

# Nets and Knots

*Today we'll look at the science and technology behind the basketball net and the types of knots that make it possible. The science of knots is called topology. As we learn about topology, we'll learn to tie a knot or two and if you're really ambitious, you can even take what you have learned and make a basketball net to replace the missing one on the playground.*

## HERE'S WHAT YOU'LL NEED:

- **Two pieces of rope, chord, or string (if you have braided rope in two colors it will be easier to see how the knots are made)**

## OPTIONAL SUPPLIES FOR OVERTIME: LET'S TAKE IT FURTHER

- **20 feet of rope**
- **A marker**
- **3 square pieces of cardboard: 3 in., 4 in., and 8 in.**

***This activity can be done individually or with a partner, as well as in a classroom or at home.***

## WARM-UPS

Have you ever noticed that there are a few common threads to the most exciting basketball games? When it comes down to the wire, tension builds, the score is all tied up. You sit spell-bound as the Thunder weaves through the traffic to the paint, shoots, and scores; swish after swish! The final buzzer leaves you wanting more. You can hardly wait for the next game!

Now, take a breather from all the excitement and think about some of the small things in the game that made a big difference—the one fast break that shifted the momentum, or the free throw that put the Thunder into the lead.

One thing you might not have thought about—the net! You may think it is one of the least important parts of the game, but take it away and everyone notices. If you have ever shot some hoops at an old playground with a worn out or missing net, then you notice just how annoying it is when the net is gone.

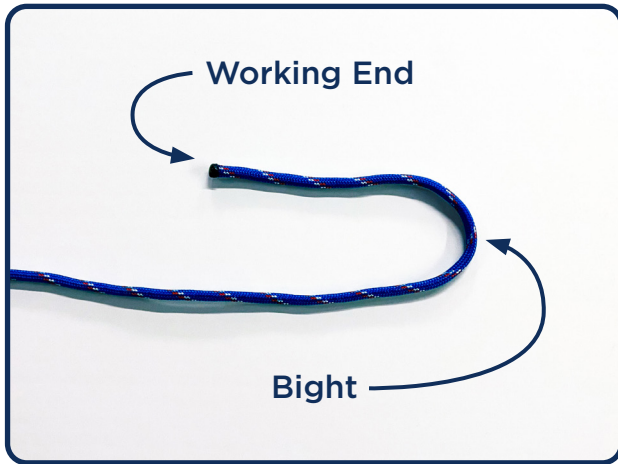
Standard basketball nets are made from about 20 feet of thin braided rope. Each net contains two types of rope. The top part attached next to the hoop is a stronger stiffer polyester rope while the lower portion of the net is made of softer, more flexible polypropylene rope. This combination makes the net more durable and gives the right combination of stiffness and floppiness to make just the right swish sound.

Knots can be hard to learn. With knots, just like basketball, when you are learning difficult new things, it is important to take it slow and practice.



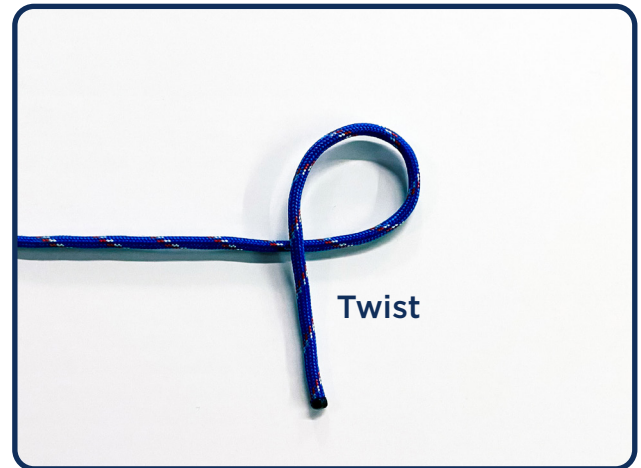
**SCIENCE  
MUSEUM**  
OKLAHOMA

To begin the study of knots and how to tie them, let's get to know four of the words we use when making knots.

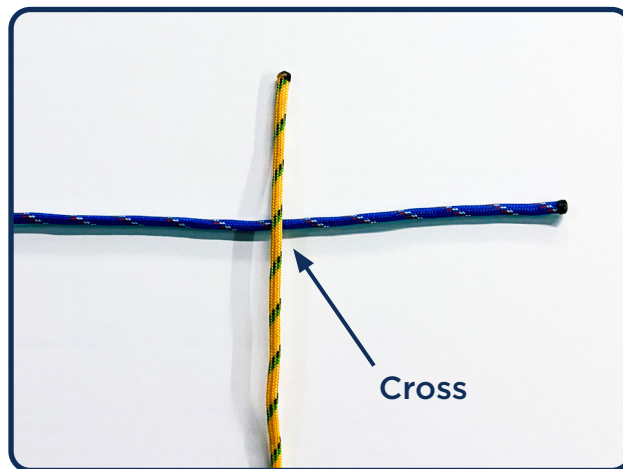


**Working end**—the short end of the rope that you are tying a knot into.

**Bight**—a U shape formed from rope.



**Twist**—a Q shape formed from the rope. Make a bight, then cross the working end over or under the rope.



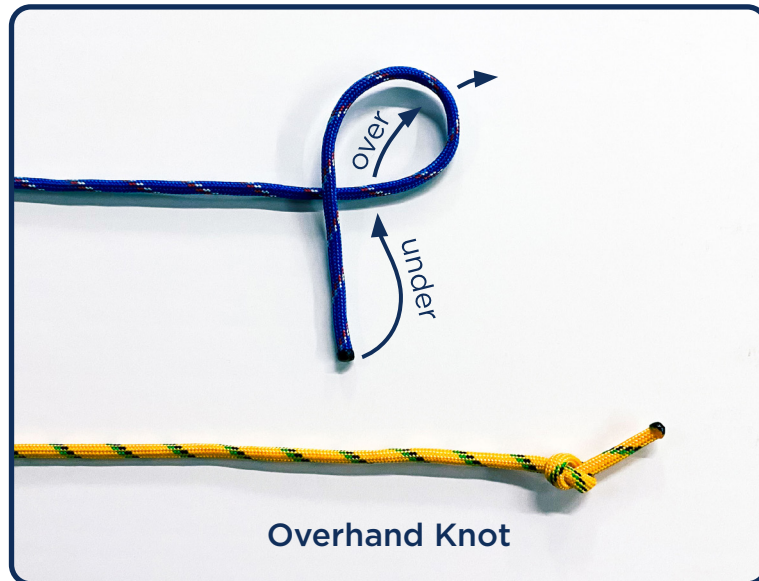
**Cross**—when a rope passes over another layer of rope.

Now try a little brain experiment—see if it is easier to tie a knot by reading instructions or by looking at a picture. First, get out your piece of rope and read the following instructions while you try to tie an overhand knot:

***Take the working end of your rope and fold it back on itself to form a bight. Then cross the working end over the rope to form a twist. Pass the working end under the twist and through the bight of the twist then pull it tight.***

Did you make a knot, or when you pulled tight, was there nothing on the rope?

Now untie your knot and try again, this time looking at the picture.

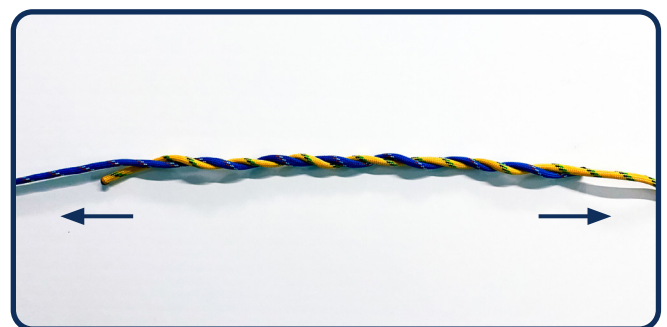
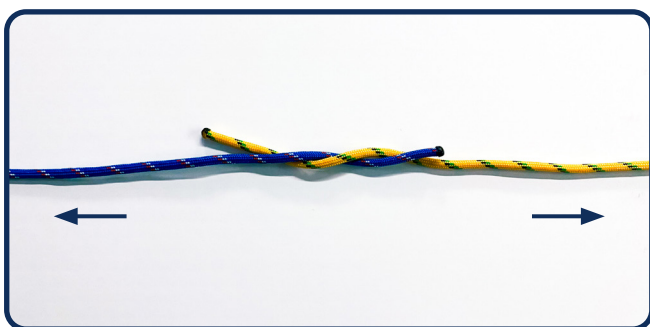


Did you make a knot? Was it easier or harder than following written instructions?

Take your knot and pull on one end of the rope and then the other. Slide your hand up and down the rope to see if the knot moves, and pick at it to see if it is easy to untie. Good knots are easy to tie and untie, but also strong and don't slip or come untied on their own. When you pull the working end tight on a good knot, the twists and bights in the rope are pulled and squeezed tightly together. The tighter the rope is pulled, the more friction in the rope.

In order to examine knots, you have to think about friction. Friction is the force that resists motion. In the case of knots, it is the force that keeps the rope from slipping along itself. Good rope is flexible and not very lumpy so it doesn't have much friction when you pull it along. There are two things that you can do to increase the friction. The first is to have more of the rope in contact. Try this, wind one end of a rope around another a few times and try to pull them apart. Then, increase the number of times they are wound together and try to pull them apart again.

It is easy to pull them apart with only a few wraps, but by the time you have one rope wound around the other 10 or 20 times you notice an increase in the friction that must be overcome to pull them apart.



In a good knot, bights and twists are in just the right spot so that pulling on the end of the rope helps squeeze parts of the rope tightly together. That means that the harder you pull, the harder you squeeze the rope together, and the more friction you have, and the less likely the knot is to slip or come untied.



## GAME TIME

Now that you can make a simple knot, it is time to learn how to make three different types of knots.

Here are instructions for how to tie two ropes together with a knot that slips. This time you can use both the written instructions and the pictures to help you with learning how to tie the knot.

1. Take two ropes. Make a bight in the working end of one.
2. Cross the working end of the other rope under and through the bight. Then form the second rope into a bight of its own that passes under both ends of the first rope.
3. Bring the working end of the second rope up and cross the working end of the first rope and pass the second rope back through the bight on the first rope. This type of bend is also called a reef knot or a square knot.



This type of knot is called a reef knot or a square knot. When you pull on the ends of the rope to tighten the knot, notice that the rope slips a bit until the knot pulls together, tightens up, and stops slipping.

Now loosen the knot a little bit and take it apart half way by uncrossing the working ends once. Put it back together by crossing them differently. For example, if the left rope crossed *over* the right one before, then cross it *under* this time.

This type of knot is called a granny knot and it will slip when you pull it tight. A close examination will show that as you pull, each rope is touching at smaller points than the square knot and not really squeezing the other ropes together that much.



There are lots of ways to tie two ropes together. Try to make your own knot by putting together a bight and a twist, or two twists, or two bights and a twist. Pull on them and watch to see if they are pulling ropes together more tightly or not. Who knows, you may invent a knot that has not been seen before!

There is only one type of knot that is used to tie a basketball net together. It is called the sheet's bend or weaver's knot. It is much stronger than the granny knot and the square knot. It is a good knot to know and it is made of only one bend and one twist.



Look at the picture and read the instructions while you tie it:

1. Form one rope into a bight.
2. Take the second rope and bring it up through the underside of the bight in the first rope, then wrap it around both ropes of the bight.
3. Finally, cross it under itself and over the bight to form a twist then pull tight.

When you pull this knot tight, look at how the twist pulls the two ends of the bight together and also pulls against itself. It is a very, very strong knot. Also notice, if you pull on the working ends of the knot, it is not as strong. In fact, that is a good way to loosen the knot before you untie it.



**ANALYZE  
THE REPLAY**  
What  
happened?

When coaches have a new play to teach players they may talk it out, show diagrams on a board, watch videos, or run through it several times during each practice until everything comes together perfectly. You may have taken the same approach when you were learning to tie a new knot. What challenges did you face when learning how to tie these different knots? Did you find it was easier to read the instructions, look at the pictures, or a combination of both? Maybe you caught on quickest by watching your teacher or a classmate tie the knot right in front of you! These are all examples of different learning styles. Identifying the ways it's easiest for you to learn a new skill can be really helpful throughout your life!



**OVERTIME**  
Let's take it  
further.

To make a basketball net, you will need about an hour, 20 feet of rope, a marker, and cardboard squares (see the materials list at the beginning of the activity). This project is a little harder and you may have to try more than once, but it is worth the effort!

1. First, take the rope and wrap it 12 times around the 6 inch piece of cardboard. Use the marker to draw a line across the loops of rope all along one edge of the cardboard. This gives you evenly placed marks along the rope to tie knots.
2. Take the rope off the cardboard and make a giant circle by tying the end of the rope to the 12th marker spot.
3. At each mark on the rope in the circle, tie a sheet's bend knot. There should be about 6 inches of rope between each knot to give the "loop" in the net (see image below). You can use the different sizes of cardboard to help make these loops, starting with the 8 inch square.
4. After you have tied 12 knots, tie a new row of sheet's bend knots to make a new circle. This new row of knots should be evenly spaced between the row of knots above it (see image below). If you feel your net is getting a little uneven, you can hang it up by the loops and ones that need a little more rope will hang a big higher. This is where you'll add a little more rope to the next lap to even it out.

After you have tied 84 knots, you should have gone around the circle 7 times. You will have only one more knot to tie. This time take the end of the rope and tie an overhand knot around the same point as the previous sheet's bend. Trim and, with an adult, melt the end of the rope to keep it from fraying. Your net should be all ready to go!



**Pro tip:** If you want your net to be multicolor, you can stop and tie in a different color of rope at any point during your net making. You just want to tie them together with the same sheet's bend, trim the ends closely, and melt them so they will not fray.



Basketball has come a long way since James Naismith fastened a peach basket to a pole. That basket gave basketball its name, but it wasn't very convenient. After every goal, somebody had to climb the pole to get the ball out of the basket.

Why do we use a net? The overlooked net's function is important to the game, and the net's design allows it to function well and for a long time. The net's main function is to slow the ball slightly as it passes through.

This makes it easier for the referees to notice that a goal has been made. It keeps the game moving because the ball falls right below the net, so players don't have to chase the ball all over the court after every goal. The net also makes the hoop easier to see, and of course provides us with the swish, the best sound in the game!

Nets are carefully designed and constructed to do this job well, but without doing any of the annoying things like tangling that string and rope are apt to do. The net can't be too tight or the ball may get hung up and not fall out. It can't be too loose or it won't slow the ball enough. The rope can't be too stiff or too floppy or it may whip around and tangle.

## OKLAHOMA ACADEMIC STANDARDS

Subject Areas and Skills/Content	4th Grade	6th Grade
<p><b>Science—Disciplinary Core Ideas</b></p> <p>ETS1: Engineering Design</p> <ul style="list-style-type: none"> <li>Possible solutions to a problem are limited by available materials and resources.</li> </ul>	●	
<p><b>Science—Disciplinary Core Ideas</b></p> <p>ETS1: Engineering Design</p> <ul style="list-style-type: none"> <li>The more precisely a design task's criteria and constraints can be defined, the more likely it is that the design solution will be successful.</li> </ul>		●
<p><b>Science—Disciplinary Core Ideas</b></p> <p>ETS1: Engineering Design</p> <ul style="list-style-type: none"> <li>The success of a designed solution is determined by considering the desired features of a solution.</li> </ul>	●	
<p><b>Science—Disciplinary Core Ideas</b></p> <p>ETS1: Engineering Design</p> <ul style="list-style-type: none"> <li>Specification of constraints includes consideration of scientific principles and other relevant knowledge that is likely to limit possible solutions.</li> </ul>		●