn



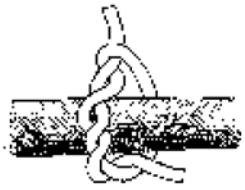
A quick way to tie down a rope end. Not secure enough to be used where safety is an issue, but excellent for temporarily securing the rope end.

If you don't pull the rope end through, but only the loop, you are left with a Slipped Round Turn (pictured), which is a great temporary fastening, as it can be released with one pull of the rope end.

Timber Hitch



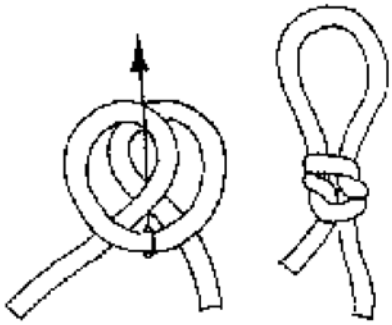
RIGHT



WRONG

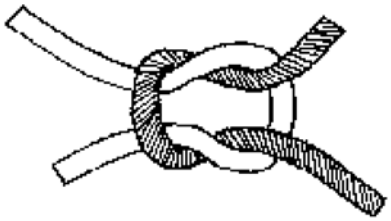
It is very important to double the working end of the rope back and twist it upon itself, not around the anchor. Look closely at the pictures to see the difference.

Fisherman's Loop



One of the easiest ways to make a loop which will not grow or shrink under a load. Useful to tie onto a wrist or other body part, because it will not tighten and cut off circulation.

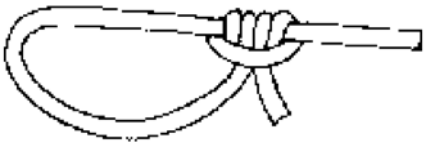
Square or Reef Knot



This is a knot for tying two rope ends together. Learn the knot by twisting one end over the other one. Then twist them again, with the same end on top once again. Tighten, and the knot is done. Make sure both twists have the same rope end on top.

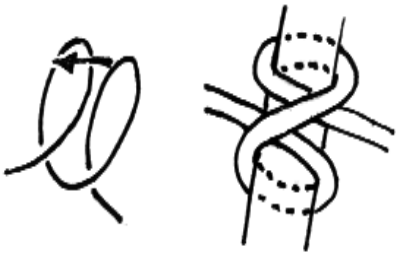
Not to be used when your safety depends on it, but appropriate when you need a knot that's really quick and easy.

Prusik



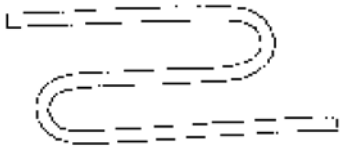
For creating a loop whose size can be changed by sliding the knot up and down the line. Sliding loops such as this one can be used to tighten down a line. Tie the loop around your anchor point, then slide the knot down the line, making the loop larger. The line will be pulled tight, and will remain there. With this knot, neatness does count.

Clove Hitch

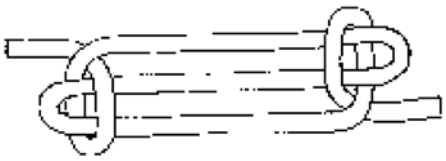


A popular knot among hobbyists, this is commonly used in many disciplines, but not too often in SM. This is because it does not tend to hold up under varying stress, only if the load is equal on both lines. However, if the ends are brought back from the anchor in the same direction, the resulting hitch is safe and elegant, provided that the load on both lines is equal.

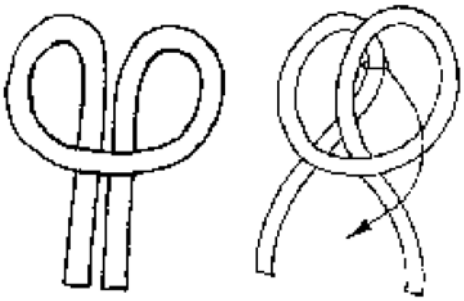
Sheepshank

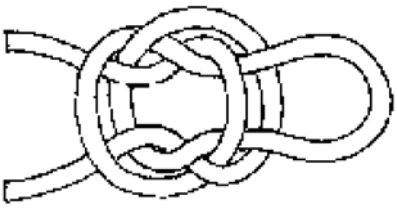


Use this to shorten the middle of a rope, for instance to take up slack in a rope already tied at both ends. It must be kept under a load, or it will come untied.



Jug Sling Hitch

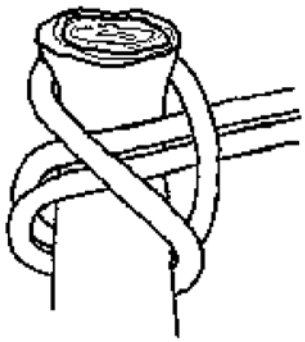




This knot got its name because it was used to create handles on the mouth of a water or wine jug. The rope was tied around the neck of a ceramic jug, with the Jug Sling Hitch tied at equidistant points on the perimeter.

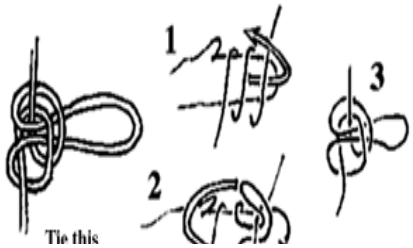
It is a useful way of forming a loop suitable for attaching tethers to the bottom, and will not resize, regardless of the load.

Pile Hitch

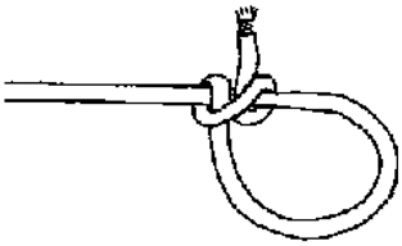


This knot can be used to tie down the end of your line.

Alpine Butterfly



A good knot for rebelays or for tying rub points out of a rope. Its main advantage is that the two strands of rope emerging from the knot are at 180 degrees to one another rather than emerging in the same direction as in a figure-of-eight for example. This makes it a good mid-rope knot and good for rebelays because it has greater strength than a

around your hand 	**figure-of-eight if the rebelay fails.**
Buntline Hitch 	**A quick and easy way to secure the end of your line.** **This hitch consists of a Clove Hitch tied around the anchor end of the line.** **The loop can resize under a load, so it can't be relied upon to attach to the body. However, like the Prusik, it can be used to tighten down a line.**

Remember - The easiest way to learn to tie these knots is to practice tying them using a short length of rope and perhaps a bedpost or other inanimate object until you can tie them well without trouble.