A Hierarchical Classification of Knots

Summary

Humans have invented thousands of knots for practical and decorative use, and hundreds are in everyday use. We group or classify things based on similarities and differences to manage such complexity. Various knot classifications have been used, according to the interests of the user. Many expert knotters are content with variations on the classification scheme inherent in the Chapter headings and text of Ashley (1944), which uses both function and structure. Others may appreciate a fuller development through additional layers in a hierarchical system. Unlike biology, no single unifying principle like evolution or genetic relatedness has been widely accepted by knotters. Moreover, the same knot structure is often used in several ways. Thus it is inevitable that any classification that includes function will include the same structure (knot species) in several functional groups. This article outlines one approach to the hierarchical classification of knots.

Introduction

Classification (arranging things in groups) is a tool that helps humans to manage complexity, assist communication, remember things and understand the relationships between those things. Ashley (1944) provided a classification of knots through his Chapter headings (and his comments within chapters) that may be enough for many knotters. Others may appreciate a fuller development through additional layers in a hierarchical system. It is possible to imagine a hierarchical classification of knots, like that used in biology except that:

(i) The classification and nomenclature of knots is not based on a single unifying principle. Unlike evolution in biology, no single unifying theory of classification has been accepted by knotters. Instead this classification uses primarily functional groupings at higher levels (Order and above) and primarily structural similarities at lower levels (Family, Genus, Species).

Although it seems untidy to mix functional and structural criteria to define different groups at the same level in a classification, it is convenient. It may be justified because all practical knots blend structure with function. It remains important to understand whether functional or structural criteria (or both) are used to define a group under consideration.

(ii) A single species (knot structure) can exist in multiple higher taxa. In other words, it is a ‘degenerate’ classification. This seems unavoidable because the classification is partly functional, and many knots are used for multiple purposes.

(iii) Knots can be stacked so a final structure includes several component knot species, but stacking alone does not create a new species. Anything other than a slipped tail that alters the structure of the original nub is classified as a distinct knot.

(iv) Though simple knots can arise otherwise, most knots are human inventions. They do not reproduce sexually, so there is no concept that a species represents a shared gene pool.

(v) Sub-species can be proposed on any criterion, and do not imply nascent species. The distinction between sub-species and distinct species is a matter of judgment (and sometimes debate).

(vi) Any knot that includes chiral components such as loops and twists will exist in two chiral forms. These are classified as the same knot, although they may behave differently in chiral (laid) cordage.

(vii) Names at all levels should be unique. The current document does not use a binomial nomenclature at genus-species level; instead each knot is known by a unique name, usually one that is commonly ascribed in English. Names are not Latinised, but common suffixes are used for Orders and Families to help identify these levels. Technically, this point is about nomenclature (not the underlying classification). There are advantages in use of a Latin binomial, as common names vary between languages and even between localities. This and other rules of nomenclature should be decided by international consensus among those interested in knot systematics, if such a classification is adopted.

Ends need not be joined. Geometric factors and forces within a knot are relevant. These points differ from ‘mathematical topological knot theory’ which uses other classifications.

In traditional cordage, knots that are woven and dressed will typically hold their shape if not loaded, against the tendency of the cordage to straighten, because of friction between parts of the cordage within the knot. Some synthetic cordage has too little flexibility or surface friction, or is too ‘springy’ to hold most traditional knots, even when tightened and loaded. This is addressed through added friction (*eg* by extra tucks or locks), or by avoiding the use of most knots in such cordage.

Thus folding geometry and frictional forces are important for knot behaviour (including strength and security). However, friction under specified environmental conditions arises from the combination of geometry in the nub and cordage properties such as hardness and surface lubricity. Knotters recognise the same knot in different cordages. This classification of knots therefore relies on geometry, but not other contributors to friction. This concept is commonly referred to as knot form, structure or similitude. Two complications of cordage that can be obtained from one another – by uniform scaling, rotation, reflection, different degrees of tightening, and differing sizes and shapes of lines, eyes, and underlying solids – have the same knot structure. They are classified here as one knot.

Knots are generally invented as tools. Humans intuitively classify tools at a high level based on function (spanners, screwdrivers, hammers). At lower levels, we use increasingly structural cues to check that a specific tool will perform a precise task as required (ring spanner, metric, steel, 5 mm, undamaged). So it is with knots. A non-redundant classification of knots based on structure alone might be developed, but it seems probable that higher taxa in that case would be arbitrary, hard to define, and forgettable.

Knots in common use tend to be the simplest structures that perform the intended task reliably. The nubs are typically composed of interlinked bights, loops, twists, helices, thumb knots, half knots and half hitches. These components are interlinked to create friction between components in the nub, thereby achieving knot security. There is no end to the complications that can be made to commonly used knots to obtain new structures.

Like knots themselves, a hierarchy is a human invention. Other hierarchies are possible. To be useful, a hierarchy must be adjustable to reflect increases in understanding of knot structure and function.

As in biology, a hierarchy of seven major layers should be enough to reveal similarities and differences among knots. The knot hierarchy outlined here uses layer names as in biology. However, there are some obvious cases where knot species can be envisaged on structural grounds in ‘clusters’ between genus and species levels. Indeed, with some tinkering, many commonly-used knots might be prime members of structurally-related ‘clusters’. Others might prefer to classify substantial ‘clusters’ as separate genera. Such matters arise in all classifications.

This classification takes no account of many properties that may be important or vary during use of a knot (*eg* whether the knot is TIB or PET, resistance to jamming or various forms of capsize, ease of visual identification, loading directions and profiles, relative strength or security in various materials, properties of any substrate over which the knot may pass). The user must consider these properties for safe application of any knot, and they may be included in catalogs and descriptions of knots.

Other devices and materials used with cordage and/or knots (*eg* carabiners, ascenders, descenders, anchors, marlingspikes, cleats, bitts, bollards, fairleads, blocks, winches, hooks, chocks, spars, planks, rings, knives, needles, pliers, tubes, tapes, toggles, fabrics, cambuckles, ratchets) are not themselves knots.

Terminology about Cordage and Structures Used in Knotting

Terms are used as defined in the *Glossary for Practical Knot Tyers*, which may be consulted for more detail.

Cordage is used here as a collective term for flexible, elongated materials. Cordage is sometimes regarded as essentially linear, and in this sense a **line** is a length of cordage.

A **knot** is any useful complication in a length of cordage. To be useful, a knot must generally hold its shape against a small force such as that from the weight of the structure itself, even when neither end is loaded. This distinguishes knots from temporary complications of cordage. Narrower usages (Ashley, 1944) referring, for example, to knob and eye structures, are not followed here.

An **end** is either extremity of a line. Some knots can be tied in the bight, without using either end.

The standing end (sometimes abbreviated as **stend**) of a line being knotted is the end which need not be accessed to make the knot. It may be fixed to some large structure, or distant from the knot tyer.

The standing part (**stand**) is the part of a line between the standing end and a knot. The term is commonly used in reference to the region just before the line enters the knot, but it may also refer to part of a line a short distance inside the nub (*eg* "the wend is nipped under the stand").

The working end (**wend**) is the end of a line used during the making of a knot. In a strict sense, the wend is ephemeral (existing only during the tying of a knot). On completion of the knot, the wend becomes the **tail** (or a tuck into the nub). If the tail end is finally very distant from the nub of the knot, the line that goes to it should probably have another name (*cf* stand *vs* stend). In practice, the term wend is often used to refer to parts of a line after knot completion, including parts just outside the nub (towards the tail end) and parts that were traced by the wend (*sensu stricto*) and which on completion of the knot are a short distance inside the nub (*eg* "the wend is nipped under the stand").

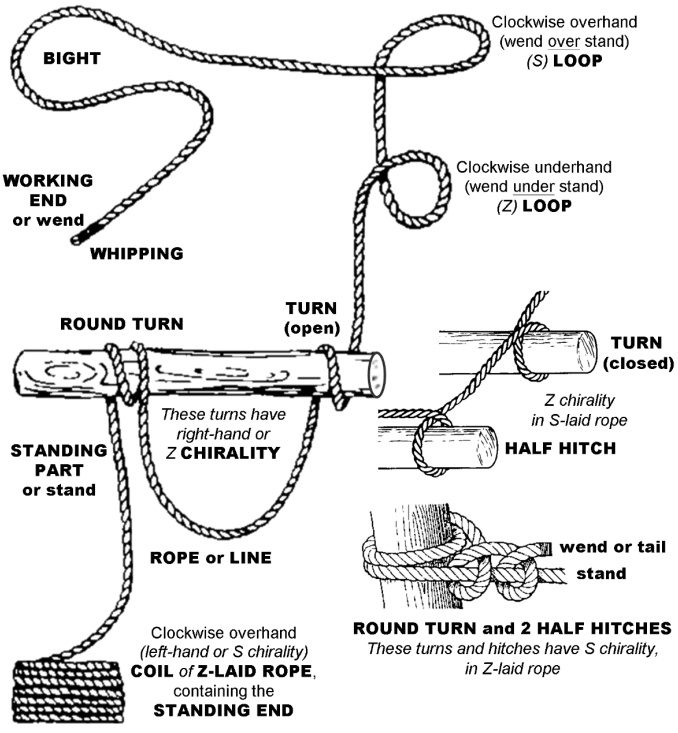
A **tail** is a working end (or region of line) that protrudes on completion of a knot.

The **nub** or core of a knot is the region in which friction exists that is relevant to the security of the knot. In many cases, this is the entire knot; but in eye knots the nub may be distinguished from the eye that emerges from it.

Nip is pressure exerted by a line on itself or on another solid with which the line intersects (resulting in friction between these components).

In context of knotting, **geometry, form or structure** of the nub includes factors that may be distinguished by mathematicians – uniform scaling, rotation, reflection, different degrees of tightening, and differing sizes and shapes of lines, eyes, and underlying solids.

Capsize is a change in geometry, which in extreme cases may **spill** (completely untie) a knot.



Some structures formed in cordage will not hold their shape against a small force such as that from the weight of the structure itself. Such structures (although they might be considered as temporary complications of cordage) are not generally considered to be knots. However, they can be very important as components of knots.

Structures that rely on seizing for practical utility are generally not included here. Exception is made for some knots such as “Single Carricks” that historically were used frequently, always with seizings.

A **bight** is a curved length of line. It may be a closed bight (if the two arms of the bight touch each other without crossing), or an open bight (if the two arms of the bight do not touch each other). If the line crosses itself, the bight becomes a loop.

A **loop** is a structure in which a line crosses once over itself.

A **U-turn** is a bight of cordage around a solid. The arc of contact between the line and the solid is about 180º. The stand and the wend are on the same side of the solid, and approximately antiparallel (at about 360º).

A **turn** (full turn) is a single loop of cordage around a solid. The arc of contact between the line and the solid is about 360º. The stand and the wend will lie at an angle to each other of about 90º to 180º (they may lie on opposite sides of the solid).

A **round turn** comprises between 1.5 and 2 consecutive turns. The arc of contact between the line and the solid is about 600º. The stand and the wend are on the same side of the solid, and approximately antiparallel (at about 360º). The traditional terminology with additional turns can be very confusing.

A **half hitch** is a turn of cordage around a solid, with the turn arranged to confer some nip on itself. The underlying solid may be another part of the same line. (Ashley [1944] proposed a different definition to distinguish a half hitch from a single hitch. That proposal is not followed here.)

Twists: If a the arms of a bight are fixed while the tip of the bight is turned through 180º (*ie* twisted once) a loop is obtained. More twists will result in a helix of the arms around each other (as in a laid rope). The same helix can be envisaged as a series of turns of one arm over the other (especially if one arm is pulled tighter). If the lower arm is passed once through the aperture of a bight that has been twisted through 180º, a thumb knot will result. If more twists are made before the lower arm is passed through the aperture, the results will be Figure Eight Knot, Figure Nine Knot, Stevedore Knot, etc. These knots are generally tied in other ways, but the example serves to illustrate a structural relationship between bights, twists, loops, helices and turns, and between a series of knots.

Hierarchy

Human Inventions
Domain, *functional* (Mechanics: devices that transmit force, usually to induce or impede motion)
Kingdom, *functional* (Ties: devices that connect objects or hold them together)
Phylum, *primarily functional* (Knots: structures formed in cordage, ie pliable, elongated material)
Class, *functional* (Practical or Decorative)
Order, *primarily functional*, suffix -ales
Family, *primarily structural,* suffix -aceae
Genus, *structural*
Species, *structural*
Sub-species, *anything*

Differences from Ashley (1944)

For those who have not examined it, *The Ashley Book of Knots* (Ashley, 1944) often called *ABOK*, is an amazing compilation and analysis of knots and related structures. We owe Ashley a huge debt, and many regret that he did not live to revise his masterpiece. Numbered knot illustrations in this document are from *ABOK*.

This classification has much in common with the one implicit in *ABOK*, but there are some key differences.

Not all chapter headings in *ABOK* are used here at the same level. For example, binding knots are considered to be a sub-group (Family level) within hitches (Order level).

Ashley (1944) wrote that 'either a different form, a different way of tying, or a different use constitutes a distinct knot'. He gave each knot that he distinguished by this definition a different number (or in one case a ½ number), but often he gave the same name to different numbered knots (*eg ABOK* #1662 vs #1663), or sometimes to different structures (*eg ABOK* #48=50=1662 vs #1516=1986=3450; #1594 and #42 vs #2019). Sometimes he gave different numbers to the same knot (*eg ABOK* #1598=#1966; #1174=#1818). He also gave numbers to many things that are not knots (*eg* Chapter 26) and even to something 'mislaid' (*ABOK* #2545). He did not explicitly distinguish knots based on geometry, though he probably meant that by the term 'form' because dressing variants are generally given different *ABOK* numbers. He did not include some knots that were ostensibly in use when he wrote (*eg* Zeppelin Bend), but more knots could certainly be added to revisions of his work. In the text, he generally acknowledged where the same named knot has multiple functions, distinguished by different *ABOK* numbers. The classification implied in *ABOK* is therefore degenerate in relation to knot names and structures, but perhaps not numbers. The possibility of a non-degenerate classification, and the rules of nomenclature for such a classification, are not discussed in *ABOK.*

In contrast, if the knot structure is identical, there is one knot as classified here, even if there are several uses. Cordage may be woven by different methods (*eg* tied in the bight or using an end), but if the resulting complications are dressed identically they are classified here as the same knot. The same knot species may exist in several functional groups (orders). It is a degenerate classification (to admit multiple uses for some knots).

A complication of cordage may be woven in a certain way, then dressed in different ways that are retained on packing (tightening). The nubs will have different geometries, and be classified here as separate knots. Below Phylum level, the classification given here applies only to knots. There is no limit on the number of knots hat can be included, but each knot (species) should have a different name.

A knot should have practical or aesthetic utility to be included in this classification (although an additional class for useless complications of cordage could be added by anyone so inclined). Ashley (1944) possibly had something similar in mind when he wrote 'A knot must have distinction of some sort to be included.'

Ashley (1944) also suggested a terminology that differs in several important respects from the one used here. As in the *Glossary for Practical Knot Tyers*, historical usage is retained here whenever this is consistent with clear and unambiguous communication.

Tabular Example

Practical Knots

	BENDS	FIXED EYES	NOOSES	STOPPER KNOTS	HITCHES	COILS	MULTI-STRANDED
Order	**Bendales**	**Fieyales**	**Noosales**	**Stopales**	**Hitchales**	**Coilales**	**Mustrales**
1º Criterion	*function*	*function*	*function*	*function*	*structure & function*	*structure*	*structure*
Families							
1	Fitting a Carrick Diagram	Bowline	Homogeneous	Simple	Line	Solid-core	Splice
2	Racked	Adjustable-tail	Eye&bight	Complex	Binding	Line-coil	Shroud-knot
3	Plaited	Multi-eye				Heaving-coil	Multi-stopper
4	Multi-turn	Drawn-bight					
5	Thumb-knotted						
Genera in Family One							
1	Bighted Carrick	Qallunaat Bowline	Few-pass	Overhand	Snug	Seizing	Line-joining
2	Looped Carrick	Inuit Bowline	Multi-pass	Twisted	Loose	Whipping	Aperture-forming
3					Open	Lashing	Terminal
4					Sliding		
Some Species in Genus One							
(examples)	Reef Knot	Common Bowline	Simple Noose	Thumb Knot	Ashley Single Hitch?	Nippering	Short Splice
	Thief Knot	Outside-tail Bowline	Figure-eight Noose	Double Thumb Knot - Open	Timber Hitch	Flat Seizing	Long Splice
	Sheet Bend	Round-turn Bowline	Poacher's Knot	Double Thumb Knot - Grapevine	Secured Clove Hitch	Round Seizing	Braid Splice
		Water Bowline	*ABOK* #1118		Fisherman's Anchor Hitches		Side Splice

- A definition would be needed for each taxon above species, as in the examples below.
- Suggested Order names are derived from the first 4-5 letters in the common name (or abbreviation thereof) with the order suffix -ales.
- Family names can be similarly derived with the suffix -aceae.
- The *ABOK #* or other clear archival description should be provided for each species (serving as a type specimen), along with a unique name other than the reference number. (Humans generally find names easier to remember than large numbers).
- Additional rules for nomenclature will need to be developed if such a classification is adopted. For example, a knot name should not imply membership of a group (taxon) to which it does not comply (*eg* certain hitches formerly called bends).

Examples

Kingdom: Ties

Phylum: Knots

Class: Practical (with a primary function other than appearance)

Many decorative knots can be useful for practical purposes. But the practical purpose can be served by more simply tied (but less handsome) knots. Thus we conclude that the primary (or special) purpose of knots classified here as decorative is their (handsome) appearance. The knots classified here as practical have a various practical uses as their primary functions. We may of course admire their simplicity and their effectiveness in use.

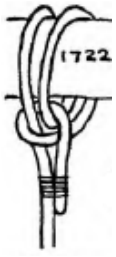
Order: Bendales (joining two or more lines or regions of a line; provided that this requires a structure such as a bight or loop in each)

Family: Cardiaceae (including a core structure in which lines can be represented as only simple loops or bights, able to be represented by a "Carrick diagram")

Genus: Bighted Carrick (≥one line in the core structure can be arranged as a bight)

Species: Reef Knot (*ABOK* #75, 76, 77, 460, 1402, 1441)

Subspecies: (a) type of cordage (*ABOK* #1403)
(b) # of slips (*ABOK* #1211, 1212)
(c) location and # of toggles (*eg ABOK* #1921, 1923)
(d) stacking with seizings, locks etc. (*ABOK* #1404)



Order: Hitchales (a structure including one to three turns of a line around a solid other than a toggle, that functions to connect the line to the solid; provided that when the solid is a line, the hitch should be made entirely by one line or region thereof, with the other serving only as a solid around which the hitch is made)

Family: Lineaceae (used to secure a line to a solid, not only to bind a solid)

Genus: Snug Line Hitch (line wrapped tight around the solid, with the end secured between a turn in the line and the underlying solid, though it may be further fastened to the stand)

Species: Fisherman's Anchor Hitch (*ABOK* #24, 1722, 1723, 1841)

Order: Fieyales (provide one or more loops or bights of cordage [the eyes] outside the nub of the knot, without separating the cordage into parts. The eye[s] will not slip material to the stand or tail in normal usage.)

Family: Bowlaceae (line forms only simple loops/half hitches, bights or helices; not thumb knots)

Genus: Qallunaat Bowline (collar passes around the stand)

Species: Common Bowline (*ABOK* #71, 287, 1010, 1011)

Order: Noosales (eye knots that will slide along the loaded stand, changing the eye size)

Family: Homogaceae (homogeneous nub that does not involve a fixed eye knot)

Genus: Few-pass (no more than two passages of the wend across the stand)

Species: Figure-eight Noose (*ABOK* #1116)

Order: Stopales (single-stranded knots that can be tied in a single line to form a knob)

Family: Simplaceae (wend passes through a single aperture in a looped or twisted line)

Genus: Overhand (single loop through which passes the wend, forming a turn)

Species: Double Thumb Knot (*ABOK* #516)

Order: Coilales (with multiple [usually more than three] loops or turns around one axis)

Family: Solidaceae (with multiple turns of the line around a solid)

Genus: Seizing (with multiple turns of small stuff around solids of larger diameter, not necessarily near the end of the underlying solids)

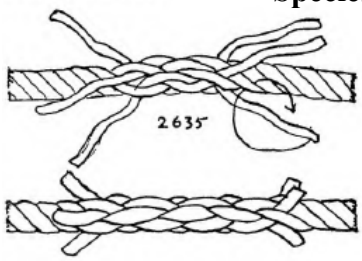
Species: Round Seizing (*ABOK* #3388)

Order: Mustrales (using multiple strands or components of cordage, commonly strands of a laid rope or layers from a braided rope)

Family: Splicaceae (a long distance of tucked strands or components to create high friction)

Genus: Line-joining (connecting two or more lines or ends)

Species: Short Splice (*ABOK* #2635)



BENDS

Order Bendales (joining two or more lines or regions of a line; provided that this requires a structure such as a bight or loop in each)

Bends involve intact cordage, whereas shroud knots and splices (which are generally more secure) involve separation of multiple cordage parts before lines or regions are joined. Modern knotters too often forget that wends were traditionally seized to stands, or to arms in eye knots, to improve security (*eg ABOK* #1011, 1461).

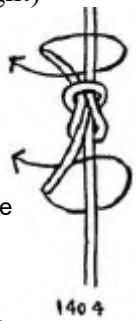
In Ashley's maritime experience, seizings or stops (temporary seizings) frequently were used to secure the tails of knots. Today 'locks' to tails frequently are made with the knotted line itself and security increases in the order: no lock < half hitch < thumb knot < grapevine stopper knot around another region of the line (usually the stand, or an arm of an eye knot). The increased friction from these locks may be essential, or insufficient, for knot security in some modern cordage. Security depends on both contact geometry in the nub, and surface lubricity of the cordage. Many bends are less secure if the joined lines differ in diameter or other properties. When in doubt, it may be preferable to join lines by interlaced eyes, provided these eyes are formed in a way that will not slip. Such interlaced eyes are sometimes considered to represent another family of bends, but here they are considered as a stacking of knots without an alteration to nub geometry.

Family Cardiaceae (including a core structure in which lines can be represented as only simple loops or bights, able to be represented by a "Carrick diagram")

The reference to a core structure allows elaborations such as "double sheet bends" and "simple simons" to be included in this family, which aligns with the way knotters typically view such knots (*eg* "sheet bend variants").

Genus: Bighted Carrick (at least one line in the core structure can be arranged as a bight)

Reef Knot (two bights interlocked with tails direct -- on the same side) *ABOK* #1402

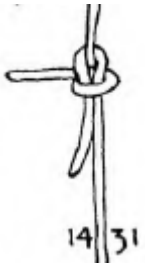


This knot has been used widely, but as a binding hitch (*ABOK* #1204) rather than a bend. For use as a bend, the tails should be seized or locked (*ABOK* #1403,1404). A form with bights provided by one or more straps is sometimes differentiated as a Strap Bend or Sling Hitch, sometimes toggled for ease of tying or release (*ABOK* #1493, 1494, 1495, 1921, 1923, 1924). Eye-to-eye connections can be very secure as neither line has a tail that can slip through the knot. Interlocked bights and interlocked thumb knots are the most common symmetric core structures used in knotting.

Thief Knot (two bights interlocked with tails oblique -- on opposite sides) *ABOK* #1207

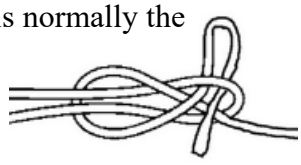
This form is obviously related to a Reef Knot, but harder to tie and more prone to slip, so it is rarely used in practice as a binding hitch; and hopefully never used as a practical bend. The form cannot be distinguished if the stands and wends are not distinguishable from each other, as in a strap bend or netting knot.

Sheet Bend (bight and loop/turn interlocked) *ABOK* #1431



The loop passes around the arms of the bight, and thus becomes a turn arranged into a half hitch. This is the most common asymmetric core structure in knotting. It is frequently used in weaving (*ABOK* #1418). Two forms, with direct (*ABOK* #1431) *vs* oblique (*ABOK* #1432) tail orientations can be differentiated as sub-species (this alignment has less effect on function than in the Reef Knot, or even the Carrick bend). If the bight component is an eye splice or fixed eye, the knot may be known as a Becket Hitch (*ABOK* #1900). This form may be more secure as the bight has no tail that can slip through the knot. The distinction becomes tenuous when the bight is seized (*ABOK* #1434). The T-Bend (Warner #403) is loaded on both ends of the loop/turn/half-hitch component. When the stands and wends cannot be distinguished on either line, the sheet bend becomes the most widely used Mesh Knot or Net Knot (*ABOK* #402). It is also possible to multiply the bight line (or the loop/hitch line) to form Multiple Sheet Bends (*eg ABOK* #1497, 1499, 1501) or Swab Hitches (*ABOK* #1901). It can be formed as a Short-End Bend (*ABOK* #1473, 2005, 2562) or a Flagstaff Knot (*ABOK* #1988). It is the nub of the Common Bowline (*ABOK* #1010). On a hook (instead of a bight), it is called a Blackwall Hitch (*ABOK* #1875) or Bill Hitch (*ABOK* #1879), though these are very unstable unless loaded.

Lapp or Girdle Knots (sheet bend structures with the load placed on what is normally the tail, thus serving as the stand) *KM* 38, 23; *KM* 101, 14-15; Warner #427



This form is typically used with a slip for fast and complete release.

Various Double (or higher multiple) Sheet Bends (sheet bends with loop/turn extended as a second twist, or turn in helix or grapevine form, around the arms of the bight) *ABOK* #486, 488, 489, 493, 1419, 1434, 1435, 1436, 1438, Warner #419, 422 ...

These include dressing variants and forms with different weaving of the lines. A case can be made that each has a distinct geometry and should be distinguished as a separate species, or that some are subspecies that may interchange under a load.

Simple Simon Bends (reef knot with additional turns around the arms of one bight) *KM* 6, 15; *KM* 131, 17-18; Asher #79, 80

Originally described along with Vice Versa bends as “decorative”, they are rarely used in traditional cordage but may be useful because of greater friction in some synthetic cordage.

Genus: Looped Carrick (both lines in the core structure are constrained into loops/turns)

Carrick Bend (two loops interlocked with alternating over and under weaving throughout) *ABOK* #1439

Two forms, with direct (*ABOK* #1428) *vs* oblique (*ABOK* #1439) tail orientations in the open knot can be distinguished only if the stands are distinguishable from the wends. They may be differentiated as separate species or as sub-species (this alignment has less effect on function as a bend than in the Reef Knot, but more than in the Sheet Bend). When the knot is seized to retain an open form under load, it may be called a Hawser Bend (*ABOK* #1446), but the confusingly-named “Open Carrick Bend” (*ABOK* #1448) is a different knot.

Various “Single Carrick” Bends (two loops/turns interlocked with at least one deviation from alternating over and under weaving) *ABOK* #1443-1445

These structures have different weaving patterns and loop/turn chiralities, resulting in different geometries (and forces under load) in the nub. *Several different species, but none is considered practical unless seizings are added.*

“Enhanced” Sheet Bends and Vice Versa Bends (Twin loop derivatives of Sheet and Simon Bends) Warner #422; *KM* 6, 15, Asher #84

If the bight of a sheet bend is twisted, it forms a loop; which becomes an added turn when threaded by the stand. Vice Versa Bends are symmetrical, twin loop, derivatives of Simon Bends. There are several different species.

Granny Knot (two loops interlocked with tails direct and minimal over and under weaving) *ABOK* #1206, 1405

Less reliable than a Reef Knot, and often tied in error. Prone to slip or jam under load in laid rope, depending on chirality.

Whatnot (two loops interlocked with tails oblique and minimal over and under weaving) *ABOK* #1208, 1406

Especially when tied with short tails, the ends are prone to be twisted or capsized into a form (sometimes called Whatnot 2 or Grief knot, *ABOK* #1407) that slips under load. The two forms have different geometries (and forces under load) in the nub. *Thus they should be distinguished as separate species, but neither is considered practical.*

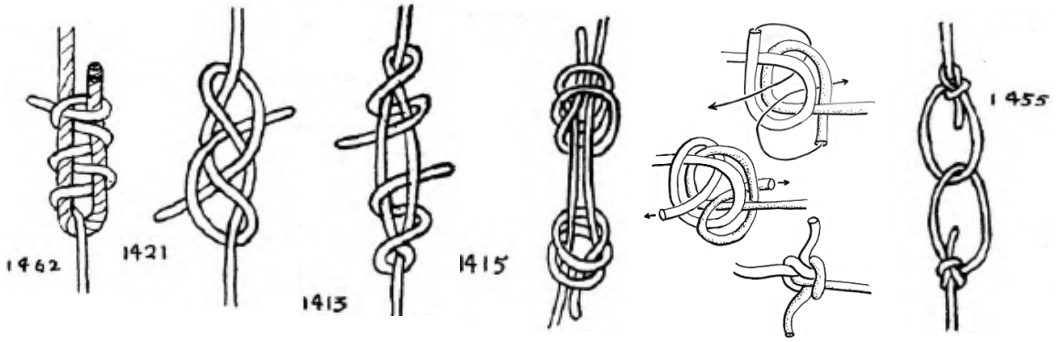
Other Families:

Rackaceae

Plaitaceae

Muturaceae

Thumbaceae



STOPPER KNOTS

Order Stopales (single-stranded knots that can be tied in a single line to form a knob)

The single-stranded stopper knots include some of the simplest and most versatile structures in knotting. They are used: to increase size [so the line will not pass through an aperture], to increase weight [for heaving], in combination with other knots to increase friction [as locks], and as foundation structures for many other knots. It is a mistake to denote them as terminal knots, as this excludes many of their uses. Traditionally, a 'stopper', a 'stopper knot' and a 'stop' were different structures (*ABOK* GLOSSARY). This taxon includes only the 'stopper knots'.

'Stops" are binding hitches used as temporary seizings, whippings or lashings: see order Hitchales. 'Stoppers' are (usually multi-turn) structures used to hold a larger line such as an anchor cable: see order Coilales.

Family Simplaceae (wend passes through a single aperture in a looped or twisted line)

All the stoppers in this family, and many of the knots based on them, are prone to jam after a heavy load. This tendency may be reduced by additional twists or turns in the nub structure, or by the insertion of other components such as toggles.

Genus: Overhand (single loop through which passes the wend, forming a turn)

The word overhand is commonly used in the context of knots in this genus, although the initial loop can equally be underhand (Warner #6, 7). The genus name "Overhand" is suggested here to retain a historical connection while avoiding use of terms derived from "Thumb Knot" at both genus and species levels.

Thumb Knot *ABOK* #515

This structure comprises a single loop, through which the wend passes once to form a turn in the line. It is the simplest, the smallest, and probably the oldest knot. Fishermen call it (disparagingly) the wind knot, and no doubt it has formed this way since the first uses of lines. It can be tied (as a skilled trick) by twirling and flicking a suitable length of line. To tie it without great skill or wind assistance, small stuff is usually rolled over a thumb, intermediate-sized rope is cast over the hand, and heavier ropes were probably woven on deck. It was named in print the Thumb Knot (Emmerson, 1754) several decades before the name Overhand Knot first appeared (Lescallier, 1777). There may well be older names as multiple forms of the knot have been used as ancient counting devices (Quipu Knots) or in decorations (Capuchin Knots).

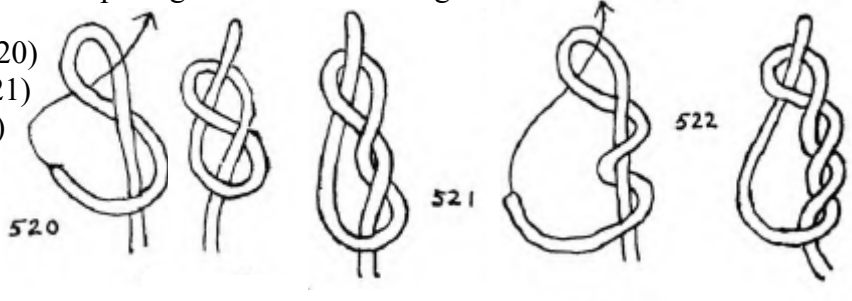
Ashley (1944) distinguishes the Thumb (or Overhand) Knot as being tied with one end whereas the Half Knot is tied with two ends around a solid (*ABOK* # 46, 47), but that is not always the case. Warner (1992) wrote that they can be obtained from the same structure, woven and dressed in one line, by tightening (packing) between an end and the nub (for a Thumb Knot), or between the ends (for a Half Knot), but that is also problematic. The forms can be obtained reliably by choice of the angle between the ends while tightening, as in the final nub. Harry Asher provided a useful terminology for the parts of the knot in Open Form (*KM* 5, 5; Warner #32). Using the criterion of geometry that is central to the present classification, we can see that the nubs of these finished knots are quite different: with a tight arc in the turn of the Thumb Knot versus a near-linear helix in the spine of the Half Knot.

Multiple Thumb Knots *ABOK* #516, 517, 566, Warner #62, 63

If the wend is passed more than once through a loop, a multiple form of the Thumb Knot will result. Double, Triple and higher multiples are common. Depending how these are dressed and tightened, two distinct forms can be obtained: an Open Form that shows the original belly outside the turns; and a Grapevine Form that transfers the turns over the original belly which thus disappears into the core of the nub (Warner # 62, 63). The distinction from Half Knots becomes more challenging in Multiple Thumb Knots, and the designation of chirality becomes tricky in the Grapevine Form. *The various forms have different geometries. Thus they should be distinguished as separate species.*

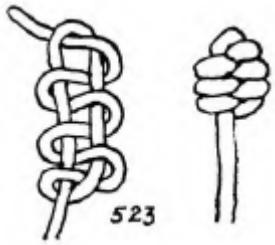
Genus: Twisted (the nub comprises multiple loops or twists, but not more complex structures such as thumb knots, before the final passage of the wend through an aperture in the nub)

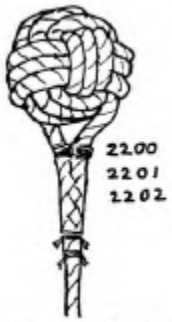
Figure Eight Knot (*ABOK* #520)
Figure Nine Knot (*ABOK* #521)
Stevedore Knot (*ABOK* #522)



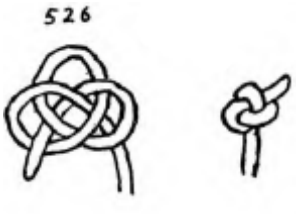
Family Complaceae (the nub involves one or more Thumb Knots before final passage of the wend)

Racked Stopper (*ABOK* #523)
Monkey's Fist (*ABOK* #542, 2200-2202)





Tweenie (*ABOK* #525)
Oysterman's Stopper (*ABOK* #526)



Coiled Heaving Line Knots (*eg ABOK* #540, may be included in this Order as well as Coilales)

HITCHES

Order Hitchales (a structure including one to three turns of a line around a solid other than a toggle, that functions to connect the line to the solid)

The turns may be U-turns or full turns. When the solid is a line, the hitch should be made entirely by one line or region thereof, with the other serving only as a solid around which the hitch is made. This helps to distinguish bends from hitches as functional Orders of knots. In this definition, 'a solid' may be a group of solids that are bound by the same turns of a line. A structure with more than three turns of a line around a solid would be classified in Order Coilales.

Some hitches (like the Girth Hitch, *ABOK* #1673) will spill completely if the underlying solid is removed, but many will not. Often there are complications of the line beyond the turns around the underlying solid, *eg* half hitches around the stand, to increase the security of the hitch.

This is the most common order of knots, with many variations in structure that sometimes correspond with particular functions. For example, binding hitches may have no apparent stand and short tails; anchor hitches may have a long stand to the object being anchored; a timber hitch may be used to haul a single log or a bundle of sticks using a long stand after an accessory half hitch around the solid(s); and a fixed-eye knot like a bowline may be used as an open hitch that can rise or fall on a pile with changes in the tide.

The shape of the solid affects the security of many hitches (particularly snug hitches without added security). Generally a round or rounded solid is preferable, though a few hitches depend on sharp angles in the cross section of the underlying solid (*eg ABOK* #1604).

Some interactions between a line and a solid do not make a knot. The crossing hitch (*ABOK* #1818), tensionless hitches (*ABOK* #1732), and Ashley single hitch (*ABOK* #49) might be considered to reside at the interface: they cannot be relied on to retain a useful form for long without a load on at least one end of the line.

Family Lineaceae (used to secure a line to a solid, not only to bind a solid)

Genus: Snug Line Hitch (line wrapped tight around the solid, with the wend secured between a turn in the line and the underlying solid, though it may be further fastened to the stand)

Ashley Single Hitch? (a single turn around a solid, with the wend laid under the stand to create nip between the stand, the solid and the wend between them)

This requires careful dressing, packing and loading of the stand. It often relies on the structure of the underlying solid to help trap the wend (*ABOK* # 49, 1594-1603, 1613, 1614). If the load on the stand is not maintained, and more so if the line is 'flirted', this hitch will not be secure, even in a line with low surface lubricity.

If the solid does not have a suitable shoulder, one may be provided by other ropework, such as a lashing (Warner # 10). In other cases, sufficient nip is obtained by the use of a multiple turns (*ABOK* #1604) crossed turns (*ABOK* #1674, 1676) a U-turn around the stand (*ABOK* #1663,1877) or the structure is used (as a binding) in a series that secures both ends (*ABOK* #2074, 2076). Some forms are close to a U-turn and Half Hitch in structure (*ABOK* #1821), and the two sources of nip can be combined (*ABOK* # 218, 1607). Security may be further increased (with additional resistance to capsize by 'flirting') by additional interactions between the parts of the line, and/or between the line and the solid (*ABOK* #216, 217, 1812, 1813).

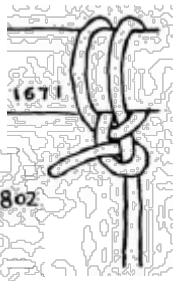
Ashley (1944) used the term ‘single hitch’ with several meanings (*eg* pp 14, 74, 283 [x2], 284, 288, 298, 299, 302, 328, 336, 518). As precedent, he cited Luce (1862) who used the phrase once only, in describing reefing, and specified “with the bight made around the standing-part”. Luce probably meant one hitch there, as he did when he wrote of a ‘single’ ... anchor, block, spoke, foot, strap, luff, whip, crown, rope, bow-line, knot etc. In the section on knots, he illustrated as a ‘half-hitch’ the structure that Ashley called a single hitch. The phrase ‘single hitch’ was not used in Luce (1884). Sometimes Ashley called the structure a half hitch (*eg* #271, 1012, 1147, 1152, 1459, 1516, 1733, 3450); or he used hitch, single hitch and half hitch apparently interchangeably (#1985, 1986). He conceded that usage is vexed (#1748). Day (1947) noted that it is impossible under some common conditions to distinguish between single hitches and half hitches as defined by Ashley. This has caused confusion and avoidance of the term (*eg* Warner #10). On balance, it seems best to apply the term ‘single hitch’ only to variants of the half hitch (see “Terminology ...”), under circumstances in which the nip from the stand pressing the wend against an underlying solid is sufficient to hold against a substantial pull on the standing part, in the absence of other complications involving the stand or the wend.

Ashley (1944) proposed similarly interesting and problematic distinctions between (i) a clove hitch and two half hitches *(ABOK* #48; perhaps from Dana, 1841*)* and (ii) midshipman’s and rolling hitches (*cf. ABOK* #1230, 1729). A comparable naming distinction was not always applied to other structures (*eg. ABOK* # 1862). The suggested distinctions are not followed here.

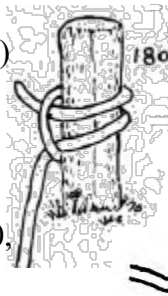
Timber Hitches (*ABOK* #1665, 1666, 1668, 1733)

The wend is nipped between stand and underlying solid so these may also be envisaged as higher-orders of the half hitch with the special dressing that defines the Single Hitch. But they also achieve substantial nip from friction of cordage on cordage as observed in knots with multiple turns of wend around stand, and in the Half-Hitched U-turn. Often used with an accessory half hitch around the solid (*ABOK* #271, 1733), for increased friction and to control direction of the solid while hauling.

Secured Clove Hitch (*ABOK* #1670, 1671, 1773, 1814, 1887)



The Clove Hitch is properly a crossing or binding hitch, because it is not always secure when one end is loaded. However, when the tail is secured to the stand, the clove hitch becomes reliable as a line hitch (with load on the stand), though it may jam under a heavy load.



Girth Hitches (*ABOK* #1673, 1683, 1694, 1763, 1802, 1816, 1859, 1890)
Sinnet Hitches (*ABOK* #1684, 1685, 1686)
Boom Hitch (*ABOK* #1687) Slingstone Hitch (*ABOK* #1697)
Picket-Line or Ground-line Hitches (*ABOK* #1674, 1676, 1680)
Halyard Hitches (*ABOK* #1675, 1677, 1678, 1679)
Snug Backhand Hitches and Tension Hitches (*ABOK* #1688, 1689, 1690, 1691, 1692, 1693, 1725, 1731, 1796, 1797, 1851, 1853)
Pile Hitch (*ABOK* #1815, 1886)
Fisherman’s Anchor Hitches (*ABOK* #24, 1722, 1723, 1724, 1840-1843, 1885)
Marlingspike Hitches (*ABOK* #1789, 1880) Camel Hitch (*ABOK* #215, 741)

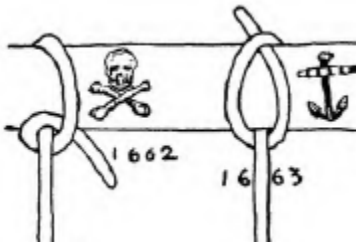
Genus: Loose Hitch (line passed in one or more turns that do not trap the wend, then having the wend or tail secured to the stand)

This name is derived from a traditional usage, but it can be misleading: some “Loose Hitches” can be very tight! In many cases they create nip through one or more half hitches around the stand (those after the first may be envisaged as single hitches).

Loose Hitches comprise several knot elements. Turns around the underlying solid dissipate load, and thereby contribute greatly to the strength and jam-resistance of the overall structure. They are part of hitch structure, so hitches with a U-turn around a solid are separate species from those made with one or more round turns; even if they use the same finish around the stand. Riding turns have a different structure, which affects overall friction in various directions of load, and tail security, depending on configuration. The number or orientation of half hitches can greatly influence hitch security and jam-resistance. Those integral to the hitch are part of the species definition, and added complications can be considered as sub-species. However, the boundary between species and sub-species may become arguable with different cordage types (coefficients of friction with the underlying solid or the stand).

Any noose may be tightened onto the underlying solid. Many of the “loose hitches” can be envisaged as nooses, even if they are primarily used as hitches (*eg ABOK* #1711, 1714). Loose Hitches with round turns will generally not hold all of their characteristic form without an underlying solid.

U-turn and one or more direct or reversed Half Hitches around the stand (*ABOK* #1662, 1707, 1710, 1713, 1727, 1780, 1781, 1786)

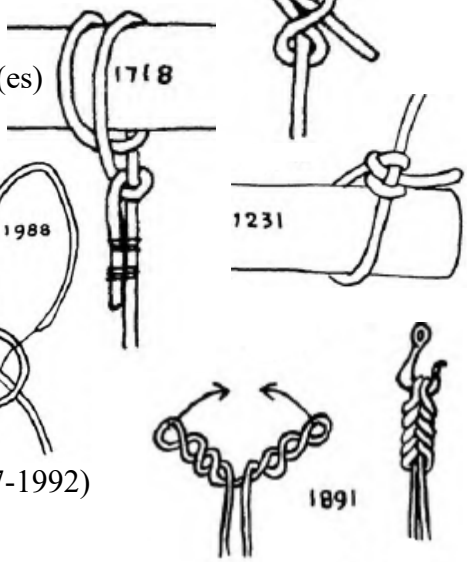


A U-turn with single half hitch around the stand (one of the structures called a half hitch in Ashley, 1944) is rarely secure, depending on the surface lubricity of both the solid and the cordage. But the half hitch can arguably be arranged as a single hitch (with the stand nipping the tail against the solid) to confer more security under sustained load. The half hitch is used in combination with many other structures in knotting to increase friction.

Buntline Hitches (*ABOK* #1711, 1838, 1847)

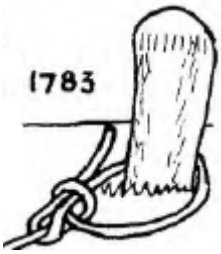
The Buntline and Lobster Buoy Hitches gain security by nipping against the underlying solid a (second) half hitch formed around the stand.

Lobster Buoy Hitch (*ABOK* #1714, 1839)
Round Turn and (one or more, direct or reversed) Half Hitch(es) (*ABOK* #1718, 1720, 1784, 1834-1837, 1883)
Grapple or Slip & Nip Hitch (*ABOK* 1231)
Loose Backhanded Hitches (*ABOK* #1795, 1852)
Midshipman Hitches (*ABOK* #1727, 1729, 1730)
Noose Hitches (*ABOK* #1803, 1825, 1881)
Halter Hitch (*ABOK* #1804, 1826)
Non-slip Hitch (*ABOK* #1829)
Hammock Hitches (*ABOK* #1832, 1833)
Double Girth Hitch (*ABOK* #1695, 1862)
Cat's Paws (*ABOK* #1888, 1891, 1892)
Capstan, Crabber's Eye, Flagstaff Knots (*ABOK* #1831, 1987-1992)



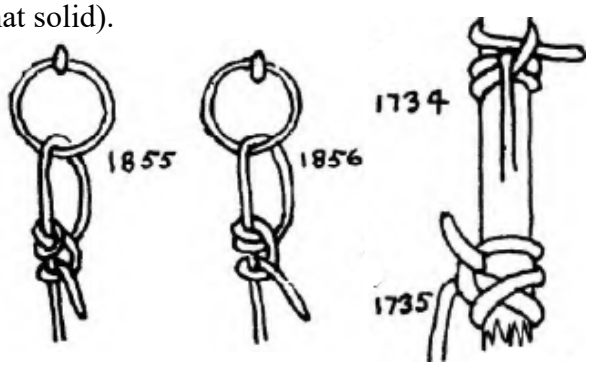
Other Genera in this Family:

Open (with multiple lines or regions of a line running from the underlying solid to a fixed nub that is separated from the solid)



Any eye knot that can be passed over a pile, cleat or bollard may serve as a hitch. A fixed eye will be Open unless the size of the eye is adjusted carefully to the diameter of the pile. Bowlines are commonly used this way (ABOK #1716, 1783, 1787, 1788). Nooses are typically tightened onto the underlying solid as Loose Hitches, but some may remain Open if friction is high. Sliding hitches are commonly Open if tied around the stand of the same line, but they are classified separately here (with a moveable nub) because of their convenience of adjustment.

Sliding (tolerate a pull in at least one direction along the underlying solid, without slipping; but are readily adjusted by sliding manually along that solid).



These knots may be tied around a separate solid such as a spar, or tied around the stand after one or more turns around a separate solid. Midshipman's or Rolling Hitches (ABOK #1027, 1729, 1730, 1734, 1735, 1799, 1800, 1855, 1856) are examples. Other nooses may behave similarly depending on friction, but are less reliable.

Family Bindaceae (used to bind one or more solids, or keep such substrates furled; with no substantial load to be carried on either end after tightening)

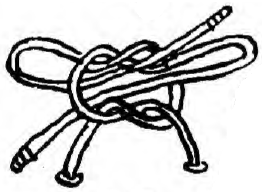
While Ashley (1944) distinguishes crossing knots (whose ends are further employed) from binding knots, it is not clear that there is any practical crossing knot that can not be classified elsewhere. Crossing knots that may not hold their form for

long when the ends are not 'further employed' are not included here, beyond the Crossing Knot and Marling (Marlin/e) hitch provided as examples. In practice, these two forms are typically secured using other knots. Some of the crossing knots that Ashley describes are quite decorative, but (decoration aside) simpler hitches serve the practical function.

On a substrate with low surface lubricity, and low forces acting to open it, even a half knot (*ABOK* # 122, 1203) or a multiple thumb knot in open form (*eg* in *ABOK* #1209) may serve as a useful (if temporary) binding knot. For longer-term use, a greater complication of cordage providing increased nip is required.

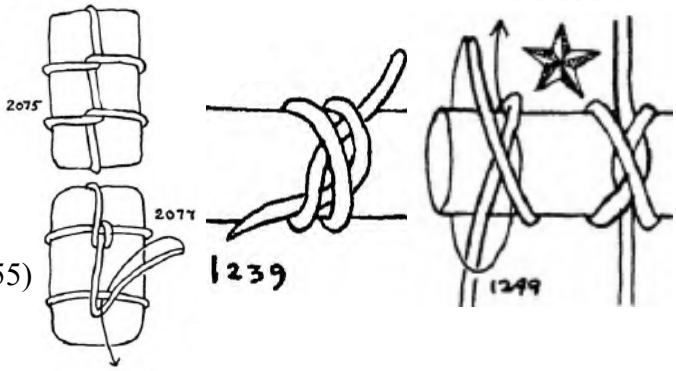
Nooses can be tightened onto a solid to bind it, but they are designed to withstand a substantial load on one end, so they are better considered in other taxa.

One Genus:
Binding



This may be the most-used category of knots. Many people tie several each day, in their shoe laces, pajama cords or parcels. Some are typically only used in particular occupations.

Reef Knot and Derivatives (*ABOK* #1204, 1210-1222)
Lesser Relatives of the Reef Knot: Granny, Thief, Whatnot (*ABOK* #1206-1208)
Ligature / Surgeons Knot (*ABOK* #1209)
Parcel Knot (*ABOK* #1227)
Twists (*ABOK* #1235, 1237, 1258-1261)
Strangle Knots (*ABOK* #1239,1240)
Miller's Knots (*ABOK* #1241-1243, 1253)
Net Line Hitches (*ABOK* #1246, 1247)
Clove Hitch (*ABOK* #1245)
Constrictor Knots (*ABOK* #1249-1252, 1255)
Roband Hitches (*ABOK* #1262-1277)
Marling (Marlin/e) Hitch? (*ABOK* #2075)
Crossing Knot and Derivatives? (*ABOK* #1171-1175, 2077, 2078)
Stops (temporary lashings, whippings or seizings, with ≤3 turns; *eg ABOK* #1181, 2096-97, 3439-41)

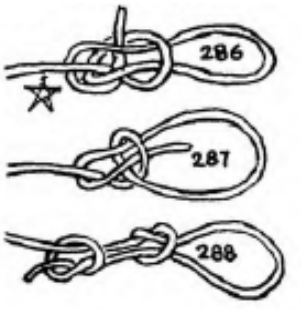


FIXED EYES

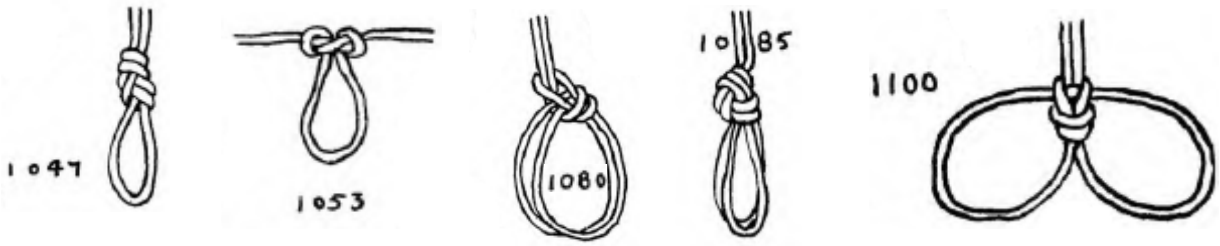
Order Fieyales (provide one or more loops or bights of cordage [the eyes] outside the nub of the knot, without separating the cordage into parts. The eye[s] will not slip material to the stand or tail in normal usage.)

Any stopper knot that is tied with a bight will yield a fixed-eye knot. This is generally too cumbersome to be undertaken with the complex family of stopper knots. It is commonly undertaken with the simple family of stopper knots, especially using string and other small stuff when the knotter is not concerned that the knot will jam after a load.

Any bend can be envisaged to yield a fixed-eye knot if the tails of the bend are joined However these often are not practical eye knots, because they are cumbersome to tie and/or are likely to be loaded in a way that makes the nub prone to capsize (Asher #136). Sometimes one of the stands may be envisaged as joined to a tail to better effect, as in the structural relationship between a sheet bend and a common bowline or an Inuit bowline (Warner #521).



As pointed out by Ashley (1944) single and multiple eye knots have been greatly elaborated, sometimes to decorative effect. Many such knots have subtle advantages for particular applications; but many practical knotters will have one preference in each of the terminal, in-line and multiple eye-knot categories, to suit many uses.



NOOSES

Order Noosales (eye knots that will slide along the loaded stand, changing the eye size)

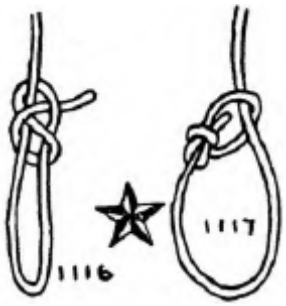
If the wend is folded into a bight before final passage through the nub of a knot, the result is a slipped form of a knot (classified here as a sub-species of that knot). A pull on the tail to withdraw the bight will simplify the nub (*eg ABOK* # 1712), and may entirely spill a simple knot (*eg ABOK* #529). In some cases the knot is complicated to prevent an unintended spill (*eg ABOK* #243), but such complications inevitably interfere with the defining function of a slipped tail.

If a stand is folded into a bight before weaving of the wend, and provided the passage of the stand into that bight remains fairly straight, the result is a noose. A pull on the stand will reduce the size of that bight (now an eye), and (if nothing is trapped in the shrinking eye) may either simplify / spill (*eg ABOK* #1116 / 1118) the knot, or merely tighten the eye onto a part of the nub (*ABOK* #1124), depending on the pattern of weaving used to form the knot.

The eye of a noose may be passed around a solid to form a hitch (*eg ABOK* #1711). Some nooses are constructed so that they can be capsized (usually by a pull on the tail) into a fixed eye knot (*eg ABOK* #1831, 1987-1992). The reverse also applies: aberrant loading of some fixed eye knots can cause capsize into a noose (*eg ABOK* #1010). Because it is generally intended that a knot tied as a fixed eye should not slip, this is avoided by careful attention to loading directions or addition of locks that make the knot resistant to such capsize.

Nooses are intended to trap a solid in a shrinking eye, in use as a hitch or as a snare in hunting. A slipped tail should be used carefully to avoid unintended trapping of any solid when the tail is pulled.

Sometimes it is difficult to distinguish between a tail and a stand. In such cases, it may be equally difficult to distinguish between a slipped knot and a noose. Both are sometimes called running knots. A noose may also be slipped (*eg ABOK* #1115).

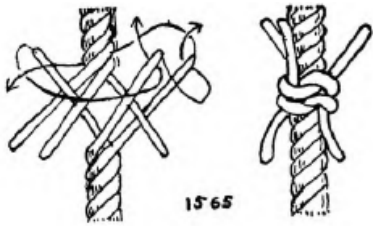


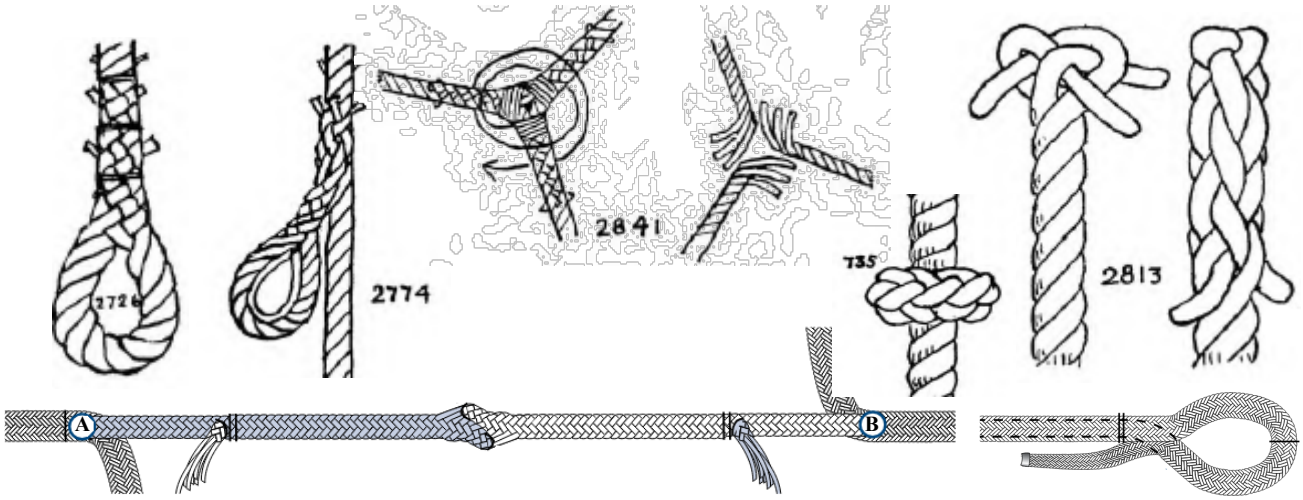
Any fixed eye knot or eye splice can form a noose if the stand is passed though it as a bight (forming the eye of the noose) (*eg ABOK* #1117). It may be argued that this should be considered as a stacking of structures, because the nub of the fixed eye knot is not altered in the process. The family is included here because it is one of the most common ways to form a structure with the function of a noose (and this order has been defined primarily on function).

MULTI-STRANDED KNOTS

Order Mustrales (using multiple strands or components of cordage, commonly strands of a laid rope or layers from a braided rope)

This is one of the two orders in this classification that are defined on primarily structural criteria. It is perhaps ironic that strands or components are first separated (which reduces strength) when the goal is to increase strength of the resulting structure. Well-made splices (*ABOK* Chapter 34-36, Samson) and shroud knots (*ABOK* Chapter 19) are substantially higher in both strength and security than single-stranded bends and eye knots. In some cordage (such as braided HMWPE) surface lubricity is so high that most common knots are insecure, but some specialized splices are effective. However, some rope constructions (notably most kernmantles) are unsuited for splices as they do not separate easily into components suitable for splicing. Stopper knots made with multiple strands of a laid rope (now becoming uncommon for practical uses) may serve both a decorative and practical purpose.





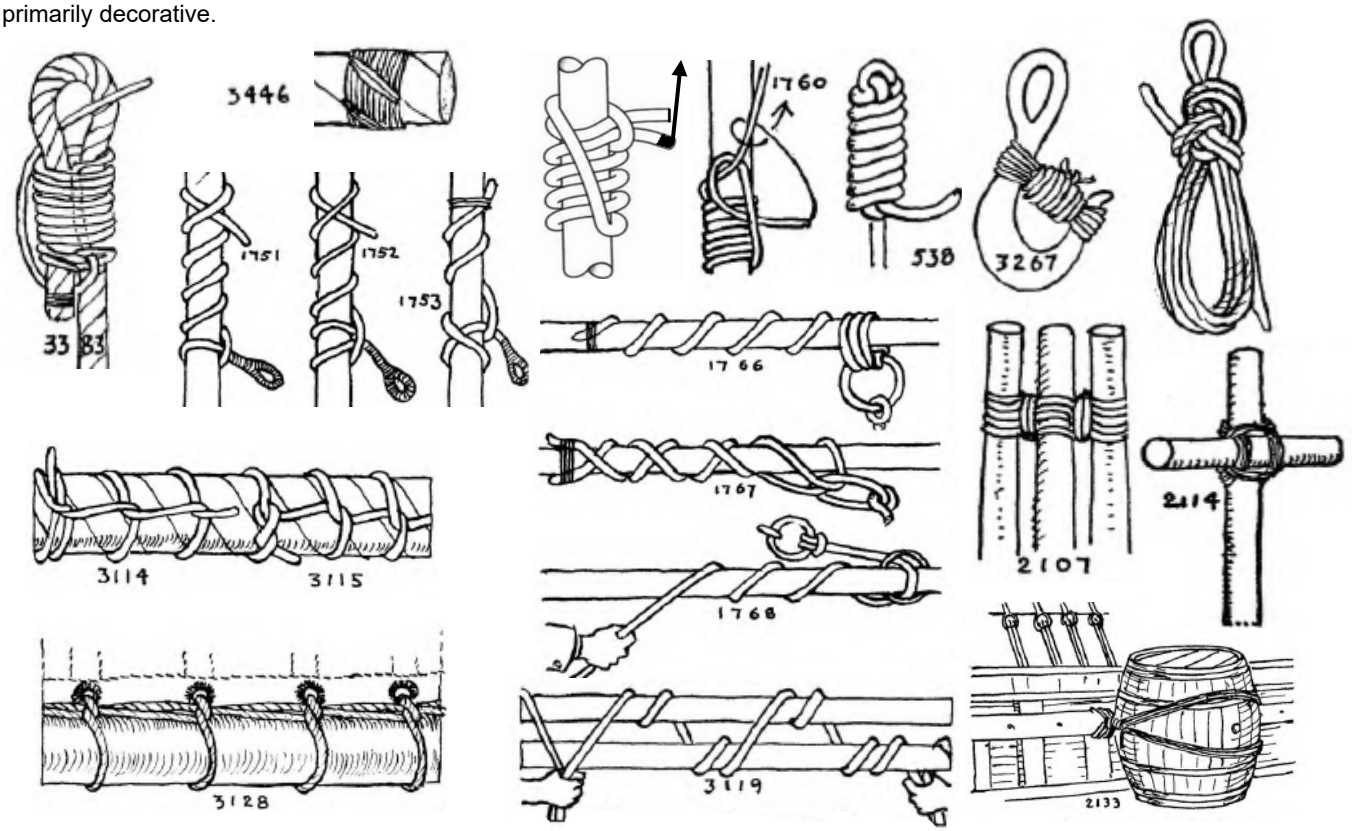
COILS

Order Coilales (with multiple [usually more than three] loops or turns around one axis)

Included in this taxon are seizings (*ABOK* #1512,1513, 3303-3306, 3353-3430), whippings (*ABOK* #3442-3462), lashings (*ABOK* #2102-2117, 2131-2145, 3432), mousings (*ABOK* #3267-3271), wormings (*ABOK* #3336-3341), servings (*ABOK* #3342-3350), gammoning (*ABOK* #3432), marling (marlin/e)- and half-hitching (*ABOK* #2074, 2075, 3114-3116), keckling (*ABOK* #3117), nippering (*ABOK* #1770, 3118-3121), snaking (*ABOK* #3122-3124), stoppers (*ABOK* #1765-1769), heaving-line knobs (*ABOK* #535-544) and open coils of cordage (*ABOK* #3083-3101). Open coils made for storage may have fewer that three loops or turns if the line is short, but most knotters would recognize that the intention was a coil. Many of the 'hitches' used to withstand a pull along a slippery substrate use multiple turns for friction (*eg ABOK* Chapter 22), but they also may be considered as lashings. The boundaries between various types of multi-turn bindings sometimes are indistinct. It may be argued that some of these structures should be excluded as knots because they will not hold the desired form without either a load or an accessory structure, such as a hitch or tuck through the substrate, at one or both ends.

It is rare for any practical knot in another order to have more than three turns around one axis. Examples are nooses in the Hangman's cluster (*ABOK* #1119), and perhaps Tensionless Hitches (*ABOK* #1732) and Timber Hitches (*ABOK* #1665) tied in cordage of low surface lubricity. Exceptions may be made for those who follow the maxim "If you can't tie a knot, tie a lot."

Multiple turns are common in knots tied for decorative effect. Even quipus, once used in Inca accounting, are now primarily decorative.



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