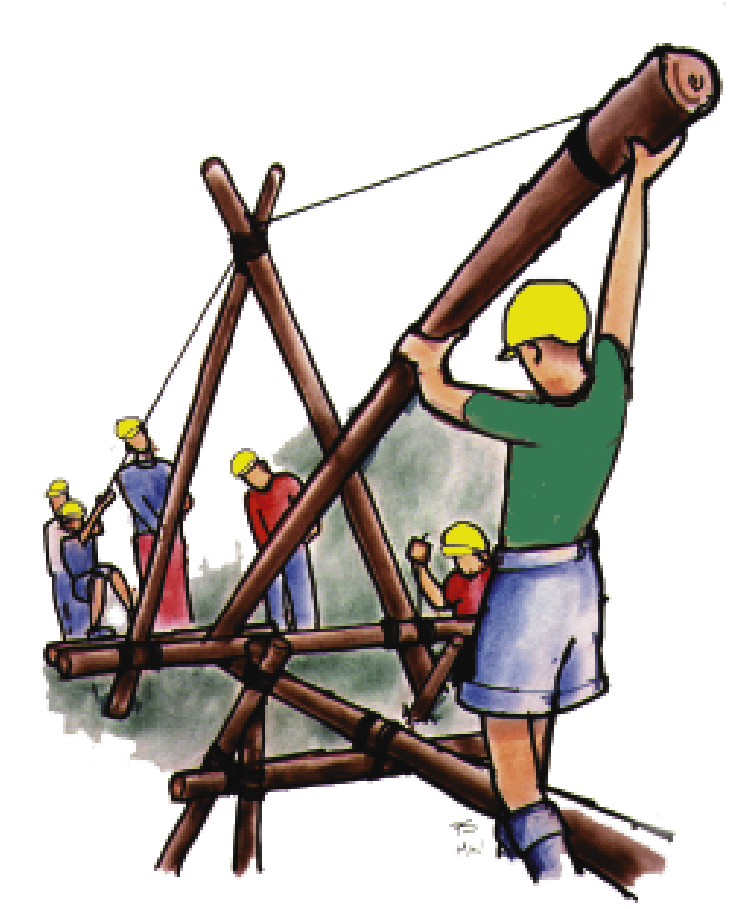
Scout Engineering



Getting started

Pioneering or Scout engineering refers to the work of military engineers who went ahead of the army on foot, to build bridges, roads and to generally prepare the way.
They got there first, often in the wilderness, and had to make do with what they could find, or carry. With axes and ropes they worked wonders and created many functional structures.
Scout Engineering provides Patrols with a challenge and an opportunity to develop as a team and achieve something worthwhile.
Before building, it is necessary to have an understanding of the skills involved, as well as enthusiasm. Firstly, you must know how to tie the required knots and lashings, secondly, you must have spars or poles with which to build your project. The next consideration is ropes and pulleys to bridge and secure your project, and, lastly, loads of common sense.

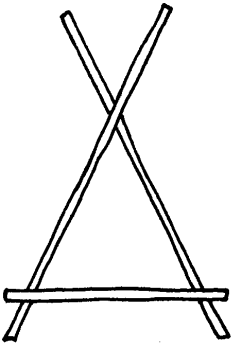
Each project should be approached in a logical way:-

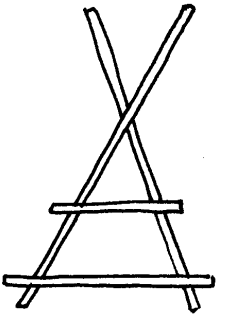
- What are we trying to do?
- What equipment do we have?
- What is the best way to use this equipment?
- Designing the project
- Planning the steps to complete the project
- Testing and safety
- Dismantling the project

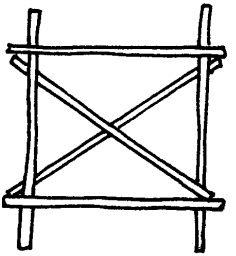
Every project should be approached in this way. The designs suggested have been tried and tested. However you will rarely find a level river bed or trees in the right places for rope bridges etc., so each of the basic designs suggested may have to be modified to suit the conditions you encounter.

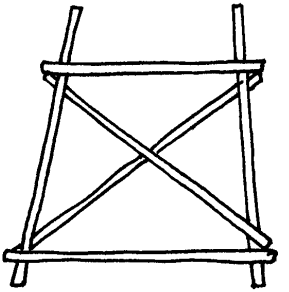
Lashings

Experience would suggest that the best lashing to use in the construction of the projects is not the traditional square lashing but rather the Norwegian lashing. This is easier and quicker to tie than the traditional lashing.
With the Norwegian lashing the sisal or lashing rope is halved, and you are constantly pulling the strain against yourself. This makes it easier to tighten and manage the construction of the lashing plus you finish it off with a reef knot or granny knot. Once you master the technique it can be adapted to the other lashings - Tripod, Diagonal, Sheer.

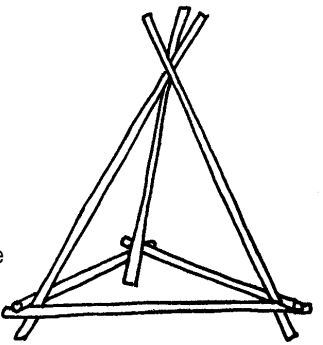






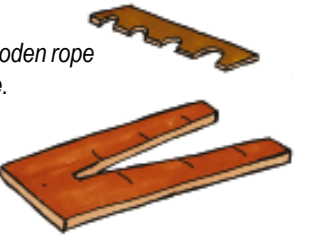


Basic Structures



All pioneering structures are created using a number of basic forms - the A frame, the A frame with double bar, the sheer legs, the square trestle and the rectangular trestle. All of these basic structures are stable, if constructed correctly, and will not move out of shape.
Once the basic shapes are constructed on the ground they are combined perhaps with a number of linking spars to provide a tower, bridge or similar structure. As a general rule it is better to build a big structure from a number of smaller and reasonably light frames than trying to lift heavy frames or poles.

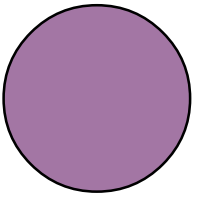
Ropes



Simple wooden rope size gauge.

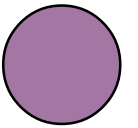
Ropes come in many types and sizes and to simplify matters you should use the following as a guide.

75mm rope (25 mm diameter) or larger, certainly no smaller than 75mm, should be used whenever it is intended to hold weight such as in the case of a monkey bridge, foot and hand rails, aerial runways, and commando rope bridges.



Quick reference - the diameter of a broom handle is approx. 25 mm.

50 mm rope (16 mm diameter) should be used for 'reeving' up pulleys and anchors and for rope ladders.



Quick reference - the diameter of a man's thumb is approx. 16mm-18mm

25mm rope (8mm diameter) should be used for guy ropes in general. On large structures this size would need to be increased.

Quick reference - the diameter of the small finger is about the size of what is known as sash cord or heavy clothes line.

Ropes below this size should be used for lashings only.

Rope lengths will vary according to how they are purchased. 25 metre lengths will normally cover most projects as the distance between sheer legs or rope bridges should not exceed 15 metres, to avoid 'flipover'. Flipover occurs when too much slack in the rope causes it to act like a skipping rope. When pressure is applied to the middle of the rope it becomes unstable, and sways, resulting in the 'rope crosser' being thrown off or becoming entangled in the ropes, which is extremely dangerous.

As most of the ropes used in pioneering structures require an element of friction to provide maximum efficiency, laid ropes of natural fibre, such as sisal or hemp are preferred. They are more expensive and need care and attention as the fibres can deteriorate and rot if not dried carefully. Synthetic ropes are less expensive but require extra care particularly when fixing them to trees and poles. These ropes are generally smoother than hemp or sisal ropes, but the knots have a tendency to slip under pressure. To ensure safety and prevent slippage you should secure all knots with extra hitches.

Coiling a Rope

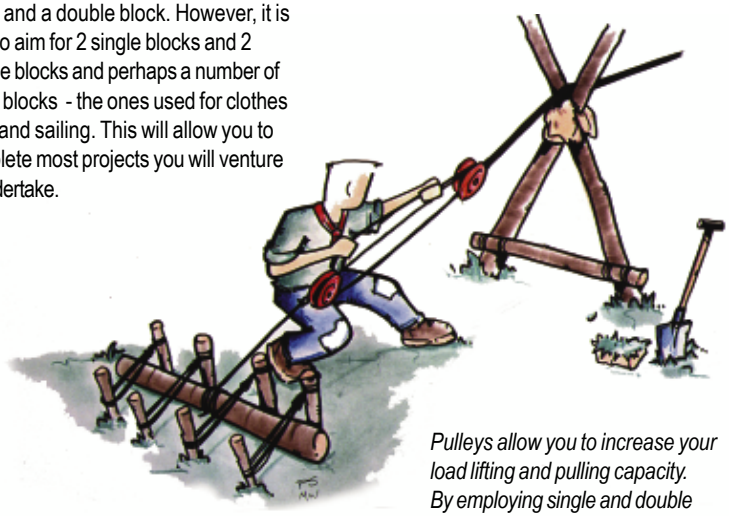
When coiling a heavy hawser it is best to coil it in large loops on the ground. Passing the hawser through your legs will aid this process and prevent tangling. The coil is secured using short sisal ties.

In order to protect a rope from damage and to aid in transporting it, you should be able to coil it properly. This can be done in a number of ways as shown. When coiling, let the rope fall into natural loops. In order for this to happen it will be necessary to flick and turn the rope. Once completed, the coil is secured by a whipping type knot or by a loop knot.

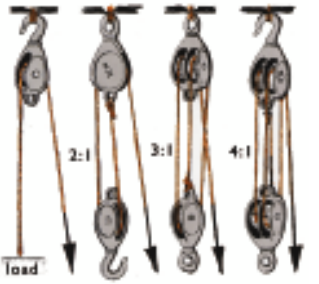
Pulleys

The size of your blocks will need to be;-
150mm for 50mm rope
230mm for 75mm rope

Most pioneering projects can be completed using 2 pulleys - a single block and a double block. However, it is best to aim for 2 single blocks and 2 double blocks and perhaps a number of small blocks - the ones used for clothes lines and sailing. This will allow you to complete most projects you will venture to undertake.



Pulleys allow you to increase your load lifting and pulling capacity. By employing single and double pulleys, different pull ratios can be achieved



Mousing

All hooked blocks need to be 'moused'. This is done using sisal which is bound around the 'bill' and back of the hook as shown.
Mousing is not 100% effective so it should be checked at regular intervals.

If you are using a closed eye pulley it may be necessary to use a D ring shackle to allow you to attach a heavy line.

Catspaw knot

This knot is used to connect a line to a hooked pulley as shown.

Fix the line to the pulley using a round turn and two half hitches. It is also a good idea to whip the free end of the line to prevent slippage. You can also use a stopper knot if you wish to do the same job.

Reeving a simple single and double pulley system

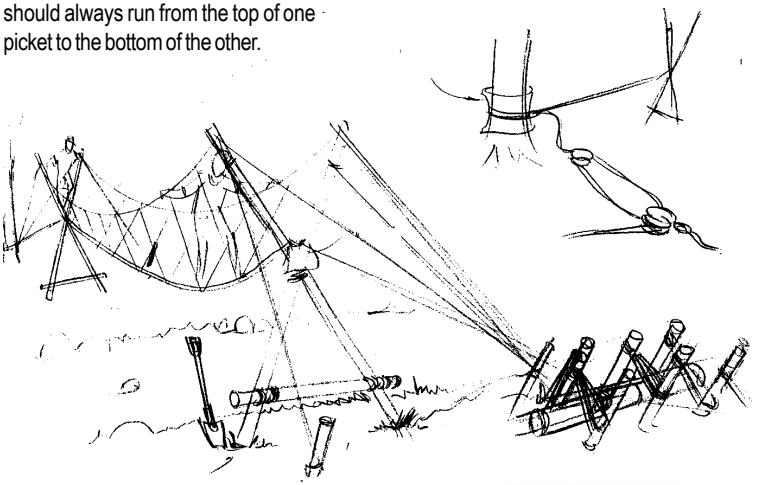
Anchorage

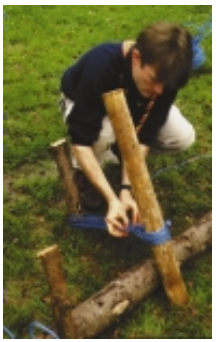
If at all possible you should anchor your ropes to a fixed object such as a 'big' tree or rock. However, they will rarely be available in the right places so we will have to create our own anchors and pickets. There are two possibilities: the 3-2-1 picket and the picket and log anchor. Both are illustrated below. In each case the pickets should be at least 160cms long and put in position with a sledge hammer or large mallet. If the ground is soft they may need to be longer. The pickets should be set in the ground at 60 degrees and the bindings between pickets should always run from the top of one picket to the bottom of the other.

As a rule of thumb

Pickets should be positioned in the ground approx., 3 times the height from which the main rope leaves the structure. i.e. if the main rope passes over the sheer legs at 3 metres above the ground then the pickets should be set in the ground 9 metres from the base of the sheer legs.

It is normal practice to fix the rope to a log and picket anchor and fix the pulley assembly to a 3-2-1 picket anchor.





3-2-1 picket

Deadmans Anchor

Log and picket anchor

Fixed anchors

With fixed anchors, such as trees, you need to create a loop of rope on which to fix pulleys. This is done by wrapping a rope around a tree a number of times as shown. The collective strength of the loops of rope must exceed the strength of the rope being strained, otherwise the loops are the weakest part of the structure. It is therefore suggested that 25mm rope is used for this job and is wound around the tree at least 4 times.

Protection of trees

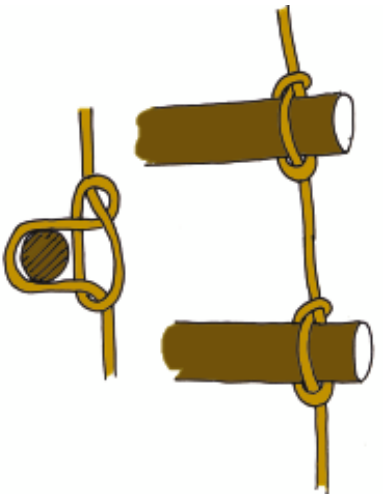
If you are fixing a rope or spar to a tree you should be careful not to damage the bark. This can be done by using some sacking or old canvas to protect the bark from friction. It may also be necessary to use sacking or padding on a structure if the rope will be subject to excessive friction, for example in the case of a monkey bridge. This is particularly important when using synthetic ropes as they are prone to melt if in a friction situation or if two ropes are rubbing off each other.

Getting up

A problem that can be encountered when pioneering, is getting up a tree to secure ropes and pulleys to branches.

Prusik Knot

The prusik knot is a friction knot, which allows it to slide on a rope when free of a load, but will grip the rope when under strain. To climb a rope you will need three prusik loops fixed onto the main rope - 2 for the feet and 1 as an underarm loop. The rope is climbed by sliding the knots, one at a time, so that it is possible to 'step up' the rope using the foot loops. With practice, a rhythm can be developed which will allow you to climb the rope with ease.



Rope ladders

Rope ladders are constructed using the Marlin Spike Hitch or Clove Hitch.

How much equipment do you need?

In order to undertake all of the projects shown in this chapter you need to have the following minimum quantities of equipment in your store. The quantity listed is to complete one project at a time.
Most Units have a stock of spars and pulleys, so it is only necessary to borrow them from the Unit quartermaster. Apart from the large spars you will also need a number of small poles for platforms, and rungs for ladders and handrails.

Rope ladder

It is better to have a permanent rope ladder made, using fixed stopper knots and in your store, rather than making one each time it is required.

Ropes

You will need a main hawser, 75mm rope, for footrails and for use whenever a rope is expected to hold weight. These ropes are sold in set lengths and you should not cut them.
50mm ropes and smaller will probably be provided in various lengths by the quartermaster and you should not cut them.
Lashing ropes will also be required. Your quartermaster will probably supply these already cut into working lengths.

A rule of thumb for lashing ropes

1 metre of lashing rope should be used for every 25mm of thickness of the spars to be secured together,
i.e. two 75mm spars require 6 metres of lashing rope.

Pulleys

You will need a minimum of 1 double block, either 150mm or 230mm, depending on the size of the rope to be used (normally 150mm). Depending on the design and location of your project you may require two of each to cover all situations.

These large blocks can be supplemented with a number of smaller pulleys which are useful for hauling and small lifting devices.

Equipment list

4	No.	5 metre spars
6	No.	4 metre spars
10	No.	3 metre spars
10	No.	2.5 metre spars
8	No.	2 metre spars
8	No.	1.5 metre spars

Selection of poles for pickets and small spars for platforms, rungs for ladders and handrails

1	No.	Rope ladder
1	No.	75mm rope - main hawser
2	No.	50mm rope - long lengths for handrails

50mm reeving rope for pulleys
25mm rope for guy lines (15 metre lengths)
Lashing rope and sisal of various lengths

Pulleys

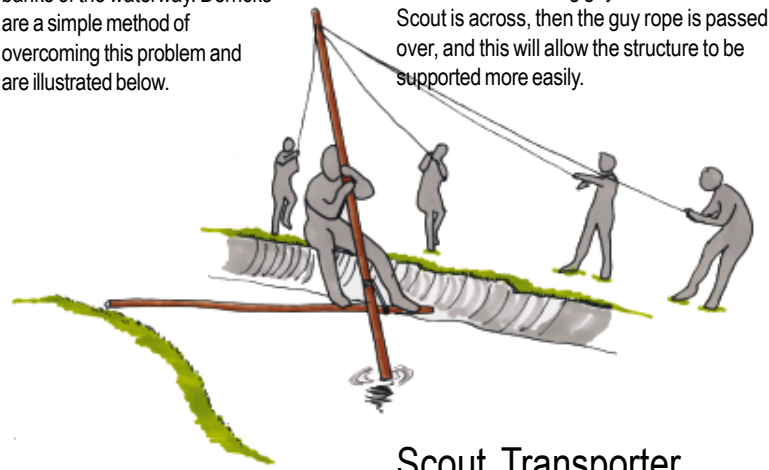
2 single (150mm or 230mm)
2 double (150mm or 230mm)
5 small pulleys (clothes lines or sailing type)

Getting over

One of the problems encountered when constructing a bridge is how to get members of a Patrol or construction crew to the other side of the river or stream so that the bridge can be completed on both banks of the waterway. Derricks are a simple method of overcoming this problem and are illustrated below.

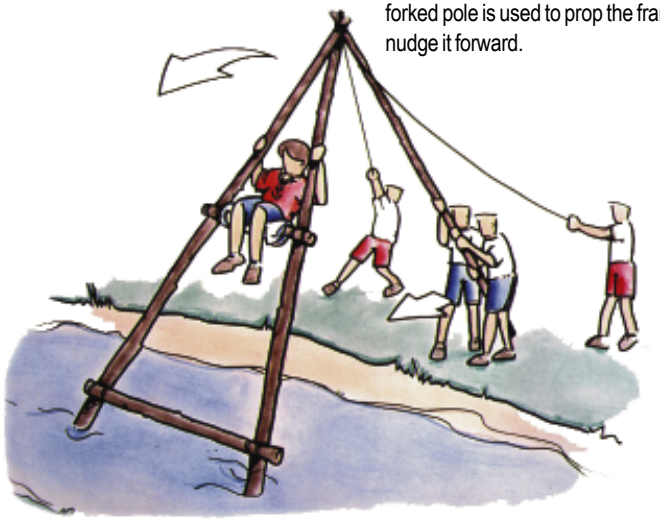
Simple Derrick

The simple derrick is constructed using two spars loosely tied together. a loop of rope is attached to both spars so that it is possible for the 'traveller' to balance and manoeuvre the spar over the waterway. The rope should be attached on each pole using a round turn and two half hitches. Guys are fixed to the top of the derrick. The derrick is balanced by Patrol members using guys until the first Scout is across, then the guy rope is passed over, and this will allow the structure to be supported more easily.

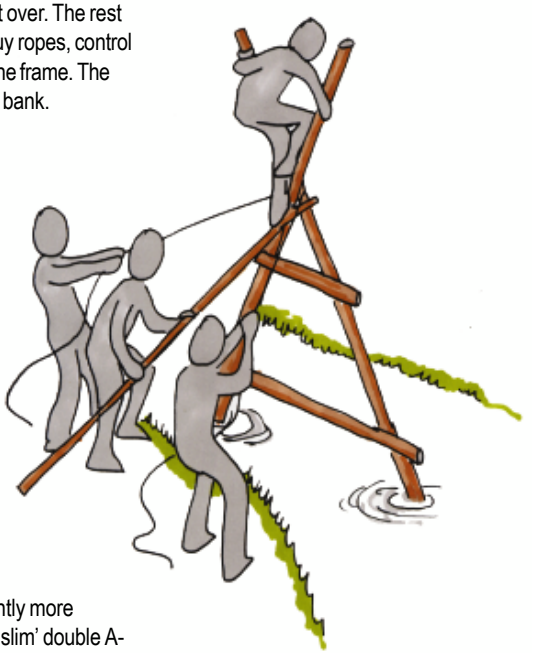


Scout Transporter

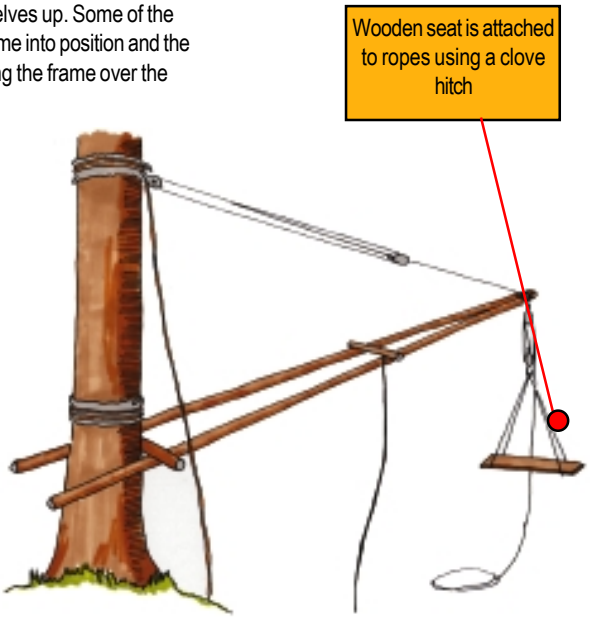
A double bar A frame is constructed and a member of the Patrol sits on the frame. A forked pole is used to prop the frame and nudge it forward.



A double bar A frame is constructed. The first Scout to cross stands on the frame and a forked pole is used to push it over. The rest of the Patrol, manning the guy ropes, control the balance and descent of the frame. The Scout on board jumps to the bank.



This swinging derrick is slightly more complicated to construct. A 'slim' double A-Frame is constructed and pulleys rigged as shown. The 'traveller' pulls on the pulley rope to raise themselves up. Some of the Patrol haul the A-frame into position and the other members swing the frame over the void.



Towers

Tripod Tower

This tower is reasonably easy to construct. All the lashings are square except the tripod lashing on the main spars.

Equipment required

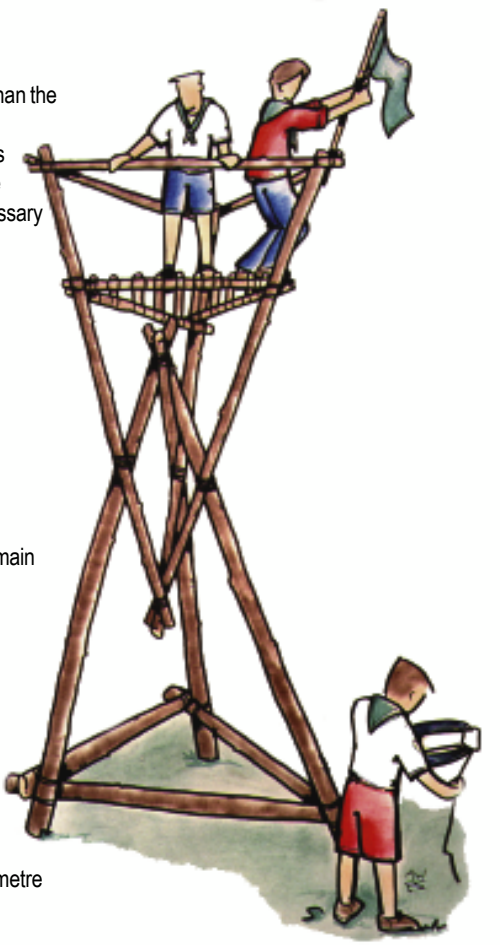
3 No. 5 metre spars
3 No. 3 metre spars
3 No. 2 metre spars
3 No. 1.5 metre spars
3 No. 1 metre spars
Small poles or planks for platform
Lashing ropes
Guys
Rope ladder
Spade to dig butt holes for tower

How to build

- Place a tripod lashing three - quarters up the 5 metre spars.
- Lift the spars straight up and create tripod shape.
- Fix 3 metre braces to the bottom of the tripod using square lashings.
- Drop the tripod to the ground and place top braces on it allowing them to jut out of each side.
- Build the rest of the platform structure. You can also build the top structure as one piece and place on top of the tripod.
- Fix the guy ropes and the rope ladder and raise into position.
- You should dig a number of small holes for the butts of the spars to fit into.
- Secure the guys and test the rope ladder and platform before use.

Hour Glass Tower

This tower is slightly more complex than the tripod tower, however the principle of construction is the same. The tower is constructed by using two tripods, one inverted on top of the other. It is necessary to brace the two tripods to prevent the top tripod swaying.



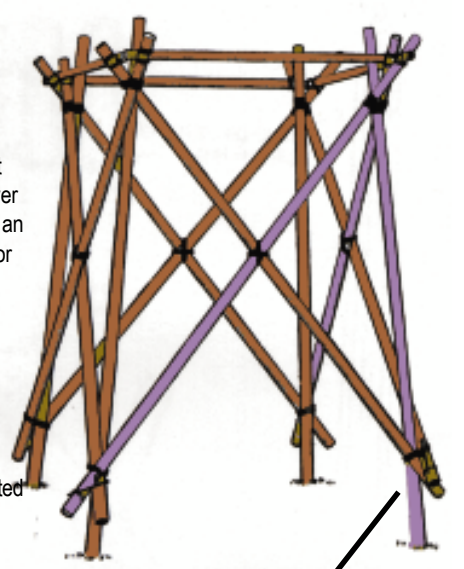
Equipment required

3 No. 4 metre spars
6 No. 2.5 metre spars
3 No. 1.5 metre spars
Small poles or planks for platform
Lashing ropes
Guy ropes
Small spade for digging holes to butt main spars.

How to build

- Create a tripod with the 3 No. 4 metre spars.
- Raise the tripod and fix braces (2.5 metres).
- Drop tripod to ground.
- Make a second tripod using 2.5 metre spars.
- The legs of this tripod should be 'threaded' through the base tripod.
- The spars are then lashed in place using square lashings.
- The top braces- (2 metre spars) are fixed onto the top tripod and platform base is created (1.5 metre spars). Fix small poles or planks to form platform.
- A loose binding is fixed at the top of the lower tripod and the base of the top tripod to prevent swaying. This will need to be tightened when tower is raised in order to straighten it.
- Rope ladder and guys should be fixed to the platform before raising the tower.
- Place butts of tower in small holes dug at base.
- Fix all guys . Test structure before general use.

Ten Minute Tower



With practice, and the use of tourniquet lashings, it is possible to erect this tower in ten minutes. This structure provides an ideal challenge for a Patrol at a Troop or Patrol meeting. However, the tower tends to be used to create more complex bridges, using a number of towers to bridge a wide river or lake. Tripod, diagonal, square and tourniquet lashings are required to hold the structure together. The structure is free standing and can be lifted or carried into position.

Equipment required

8 No. 3 metre spars
8 No. 2.5 metre spars
Planks for platform base
Lashing ropes
Small poles for tourniquet lashings

How to build

- Place a tripod lashing on 4 sets of spars as shown in diagram, the centre pole being 2.5 metres in length, the two ouside spars being 3 metres in length.
- Stand up tripod 'sets' and spread out legs so that the 3 metre spars act as braces and the centre spar acts as the corner support of the tower.
- Move the sets together using tourniquet lashings at the bottom and diagonal lashings where the braces cross.

- Place 2.5 metre spars on top to brace top sections together.
- Place planks on top to provide platforms if it is to be used as a single tower.

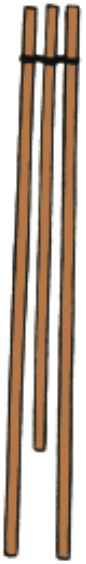
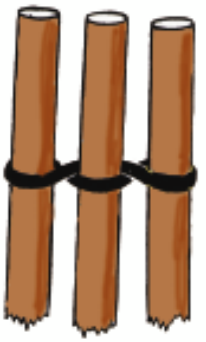
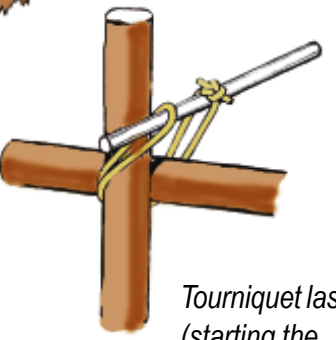


Figure of Eight lashing





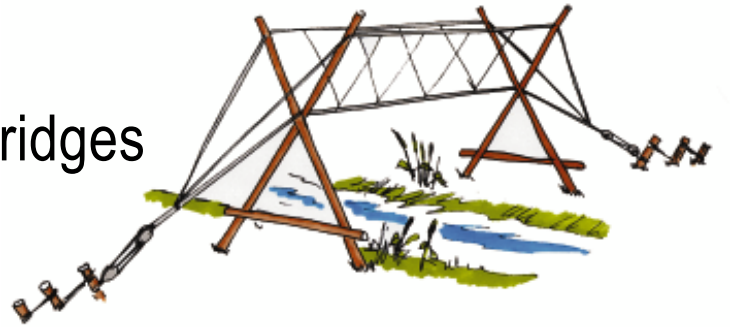
Tourniquet lashing (starting the lashing)

Tourniquet lashing (tightening the lashing)

Tourniquet lashing

The tourniquet lashing is made using a loop of rope and a small pole. A small pole is inserted in a loop that is passed around the spars. This is twisted until the binding is tight. The small pole is then secured to the nearest spar, with sisal, to prevent it unraveling.

Bridges



Monkey Bridge

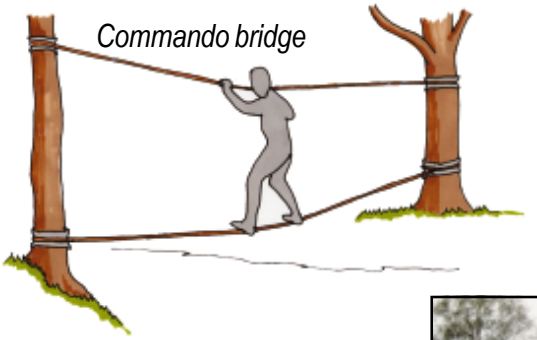
The monkey bridge is constructed using two sets of sheer legs and bridged with a hawser, with handrails secured using pickets. This is an easy structure to build as most of the bridge is constructed using rope.

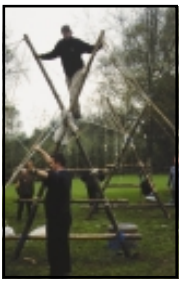
How to build

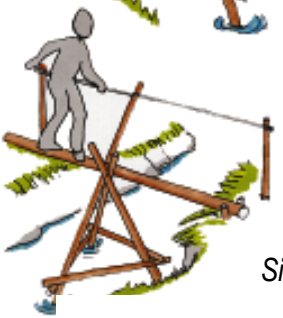
- Assuming you have access to both banks, construct two sheer legs with the crossing of the spars being a little above half way. The top portion of the spar should allow you to position the handrails at about shoulder height. The distance between the tips of the spars should be 1 metre.
- The sheer legs are then raised into position and the bases of the spars butted into the ground and guyed into position.
- Old canvas or sacking should be placed in the diagonal to reduce friction and wear on main footrope.
- The main rope (75mm) is passed over the sheer legs and the rope is aligned and hand strained, so that the position of anchors can be determined.

- A 3-2-1 picket anchor is placed in a straight line to the 'foot rope' on each side of the river bank. If only one set of pulleys is available then a log and picket anchor is placed on one bank and a 3-2-1 picket anchor on the other, to which your pulleys are attached.
- Hand rails are attached using clove hitches and are carried down to the ground like guys.
- Securing ropes are tied between the handrails and footrope, using clove hitches.
- Test structure before using.
- Pulleys will need to be checked at regular intervals as ropes slacken with use.

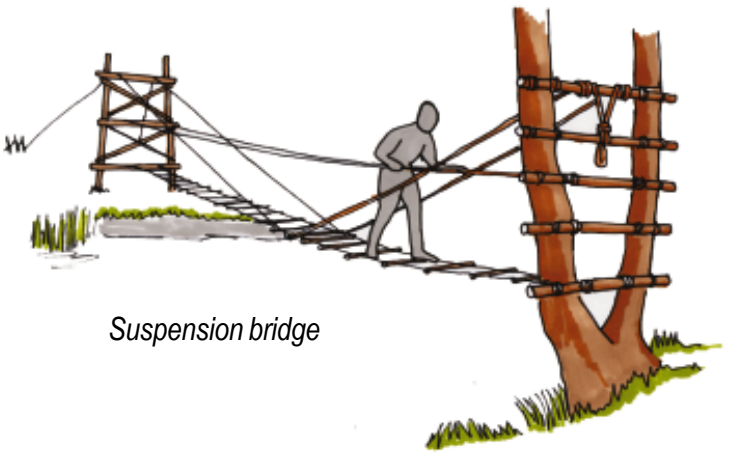
Commando bridge







Single log bridges



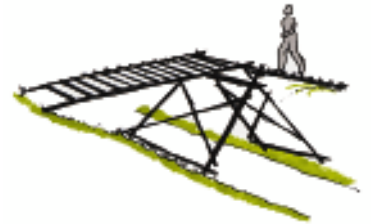
Suspension bridge

Trestle Bridge

The trestle can be used as a basic building block for a whole range of bridges. The bridge illustrated is the locking trestle bridge which can either have a see-saw bridging platform or a fixed ramp on each side.

Equipment required

2 No. 6 metre spars
8 No. 4 metre spars
2 No. 3 metre spars
3 No. 2.5 metre spars
Spars for handrail supports and rungs for bridge
Lashing ropes
Handrail ropes

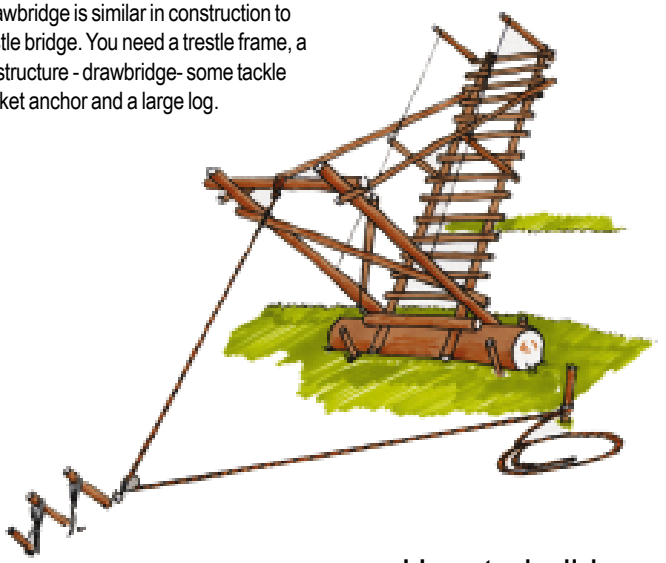


How to build

- Construct two trestles. It will be necessary to construct these according to the depth of the river and river bank.
- These trestles are placed opposite each other on the banks of the river and lowered into each other.
- A ladder type construction is created using the 6 metre spars and small poles and handrail supports.
- A 2.5 metre spar is placed between the diagonal created by the joined trestles.
- This is not fixed as it is a rolling pivot for the ladder structure.
- The ladder is fixed to this rolling spar.
- A large log placed on each bank will protect the bank from damage caused by the see-saw action of the bridge.

Drawbridge

The drawbridge is similar in construction to the trestle bridge. You need a trestle frame, a ladder structure - drawbridge- some tackle and picket anchor and a large log.



Equipment required

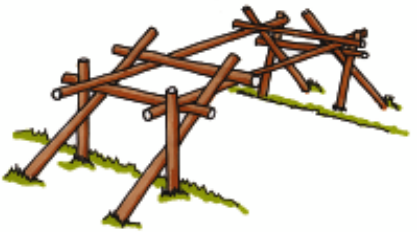
2 No. 6 metre spars
6 No. 4 metre spars
1 No. 3 metre spar
1 No. 2.5 metre spar
Small poles for ladder
A large log
Pickets
Pulley and 50mm rope
Lashing ropes

How to build

- Construct the trestle frame, the bottom brace position will be determined by the height of the log.
- Make a ladder structure using 2 No. 6 metre spars with small poles as rungs.
- Fix 4 metre braces from trestle frame to ladder and fix handrails. The handrails can be of rope, or spars if you prefer.
- Place 3-2-1 picket anchor in the ground and rig up a pulley to it.

Other challenges

Outback Bridge



Friction bridge

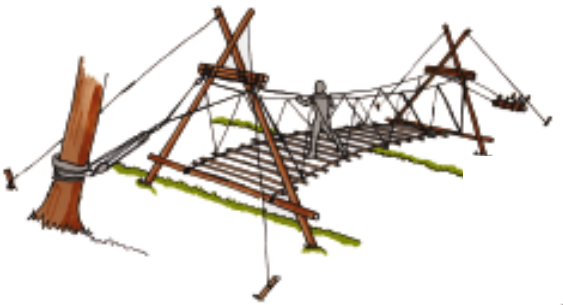
No lashings are used in its construction. You rely, rather, on the friction and tension of each log in the bridge, to hold the structure together.

Square tower

Stilt Tower

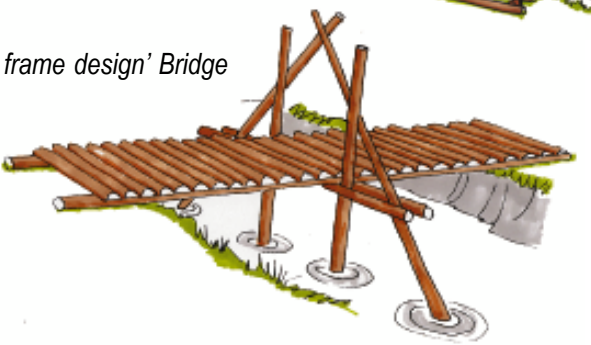
See-saw Bridge

Handrail detail



Abington Spring Bridge

Simple 'A frame design' Bridge



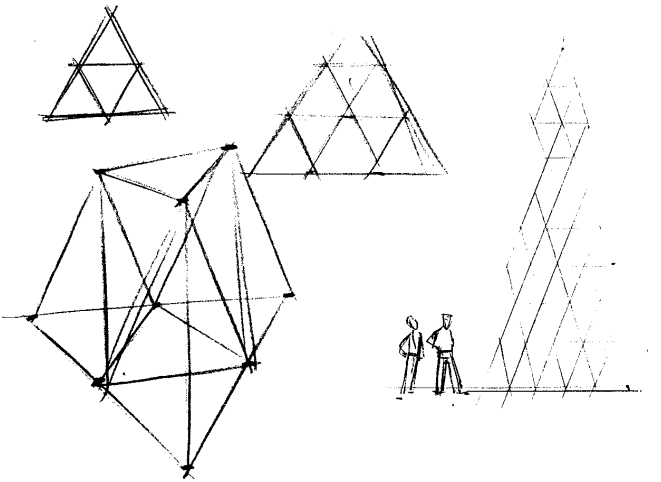
Levering and lifting

Did you ever wonder how ancient peoples such as the Egyptians and the Druids managed to move large stones to form the pyramids or Newgrange - they used levers. This tried and proven method of shifting heavy loads should be used by your Patrol, to conserve energy and prevent injury.

When levers are being used for moving logs, or prising out boulders, care must be taken that the lever is strong enough to withstand the strain that is being placed on it. If you are using a lever to lift an object, lift it only a small distance at a time and place a roller or solid block under the object as you lift it. This will enable you to reposition the lever after each lift. Work as a team to complete these types of tasks, as accidents can happen, if lifting is not undertaken with care.

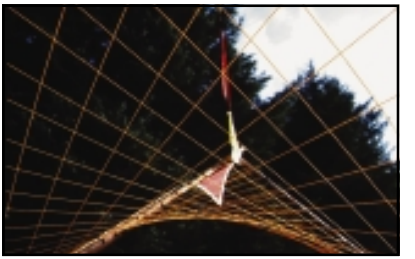
Lift large poles using a team of people and use guy ropes to control the lift. It may be necessary to construct an A frame to aid lifting.

Bamboo and elastic bands



Simple and elaborate structures can be built using bamboo canes and elastic bands. The secret is to construct small pyramid shapes which are strong and stable. These pyramids are then locked together to make more complex structures. It is important however that you maintain the pyramid shape in your design as it adds stability to the final project. It may be necessary to peg down the structure to the ground, in case of windy conditions.

Rope weave



There are few pioneering projects which can be described as 'aesthetically beautiful'. Rope weave decoration has no structural value but the finished product is eye-catching, graceful, and looks far more complicated than it really is.

Siting

The transparent nature of the rope weave means that it will blend in with any countryside and would not look out of place on top of a hill.

Digging

Guy lines will ruin the effect of any rope weave project, which means that any upright poles must be dug firmly into the ground.

Staples

You will need strong wire staples to complete the rope weave. There should be the same number of staples on each spar. The distance between the staples is normally 100mm - 150mm, however, it is possible to vary the distance on both spars to create new effects - so experiment!

Stringing up

The poles should be loosely strung up on the ground, using a continuous length of string or coloured bailing twine, which can be tightened once the poles are firmly in place.

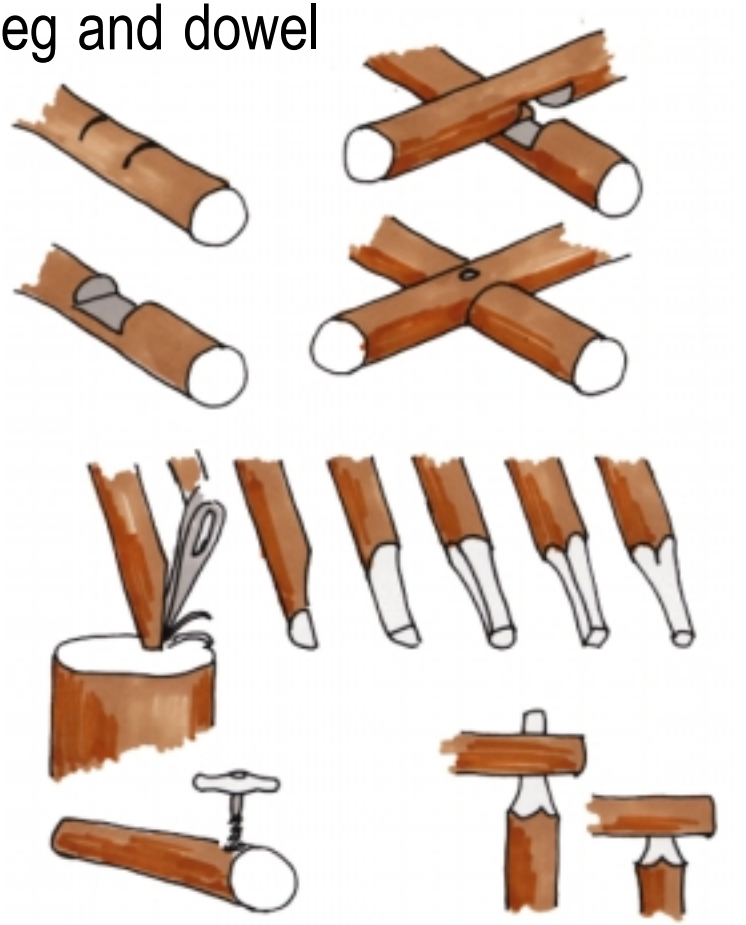
Erection

Erecting the structure is best done using sheer legs and temporary guys until the spars are firmly in the ground.

Tightening

Tightening will probably need to be done several times, depending on the weather. A 'saggy' weave does not look good.

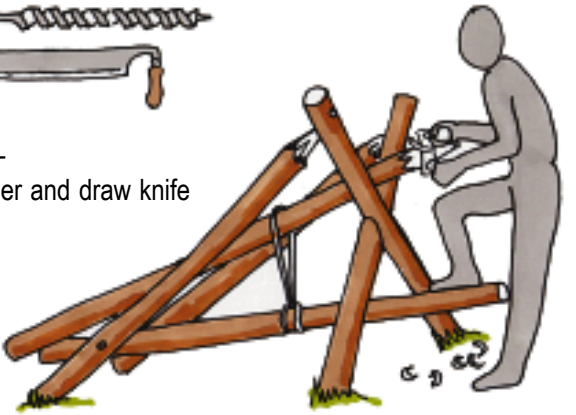
Peg and dowel



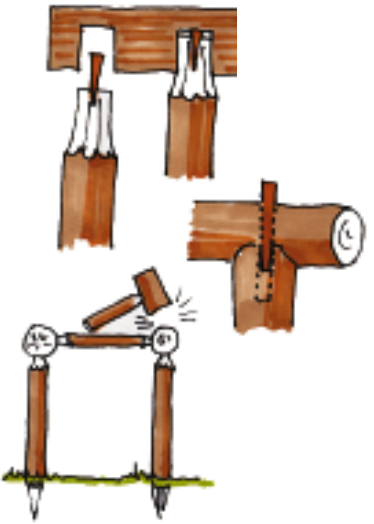
Peg and dowel is a traditional technique used by craftspersons in the creation of rustic and traditional furniture and fencing. The technique involves the paring of poles and stakes and the drilling of holes, to accept the pared poles. A 'scotch eyed auger' is used for drilling. This needs to be about 30mm in diameter.
Many designs are possible and any item of furniture normally made on camp can be created using the peg and dowel method.

Of course you could also use a hammer and a few nails but where is the skill in that ? Peg and dowel is a secure method of making camp structures which will last the rigours of camp. You may want to consider making a set of rustic furniture for your den to give it that Scouty feel. It is also possible to make larger projects such as camp gates and simple bridges.

Tools required:-
Scotch eye auger and draw knife



The 'horse' allows the paring of stakes to be done with safety, and ease. Pressure is applied to the foot pole which in turn applies tension to the rope tie and secures the working stake to the horse.



Any camp furniture that is created using lashings can also be made using the peg and dowel technique.

Joints are secured using a 'hidden wedge'- a hole is bored to accept the pared point. A small wedge is placed in the peg and as the joint is knocked together the wedge seals the joint. A dowel can also be used, which is driven down through the stakes as shown.

Fun projects

Tree houses and raised sleeping platforms

The first step in building a tree house or sleeping platform is to find a suitable tree or collection of trees. Look for a tree that has branches which are strong and suitably spread apart so that a platform can be constructed. Gather together all the equipment you will require - tools, timber, pallets or plywood sheeting, ropes and safety equipment.

The design of your tree house will be determined by the shape of the tree you select, so many designs are possible. Start off by making a simple sketch, taking into account the branches available, in particular the 'branch elbows', where the branch attaches itself to the main trunk.

Use pulleys and ropes to lift the logs up to the platform area. This should be done carefully so as to avoid accidents. The base of the platform can be constructed using spars to get a rustic feel. You can also use a number of pallets or a sheet of shuttering plywood. Be prepared to cut any sheeting to shape.

Anyone working up the tree should be protected by means of a safety belt and fixed loops on to the main tree. You should also be wearing a helmet both up on the platform and on the ground. Be careful when using tools on the platform so that Scouts on the ground are not injured from items falling on their heads.

Once the platform is constructed you can then consider building the rest of the structure.

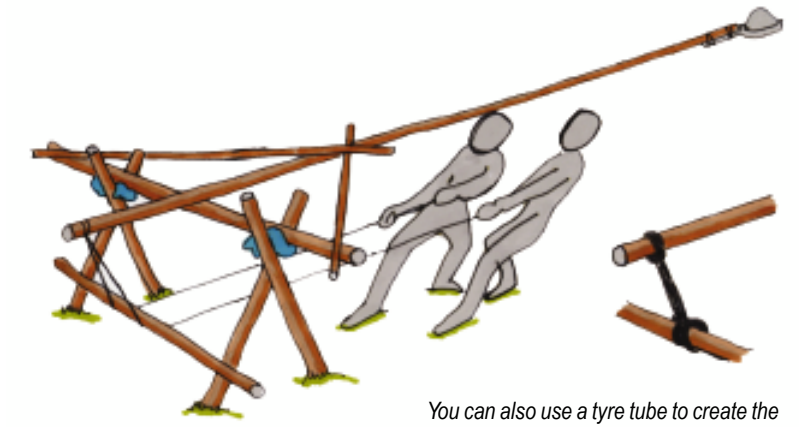
Bodgers Lathe

The Bodger lathe is a fun project to build. The lathe is created by first placing a large stake in the ground and attaching a springy sapling to it. This is the driving force behind the lathe. A string or light rope is attached to the top of the sapling and in turn is wound around the wood to be turned and on to a foot pedal device. The foot pedal can either be a piece of flat timber or a forked stick that is pivoted so it can move freely.

Two other stakes are required which should be bored on each side to accept the wood to be worked. The working piece should be able to move freely and spin backwards and forwards when the foot pedal is operated.

You will also require a set of sharp chisels to work on the spindle.

Camp ballista



You can also use a tyre tube to create the tension on the ballista.

Camp Gateways