

# Trebuchet Project



## Foreword:

The purpose of the project is to create a fun exercise to practice some basic knots hitches and lashings. There are also opportunities to experiment and with the real physics behind this miniature version ancient weapon.

The assembly is somewhat challenging here are some ideas to help if things get frustrating

1. This guide breaks up the assembly into five sections. Do not feel like you need to do it in one sitting
2. The provided twine works well, but if fine motor skills are a challenge, a slightly thicker cord could be used (1/8" cord or 425 Paracord could be options)
3. The instructions call out places where a temporary attachment may be helpful. Going a step further a spot of hot glue could be used to tack the pieces together so that they can be lashed.

Take your time, have fun and after it is finished feel free to improve the design with the extra parts!

## In this document

1. Supplies in Kit
2. Tools needed
3. Directions
4. Other helpful resources
  - a. Lashing and hitches directions
  - b. Links to Trebuchet physics
  - c. Links to Simulation tools
  - d. Data for simulation

## Supplies in Kit

### Dowels

| Quantity | Size        | Notes                            |
|----------|-------------|----------------------------------|
| 1        | 16" by 3/8" | Arm                              |
| 9        | 8" by 3/8"  | Base tringles, axle, Cross-brace |
| 2        | 6" by 3/8"  | Front braces                     |
| 3        | 2" by 3/8"  | Axle guides, weight support      |
| 2        | 4" by 1/4"  | "basket"                         |
| 1        | 2" by 1/4"  | "basket"                         |
|          |             |                                  |
| 2        | 18" by 3/8" | Extra for creative modifications |
| 1        | 12" by 1/4" | Extra for creative modifications |
| 2        | 2" by 3/8"  | Extra for creative modifications |

### Other

| Quantity | Item                       | Notes   |
|----------|----------------------------|---|
| 2        | Waxed Polyester Twine Cord | 10 yards by 1.0 mm each   |
| 2        | 1" Hex nuts                | For counterweight, 0.27 pounds each   |
| 2        | Ping-Pong balls            | Projectiles   |
| 1        | Small nail                 | Option modification; release pin for sling  |
| 1        | Large Zip top bag          | Bag that the supplies are in. Be thrifty and save this for packing clothes in for camping |

### Tools needed

|                       |   |
|-----------------------|---|
| Knife                 | Required, there is a small amount of cutting grooves in some parts  |
| Scissors              | Optional, but preferred for cutting twine   |
| Ruler or tape measure | Optional, but may be useful to identify parts   |
| Pruning shears        | Optional, may be used to adjust to cut extra parts for those that want to go off script.                                    |
| Twist ties or similar | Optional, it may be helpful to have a "third hand" to hold a piece in place temporarily while you are lashing the other end |

## Assembly Directions

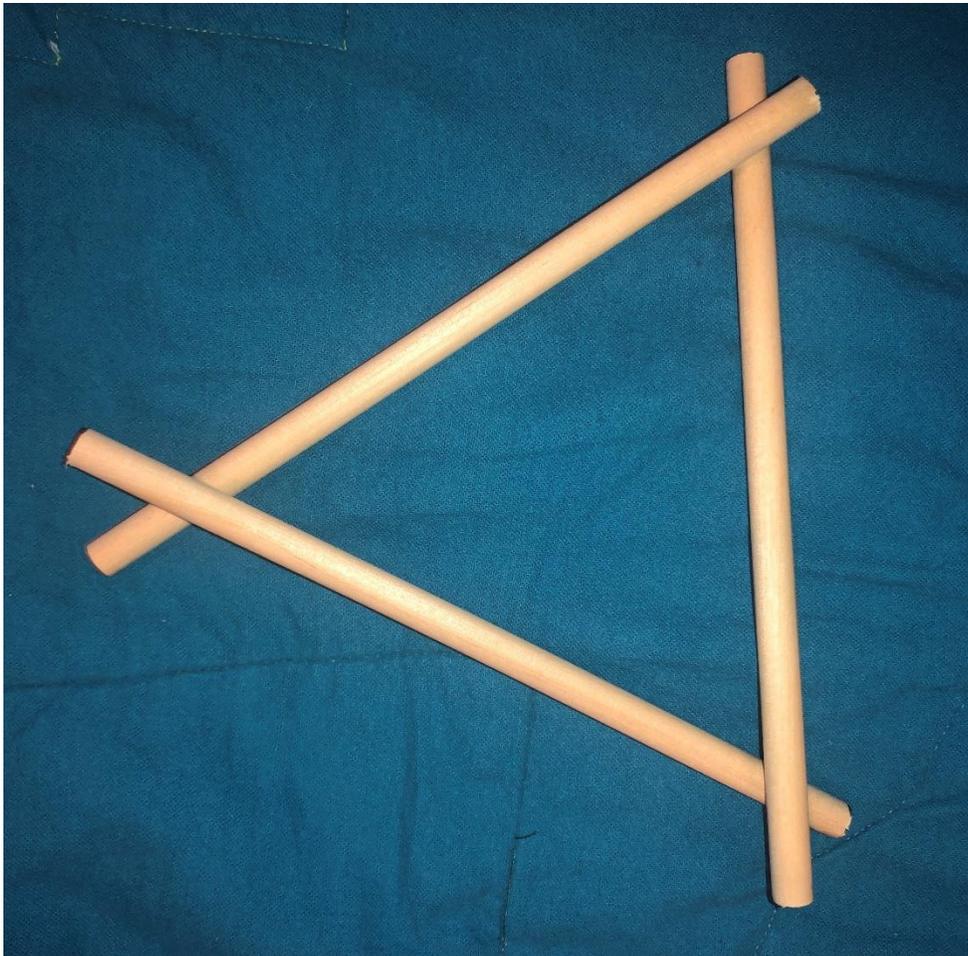
Build triangle sides of base

### Supplies

| Quantity | Size                |
|----------|---------------------|
| 6        | 8" by 3/8" dowels   |
| 6        | 24" pieces of twine |

### Steps

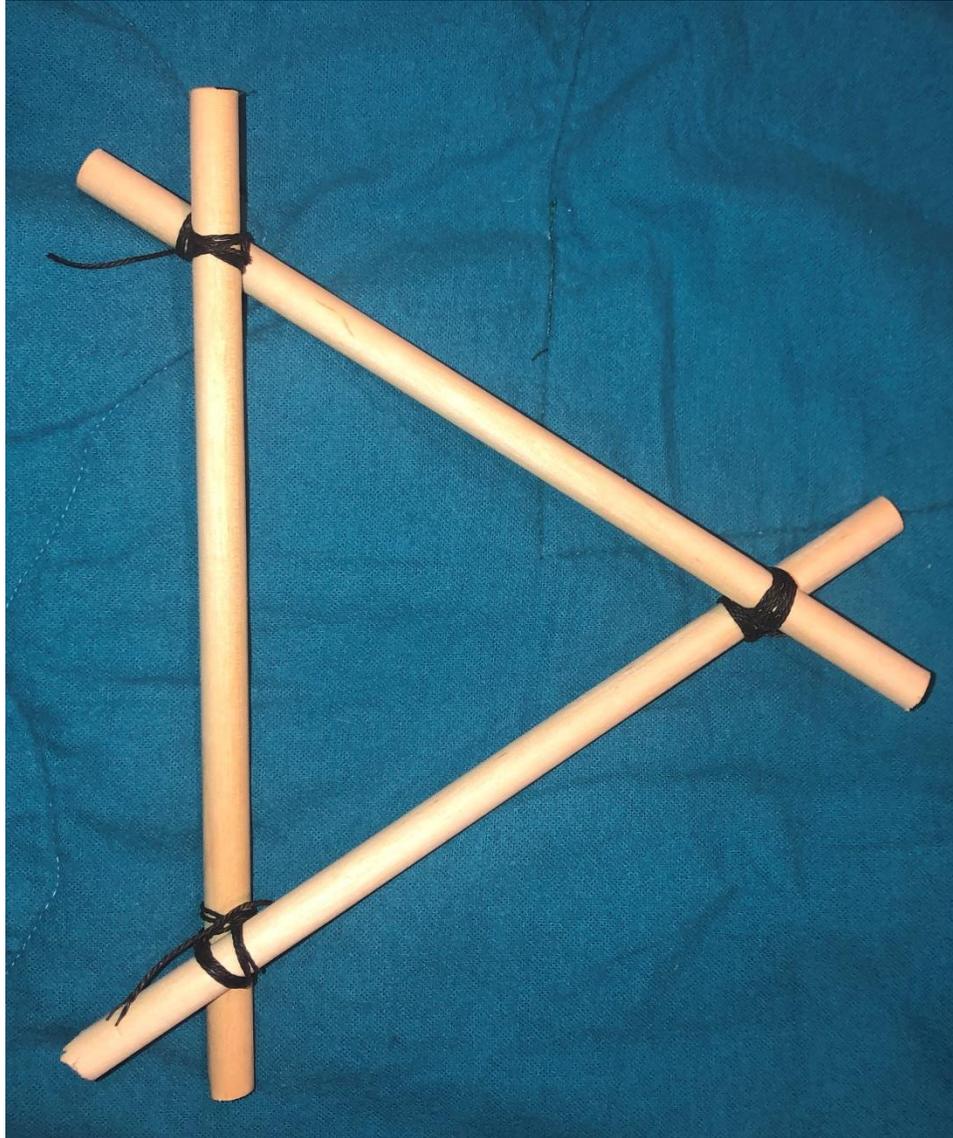
1. Arrange 3 dowels to approximately make an equilateral triangle
  - a. The intersections should be approximately 1 to 1 ½ inches from the end



2. Lash each intersection with a Diagonal Lashing
  - a. Begin by tying a timber hitch around the bigger angles.
    - i. Remember that for a timber hitch the rope/twine wraps back on itself. Like a lasso.
    - ii. Instructions in the resources section

b. Complete Diagonal Lashing

- i. Proceed to wrap three times in each direction forming an X across the intersection; pull tight as you go
- ii. Frap three times by going between the two pieces; pull tight as you go
- iii. Finish by tying at least two half hitches
- iv. Instructions in the resources section



3. Repeat to form second side triangle

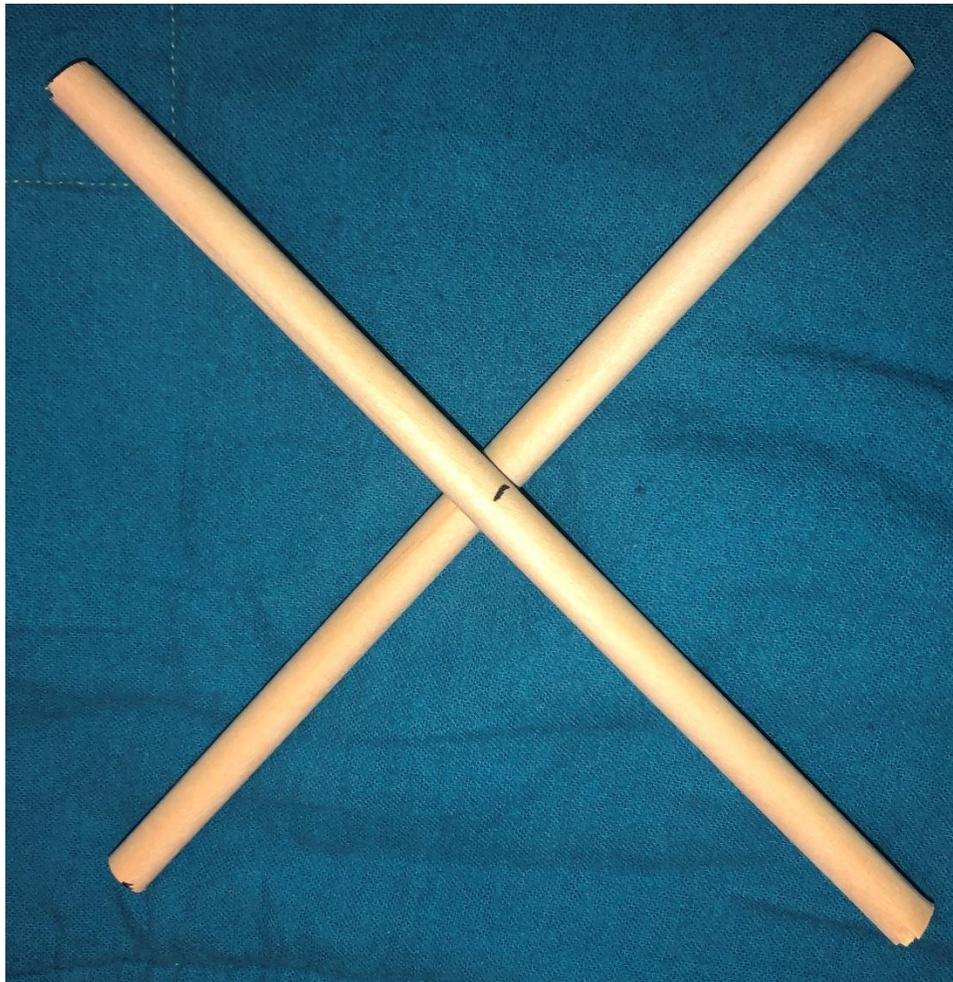
## Make Cross-brace

### Supplies

| Quantity | Parts                   |
|----------|-------------------------|
| 2        | Finished side triangles |
| 2        | 8" by 3/8" dowels       |
| 5        | 24" pieces of twine     |

### Steps

1. Arrange 2 dowels to approximately make an "X" shape
  - a. It will fit better if shaped like the letter X on your keyboard, i.e. the dowels should not cross at 90 degrees.
  - b. I may be helpful to mark the center (as shown in photo)



- c. Join with a Square Lashing
  - i. Begin with a Clove Hitch
  - i. Wrap 3 to 5 times; pull tight as you go
  - ii. Frap 2 to 3 times; pull tight as you go
  - ii. Finish with half hitches around the dowel
  - iii. Instructions in the resources section
- d. Position the cross-brace in the triangles
  - i. Triangles should be about 6 inches apart (outside to outside)
  - ii. It may be helpful to temporarily attach 6-inch dowels with string/zip ties/twist ties to hold triangles while you work
  - iii. Note one leg of cross-brace is inside a triangle



iv. Secure with Diagonal lashings



Finish front

Supplies

| Quantity | Parts                  |
|----------|------------------------|
| 1        | Partial completed base |
| 2        | 6" by 3/8" dowels      |
| 2        | 2" by 3/8" dowels      |
| 4        | 24" pieces of twine    |

Steps

1. Arrange 1 dowel to across bottom of front. It may be easier to turn base upside down for this step
2. Attach with Square Lashings
  - a. Note: you want the position of the dowel as close to the end of the triangle dowels as possible to avoid interference with the swinging counterweight latter on.



3. Attach a 6-inch dowel across the front. It should be near the center, about 3 ½ inches from the top.
  - a. Again, It may be helpful to temporarily attach one side with string/zip ties/twist ties, as shown in the picture



4. Attach with Square Lashings
  - a. Note: This piece controls the release point for launching a projectile with the “Basket Arm”
  - b. You may want to experiment with moving up or down, inside the frame or extending it by adding another piece of dowel to with a Round Lashing to optimize performance
  - c. This piece is removed for the alternate “Sling Arm” option



- d. Add the Axle guides to the top of the Triangle Frames
  - i. The Basket Arm as will have some horizontal travel (quasi-floating arm design) and need stops to limit it. The Sling Arm does not require these pieces.
- e. Attach with Square Lashes



## Basket Arm

### Supplies

| Quantity | Parts                  |
|----------|------------------------|
| 1        | Partial completed base |
| 2        | 16" by 3/8" dowels     |
| 1        | 8" by 3/8" dowels      |
| 2        | 4" by 1/4" dowels      |
| 1        | 1" by 1/4" dowels      |
| 2        | 36" pieces of twine    |
| 2        | 18" pieces of twine    |

### Steps

1. Notch one end of 16" dowel, this will be used to hold counterweight
  - a. Mark a line about one quarter inch from the end of dowel
  - b. Carefully make a shallow cut around the circumference of the dowel at the mark
    - i. It may be helpful to place the dowel on a cutting board or similar surface for this to help you cut away from your body
  - c. Carefully cutting away from your body, cut along the dowel to remove some to the wood above the first cut. Try to stop at the first cut.



2. Arrange the un-notched end of large dowel and the two small to form a "fork"
3. Attach with Tripod Lashing, using a 36" piece or twine
  - a. Begin with a Clove Hitch

- b. Wrap around all three dowels; unlike every other lashing it is better to leave the wraps slightly loose
- c. Apply tight frapping turns between the pieces
- d. Finish with half hitches



- e. Adjust the short pieces in the shape of a lacrosse stick



4. Add the two-inch dowel to the ends of the legs to be the top of the basket
  - a. Use 18" pieces to twine to complete Square Lashings



5. Add Axle
  - a. Position the axle about three inches above the notch cut



- b. Use a 36 inch piece of secure with a Square Lashing.
      - i. Make sure the pieces are square to each other
      - ii. You will want to add extra wraps to help stabilize the lashing



## Counterweight

### Supplies

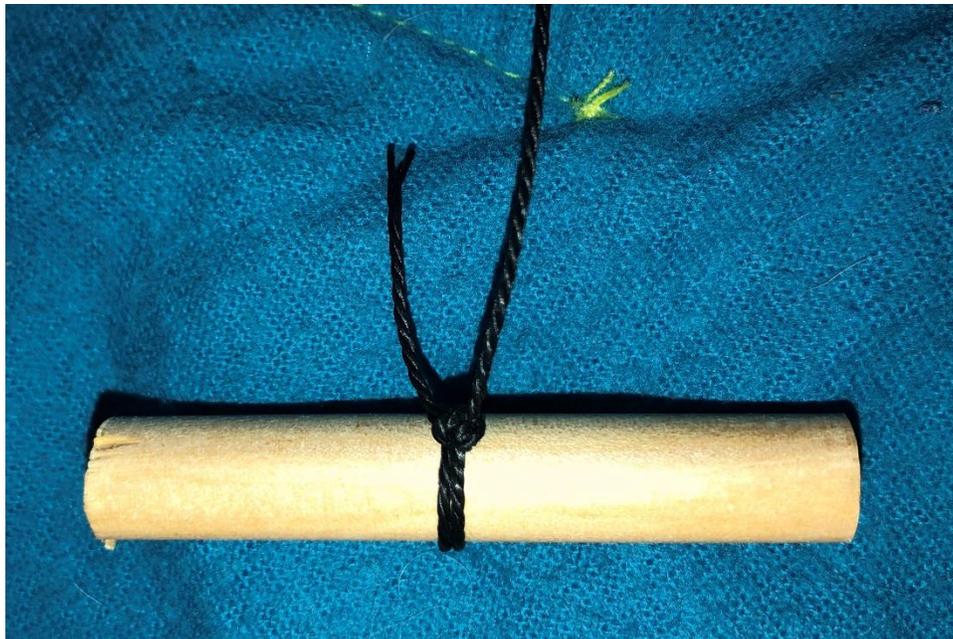
| Quantity | Parts               |
|----------|---------------------|
| 1        | Basket Arm          |
| 2        | 1-inch nut          |
| 1        | 2" by 3/8" dowels   |
| 3        | 12" pieces of twine |

### Steps

1. Carefully make a small notch the center of the 2-inch dowel



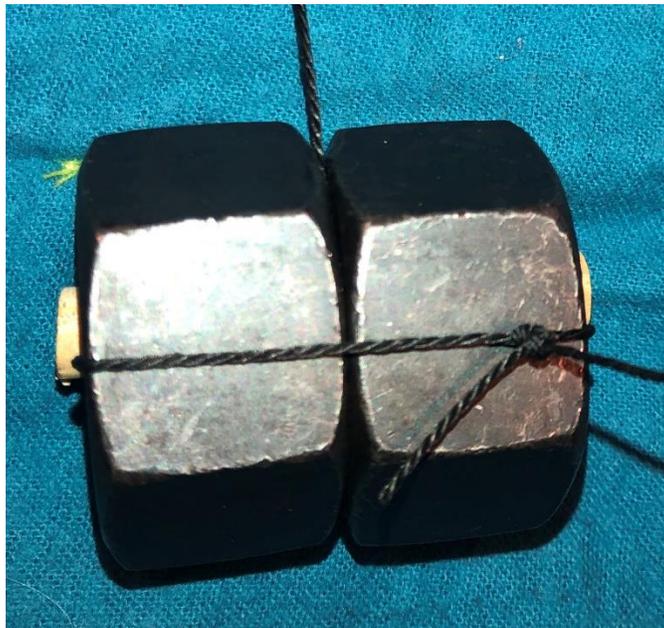
2. Tie one end around the notch using Round Turn and Two Half Hitches
  - a. [Link to instructions in resources](#)



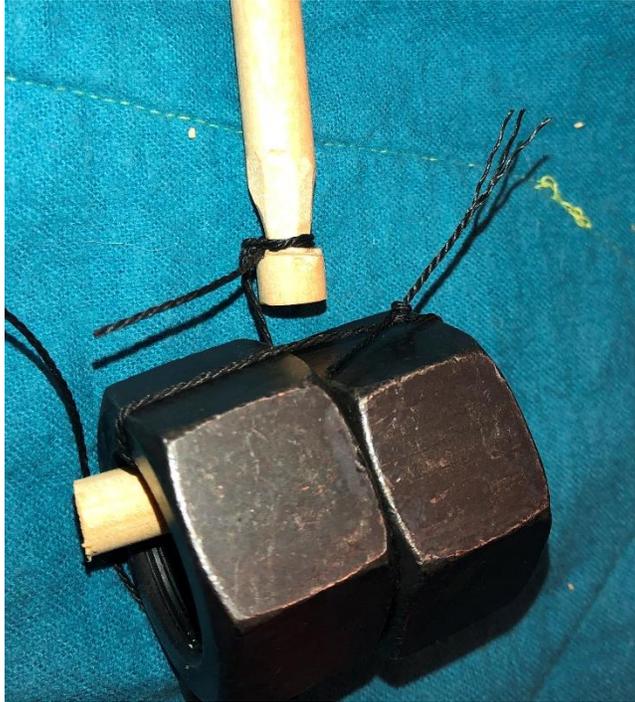
3. Place nuts over dowel



4. Thread a piece of string through both nuts and tie a knot
  - a. Several knots would work, I used a simple slip knot, with two half hitches keep it from loosening
5. Repeat on other side



6. Tie the assembled counterweight to end of the Basket Arm
  - a. Use another Round Turn and Two Half Hitches
  - b. Try only leave about an inch of twine from the knot to the top of the nuts



### Optional Sling Arm

*This modification requires more experimentation to launch successfully and additional craftsmanship to device the sling*

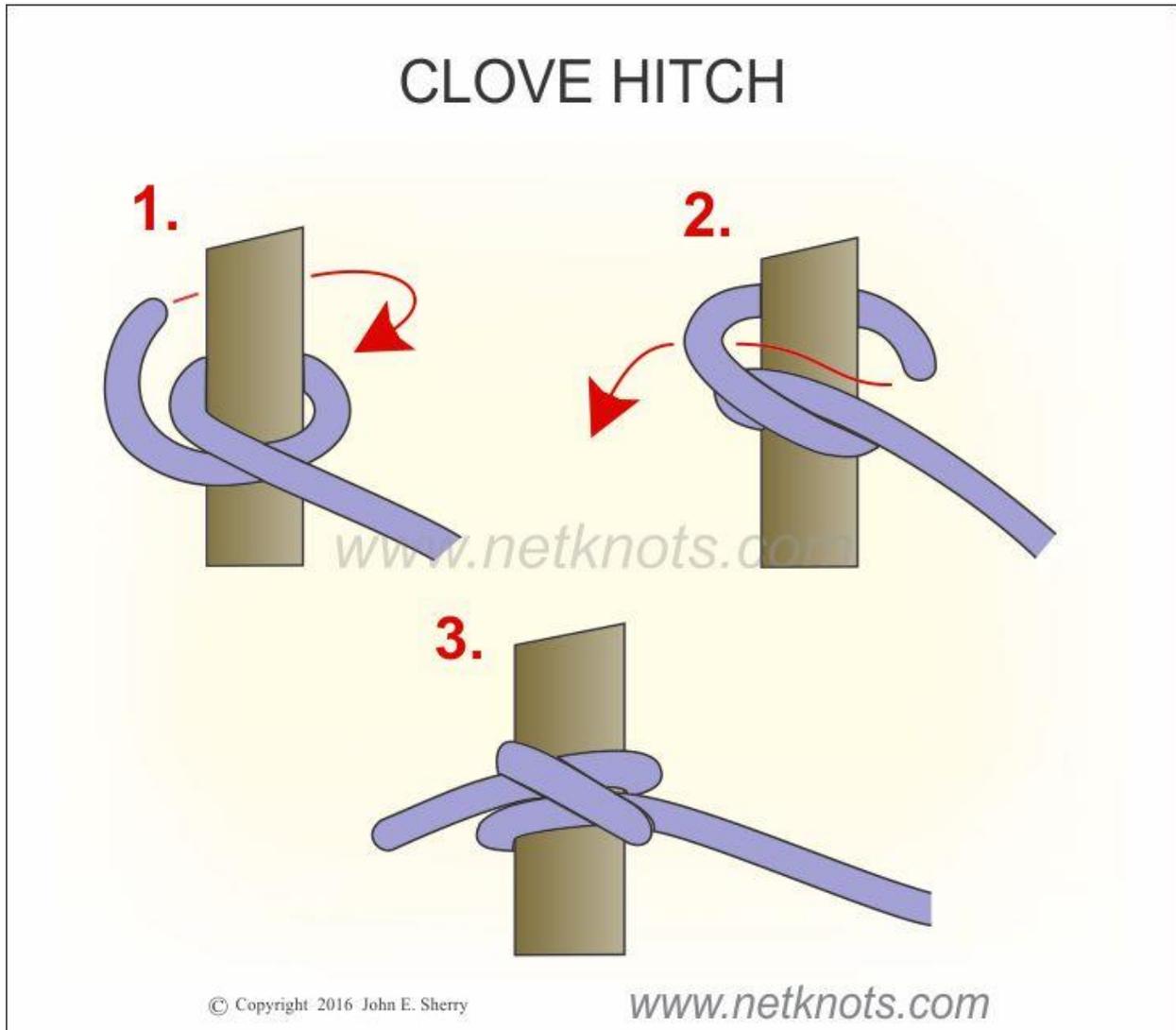
#### Steps

1. Instead of basket lash a small nail to the end of the 18-inch dowel
  - a. You will need to experiment with angle of the nail relative to the dowel
  - b. This “pin angle” control the release point of the projectile
2. Attach one end of a sling to the arm and the other to the release pin to hold the projectile
  - a. An alternate approach is to attach a piece to string to the projectile and attach the other end to the pin
3. You will likely need to remove the upper front horizontal brace to successfully launch

Resources:

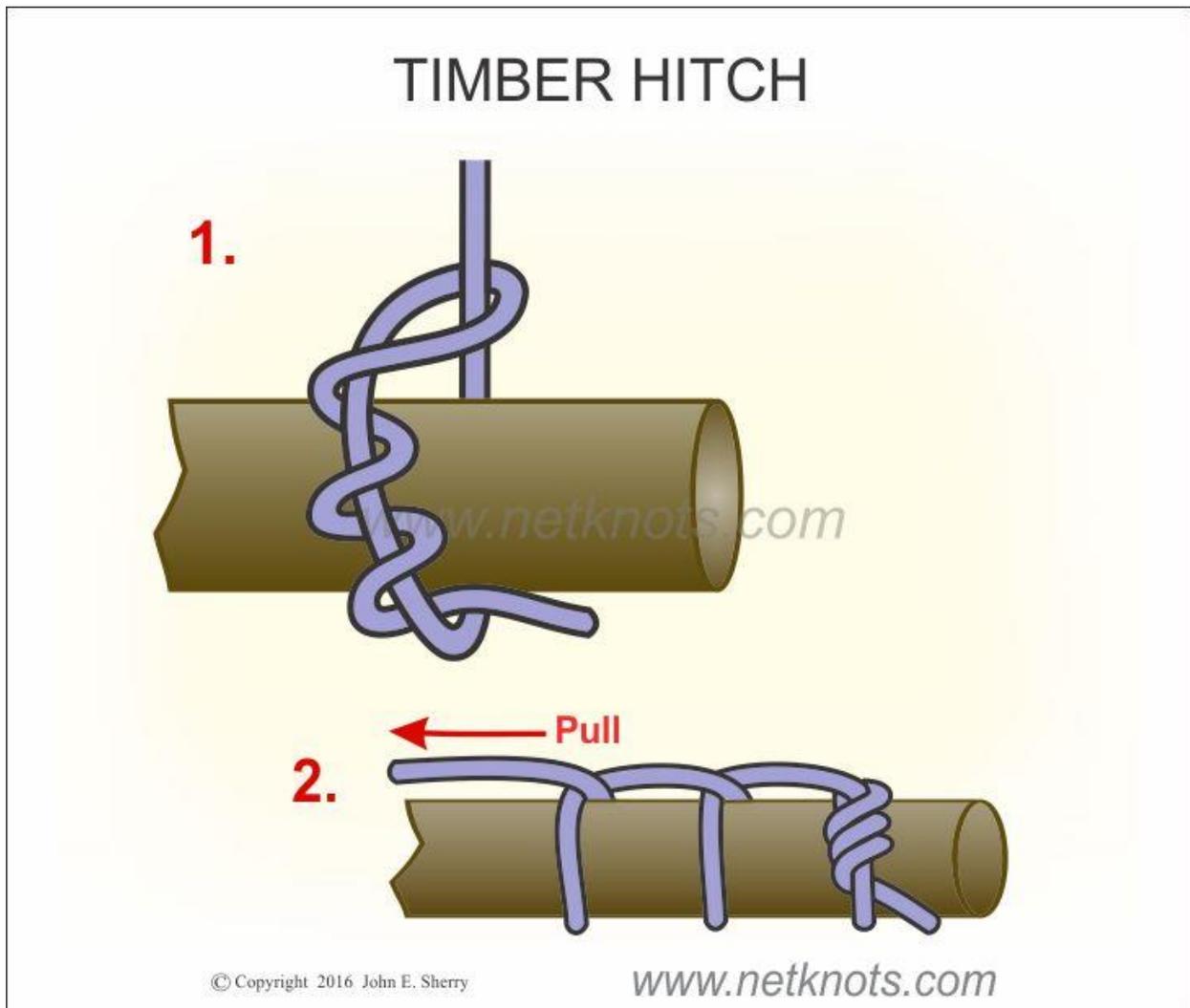
Hitches

Clove Hitch



[https://www.netknots.com/rope\\_knots/clove-hitch](https://www.netknots.com/rope_knots/clove-hitch)

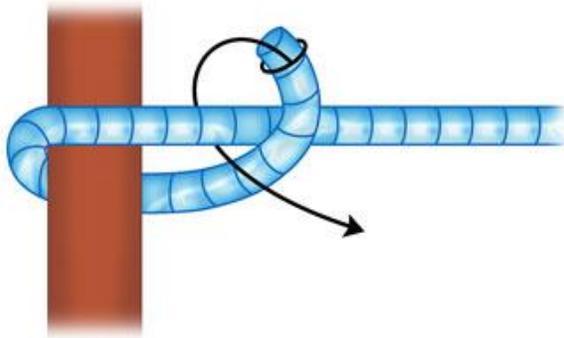
## Timber Hitch



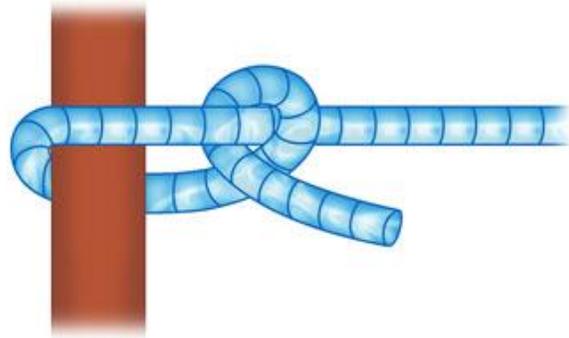
[https://www.netknots.com/rope\\_knots/timber-hitch](https://www.netknots.com/rope_knots/timber-hitch)

# Half Hitch Instructions

---



- 1 Wrap the rope around the support

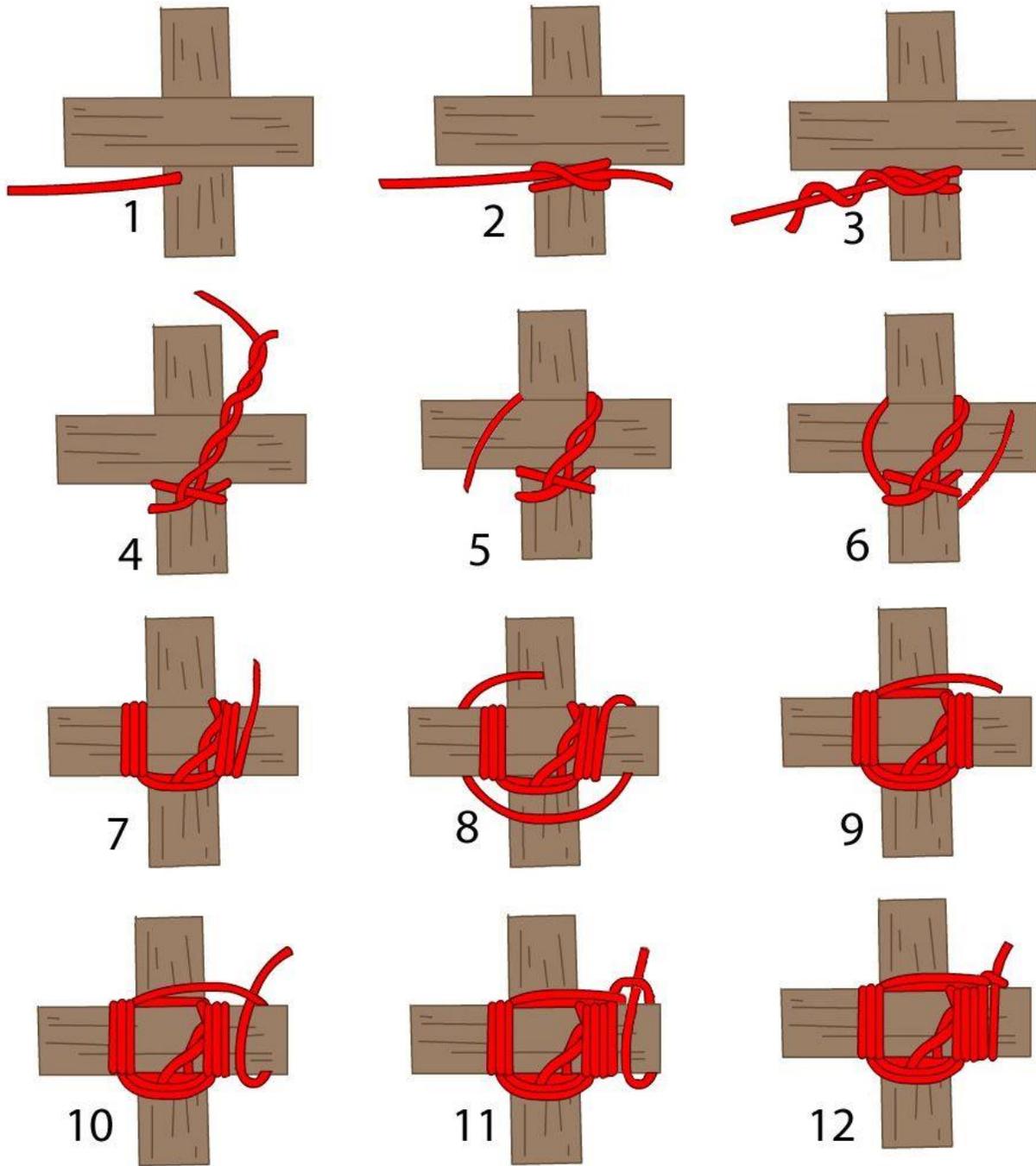


- 2 Pass the end through the loop and tighten

101KNOTS

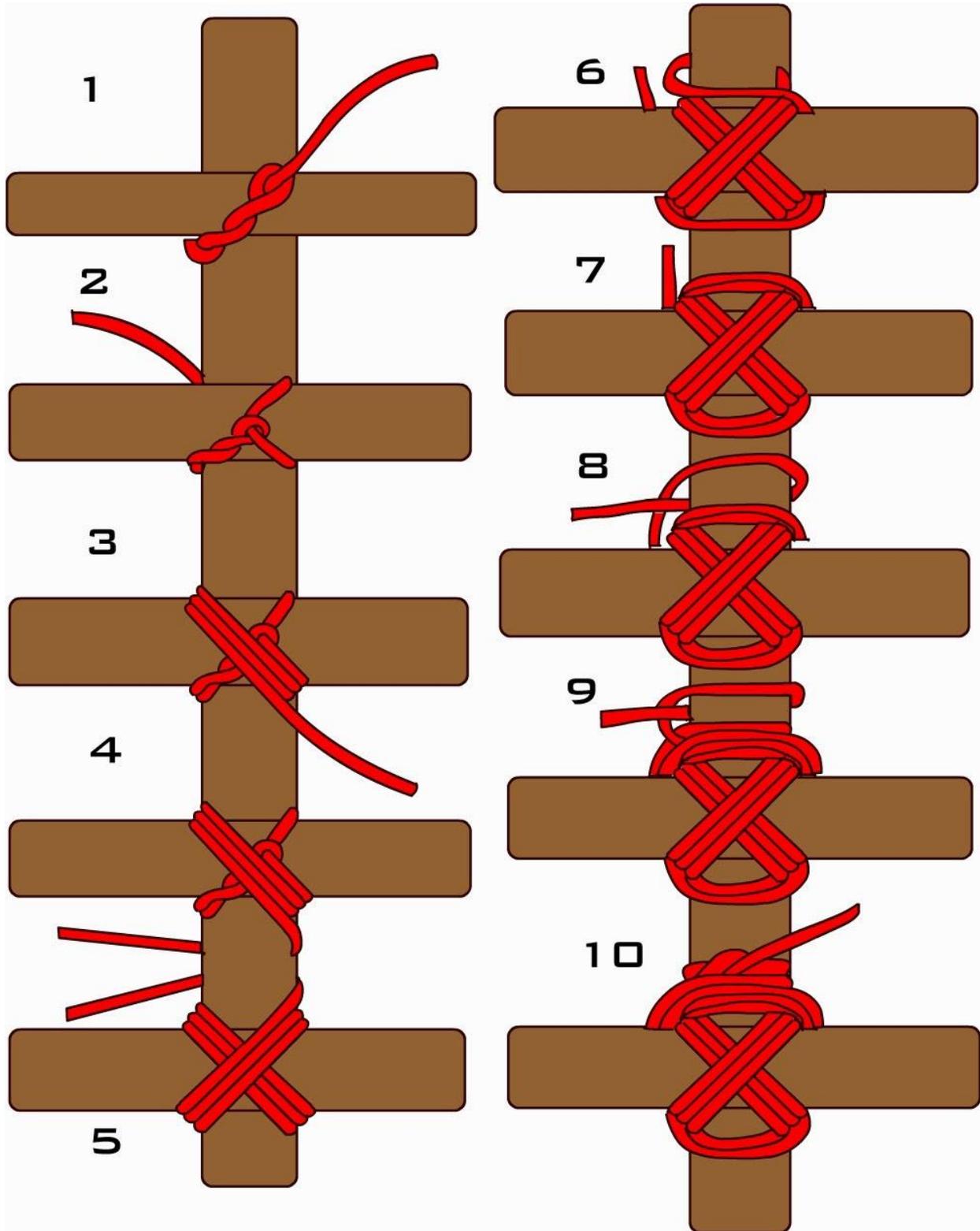
<https://www.101knots.com/half-hitch.html>

Square Lashing-



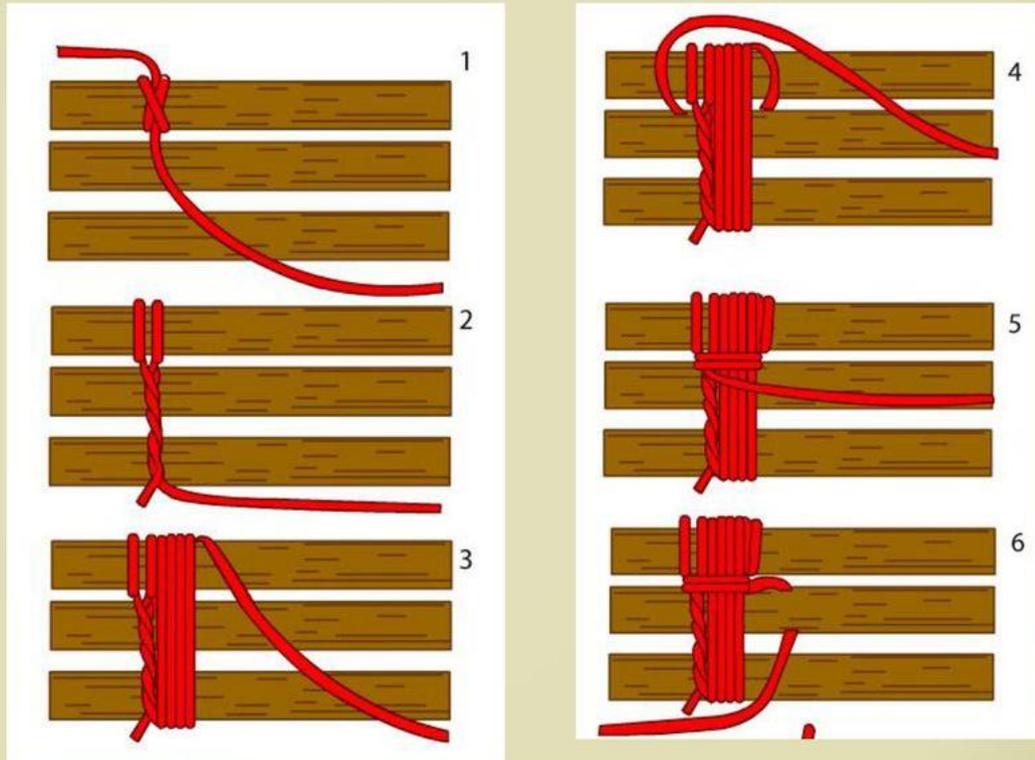
<https://www.animatedknots.com/square-lashing-knot>

Diagonal Lashing-

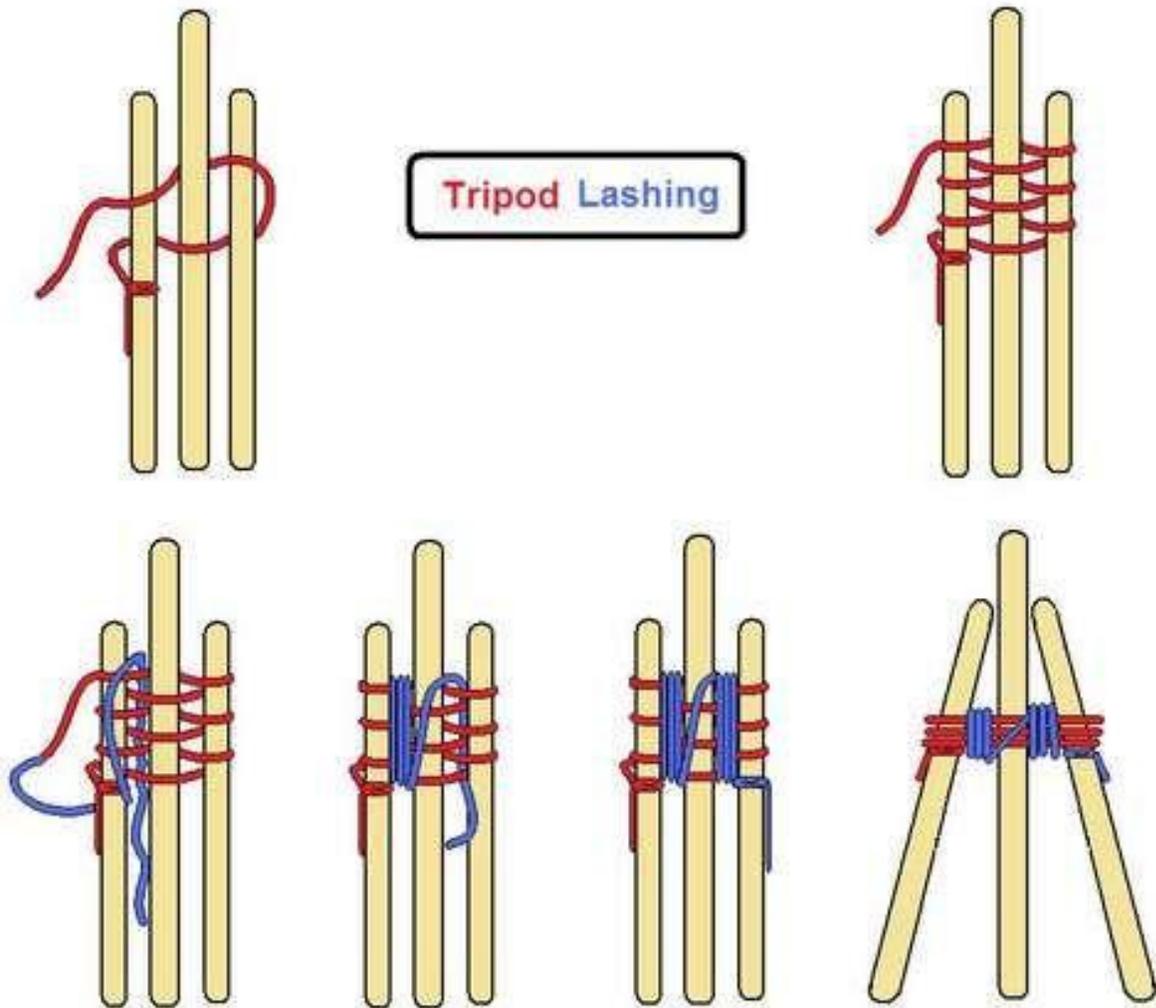


<https://www.animatedknots.com/diagonal-lashing-knot>

# Tripod Lashing



Tripod alternating:



<https://www.animatedknots.com/tripod-lashing-knot>

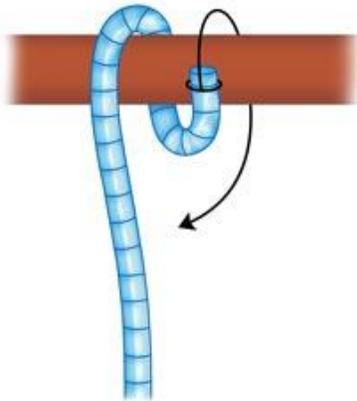
## Round Lashing



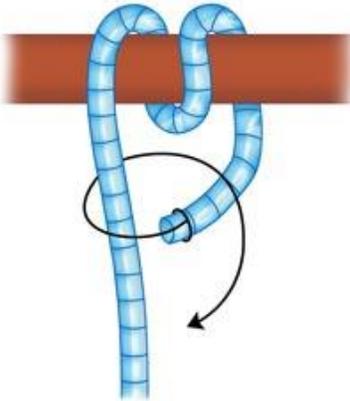
<https://www.animatedknots.com/round-lashing-knot>

# Round Turn and Two Half Hitches

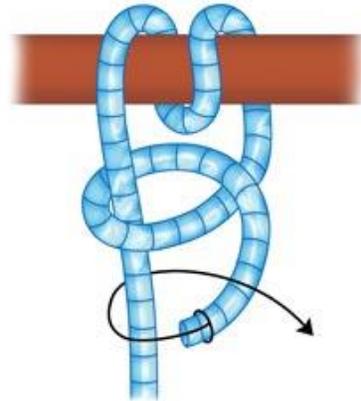
## Tying Instructions



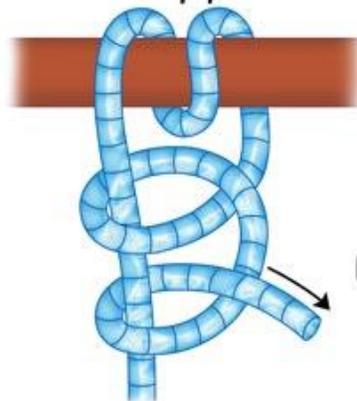
1 Wrap the end around the support



2 Wrap it around the standing part of the rope

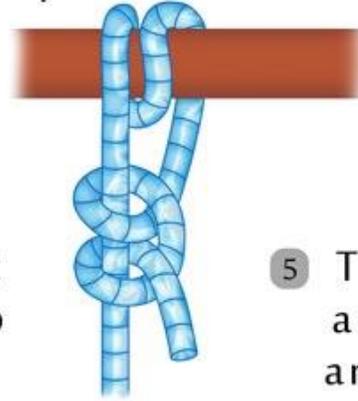


3 Make another turn



4 Take it out of the loop

101KNOTS



5 Tighten and you are done

<https://www.101knots.com/round-turn-and-two-half-hitches.html>

Trebuchet design:

<https://www.comsol.com/blogs/what-is-the-physics-behind-a-counterweight-trebuchet/>

Simulation:

<http://www.virtualtrebuchet.com/#simulator>

Loaded with our basic design:

[http://virtualtrebuchet.com/#simulator %24id=003&LengthArmShort=3&LengthArmLong=12&LengthSling=.01&LengthWeight=1.5&HeightOfPivot=5&MassWeight=.5&MassProjectile=0.0101&MassArm=.01875&ReleaseAngle=30&uniformArm=true&ProjectileDiameter=1.680&InertiaArm=0.35&PivotToArmCG=4.50&InertiaWeight=1&CalculateDrag=true&WindSpeed=0&projectile=custom&customProjectile=true&units=englishi&advancedMode=true&playSpeed=1&customPlaySpeed=0.15&length=in&mass=lb&angle=deg&velocity=in%2Fs&inertia=lb%C2%B7in%C2%B2&time=s&distance=2.2922163444567487&=](http://virtualtrebuchet.com/#simulator%24id=003&LengthArmShort=3&LengthArmLong=12&LengthSling=.01&LengthWeight=1.5&HeightOfPivot=5&MassWeight=.5&MassProjectile=0.0101&MassArm=.01875&ReleaseAngle=30&uniformArm=true&ProjectileDiameter=1.680&InertiaArm=0.35&PivotToArmCG=4.50&InertiaWeight=1&CalculateDrag=true&WindSpeed=0&projectile=custom&customProjectile=true&units=englishi&advancedMode=true&playSpeed=1&customPlaySpeed=0.15&length=in&mass=lb&angle=deg&velocity=in%2Fs&inertia=lb%C2%B7in%C2%B2&time=s&distance=2.2922163444567487&=)

Data

| <b>Part</b>  | <b>Weight</b>                 |
|--|-------------------------------|
| Ping Pong ball                                       | 0.006 pounds                  |
| 3/8 inch dowel                                       | 0.0024 pounds per linear inch |
| 1/4 inch dowel                                       | 0.0010 pounds per linear inch |
| 1-inch nuts  | 0.27 pounds each              |
| Basket Arm rotational weight (without counterweight) | 0.056 pounds                  |