

Turtles and Geometry

In this project, you explore geometric shapes with the help of the turtle.

Remember: if you must leave your activity before the end, remember to save your project.

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Step 1: Drawing with the turtle

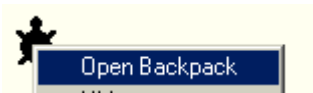
The turtle is a very talented creature. Not only can you use it to create animation, but it can draw, too.

Click on the Create a Turtle tool on the Toolbar to hatch a new turtle:



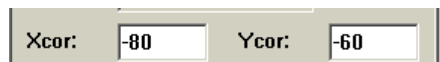
Click on the screen to place the turtle.

Right-click on the turtle and select **Open Backpack**.



The turtle's State tab should be showing.

Check the turtle's starting xcor and ycor to record the turtle's starting position (just in case you need to start over again and want to reset the turtle to this position). The settings may look like this:



All turtle's have a pen. The pen's state is shown in the State tab. Usually, the pen is up. To put it down, click **Down (pd)**.



In order to get the turtle to draw, you need to give it instructions in a language that it understands.

MicroWorlds comes with a built-in language you can use to "talk to" the turtle.

Click in the Command center, the space below the white page, and type this:

```
forward 100
```

The turtle moves forward 100 turtle steps, drawing a line as it goes.

Now type:

```
right 90
```

The turtle turns right 90 degrees (without moving forward)– a right angle.

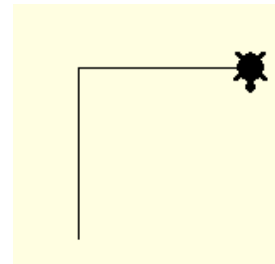
You can put these two instructions together, to get:

```
fd 100 rt 90
```

(Fd is short for forward. Rt is short for right.)

Forward and right each take one input – a number.

You probably now have two lines that look like this:



As you can see, this looks like the beginning of a square. Try to finish the square.

(Hint: A square has 4 equal sides and 4 equal corners. You already have two lines and two turns or corners.)

Step 2: Drawing by Command

Here are two ways you can write the instructions to draw a square:

```
forward 100 or whatever number you want to use
right 90
forward 100
right 90
forward 100
right 90
forward 100
right 90
```

Or:

```
repeat 4 [forward 100 right 90]
```

Repeat is another built-in word in MicroWorlds. It needs two inputs. The first input is always a number. The second input must be a list of instructions to run, and it's always enclosed in square brackets []. The number tells MicroWorlds how many times to run the list of instructions.

The input to `forward` sets the length of the sides. Move the turtle around and draw some different sized squares.

Is your screen getting cluttered?

If you want to clear the screen graphics without moving the turtle, type:
`clean`

To clear the screen graphics and set the turtle to the middle of the screen, type:
`cg` stands for clear graphics

Step 3: Doing a 360

Try drawing an equilateral triangle using `repeat`.

Here are some hints:

1) Since a triangle has 3 sides and 3 corners, you probably realize that you need to repeat a set of instructions 3 times.

```
repeat 3 [???
```

2) Use `forward` to draw a side. The input to `forward` determines the length of the side. An equilateral triangle can have sides that are of any length (as long as they are all equal).

```
repeat 3 [fd 100 ???]
```

3) Use `right` to create a corner. How much should the turtle turn at each corner in order to make a triangle?

When a turtle draws a square it ends up facing in the exact same direction it was facing when it started. Each turn is $1/4^{\text{th}}$ of the way around.

So, if the turtle turns three times, on each turn it turns $1/3^{\text{rd}}$ of the way around.

But how much is "all the way around?"

Skateboarders talk about "doing a 360" when actually they mean they've turned all the way around. They end up facing in the exact same direction as when they started. In doing so, they've turned 360 degrees. That's just what the turtle does.

When a turtle draws a square, it turns `right 90` four times.
 $4 \times 90 = 360$

When a turtle draws a triangle, each time it turns it turns `right 360 x 1/3` or 120.

```
repeat 3 [fd 100 rt 120]
```

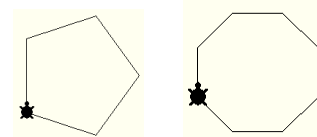
Try these:

1) Draw some different sized triangles. Remember, the input to `forward` sets the length of the sides.

2) Here are the instructions to draw another geometric shape. What do you think this shape is?

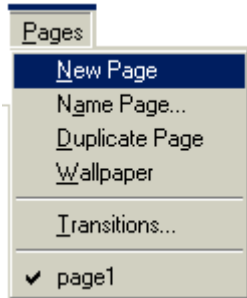
```
repeat 6 [fd 100 rt 60]
```

Now try to draw these other shapes:
pentagon octagon



Step 4: Circles

You can use buttons to help you explore geometry. In the Pages menu, select New Page to add a second page to the project.



Hatch a new turtle.



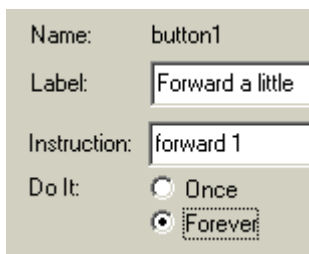
Create a button. First, click the Button tool on the Toolbar:



Then click on the page. A dialog box opens. The instruction is executed when the button is clicked. In the instruction line, type:
`forward 1`

The label shows on the button face. Give the button a label that explains what this button does. (The label can be anything, but the instruction must be exactly as shown above.) In this case, the label could be Forward a Little

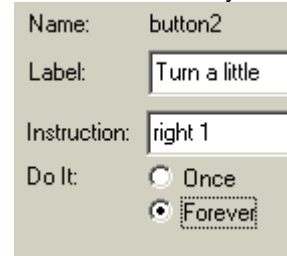
Set the Do It mode to Forever.



Click OK. You should see a button on your page. If you can't read the label, select the button by dragging around it with the mouse or by pressing CTRL and clicking on it. Then drag one of the "corners" to make the button larger.

Now create a second button, following the steps above. This time, in the instruction line, type:
`right 1`

Label the button so you know what it does.



Set the Do It mode to Forever. Click OK.

Put the turtle's pen down in the State tab or by typing, in the Command center:
`pd`

Click on the Forward button. The turtle draws a straight line.

When the button is clicked, the turtle goes forward one turtle step, but it does this many times (forever – or, at least until the button is clicked again.).

Click the button to stop it. Then click the other button - Turn a little. The turtle spins in one spot. It turns right a little (1 degree) many times.

Now, as the turtle is spinning, click the Forward button.

What happens? When the turtle moves forward a little and turns a little and does each of these actions many times, it draws a circle.

Drawing a circle is like drawing a geometric shape with an infinite number of sides and turns. In MicroWorlds, this means repeating `forward` and `right` a large number of times (since there's no infinity command).

Here's a way to draw a circle using commands:
`cg`
`repeat 360 [fd 1 rt 1]`

Try changing the input to forward. Try:
`repeat 360 [fd 10 rt 1]`

Can you explain what happened?
(If not, the answer is at the end of this tutorial.)

Circles can also go to the left.
`repeat 360 [fd 1 left 1]`

If your page is getting too messy, click on the button tool in the Toolbar and click on the page. The button dialog opens. In the instruction line, type:
`cg`

Leave the Mode set to Once. Try the button.

Step 5: Procedures

Not only does MicroWorlds contain built-in words, but you can also add new words to its vocabulary by writing procedures.

It would be useful to have a command that draws a circle. So, add one!

Right-click on the turtle and select Open Backpack.



Click on the Procedures tab.



A turtle's Procedures tab is the place where you define new words for that specific turtle to know. It contains the turtle's private list of words.

To define a command that draws a circle to the right, type:

```
to rightcircle
repeat 360 [fd 1 rt 1]
end
```

Procedures always start with `to` and the name of the procedure. They always finish with the word `end`. `End` must be on its own line, so you must press Enter after you type it.

There are a couple of rules for naming procedures. You can name a procedure whatever you like as long as:

- it's a single word (rightcircle **not** right circle); and,
- it is not a word that MicroWorlds already knows (for example, not `forward`).

Now type `rightcircle` in the command center. The turtle should draw a circle.

(If you get this message:

I don't know how to rightcircle.

Open the turtle's backpack and check that you typed the procedure correctly.)

Write procedures for other geometric shapes, such as a square or a triangle. Remember to always start the procedure with `to` and end it with the word `end`.

Step 6: Please repeat

Geometric shapes can be used to create some interesting designs and patterns.

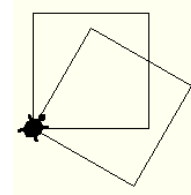
First, define a `square` procedure, if you haven't done so already:

```
to square
repeat 4 [fd 100 rt 90]
end
```

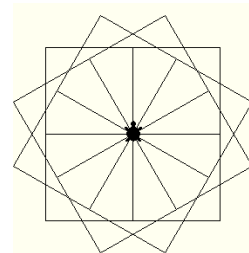
In the Command center, type:
`square`

Next, turn the turtle and draw the same size square again. For example:

```
rt 30
square
```



Repeat these two lines until the turtle is heading in the same direction as it was when it started.



Try using `repeat` to run these two lines.

First, clear the screen:
`cg`

How many times do you need to repeat these two lines? Try:

```
repeat 12 [rt 30 square]
```

Do you know why you repeat 12 times?

Use the same technique to create a design using another geometric shape, such as a triangle or a pentagon.

Step 7: Exploring more patterns

As you can see, you can use your procedures with `repeat`, `forward`, `back`, `right`, and `left` to create interesting patterns. For example, define a `leftcircle` procedure:

```
to leftcircle
repeat 360 [fd 1 lt 1]
end
```

Now try:

```
repeat 18 [rightcircle leftcircle rt
          10]
```

Think about why you get this effect. Why does it only need to repeat 18 times? What if you used a different shape in the `repeat` instruction, for example:

```
repeat 18 [rightsquare leftsquare rt
          10]
```

(Make sure you have a `rightsquare` procedure and a `leftsquare` procedure. You have to create these yourself.)

Do you get the same effect? Try other shapes, too.

Here's another way to create patterns.

```
repeat 8 [rightsquare bk 20
leftsquare
          fd 20 rt 45]
```

To understand what is happening, run the instruction once.

```
rightsquare bk 20 leftsquare fd 20
rt 45
```

Experiment with other shapes. Remember to define the procedures you need first.

Try using different pen colors to see if this changes the effect. Use `setc` (**set color**) to change the pen color.

```
setc "blue
```

Remember to use a quotation mark before the name of the color.

Here's another type of pattern:

```
repeat 180 [fd 100 bk 100 rt 2]
```

Now you have all the tools you need to experiment with geometric shapes. Use them to create other types of patterns.

(Answer to the question in Step 4: The turtle "wrapped" around the screen while it was drawing the circle.)