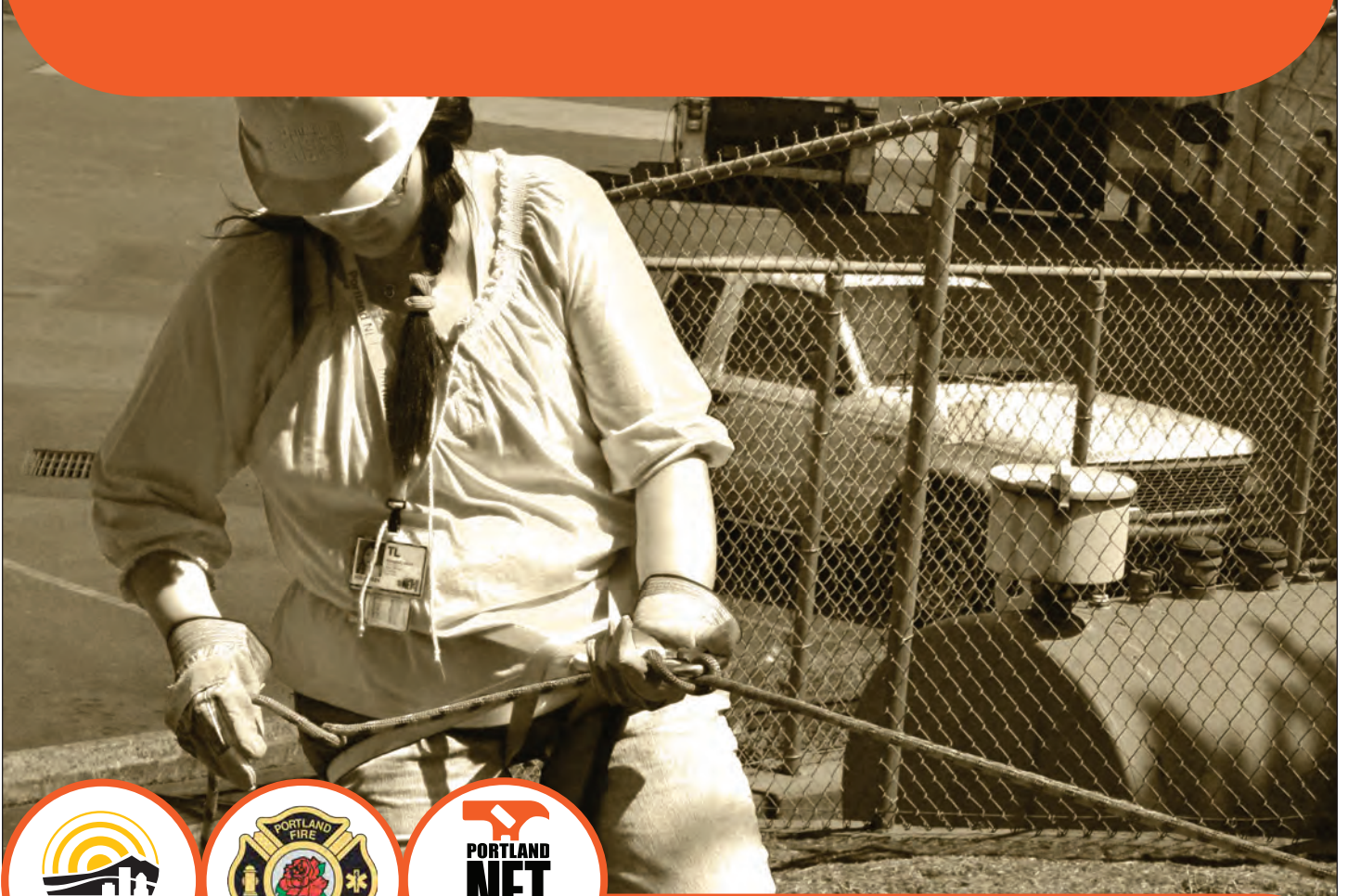


# Portland NET KNOTS GUIDEBOOK

Assembled by  
Lt. Joe Troncoso  
Portland Fire & Rescue



**PORTLAND BUREAU OF EMERGENCY MANAGEMENT**

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# Portland Neighborhood Emergency Teams (NET)

## Knots Guidebook

Assembled by Lt. Joe Troncoso, Portland Fire & Rescue

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Photo credits:

Jeremy Van Keuren, cover

Joe Troncoso, p. 10

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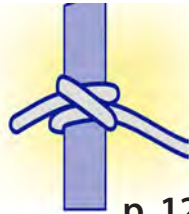
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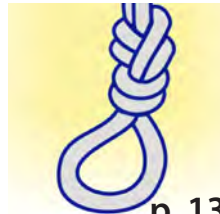
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# Introduction

Though not a basic skillset for NET or CERT, knots nonetheless prove themselves valuable time and again in emergency response scenarios. A volunteer with suitable equipment and knowledge can use knots and a tarp to protect equipment from the elements, set up makeshift shelter, or tie down assets for transport.

Knots have more immediate and potentially life-saving applications as well. Good knots will allow NETs to use SKED stretchers more effectively, and set up a hauling system when needed.

Over thousands of years, civilization has developed hundreds of different knots. Which are the most important for NET volunteers to learn? **Portland Fire & Rescue recommend that volunteers focus on eight basic knots:** the Bowline, the Clove Hitch, the Figure Eight, the Munter, the Overhand, the Prusik, the Square Knot, and the Water Knot. A NET volunteer who is well-practiced in these eight knots has all the knowledge needed to make themselves more capable as a volunteer emergency responder.

Knowing how to tie other knots is welcome, but the eight in this Guide should form the core of a NET volunteer's knotsmanship. It is better for a NET volunteer to be able to tie this small selection of knots well and under stress than to know how to tie many different kinds of knots.

Knowing how to tie these knots is also a part of the NET task book challenge. **A part of completing the NET task book requires that a NET tie six of these knots (all but the munter and prusik) in three minutes and thirty seconds.**

A volunteer needs minimal equipment to practice these knots. Two lengths of rope will get a trainee through most of the knots; adding a locking carabiner and a length of webbing will be enough for all eight. A list of equipment recommended for a complete rope kit for volunteer emergency responders is included in this Guide for those who want to splurge (p. 9). However, nothing so elaborate is required to merely practice.

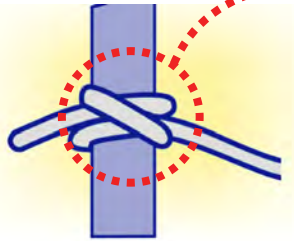
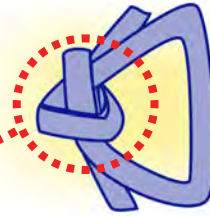
Once you begin to practice, don't stop! Build up your muscle memory for tying these knots and keep yourself sharp with continual practice.

Good luck!

# Definitions

## Bend

A knot to tie the ends of two ropes together, such as a water knot.



## Hitch

A knot to attach a rope to something else, like a pole. For example, the clove hitch.

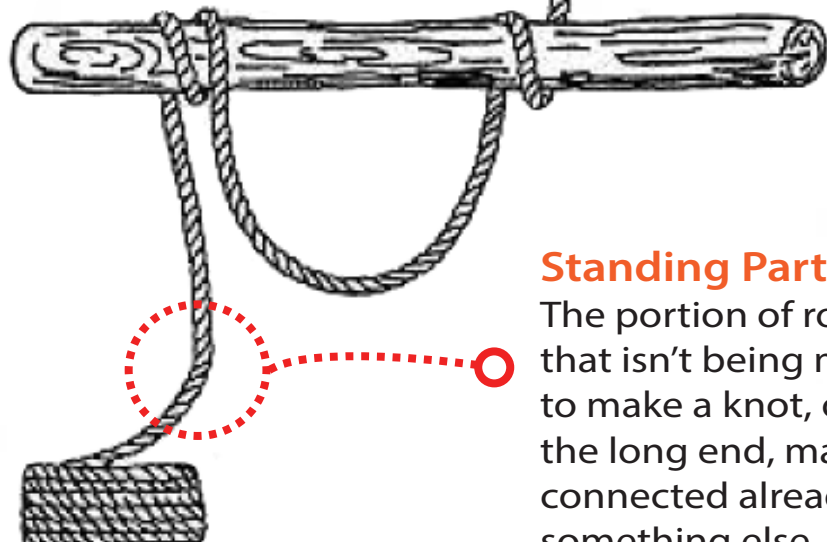
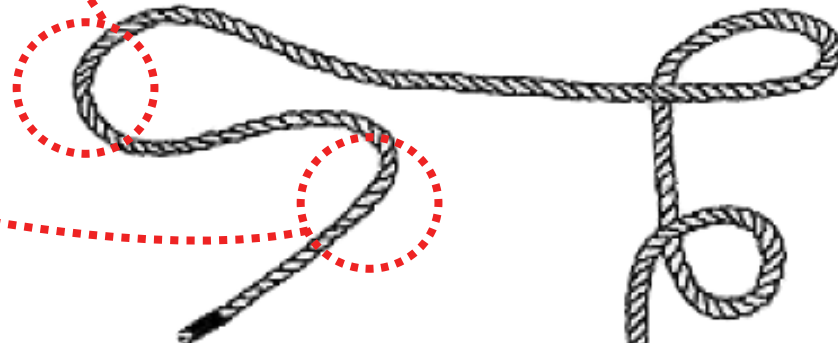
## Bight

A curve in a rope, making it into a "U" shape.



## Running End

The part of the rope you are using to make the knot, often the short end.



## Standing Part

The portion of rope that isn't being moved to make a knot, often the long end, may be connected already to something else.

# Definitions

## Whipping

Using thread or string to bind the end of a rope to prevent fraying.

## Loop

A **Bight** where the running end crosses the standing part, closing the **Bight**.

## Dressing

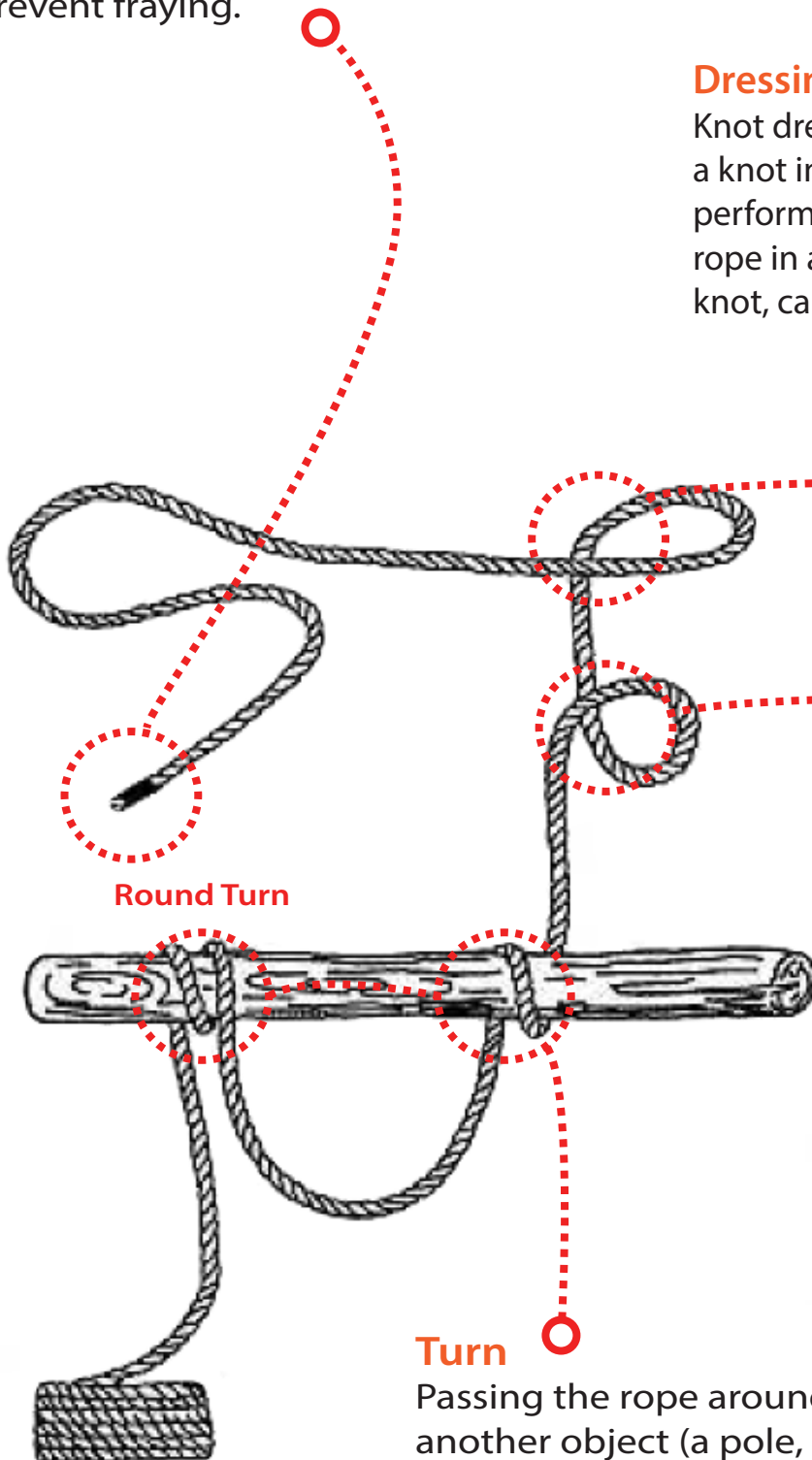
Knot dressing is the process of arranging a knot in such a way as to improve its performance. Crossing or uncrossing the rope in a specific way, depending on the knot, can reduce its jamming potential.

## Overhand Loop

A **Loop** where the **Running End** passes over the **Standing Part**.

## Underhand Loop

A **Loop** where the **Running End** passes under the **Standing Part**.



## Turn

Passing the rope around another object (a pole, ring, hook or even a rope).

# Personal Equipment

## Helmets

Wearing a helmet is the accepted safety practice in rope rescue. Besides falling rocks and debris, a helmet will protect individuals from dropped or falling equipment and offer protection from falls. NET or CERT helmets provide protection required in fire ground operations and can also be used in many areas of rope rescue.

Climbing helmets are designed to offer protection from falling objects as well as protecting the head during a fall. Their light weight, size and ease of attaching a headlamp make their use in many situations desirable.

## Clothing

Long sleeve shirts or sweatshirts (with sleeves down) are needed on any member over the edge. In addition to protecting from abrasions, long sleeves can offer protection from other hazards such as poison oak.



## Gloves

The hands need protection from moving rope (i.e. lowering operations), as well as other hazards found in rescue work.

Almost any type of leather glove will work. Gloves shall be worn by all NET or CERT personnel when handling working ropes.

## Boots

Boots are needed to provide protection for the feet, support for ankles and provide traction on a variety of surfaces.

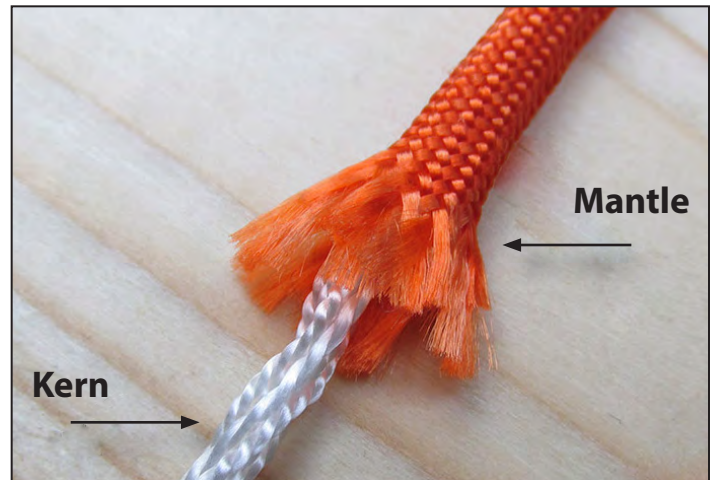
Many types of boots are adequate for rope rescue, provided they meet these requirements: stiff narrow sole, traction type tread and snug laced uppers.

## Lighting

A rescue team must be able to operate after nightfall as well as during daylight. When working around or on the rope, a headlamp provides adequate light and keeps the hands free. There should be one headlamp per member on each team. These must be stored in a sealed container if kept in the same compartment as rope and/or webbing. It is recommended that the batteries be stored separately from the headlamps.

# Rope

The rope used is *static* one-half inch kernmantel type construction. The term “static” refers to the rope’s low stretch characteristic (only 2% at working loads and no more than 20% at failure). The term “kern” refers to the core of the rope and is about 70% of the rope’s strength. The “mantel” is the sheath and protects the core from damage. It makes up the remaining 30% of the rope’s strength.



## Maintenance

- Do not walk on ropes as this may force dirt and grit into the sheath and core resulting in abrasion of the sheath and/or weakening of the rope.
- Protect the rope from sharp bends, edges or sharp objects. If a sharp edge is unavoidable, pad the area with any available padding such as carpet, edge guards, rope guards or similar material.
- Rope must be protected from chemical and physical damage in use as well as when in storage. Do not store rope or webbing in the same compartment as batteries, petroleum products or other chemicals.
- Use rope rescue ropes and equipment *only* for rope rescue related operations.

## Inspection

Inspection of rope is both a visual and a hands-on operation.

- Look for smooth glossy spots indicating possible heat damage.
- Increases or decreases in rope size may indicate internal damage.
- Check for exposed core fibers (usually white in color) and excessive fraying for evidence of sheath damage.
- Determine possible contamination from dirt and other substances.
- Slowly run the rope through your bare hands feeling for changes in diameter, texture, stiffness or hard spots.
- If you have any doubt as to the condition of the rope, take it out of service.

# Webbing

Portland NETs utilize one inch, nylon, tubular webbing. The webbing is color coded red and comes in a 12-foot length. One-inch tubular webbing has a rated strength of 4,000 pounds. Webbing is used in many phases of rope rescue, ie; anchors, harnesses, litter use and pick off procedures.

Webbing is often used to construct an anchor. It is a good alternative to manufactured anchors because of its characteristics:

- **abrasion resistance**
- **adaptable length**
- **easily replaced if damaged or worn**
- **easily untied**
- **less strength loss when sharply bent**
- **low cost**

The preferred method of using webbing for anchors is to wrap webbing around an anchor point two or more times, keeping the webbing flat without twists. The knot should be on the same side of the anchor as the load minimizing the loading of the knot. Any sharp bends or abrasive surfaces that webbing must pass over or around should



be padded to protect the webbing from damage that may compromise its strength. Anchor webbing which will be in a high load situation must be double webbed (i.e. two separate pieces of webbing tied to be the same length). The only knot that will be used to join two pieces of webbing together is the Water Knot ([page 18](#)).

## Maintenance

- **Storage of webbing will be in such a manner that it will not become contaminated with petroleum products or chemicals.**
- **Do not store webbing in any way that makes it susceptible to physical damage.**

## Inspection

Webbing is inspected in the same manner as rope, with a visual check and by feel.

- **Visually check for discoloration (contamination or chemical damage), glossy spots (heat damage), excessive fraying, cuts or abrasion.**
- **Run the webbing through your hands feeling for hard spots, changes in texture, changes in size, and contamination.**
- **If the condition of webbing is questionable in any way, replace it.**

# An Ideal Rope Kit for NET

To enhance their kits, a team or individual NET may wish to purchase their own rope rescue kit. Portland Fire & Rescue recommends that the kit include the following elements:

1. 20' length of 1" webbing (qty. 2)
2. 12' length of 1" webbing (qty. 2)
3. Rope bag (qty. 1)
4. Pre-tied Prusik loops (qty. 2)
5. Locking carabiners (qty. 4)
6. 3" dual pulley (qty. 1)
7. 1" single pulley (qty. 2)
8. 150' 10 mm kernmantle rope



# Knots, Hitches, and Ties

Although knots, hitches and bends refer to different uses of rope, the generic term “knot” will be used throughout for simplification.

## Knot

A compact intersection of interlaced material tied in a prescribed way.

## Hitch

To fasten temporarily with a loop or series of loops.

## Bend

A knot that joins a rope to another rope or to another object.

**Any time a rope or webbing makes a bend around itself or an object, there is a resulting loss of strength.** Therefore, any knot will reduce the strength of the rope.

<b>Rope with no knot</b>	100% of full strength
<b>Figure Eight</b>	75-80% of full strength
<b>Bowline</b>	70 - 75% of full strength
<b>Double Fisherman's</b>	65 - 70% of full strength
<b>Water Knot</b>	60 - 70% of full strength
<b>Safety Knot</b>	60 - 70% of full strength (tied in a piece of webbing)
<b>Square Knot</b>	43 - 47% of full strength

The table in the previous column is a comparison of relative strengths for single kernmantle rope. It is shown so that you understand that different knots affect the rope strength to different degrees.

Most knots do not require a safety knot, provided they are properly tied and dressed. When a safety knot is needed, half a double fisherman's will be used. This knot will be referred to as the safety knot. The Bowline (mainly used to secure the working end of the safety/belay line to the rescuer) and the Square Knot (only used in the vertical raising of the SKED litter), must always be secured with a safety knot.

Many authorities feel the “Figure Eight” family of knots is preferable for use in rope rescue operations for the following reasons:

- **The Figure Eight knots are more likely to be tied correctly.**
- **They are more likely to be remembered.**
- **They remain stable even if the loading direction should change.**
- **They are more likely to remain tied after repeated loading and unloading.**
- **They are less likely to capsize when pulled across an obstruction.**
- **They tend to weaken the rope less than a bowline-type knot.**

.....  
In the section that follows, click on the orange camera icon to open an instructional video for the knot on that page.

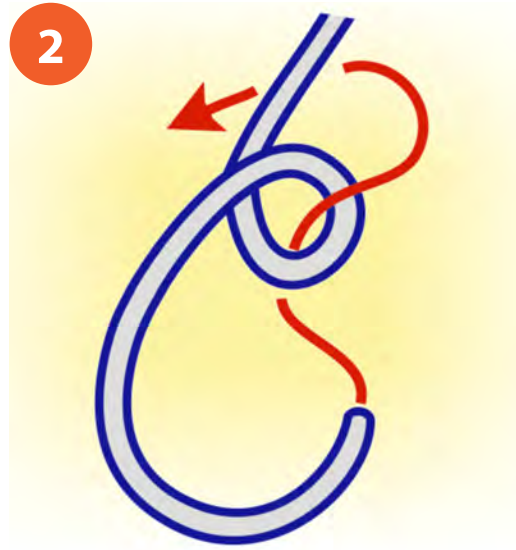


# Bowline

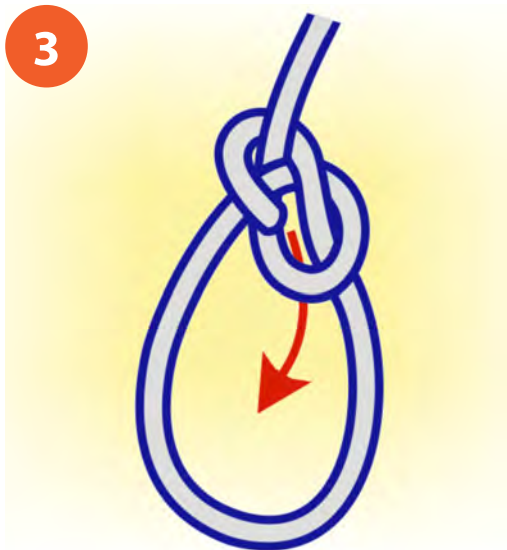
One of the most useful knots to know. The Bowline forms a secure loop that cannot jam. It remains easy to tie and untie. It is commonly used to create a fixed loop of variable size at the end of a line. It is reliable, strong and stable. Even after being loaded with extreme tension, it is easy to untie.



Lay the rope across your left hand with the free end hanging down. Form a small loop in the line in your hand.



Bring the free end up to and pass through the eye from the under side (the rabbit comes out of the hole).



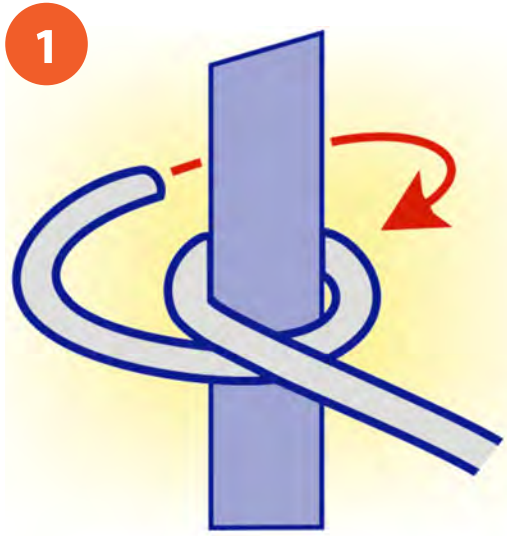
Wrap the line around the standing line and back down through the loop (around the tree and back down the hole).



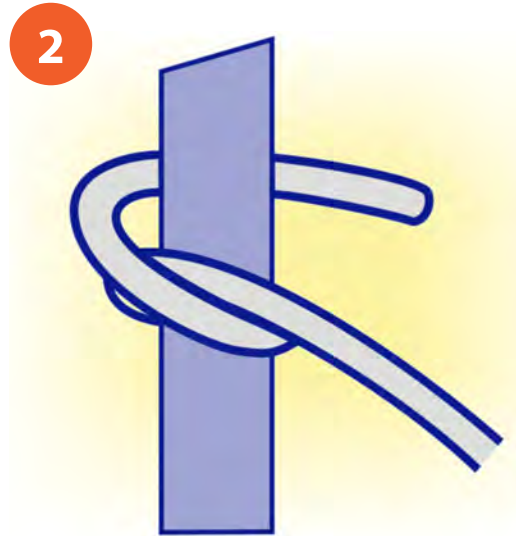
Tighten knot by pulling on free end while holding standing line.

# Clove Hitch

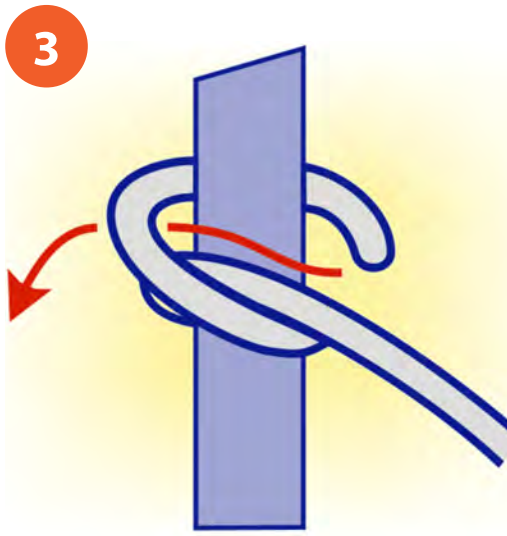
A simple, all-purpose hitch that is both easy to tie and to untie. It is a good binding notch. It should be noted that the knot can slip or come undone if the object tied to it rotates or if constant pressure isn't maintained on the line.



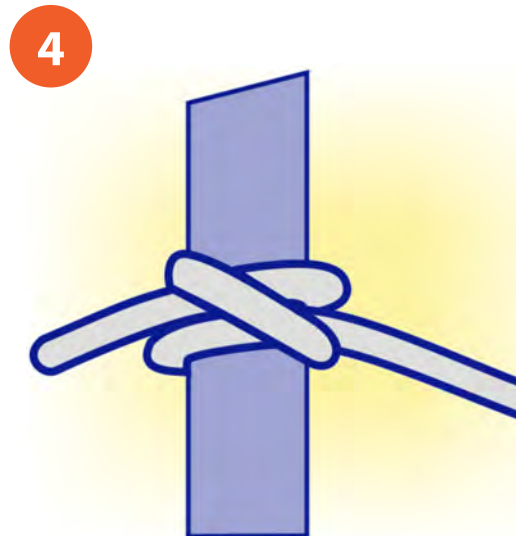
1  
Wrap the free end of a rope around a post.



2  
Cross over itself and around the post again.



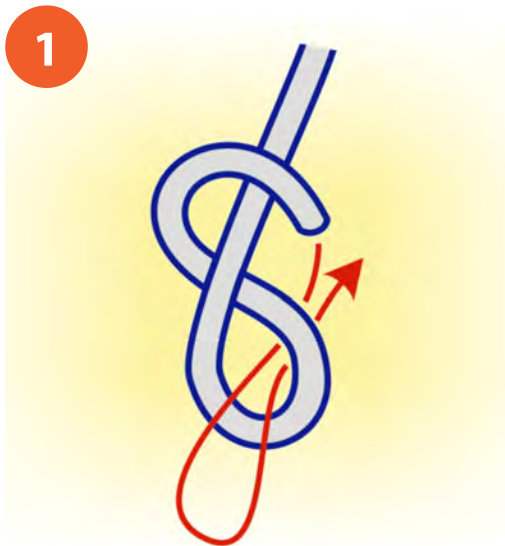
3  
Slip working end under last wrap.



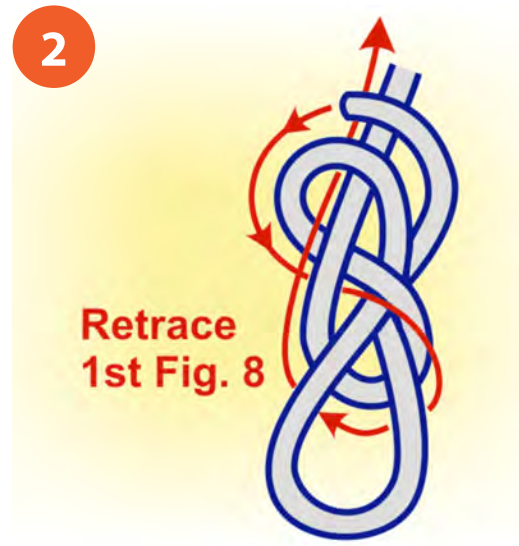
4  
Pull tight.

# Figure Eight (follow through or on a bight)

The Figure Eight is one of the strongest knots. It forms a secure, non-slip loop at the end of a rope. This is one of the safest knots and for that reason, it is commonly used by both the Alpine and Rescue communities. It is strong, secure and easily inspected. It can be tied with a doubled line at the end of a rope to create a free loop, or tied using the "Figure Eight follow through" to tie it around an object.



1 Tie a single eight in the rope two feet from its end. Pass the free end through any tie-in point if desired.



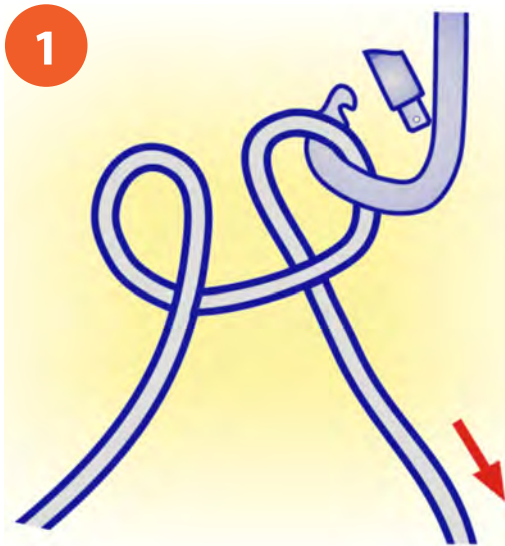
2 Retrace the original eight with the free end leaving a loop at the bottom of the desired size.



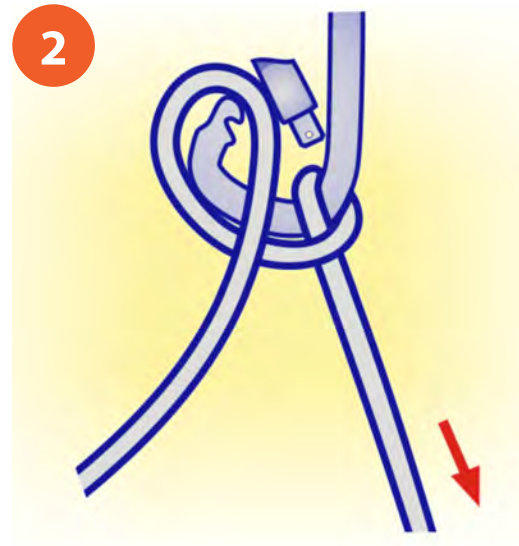
3 Pull all four strands of rope to cinch down the knot.

# Munter

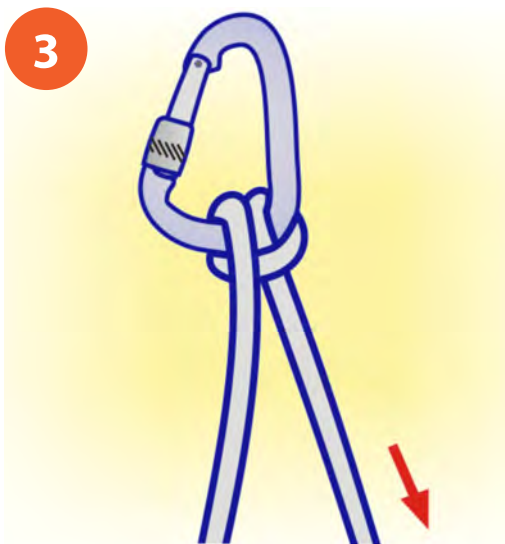
This reversible hitch provides a method for belaying and rappelling without a device. This is an important knot for rescuers to know, and can be tied around carabiners. Please note that this should **ONLY** be used in conjunction with a locking carabiner. When belaying with the Munter, be sure that the strand of rope carrying the load is adjacent to the back of the carabiner. Always use this knot correctly, as it can cause kinks or twists in the rope.



1 Make a loop in the rope and slip the loop into a locking carabiner. Form a second loop with the line crossing opposite the first loop.



2 Slip second loop into the carabiner and lock carabiner.

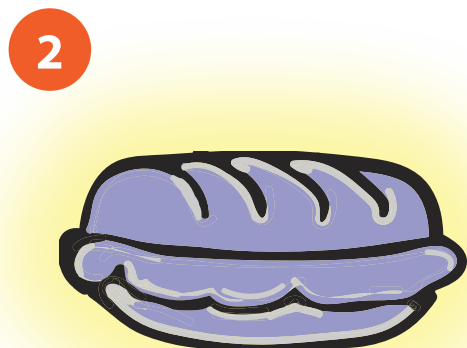


3 Make sure the strand carrying the load is next to the spine of the carabiner.

# Overhand



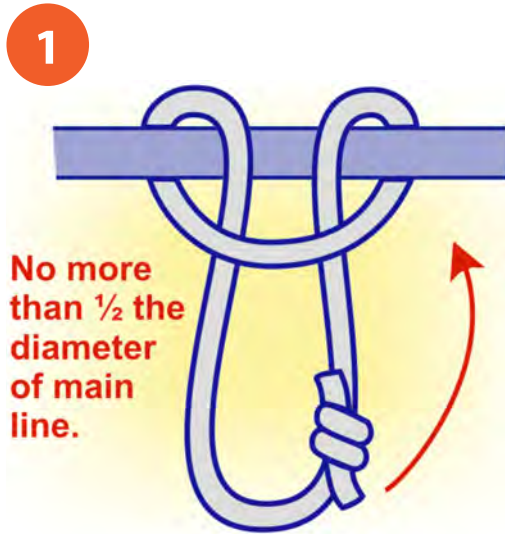
Tie an Overhand Knot at the end of a rope but do not tighten the knot down.



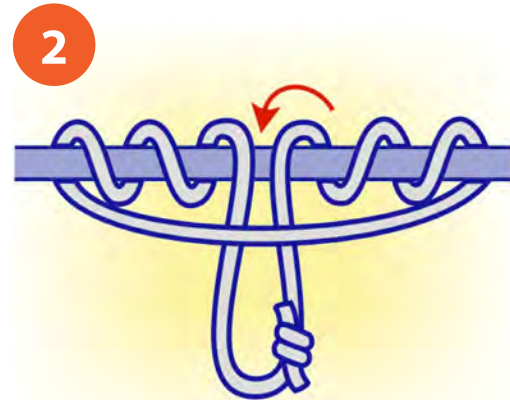
Yeah, that's it. This one is pretty easy. Go take a break and eat a sandwich or watch cat videos or something.

# Prusik

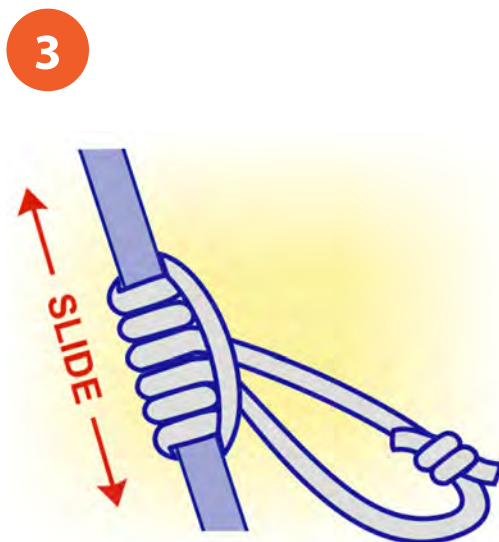
Use the Prusik Knot to secure a load to a tight line. It slides when it is not weighted along a tight rope, but jams and holds solidly upon loading. Mountaineers use this knot to for footholds to help them climb a vertical rope. This loop needs to be made by rope or cord that is equal to or lesser than  $\frac{1}{2}$  the diameter of the main line. This knot is used in Rescue as a safety line.



Use a sling of cordage to tie a Girth Hitch around the main rope.



Pass the loop of the sling back through the center of the Girth Hitch three or four more times.



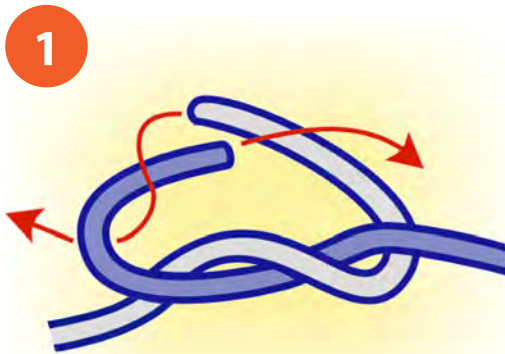
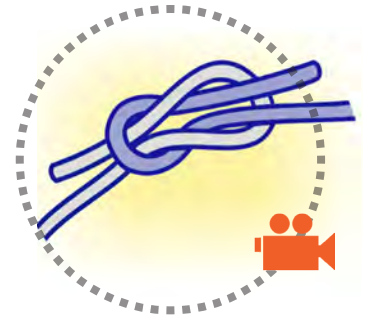
Load with weight to make sure it "bites". If it slips add more wraps.

## What knot is used on a Prusik?

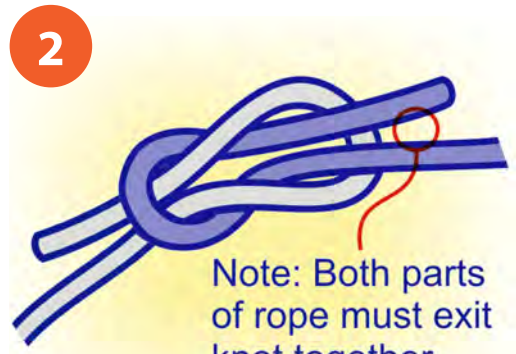
A Prusik is secured with a Double Fisherman's Knot. However, it is a fairly complex knot and not demonstrated in this guide. Portland Fire & Rescue recommends that NET volunteers purchase pre-tied Prusiks and keep them in their kits tied and ready to go.

# Square Knot

The Square Knot is a good knot for securing non-critical items. It is **not** to be trusted during life safety operations to join two ropes. This knot can come apart. Be sure when tying the knot to avoid a granny knot.



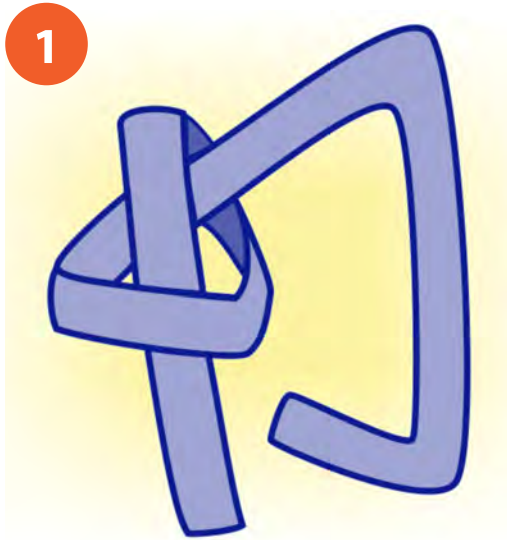
Tie two overhand knots. First, right over left and twist. Then left over right and twist.



Make sure both parts of the rope exit the knot together!

# Water Knot

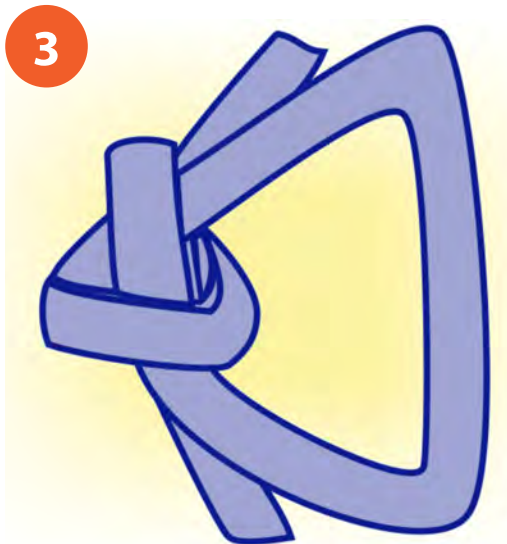
This is by far the best knot to use for tying knots in webbing. It can be used to make slings and grab handles. Be sure that the tails exit from different sides of the knot and make certain that they are at least 3" long to be able to inspect for slippage in the knot.



1 Tie an overhand knot in one end of the webbing leaving the desired length of the loop free.



2 Retrace the knot in the opposite direction with the other end of the webbing.



3 Pull tight. Make sure the free ends are a couple inches long to visually inspect for slippage during use.

**Quick note here:** to pass the knots test, a NET must be able to tie this with webbing and NOT with rope.

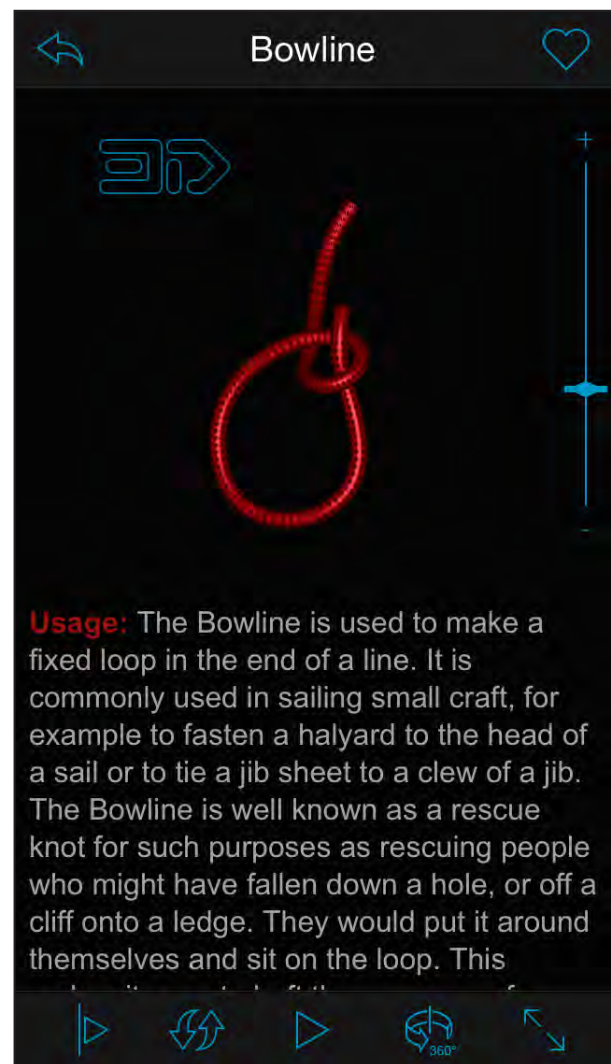
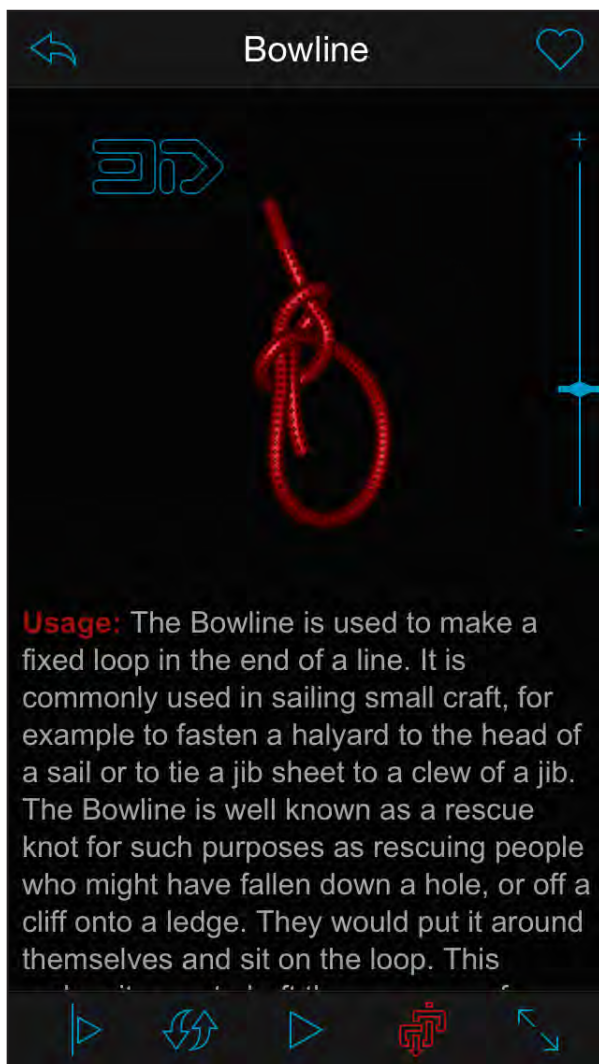
# Supplemental Resources

As an aide to learning knots and having a ready resource, owners of smart phones may wish to consider downloading the Knots 3D app onto their phones.

Knots 3D includes an extensive library of knots, with easy to follow graphics that walk the viewer through every turn and bight of a knot. Device interaction also allows a user to rotate the view of a knot to any angle.

The app is not free, but it is fairly inexpensive. The price ranges between \$.99 to \$1.99 depending on the type of phone.

More information about this app is at: <http://knots3d.com/>



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