Chapter 3. Making Shapes

"What's that mean, 'Making Shapes?" asked Morf.

"It means that it's time to take all that you learned about moving Ernestine around the screen and put it to good use!" responded Logy. "We're going to start with simple shapes to make sure everyone knows what they are. Then we'll move on to some fancier stuff."

"Whadda you mean, 'fancier stuff?"

"There's a lot more to shapes than just lines. What makes one shape different from another? What's different? What's the same? What can you learn from that? What are the rules that make one shape different from another?

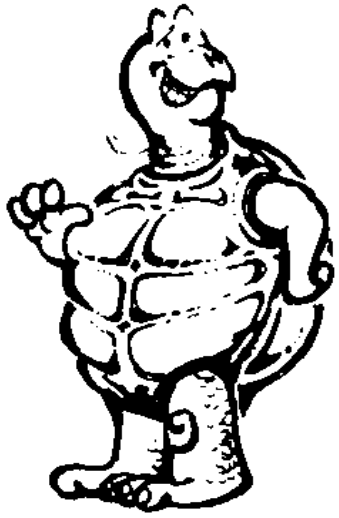
"The study of shapes is part of geometry, right? And that opens all sorts of possibilities!"

"Ok, Ok, Ok! How do we get started?"

Exploring Shapes

Let's play turtle.
That's what I do best.

You can use your Pencil Turtle, you can use yourself, or you can use some of your friends. In fact, why not try all three?



Rabbit Trail 6. Body Geometry

Can you use your fingers to make a shape that looks like a square? It's not too easy, is it.

So try this one.

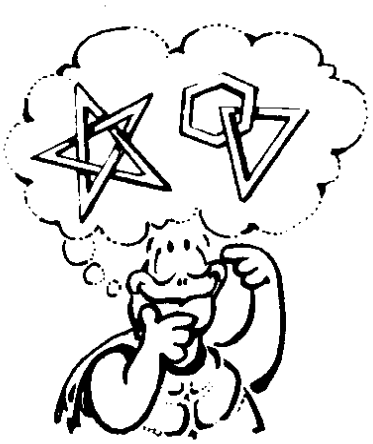
Get with a friend. Hold your arms out. Can you make a better square now?

Get a bunch of friends together and make a big circle. Now make a very small circle. In fact, why not have the group make all sorts of shapes?

What do you have to do to make a triangle? Can you make a triangle by yourself?

Or do you need some friends to help you out?

Playing turtle gives you an idea of just what it takes to make different shapes.



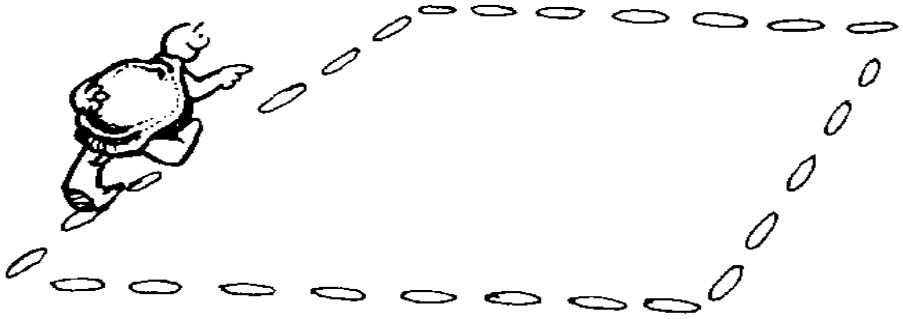
Exploring Squares

Let's start with an easy shape, like a square.

Do you know what makes a square different from, say, a triangle? Or a rectangle? Well, for one thing, all the sides of a square are the same size.

Tell the turtle to go HOME — not on the computer — you're still doing Body Geometry, remember? Pretend that HOME is in the middle of the room or the middle of your paper.

Now, what commands must you give the turtle to walk through a square?



1. FORWARD _____ TURTLE STEPS

Are you going to make a BIG square or a little square?

2. RIGHT _____ TURTLE TURNS

You can turn left if you want. But how many turns do you have to make for the corner of a square? 30? 67? 105? 298?

We've already done this. It was when we were talking about turtle turns. If you forgot, why not turn back to Chapter 1 and find it again?

3. FORWARD _____ TURTLE STEPS

Fill in the blank with the same number of steps that you did in step 1.

4. RIGHT _____ TURTLE TURNS

How many turns should you make here? Should this be the same number of turns as you made in step 2?

5. FORWARD _____ TURTLE STEPS

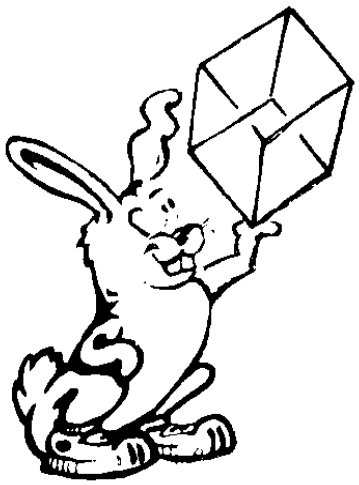
You should already know how many steps to go this time.

6. RIGHT _____ TURTLE TURNS

How many turtle turns this time?

7. FORWARD _____TURTLE STEPS

8. RIGHT _____ TURTLE TURNS



What did you discover about a square?

Sure, the four sides have to be the same. But what about the corners? Do they have to be the same? Why?

That's simple!

If they're not the same, you'll end up going off in some strange direction and your shape will have too many sides.

Let's try this on the computer.

Get Logo up and running. Then type these commands.

FD _____ RT _____ FD _____ RT _____

FD _____ RT _____ FD _____ RT _____

Wow! All the sides and all the corners have to be the same. But that's a lot of typing when you do that four times. There has to be an easier way!

Repeating Commands

Look at all those commands. Do you see what you did? You repeated the commands FD _____ and RT _____ four times. So let's try a new command.

Here's what it looks like in Logo.

REPEAT 4 [FD 100 RT 90]

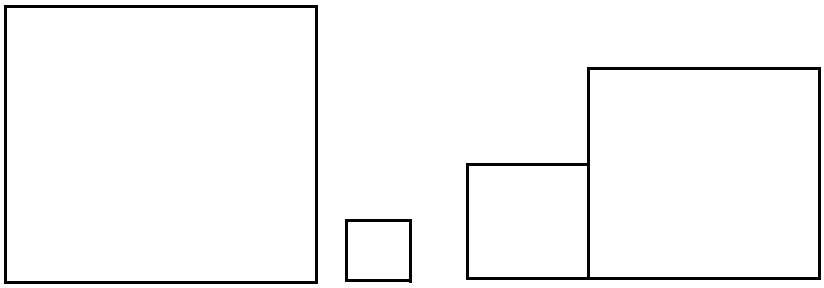
This tells the turtle to REPEAT the commands that are inside the brackets four times. Brackets look like square parentheses — []. They hold lists of numbers, words, and things. You'll use brackets and lists a lot.

First, let's try some other squares. You fill in the steps. The number of turns has to be 90, right?

REPEAT 4 [FD _____ RT 90]

Make a great big square!

REPEAT 4 [FD _____ RT 90]



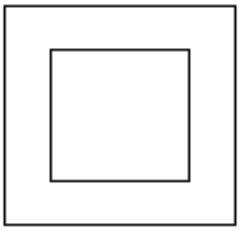
Make a little bitty square!

Morf tried the number 7 but decided that was a bit too itty-bitty. What are you going to use?

How about joining some squares together? Maybe you can think up a nice pattern using squares.

Terrific! Now for a tough one. Put a square inside a square?

That means you have to draw a big square, pick the pen up, move inside the big square, and draw a little square.



Whoops, one of the steps has been left out. Think about it. Which one is it?

Let's see. Draw a big square. Pick the pen up. Move inside the big square and draw a little square. You can't draw another square until you put the pen back down, right?

OK, no more tricks. Put the pen down and then draw a little square.

Don’t forget!

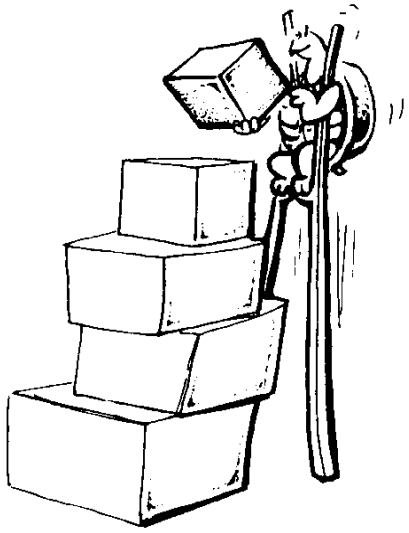
When you start exploring squares and things, it’s good to write all your great ideas on paper or in your journal. Then you can use the same ideas again later.

More Adventures with Squares

There are lots of things you can do with squares.

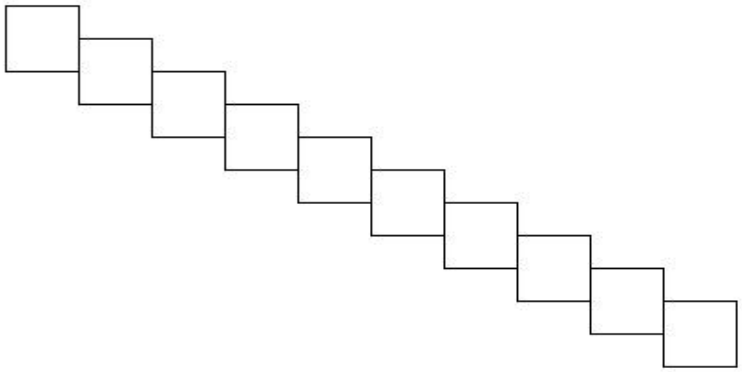
Draw a little square first and then draw a big square around the outside. Draw a big square and then put a little square in the corner.

Draw a big square and then stack some other squares on top of it, like stacking up boxes.



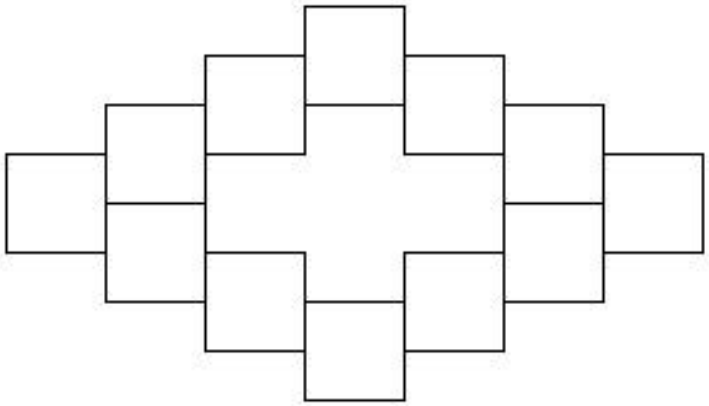
What else can you do with squares?

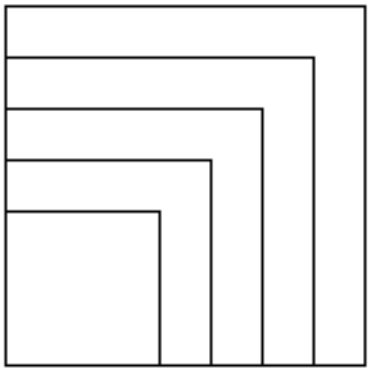
Take a look at the pictures below and on the next page. Can you make them on the computer?

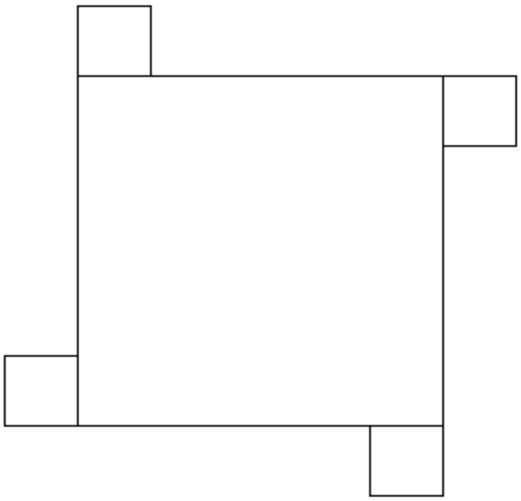


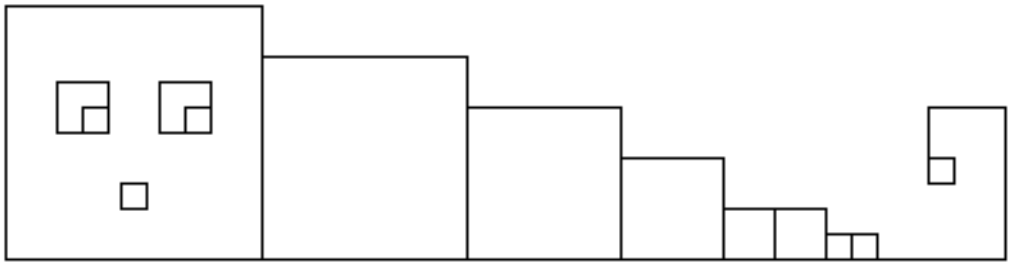
How about some stairs?

What's the same about these pictures? What's different? What other things can you make?

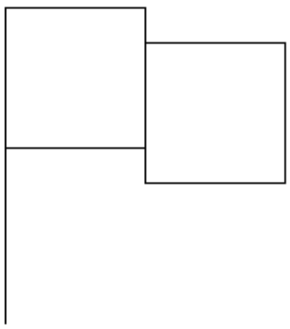


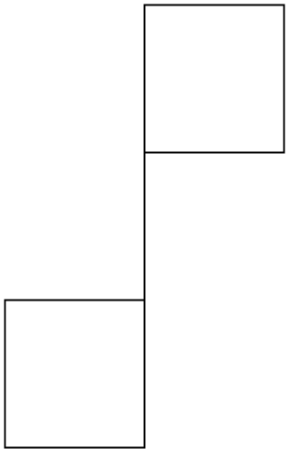


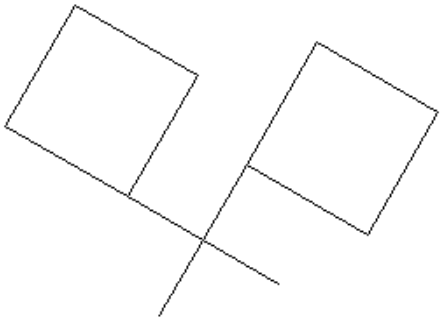


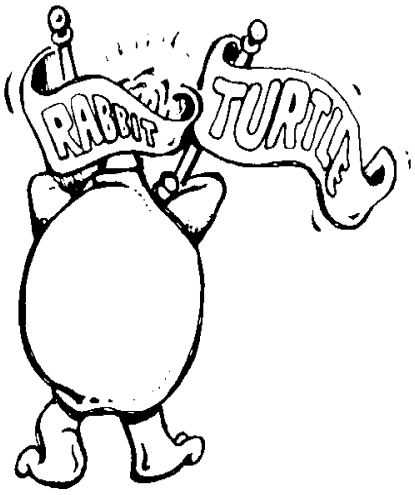


How about flags?

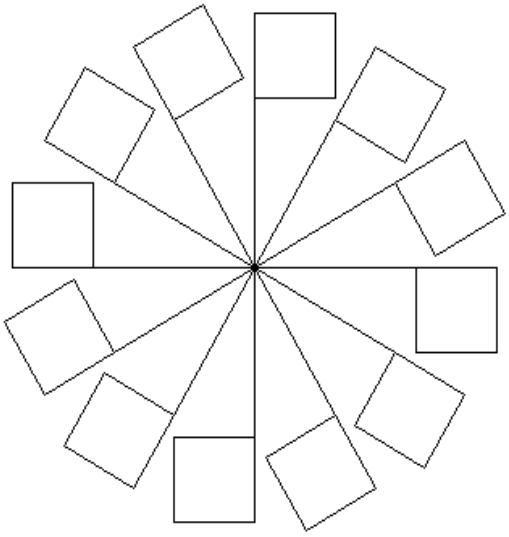


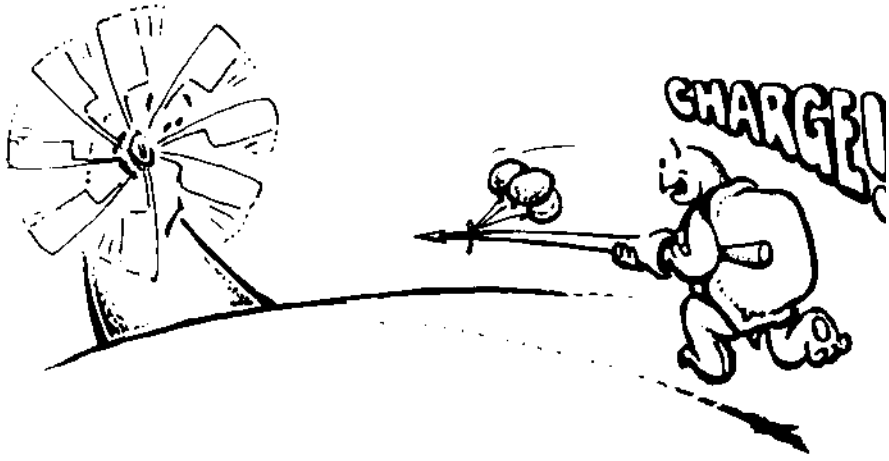






A windmill?

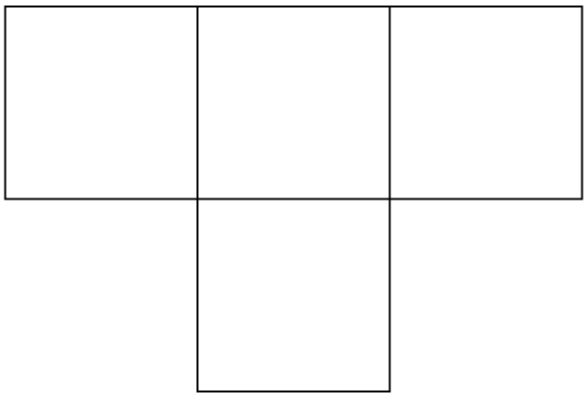




Don’t forget to write down your ideas. You may just want to use some of these ideas later on.

Rabbit Trail 7. Logo Puzzles

Here's a puzzle for you. Look at this picture.



It looks like four squares hooked together, doesn't it.

Get some straws or some sticks and make this puzzle on a table top. Now, take away just one straw or stick so that there are only three squares left.

Can you do that?

You can also try solving the puzzle by drawing it on paper or on the computer. Later, after you learn about writing procedures, we'll show you how to have the turtle solve the puzzle for you.

If you like puzzles, take a look at the puzzle projects on the CD that came with this book. You'll find them in the Projects directory.

Exploring Triangles

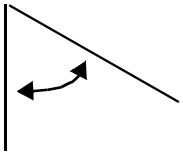
Now, are you ready to tackle a triangle? What makes a triangle different from a square?

That's right, a triangle has three sides and three corners. A square has four of each — four equal sides and four equal corners or angles.

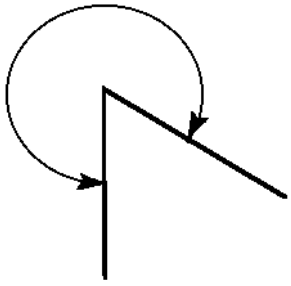
Adventures With Angles

There's a new word for you. Angles! Is that something like a corner?

Draw a line. Make a turtle turn of any size and draw another line.



Just like magic, there's an angle between the lines, right? But what about on the outside? Is that an angle, too?

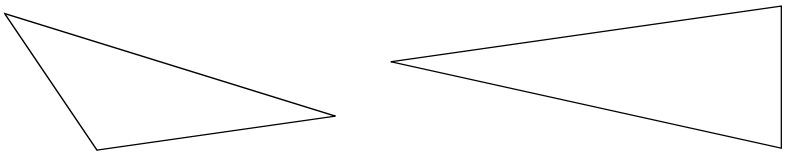


Sure it is. It's just a big angle.

Wow! That's a lot of turtle turns!

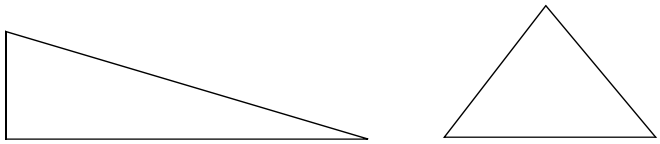
Morf still likes to call them turtle turns. While Morf measures angles in turtle turns, most people measure angles in "degrees." More about degrees later.

Now, what about a triangle? Do all the sides and corners have to be the same or can they be different?



If you said the sides and the corners can be different, give yourself a big Gold Star!

But there's a funny thing about triangles. If all the sides *are* the same, can the angles be different?



Give yourself another Gold Star if you said, No!

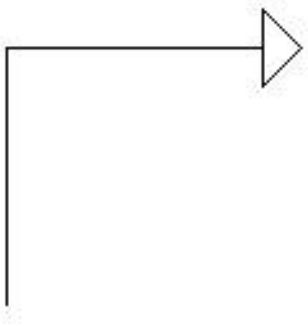
But how do you know? If all the sides are the same, why do the angles have to be the same? Let's explore some triangles and see if we can figure this out.

Get Logo up and running. Let's start where we left off with the squares.

```
FD 100

RT 90

FD 100
```

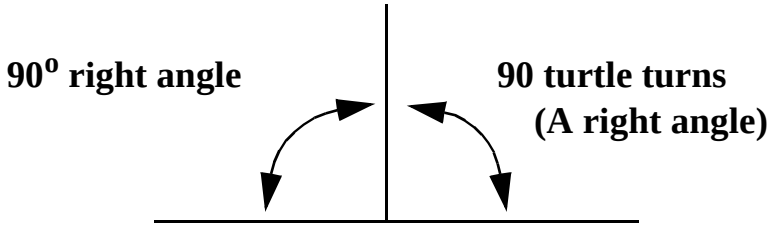


Adventures With Right Angles

OK! Now you have two sides and one angle on the screen. That angle has a special name. It's called a **Right Angle**.

"I know," Morf chimed in. "That's because the turtle goes to the right!"

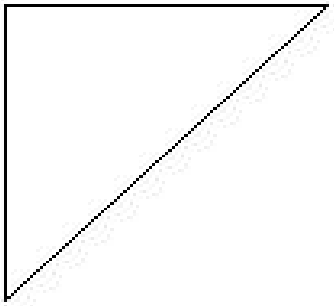
"No, I'm afraid not, Morf. They call it a right angle because it has 90 degrees. You can also make a right angle by turning left. I know that sounds crazy. Just trust me."



"When you talk about degrees, you use that little ° symbol. A triangle has three sides and three angles. So, let's make the corner you just made into a triangle.

The easy way is to just type HOME.

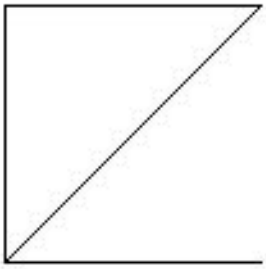
There's a triangle: three sides and three angles.



We know for a fact that two of the sides are equal. You typed FD 100 two times, right?

Look at the angle down near HOME. Compare that with the one in the upper right corner. Do they look to be the same? Are they the same as the corner you made when you went RT 90? Let's see.

With the turtle at HOME, type

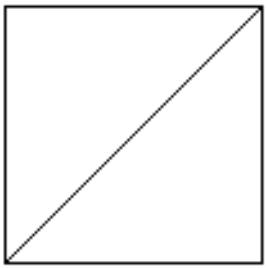


RT 90 FD 100

Hey! That looks like three sides of a square. What commands do you need to finish the square? RIGHT 90 sends you in the wrong direction. So why not try

LT 90 FD 100

Now you should be at the upper right corner of a square that is also two triangles, correct? OK, now type HOME.



Look at the angles at HOME. Compare them with the angles in the upper right corner of the square. Do all four of the angles look the same?

You're right. They do look the same. Let's check this out.

Check It Out

Type CS to clear the screen and take the turtle HOME. Then type

REPEAT 4 [FD 100 RT 90] to draw a square.

Now turn RIGHT 45 and go FD 200. What happened? The turtle drew a line right through the upper right corner. Now type HOME and then type

REPEAT 2 [FD 100 RT 90]

This takes you to the upper right corner of the square with the turtle facing the bottom of the screen.

Turn RIGHT 45 and go FD 200 again, just as you did before. What happened?

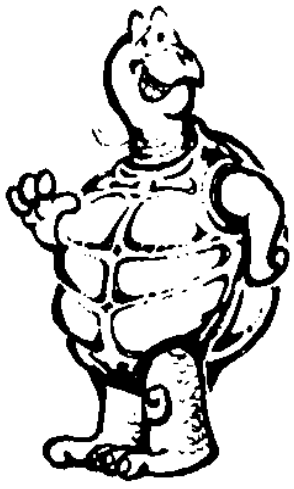
The same thing, right? Only this time the turtle drew a line through the lower left corner.

Do you think we can make a rule from all this?

A Rule for Triangles

It looks like it. It seems that when a triangle has two equal sides, you're going to have two equal corners or angles.

In the example above, you turned RT 45 twice, correct?

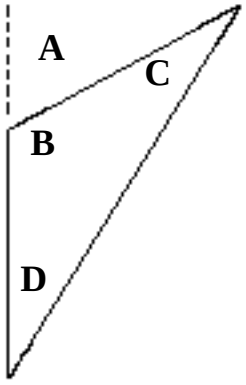


Just to make sure, let's try another triangle. Clear the screen. Then try this

FD 100 RT _____ FD 100 HOME

Add any number you want. Do you see two equal sides and two equal angles on the screen? Try it a few more times, just to be sure. Use lots of different numbers for the turtle turns.

This idea seems to work, doesn't it. Do you notice anything else about your triangles?



First you went FD 100. Then you turned right and went FD 100 again. When you turn, you create the angles A and B as shown in the drawing above. Then, after going FD 100 the second time, you went home, creating the C and D angles.

Now let's try something else. Clear the screen and type

FD 100 RT 60 FD 100 HOME

Now you know that angle A is 60 degrees and angle B is 120 degrees, right? Why?

Now type

RT 60 / 2 FD 200

That’s RT 60 divided by 2, then FD 200.

WOW! The angles C and D are half the size of angle A. Why? Type

FD 100 RT _____ FD 100 (Fill in a number.)

Now type RT 180 - _____ Fill in the number of turns you just made when you turned right. What happened? Is the turtle facing the bottom of the screen?

Hmmmmm! This is getting interesting. Now type

RT _____ / 2 FD 200

Fill in the number of turns you made above and divide it by two and then go FD 200. What happened?

DOUBLE WOW! You’re discovering all sorts of things about triangles!

Take another look at the triangle drawing on the last page, the one with angles A, B, C, and D. What do you know now?

Angles A + B = 180
Angles C + D = Angle A
Angle C = Angle D

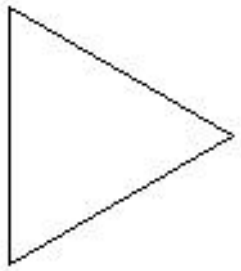
If all this is true, then

Angles B + C + D = 180

So, the sum of all the angles in a triangle equals 180. But before we look at more rules, try this one

FD 100 RT 120 FD 100 HOME

Do you see anything different about this triangle? Let's check this out. Type



RT 60 FD 100

What happened? Where's the turtle? All three sides are equal now, aren't they? And if the sides are equal, what about the angles?

Well, that's easy to check, too! All you have to do is use the REPEAT command to draw three sides and three corners.

REPEAT 3 [FD 100 RT 120]

Wow! It works! And just to be completely certain, let's go back to the triangle with two equal sides. Clear the screen and type

FD 100 RT 90 FD 100 HOME

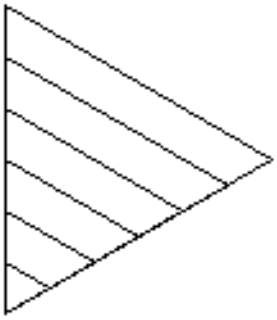
Now let's check that last line. Turn RIGHT 45 and go FORWARD 100. Did this take you back to the other corner?

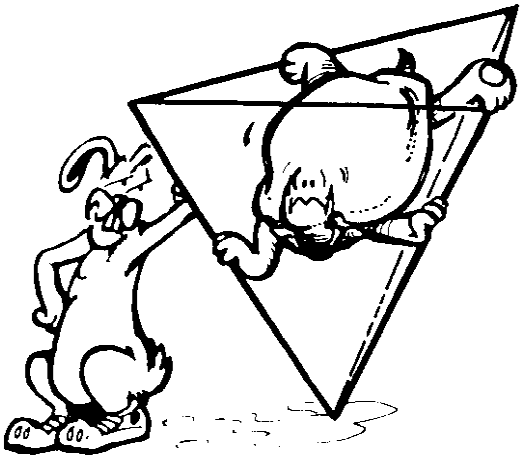
More Rules for Triangles

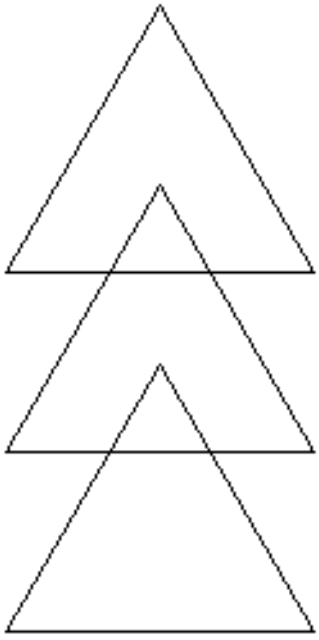
No, not quite. However, it looks like you proved something about triangles.

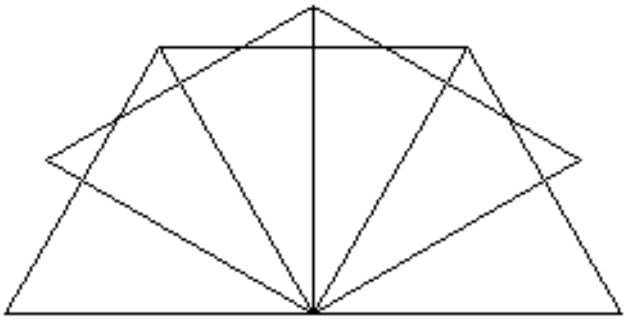
1. If you have three equal sides, you'll have three equal angles.
2. If you have two equal sides, you'll have two equal angles.
3. If you have no equal sides, none of the angles will be equal.
4. The sum of the three angles in a triangle equals 180 degrees.

Looks like Logy got into a bit of trouble exploring triangles. How about you?

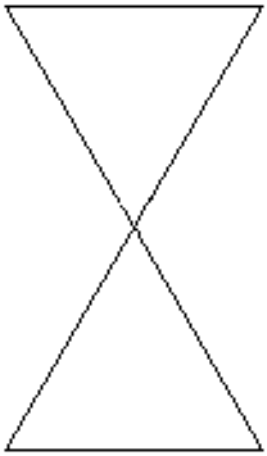


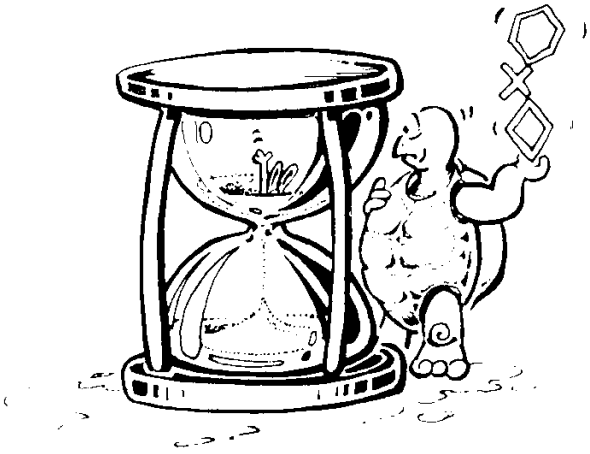




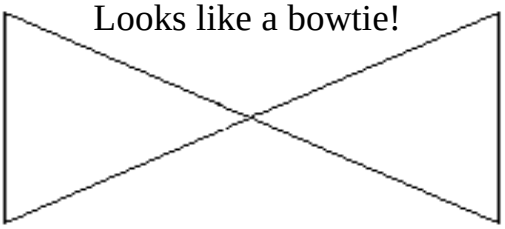


Can you make an hourglass?

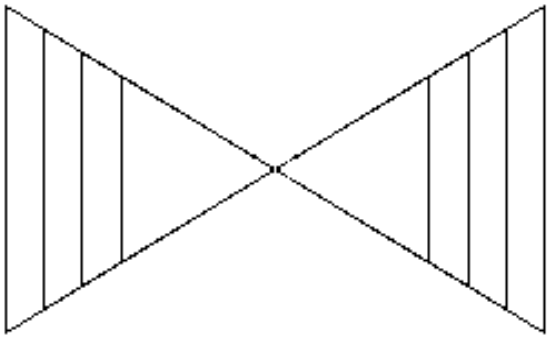




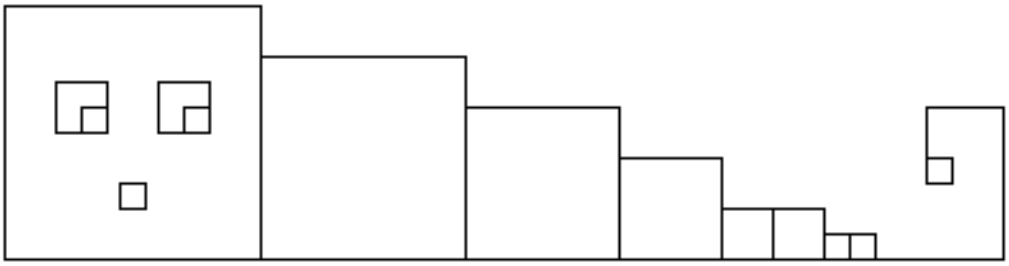
Looks like a bowtie!



A fancy bowtie!

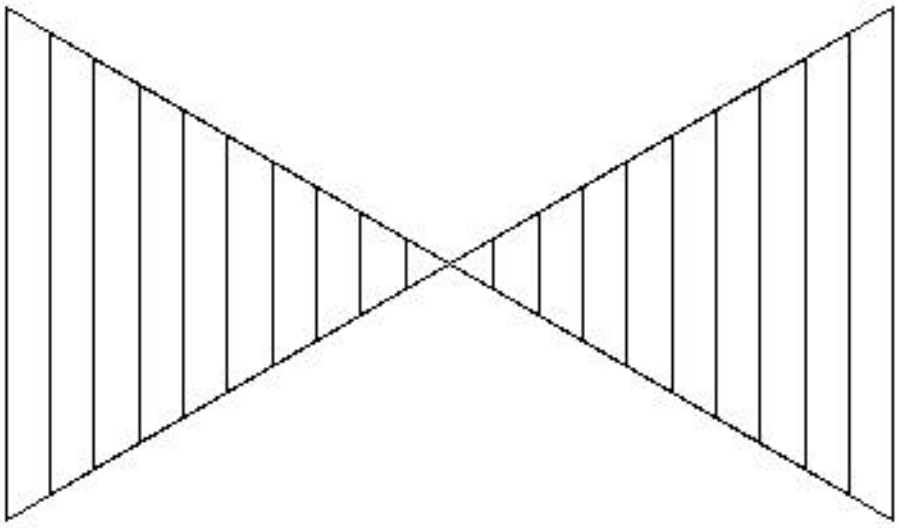


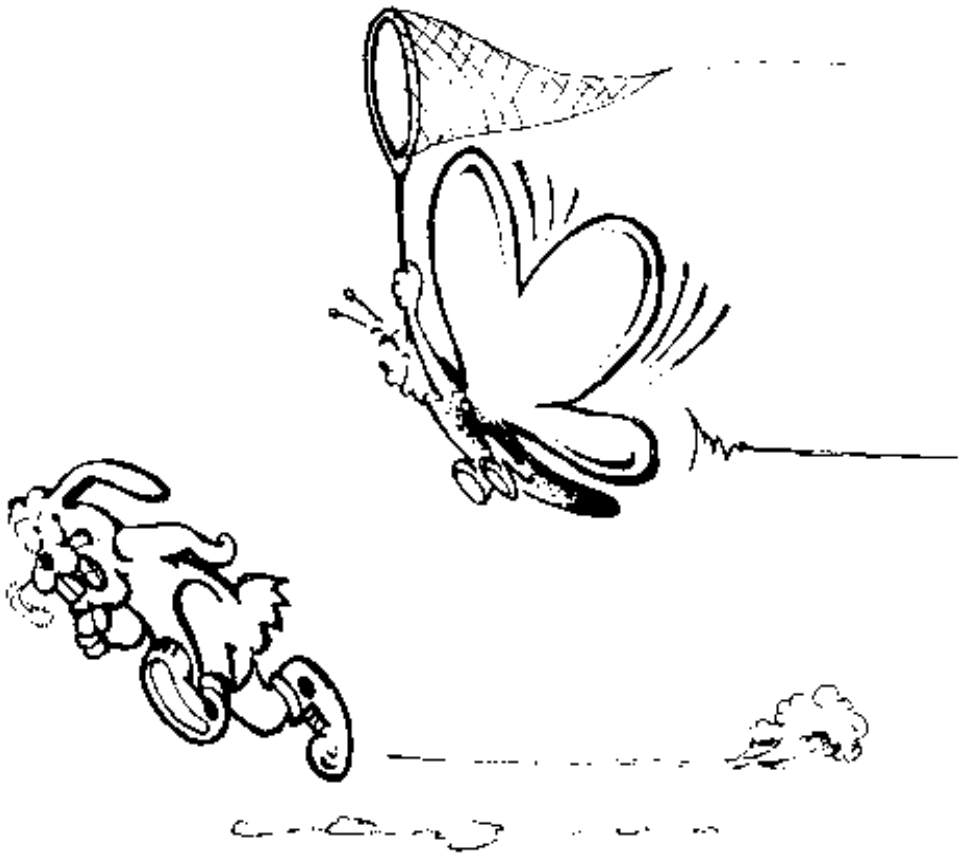
Morf wanted to go find another caterpillar.



Can you draw a caterpillar with triangles for Morf?

Look what that caterpillar changed into. Why not draw a big butterfly?

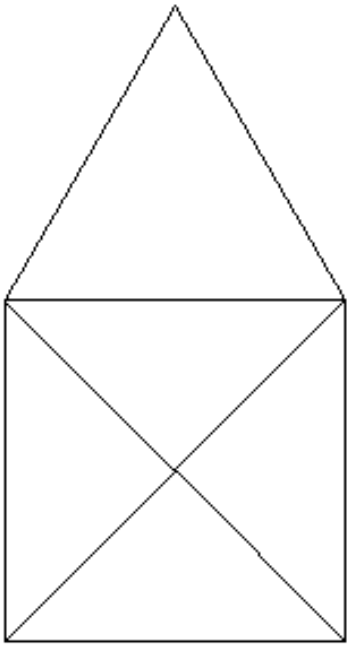


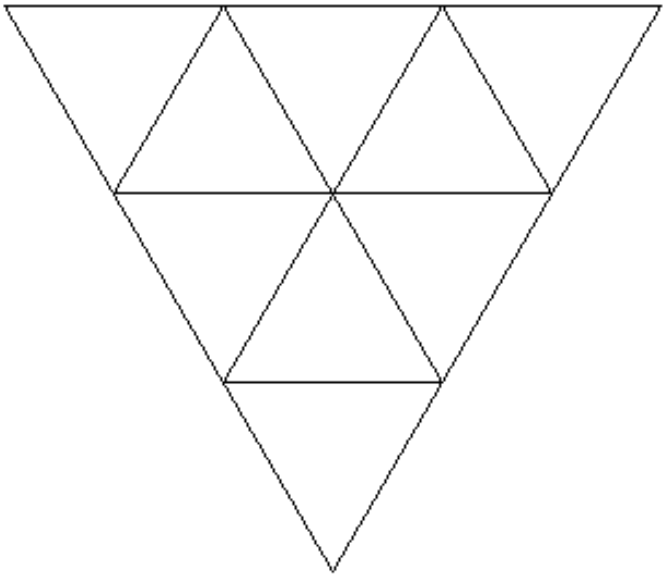


Rabbit Trail 8. More Logo Puzzles

Here are some more Logo puzzles to do using a pencil and paper.

Draw each of these figures without retracing any line, and without lifting your pencil from the paper. Later on, you'll find Logo procedures that will solve the puzzles for you.

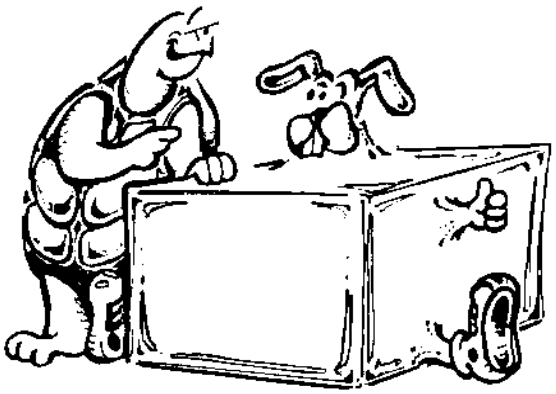




Adventures With Rectangles

Speaking of rules, what about squares and rectangles? We know a square has four equal sides. And, we know the four angles are all 90 degrees.

What makes a square different from a rectangle? Or is it different? They're both look like the side of a box. Some have square sides and some have rectangles for sides. I'm confused!



"Morf, seems like you got yourself into a box; I mean it looks like the box got into you!"

To start, let's draw rectangles. You know that this draws a square:

```
REPEAT 4 [FD 100 RT 90]
```

How would you change that command to draw a rectangle?

Why not break it in half?

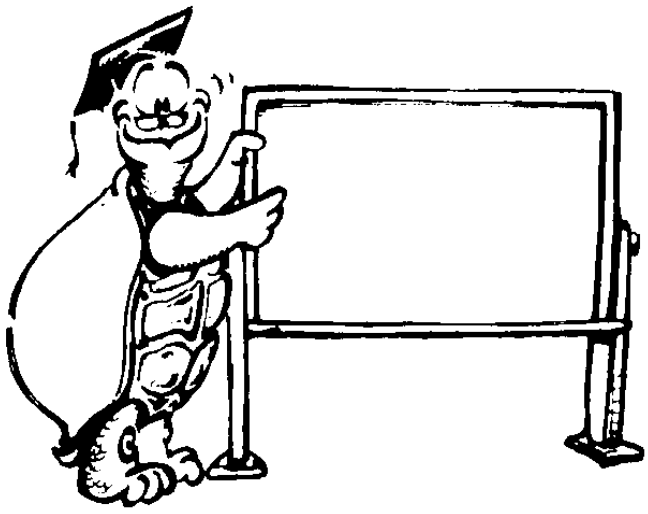
```
REPEAT 2 [FD _____ RT 90 FD _____ RT 90]
```

Works for me! If you fill in the blanks with the same number, you get a square, right? Fill in different numbers and you get a rectangle.

What rules did you discover when trying to draw a rectangle?

Can you draw a rectangle where all four sides are different lengths? Not very easily, right? Wonder what that shape would be?

Can you draw a rectangle with only two equal sides? The other two would be unequal? No, that doesn't work either.



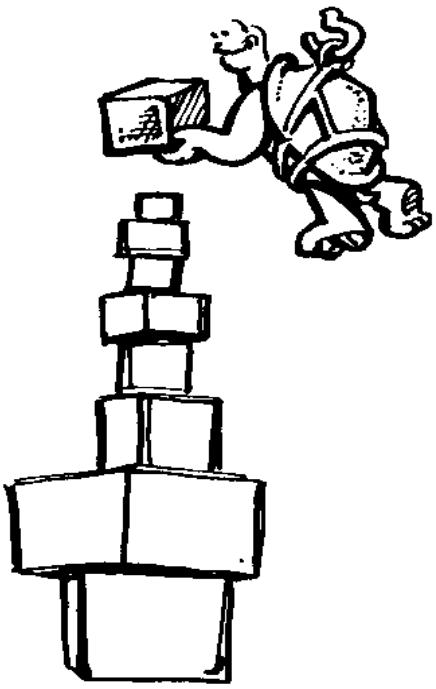
What about this blackboard? Is it a rectangle?

Can you draw a rectangle that has two sets of equal sides, where two sides are say, 100 steps long and two other sides are 200 steps long?

Yes! That's something you can do!

What does all this tell you about rectangles? If a square is a rectangle, then you’re going to have four right angles/ Right angles have to be 90 turtle turns, or 90 degrees.

Now, go ahead. Try stacking up some rectangle boxes.



Rules for Rectangles

So, I guess you can make some rules about rectangles and squares.

1. A rectangle has to have four equal angles and four sides.
2. A square is a rectangle with four equal sides and four equal angles.
3. A rectangle has two sets of equal sides.

One more thing, what's the sum of the angles of a rectangle? Where have you seen that number before?

You'll explore the Rule of 360 and lots of other shapes in the later chapters of this book. In the meantime, let's get some practice using what you're just learned.

Drawing From the Center

Here's a challenge for you. Suppose you had to draw a rectangle around a spot somewhere on the screen. How would you do that?

The first thing you need to know is the size of the rectangle. Then you need to know where to put it.

- Draw a rectangle that is 50 turtle steps wide and 120 turtle steps high.
- Put the center of the rectangle 100 turtle steps from HOME and 100 turtle steps to the left.
-

Now let's figure out how to do this.

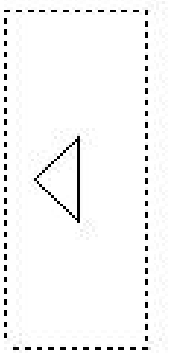
The command to draw the rectangle looks easy enough. From the lower right corner of the rectangle, tell the turtle to

```
REPEAT 2 [FD 120 RT 90 FD 50 RT 90]
```

That will work, won't it?

Next, finding the center of the rectangle seems easy enough, also. How about this:

```
PU HOME FD 100 LT 100
```



This is the center of the rectangle.

Looking at the picture should give you an idea for drawing the rectangle around that spot. Do you see how to do it?

Sure! You go FD half the width of the rectangle, turn RT 90, and then go FD half the length of the rectangle. Turn around and your set to draw. Remember to put the pen down first.

```
FD 50 / 2
RT 90
FD 120 / 2
RT 180
PD
```

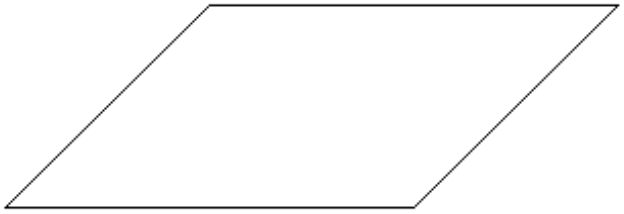
Now draw your rectangle.

```
REPEAT 2 [FD 120 RT 90 FD 50 RT 90]
```

There you are, a rectangle drawn around a center spot somewhere on the screen. You'll see more of this type of thing as you move through the book.

What's a Parallelogram

"Logy, there's something strange here? You've got a rectangle that looks like it's falling over."



"You're right, you know. I never thought of a parallelogram like that," said Logy.

"Para-who?"

"That's another shape, a parallelogram. You might call that the granddaddy of a square," Logy answered.

"I don't get it? What do you mean, granddaddy?"

"Take a look at this command. It's a bit different from the one in the rectangle procedure. Yet it also does the same thing."

```
REPEAT 2 [FD _____ RT _____ FD _____ ~
RT 180 - _____]
```

"Whoa! What's that little squiggly thing?"

That's a tilde. In MSW Logo, it tells Ernestine to look on the next line for the rest of the command. You'll see lots more of these in this book. Right now, go ahead and fill in the blanks of the REPEAT command above and then press Enter.

Look familiar? It's draws a parallelogram something like the one on the previous page. What would happen if I changed the angles to RT 90?

"Hey, that would be a rectangle," said Morf, jumping up and down excitedly.

"So, you can say that a rectangle is sort of like the 'child' of a parallelogram. A parallelogram can take many shapes, one of which is a rectangle."

"Now look at the sides. What would happen if both FD commands used the same number?"

"Well, let's see. You'd have two sets of sides that are all the same."

"And if all the angles are RT 90, what's that?"

"Hey, that's a square!"

"OK, then. Is it fair to say that a square is the child of a rectangle?"

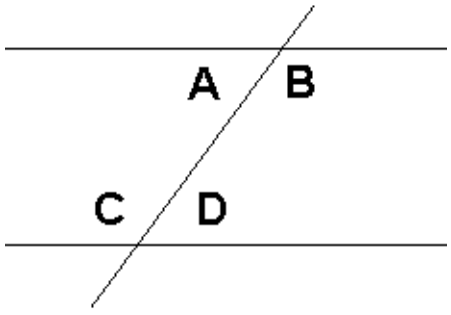
"Seems that way."

"Right! So now we can add a new shape rule."

- A square has four equal sides and four equal angles.
- A rectangle has two sets of equal sides and four equal angles.
- A parallelogram has two sets of equal sides and two sets of equal angles.

Rules for Parallel Lines

There's something else important that we need to look into before we leave parallelograms. This is a project you can do on your own.



1. Draw two parallel lines like those shown in the drawing above. You know what parallel lines are by now, don't you? They're lines that are always the same distance apart no matter how long they are.
2. Next, draw a line at an angle. You pick the angle.

3. Now what are the relationships between all these angles?

   Which angles are equal?

   What's the total of angles C and D? A and B?

4. Try the same thing using a different angle, two parallel lines with a different angle.

   Did you discover some new rules here about parallel lines and angles?

Sure there are! You discovered some things on your own. So write them down in your Logo journal. They may come in handy later on.

Morf's Oneliners

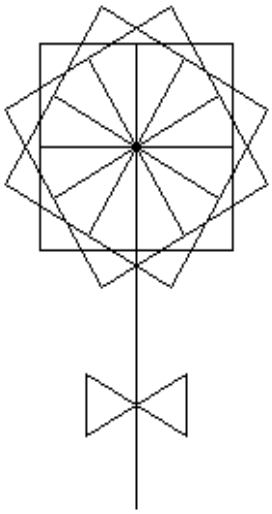
OK, so this one isn't really a Rabbit Trail. It's all about having some fun with your new shape commands on the computer rather than off the computer.

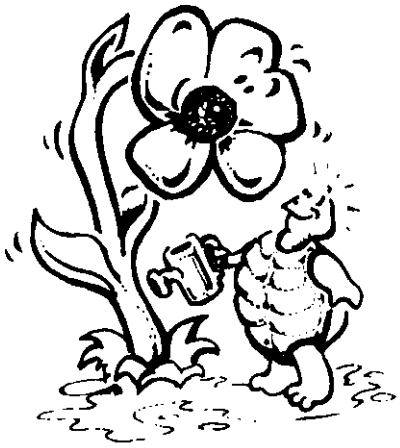
Think about all the things you know how to do now. You can move Ernestine around the screen. You can draw squares, rectangles, and triangles using the REPEAT command. Why not put them all together in one Big, Fantastic, Gorgeous "oneliner."

What's a "oneliner?" Well, why not start with this one. It uses a square.

```
REPEAT 12 [REPEAT 4 [FD 100 RT 90] RT 30]
```

Add a stem and it looks like a flower, doesn't it?





What do these look like?

```
REPEAT 6 [FD 100 REPEAT 6 [FD 10 BK 10 RT 60]~
    BK 100 RT 60]
REPEAT 6 [FD 100 REPEAT 60 [FD 20 BK 20 RT 6]~
    RT 60]
REPEAT 8 [RT 45 REPEAT 6 [REPEAT 90 [FD 2 RT 2] ~
    RT 90]]
```

Try changing the REPEATs to see what other designs you can produce.

Don't forget your pen commands. They can add some interesting variations to your creations. Here's one from some Logo friends in Israel. It sort of looks like a radar screen.

```
PX REPEAT 10000 [FD 200 RT 179]
```

Here's a real puzzler to think about.

```
PX REPEAT 1000000[FD 40 FD 40 BK 80 RT 1]
```

Now try it this way. After all, 40 + 40 = 80, right? Does it do the same thing?

```
PX REPEAT 1000000 [FD 80 BK 80 RT 1]
```

We'll look at this one again when we talk about bitmaps and graphics. For now, why not see who can come up the prettiest or the fanciest "one-liner."

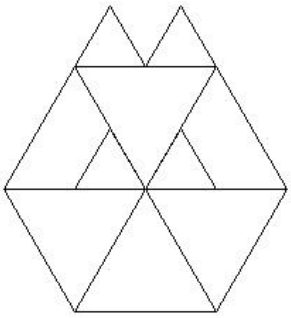
Try It on Paper

Dreaming up one-liners can be tough sometimes. So why not try it on paper first?

Draw a design or a picture using just one shape. Earlier in this chapter, you saw a caterpillar made from squares. You also saw stacks of boxes, flowers, bowties, hourglasses, and other things made from just one shape.

What can you do with triangles or rectangles?

A young lady in the third grade drew a cat using just triangles. Then she drew it on the computer so she could print it to show to her family.



Think of what you can do with just one shape.

Reading Oneliners

When you have very long oneliners or other long and complicated commands, it can be tough to keep things straight That's OK. Logo lets you get as complicated as you want. But Logo is really very straight forward. It operates one command at a time, from left to right. To understand a command, all you have to do is read it.

Let's take a look at one of Morf's one-liners as an example.

REPEAT 12 [REPEAT 4 [FD 100 RT 90] RT 30]

Is this right? Let's see.

Logo starts from the left and reads the first word, the command REPEAT. To run correctly, REPEAT needs a number to tell it how many times to repeat, followed by a list of the instructions to be repeated.

So, Logo reads to the right. Yes, there's the number 12. So the next step is to look for a list that will tell REPEAT what it is going to repeat twelve times.

The brackets — those are the things that look like square parentheses [ ] — tell you that the things inside them are a Logo list. In Logo, lists can be groups of words, numbers, letters, or even other lists. Among other things, lists can include spaces. You'll see lots of lists in this book.

And that's just what you find after REPEAT 12, another list.

There's that REPEAT command again. And, yes, it is followed by the number 4 and a list. The list tells the turtle to

do what's inside the brackets — go forward 100 steps and turn 90-degrees to the right.

That's OK. This list is followed by the command RT 30. So it seems that there's a perfectly good list for the first REPEAT command. This is what Logo repeats 12 times.

[REPEAT 4 [FD 100 RT 90] RT 30]

Now let's try something. Type the REPEAT command shown below and press **Enter**.

REPEAT 12 [REPEAT 4 [FD 100 RT 90 RT 30]

What happened? What's that tell you about brackets?

For every left bracket, there has to be a right bracket.

You'll see long, complicated command lines in this book and in the procedures on the CD. To understand them, just remember to read from left to right, one command at a time. You'll learn more about tracing and stepping through commands in the next chapter.

Time to Experiment

Here's an experiment to try using brackets and parentheses — quotation marks, too.

You know how Morf loves experiments. So let's experiment with something new, the PRINT and SHOW commands.

Type this in the Input Box:

PRINT "HELLO, "LOGY!

What happened?

Now try this:

(PRINT "HELLO, "LOGY!)

What happened this time? Do you see what the parentheses did? Normally the PRINT and SHOW commands display a single word or list on the screen. When you want to print more than just one word or list, you use parentheses. More on this later.

Now try this one:

SHOW "HELLO,\ LOGY!

What's the difference between the command above and this one?

SHOW "|HELLO, LOGY!|

One command uses the backslash and the other uses the big vertical lines. But what they show looks the same, doesn't it.

PRINT and SHOW are a lot alike as you'll see. Use either one, for now. Can you find the difference between the two commands?

What does that backslash do? It creates a space, right? See what happens with this one:

PRINT "HELLO,\ LOGY.\ \ MY\ NAME\ IS\ MORF.

OK, let's get back to brackets. Try this one:

```
PRINT [HELLO, LOGY!]
```

No quotation marks this time. Why not? What happens if you include parentheses or quotation marks inside the brackets?

```
PRINT ["HELLO, "LOGY!]
```

What does this tell you about quotation marks? Think about that.

```
(PR [HI, MY NAME IS] "LOGY, [WHAT'S YOURS?])
```

Now there's one for you. Try it. We'll talk about quotes, words, lists, brackets, and parentheses lots more. But, before we go, what else can you do with the PRINT command? How about this!

```
REPEAT 12 [REPEAT 4 [FD 100 RT 90] RT 30
  PR "WOW]
```

You guessed it, I bet. PR is a shortcut for PRINT. But we're getting off track. Brackets and parentheses are very important but we need to get back to what we were doing.

Rabbit Trail 9. Clocks, String, and Other Stuff

Do you need some help understanding angles, degrees, and things?

Well, here are some off-the-computer activities you can use to make some sense out of this. In these activities, you'll

be looking at angles, degrees, shapes, and planes — using clocks, string boards, balls of string, or colored yarn.

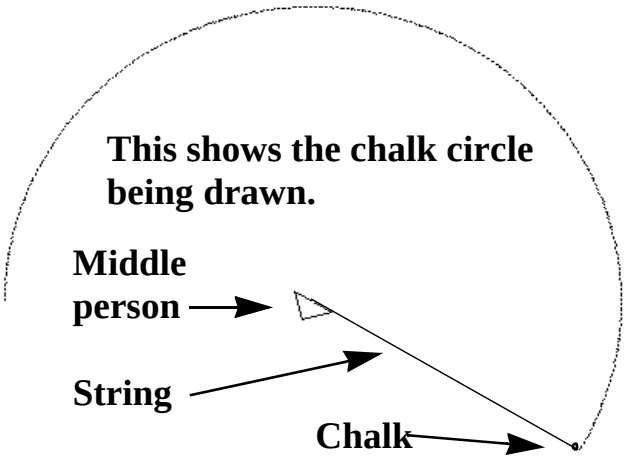
The Turtle's Clock

Let's start with a clock. If you can tell time, you can understand angles and degrees.

You'll need some help from your friends or the others in your class. You'll also need a large room or a big space outside. The last thing you'll need is a long piece of string or rope at least as wide as your circle will be.

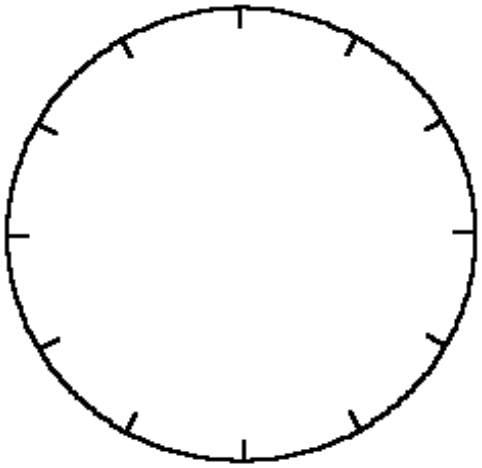
The first thing to do is draw a large chalk circle on the floor. Here's an easy way to do it.

1. Have one person hold the string down on the floor in the center of the room.
2. Stretch the string out to where you want the edge of the circle to be.
3. At the edge of the circle, wrap the string around the chalk a few times.
4. With the chalk on the floor, keep the string tight and walk in a circle around the person in the middle. Make sure the middle person turns with you so the string doesn't get wrapped around them.



5. When your circle is complete, stretch your string across the middle of the circle from top to bottom.
6. Mark the top and bottom positions on the circle as 12:00 o'clock and 6:00 o'clock.
7. Stretch the string across the middle of the circle from side to side. This should divide the circle into four equal parts. Mark the side positions as 3:00 o'clock to the right of 12:00 o'clock and 9:00 o'clock to the left.
8. With the string stretched across the center of the circle, mark off the positions for 1:00 o'clock and 7:00 o'clock, 2:00 o'clock and 8:00 o'clock, 4:00 o'clock and 10:00 o'clock, 5:00 o'clock and 11:00 o'clock.

Now you have a clock face on the floor.



If you're at HOME facing 12:00 o'clock, what time will it be if you turn RIGHT 90? It will be 3:00 o'clock, right?

If you turn RIGHT 90 again, what time is it? 6:00 o'clock, right?

Turn RIGHT 90 again and it's 9:00 o'clock. Turn RIGHT 90 once more and you're back at 12:00 o'clock again.

You turned RIGHT 90 four times for a total of 360^{o} or 360 turtle turns.

There's that number again, 360!

Standing at HOME and looking at 12:00 o'clock, turn to 1:00 o'clock. If it's 90 turns to 3:00 o'clock, how many is it to 1:00 o'clock? To 2:00 o'clock?

Turn back to 12:00 o'clock. How far will you have to turn to look at 6:00 o'clock?

How far is it if you turn right? If you turn left?

It's the same, isn't it. It's 180 turns each way.

Let someone else have a turn playing turtle. If that person faces 6:00 o'clock and turns RIGHT 90, where are they facing? Remember the turtle turns from the direction she is facing, so it's 9:00 o'clock.

Don't play using just RIGHT or LEFT 90.

What's the turn from 4:00 o'clock to 8:00 o'clock? From 1:00 o'clock to 10:00 o'clock? Try out all sorts of turns in both directions. Here's your chance to get used to working with many different angles.

There's a clock face with hands on the next page that you can use for practice. There's also a file on your Discovery book diskette called CLOCK.PCX. Print it and then cut out the hands.

Use the clock with the hands that are included. Or use your pencil turtle or the walnut turtle described below.

Rabbit Trail 10. Clocks On and Off the Computer

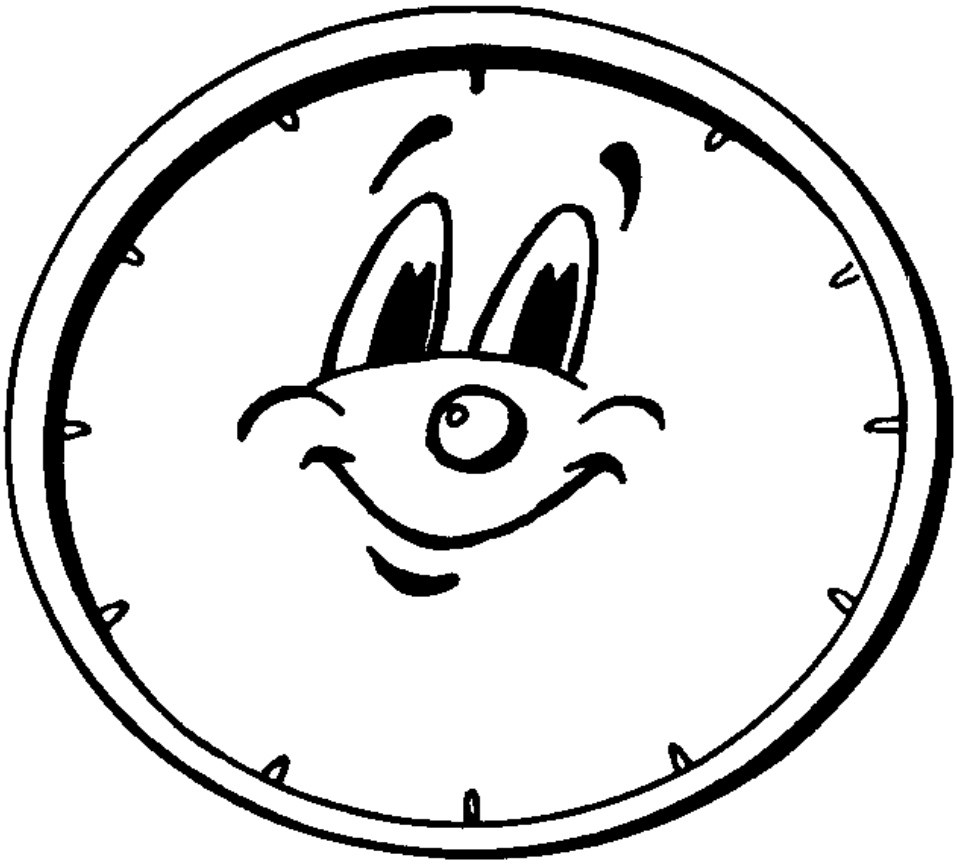
Write the numbers 1 through 12 on small stickers. Start with the turtle at HOME and have one of your friends type FD 100 BK 100. Put the 12:00 o'clock sticker at the top of the first line. Have the next friend type RT 30 FD 100 BK 100. Put the 1:00 o'clock sticker at the end of this line. Continue like this all the way around the circle until you have all twelve numbers on the screen. Does this look like a clock?

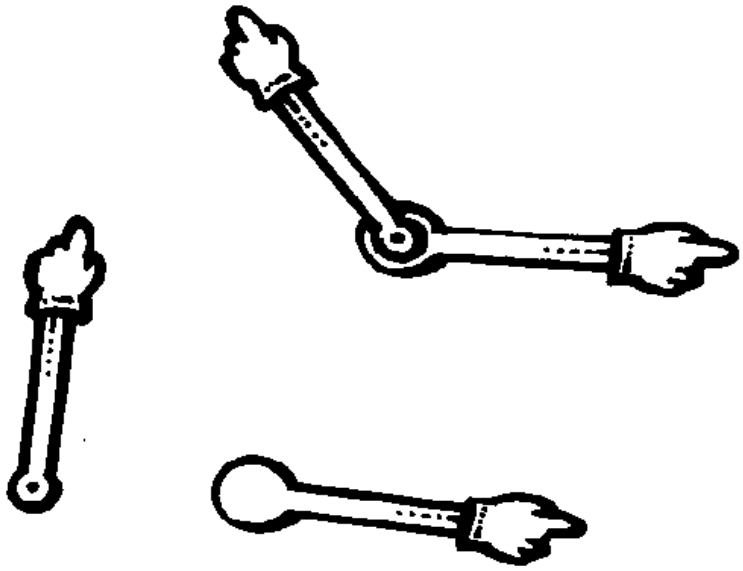
Now you can play *Simon Sez* or *Mother, May I* on and off the computer using times instead of distances.

Simon Sez turn to 4:30 o'clock.

Simon Sez turn to 11:00 o'clock.

Turn to 9:00 o'clock.

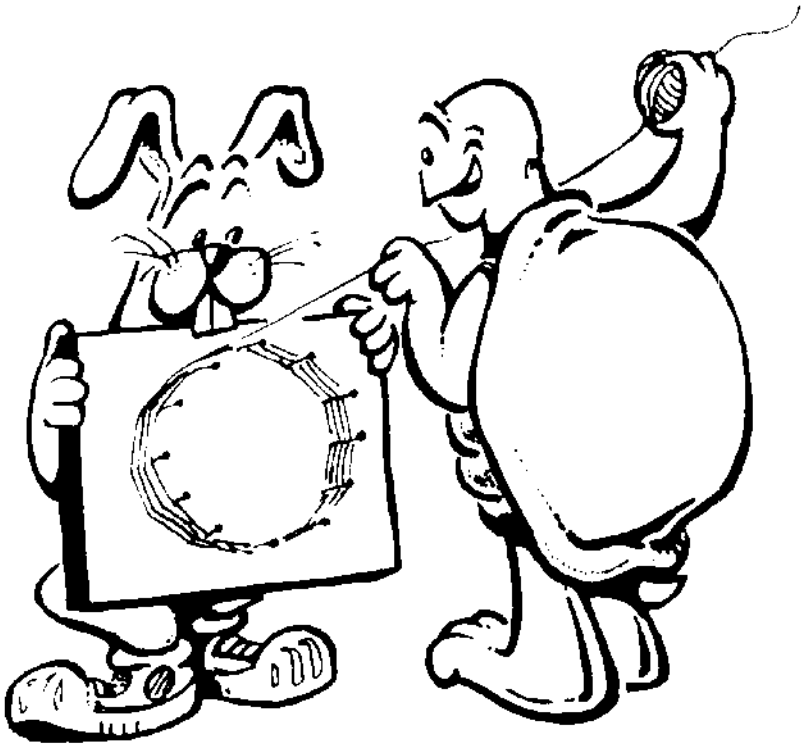




Rabbit Trail 11. Learning With a Ball of String

You're going to need a piece of wood from which you can cut a square that is about 12 inches on each side. Use a piece of shelf board or a piece of plywood.

You're also going to need at least thirteen small nails about 1-1/2 inches long, a hammer, a pencil, and about 12 feet of yarn. String will do.



1. Hammer a nail into the center of the board, just part way so that you have an inch or more sticking up from the board.
2. Tie the string to the nail in the center. Now you're going to make a circle around the center nail.
3. Stretch the string out to the edge of the board.
4. Put your pencil out near the edge of the board. (Hold it up straight.) Then wrap the string around the pencil.
5. Hold the pencil up straight and stretch the string out from the nail. Make sure you hold the string so that it doesn't

come off the pencil. Then draw a circle around the center nail.

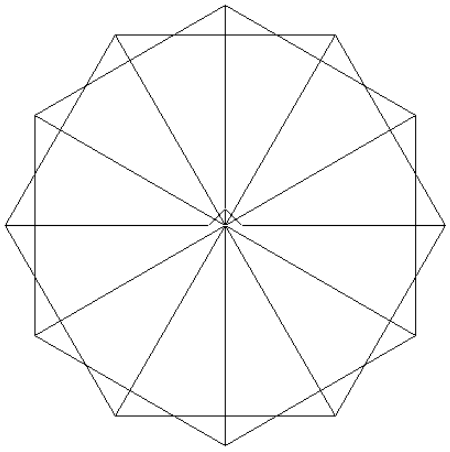
Now we're ready to hammer the other twelve nails into the board. But first, do you have a printer that can print pictures? If so, the turtle can make you a pattern for your string board.

Do you remember how to draw a triangle with three equal sides?

```
REPEAT 3 [FORWARD 100 RIGHT 120]
```

Now let’s use that in a one-liner to make a pattern.

```
REPEAT 12 [REPEAT 3 [FORWARD 100 RIGHT 120]~
  RIGHT 30]
```



Wow! There’s a pattern with twelve points, just like the numbers on a clock. Print the screen.

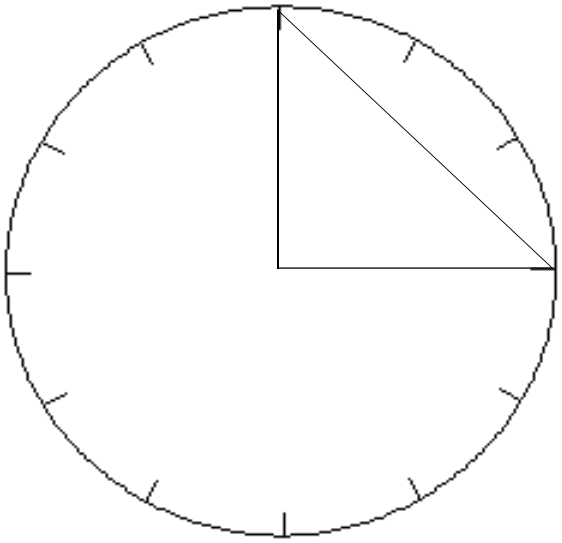
Now carefully push the pattern over the nail in the center of the board. Hold or tape the pattern in place. Then draw a line along each of the pattern lines to the circle you drew before. Where each line crosses the circle, hammer in a nail.

Looks like a clock, doesn’t it? Well, now you and the string can play turtle graphics.

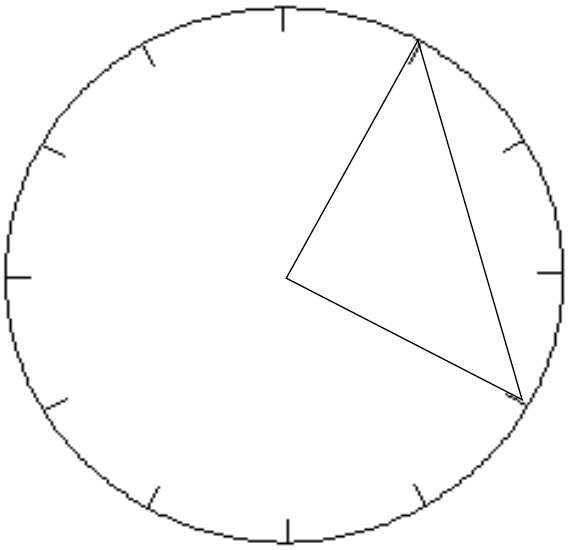
Take the string from the center nail (that’s HOME on the screen) and stretch it up to the nail at 12 o'clock.

Rockin' Around the Clock

Go around the 12:00 o'clock nail and take the string around the 3:00 o'clock nail. Then take the string HOME.



Now do the same thing, only go around the 1:00 o'clock nail and the 4:00 o'clock nail.



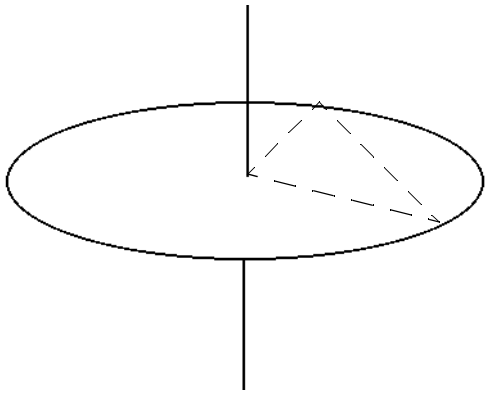
What's really going on here?

You're moving a triangle through space, turning it on a vertical axis that passes through HOME. Can you think of a better way to demonstrate how things move through space?

"You're moving around a what?"

"The circle is on a *vertical axis*. Vertical means it goes up and down or top to bottom. It's the opposite of *horizontal*, which means it's lying flat or going from side to side.

"It looks something like this."



The line is the center is the axis. As you draw triangles on the circle, it's like they are moving through space on the circle. That's the plane or surface.

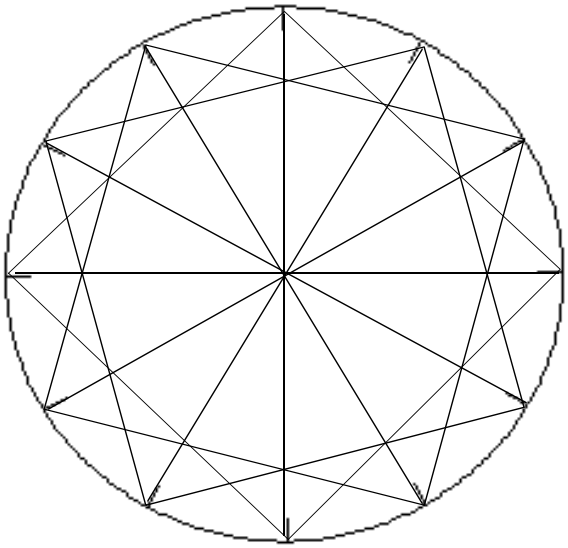
But let's not get too complicated. You're supposed to be having fun, remember?

Yeah, but how do you draw a circle to look like that?

You'll learn more about that in Chapter 8.

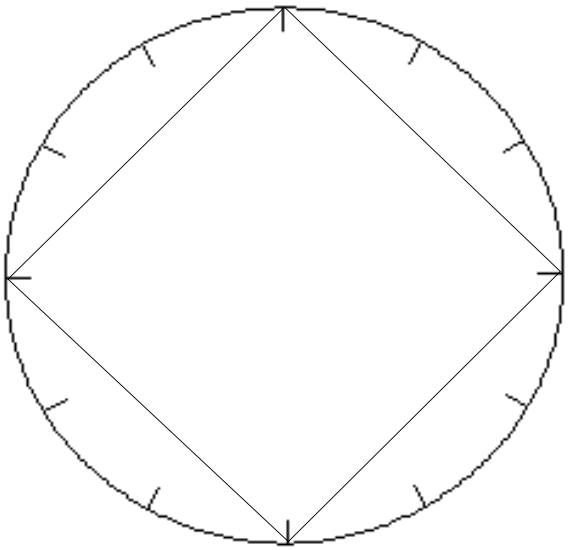
Now, go around the 2:00 o'clock nail and the 5:00 o'clock nail, the 3:00 o'clock nail and the 6:00 o'clock nail, the 4:00 o'clock nail and the 7:00 o'clock nail. Continue on all the way around.

What pattern has the string made? It looks just like the one you printed, doesn't it. Only this one's inside a circle.



Your hand acted like the turtle as it moved around the string board, didn't it? But instead of drawing lines on the screen, you made a line of string.

Take a close look at this drawing. We've been talking about and using triangles to create this. But do you see some other shapes here? Do you see the squares? Can you find the one shown in the picture below?



How many squares can you find?

Now look carefully at the command that made the pattern.

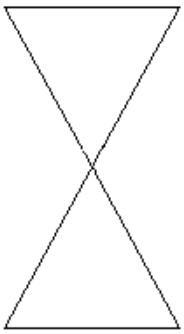
```
REPEAT 12 [REPEAT 3 [FORWARD 100~
   RIGHT 120] RIGHT 30]
```

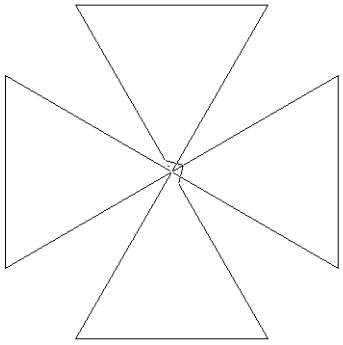
Your first REPEAT 3 [FORWARD 100 RIGHT 120] went from HOME, around the 12:00 o'clock nail, around the 3:00 o'clock nail, and then HOME. Then did you turn RIGHT 30 turtle turns?

Guess so, right?

If you turn back to the beginning of this Rabbit Trail, you'll find that you can do all the clock activities you did on the floor on your new string board.

How about doing your string board activities on the floor, too!





Rabbit Trail 12. The String Toss Game

This can be a great game with a group of friends. It gives you the chance to act out Logo commands by drawing with a ball of string or, better yet, a ball of colored yarn.

Have one person stand in the middle of your chalk circle. Then put other friends at each of the twelve points at the edge of the circle. You can also have one friend write down commands. Another can do the commands on the computer.

The person in the middle is like the turtle. The turtle always starts facing 12:00 o'clock.

LEFT 30

Toss the string to 11:00 o'clock, then to 1:00 o'clock. Then toss it HOME.

What shape is this?

Sure, it's a triangle. See how this works? It's even more fun when you make crazy shapes. Try it.

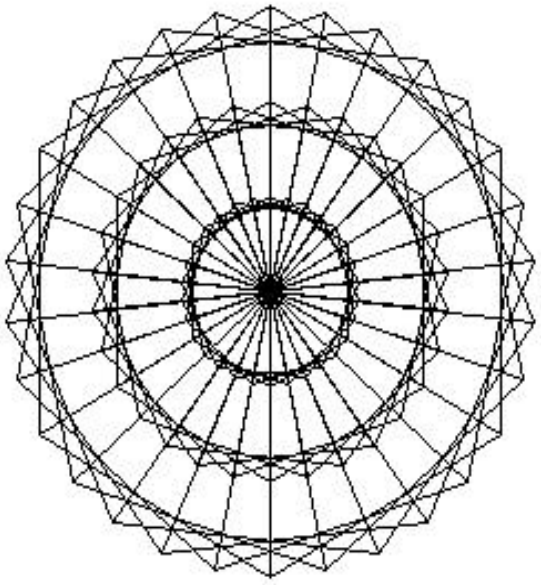
Finding Shapes All Over

One more thing!

Now that you've had some fun working with different shapes, why not go outside and see if you can find any of them in your neighborhood?

Look at your house. Can you find a rectangle there? A square? A triangle? Do you see any trees that look like circles? Triangles?

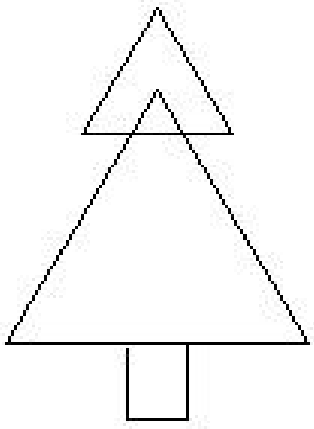
There are lots of basic shapes in nature and in the things we build. That's why it's important to know how to work with them.



Morf loves flowers.

```
TO DAISY
CS HT
REPEAT 30 [TRI 120 RT 12]
REPEAT 30 [TRI 80 RT 12]
REPEAT 30 [TRI 40 RT 12]
END
```

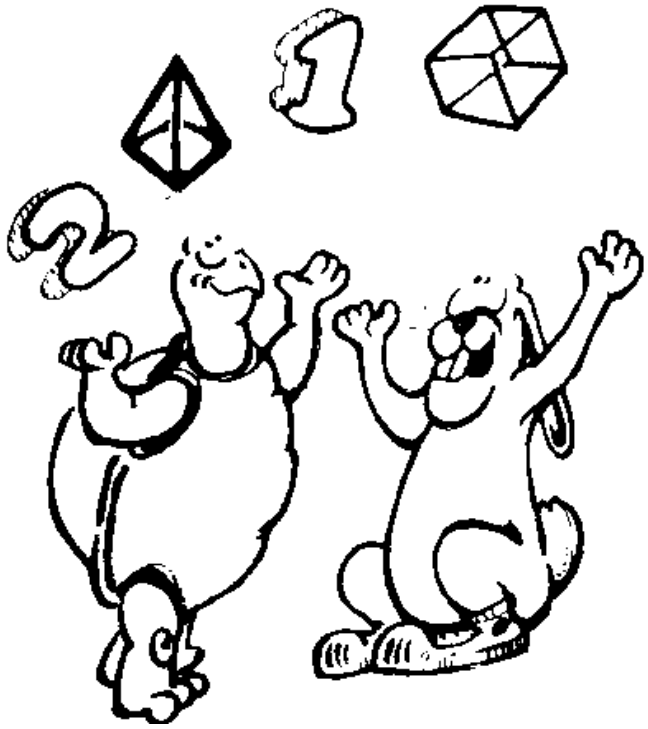
How about a tree?



Why not draw some fancy ornaments? Print them out and then color them for a holiday.

Why not decorate your room?

There are all sorts of things you can do!



“But what about the other kinds of shapes?”

You really need to learn more about writing procedures first. You’ll see lots of different shapes in later chapters. In the meantime, you’ve got enough to enjoy for a while.

Have fun! In fact, have lots of fun!


MY JOURNAL
OR HOW I DID IT!