Mathematics 308—Fall 1996

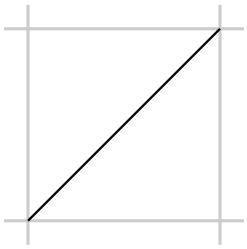
Some simple pictures

In this section we'll see some very simple PostScript graphics, although some of the details won't make sense right now.

1. Drawing lines

The basic drawing routine in PostScript is to draw a line segment between two points. For example, to draw a line between the points $(0,0)$ and $(1,1)$ on the plane you write

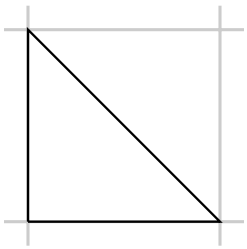
```
newpath
0 0 moveto
1 1 lineto
stroke
```



What does this do? • Every time you want to draw a path of some kind you begin with **`newpath`**. Next you build your path, for example by constructing line segments with operations like **`moveto`** and **`lineto`**. Finally you do the actual drawing with a command like **`stroke`** which goes over the path you have built and does the actual drawing. • The **`moveto`** command can be thought of as moving your pen to the point $(0,0)$ without drawing anything. • The **`lineto`** command then adds to the path you are building a line to $(1,1)$ from the point you moved to. In general, a **`lineto`** command will add a line segment to the path you are building, starting at the **current point** you are located at (which will be where you last moved to or drew to). One thing to notice is that PostScript uses **reversed notation**, so that you write **`0 0 moveto`** instead of **`moveto 0 0`**.

For a more complicated path, suppose you want to draw the right triangle with corners at $(0,0)$, $(1,0)$, $(0,1)$. There are many ways to do this, but the natural one in PostScript as well as by hand is to trace out the triangle without lifting your pen. This one goes around clockwise.

```
newpath
0 0 moveto
1 0 lineto
0 1 lineto
0 0 lineto
stroke
```



2. Coordinates

The pictures above were not quite drawn with the commands listed. PostScript uses an elegant system of coordinates to draw pictures. When you start up a program the coordinate system PostScript assumes a **default coordinate system** on the page.

- *The origin of the default coordinate system in* PostScript *is at the bottom left of the page.*

- *The default scale is in* **points***—there are* 72 *points to an inch.*

The things we have been drawing so far, for example, are extremely small and indeed probably almost invisible unless we scale things up and shift the origin of the coordinate system towards the middle of the page. This was done with lines

```
72 72 scale
3.25 0 translate
```

By the way, the default page in PostScript is $8.5'' \times 11''$.

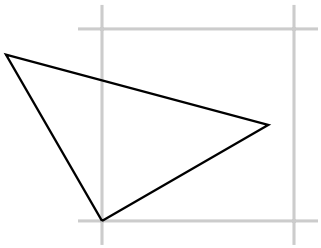
Notice that it makes a difference in which order you do the scaling and translation, since the translation takes place in the new units.

Also, the default line width is one unit—one inch, one point, whatever. A line width of 0 will give you the thinnest line the computer can display. In the pictures above I used

```
0.012 setlinewidth
```

Other coordinate changes are possible.

```
72 72 scale
3.25 translate
30 rotate
newpath
0 0 moveto
1 0 lineto
0 1 lineto
0 0 lineto
stroke
```



Ignore the grey frame for the moment.

3. Variables in PostScript

PostScript allows you to use variables. Assignments are made like this:

```
/x 3 def
```

means that the variable `x` is assigned the value 3. Variable names can be just about anything—for example `silly-variable-name-without-any-significance` is as far as I know perfectly OK. But silly.

Here is an example of how variables can be used in a drawing routine:

```
/a 2 def
/b 3 def
newpath
0 0 moveto
a 0 lineto
0 b lineto
0 0 lineto
stroke
```

will draw a triangle with corners at $(0,0)$, $(2,0)$, $(0,3)$. The point is that it is now very simple to draw a different triangle by changing the values of a or b, or to draw several pictures with the same values of a and b.

4. A complete example

Here is a complete working program to draw a rectangle with corner at the centre of a blank page, with sides $2''$ and $3''$.

```
%!

72 72 scale
4.25 5.5 translate

0.012 setlinewidth

newpath
0 0 moveto
3 0 lineto
3 2 lineto
0 2 lineto
0 0 lineto
stroke

showpage
```

There are a number of minor but new things to notice here.

One odd thing to keep in mind is that

- *On some computers, and nearly all printers, you will get no picture at all without the* **%!** *starting off your program.*

This is just a convention you have to take into account.

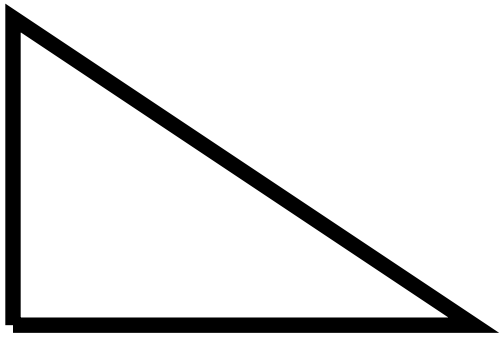
The **showpage** at the end is not usually required to get a picture displayed on the monitor, but it may be required to get printed output. It is good practice always to include it. You can draw on a sequence of pages by drawing a sequence of figures separated by **showpage** commands. We will see later that we can even get some convincing animations in this way. One thing that may cause you trouble is that

- *The coordinate system must be set up all over again on each page.*

5. Some fine points

Here are some other points which you can ignore for the moment if you want, but which will you help you to produce pictures of generally higher quality.

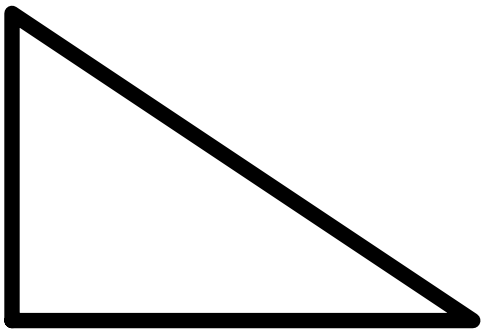
If you draw the same triangle scaled a bit you will get



This may or may not be what you want. You can change the way the computer draws corners and the ends of lines with commands **setlinecap** and **setlinejoin**. Adding

```
1 setlinejoin
1 setlinecap
```

before the path is drawn will give you



You can draw in any shade of gray with a command like

```
0.8 setgray
```

to get

Note that 0 is black, 1 white. If you are working with a colour monitor or a colour printer you could try something like

```
0 0 1 setrgbcolor
```

Colours are specified by **RGB** components, so this makes the current colour equal to **blue**.

6. Making solid colours

You can draw paths by applying the **stroke** command, but you can fill closed paths with various colours (including grey) by applying **fill** instead of **stroke**.

```
0.8 setgray

newpath
0 0 moveto
3 0 lineto
0 2 lineto
closepath
fill
```

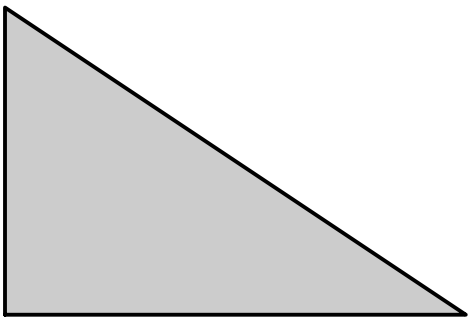
will give you

Without applying **closepath** you might have the fill colour leak out onto the whole page. Note that **closepath** draws a line from the current point to the place your path started, so it is not necessary to draw that line explicitly.

You can do an even nicer job by two drawings.

```
0.8 setgray

newpath
0 0 moveto
3 0 lineto
0 2 lineto
closepath
fill

0 setgray

newpath
0 0 moveto
3 0 lineto
0 2 lineto
0 0 lineto
stroke
```

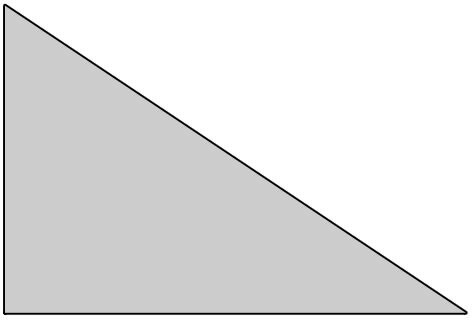
leads to



You have to be careful about the order in which you stroke and fill.

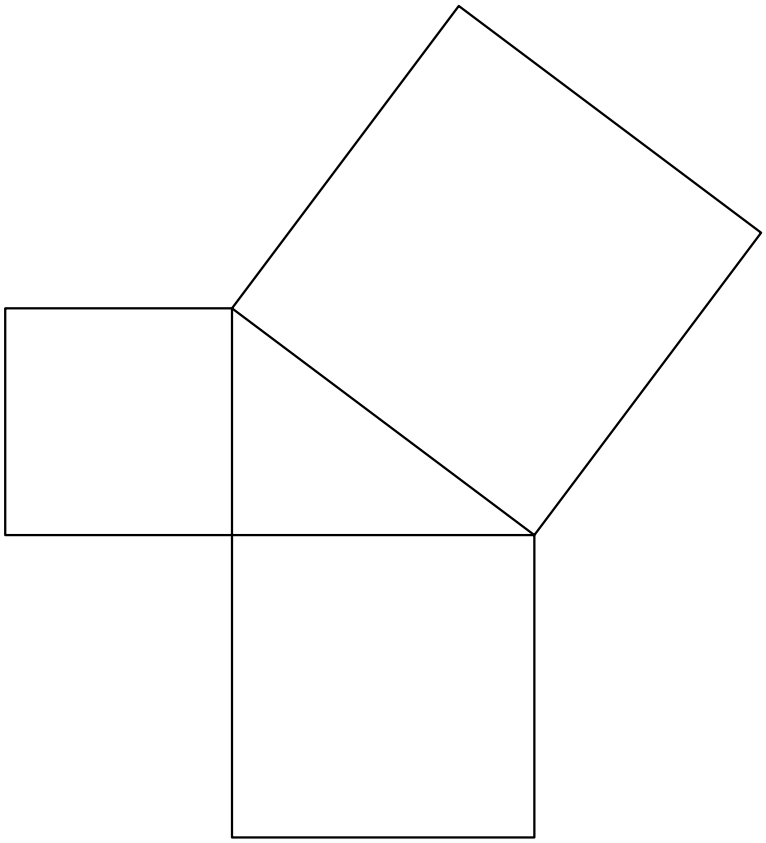
```
0 setgray

newpath
0 0 moveto
3 0 lineto
0 2 lineto
0 0 lineto
stroke

0.8 setgray

newpath
0 0 moveto
3 0 lineto
0 2 lineto
closepath
fill
```

gives you the slightly peculiar



In other words, you should think of drawing in PostScript as painting over whatever drawings you have already made on the same page.

Exercise 6.1. Write a PostScript program to draw the following figure in PostScript. The sides of the triangle are 3, 4, and 5 centimeters.



Exercise 6.2. Draw the following equilateral triangle, centered in the middle of the page, one inch on a side.