Paradigms: Just a little bit of PostScript

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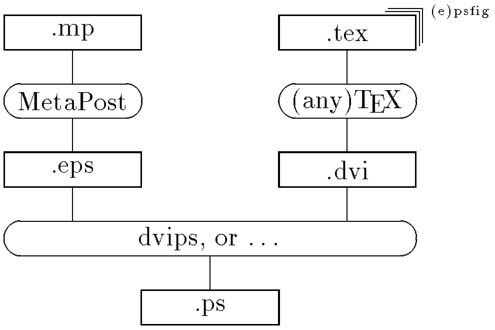
Keywords: Declarative program, education, EPS, Escher, graphics, imperative code, (LA)TEX, math graphs, METAFONT, merging EPS and (LA)TEX, MetaPost, mftoeps, PostScript, sideways tables, text along curved paths.

Abstract

It is all about creating EPS—with graphics—to be merged with (LA)TEX scripts. The emphasis is on creating raw PostScript for simple symmetrical pictures. Asides, like incorporating accurate graphs of math functions, typesetting text along curved paths, or tables set sideways have been addressed. A poor man's mftoeps approach is touched upon: (declarative) METAFONT into (imperative) PostScript.

BLUe's Design X

Hi folks. The user's guide which comes with BLUe's format system—Publishing with TEX, PWT for short—is processed *completely* by TEX, *no* other tools such as PostScript are needed.[1] However, of late I exercised METAFONT—well, eventually MetaPost with the help of Jos Winnink—for graphics to be included in TEX documents, and finally embarked PostScript straightaway to create EPS pictures.



PostScript is involuntary needed to (electronically) paste up the graphics, and as resulting file format.[2]

If we come to think of graphics as

just doing the 'right' strokes or fills

then PostScript provides the means for this: lines, splines and circular arcs, to be drawn or filled.[3] I use the sidestep

METAFONT →MetaPost → EPS

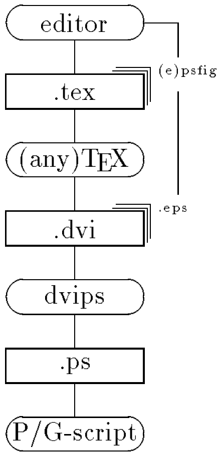
for general pictures but also for obtaining the right (control) points explicitly from a decalarative specification in METAFONT, as shown by Escher's knot at the end.[4]

[1] Nobody knows what the future has in store, but for the moment I consider it a good thing that the PWT guide can be processed just by TEX, well ... with BLUe's format.

[2] For exchange the `.tex` and (hand-coded) `.eps` files are much better suited because of their conciseness. This can't be beaten, not even by Adobe's PDF—Portable Document Format.

[3] PostScript II also provides for colors and processing in a network.

[4] Another way for arriving at the EPS code is to use Jackowski's **`mftoeps`** package or to use MetaPost.



With respect to graphics PostScript can be seen as a *little* language in the UNIX tradition.[5] A little bit of PostScript adheres the 80%–20% adage: 80% of the effects (or more) with 20% of the energy (or less).

One can with a little knowledge of PostScript code graphics immediately and *completely* in PostScript. The more so because of the ubiquitous public domain GhostScript previewers to verify the result, next to of course the PostScript laser printers.

Furthermore, text is just a special case of graphics, and merging just a little bit of text—malenki Russians would say—with the graphics goes equally simple at first glance.

And to end the lovesong the inclusion of accurate graphs of mathematical functions goes well via coding these in PostScript and including these as figures. (Of course Hobby's graph extension could be used as well, or other advanced graphics packages.) This is illustrated by a graph of the sine function to convey the idea.

PStricks is about *interfacing.* Not assuming knowledge of PostScript. This note discusses mainly *merging.* Is about extending your TEXpertise with just a little—tsjut-tsjut Russians would say—knowledge of PostScript rewarded by high returns.

Below I'll summarize what is needed from PostScript, and illustrate the use of it with a few examples, introducing en route the operators we need given the example.

PostScript

Processing PostScript comes with a user's guide (cookbook) and reference manual, the so-called blue and red books in the Adobe PostScript series. For processing PostScript an interpreter is needed, such as a PostScript laser printer or a GhostScript previewer. For inclusion in (LA)TEX I use the psfig macros.[6] Goossens in his PostScript and (LA)TEX, MAPS 92.1, nicely details about inclusion of PostScript.[7]

[5] See Bentley's Little languages in 'More programming pearls—Confessions from a coder.' Addison-Wesley.

[6] Courtesy Trevor J. Darrell.

[7] See also the LATEX Companion.

As with PDF I consider the post-processing capability *independently* from the tool which created the PostScript source, very powerful and flexible.

Subset 0 from the language PostScript is stack-oriented. This means that operations are prescribed in polish-reverse notation, also known as prefix notation, similar to the HP pocket calculators. Addition—use of operator `add`—for example is notated as follows.

```
2 3 add%yields 5 on the stack, 2 3 consumed
```

PostScript is artificially structured via structure information in comments, double %-ed comments. Programs which obey the Adobe structure are called conforming and this is usually needed for inclusion within (LA)TEX, especially the BoundingBox line is required.

Example *(Conforming EPS structure)*

```
%!PS EPS
%%Title: <name>
%%Creator: <name>
%%CreationData: <date>
%%BoundingBox: <llx> <lly> <urx> <ury>
%%DocumentFonts: (atend)
%%EndComments
<prolog>
%%EndProlog
%%Page: 0 1
<page 1>
%%Page: 1 2
<page 2>
%%Trailer
<...>
%%DocumentFonts: Times-Roman ...
%%Pages: 3
%%EOF
```

Creating and drawing paths is done by separate operators. For creating paths operations like `moveto` are provided while drawing goes via `stroke`.

```
0 0 moveto 0 10 lineto%create path
stroke%draw a v-line of 10pt height
```

Variables—names to be associated with their values—are handled via the so-called dictionaries. The functionality can also be obtained via procedures.

```
/size {10} def
```

The so-called literal name is preceded by a slash to distinguish the declaration from its invoke. The invoke is done by just the name, also called executable name. The procedure text is surrounded by curly braces. Parameters are absent too. The (operand) stack is used.

For graphics we have a CurrentTransformMatrix—CTM—which maps the user space on the device space, the printer or screen. Equally powerful is the concept of encapsulating graphics via `gsave` and `grestore`, that is the graphics state is local—encapsulated—after `gsave` until `grestore`.

Next to the CTM PostScript maintains the currentpoint and currentpath.

Batagelj, MAPS 95.1—Combining TEX and PostScript—provides an in a nutshell overview.[8] Another introduction is in Fokker en van Oostrum's 'Plaatjes in een tekst,' MAPS 94.2, next to a survey of drawing software.

Summary of (graphics) commands The following snapshot is borrowed from Gurari, well . . . a little modified.[9] Its main purpose is to show that the number of relevant graphics primitives is low. The functionalities will be dealt with along the way in the examples. For the details of the commands or the list of operators see the red book.[10]

Arithmetic and math operators

$\langle num\rangle$ $\langle num\rangle$ mul *num*
$\langle num\rangle$ sine *num*

Path construction operators

currentpoint x y
$\langle x\rangle$ $\langle y\rangle$ moveto
$\langle dx\rangle$ $\langle dy\rangle$ rmoveto
$\langle x\rangle$ $\langle y\rangle$lineto
$\langle dx\rangle$ $\langle dy\rangle$ rlineto
$\langle q_{1x}\rangle$ $\langle q_{1y}\rangle$ $\langle q_{2x}\rangle$ $\langle q_{2y}\rangle$ $\langle p_{2x}\rangle$ $\langle p_{2y}\rangle$ curveto
$\langle c_x\rangle$ $\langle c_y\rangle$ $\langle r\rangle$ $\langle ang_1\rangle$ $\langle ang_2\rangle$ arc

String operators

$\langle string\rangle$ $\langle num\rangle$ $\langle num\rangle$ getinterval

Character and font operators

\\$\langle fontname\rangle$ findfont
$\langle fontsize\rangle$ scalefont setfont
$\langle string\rangle$ show
`{`$\langle body\rangle$`}` $\langle string\rangle$ kshow

Graphics state operators

$\langle num\rangle$ setgray
$\langle num\rangle$ setlinewidth

Dictionary operators

/$\langle defname\rangle$ `{`$\langle body\rangle$`}` def

Coordinate system and matrix operators

$\langle num\rangle$ $\langle num\rangle$ translate
$\langle num\rangle$ $\langle num\rangle$ scale
$\langle num\rangle$ rotate

Relational, boolean, and bitwise operators

$\langle num\rangle$|$\langle string\rangle$ $\langle num\rangle$|$\langle string\rangle$ le *bool*

Control operators

$\langle bool\rangle$ `{`$\langle truepart\rangle$`}` `{`$\langle falsepart\rangle$`}` ifelse
$\langle num\rangle$ `{`$\langle body\rangle$`}` repeat
$\langle from\rangle$ $\langle step\rangle$ $\langle to\rangle$`{`$\langle body\rangle$`}` for

With prefix $\langle in\rangle$ $\langle operator\rangle$ $\langle result\rangle$ is elegant.

8 Nice are the hints to remove repeated parts from files which are generated by CorelDRAW and Mathematica, in order to reduce the size of the automatically generated and to be included files. (The idea is to remove duplicate 'dictionaries' which are included with each result.) The example of how to include graphs of math functions in a document is *very* useful. However, with respect to his first picture I would prefer to use the inherent symmetry in the data as opposed to providing all the data.

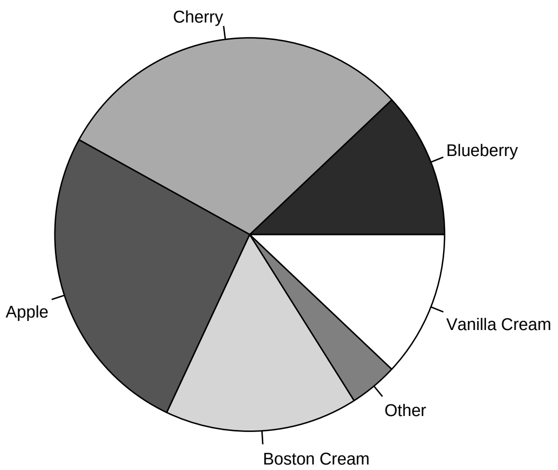
9 Gurari E.M (1994): TEX & LATEX—Drawing & Literate Programming. McGraw Hill. ISBN 0-07-025208-4.

10 A complete list with functional summaries is in the red book section 6.2 Operator summary.

What is not allowed as EPS? I'm not knowledgeable enough to answer that question, nor do I know of a full-blown definition of EPS. For the moment it is some subset which works with all interpretors, with my subset 0 in there. When one restricts oneself to the basics of graphics, arithmetic and similar operations then the boundary area between EPS and full PostScript—or its various implementations—is not in sight.

Documentation The red book—the reference manual—is generally recommended, though the blue book—the tutorial and cookbook—is also nice.[11]

Example *(Pie chart from the blue book)*



January Pie Sales

The invoke is essentially as follows and shows that the codes can be used straightforwardly.[12] It is no longer necessary to mesh around with the picture environment or so, to achieve the effect.

```
%preliminary matter
(January Pie Sales)
  24 12 %... array size
  [ [(Blueberry) .12 ]
    [(Cherry) .30 ]
    [(Apple) .26 ]
    [(Boston Cream) .16 ]
    [(Other) .04 ]
    [(Vanilla Cream) .12 ]
  ] 306 396%translate center to
    140    %size
    DrawPieChart
showpage
```

There is also a PostScript-FAQ, consult

```
ftp  wilma.cs.brown.edu:
     pub/comp.lang.postscript.
```

It contains an annotated bibliography as well.

The examples from Adobe's blue book are available on the net.

Proofing For previewing or printing, *as such* I have to include a shift to move the picture away from the lower left corner, say

```
300 500 translate
```

Inclusion I usually build a figure symmetrically around the origin and then include it via

```
$$\psfig{file=<name>,height=<number><unit>}$$
```

A unit can be `in`(ch), `cm`, and ilks. `\psfig` is very vulnerable to spaces because of TEX's parsing. So no spaces in there. Now and then I forget to inactivate the `translate` needed while previewing. No real problem.

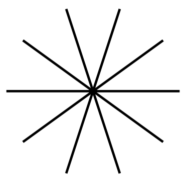
BoundingBox Providing the right BoundingBox coordinates has all to do with proper placement within context, the look-and-feel. Default PostScript assumes the origin—in user space—at the lower left corner of the paper—in device space.

Surround the picture by as-if lines and supply the coordinates, in points as units in user space coordinates, of the lower left corner and the upper right corner in the BoundingBox specification. Simple is to build a picture around its symmetry point—and let this coincide with the origin—with as pleasing result that the horizontal positioning comes out centered, when used within math display. Vertically, I add a 10 or so extra on either side in the BoundingBox specification, but that depends on the character of the picture.

Some preview systems can measure the BoundingBox and allow adjustment interactively.[13]

Writing PostScript A line bundle and a variant of it are introduced to show how to create simple EPS.

A line bundle



How to do this in PostScript? A line as such is simple. First a `moveto` and then a `lineto`. So a way is to create a loop and repeatedly draw from the origin to the end of the various lines. This can be done elegantly by using appropriately the CTM.

```
%!PS EPS
%%Title: Line bundle
```

[11] I used the PostScriptI red book and this is well-suited to get the flavour. For TEX and METAFONT this is similar. To grasp the basic ideas Knuth's first book is a more concise survey of the main lines of thought than *The TEXbook* and *The METAFONTbook*.

[12] It is not standard PostScript. We have to construct some kind of library to use the PostScript programs from. Maybe the CTAN as global network library? Copied on the various CD-ROMS?

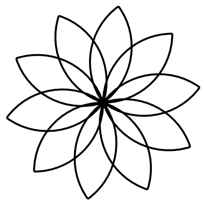
[13] For a summary of tools to assist finding the BoundingBox coordinates see, Reckdahl K (1995): Using EPS graphics in LATEX documents. reckdahl@leland.stanford.edu.

```
%%Creator: cgl
%%CreationDate: June 4 1996
%%BoundingBox: -40 -45 40 45
%%Pages: 1
%%EndProlog
%%Page: 1 1
/r 36 def
10{0 0 moveto r 0 lineto
   36 rotate
}repeat stroke showpage
```

Explanation. The idea is that first a simple line is draw, for example along the x-axes. What happens if after that we rotate? Right, the mapping is changed. And what happens if we supply the *same* line after this? Indeed, it will show up rotated. Because PostScript is an interpretive language we can realize this specification after the rotate via a loop, which for this simple case reads `10{...}repeat`.[14]

Appropriately maintaining the CTM for symmetrical pictures can yield simple looking PostScript programs.

A flower



This exercises the use of `arc`.

```
%!PS EPS
%%Title: Flower
%%Creator: cgl (Courtesy Papert)
%%CreationDate: June 4 1996
%%BoundingBox: -40 -45 40 45
%%Pages: 1
%%EndProlog
%%Page: 1 1
/r 36 def
10{r r moveto%begin drawing point
   r 0 r 90 180 arc
   currentpoint%origin
   0 r r 270 360 arc
   36 rotate
}repeat stroke showpage
```

Explanation. We have the same structure as the previous program but the 'line' is now a little more elaborated: two arcs of a circle. PostScript provides an operator for drawing circular arcs, called arc. The arc has (x, y) as centre, r as radius, ang_1 the angle of a vector from (x, y) of length r to the first endpoint of the arc, and ang_2 the angle of a vector from (x, y) of length r to the second endpoint of the arc.[15] These arguments are expected to be on the stack.

```
x y r ang1 ang2  arc
```

Important is to realize that arc *counts* its angle from (x, 0) and that the *drawing* starts from the point on the stack

The specification of the flower in METAFONT/METAPOST reads essentially as follows.

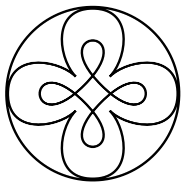
```
for k:= 1 upto 10:
draw(origin{up}..{right}(up+right){down}..
    {left}origin) rotated 36k;
endfor
```

Explanantion. METAFONT allows for specification of the directions[16] $up = (0, 1), right = (1, 0)$.

IMHO, with all respect the METAFONT and PostScript programs are similar modulo some syntactic sugar. However, the extra possibility of specifying the directions is more convenient than using control points. But perhaps that is a matter of taste, although the handling of control points is powerful as Bézier himself has shown in the past. From this I conclude that for these simple kinds of pictures we can as well use PostScript straightaway.

Some more Graphics

Example *(Malbork window)*
This is all about using `curveto`, especially choosing suitable control points.



```
%!PS EPS
%%Title: Malbork Window
%%Creator: cgl
%%CreationDate: May 21 1996
%%BoundingBox: -40 -40 40 40
%%Pages: 1
%%EndProlog
%%Page: 1 1
45 rotate 10 0 moveto
4{20 0 37.5 12.5 25 25 curveto
  12.5 37.5 0 20 0 10 curveto
 90 rotate
}repeat%inside lops next
5 0 moveto
4{5 35 35 5 0 5 curveto
  90 rotate
}repeat%enclosing circle next
36 0 moveto
0 0 36 0 360 arc
stroke showpage
```

[14] Do you see the variant for drawing a polygon? This duality linebundle and polygon has been used by Gabo and is about what he called stereometry versus perimetry, the structure versus the surface

[15] The arc is drawn counter clockwise. `arcn` draws clockwise.

[16] There is also a quartercircle which apart from orientation is drawn similarly.

Explanation. `translate` changes the CTM, with the effect that the device coordinates are shifted. (Useful for use of PostScript alone out of context.)

`rotate` changes the CTM, and because of being an interpretive language the various loop traversals map the *same* user coordinates on the rotated device coordinates.

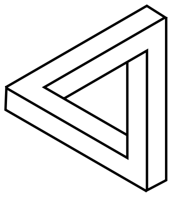
⟨*number*⟩{...} `repeat` is a loop to be traversed ⟨*number*⟩ of times.

`curveto` adds a spline to the current path from the currentpoint to the last point on the stack. The first two points are the so-called control points of the spline.[17]

`arc` adds a circular arc to the current path from the currentpoint.

The details of the arguments for the operators are nicely documented in the red book.

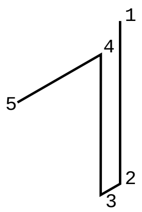
Example *(Escher's impossible triangle)*
This is all about *wrong* projections. However, these kinds of pictures are intriguing and fun. I consider them well-suited to illustrate PostScript's drawing capabilities.



```
%!PS EPS
%%Title: Escher's impossible triangle
%%Creator: cgl (inspired  by Guy Shaw)
%%CreationDate:  May 23 1996
%%BoundingBox: -40 -40 40 40
%%Pages: 1
%%EndProlog
%%Page: 1 1
3{25  34 moveto
  25 -34 lineto
  17 -38.2 lineto
  17 20 lineto
 -17.6 0 lineto
120 rotate
}repeat stroke showpage
```

5 points, the right stroke and a rotation or two, that's it. End of story.

However, it is all about finding those 5 points.




```
%!PS EPS
%%Title: Essential stroke
%%Creator: cgl (inspired  by Guy Shaw)
%%CreationDate: May 23 1996
%%BoundingBox: -40 -40 40 40
%%Pages: 1
%%EndProlog
%%Page: 0 1
25  34 moveto currentpoint
0  -68 rlineto currentpoint%down
  -120 rotate
25  34 lineto%preserve symmetry
   120 rotate currentpoint
17  20 lineto currentpoint
-17.6 0 lineto currentpoint
%labels
/Courier findfont 8 scalefont setfont
moveto -5 -3 rmoveto (5) show
moveto 1 1 rmoveto (4) show
moveto 2 -5 rmoveto (3) show
moveto 2 0 rmoveto (2) show
moveto 2 0 rmoveto (1) show
stroke showpage
```

Explanation. The essential stroke figure also illustrates the integration of text in this case digits. `currentpoint` pushes the point on the stack. The last `moveto`-s pop these coordinates up. `rmoveto` moves *relatively.*

And what about their relationships, and what about the minimal information to be prescribed?

Looking more closely it turns out that *only* the first point is all that is needed. The rest is implicit to the nature of the figure.[18]

```
%!PS EPS
%%Title: Escher's Impossible triangle II
%%Creator: cgl
%%CreationDate: May 23 1996
%%BoundingBox: -40 -40 40 40
%%Pages: 1
%%EndProlog
%%Page: 1 1
%Parameterized over p1
/point {25 34} def%note x<y
%
3{point moveto
currentpoint neg lineto%down
  -120 rotate
point  lineto%preserve symmetry
   120 rotate
currentpoint 2 div neg lineto
currentpoint 3 sqrt mul sub 0 lineto
120 rotate
}repeat stroke showpage
```

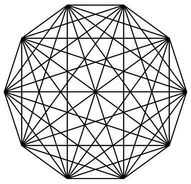
Explanation. `currentpoint` yields the coordinates of the current point of the path on the stack. The other operations do what their names suggest. The temporarily

[17] Much similar as in METAFONT. Choosing for the inner lop the control points in this way is borrowed from Haralambous Y (1995): Some METAFONT techniques. TUGboat 16, 1, 46–53. It is also supplied in the description of `curveto` in the red book.

[18] Of course one can also think of other equivalent parameters like size and thickness.

change of the CTM within the loop expresses the rotation symmetry relation between points 1 and 3.

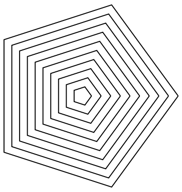
Example *(Bentley's polygon)*
This code is all about a double loop and using the loop variable from the stack, next to using the `gsave` and `grestore` advantageously.



```
%!PS EPS
%%Title: Bentley's double loop
%%Creator: cgl
%%CreationDate: May 30 1996
%%BoundingBox: -100 -105  100 105
%%EndProlog
10{1 1 9{100 0 moveto
         gsave
         36 mul rotate%loopcount*36
         100 0 lineto stroke
         grestore
   } for
   36 rotate
}repeat showpage
```

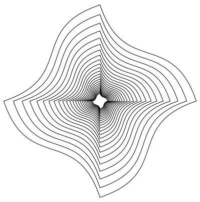
Explanantion. `gsave` and `grestore` are needed to draw locally, that is at the end the graphics state—currentpoint, currentpath and CTM—is restored with the values at the beginning. 1 1 9 stand for beginvalue step and endvalue of the `for` counter.

Example *(Another double loop)*
A set of nested polygons provide also a double loop situation.



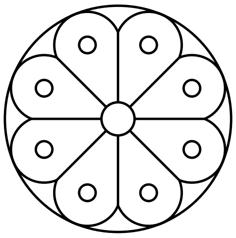
```
%!PS EPS Nested pentagons
%%Title: Pentagons
%%Creator: cgl
%%CreationDate: June 17 1996
%%BoundingBox: -100 -100 100 100
%%Pages: 1
%%EndProlog
%%Page: 1 1
10 10 100{dup 0 moveto
   5{72 rotate
     dup 0 lineto
     }repeat
}for stroke showpage
```

Example *(Polygons with splines as sides)*
This generalization of polygons was introduced by Jackowski at EuroTEX 95. A special case of METAFONT's interpath functionality is shown en-passant.



```
%!PS EPS Nested 'squares'
%%Title: polygon.eps II
%%Creator: cgl
%%CreationDate: June 17 1996
%%BoundingBox: -100 -100 100 100
%%Pages: 1
%%EndProlog
%%Page: 1 1
/r 100 def
/r1 {r .25 mul} def
/r3 {r .75 mul} def
25{r 0 moveto
   4{r3 r3 r1 r1 0 r curveto
     90 rotate
     }repeat
   .9 .9 scale
}repeat stroke showpage
```

Example *(Barn window)*
This is all about playing with circles and circular arcs.[19]



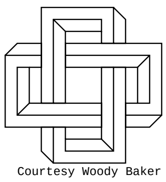
```
%!PS EPS
%%Title: Barn Window II
%%Creator: cgl
%%CreationDate: May 29 1996
%%BoundingBox: -45 -45 45 45
%%Pages: 1
%%EndProlog
%%Page: 1 1
/l 36 def
/r {l 22.5 sin mul} def
/m {l 22.5 cos mul} def
8{r .5 mul 0  moveto
  l 0 lineto
  currentpoint   %begin circular arc
```

19 The first example in the blue book collection provides a similar picture with gradually changing scales of grey.

```
    22.5 rotate m 0%center
    r              %radius
    -90 90 arc
    22.5 rotate
  }repeat
  %inner circle
  /rin {r .5 mul} def
  rin 0  moveto
  0 0 rin 0 360 arc
  %outer circle
  /rout {r m add} def
  rout 0  moveto
  0 0 rout 0 360 arc
  %extra circles
  /rin {r .25 mul} def
  22.5 rotate
  8{m rin add 0 moveto
    m 0 rin 0 360 arc
    45 rotate
  }repeat stroke showpage
```

I'm sure I'll come back some day and look again through this window, but then pastel colored.

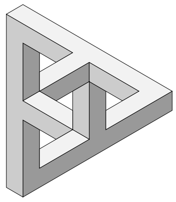
Example *(Baker's inspiration)*



This example is similar to Escher's impossible triangle. Find the essential stroke and rotate.

```
  %!PS EPS
  %%Creator: cgl (inspired  by Woody Baker)
  %%CreationDate: May 1996
  %%BoundingBox: -80 -80 80 80
  %%Pages: 1
  %%EndProlog
  %%Page: 1 1
  4{-15 25 moveto
      0 -10 rlineto
     60 0 rlineto
      0 -30 rlineto
     10 0 rlineto
      0 40 rlineto
    -70 0 rlineto
      0 10 rlineto
     80 0 rlineto
      0 -60 rlineto
    -30 0 rlineto
      0 10 rlineto
     10 0 rlineto
  %
     35 -25 moveto
      0 -10 rlineto
     20 0 rlineto
     10 10 rlineto
  %
     45 15 moveto
     10 10 rlineto
  90 rotate
  }repeat stroke
  %
  /Courier findfont 10 scalefont setfont
  -55 -75 moveto
  (Courtesy Woody Baker)show
  showpage
```

Example *(Romanovsky's real Escher)*

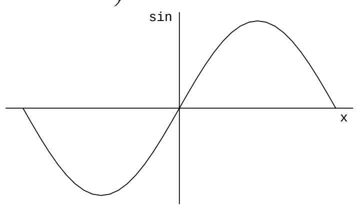


Grey scales can be obtained simply via $\langle number \rangle$ `setgray`, with $\langle number \rangle \in [0,1]$. 0 denotes black and 1 is white. The idea is to construct the essential path—the stroke denoted by a grey scale—and to use this 3 times.

Math graphs

In (LA)TEX documents it is a problem[20] how to include accurate graphs of mathematical functions. Because of PostScript's arithmetic and graphics capabilities it is handy to use PostScript.

Example *(Sine function)*




```
  %!PS EPS
  %%Title: Sine function
  %%Creator: cgl (inspired  by Batagelj)
  %%CreationDate: May 27 1996
  %%BoundingBox: -200 -110  200 110
  %%EndProlog
  /Courier findfont 15 scalefont setfont
  %figure scaled by 100
  %x-axes and label
  -200 0 moveto 200 0 lineto
  -15 -15 rmoveto (x) show
  %y-axes and label
  0 -110 moveto 0 110 lineto
  -35 -10 rmoveto (sin) show
  %function
  -180 0 moveto
```

[20] Communicated by Nico Temme. He solved the problem by doing the calculations in PASCAL. For advanced manipulations Mathematica or Mapple are generally used where the resulting EPS is pasted up in the (LA)TEX script as usual.

```
-180 10 180{%from step to
   dup sin 100 mul%(x, 100sin x)
   lineto
}for stroke showpage
```

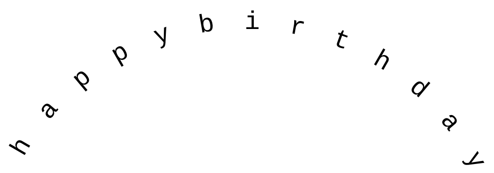
The invoke might read as follows.

```
$$\psfig{file=sine.eps,height=1in}$$
```

Text set along curved paths

A teaser. With the advent of scalable and rotationable outline fonts this is possible too.

Example *(Along a circle)*




```
%!PS EPS
%%Title: Typesetting along arcs
%%Creator: cgl
%%CreationDate: June 4 1996
%%BoundingBox: -100 50 100 125
%%Pages: 1
%%EndProlog
%%Page: 1 1
/Courier findfont 10 scalefont setfont
/text (happybirthday) def
50 rotate
0 1 12{0 100 moveto
  text exch 1 getinterval show
  -10 rotate
}for stroke showpage
```

Joseph Romanovsky communicated that `kshow`—kerning (and more general positioning) under user control—is available which allows a general def to be executed between two characters of a string.

Example *(Along a spiral)*

The blue book provides an example of typesetting along a path—a quotation of Woody Allen—where the path accentuates his filmmaker profession. The example below shows a nice effect with little knowledge of PostScript, essentially the use of `kshow`.

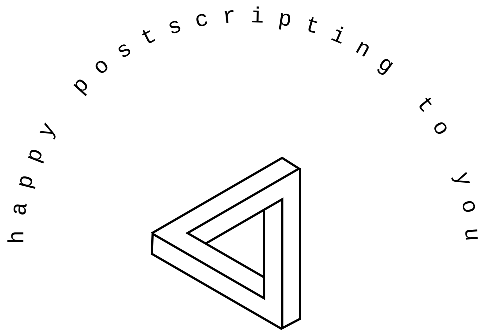

```
%!PS EPS
%%Title: Text along spiral
%%Creator: J.V. Romanovsky
%%BoundingBox: -100 -90 60 70
%%EndProlog
/Courier findfont 20 scalefont setfont
-100 0 moveto 50 rotate
{-10 rotate 3 0 rmoveto .98 .98 scale}
 (Olga Grineva my charming
  St Peterburg hostess)kshow
showpage
```

Example *(Seals)*
The problem has been discussed by Hoenig at EuroTEX 92, and Zlatuška at EuroTEX 95, both biased by METAFONT. PostScript alone is suited too with an overall simpler process. Combining two earlier supplied examples yields Zlatuška's seal in principle.[21]

```
%!PS EPS
%%Title: Seal, in principle
%%Creator: cgl
%%CreationDate: June 6 1996
%%BoundingBox: -110 -45 110 100
%%Pages: 1
%%EndProlog
%%Page: 1 1
%150 650 translate
/Courier findfont 10 scalefont setfont
/text (happy postscripting to you) def
/r 100 def
gsave
   90 rotate %begin orientation
   0 r moveto%begin point
{-7.04 rotate 0 r moveto} text kshow
grestore%next the central Escher
3{25  34 moveto
  25 -34 lineto
```

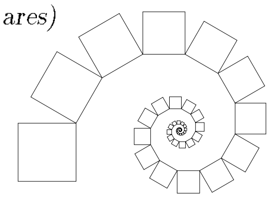
21 The blue book also provides a seal—Symphony No.9—but that is more complex and ipso facto requires more knowledge of PostScript to understand what is going on, IMHO, with all respect. To set this poster from the blue book is no more difficult than the use of `arc`, however. My example gives you the feeling that you understand what is going on, I hope.

```
    17 -38.2 lineto
    17 20 lineto
   -17.6 0 lineto
  120 rotate
  }repeat stroke showpage
```



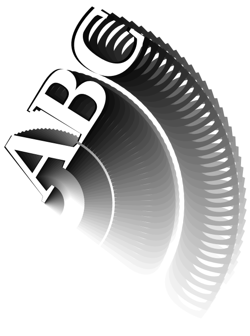
Remark. The difference of fonts in the main text and that used by PostScript is no longer there when PostScript fonts are used throughout, be it the PostScript version of the CM family.

Example *(Gurari's squares)*



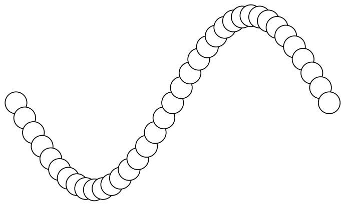
```
%!PS Gurari squares
%%BoundingBox: -200 -110  200 110
%%Creator: cgl
%%CreationDate: June 20 1996
%%EndProlog
/r 22 def
/square {1 1 4{0 r rlineto
         90 rotate}for} def
0 0 moveto 90 rotate
50{r 0 rmoveto square
   -30 rotate .9 .9 scale
}repeat stroke showpage
```

Example *(Gurari's ABC)*
Very nice this suggestion of motion.




```
%PostScript EPS
%%Title: Guarai's ABC
%%BoundingBox: 0 -45  100 75
%%Creator: Gurari
%%CreationDate: copied June 17 1996
%%Pages: 1
%%EndComments
%%EndProlog
%%Page: 1 1
/Times-Bold findfont 45 scalefont setfont
-40 rotate
1 -.03 0{setgray
         0 0 moveto
         (ABC) show
         3 rotate
        } for
0 0 moveto -4 rotate
1 setgray (ABC) show
showpage
```

Example *(Walking along the S-curve)*
In *The METAFONTbook* ex13.10 is about drawing overlapping disks along a path, the S-figure. How to do this in PostScript straightaway? There is no 'point of' a path operator so the best we can attain is to walk along a math function.



```
%PostScript Sine with overlapping disks
%%BoundingBox: -200 -110  200 110
%%Creator: cgl (METAFONTbook ex13.10)
%%CreationDate: June 17 1996
%%EndProlog
newpath
-180 10 180{dup sin 100 mul%(x, 100sin x)
    12.5 0 360 arc
    gsave 1 setgray fill grestore
    stroke
}for showpage
```

Explanation. `1 setgray fill` is the erase functionality, encapsulated to yield what we want.

Tables set sideways

Another teaser is to set tables rotated. Rokicki provided rotate macros along with his `dvips`, among others. I have borrowed the essence from his rotate macros and recast into the following.

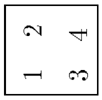
```
\def\rotate#1%stuff
           #2%degrees in PS direction
{\setbox\abox=\hbox{#1}%
 \adim\ht\abox\advance\adim by\dp\abox
 \hbox to\adim{\vbox to\wd\abox
 {\vskip\wd\abox
```

```
 \special{ps: gsave
    currentpoint currentpoint translate
    #2 neg rotate
    neg exch neg exch translate}%
 \box\abox\vss}\hss}%
 \special{ps: currentpoint
        gresture moveto}%
}%end rotate
```

The point is that it is not much. The `ps:` is dependent on the system still, alas.

Example *(Rotated table)*
The example works under UNIX with Rokicky's `dvips`.

```
\def\data{1\cs2\rs
          3\cs4 }
pre
\rotate{\framed
        \btable\data}
       {90}
post
```

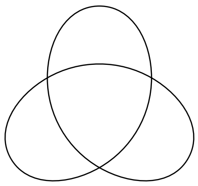
pre  post

Remark. Gurari (1994) has provided some more examples of PostScript↔(Al)DraTEX interaction. Real interfacing. Apart from portability problems it gets quite complicated. For the moment I refrain and code the 'pictures' in raw PostScript assisted by METAFONT for prompting control points of those curves which can be specified elegantly in a declarative way.

METAFONT/MetaPost user interface

Sometimes it is more natural to specify points and *directions*. It is true that specifying a control point along the direction can yield the same effect but the distance between the point and its control point influences the shape.

Example *(Escher's knot)*
This example is all about specifying directions.



In METAFONT the coding would read as follows.

```
%Escher's Knot. June 96. cgl@rc.service.rug.nl
def openit = openwindow currentwindow
   from origin to (screen_rows,screen_cols)
   at (-2r,3r)enddef;
pickup pencircle scaled 1;
tracingstats:=proofing:=1; screenstrokes;
pair p[];
%parameters
r:=100; alfa=90;
%
p2:=(0,.85r); %independent from p1,3,4
p4:=(0,-.5r);
%dependent points because of symmetry
p1:=p4 rotated -120;
p3:=p4 rotated  120;
path q;
q=p1{dir alfa}..{(1,0)}p2..
    {dir(-alfa)}p3..{dir(alfa-240)}p4;
draw q;
draw q rotated 120;
draw q rotated-120;
showit;
end
```

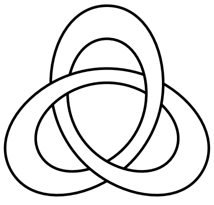
By the nature of the figure not only points are related but also their directions. How to cope with this in PostScript? It can be done but is not so elegant, honestly speaking cumbersome. But ... there is a solution or two, hang on.

```
%!PS EPS
%%Title: Escher knot II
%%Creator: cgl (inspired  by Knotplot)
%%CreationDate: June 1996
%%BoundingBox: -95 -95 95 95
%%Pages: 1
%%EndProlog
%%Page: 1 1
%
/angle 90 def
/r 100 def
/point {0 -.5 r mul}def
/p1 {-.25 r mul 3 sqrt mul  .25 r mul moveto
     currentpoint
     angle sin 2 mul add exch
     angle cos 2 mul add exch
     -20 .85 r mul
     0 .85 r mul
     curveto stroke} def
/p3 { .25 r mul 3 sqrt mul  .25 r mul moveto
     %Control point
     currentpoint
     angle sin -15 mul add  exch
     angle cos  15 mul add  exch
     %Control point:
     % 58.62 -.5 r mul 5 add%angle 90
     0          angle -240 add cos -15 mul add
      -.5 r mul angle -240 add sin -15 mul add
     0 -.5 r mul
     curveto stroke} def
3{p1
  gsave -1 1 scale p1 grestore%reflect
  p3
  120 rotate
}repeat showpage
```

Explanation. The essential curve is split into 3 pieces: $p_1, \ldots p_3$. The first two are related by reflection. The third must properly match. In the Columbus's egg paragraph the straight `.eps` code is given, biased by the knowledge of the (control) points.

A teaser More complicated is when the line is changed into a tube, and when we have to deal with hidden lines. In METAFONT the code could read as follows, where use is made of `intersectiontimes` and of subpaths.[22]

Example *(Escher's knot III)*
This example is all about getting from a *declarative* specification in METAFONT to a *imperative* EPS code.



First the declarative METAFONT code.

```
%Escher Knot III. June 96. cgl@rc.service.rug.nl
def openit = openwindow currentwindow
   from origin to (screen_rows,screen_cols)
   at (-2r,3r)enddef;
pickup pencircle scaled 1;
tracingstats:=proofing:=1; screenstrokes;
numeric t, u, v, w;
pair p[]; path q[];
def assignpoints=
 p2:=(0,.85r); %independent from p1,3,4
 p4:=(0,-.5r);
 %dependent points because of symmetry
 p1:=p4 rotated -120;
 p3:=p4 rotated  120;
enddef;
%
alfa=90;r:=100;  assignpoints;
q1:=p1{dir alfa}..{(1,0)}p2..
    {dir(-alfa)}p3..{dir(alfa-240)}p4;
%inside
        r:=.75r; assignpoints;
q2:=p1{dir alfa}..{(1,0)}p2..
 {dir(-alfa)}p3..{dir(alfa-240)}p4;
(t,u)= subpath (2.5,3) of q1
   intersectiontimes (q2 rotated -120);
(v,w)= q2 intersectiontimes
                      (q1 rotated 120);
%showvariable t,u;
draw subpath (0,2.5 + t/2) of q1;
draw subpath (0,2.5 + t/2) of q1
                           rotated 120;
draw subpath (0,2.5 + t/2) of q1
                           rotated-120;
%showvariable v,w;
draw subpath (v,3) of q2;
draw subpath (v,3) of q2 rotated 120;
draw subpath (v,3) of q2 rotated-120;
showit;
end
```

To give the reader an impression of what METAPOST will yield `escherknotIII.eps`, the imperative code, is included.[23]

```
%!PS EPS
%%BoundingBox: -40 -31 40 43
%%Creator: MetaPost and JJW, CGL
%%CreationDate: June 17 1996
%%Pages: 1
%%EndProlog
%%Page: 1 1
3{-21.6507 12.5 moveto
-21.6507 27.74551 -13.78212 42.5003
    0 42.5003 curveto
13.78212 42.5003 21.6507 27.74551
   21.6507 12.5 curveto
21.6507 -0.24506 16.04897 -12.19249
   6.58395 -20.3313 curveto
%
-14.3152 15.86746 moveto
-12.43301 23.58928 -7.45113 29.75021
   0 29.75021 curveto
9.64748 29.75021 15.15549 19.42186
   15.15549 8.75 curveto
15.15549 -2.07904 9.37823 -12.08548
   0 -17.5 curveto
120 rotate
}repeat stroke showpage
```

As can be seen from the last code it is all about finding the right (control) points and draw the strokes, as remarked at the beginning of this note. The difference between the declarative METAFONT specification and the resulting (unedited) METAPOST code is striking. When the last code is shown first one would say, ah…PostScript is easy just data and some strokes. The resulting code is equivalent to Woody Baker's code: just the right stroke and a rotation or two.

KnotPlot on the net provides a more complicated version where the light reflection is emulated by shades of grey. The gzipped file is 64KB, however. A world of difference.

Columbus' egg Why not use METAFONT to create 'the (control) points' from the descriptive picture and use these in raw PostScript straightaway?

After assigning `precontrol`-s and `postcontrol`-s to pairs and inserting `show`-s, METAFONT yielded for the simple Escher knot the data in the transcript file. A little editing of this log file resulted in the following imperative EPS code.

```
%!PS EPS
%%Title: Escher knot (mf prompted)
```

[22] This code works as such on my Mac with Bluesky's PD METAFONT. For other environments build a character from it, or adapt it for use in MetaPost, or even simpler copy the bread-and-butter EPS code which is appended at the end.

[23] A white lie. I have edited the file and reduced the data—and deleted `dtransform`, `idtransform` and the various `set`…—for the 6 strokes into only 2 and rotated these. METAFONT allowed me to declaratively specify the picture while MetaPost provided me with the essential path data. Well…even METAFONT can be asked to provide those (control) points.

```
%%Creator: cgl
%%CreationDate: June 1996
%%BoundingBox: -80 -80 80 80
%%Pages: 1
%%EndProlog
%%Page: 1 1
3{-43.30139 25 moveto
 -43.30139 55.49103 -27.56424 85.00061
  0 85.00061 curveto
  27.56424 85.00061 43.30139 55.49103
  43.30139 25 curveto
  43.30139 -5.94014 26.79497 -34.5299
  0 -50 curveto
120 rotate
}repeat stroke showpage
```

I presume the functionality is similar to Jackowski's `mftoeps`. The above method is my Poor Man's METAFONT2EPS, with concise, very concise and intelligible EPS as result.

Acknowledgements

First of all Don Knuth and John Hobby thank you.

Thank you Joseph Romanovsky for showing by example the power of PostScript, and for your cooperation on the METAFONT↔PostScript duality.

Thank you Bogusław Jackowski for your 'PostScript for TEXies' at BachoTEX 96, suggesting that PostScript as such is beneficial for TEXies, next to your mftoeps.

Thank you Eitan Gurari and anonymous TEXies of which I borrowed material, not in the least Adobe for providing PostScript to start with.

Piet Tutelaers provided me with a copy of the PSFAQ, and Erik Frambach traced the file with examples from the blue book, next to KnotPlot.

As usual Jos Winnink proofed the paper and lend a helping hand in procrusting towards MAPS inclusion if not for processing `escherknot.mf` into `escherknot.eps` via METAPOST.

Conclusion

To code symmetrical and simple curves in raw PostScript is fun and yields elegant scripts and concise files. To merge text with graphics is fun too, and the teaser to set along curved paths can be done by PostScript elegantly. Another teaser of drawing math curves accurately along with (LA)TEX is solved also by means of PostScript. Powerful too is to *extend* the inclusion of .eps files at the dvi level by a little more interaction between (LA)TEX and PostScript. Rotating a box, with as applications for example typesetting tables in landcape, is possible in PostScript, at the expense of system dependency because of the `\special`-s.

Merging a little knowledge of PostScript with TEXpertise is powerful. PStricks concentrates on *interfacing* (LA)TEX with PostScript at the expense of burdening (LA)TEX too much, IMHO, with all respect. For `\rotate` I interfaced too. However, for typesetting along curved paths I would not think of interfacing via rotated boxes or so.

Of course, people who do need advanced features or have special wishes might better use Adobe Illustrator, CorelDRAW, Mathematica, or Adobe Photoshop, and not to forget the pleasing MetaPost.

To understand and learn TEX did take me a couple of years. To acqaint myself with METAFONT did cost me a few months. Learning just a little bit of PostScript was a matter of weeks, and when concentrating on paths and (control) points the `moveto`, `arc` and `curveto` can be grasped in a late afternoon.

Although the blue book contains also examples of typesetting text, I consider TEX unsurpassed for this. The best of both worlds is to combine (LA)TEX and PostScript.

Maybe we should follow Adobe and extend the use of PostScript by PDF—or use the alternative HTML—to facilitate WWW surfing.

What more?

For pictures I use a TEX controlled database with the beneficial side-effect that I don't have to worry about file systems when using pictures (tools, references and ilks) on different machines. I would welcome a similar functionality for my collection of PostScript pictures to be used with `\psfig`.

A next step is the manipulation of colors either via METAPOST or PostScript directly. Jackowski uses Adobe Illustrator for example to enrich interactively the systematic EPS pictures created by METAFONT. Indeed interesting, very interesting, but beyond my possibilities for some time to come. Neither do I have access to color PostScript printers as yet, alas. My case rests.

Have fun, and all the best.

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