



Career Recruit
Programme

Study
Guide

Knots and Lines

**NATIONAL
TRAINING**

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Introduction

Module aim

This module will equip you with the skills and knowledge you will need to identify various knots used by the New Zealand Fire Service (NZFS) and how to tie various rescue and non-rescue knots.

What this module contains

Theory:

The theory component contains this study guide, a workbook, and consolidation work.

This study guide has three sections:

1. Introduction to Knots and Lines
2. General-purpose Knots
3. Rescue Knots.

Practical training:

Practical training for this module is done before attending the Career Recruit Programme with the supplied line.

Consolidation period:

Consolidation contains post-course work with knots and lines when you are at your new station.

Delivery

The theory component is delivered before the course and classroom learning.

Section 1: Introduction to Knots and Lines

It is essential to use knots and lines in many of the activities carried out by the NZFS.

These activities include:

- Rescue activities, where a person's life could depend on the knot and line
- Non-rescue activities, such as when using line to lift a piece of equipment.

Before attending the course

Before you begin the Career Recruit Programme, you will be expected to have learnt 14 of the standard NZFS knots. Learning these knots prior to the course will provide more time on course for you to focus on other fire fighting skills.

To help you do this, the following has been included in your pre-course package:

- One piece of line
- Instructions on how to tie each knot.

Included in the instructions is the maximum time it should take you to tie each knot.

It is extremely important that you take the time to practise these knots. Once on the course, you are expected to be able to tie each knot within the provided time period without error in any given situation, including light and darkness.

If you have difficulty with any of the knots, the instructors will provide assistance on course.

Knot types

Knots all have very specific uses. As well as knowing how to tie a knot, you need to know what the knot is used for. The knots in this section fall into two broad categories: general-purpose knots and rescue knots.

Rescue knots may be used in any situation.



Safety Note

Only rescue knots are to be used during rescues.

Types of line

The NZFS uses three main types of line: general-purpose lines, bucket lines, and rescue lines.

General-purpose line

General-purpose (GP) line varies from 3 to 30 metres in length. It is used for many non-rescue purposes.

For example, it can be used as a suction line. Suction line is used to secure and manoeuvre suction hose. Some districts carry dedicated suction lines, which are 20 metres long and are stowed separately on the appliance.



Figure 1.1: GP line used to secure suction hose

Bucket line

Bucket line is a 12-mm-diameter line that is 30 metres long. This line is stowed in a canvas or PVC bag, which helps to keep the line together when it is thrown. The bucket line is predominantly used when lifting items of equipment aloft.



Figure 1.2: Bucket line

Rescue line

The only rope used in rescue operations is static life rescue line of kernmantle construction. We cover the construction of rescue line in more detail on course.

Line construction

Line characteristics

Lines can be made of natural or synthetic fibres.

Natural fibres for lines:

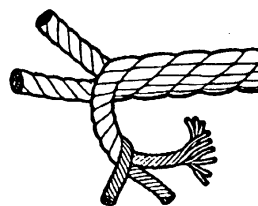
- Can rot (even inside-out)
- Have low resistance to abrasion
- Have limited ability to absorb shock
- Have low strength.

Synthetic fibres for lines are nylon, polyolefins, polyester, or Kevlar, which:

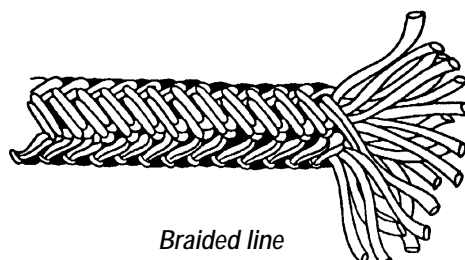
- Do not rot
- Do not age as quickly as natural fibre
- Can be made into more advanced designs
- Have high strength.

Synthetic fibre lines can be constructed in the following ways:

- Kernmantle
- Hawser or laid (twisted)
- Braided (double braid and single braid).



Laid line



Braided line

Figure 1.3: Laid and braided line

Kernmantle

The term kernmantle comes from the German words *kern*, meaning core, and *mantel*, meaning sheath.

The kernmantle style of construction consists of a kern or core of filaments designed to sustain the greater part of the load. This core is covered by a woven or braided sheath that supports a lesser portion of the load but provides protection for the core against abrasion, dirt, and sunlight (ultra-violet light). This construction style provides a line that is strong and resistant to damage yet light and easy to handle. These lines also tend to be highly resistant to spin or twist.

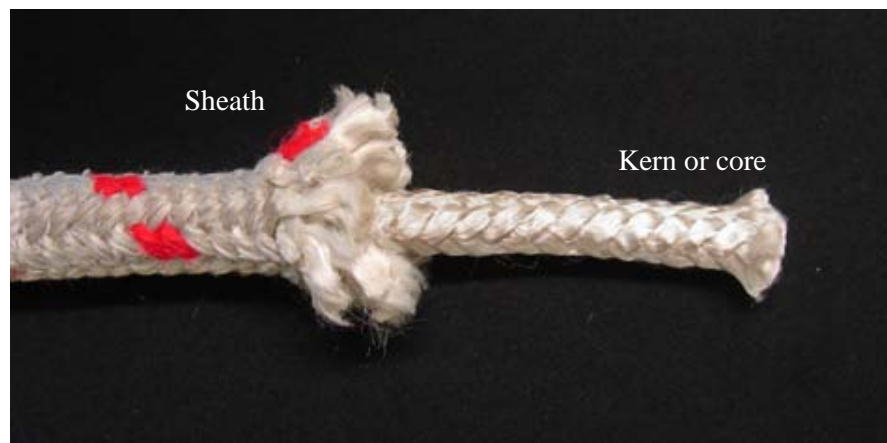


Figure 1.4: Kernmantle line

Parts of the line

A line consists of the following parts:

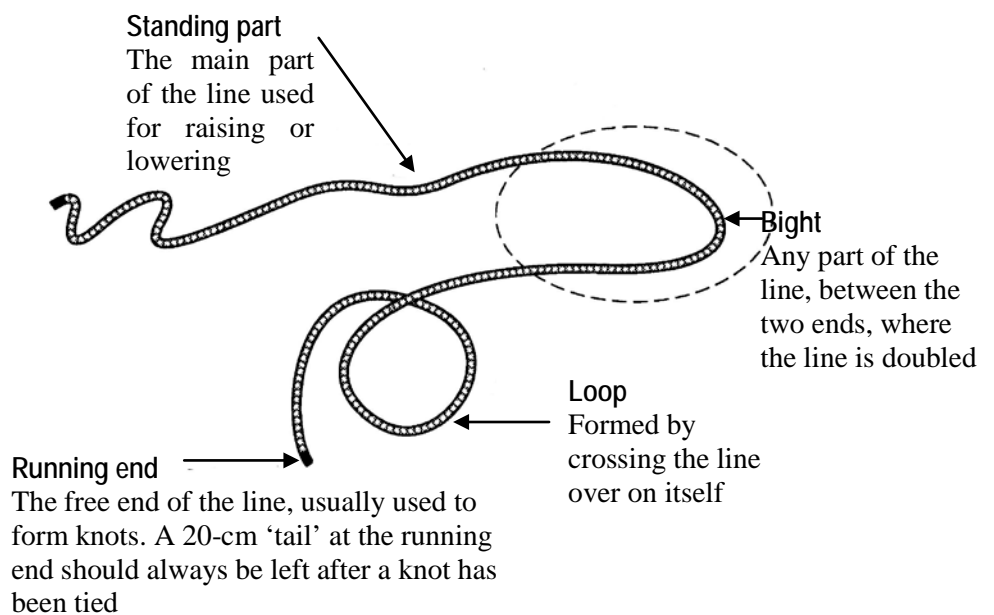


Figure 1.5: Parts of a line

Care of lines

Guidelines

Follow these guidelines to care for lines:

- Do not store lines wet. They should be flaked and left lying flat to dry in a well-aired position away from direct heat and sunlight.
- Do not dry lines artificially, for example, in station dryers or clothes dryers.
- Do not leave lines tightly stretched or knotted for any longer than necessary.
- Use line edge protection at all times. For example, use an off-cut of a fire hose.
- Use only synthetic lines approved by the NZFS.
- Check each line before and after use and six-monthly.
- Do not step on lines while on the ground.
- Wash lines with warm water and natural soap, not detergent.

Tests and inspections

Lines are susceptible to damage from heat, chemicals, and UV light and mechanical damage. It is therefore important that lines are tested and inspected to ensure they are fit for use.

Two types of inspections and tests must be completed:

- A visual and tactile inspection
- A measurement test.

Inspections are completed:

- On acceptance
- After repair
- Six-monthly
- For lowering, rescue, and safety lines, after use.

Measurement tests are carried out annually and as required by the Line Rescue Maintenance Department (LRMD). They usually involve adding weight and making sure it doesn't stretch too much.

For more information on the inspection and testing of lines, see *RD 5 Equipment Maintenance and Testing*, which is available on FireNet.

Documentation

Logs must be kept for all rescue lines. This ensures that the history of the line verified and factors controlling the life of the rope (such as amount of use or age) can be controlled.

The following information should be recorded in the log:

- Date of issue
- Line type and diameter
- Length
- ID/serial number
- Location of the line
- Amount of use
- Comments (such as type of use, defects, and condition of the line).

The log must be filled out every time the line is used or inspected.

Section 2: General-purpose Knots

Knot tying

Knot tying consists of tying knots, bends, and hitches.

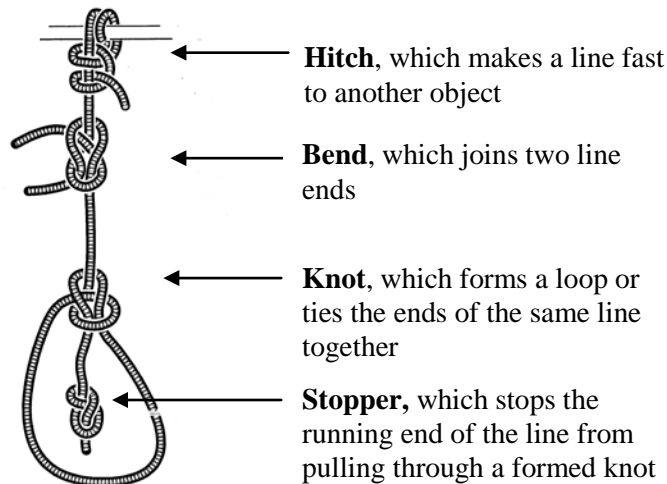


Figure 2.1: Parts of a knot

A **round turn** is when a line completes a revolution around an object.

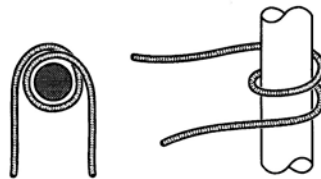


Figure 2.2: Round turn

Characteristics of a satisfactory knot

A satisfactory knot will:

- Be easy to tie and remember
- Safely do what it was employed to do
- Work in both wet and dry conditions
- Be easy to untie after it has been loaded
- Reduce the breaking strength of the line by the least amount
- Not damage the line.

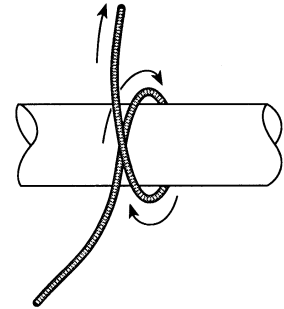
NZFS knots

The following pages give instructions for tying the knots you need to learn before you attend the recruit course.

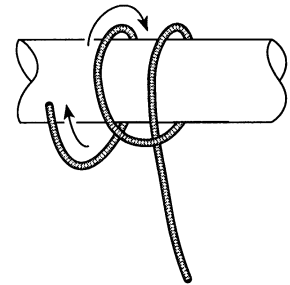
Clove hitch (around an object)

Description	Two types of clove hitch are used by the NZFS. The first is the clove hitch tied around an object. This is often used to haul a piece of equipment aloft.
Time allowed	15 seconds

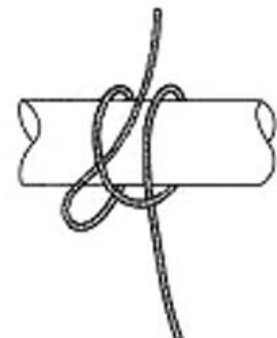
Step 1. Pass the running end over and around the object. Bring the running end over the standing part.



Step 2. Continue taking the running end around the object keeping it to the left of the standing part.



Step 3. Take the running end under the standing part to the left of the first half hitch.



Step 4. Holding the running end in one hand and the standing part in the other, pull the hitch up tight.

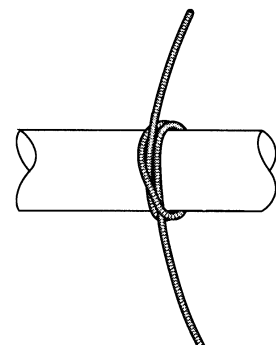


Figure 2.3: Clove hitch (around an object)

Clove hitch (preformed)

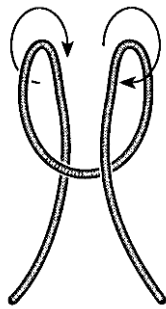
Description

The second type of hitch is the preformed clove hitch. This is used when the knot is being tied in the middle of the line (when one or both of the ends are not available) and the end of the object you wish to tie the clove hitch on is free.

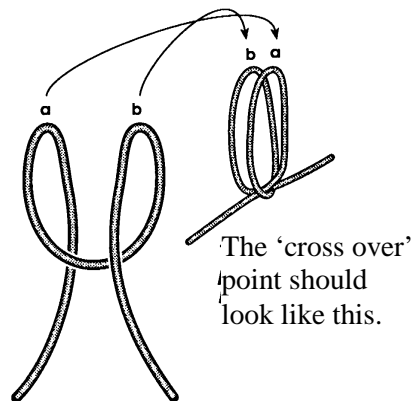
Time allowed

10 seconds

- Step 1. Hold the line in both hands, with about 50 cm of line between them. Twist the line form two loops. One loop should have the standing part to the **front**, the other to the **rear**.



- Step 2. Cross the loop that has the standing part at the front behind the loop with the standing part at the back.



- Step 3. Holding the loops together, place them over the object and pull the hitch tight.

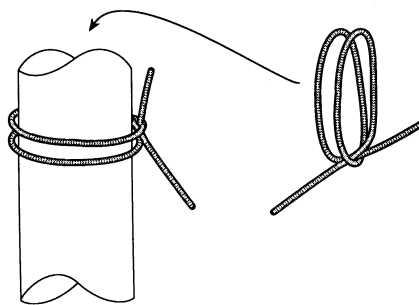


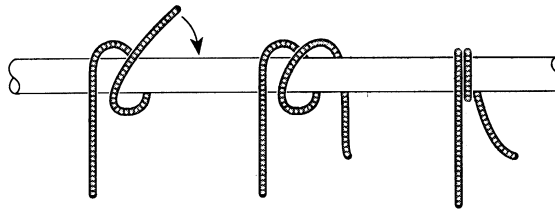
Figure 2.4: Clove hitch (preformed)

Round turn and two half hitches

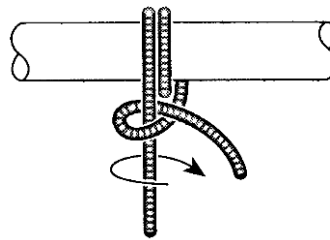
Description This knot is used to attach a line to an anchor point. It is a very useful knot as it can be used to tie off a line that has a load on it.

Time allowed 20 seconds

Step 1. Complete a round turn around the anchor point and pull the line up tight. You will need at least 50 cm of running end to complete the next two steps.



Step 2. Form a half hitch around the standing part with the running end.



Step 3. Continue the running end back over the standing part and form another half hitch. You will see that you have formed a clove hitch around the standing part with the running end.

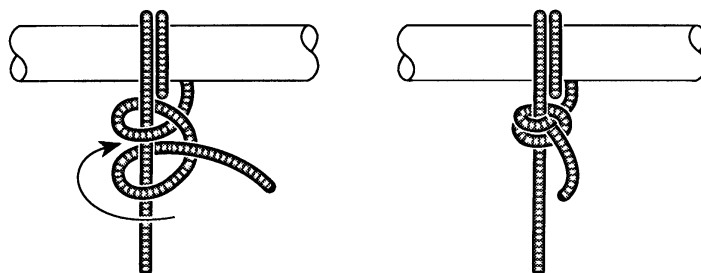


Figure 2.5: Round turn and two half hitches

The most common mistake in tying this knot is failing to form identical half hitches.

Reef knot**Description**

This knot is rarely used as it is not particularly secure. It is most often used in the NZFS for tying bandages. It is also commonly used as a parcel knot. It should never be used to tie two lines together. To see why, put a light load on the finished knot and then pull one of the running ends. The knot will invert and undo.

Time allowed

10 seconds

Step 1. Cross two lines over each other.



Step 2. Do the same with the running ends.



Step 3. Place the knot over the object and pull the running ends to secure the knot.



Figure 2.6: Reef knot

**Safety Note**

Never use the reef knot to join two lines together.

Rolling hitch

Description

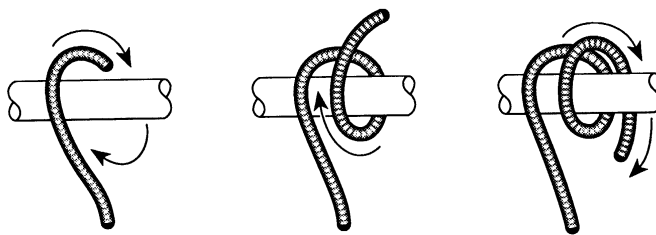
This knot can be used to secure a line to an object or to another line.

The next few steps will show you how to tie the hitch to an object so the object can be pulled to your right.

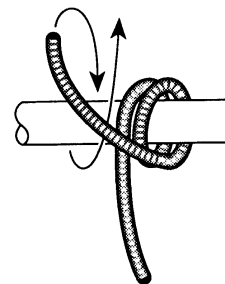
Time allowed

20 seconds

- Step 1.** The running end of the line forms a round turn. Start at the left of the tying point and work to your right (as seen below). If the object was to be pulled to the left you would start at the right of the tying point and work to your left.



- Step 2.** Bring the running end back over the standing part.



- Step 3.** Using the running end, form a half hitch to the left of the round turn and pull the hitch up tight.

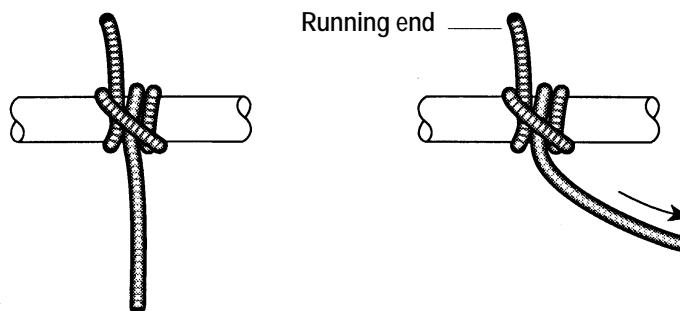
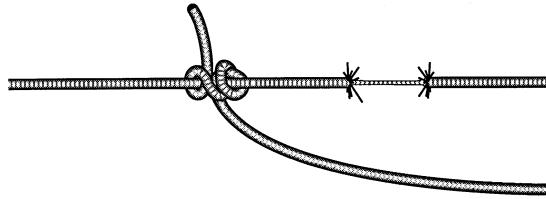


Figure 2.7: Rolling hitch

Uses

The rolling hitch can also be used to take over part of a load or the entire load on a line. This may be needed if an anchor point begins to fail, an anchor knot is insecure, part of the line is damaged, or you wish to shorten the line.

**Sheet bend****Description**

This knot is used to join two lines together.

However, it should not be used for rescue purposes.

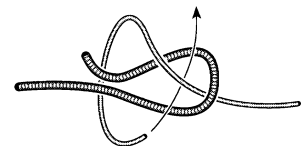
Time allowed

20 seconds

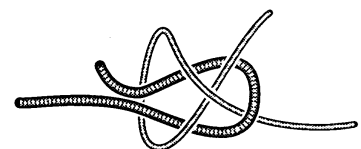
- Step 1.** Form a bight with the larger diameter line and pass the other line through the bight.



- Step 2.** Carry the line around behind the bight as shown.



- Step 3.** Take the line across the front of the bight and under the standing part of the line you are using.



- Step 4.** Pull the running ends to secure the knot.

Figure 2.8: Sheet bend

Double sheet bend

Description

The double sheet bend is no stronger than the single, but it is more secure. It should not be used for rescue purposes.

Time allowed

30 seconds

Proceed in the same manner as you did with the single sheet bend. By including another turn (as shown), you now have a double sheet bend.

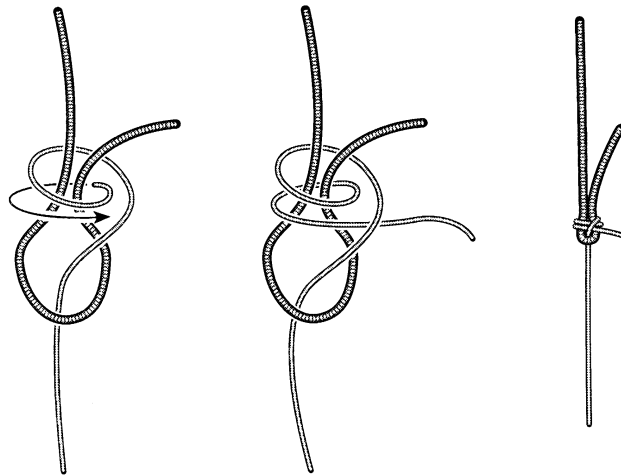


Figure 2.9: Double sheet bend

Bowline

Description	This knot is used to form a loop in the end of a line. It can then be used to secure the line to an object. It is possible to tie the knot first and drop the loop over the object, or you can pass the running end of the line around the object and then tie the knot.
Time Allowed	20 seconds

- Step 1.** Form a loop with the running end to the front.



- Step 2.** Pass the running end through the loop (from below the loop).



- Step 3.** Pass the running end behind the standing part and back through the loop (this time from above the loop).



- Step 4.** Pull the knot tight holding the running end and standing part. Then tie a figure of eight knot in the running end.



Figure 2.11 – Bowline

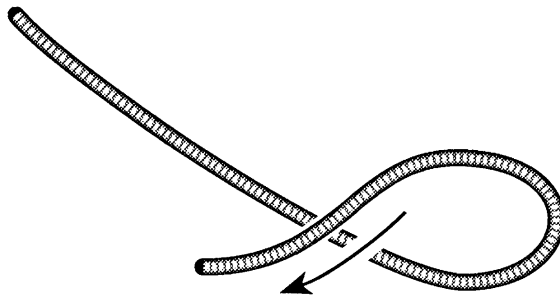
Section 3: Rescue Knots

Figure of eight

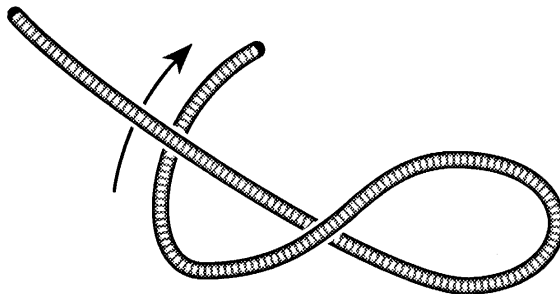
Description This is a stopper knot. It prevents the running end of the line from pulling through a formed knot or block (pulley).

Time allowed 10 seconds

Step 1. Make a loop near the running end.



Step 2. Take the running end around the standing part.



Step 3. Pass the running end through the loop and pull the knot tight.

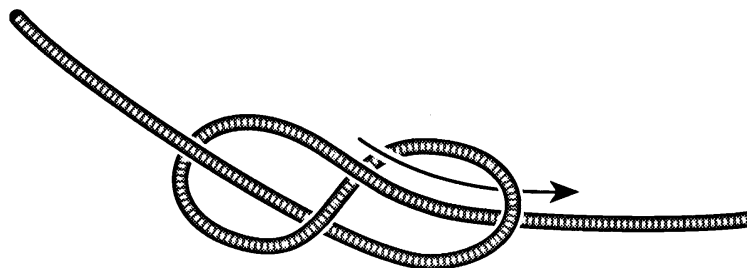


Figure 3.1: Figure-of-eight knot

The most common mistake in tying this knot is failing to take the running end around the standing part before passing it through the loop. (See Step 2.)

Figure of eight on the bight

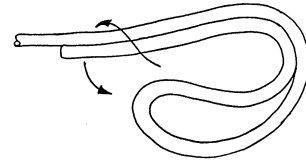
Description

The figure of eight on the bight is tied the same way as a standard figure of eight, but a bight is formed in the line first and the knot is tied on this. The result is a quick, simple and secure loop tied in the end of a line that can be used in a rescue or lowering situation.

Time allowed

15 seconds

- Step 1. Form a bight in the end of the line, allowing enough length to complete the knot.



- Step 2. Using the bight as the running end, tie the knot the same way as a standard figure of eight.

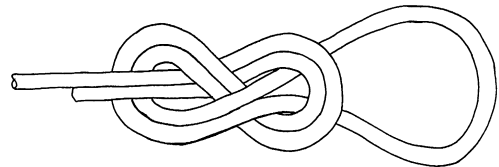
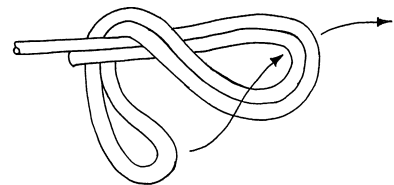


Figure 3.2: Figure of eight on the bight

Double figure of eight

Description

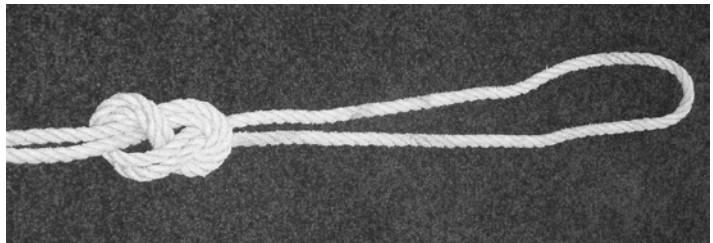
The double figure of eight is used to secure two anchor points in a line rescue situation. This allows the load on the line to be shared between two separate points, providing an added safety factor in the event of a suspect anchor. The legs of the double figure of eight can be adjusted in length once the knot is made.

Time allowed

30 seconds

Tie a figure of eight on the bight, except instead of pulling the loop all the way through at the end, double it back on itself through the knot.

Step 1. Tie a figure of eight on the bight with an extra long loop.

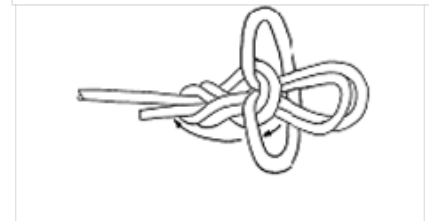
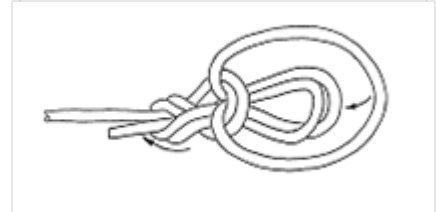
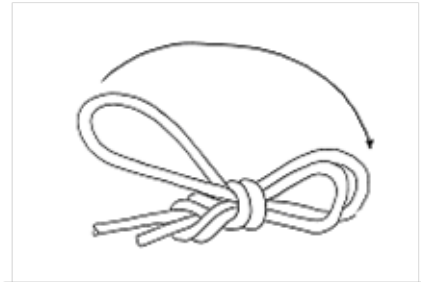


Step 2. Feed the end of the loop back into the knot and pull a short length through to form a new loop.



Figure 3.3: Double figure of eight

Step 3. Take this new loop and pass it over the rest of the knot.



Note: Make sure you pass the loop completely over the knot so that it rests against the standing part of the line.

Step 4. Turn the knot over. It should look like this.



Step 5. The dressed knot should look like this, with two loops available for anchor points.

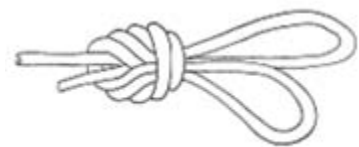


Figure 3.4: Double figure of eight

Threaded figure of eight on the bight

Description

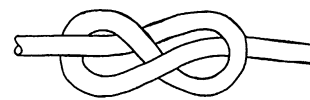
The finished knot is identical to a figure of eight on the bight, but this one may be tied **after** the running end has been looped around the anchor.

The threaded figure of eight on the bight has a number of uses, particularly securing a line in a rescue situation around a closed-ended anchor point such as a railing or fence post.

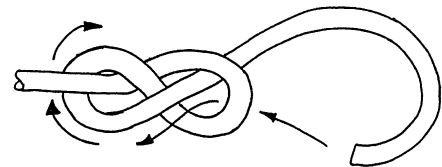
Time allowed

30 seconds

Step 1. Tie a figure of eight, leaving a long tail.



Step 2. Using the running end of the tail, re-enter the knot at the point the tail exits.



Step 3. Retrace the path of the knot with the running end.

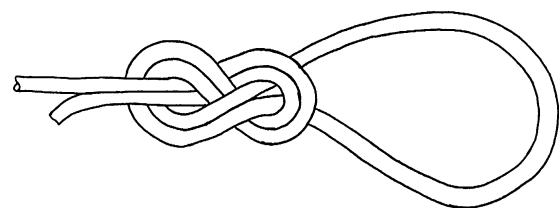
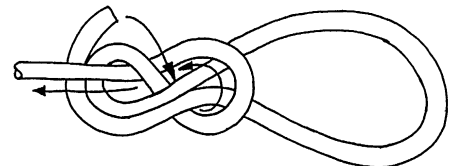


Figure 3.5: Threaded figure of eight on the bight

Alpine butterfly

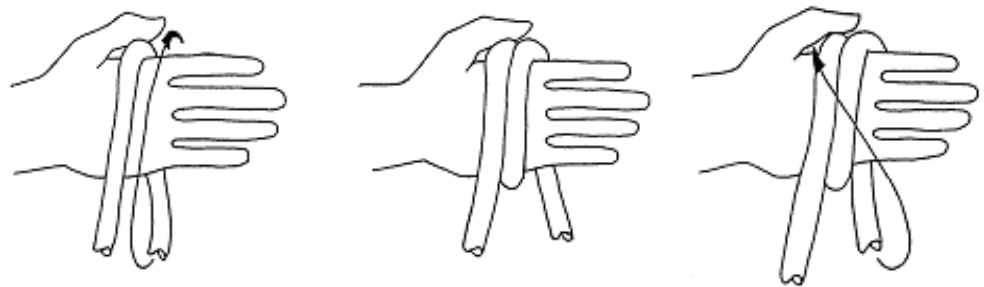
Description

The alpine butterfly is used to form a loop in the middle of a line. This is used to hang equipment onto or to hook another line. It can also be used in anchor points. The loop will not slip or come undone when the line is tensioned.

Time allowed

15 seconds

- Step 1.** Wrap the line loosely around your hand, with the final loop crossing over as illustrated.



- Step 2.** Then bring the second or middle loop across the top of the knot and loop it between the knot and your hand.



- Step 3.** Once you have adjusted it for size, pull the line ends away from each other to tighten the knot.

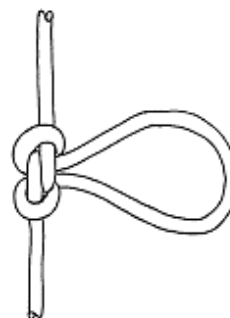


Figure 3.6: Alpine butterfly

Vertical lift knot

Description

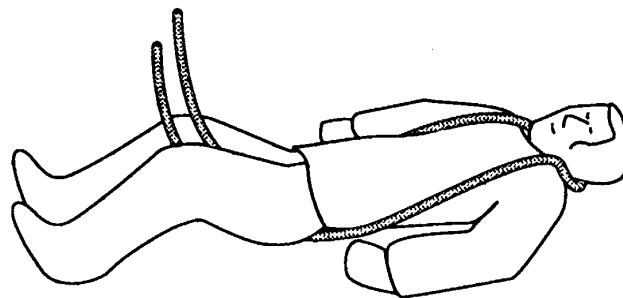
The vertical lift knot is used to raise patients in a vertical position, when a rescue strop is unavailable, usually in a confined space such as a shaft. Originally used to rescue workers overcome by gases in sewers, it is sometimes referred to as a 'sewer knot'. The feature of this knot is that you can tie it in the bight of a line without using the ends. This, in turn, means that two legs of line are available to haul on and to keep the patient in the centre of the shaft, instead of hauling them up the side.

The significant safety feature of the knot is that it cannot slip undone.

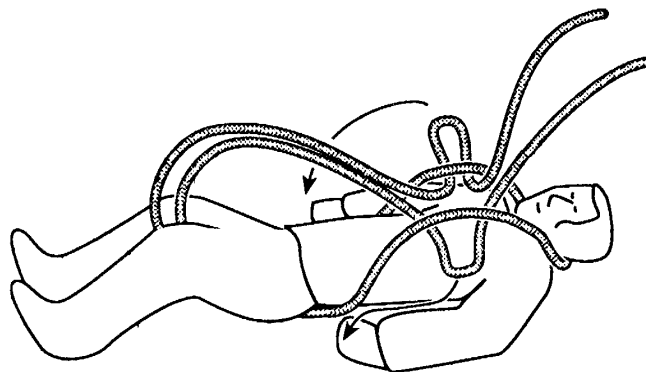
Time allowed

60 seconds

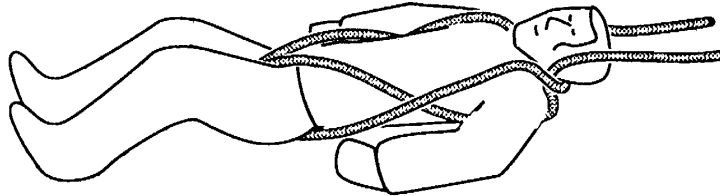
- Step 1. The bight of line is taken behind the patient's neck, run down the body over the arms, down under the legs and up through the crotch.



- Step 2. The line is then brought back up the body, looped under the line and passed around each arm. The line is kept to the same side of the body.



- Step 3. You adjust the line behind the patient's neck and adjust the standing part to tighten the complete knot around the body.



The knot shown front and rear. For comfort, the line should be in the position shown in the rear diagram and not as shown by the shaded line.

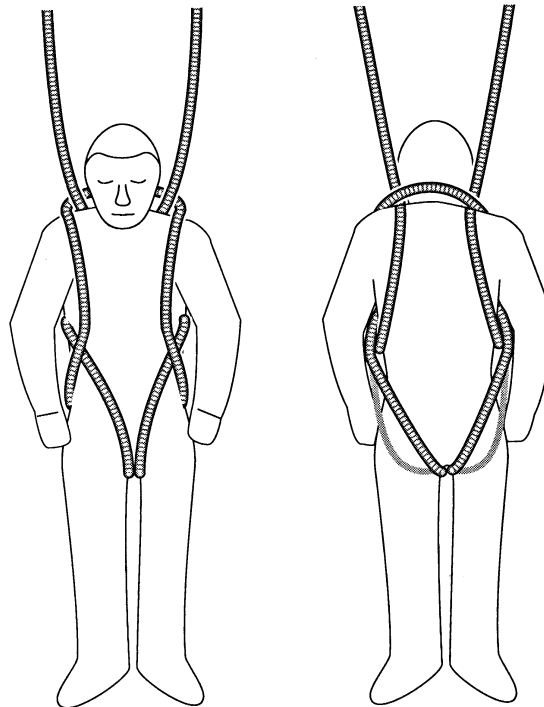


Figure 3.7: Vertical lift knot

Hand-hauling

A patient may be easily dragged through confined areas using this technique. With four firefighters (two hauling on each line), raising a patient vertically is also reasonably easy.