

Entry-level MetaPost: On the grid

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1 Running MetaPost

The basic method for running MetaPost is to create a file with extension `.mp` and run MetaPost directly on the command line: `mpost yourfile.mp`. In the `.mp` file, the code for making graphics is enclosed within `beginfig ... endfig`; the result is a PostScript file. The file extension is the figure number. With this example, the output would be a file `yourfile.1`.

```
beginfig (1) ;
  % Draw a line
  draw (1cm,2cm) -- (3cm,5cm) ;
endfig ;
end .
```

If you add `outputformat:="svg"`; at the very beginning of the file, the output will be in SVG format. However, the resulting file will still be named `yourfile.1`; depending on your system, you may have to rename it to `yourfile.svg` for it to be recognized.

Another method, available in any decent \TeX distribution, is to run MetaPost inside a \ConTeXt file. (I am a \ConTeXt user, so I find it handiest to do it this way.) The file extension is the usual `.tex`, and the MetaPost code (the same MetaPost code as when running standalone) is enclosed inside `\startMPpage ... \stopMPpage`. I run my files within an editor with a menu command *Typeset*, but you can also typeset the file on the command line with `context yourfile.tex`.

```
\startMPpage
  % Draw a line
  draw (1cm,2cm) -- (3cm,5cm) ;
\stopMPpage
```

The output from \ConTeXt is (by default) a PDF file, `yourfile.pdf`. Graphics code can be included in any `.tex` file; you can have text and MP code in one and the same \ConTeXt file.

2 Building up a graphic

To draw anything with MetaPost, you have to have some kind of idea of where your drawings end up and why. Everything is related to a base grid; it doesn't usually show, but in our examples here I've put a grid in the background to help you figure out how to place objects in MetaPost. (A blank grid is shown in fig. 1. We'll see how to draw the grid itself later.)

The MP grid extends to all directions, e.g., coordinates $(1, 2)$, $(-1, 2)$, $(-1, -2)$ and $(1, -2)$ all exist. However, I find it easiest to stay on the positive side when coding a drawing or an element; objects can be easily shifted later to their proper locations.

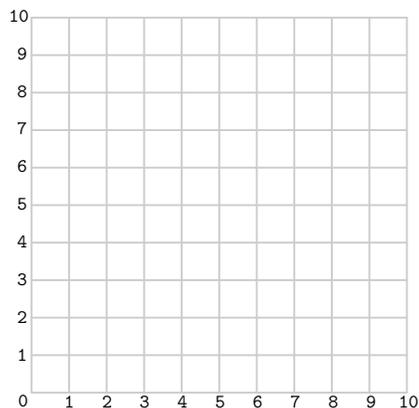


Figure 1: MetaPost drawings are made on a grid.

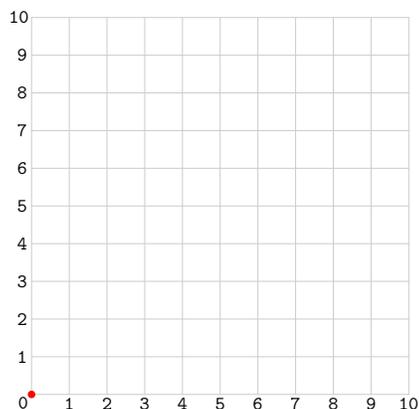


Figure 2: A red dot at the origin.

The basic unit of MetaPost is a “big point” (bp), and that one is tiny ($72 \text{ bp} = 1 \text{ in}$). There are several ways of changing the scale: in the examples below we'll use a user-defined unit `u`. That way we only have to change `u` if we want to adapt the drawing to a different size/scale. Here, we'll define the unit `u` at the beginning of the MetaPost file to fit *TUGboat*:

```
numeric u ; u := .5cm ;
```

As a first example, let's draw a small red dot—a filled circle—at the origin. The output is in fig. 2. (If we had nothing else in the picture, we'd get a red dot in the middle of the page with some white around and that's it; our dot here isn't in the middle because of the grid in the background.)

```
% Set the scale
numeric u ; u := .5cm ;

% Draw a red dot at origin
fill fullcircle scaled (1/5u) withcolor red ;

% Add whitespace around the drawing
```

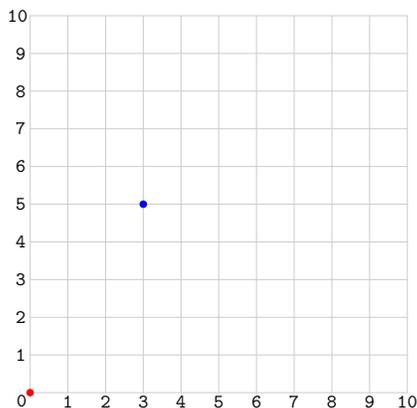


Figure 3: Add a blue dot at (3,5).

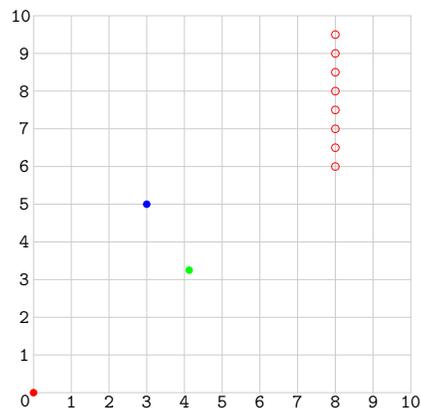


Figure 5: Add a vertical series of red dots with a loop.

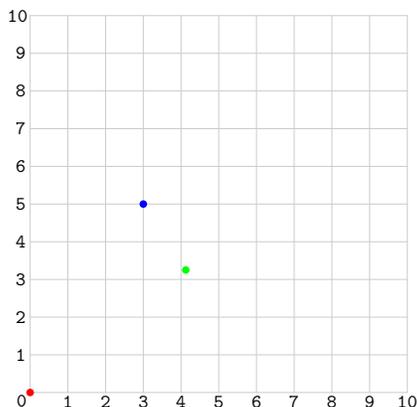


Figure 4: Add a green dot, off the integer grid.

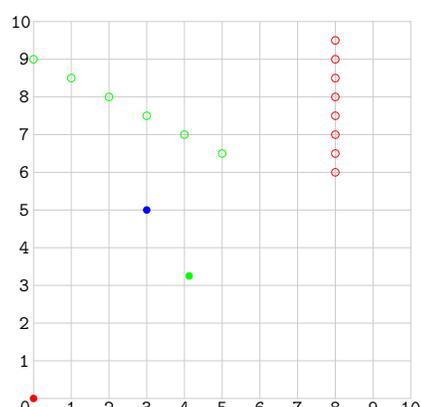


Figure 6: Add a diagonal series of green dots.

```
setbounds currentpicture to
  boundingbox currentpicture enlarged 1/2u ;
  Next, let's add another dot in blue at (3,5):
```

```
fill fullcircle scaled (1/5u)
  shifted (3u,5u) withcolor blue ;
```

This command goes after the previous `fill`, *above* the `setbounds` command (as do our subsequent additions). Output in fig. 3.

We don't have to use whole numbers; MetaPost is just as handy with decimals and fractions (fig. 4):

```
fill fullcircle scaled (1/5u)
  shifted ((4u+1/8u),3.25u) withcolor green ;
```

When something is repeated at regular intervals, a *loop* can be used (fig. 5):

```
for i = 6u step 1/2u until 10u :
  draw fullcircle scaled (1/5u) shifted (8u,i)
    withcolor red ;
endfor ;
```

We can change both coordinates inside one loop:

```
for i = 0 step 1/2u until 3u :
```

```
  draw fullcircle scaled (1/5u)
    shifted (2*i,(-i+9u)) withcolor green ;
endfor ;
```

Lines and objects are drawn by connecting two or more sets of coordinates. Either a straight line (specified with `--`) or a curved line (`..`) is drawn between the given coordinates. A line is turned into a closed object with the final command `cycle`. Only a closed object can be filled with colour! (See fig. 7.)

```
fill (5u,1u) -- (7u,5u) -- (7.5u,5u) .. (8u,3u)
  .. (9u,3u) .. (7u,1/2u) .. cycle ;
```

In the next picture (fig. 8) these curve coordinates have been marked with small red dots. If you are not familiar with Bezier curves, the behaviour of the curved lines can be surprising.

A line or an object always has a bounding box, a rectangular frame. MetaPost knows where the corners of the bounding box are; in fig. 9, the box is drawn as a line from corner to corner on the black object (red dots are added later) and the dark blue

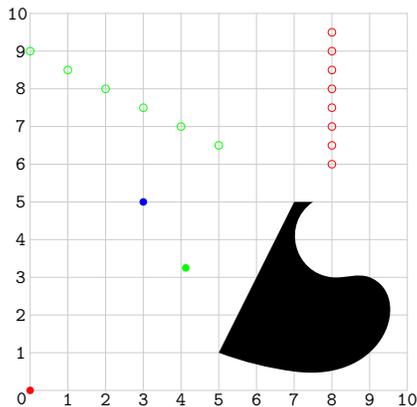


Figure 7: Add a filled shape which uses both curves and lines.

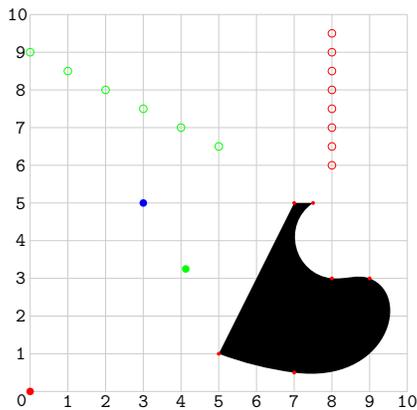


Figure 8: Show the curve coordinates with red dots.

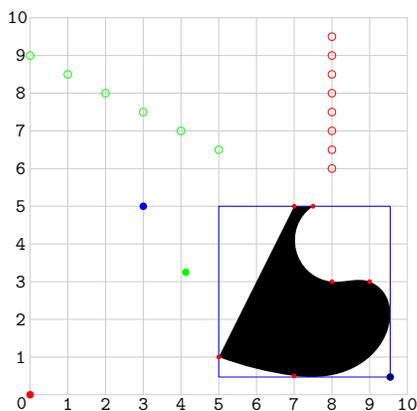


Figure 9: Outline the shape's bounding box with a dot at its lower-right.

dot is placed on the lower-right corner (`lrcorner`) of the black object.

All of the code we've built up follows, and the output without the background grid is in fig. 10.

```
% -- begin full example --
numeric u ; u := .5cm ;

fill fullcircle scaled (1/5u) withcolor red ;
fill fullcircle scaled (1/5u) shifted (3u,5u)
withcolor blue ;
fill fullcircle scaled (1/5u)
  shifted ((4u+1/8u),3.25u) withcolor green ;

for i = 6u step 1/2u until 10u :
  draw fullcircle scaled (1/5u) shifted (8u,i)
  withcolor red ;
endfor ;

for i = 0 step 1/2u until 3u :
  draw fullcircle scaled (1/5u)
  shifted (2*i,(-i+9u)) withcolor green ;
endfor ;

% Define the black object
picture curvy ;
curvy := image (
  fill (5u,1u) -- (7u,5u) -- (7.5u,5u)
  .. (8u,3u) .. (9u,3u) .. (7u,1/2u)
  .. cycle ; );

% Draw the black object
draw curvy ;

% Draw bounding box around the object
draw llcorner curvy -- lrcorner curvy
  -- urcorner curvy -- ulcorner curvy
  -- cycle withcolor blue;

% Add dot at lrcorner of object bounding box
fill fullcircle scaled (1/5u)
  shifted (lrcorner curvy) withcolor 0.5blue;

% Add red dots at object 'turning points'
fill fullcircle scaled (1/10u) shifted (5u,1u)
withcolor red;
fill fullcircle scaled (1/10u) shifted (7u,5u)
withcolor red;
fill fullcircle scaled (1/10u) shifted (7.5u,5u)
withcolor red;
fill fullcircle scaled (1/10u) shifted (8u,3u)
withcolor red;
fill fullcircle scaled (1/10u) shifted (9u,3u)
withcolor red;
fill fullcircle scaled (1/10u) shifted (7u,1/2u)
withcolor red;

% Add whitespace
setbounds currentpicture
```

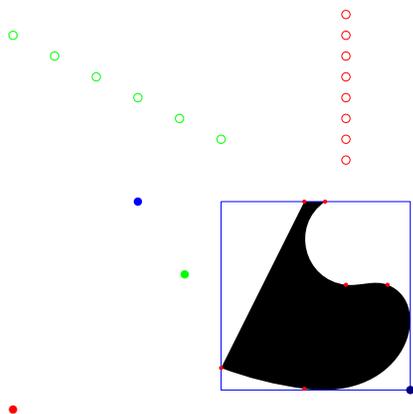


Figure 10: The complete example figure without the background grid.

```
to boundingbox currentpicture enlarged 1/2cm ;
% Scale up to be readable
currentpicture := currentpicture xsized 6cm ;
% -- end full example --
```

2.1 Troubleshooting

With MetaPost — as well as with T_EX — I’ve found that it is a good idea to compile (typeset) the file fairly frequently, especially when doing something for the first time. I carefully “grow” my MetaPost graphics stage by stage, very much like the examples above. If my file suddenly stops working, I comment out the newest lines (with %) and recompile to check that I haven’t, say, accidentally deleted a semicolon in the older code, and then proceed to debug the newest code.

If your file doesn’t compile, the first thing to look for is an omission: a missing semicolon at the end of a command, a missing `endfig/\stopMPpage`, missing parentheses. If the semicolon on the last line is missing, the file will compile — but only until something is added after that line, then it fails.

If you draw something with the `fill` command, the item to fill must be a closed path, either a line/curve closed with `cycle`, or a circle or square, e.g. `fullcircle`. If you try to fill a non-cyclical path, your file won’t compile because MetaPost hangs at the “impossible” command.

If your drawing is tiny and needs lots of zooming to be visible, you may be using MetaPost’s default unit, the big point. Try the above-mentioned trick of defining a unit `u` to suit your taste, or use units with your coordinates. In the beginning I found it easiest to think on a millimeter grid, so I defined lines with, e.g., `draw (8mm,20mm) -- (10mm,40mm);`.

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MetaPost draws items in the order they are defined. If your file compiles, but you only get some of the objects, the missing ones may be underneath everything else. Our examples above are carefully spread out so they don’t overlap, but if you play with the coordinates, you may encounter this feature. If you draw several items at the same spot, the first (highest up) in the code is at the bottom in the drawing and the last in the file is on top in the final graphic; it may help to think of the lines and objects as pieces of paper piled up on top of each other, so the last piece ends up on top of everything else.

2.2 Drawing the background grid

I used Metafun to draw the gray grid in the illustrations above. Metafun comes with ConT_EXt, so if you have ConT_EXt, your T_EX installation already includes it. Besides a plain grid, Metafun also supports creating slanted or logarithmic grids (see pages 213–214 in the Metafun manual).

First we define the grid, then draw it:

```
picture grid ;
grid := image (
  width := 10 ;
  height := 10 ;
  draw vlingrid (0, 10, 1, width, height)
  withcolor .8white ;
  draw hlingrid (0, 10, 1, height, width)
  withcolor .8white ;
) ;
draw grid withpen pencircle scaled 1/20 ;
```

I put the grid code in the beginning of my MetaPost file(s), and thus it gets drawn first and ends up in the background, behind all other elements. The numbers are standard labels, set with the `label ("labelname", (x,y))` command. For example: `label ("1", (-1/4u,1u)) ;`

2.3 Further reading

Metafun manual: <http://www.pragma-ade.com/general/manuals/metafun-p.pdf>.

Many examples work in plain MetaPost.

More graphical than, e.g., the user’s manual.

MetaPost user’s manual: <http://www.tug.org/docs/metapost/mpman.pdf>.

MetaPost, a very brief tutorial: <http://www.ursoswald.ch/metapost/tutorial.html>.

A more traditional approach to MetaPost.

Click on filenames to get the code!

MetaPost home page: <http://www.tug.org/metapost>.

Lots of links to other tutorials, examples, articles, packages, and more.

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