

File I

Implementation

1 l3draw implementation

```

1 <*initex | package>
2 <@@=draw>
3 <*package>
4 \ProvidesExplPackage{l3draw}{2018-09-24}{}
5 {L3 Experimental core drawing support}
6 </package>
7 \RequirePackage { l3color }
8
9 Everything else is in the sub-files!
10 </initex | package>

```

2 l3draw-paths implementation

```

9 <*initex | package>
10 <@@=draw>

```

This sub-module covers more-or-less the same ideas as `pgfcorepathconstruct.code.tex`, though using the expandable FPU means that the implementation often varies. At present, equivalents of the following are currently absent:

- `\pgfpatharcto`, `\pgfpatharctoprecomputed`: These are extremely specialised and are very complex in implementation. If the functionality is required, it is likely that it will be set up from scratch here.
- `\pgfpathparabola`: Seems to be unused other than defining a *TikZ* interface, which itself is then not used further.
- `\pgfpathsine`, `\pgfpathcosine`: Need to see exactly how these need to work, in particular whether a wider input range is needed and what approximation to make.
- `\pgfpathcurvebetweentime`, `\pgfpathcurvebetweentimecontinue`: These don't seem to be used at all.

```

\l__draw_path_tmp_tl Scratch space.
\l__draw_path_tmpa_fp 11 \tl_new:N \l__draw_path_tmp_tl
\l__draw_path_tmpb_fp 12 \fp_new:N \l__draw_path_tmpa_fp
13 \fp_new:N \l__draw_path_tmpb_fp

```

(End definition for `\l__draw_path_tmp_tl`, `\l__draw_path_tmpa_fp`, and `\l__draw_path_tmpb_fp`.)

2.1 Tracking paths

`\g__draw_path_lastx_dim` The last point visited on a path.

`\g__draw_path_lasty_dim` 14 `\dim_new:N \g__draw_path_lastx_dim`
15 `\dim_new:N \g__draw_path_lasty_dim`

(End definition for `\g__draw_path_lastx_dim` and `\g__draw_path_lasty_dim`.)

`\g__draw_path_xmax_dim` The limiting size of a path.

`\g__draw_path_xmin_dim` 16 `\dim_new:N \g__draw_path_xmax_dim`
17 `\dim_new:N \g__draw_path_xmin_dim`
18 `\dim_new:N \g__draw_path_ymax_dim`
19 `\dim_new:N \g__draw_path_ymin_dim`

(End definition for `\g__draw_path_xmax_dim` and others.)

`__draw_path_update_limits:nn` Track the limits of a path and (perhaps) of the picture as a whole. (At present the latter is always true: that will change as more complex functionality is added.)

`__draw_path_reset_limits:` 20 `\cs_new_protected:Npn __draw_path_update_limits:nn #1#2`
21 `{`
22 `\dim_gset:Nn \g__draw_path_xmax_dim`
23 `{ \dim_max:nn \g__draw_path_xmax_dim {#1} }`
24 `\dim_gset:Nn \g__draw_path_xmin_dim`
25 `{ \dim_min:nn \g__draw_path_xmin_dim {#1} }`
26 `\dim_gset:Nn \g__draw_path_ymax_dim`
27 `{ \dim_max:nn \g__draw_path_ymax_dim {#2} }`
28 `\dim_gset:Nn \g__draw_path_ymin_dim`
29 `{ \dim_min:nn \g__draw_path_ymin_dim {#2} }`
30 `\bool_if:NT \l_draw_bb_update_bool`
31 `{`
32 `\dim_gset:Nn \g__draw_xmax_dim`
33 `{ \dim_max:nn \g__draw_xmax_dim {#1} }`
34 `\dim_gset:Nn \g__draw_xmin_dim`
35 `{ \dim_min:nn \g__draw_xmin_dim {#1} }`
36 `\dim_gset:Nn \g__draw_ymax_dim`
37 `{ \dim_max:nn \g__draw_ymax_dim {#2} }`
38 `\dim_gset:Nn \g__draw_ymin_dim`
39 `{ \dim_min:nn \g__draw_ymin_dim {#2} }`
40 `}`
41 `}`
42 `\cs_new_protected:Npn __draw_path_reset_limits:`
43 `{`
44 `\dim_gset:Nn \g__draw_path_xmax_dim { -\c_max_dim }`
45 `\dim_gset:Nn \g__draw_path_xmin_dim { \c_max_dim }`
46 `\dim_gset:Nn \g__draw_path_ymax_dim { -\c_max_dim }`
47 `\dim_gset:Nn \g__draw_path_ymin_dim { \c_max_dim }`
48 `}`

(End definition for `__draw_path_update_limits:nn` and `__draw_path_reset_limits:.`)

`__draw_path_update_last:nn` A simple auxiliary to avoid repetition.

49 `\cs_new_protected:Npn __draw_path_update_last:nn #1#2`
50 `{`
51 `\dim_gset:Nn \g__draw_path_lastx_dim {#1}`
52 `\dim_gset:Nn \g__draw_path_lasty_dim {#2}`
53 `}`

(End definition for _draw_path_update_last:nn.)

2.2 Corner arcs

At the level of path *construction*, rounded corners are handled by inserting a marker into the path: that is then picked up once the full path is constructed. Thus we need to set up the appropriate data structures here, such that this can be applied every time it is relevant.

\l__draw_corner_xarc_dim The two arcs in use.

```
\l__draw_corner_yarc_dim 54 \dim_new:N \l__draw_corner_xarc_dim
55 \dim_new:N \l__draw_corner_yarc_dim
```

(End definition for \l__draw_corner_xarc_dim and \l__draw_corner_yarc_dim.)

\l__draw_corner_arc_bool A flag to speed up the repeated checks.

```
56 \bool_new:N \l__draw_corner_arc_bool
```

(End definition for \l__draw_corner_arc_bool.)

\draw_path_corner_arc:nn Calculate the arcs, check they are non-zero.

```
57 \cs_new_protected:Npn \draw_path_corner_arc:nn #1#2
58 {
59   \dim_set:Nn \l__draw_corner_xarc_dim {#1}
60   \dim_set:Nn \l__draw_corner_yarc_dim {#2}
61   \bool_lazy_and:nnTF
62     { \dim_compare_p:nNn \l__draw_corner_xarc_dim = { 0pt } }
63     { \dim_compare_p:nNn \l__draw_corner_yarc_dim = { 0pt } }
64     { \bool_set_false:N \l__draw_corner_arc_bool }
65     { \bool_set_true:N \l__draw_corner_arc_bool }
66 }
```

(End definition for \draw_path_corner_arc:nn. This function is documented on page ??.)

__draw_path_mark_corner: Mark up corners for arc post-processing.

```
67 \cs_new_protected:Npn \__draw_path_mark_corner:
68 {
69   \bool_if:NT \l__draw_corner_arc_bool
70   {
71     \__draw_softpath_roundpoint:VV
72       \l__draw_corner_xarc_dim
73       \l__draw_corner_yarc_dim
74   }
75 }
```

(End definition for __draw_path_mark_corner:.)

2.3 Basic path constructions

At present, stick to purely linear transformation support and skip the soft path business: that will likely need to be revisited later.

```

\draw_path_moveto:n
\draw_path_lineto:n
__draw_path_moveto:nn
__draw_path_lineto:nn
\draw_path_curveto:nnn
__draw_path_curveto:nnnnnn
76 \cs_new_protected:Npn \draw_path_moveto:n #1
77 {
78   __draw_point_process:nn
79   { __draw_path_moveto:nn }
80   { \draw_point_transform:n {#1} }
81 }
82 \cs_new_protected:Npn __draw_path_moveto:nn #1#2
83 {
84   __draw_path_update_limits:nn {#1} {#2}
85   __draw_softpath_moveto:nn {#1} {#2}
86   __draw_path_update_last:nn {#1} {#2}
87 }
88 \cs_new_protected:Npn \draw_path_lineto:n #1
89 {
90   __draw_point_process:nn
91   { __draw_path_lineto:nn }
92   { \draw_point_transform:n {#1} }
93 }
94 \cs_new_protected:Npn __draw_path_lineto:nn #1#2
95 {
96   __draw_path_mark_corner:
97   __draw_path_update_limits:nn {#1} {#2}
98   __draw_softpath_lineto:nn {#1} {#2}
99   __draw_path_update_last:nn {#1} {#2}
100 }
101 \cs_new_protected:Npn \draw_path_curveto:nnn #1#2#3
102 {
103   __draw_point_process:nnn
104   {
105     __draw_point_process:nn
106     {
107       __draw_path_mark_corner:
108       __draw_path_curveto:nnnnnn
109     }
110     { \draw_point_transform:n {#1} }
111   }
112   { \draw_point_transform:n {#2} }
113   { \draw_point_transform:n {#3} }
114 }
115 \cs_new_protected:Npn __draw_path_curveto:nnnnnn #1#2#3#4#5#6
116 {
117   __draw_path_update_limits:nn {#1} {#2}
118   __draw_path_update_limits:nn {#3} {#4}
119   __draw_path_update_limits:nn {#5} {#6}
120   __draw_softpath_curveto:nnnnnn {#1} {#2} {#3} {#4} {#5} {#6}
121   __draw_path_update_last:nn {#5} {#6}
122 }

```

(End definition for \draw_path_moveto:n and others. These functions are documented on page ??.)

`\draw_path_close:` A simple wrapper.

```

123 \cs_new_protected:Npn \draw_path_close:
124 {
125     \__draw_path_mark_corner:
126     \__draw_softpath_closepath:
127 }

```

(End definition for `\draw_path_close:`. This function is documented on page ??.)

2.4 Canvas path constructions

`\draw_path_canvas_moveto:n` Operations with no application of the transformation matrix.

```

\draw_path_canvas_lineto:n
\draw_path_canvas_curveto:nnn
128 \cs_new_protected:Npn \draw_path_canvas_moveto:n #1
129 { \__draw_point_process:nn { \__draw_path_moveto:nn } {#1} }
130 \cs_new_protected:Npn \draw_path_canvas_lineto:n #1
131 { \__draw_point_process:nn { \__draw_path_lineto:nn } {#1} }
132 \cs_new_protected:Npn \draw_path_canvas_curveto:nnn #1#2#3
133 {
134     \__draw_point_process:nnn
135     {
136         \__draw_point_process:nn
137         {
138             \__draw_path_mark_corner:
139             \__draw_path_curveto:nnnnnn
140         }
141         {#1}
142     }
143     {#2} {#3}
144 }

```

(End definition for `\draw_path_canvas_moveto:n`, `\draw_path_canvas_lineto:n`, and `\draw_path_canvas_curveto:nnn`. These functions are documented on page ??.)

2.5 Computed curves

More complex operations need some calculations. To assist with those, various constants are pre-defined.

`\draw_path_curveto:nn` A quadratic curve with one control point (x_c, y_c) . The two required control points are then

$$x_1 = \frac{1}{3}x_s + \frac{2}{3}x_c \quad y_1 = \frac{1}{3}y_s + \frac{2}{3}y_c$$

`\c__draw_path_curveto_a_fp`
`\c__draw_path_curveto_b_fp`

and

$$x_2 = \frac{1}{3}x_e + \frac{2}{3}x_c \quad x_2 = \frac{1}{3}y_e + \frac{2}{3}y_c$$

using the start (last) point (x_s, y_s) and the end point (x_e, y_e) .

```

145 \cs_new_protected:Npn \draw_path_curveto:nn #1#2
146 {
147     \__draw_point_process:nnn
148     { \__draw_path_curveto:nnnn }
149     { \draw_point_transform:n {#1} }
150     { \draw_point_transform:n {#2} }
151 }

```

```

152 \cs_new_protected:Npn \__draw_path_curveto:nnnn #1#2#3#4
153 {
154   \fp_set:Nn \l__draw_path_tmpa_fp { \c__draw_path_curveto_b_fp * #1 }
155   \fp_set:Nn \l__draw_path_tmpb_fp { \c__draw_path_curveto_b_fp * #2 }
156   \use:x
157   {
158     \__draw_path_mark_corner:
159     \__draw_path_curveto:nnnnnn
160     {
161       \fp_to_dim:n
162       {
163         \c__draw_path_curveto_a_fp * \g__draw_path_lastx_dim
164         + \l__draw_path_tmpa_fp
165       }
166     }
167     {
168       \fp_to_dim:n
169       {
170         \c__draw_path_curveto_a_fp * \g__draw_path_lasty_dim
171         + \l__draw_path_tmpb_fp
172       }
173     }
174     {
175       \fp_to_dim:n
176       { \c__draw_path_curveto_a_fp * #3 + \l__draw_path_tmpa_fp }
177     }
178     {
179       \fp_to_dim:n
180       { \c__draw_path_curveto_a_fp * #4 + \l__draw_path_tmpb_fp }
181     }
182     {#3}
183     {#4}
184   }
185 }
186 \fp_const:Nn \c__draw_path_curveto_a_fp { 1 / 3 }
187 \fp_const:Nn \c__draw_path_curveto_b_fp { 2 / 3 }

```

(End definition for \draw_path_curveto:nn and others. This function is documented on page ??.)

<pre> \draw_path_arc:nnn \draw_path_arc:nnnn __draw_path_arc:nnnn __draw_path_arc:nnNnn __draw_path_arc_auxi:nnnnNnn __draw_path_arc_auxi:fnnnNnn __draw_path_arc_auxi:fnfnNnn __draw_path_arc_auxii:nnnNnnnn __draw_path_arc_auxiii:nn __draw_path_arc_auxiv:nnnn __draw_path_arc_auxv:nn __draw_path_arc_auxvi:nn __draw_path_arc_add:nnnn \l__draw_path_arc_delta_fp \l__draw_path_arc_start_fp \c__draw_path_arc_90_fp \c__draw_path_arc_60_fp </pre>	<p>Drawing an arc means dividing the total curve required into sections: using Bézier curves we can cover at most 90° at once. To allow for later manipulations, we aim to have roughly equal last segments to the line, with the split set at a final part of 115°.</p> <pre> 188 \cs_new_protected:Npn \draw_path_arc:nnn #1#2#3 189 { \draw_path_arc:nnnn {#1} {#2} {#3} {#3} } 190 \cs_new_protected:Npn \draw_path_arc:nnnn #1#2#3#4 191 { 192 \use:x 193 { 194 __draw_path_arc:nnnn 195 { \fp_eval:n {#1} } 196 { \fp_eval:n {#2} } 197 { \fp_to_dim:n {#3} } 198 { \fp_to_dim:n {#4} } 199 } </pre>
--	---

```

200 }
201 \cs_new_protected:Npn \__draw_path_arc:nnnn #1#2#3#4
202 {
203   \fp_compare:nNnTF {#1} > {#2}
204   { \__draw_path_arc:nnNnn {#1} {#2} - {#3} {#4} }
205   { \__draw_path_arc:nnNnn {#1} {#2} + {#3} {#4} }
206 }
207 \cs_new_protected:Npn \__draw_path_arc:nnNnn #1#2#3#4#5
208 {
209   \fp_set:Nn \l__draw_path_arc_start_fp {#1}
210   \fp_set:Nn \l__draw_path_arc_delta_fp { abs( #1 - #2 ) }
211   \fp_while_do:nNnn { \l__draw_path_arc_delta_fp } > { 90 }
212   {
213     \fp_compare:nNnTF \l__draw_path_arc_delta_fp > { 115 }
214     {
215       \__draw_path_arc_auxi:ffnnNnn
216       { \fp_to_decimal:N \l__draw_path_arc_start_fp }
217       { \fp_eval:n { \l__draw_path_arc_start_fp #3 90 } }
218       { 90 } {#2}
219       #3 {#4} {#5}
220     }
221     {
222       \__draw_path_arc_auxi:ffnnNnn
223       { \fp_to_decimal:N \l__draw_path_arc_start_fp }
224       { \fp_eval:n { \l__draw_path_arc_start_fp #3 60 } }
225       { 60 } {#2}
226       #3 {#4} {#5}
227     }
228   }
229   \__draw_path_mark_corner:
230   \__draw_path_arc_auxi:fnfnNnn
231   { \fp_to_decimal:N \l__draw_path_arc_start_fp }
232   {#2}
233   { \fp_eval:n { abs( \l__draw_path_arc_start_fp - #2 ) } }
234   {#2}
235   #3 {#4} {#5}
236 }

```

The auxiliary is responsible for calculating the required points. The “magic” number required to determine the length of the control vectors is well-established for a right-angle: $\frac{4}{3}(\sqrt{2} - 1) = 0.552\,284\,75$. For other cases, we follow the calculation used by `pgf` but with the second common case of 60° pre-calculated for speed.

```

237 \cs_new_protected:Npn \__draw_path_arc_auxi:nnnnNnn #1#2#3#4#5#6#7
238 {
239   \use:x
240   {
241     \__draw_path_arc_auxii:nnnnNnnnn
242     {#1} {#2} {#4} #5 {#6} {#7}
243     {
244       \fp_to_dim:n
245       {
246         \cs_if_exist_use:cF
247         { c__draw_path_arc_ #3 _fp }
248         { 4/3 * tand( 0.25 * #3 ) }

```

```

249         * #6
250     }
251 }
252 {
253     \fp_to_dim:n
254     {
255         \cs_if_exist_use:cF
256         { c__draw_path_arc_ #3 _fp }
257         { 4/3 * tand( 0.25 * #3 ) }
258         * #7
259     }
260 }
261 }
262 }
263 \cs_generate_variant:Nn \__draw_path_arc_auxi:nnnnNnn { fnf , ff }

```

We can now calculate the required points. As everything here is non-expandable, that is best done by using x-type expansion to build up the tokens. The three points are calculated out-of-order, since finding the second control point needs the position of the end point. Once the points are found, fire-off the fundamental path operation and update the record of where we are up to. The final point has to be

```

264 \cs_new_protected:Npn \__draw_path_arc_auxii:nnnnNnnnn #1#2#3#4#5#6#7#8
265 {
266     \tl_clear:N \l__draw_path_tmp_tl
267     \__draw_point_process:nn
268     { \__draw_path_arc_auxiii:nn }
269     {
270         \__draw_point_transform_noshift:n
271         { \draw_point_polar:nnn { #1 #4 90 } {#7} {#8} }
272     }
273     \__draw_point_process:nn
274     {
275         \__draw_point_process:nn
276         { \__draw_path_arc_auxiv:nnnn }
277         {
278             \draw_point_transform:n
279             { \draw_point_polar:nnn {#1} {#5} {#6} }
280         }
281     }
282     {
283         \draw_point_transform:n
284         { \draw_point_polar:nnn {#2} {#5} {#6} }
285     }
286     \__draw_point_process:nn
287     { \__draw_path_arc_auxv:nn }
288     {
289         \__draw_point_transform_noshift:n
290         { \draw_point_polar:nnn { #2 #4 -90 } {#7} {#8} }
291     }
292     \exp_after:wN \__draw_path_curveto:nnnnnn \l__draw_path_tmp_tl
293     \fp_set:Nn \l__draw_path_arc_delta_fp { abs ( #2 - #3 ) }
294     \fp_set:Nn \l__draw_path_arc_start_fp {#2}
295 }

```

The first control point.


```

296 \cs_new_protected:Npn \__draw_path_arc_auxiii:nn #1#2
297 {
298   \__draw_path_arc_aux_add:nn
299   { \g__draw_path_lastx_dim + #1 }
300   { \g__draw_path_lasty_dim + #2 }
301 }

```

The end point: simple arithmetic.

```

302 \cs_new_protected:Npn \__draw_path_arc_auxiv:nnnn #1#2#3#4
303 {
304   \__draw_path_arc_aux_add:nn
305   { \g__draw_path_lastx_dim - #1 + #3 }
306   { \g__draw_path_lasty_dim - #2 + #4 }
307 }

```

The second control point: extract the last point, do some rearrangement and record.

```

308 \cs_new_protected:Npn \__draw_path_arc_auxv:nn #1#2
309 {
310   \exp_after:wN \__draw_path_arc_auxvi:nn
311   \l__draw_path_tmp_tl {#1} {#2}
312 }
313 \cs_new_protected:Npn \__draw_path_arc_auxvi:nn #1#2#3#4#5#6
314 {
315   \tl_set:Nn \l__draw_path_tmp_tl { {#1} {#2} }
316   \__draw_path_arc_aux_add:nn
317   { #5 + #3 }
318   { #6 + #4 }
319   \tl_put_right:Nn \l__draw_path_tmp_tl { {#3} {#4} }
320 }
321 \cs_new_protected:Npn \__draw_path_arc_aux_add:nn #1#2
322 {
323   \tl_put_right:Nx \l__draw_path_tmp_tl
324   { { \fp_to_dim:n {#1} } { \fp_to_dim:n {#2} } }
325 }
326 \fp_new:N \l__draw_path_arc_delta_fp
327 \fp_new:N \l__draw_path_arc_start_fp
328 \fp_const:cn { c__draw_path_arc_90_fp } { 4/3 * (sqrt(2) - 1) }
329 \fp_const:cn { c__draw_path_arc_60_fp } { 4/3 * tand(15) }

```

(End definition for \draw_path_arc:nnn and others. These functions are documented on page ??.)

\draw_path_arc_axes:nnnn A simple wrapper.

```

330 \cs_new_protected:Npn \draw_path_arc_axes:nnnn #1#2#3#4
331 {
332   \draw_transform_triangle:nnn { 0cm , 0cm } {#3} {#4}
333   \draw_path_arc:nnn {#1} {#2} { 1pt }
334 }

```

(End definition for \draw_path_arc_axes:nnnn. This function is documented on page ??.)

\draw_path_ellipse:nnn Drawing an ellipse is an optimised version of drawing an arc, in particular reusing the same constant. We need to deal with the ellipse in four parts and also deal with moving to the right place, closing it and ending up back at the center. That is handled on a per-arc basis, each in a separate auxiliary for readability.

```

\__draw_path_ellipse:nnnnnn
  \__draw_path_ellipse_arci:nnnnnn
  \__draw_path_ellipse_arci:nnnnnn
  \__draw_path_ellipse_arci:nnnnnn
  \__draw_path_ellipse_arci:nnnnnn
335 \cs_new_protected:Npn \draw_path_ellipse:nnn #1#2#3
\c__draw_path_ellipse_fp

```

```

336 {
337   \__draw_point_process:nnn
338   {
339     \__draw_point_process:nn
340     { \__draw_path_ellipse:nnnnnn }
341     { \draw_point_transform:n {#1} }
342   }
343   { \__draw_point_transform_noshift:n {#2} }
344   { \__draw_point_transform_noshift:n {#3} }
345 }
346 \cs_new_protected:Npn \__draw_path_ellipse:nnnnnn #1#2#3#4#5#6
347 {
348   \use:x
349   {
350     \__draw_path_moveto:nn
351     { \fp_to_dim:n { #1 + #3 } } { \fp_to_dim:n { #2 + #4 } }
352     \__draw_path_ellipse_arci:nnnnnn {#1} {#2} {#3} {#4} {#5} {#6}
353     \__draw_path_ellipse_arcii:nnnnnn {#1} {#2} {#3} {#4} {#5} {#6}
354     \__draw_path_ellipse_arciiii:nnnnnn {#1} {#2} {#3} {#4} {#5} {#6}
355     \__draw_path_ellipse_arciv:nnnnnn {#1} {#2} {#3} {#4} {#5} {#6}
356   }
357   \__draw_softpath_closepath:
358   \__draw_path_moveto:nn {#1} {#2}
359 }
360 \cs_new:Npn \__draw_path_ellipse_arci:nnnnnn #1#2#3#4#5#6
361 {
362   \__draw_path_curveto:nnnnnn
363   { \fp_to_dim:n { #1 + #3 + #5 * \c__draw_path_ellipse_fp } }
364   { \fp_to_dim:n { #2 + #4 + #6 * \c__draw_path_ellipse_fp } }
365   { \fp_to_dim:n { #1 + #3 * \c__draw_path_ellipse_fp + #5 } }
366   { \fp_to_dim:n { #2 + #4 * \c__draw_path_ellipse_fp + #6 } }
367   { \fp_to_dim:n { #1 + #5 } }
368   { \fp_to_dim:n { #2 + #6 } }
369 }
370 \cs_new:Npn \__draw_path_ellipse_arcii:nnnnnn #1#2#3#4#5#6
371 {
372   \__draw_path_curveto:nnnnnn
373   { \fp_to_dim:n { #1 - #3 * \c__draw_path_ellipse_fp + #5 } }
374   { \fp_to_dim:n { #2 - #4 * \c__draw_path_ellipse_fp + #6 } }
375   { \fp_to_dim:n { #1 - #3 + #5 * \c__draw_path_ellipse_fp } }
376   { \fp_to_dim:n { #2 - #4 + #6 * \c__draw_path_ellipse_fp } }
377   { \fp_to_dim:n { #1 - #3 } }
378   { \fp_to_dim:n { #2 - #4 } }
379 }
380 \cs_new:Npn \__draw_path_ellipse_arciiii:nnnnnn #1#2#3#4#5#6
381 {
382   \__draw_path_curveto:nnnnnn
383   { \fp_to_dim:n { #1 - #3 - #5 * \c__draw_path_ellipse_fp } }
384   { \fp_to_dim:n { #2 - #4 - #6 * \c__draw_path_ellipse_fp } }
385   { \fp_to_dim:n { #1 - #3 * \c__draw_path_ellipse_fp - #5 } }
386   { \fp_to_dim:n { #2 - #4 * \c__draw_path_ellipse_fp - #6 } }
387   { \fp_to_dim:n { #1 - #5 } }
388   { \fp_to_dim:n { #2 - #6 } }
389 }

```

```

390 \cs_new:Npn \__draw_path_ellipse_arciv:nnnnnn #1#2#3#4#5#6
391 {
392   \__draw_path_curveto:nnnnnn
393   { \fp_to_dim:n { #1 + #3 * \c__draw_path_ellipse_fp - #5 } }
394   { \fp_to_dim:n { #2 + #4 * \c__draw_path_ellipse_fp - #6 } }
395   { \fp_to_dim:n { #1 + #3 - #5 * \c__draw_path_ellipse_fp } }
396   { \fp_to_dim:n { #2 + #4 - #6 * \c__draw_path_ellipse_fp } }
397   { \fp_to_dim:n { #1 + #3 } }
398   { \fp_to_dim:n { #2 + #4 } }
399 }
400 \fp_const:Nn \c__draw_path_ellipse_fp { \fp_use:c { c__draw_path_arc_90_fp } }

```

(End definition for \draw_path_ellipse:nnn and others. This function is documented on page ??.)

\draw_path_circle:nn A shortcut.

```

401 \cs_new_protected:Npn \draw_path_circle:nn #1#2
402 { \draw_path_ellipse:nnn {#1} { #2 , Opt } { Opt , #2 } }

```

(End definition for \draw_path_circle:nn. This function is documented on page ??.)

2.6 Rectangles

\draw_path_rectangle:nn Building a rectangle can be a single operation, or for rounded versions will involve step-by-step construction.

```

\__draw_path_rectangle:nnnn
\__draw_path_rectangle_rounded:nnnn
403 \cs_new_protected:Npn \draw_path_rectangle:nn #1#2
404 {
405   \__draw_point_process:nnn
406   {
407     \bool_lazy_or:nnTF
408     { \l__draw_corner_arc_bool }
409     { \l__draw_matrix_active_bool }
410     { \__draw_path_rectangle_rounded:nnnn }
411     { \__draw_path_rectangle:nnnn }
412   }
413   { \draw_point_transform:n {#1} }
414   {#2}
415 }
416 \cs_new_protected:Npn \__draw_path_rectangle:nnnn #1#2#3#4
417 {
418   \__draw_path_update_limits:nn {#1} {#2}
419   \__draw_path_update_limits:nn { #1 + #3 } { #2 + #4 }
420   \__draw_softpath_rectangle:nnnn {#1} {#2} {#3} {#4}
421   \__draw_path_update_last:nn {#1} {#2}
422 }
423 \cs_new_protected:Npn \__draw_path_rectangle_rounded:nnnn #1#2#3#4
424 {
425   \draw_path_moveto:n { #1 + #3 , #2 + #4 }
426   \draw_path_lineto:n { #1 , #2 + #4 }
427   \draw_path_lineto:n { #1 , #2 }
428   \draw_path_lineto:n { #1 + #3 , #2 }
429   \draw_path_close:
430   \draw_path_moveto:n { #1 , #2 }
431 }

```

(End definition for `\draw_path_rectangle:nn`, `__draw_path_rectangle:nnnn`, and `__draw_path_rectangle_rounded:nnnn`. This function is documented on page ??.)

```

\draw_path_rectangle_corners:nn Another shortcut wrapper.
\__draw_path_rectangle_corners:nnnn
432 \cs_new_protected:Npn \draw_path_rectangle_corners:nn #1#2
433 {
434   \__draw_point_process:nnn
435   { \__draw_path_rectangle_corners:nnnnn {#1} }
436   {#1} {#2}
437 }
438 \cs_new_protected:Npn \__draw_path_rectangle_corners:nnnnn #1#2#3#4#5
439 { \draw_path_rectangle:nn {#1} { #4 - #2 , #5 - #3 } }

```

(End definition for `\draw_path_rectangle_corners:nn` and `__draw_path_rectangle_corners:nnnn`. This function is documented on page ??.)

2.7 Grids

`\draw_path_grid:nnnn` The main complexity here is lining up the grid correctly. To keep it simple, we tidy up the argument ordering first.

```

\__draw_path_grid_auxi:nnnnnn
\__draw_path_grid_auxi:ffnnnn
\__draw_path_grid_auxii:nnnnnn
\__draw_path_grid_auxiii:nnnnnn
\__draw_path_grid_auxiiii:ffnnnn
\__draw_path_grid_auxiv:nnnnnnnn
\__draw_path_grid_auxiv:ffnnnnnn
440 \cs_new_protected:Npn \draw_path_grid:nnnn #1#2#3#4
441 {
442   \__draw_point_process:nnn
443   {
444     \__draw_path_grid_auxi:ffnnnn
445     { \dim_eval:n { \dim_abs:n {#1} } } }
446     { \dim_eval:n { \dim_abs:n {#2} } } }
447   }
448   {#3} {#4}
449 }
450 \cs_new_protected:Npn \__draw_path_grid_auxi:nnnnnn #1#2#3#4#5#6
451 {
452   \dim_compare:nNnTF {#3} > {#5}
453   { \__draw_path_grid_auxii:nnnnnn {#1} {#2} {#5} {#4} {#3} {#6} }
454   { \__draw_path_grid_auxii:nnnnnn {#1} {#2} {#3} {#4} {#5} {#6} }
455 }
456 \cs_generate_variant:Nn \__draw_path_grid_auxi:nnnnnn { ff }
457 \cs_new_protected:Npn \__draw_path_grid_auxii:nnnnnn #1#2#3#4#5#6
458 {
459   \dim_compare:nNnTF {#4} > {#6}
460   { \__draw_path_grid_auxiii:nnnnnn {#1} {#2} {#3} {#6} {#5} {#4} }
461   { \__draw_path_grid_auxiii:nnnnnn {#1} {#2} {#3} {#4} {#5} {#6} }
462 }
463 \cs_new_protected:Npn \__draw_path_grid_auxiii:nnnnnn #1#2#3#4#5#6
464 {
465   \__draw_path_grid_auxiv:ffnnnnnn
466   { \fp_to_dim:n { #1 * trunc(#3/(#1)) } } }
467   { \fp_to_dim:n { #2 * trunc(#4/(#2)) } } }
468   {#1} {#2} {#3} {#4} {#5} {#6}
469 }
470 \cs_new_protected:Npn \__draw_path_grid_auxiv:nnnnnnnn #1#2#3#4#5#6#7#8
471 {
472   \dim_step_inline:nnnn
473   {#1}

```

```

474     {#3}
475     {#7}
476     {
477         \draw_path_moveto:n { ##1 , #6 }
478         \draw_path_lineto:n { ##1 , #8 }
479     }
480     \dim_step_inline:nnnn
481     {#2}
482     {#4}
483     {#8}
484     {
485         \draw_path_moveto:n { #5 , ##1 }
486         \draw_path_lineto:n { #7 , ##1 }
487     }
488 }
489 \cs_generate_variant:Nn \__draw_path_grid_auxiv:nnnnnnnn { ff }

```

(End definition for \draw_path_grid:nnnn and others. This function is documented on page ??.)

2.8 Using paths

Actions to pass to the driver.

```

\l__draw_path_use_clip_bool
\l__draw_path_use_fill_bool
    \l__draw_path_use_stroke_bool
490 \bool_new:N \l__draw_path_use_clip_bool
491 \bool_new:N \l__draw_path_use_fill_bool
492 \bool_new:N \l__draw_path_use_stroke_bool

```

(End definition for \l__draw_path_use_clip_bool, \l__draw_path_use_fill_bool, and \l__draw_path_use_stroke_bool.)

Actions handled at the macro layer.

```

\l__draw_path_use_bb_bool
\l__draw_path_use_clear_bool
493 \bool_new:N \l__draw_path_use_bb_bool
494 \bool_new:N \l__draw_path_use_clear_bool

```

(End definition for \l__draw_path_use_bb_bool and \l__draw_path_use_clear_bool.)

There are a range of actions which can apply to a path: they are handled in a single function which can carry out several of them. The first step is to deal with the special case of clearing the path.

```

\draw_path_use:n
\draw_path_use_clear:n
    \__draw_path_use:n
        \__draw_path_use_action_draw:
        \__draw_path_use_action_fillstroke:
\__draw_path_use_stroke_bb:
    \__draw_path_use_stroke_bb_aux:NnN
495 \cs_new_protected:Npn \draw_path_use:n #1
496 {
497     \tl_if_blank:nF {#1}
498     { \__draw_path_use:n {#1} }
499 }
500 \cs_new_protected:Npn \draw_path_use_clear:n #1
501 {
502     \bool_lazy_or:nnTF
503     { \tl_if_blank_p:n {#1} }
504     { \str_if_eq_p:nn {#1} { clear } }
505     {
506         \__draw_softpath_clear:
507         \__draw_path_reset_limits:
508     }
509     { \__draw_path_use:n { #1 , clear } }
510 }

```

Map over the actions and set up the data: mainly just booleans, but with the possibility to cover more complex cases. The business end of the function is a series of checks on the various flags, then taking the appropriate action(s).

```

511 \cs_new_protected:Npn \__draw_path_use:n #1
512 {
513   \bool_set_false:N \l__draw_path_use_clip_bool
514   \bool_set_false:N \l__draw_path_use_fill_bool
515   \bool_set_false:N \l__draw_path_use_stroke_bool
516   \clist_map_inline:nn {#1}
517   {
518     \cs_if_exist:CTF { l__draw_path_use_ ##1 _ bool }
519     { \bool_set_true:c { l__draw_path_use_ ##1 _ bool } }
520     {
521       \cs_if_exist_use:cF { __draw_path_use_action_ ##1 : }
522       { \ERROR }
523     }
524   }
525   \__draw_softpath_round_corners:
526   \bool_lazy_and:nnT
527   { \l_draw_bb_update_bool }
528   { \l__draw_path_use_stroke_bool }
529   { \__draw_path_use_stroke_bb: }
530   \bool_if:NTF \l__draw_path_use_clear_bool
531   { \__draw_softpath_use_clear: }
532   { \__draw_softpath_use: }
533   \bool_if:NT \l__draw_path_use_clip_bool
534   { \driver_draw_clip: }
535   \bool_lazy_or:nnT
536   { \l__draw_path_use_fill_bool }
537   { \l__draw_path_use_stroke_bool }
538   {
539     \use:c
540     {
541       driver_draw_
542       \bool_if:NT \l__draw_path_use_fill_bool { fill }
543       \bool_if:NT \l__draw_path_use_stroke_bool { stroke }
544       :
545     }
546   }
547 }
548 \cs_new_protected:Npn \__draw_path_use_action_draw:
549 {
550   \bool_set_true:N \l__draw_path_use_stroke_bool
551 }
552 \cs_new_protected:Npn \__draw_path_use_action_fillstroke:
553 {
554   \bool_set_true:N \l__draw_path_use_fill_bool
555   \bool_set_true:N \l__draw_path_use_stroke_bool
556 }

```

Where the path is relevant to size and is stroked, we need to allow for the part which overlaps the edge of the bounding box.

```

557 \cs_new_protected:Npn \__draw_path_use_stroke_bb:
558 {

```

```

559     \__draw_path_use_stroke_bb_aux:NnN x { max } +
560     \__draw_path_use_stroke_bb_aux:NnN y { max } +
561     \__draw_path_use_stroke_bb_aux:NnN x { min } -
562     \__draw_path_use_stroke_bb_aux:NnN y { min } -
563   }
564 \cs_new_protected:Npn \__draw_path_use_stroke_bb_aux:NnN #1#2#3
565 {
566   \dim_compare:nNnF { \dim_use:c { g__draw_ #1#2 _dim } } = { #3 -\c_max_dim }
567   {
568     \dim_gset:cn { g__draw_ #1#2 _dim }
569     {
570       \use:c { dim_ #2 :nn }
571       { \dim_use:c { g__draw_ #1#2 _dim } }
572       {
573         \dim_use:c { g__draw_path_ #1#2 _dim }
574         #3 0.5 \g__draw_linewidth_dim
575       }
576     }
577   }
578 }

```

(End definition for `\draw_path_use:n` and others. These functions are documented on page ??.)

2.9 Scoping paths

`\l__draw_path_lastx_dim` Local storage for global data. There is already a `\l__draw_softpath_main_tl` for path manipulation, so we can reuse that (it is always grouped when the path is being reconstructed).

```

\l__draw_path_xmax_dim
\l__draw_path_xmin_dim
\l__draw_path_ymax_dim
\l__draw_path_ymin_dim
\l__draw_softpath_corners_bool
579 \dim_new:N \l__draw_path_lastx_dim
580 \dim_new:N \l__draw_path_lasty_dim
581 \dim_new:N \l__draw_path_xmax_dim
582 \dim_new:N \l__draw_path_xmin_dim
583 \dim_new:N \l__draw_path_ymax_dim
584 \dim_new:N \l__draw_path_ymin_dim
585 \dim_new:N \l__draw_softpath_lastx_dim
586 \dim_new:N \l__draw_softpath_lasty_dim
587 \bool_new:N \l__draw_softpath_corners_bool

```

(End definition for `\l__draw_path_lastx_dim` and others.)

`\draw_path_scope_begin:` Scoping a path is a bit more involved, largely as there are a number of variables to keep hold of.

```

\draw_path_scope_end:
588 \cs_new_protected:Npn \draw_path_scope_begin:
589 {
590   \group_begin:
591     \dim_set_eq:NN \l__draw_path_lastx_dim \g__draw_path_lastx_dim
592     \dim_set_eq:NN \l__draw_path_lasty_dim \g__draw_path_lasty_dim
593     \dim_set_eq:NN \l__draw_path_xmax_dim \g__draw_path_xmax_dim
594     \dim_set_eq:NN \l__draw_path_xmin_dim \g__draw_path_xmin_dim
595     \dim_set_eq:NN \l__draw_path_ymax_dim \g__draw_path_ymax_dim
596     \dim_set_eq:NN \l__draw_path_ymin_dim \g__draw_path_ymin_dim
597     \dim_set_eq:NN \l__draw_softpath_lastx_dim \g__draw_softpath_lastx_dim
598     \dim_set_eq:NN \l__draw_softpath_lasty_dim \g__draw_softpath_lasty_dim
599     \__draw_path_reset_limits:

```

```

600     \tl_build_get:NN \g__draw_softpath_main_tl \l__draw_softpath_main_tl
601     \bool_set_eq:NN
602         \l__draw_softpath_corners_bool
603         \g__draw_softpath_corners_bool
604     \__draw_softpath_clear:
605 }
606 \cs_new_protected:Npn \draw_path_scope_end:
607 {
608     \__draw_softpath_clear:
609     \bool_gset_eq:NN
610         \g__draw_softpath_corners_bool
611         \l__draw_softpath_corners_bool
612     \__draw_softpath_add:o \l__draw_softpath_main_tl
613     \dim_gset_eq:NN \g__draw_softpath_lastx_dim \l__draw_softpath_lastx_dim
614     \dim_gset_eq:NN \g__draw_softpath_lasty_dim \l__draw_softpath_lasty_dim
615     \dim_gset_eq:NN \g__draw_path_xmax_dim \l__draw_path_xmax_dim
616     \dim_gset_eq:NN \g__draw_path_xmin_dim \l__draw_path_xmin_dim
617     \dim_gset_eq:NN \g__draw_path_ymax_dim \l__draw_path_ymax_dim
618     \dim_gset_eq:NN \g__draw_path_ymin_dim \l__draw_path_ymin_dim
619     \dim_gset_eq:NN \g__draw_path_lastx_dim \l__draw_path_lastx_dim
620     \dim_gset_eq:NN \g__draw_path_lasty_dim \l__draw_path_lasty_dim
621 \group_end:
622 }

```

(End definition for `\draw_path_scope_begin:` and `\draw_path_scope_end:`. These functions are documented on page ??.)

```

623 \</initex | package>

```

3 l3draw-points implementation

```

624 \<*initex | package>

```

```

625 \<@@=draw>

```

This sub-module covers more-or-less the same ideas as `pgfcorepoints.code.tex`, though the approach taken to returning values is different: point expressions here are processed by expansion and return a co-ordinate pair in the form $\{\langle x \rangle\}\{\langle y \rangle\}$. Equivalents of following `pgf` functions are deliberately omitted:

- `\pgfpointorigin`: Can be given explicitly as `0pt,0pt`.
- `\pgfpoint`, `\pgfpointadd`, `\pgfpointdiff`, `\pgfpointscale`: Can be given explicitly.
- `\pgfextractx`, `\pgfextracty`: Available by applying `\use_i:nn/\use_ii:nn` or similar to the `x`-type expansion of a point expression.
- `\pgfgetlastxy`: Unused in the entire `pgf` core, may be emulated by `x`-type expansion of a point expression, then using the result.

In addition, equivalents of the following *may* be added in future but are currently absent:

- `\pgfpointcylindrical`, `\pgfpointsspherical`: The usefulness of these commands is not currently clear.

- `\pgfpointborderrectangle`, `\pgfpointborderellipse`: To be revisited once the semantics and use cases are clear.
- `\pgfqpoint`, `\pgfqpointscale`, `\pgfqpointpolar`, `\pgfqpointxy`, `\pgfqpointxyz`: The expandable approach taken in the code here, along with the absolute requirement for ε -TeX, means it is likely many use cases for these commands may be covered in other ways. This may be revisited as higher-level structures are constructed.

3.1 Support functions

Execute whatever code is passed to extract the x and y co-ordinates. The first argument here should itself absorb two arguments. There is also a version to deal with two co-ordinates: common enough to justify a separate function.

```

\__draw_point_process:nn
  \__draw_point_process_auxi:nn
  \__draw_point_process_auxi:fn
  \__draw_point_process_auxii:nw
\__draw_point_process:nnn
  \__draw_point_process_auxiii:nnn
  \__draw_point_process_auxiii:ffn
  \__draw_point_process_auxiv:nw
626 \cs_new:Npn \__draw_point_process:nn #1#2
627 {
628   \__draw_point_process_auxi:fn
629   { \__draw_point_to_dim:n {#2} }
630   {#1}
631 }
632 \cs_new:Npn \__draw_point_process_auxi:nn #1#2
633 { \__draw_point_process_auxii:nw {#2} #1 \q_stop }
634 \cs_generate_variant:Nn \__draw_point_process_auxi:nn { f }
635 \cs_new:Npn \__draw_point_process_auxii:nw #1 #2 , #3 \q_stop
636 { #1 {#2} {#3} }
637 \cs_new:Npn \__draw_point_process:nnn #1#2#3
638 {
639   \__draw_point_process_auxiii:ffn
640   { \__draw_point_to_dim:n {#2} }
641   { \__draw_point_to_dim:n {#3} }
642   {#1}
643 }
644 \cs_new:Npn \__draw_point_process_auxiii:nnn #1#2#3
645 { \__draw_point_process_auxiv:nw {#3} #1 \q_mark #2 \q_stop }
646 \cs_generate_variant:Nn \__draw_point_process_auxiii:nnn { ff }
647 \cs_new:Npn \__draw_point_process_auxiv:nw #1 #2 , #3 \q_mark #4 , #5 \q_stop
648 { #1 {#2} {#3} {#4} {#5} }

```

(End definition for `__draw_point_process:nn` and others.)

Co-ordinates are always returned as two dimensions.

```

\__draw_point_to_dim:n
\__draw_point_to_dim_aux:n
\__draw_point_to_dim_aux:f
\__draw_point_to_dim_aux:w
649 \cs_new:Npn \__draw_point_to_dim:n #1
650 { \__draw_point_to_dim_aux:f { \fp_eval:n {#1} } }
651 \cs_new:Npn \__draw_point_to_dim_aux:n #1
652 { \__draw_point_to_dim_aux:w #1 }
653 \cs_generate_variant:Nn \__draw_point_to_dim_aux:n { f }
654 \cs_new:Npn \__draw_point_to_dim_aux:w ( #1 , ~ #2 ) { #1pt , #2pt }

```

3.2 Polar co-ordinates

Polar co-ordinates may have either one or two lengths, so there is a need to do a simple split before the calculation. As the angle gets used twice, save on any expression evaluation there and force expansion.

```

\draw_point_polar:nn
\draw_point_polar:nnn
\__draw_draw_polar:nnn
\__draw_draw_polar:fnn

```

```

655 \cs_new:Npn \draw_point_polar:nn #1#2
656 { \draw_point_polar:nnn {#1} {#2} {#2} }
657 \cs_new:Npn \draw_point_polar:nnn #1#2#3
658 { \__draw_draw_polar:fnn { \fp_eval:n {#1} } {#2} {#3} }
659 \cs_new:Npn \__draw_draw_polar:nnn #1#2#3
660 { \__draw_point_to_dim:n { cosd(#1) * (#2) , sind(#1) * (#3) } }
661 \cs_generate_variant:Nn \__draw_draw_polar:nnn { f }

```

3.3 Point expression arithmetic

These functions all take point expressions as arguments.

Only a single point expression so the expansion is done here. The outcome is the normalised vector from (0,0) in the direction of the point, *i.e.*

```

\draw_point_unit_vector:n
\__draw_point_unit_vector:nn

```

$$P_x = \frac{x}{\sqrt{x^2 + y^2}} \quad P_y = \frac{y}{\sqrt{x^2 + y^2}}$$

```

662 \cs_new:Npn \draw_point_unit_vector:n #1
663 { \__draw_point_process:nn { \__draw_point_unit_vector:nn } {#1} }
664 \cs_new:Npn \__draw_point_unit_vector:nn #1#2
665 {
666   \__draw_point_to_dim:n
667   { ( #1 , #2 ) / (sqrt(#1 * #1 + #2 * #2)) }
668 }

```

3.4 Intersection calculations

The intersection point P between a line joining points (x_1, y_1) and (x_2, y_2) with a second line joining points (x_3, y_3) and (x_4, y_4) can be calculated using the formulae

```

\draw_point_intersect_lines:nnnn
\__draw_point_intersect_lines:nnnnnnn
\__draw_point_intersect_lines:nnnnnnnn
\__draw_point_intersect_lines_aux:nnnnnn
\__draw_point_intersect_lines_aux:fffff

```

$$P_x = \frac{(x_1 y_2 - y_1 x_2)(x_3 - x_4) - (x_3 y_4 - y_3 x_4)(x_1 - x_2)}{(x_1 - x_2)(y_3 - y_4) - (y_1 - y_2)(x_3 - x_4)}$$

and

$$P_y = \frac{(x_1 y_2 - y_1 x_2)(y_3 - y_4) - (x_3 y_4 - y_3 x_4)(y_1 - y_2)}{(x_1 - x_2)(y_3 - y_4) - (y_1 - y_2)(x_3 - x_4)}$$

The work therefore comes down to expanding the incoming data, then pre-calculating as many parts as possible before the final work to find the intersection. (Expansion and argument re-ordering is much less work than additional floating point calculations.)

```

669 \cs_new:Npn \draw_point_intersect_lines:nnnn #1#2#3#4
670 {
671   \__draw_point_process:nnn
672   {
673     \__draw_point_process:nnn
674     { \__draw_point_intersect_lines:nnnnnnnn } {#3} {#4}
675   }
676   {#1} {#2}
677 }

```

At this stage we have all of the information we need, fully expanded:

```
#1 x3
```

#2 y_3
#3 x_4
#4 y_4
#5 x_1
#6 y_1
#7 x_2
#8 y_2

so now just have to do all of the calculation.

```

678 \cs_new:Npn \__draw_point_intersect_lines:nnnnnnnn #1#2#3#4#5#6#7#8
679 {
680   \__draw_point_intersect_lines_aux:ffffff
681   { \fp_eval:n { #1 * #4 - #2 * #3 } }
682   { \fp_eval:n { #5 * #8 - #6 * #7 } }
683   { \fp_eval:n { #1 - #3 } }
684   { \fp_eval:n { #5 - #7 } }
685   { \fp_eval:n { #2 - #4 } }
686   { \fp_eval:n { #6 - #8 } }
687 }
688 \cs_new:Npn \__draw_point_intersect_lines_aux:nnnnnn #1#2#3#4#5#6
689 {
690   \__draw_point_to_dim:n
691   {
692     ( #2 * #3 - #1 * #4 , #2 * #5 - #1 * #6 )
693     / ( #4 * #5 - #6 * #3 )
694   }
695 }
696 \cs_generate_variant:Nn \__draw_point_intersect_lines_aux:nnnnnn { fffffff }

```

Another long expansion chain to get the values in the right places. We have two circles, the first with center (a, b) and radius r , the second with center (c, d) and radius s . We use the intermediate values

$$\begin{aligned}
e &= c - a \\
f &= d - b \\
p &= \sqrt{e^2 + f^2} \\
k &= \frac{p^2 + r^2 - s^2}{2p}
\end{aligned}$$

in either

$$\begin{aligned}
P_x &= a + \frac{ek}{p} + \frac{f}{p}\sqrt{r^2 - k^2} \\
P_y &= b + \frac{fk}{p} - \frac{e}{p}\sqrt{r^2 - k^2}
\end{aligned}$$

or

$$P_x = a + \frac{ek}{p} - \frac{f}{p}\sqrt{r^2 - k^2}$$

$$P_y = b + \frac{fk}{p} + \frac{e}{p}\sqrt{r^2 - k^2}$$

depending on which solution is required. The rest of the work is simply forcing the appropriate expansion and shuffling arguments.

```

697 \cs_new:Npn \draw_point_intersect_circles:nnnnn #1#2#3#4#5
698 {
699   \__draw_point_process:nnn
700   { \__draw_point_intersect_circles_auxi:nnnnnnn {#2} {#4} {#5} }
701   {#1} {#3}
702 }
703 \cs_new:Npn \__draw_point_intersect_circles_auxi:nnnnnnn #1#2#3#4#5#6#7
704 {
705   \__draw_point_intersect_circles_auxii:ffnnnnnn
706   { \fp_eval:n {#1} } { \fp_eval:n {#2} } {#4} {#5} {#6} {#7} {#3}
707 }

```

At this stage we have all of the information we need, fully expanded:

```

#1 r
#2 s
#3 a
#4 b
#5 c
#6 d
#7 n

```

Once we evaluate e and f , the co-ordinate (c, d) is no longer required: handy as we will need various intermediate values in the following.

```

708 \cs_new:Npn \__draw_point_intersect_circles_auxii:nnnnnnn #1#2#3#4#5#6#7
709 {
710   \__draw_point_intersect_circles_auxiii:ffnnnnnn
711   { \fp_eval:n { #5 - #3 } }
712   { \fp_eval:n { #6 - #4 } }
713   {#1} {#2} {#3} {#4} {#7}
714 }
715 \cs_generate_variant:Nn \__draw_point_intersect_circles_auxii:nnnnnnn { ff }
716 \cs_new:Npn \__draw_point_intersect_circles_auxiii:nnnnnnn #1#2#3#4#5#6#7
717 {
718   \__draw_point_intersect_circles_auxiv:fnnnnnnnn
719   { \fp_eval:n { sqrt( #1 * #1 + #2 * #2 ) } }
720   {#1} {#2} {#3} {#4} {#5} {#6} {#7}
721 }
722 \cs_generate_variant:Nn \__draw_point_intersect_circles_auxiii:nnnnnnn { ff }

```

We now have p : we pre-calculate $1/p$ as it is needed a few times and is relatively expensive. We also need r^2 twice so deal with that here too.

```

723 \cs_new:Npn \__draw_point_intersect_circles_auxiv:nnnnnnnn #1#2#3#4#5#6#7#8
724 {
725   \__draw_point_intersect_circles_auxv:ffnnnnnnnn
726   { \fp_eval:n { 1 / #1 } }
727   { \fp_eval:n { #4 * #4 } }
728   {#1} {#2} {#3} {#5} {#6} {#7} {#8}
729 }
730 \cs_generate_variant:Nn \__draw_point_intersect_circles_auxiv:nnnnnnnn { f }
731 \cs_new:Npn \__draw_point_intersect_circles_auxv:nnnnnnnnnn #1#2#3#4#5#6#7#8#9
732 {
733   \__draw_point_intersect_circles_auxvi:fnnnnnnnn
734   { \fp_eval:n { 0.5 * #1 * ( #2 + #3 * #3 - #6 * #6 ) } }
735   {#1} {#2} {#4} {#5} {#7} {#8} {#9}
736 }
737 \cs_generate_variant:Nn \__draw_point_intersect_circles_auxv:nnnnnnnnnn { ff }

```

We now have all of the intermediate values we require, with one division carried out up-front to avoid doing this expensive step twice:

#1 k
#2 $1/p$
#3 r^2
#4 e
#5 f
#6 a
#7 b
#8 n

There are some final pre-calculations, k/p , $\frac{\sqrt{r^2-k^2}}{p}$ and the usage of n , then we can yield a result.

```

738 \cs_new:Npn \__draw_point_intersect_circles_auxvi:nnnnnnnnnn #1#2#3#4#5#6#7#8
739 {
740   \__draw_point_intersect_circles_auxvii:fffnnnnn
741   { \fp_eval:n { #1 * #2 } }
742   { \int_if_odd:nTF {#8} { 1 } { -1 } }
743   { \fp_eval:n { sqrt ( #3 - #1 * #1 ) * #2 } }
744   {#4} {#5} {#6} {#7}
745 }
746 \cs_generate_variant:Nn \__draw_point_intersect_circles_auxvi:nnnnnnnnnn { f }
747 \cs_new:Npn \__draw_point_intersect_circles_auxvii:nnnnnnnnnn #1#2#3#4#5#6#7
748 {
749   \__draw_point_to_dim:n
750   { #6 + #4 * #1 + #2 * #3 * #5 , #7 + #5 * #1 + -1 * #2 * #3 * #4 }
751 }
752 \cs_generate_variant:Nn \__draw_point_intersect_circles_auxvii:nnnnnnnnnn { fff }

```

3.5 Interpolation on a line (vector) or arc

Simple maths after expansion.

```

\draw_point_interpolate_line:nnm
\_draw_point_interpolate_line_aux:nnnnn
\_draw_point_interpolate_line_aux:fnnnn
\_draw_point_interpolate_line_aux:nnnnnn
\_draw_point_interpolate_line_aux:fnnnnn
753 \cs_new:Npn \draw_point_interpolate_line:nnn #1#2#3
754 {
755   \__draw_point_process:nnn
756   { \__draw_point_interpolate_line_aux:fnnnn { \fp_eval:n {#1} } }
757   {#2} {#3}
758 }
759 \cs_new:Npn \__draw_point_interpolate_line_aux:nnnnn #1#2#3#4#5
760 {
761   \__draw_point_interpolate_line_aux:fnnnnn { \fp_eval:n { 1 - #1 } }
762   {#1} {#2} {#3} {#4} {#5}
763 }
764 \cs_generate_variant:Nn \__draw_point_interpolate_line_aux:nnnnn { f }
765 \cs_new:Npn \__draw_point_interpolate_line_aux:nnnnnn #1#2#3#4#5#6
766 { \__draw_point_to_dim:n { #2 * #3 + #1 * #5 , #2 * #4 + #1 * #6 } }
767 \cs_generate_variant:Nn \__draw_point_interpolate_line_aux:nnnnnn { f }

```

Same idea but using the normalised length to obtain the scale factor. The start point is needed twice, so we force evaluation, but the end point is needed only the once.

```

\draw_point_interpolate_distance:nnm
\_draw_point_interpolate_distance:nnnnn
\_draw_point_interpolate_distance:nnnnnn
\_draw_point_interpolate_distance:fnnnnn
768 \cs_new:Npn \draw_point_interpolate_distance:nnn #1#2#3
769 {
770   \__draw_point_process:nn
771   { \__draw_point_interpolate_distance:nnnn {#1} {#3} }
772   {#2}
773 }
774 \cs_new:Npn \__draw_point_interpolate_distance:nnnn #1#2#3#4
775 {
776   \__draw_point_process:nn
777   {
778     \__draw_point_interpolate_distance:fnnnn
779     { \fp_eval:n {#1} } {#3} {#4}
780   }
781   { \draw_point_unit_vector:n { ( #2 ) - ( #3 , #4 ) } }
782 }
783 \cs_new:Npn \__draw_point_interpolate_distance:nnnnn #1#2#3#4#5
784 { \__draw_point_to_dim:n { #2 + #1 * #4 , #3 + #1 * #5 } }
785 \cs_generate_variant:Nn \__draw_point_interpolate_distance:nnnnn { f }

```

(End definition for `__draw_point_to_dim:n` and others. These functions are documented on page ??.)

Finding a point on an ellipse arc is relatively easy: find the correct angle between the two given, use the sine and cosine of that angle, apply to the axes. We just have to work a bit with the co-ordinate expansion.

```

\draw_point_interpolate_arcaxes:nnnnnn
draw_point_interpolate_arcaxes_auxi:nnnnnnnnn
draw_point_interpolate_arcaxes_auxii:nnnnnnnnn
draw_point_interpolate_arcaxes_auxiii:fnnnnnnnn
draw_point_interpolate_arcaxes_auxiii:nnnnnnnn
draw_point_interpolate_arcaxes_auxiv:nnnnnnnnn
draw_point_interpolate_arcaxes_auxiv:fnnnnnnnn
786 \cs_new:Npn \draw_point_interpolate_arcaxes:nnnnnn #1#2#3#4#5#6
787 {
788   \__draw_point_process:nnn
789   {
790     \__draw_point_process:nn
791     { \__draw_point_interpolate_arcaxes_auxi:nnnnnnnnn {#1} {#5} {#6} }
792     {#4}
793   }
794   {#2} {#3}

```

```

795 }
796 \cs_new:Npn \__draw_point_interpolate_arcaxes_auxi:nnnnnnnnn #1#2#3#4#5#6#7#8#9
797 {
798   \__draw_point_interpolate_arcaxes_auxii:fnnnnnnnn
799   { \fp_eval:n {#1} } {#2} {#3} {#6} {#7} {#8} {#9} {#4} {#5}
800 }

```

At this stage, the three co-ordinate pairs are fully expanded but somewhat re-ordered:

```

#1 p
#2  $\theta_1$ 
#3  $\theta_2$ 
#4  $x_c$ 
#5  $y_c$ 
#6  $x_{a1}$ 
#7  $y_{a1}$ 
#8  $x_{a2}$ 
#9  $y_{a2}$ 

```

We are now in a position to find the target angle, and from that the sine and cosine required.

```

801 \cs_new:Npn \__draw_point_interpolate_arcaxes_auxii:nnnnnnnnn #1#2#3#4#5#6#7#8#9
802 {
803   \__draw_point_interpolate_arcaxes_auxiii:fnnnnnnn
804   { \fp_eval:n { #1 * (#3) + ( 1 - #1 ) * (#2) } }
805   {#4} {#5} {#6} {#7} {#8} {#9}
806 }
807 \cs_generate_variant:Nn \__draw_point_interpolate_arcaxes_auxii:nnnnnnnnn { f }
808 \cs_new:Npn \__draw_point_interpolate_arcaxes_auxiii:nnnnnnn #1#2#3#4#5#6#7
809 {
810   \__draw_point_interpolate_arcaxes_auxiv:ffnnnnnnn
811   { \fp_eval:n { cosd (#1) } }
812   { \fp_eval:n { sind (#1) } }
813   {#2} {#3} {#4} {#5} {#6} {#7}
814 }
815 \cs_generate_variant:Nn \__draw_point_interpolate_arcaxes_auxiii:nnnnnnn { f }
816 \cs_new:Npn \__draw_point_interpolate_arcaxes_auxiv:nnnnnnnn #1#2#3#4#5#6#7#8
817 {
818   \__draw_point_to_dim:n
819   { #3 + #1 * #5 + #2 * #7 , #4 + #1 * #6 + #2 * #8 }
820 }
821 \cs_generate_variant:Nn \__draw_point_interpolate_arcaxes_auxiv:nnnnnnnn { ff }

```

(End definition for `\draw_point_interpolate_arcaxes:nnnnnn` and others. This function is documented on page ??.)

```

\draw_point_interpolate_curve:nnnnn
\draw_point_interpolate_curve_auxi:nnnnnnnnn
\draw_point_interpolate_curve_auxii:nnnnnnnnn
\draw_point_interpolate_curve_auxiii:fnnnnnnnnn
\draw_point_interpolate_curve_auxiiii:nnnnnnn
\draw_point_interpolate_curve_auxv:nnnnnnn
\draw_point_interpolate_curve_auxv:nnw
\draw_point_interpolate_curve_auxv:ffw
\draw_point_interpolate_curve_auxvi:n
\draw_point_interpolate_curve_auxvii:nnnnnnnnn
\draw_point_interpolate_curve_auxviii:nnnnnnn
\draw_point_interpolate_curve_auxviii:ffnnnnn

```

Here we start with a proportion of the curve (p) and four points

1. The initial point (x_1, y_1)

2. The first control point (x_2, y_2)
3. The second control point (x_3, y_3)
4. The final point (x_4, y_4)

The first phase is to expand out all of these values.

```

822 \cs_new:Npn \draw_point_interpolate_curve:nnnnnn #1#2#3#4#5
823 {
824   \__draw_point_process:nnn
825   {
826     \__draw_point_process:nnn
827     { \__draw_point_interpolate_curve_auxi:nnnnnnnnn {#1} }
828     {#4} {#5}
829   }
830   {#2} {#3}
831 }
832 \cs_new:Npn \__draw_point_interpolate_curve_auxi:nnnnnnnnn #1#2#3#4#5#6#7#8#9
833 {
834   \__draw_point_interpolate_curve_auxii:fnnnnnnnnn
835   { \fp_eval:n {#1} }
836   {#6} {#7} {#8} {#9} {#2} {#3} {#4} {#5}
837 }
```

At this stage, everything is fully expanded and back in the input order. The approach to finding the required point is iterative. We carry out three phases. In phase one, we need all of the input co-ordinates

$$\begin{aligned}
x'_1 &= (1-p)x_1 + px_2 \\
y'_1 &= (1-p)y_1 + py_2 \\
x'_2 &= (1-p)x_2 + px_3 \\
y'_2 &= (1-p)y_2 + py_3 \\
x'_3 &= (1-p)x_3 + px_4 \\
y'_3 &= (1-p)y_3 + py_4
\end{aligned}$$

In the second stage, we can drop the final point

$$\begin{aligned}
x''_1 &= (1-p)x'_1 + px'_2 \\
y''_1 &= (1-p)y'_1 + py'_2 \\
x''_2 &= (1-p)x'_2 + px'_3 \\
y''_2 &= (1-p)y'_2 + py'_3
\end{aligned}$$

and for the final stage only need one set of calculations

$$\begin{aligned}
P_x &= (1-p)x''_1 + px''_2 \\
P_y &= (1-p)y''_1 + py''_2
\end{aligned}$$

Of course, this does mean a lot of calculations and expansion!

```

838 \cs_new:Npn \__draw_point_interpolate_curve_auxii:fnnnnnnnnn
839   #1#2#3#4#5#6#7#8#9
840 {
841   \__draw_point_interpolate_curve_auxiii:fnnnnnn
```



```

842     { \fp_eval:n { 1 - #1 } }
843     {#1}
844     { {#2} {#3} } { {#4} {#5} } { {#6} {#7} } { {#8} {#9} }
845 }
846 \cs_generate_variant:Nn \__draw_point_interpolate_curve_auxii:nnnnnnnn { f }
847 % \begin{macrocode}
848 % We need to do the first cycle, but haven't got enough arguments to keep
849 % everything in play at once. So here we use a bit of argument re-ordering
850 % and a single auxiliary to get the job done.
851 % \begin{macrocode}
852 \cs_new:Npn \__draw_point_interpolate_curve_auxiii:nnnnnn #1#2#3#4#5#6
853 {
854     \__draw_point_interpolate_curve_auxiv:nnnnnn {#1} {#2} #3 #4
855     \__draw_point_interpolate_curve_auxiv:nnnnnn {#1} {#2} #4 #5
856     \__draw_point_interpolate_curve_auxiv:nnnnnn {#1} {#2} #5 #6
857     \prg_do_nothing:
858     \__draw_point_interpolate_curve_auxvi:n { {#1} {#2} }
859 }
860 \cs_generate_variant:Nn \__draw_point_interpolate_curve_auxiii:nnnnnn { f }
861 \cs_new:Npn \__draw_point_interpolate_curve_auxiv:nnnnnn #1#2#3#4#5#6
862 {
863     \__draw_point_interpolate_curve_auxv:ffw
864     { \fp_eval:n { #1 * #3 + #2 * #5 } }
865     { \fp_eval:n { #1 * #4 + #2 * #6 } }
866 }
867 \cs_new:Npn \__draw_point_interpolate_curve_auxv:nnw
868 #1#2#3 \prg_do_nothing: #4#5
869 {
870     #3
871     \prg_do_nothing:
872     #4 { #5 {#1} {#2} }
873 }
874 \cs_generate_variant:Nn \__draw_point_interpolate_curve_auxv:nnw { ff }
875 % \begin{macrocode}
876 % Get the arguments back into the right places and to the second and
877 % third cycles directly.
878 % \begin{macrocode}
879 \cs_new:Npn \__draw_point_interpolate_curve_auxvi:n #1
880 { \__draw_point_interpolate_curve_auxvii:nnnnnnnn #1 }
881 \cs_new:Npn \__draw_point_interpolate_curve_auxvii:nnnnnnnn #1#2#3#4#5#6#7#8
882 {
883     \__draw_point_interpolate_curve_auxviii:ffffnn
884     { \fp_eval:n { #1 * #5 + #2 * #3 } }
885     { \fp_eval:n { #1 * #6 + #2 * #4 } }
886     { \fp_eval:n { #1 * #7 + #2 * #5 } }
887     { \fp_eval:n { #1 * #8 + #2 * #6 } }
888     {#1} {#2}
889 }
890 \cs_new:Npn \__draw_point_interpolate_curve_auxviii:nnnnnn #1#2#3#4#5#6
891 {
892     \__draw_point_to_dim:n
893     { #5 * #3 + #6 * #1 , #5 * #4 + #6 * #2 }
894 }
895 \cs_generate_variant:Nn \__draw_point_interpolate_curve_auxviii:nnnnnn { ffff }

```

(End definition for `\draw_point_interpolate_curve:nnnnn` and others. These functions are documented on page ??.)

3.6 Vector support

As well as co-ordinates relative to the drawing

```
\l__draw_xvec_x_dim Base vectors to map to the underlying two-dimensional drawing space.
\l__draw_xvec_y_dim
\l__draw_yvec_x_dim
\l__draw_yvec_y_dim
\l__draw_zvec_x_dim
\l__draw_zvec_y_dim
```

(End definition for `\l__draw_xvec_x_dim` and others.)

```
\draw_xvec:n Calculate the underlying position and store it.
\draw_yvec:n
\draw_zvec:n
\__draw_vec:nn
\__draw_vec:nnn
```

```
902 \cs_new_protected:Npn \draw_xvec:n #1
903 { \__draw_vec:nn { x } {#1} }
904 \cs_new_protected:Npn \draw_yvec:n #1
905 { \__draw_vec:nn { y } {#1} }
906 \cs_new_protected:Npn \draw_zvec:n #1
907 { \__draw_vec:nn { z } {#1} }
908 \cs_new_protected:Npn \__draw_vec:nn #1#2
909 {
910   \__draw_point_process:nn { \__draw_vec:nnn {#1} } {#2}
911 }
912 \cs_new_protected:Npn \__draw_vec:nnn #1#2#3
913 {
914   \dim_set:cn { l__draw_ #1 vec_x_dim } {#2}
915   \dim_set:cn { l__draw_ #1 vec_y_dim } {#3}
916 }
```

(End definition for `\draw_xvec:n` and others. These functions are documented on page ??.)

Initialise the vectors.

```
917 \draw_xvec:n { 1cm , 0cm }
918 \draw_yvec:n { 0cm , 1cm }
919 \draw_zvec:n { -0.385cm , -0.385cm }
```

```
\draw_point_vec:nn Force a single evaluation of each factor, then use these to work out the underlying point.
\__draw_point_vec:nn
\__draw_point_vec:ff
\draw_point_vec:nnn
\__draw_point_vec:nnn
\__draw_point_vec:fff
```

```
920 \cs_new:Npn \draw_point_vec:nn #1#2
921 { \__draw_point_vec:ff { \fp_eval:n {#1} } { \fp_eval:n {#2} } }
922 \cs_new:Npn \__draw_point_vec:nn #1#2
923 {
924   \__draw_point_to_dim:n
925   {
926     #1 * \l__draw_xvec_x_dim + #2 * \l__draw_yvec_x_dim ,
927     #1 * \l__draw_xvec_y_dim + #2 * \l__draw_yvec_y_dim
928   }
929 }
930 \cs_generate_variant:Nn \__draw_point_vec:nn { ff }
931 \cs_new:Npn \draw_point_vec:nnn #1#2#3
932 {
```

```

933   \__draw_point_vec:fff
934   { \fp_eval:n {#1} } { \fp_eval:n {#2} } { \fp_eval:n {#3} }
935 }
936 \cs_new:Npn \__draw_point_vec:nnn #1#2#3
937 {
938   \__draw_point_to_dim:n
939   {
940     #1 * \l__draw_xvec_x_dim
941     + #2 * \l__draw_yvec_x_dim
942     + #3 * \l__draw_zvec_x_dim
943   ,
944     #1 * \l__draw_xvec_y_dim
945     + #2 * \l__draw_yvec_y_dim
946     + #3 * \l__draw_zvec_y_dim
947   }
948 }
949 \cs_generate_variant:Nn \__draw_point_vec:nnn { fff }

```

(End definition for `\draw_point_vec:nn` and others. These functions are documented on page ??.)

```

\draw_point_vec_polar:nn Much the same as the core polar approach.
\draw_point_vec_polar:nnn
\__draw_point_vec_polar:nnn
\__draw_point_vec_polar:fnn
950 \cs_new:Npn \draw_point_vec_polar:nn #1#2
951 { \draw_point_vec_polar:nnn {#1} {#2} {#2} }
952 \cs_new:Npn \draw_point_vec_polar:nnn #1#2#3
953 { \__draw_draw_vec_polar:fnn { \fp_eval:n {#1} } {#2} {#3} }
954 \cs_new:Npn \__draw_draw_vec_polar:nnn #1#2#3
955 {
956   \__draw_point_to_dim:n
957   {
958     cosd(#1) * (#2) * \l__draw_xvec_x_dim ,
959     sind(#1) * (#3) * \l__draw_yvec_y_dim
960   }
961 }
962 \cs_generate_variant:Nn \__draw_draw_vec_polar:nnn { f }

```

(End definition for `\draw_point_vec_polar:nn`, `\draw_point_vec_polar:nnn`, and `__draw_point_vec_polar:nnn`. These functions are documented on page ??.)

3.7 Transformations

`\draw_point_transform:n` Applies a transformation matrix to a point: see `l3draw-transforms` for the business end. Where possible, we avoid the relatively expensive multiplication step.

```

963 \cs_new:Npn \draw_point_transform:n #1
964 {
965   \__draw_point_process:nn
966   { \__draw_point_transform:nn } {#1}
967 }
968 \cs_new:Npn \__draw_point_transform:nn #1#2
969 {
970   \bool_if:NTF \l__draw_matrix_active_bool
971   {
972     \__draw_point_to_dim:n
973     {
974       (

```

```

975         \l__draw_matrix_a_fp * #1
976         + \l__draw_matrix_c_fp * #2
977         + \l__draw_xshift_dim
978     )
979     ,
980     (
981         \l__draw_matrix_b_fp * #1
982         + \l__draw_matrix_d_fp * #2
983         + \l__draw_yshift_dim
984     )
985 }
986 }
987 {
988     \__draw_point_to_dim:n
989     {
990         (#1, #2)
991         + ( \l__draw_xshift_dim , \l__draw_yshift_dim )
992     }
993 }
994 }

```

(End definition for `\draw_point_transform:n` and `__draw_point_transform:nn`. This function is documented on page ??.)

`__draw_point_transform_noshift:n` A version with no shift: used for internal purposes.

```

\__draw_point_transform_noshift:nn
995 \cs_new:Npn \__draw_point_transform_noshift:n #1
996 {
997     \__draw_point_process:nn
998     { \__draw_point_transform_noshift:nn } {#1}
999 }
1000 \cs_new:Npn \__draw_point_transform_noshift:nn #1#2
1001 {
1002     \bool_if:NTF \l__draw_matrix_active_bool
1003     {
1004         \__draw_point_to_dim:n
1005         {
1006             (
1007                 \l__draw_matrix_a_fp * #1
1008                 + \l__draw_matrix_c_fp * #2
1009             )
1010             ,
1011             (
1012                 \l__draw_matrix_b_fp * #1
1013                 + \l__draw_matrix_d_fp * #2
1014             )
1015         }
1016     }
1017     { \__draw_point_to_dim:n { (#1, #2) } }
1018 }

```

(End definition for `__draw_point_transform_noshift:n` and `__draw_point_transform_noshift:nn`.)

1019 `</initex | package>`

4 l3draw-scopes implementation

1020 \langle *initex | package \rangle

1021 \langle @@=draw \rangle

4.1 Drawing environment

\backslash g__draw_xmax_dim Used to track the overall (official) size of the image created: may not actually be the natural size of the content.

\backslash g__draw_xmin_dim 1022 \backslash dim_new:N \backslash g__draw_xmax_dim

\backslash g__draw_ymax_dim 1023 \backslash dim_new:N \backslash g__draw_xmin_dim

\backslash g__draw_ymin_dim 1024 \backslash dim_new:N \backslash g__draw_ymax_dim

1025 \backslash dim_new:N \backslash g__draw_ymin_dim

(End definition for \backslash g__draw_xmax_dim and others.)

\backslash l_draw_bb_update_bool Flag to indicate that a path (or similar) should update the bounding box of the drawing.

1026 \backslash bool_new:N \backslash l_draw_bb_update_bool

(End definition for \backslash l_draw_bb_update_bool. This variable is documented on page ??.)

\backslash l__draw_main_box Box for setting the drawing.

1027 \backslash box_new:N \backslash l__draw_main_box

(End definition for \backslash l__draw_main_box.)

\backslash g__draw_id_int The drawing number.

1028 \backslash int_new:N \backslash g__draw_id_int

(End definition for \backslash g__draw_id_int.)

\backslash __draw_reset_bb: A simple auxiliary.

1029 \backslash cs_new_protected:Npn \backslash __draw_reset_bb:

1030 {

1031 \backslash dim_gset:Nn \backslash g__draw_xmax_dim { $-\backslash$ c_max_dim }

1032 \backslash dim_gset:Nn \backslash g__draw_xmin_dim { \backslash c_max_dim }

1033 \backslash dim_gset:Nn \backslash g__draw_ymax_dim { $-\backslash$ c_max_dim }

1034 \backslash dim_gset:Nn \backslash g__draw_ymin_dim { \backslash c_max_dim }

1035 }

(End definition for \backslash __draw_reset_bb:.)

\backslash draw_begin: Drawings are created by setting them into a box, then adjusting the box before inserting into the surroundings. Color is set here using the drawing mechanism largely as it then sets up the internal data structures. It may be that a coffin construct is better here in the longer term: that may become clearer as the code is completed. As we need to avoid any insertion of baseline skips, the outer box here has to be an hbox.

\backslash draw_end:

1036 \backslash cs_new_protected:Npn \backslash draw_begin:

1037 {

1038 \backslash group_begin:

1039 \backslash int_gincr:N \backslash g__draw_id_int

1040 \backslash hbox_set:Nw \backslash l__draw_main_box

1041 \backslash driver_draw_begin:

1042 \backslash __draw_reset_bb:

1043 \backslash __draw_path_reset_limits:

```

1044     \bool_set_true:N \l_draw_bb_update_bool
1045     \draw_transform_matrix_reset:
1046     \draw_transform_shift_reset:
1047     \__draw_softpath_clear:
1048     \draw_linewidth:n { \l_draw_default_linewidth_dim }
1049     \draw_color:n { . }
1050     \draw_nonzero_rule:
1051     \draw_cap_but:
1052     \draw_join_miter:
1053     \draw_miterlimit:n { 10 }
1054     \draw_dash_pattern:nn { } { 0cm }
1055   }
1056   \cs_new_protected:Npn \draw_end:
1057   {
1058     \driver_draw_end:
1059     \hbox_set_end:
1060     \dim_compare:nNnT \g__draw_xmin_dim = \c_max_dim
1061     {
1062       \dim_gzero:N \g__draw_xmax_dim
1063       \dim_gzero:N \g__draw_xmin_dim
1064       \dim_gzero:N \g__draw_ymax_dim
1065       \dim_gzero:N \g__draw_ymin_dim
1066     }
1067     \hbox_set:Nn \l__draw_main_box
1068     {
1069       \skip_horizontal:n { -\g__draw_xmin_dim }
1070       \box_move_down:nn { \g__draw_ymin_dim }
1071       { \box_use_drop:N \l__draw_main_box }
1072     }
1073     \box_set_ht:Nn \l__draw_main_box
1074     { \g__draw_ymax_dim - \g__draw_ymin_dim }
1075     \box_set_dp:Nn \l__draw_main_box { 0pt }
1076     \box_set_wd:Nn \l__draw_main_box
1077     { \g__draw_xmax_dim - \g__draw_xmin_dim }
1078     \mode_leave_vertical:
1079     \box_use_drop:N \l__draw_main_box
1080   \group_end:
1081   }

```

(End definition for `\draw_begin:` and `\draw_end:`. These functions are documented on page ??.)

4.2 Scopes

<code>\l__draw_linewidth_dim</code>	Storage for local variables.
<code>\l__draw_fill_color_tl</code>	1082 <code>\dim_new:N \l__draw_linewidth_dim</code>
<code>\l__draw_stroke_color_tl</code>	1083 <code>\tl_new:N \l__draw_fill_color_tl</code>
	1084 <code>\tl_new:N \l__draw_stroke_color_tl</code>

(End definition for `\l__draw_linewidth_dim`, `\l__draw_fill_color_tl`, and `\l__draw_stroke_color_tl`.)

<code>\draw_scope_begin:</code>	As well as the graphics (and T _E X) scope, also deal with global data structures.
<code>\draw_scope_begin:</code>	1085 <code>\cs_new_protected:Npn \draw_scope_begin:</code>
	1086 <code>{</code>

```

1087 \driver_draw_scope_begin:
1088 \group_begin:
1089 \dim_set_eq:NN \l__draw_linewidth_dim \g__draw_linewidth_dim
1090 \draw_path_scope_begin:
1091 }
1092 \cs_new_protected:Npn \draw_scope_end:
1093 {
1094 \draw_path_scope_end:
1095 \dim_gset_eq:NN \g__draw_linewidth_dim \l__draw_linewidth_dim
1096 \group_end:
1097 \driver_draw_scope_end:
1098 }

```

(End definition for \draw_scope_begin:. This function is documented on page ??.)

```

\l__draw_xmax_dim Storage for the bounding box.
\l__draw_xmin_dim 1099 \dim_new:N \l__draw_xmax_dim
\l__draw_ymax_dim 1100 \dim_new:N \l__draw_xmin_dim
\l__draw_ymin_dim 1101 \dim_new:N \l__draw_ymax_dim
1102 \dim_new:N \l__draw_ymin_dim

```

(End definition for \l__draw_xmax_dim and others.)

__draw_scope_bb_begin: The bounding box is simple: a straight group-based save and restore approach.

```

\__draw_scope_bb_end: 1103 \cs_new_protected:Npn \__draw_scope_bb_begin:
1104 {
1105 \group_begin:
1106 \dim_set_eq:NN \l__draw_xmax_dim \g__draw_xmax_dim
1107 \dim_set_eq:NN \l__draw_xmin_dim \g__draw_xmin_dim
1108 \dim_set_eq:NN \l__draw_ymax_dim \g__draw_ymax_dim
1109 \dim_set_eq:NN \l__draw_ymin_dim \g__draw_ymin_dim
1110 \__draw_reset_bb:
1111 }
1112 \cs_new_protected:Npn \__draw_scope_bb_end:
1113 {
1114 \dim_gset_eq:NN \g__draw_xmax_dim \l__draw_xmax_dim
1115 \dim_gset_eq:NN \g__draw_xmin_dim \l__draw_xmin_dim
1116 \dim_gset_eq:NN \g__draw_ymax_dim \l__draw_ymax_dim
1117 \dim_gset_eq:NN \g__draw_ymin_dim \l__draw_ymin_dim
1118 \group_end:
1119 }

```

(End definition for __draw_scope_bb_begin: and __draw_scope_bb_end:.)

\draw_suspend_begin: Suspend all parts of a drawing.

```

\draw_suspend_end: 1120 \cs_new_protected:Npn \draw_suspend_begin:
1121 {
1122 \__draw_scope_bb_begin:
1123 \draw_path_scope_begin:
1124 \draw_transform_matrix_reset:
1125 \draw_transform_shift_reset:
1126 }
1127 \cs_new_protected:Npn \draw_suspend_end:
1128 {
1129 \draw_path_scope_end:

```

```

1130     \__draw_scope_bb_end:
1131 }

```

(End definition for `\draw_suspend_begin:` and `\draw_suspend_end:`. These functions are documented on page ??.)

```

1132 </initex | package>

```

5 l3draw-softpath implementation

```

1133 <*initex | package>

```

```

1134 <@@=draw>

```

5.1 Managing soft paths

There are two linked aims in the code here. The most significant is to provide a way to modify paths, for example to shorten the ends or round the corners. This means that the path cannot be written piecemeal as specials, but rather needs to be held in macros. The second aspect that follows from this is performance: simply adding to a single macro a piece at a time will have poor performance as the list gets long so we use `\tl_build...` functions.

Each marker (operation) token takes two arguments, which makes processing more straight-forward. As such, some operations have dummy arguments, whilst others have to be split over several tokens. As the code here is at a low level, all dimension arguments are assumed to be explicit and fully-expanded.

`\g__draw_softpath_main_tl` The soft path itself.

```

1135 \tl_new:N \g__draw_softpath_main_tl

```

(End definition for `\g__draw_softpath_main_tl`.)

`\l__draw_softpath_internal_tl` The soft path itself.

```

1136 \tl_new:N \l__draw_softpath_internal_tl

```

(End definition for `\l__draw_softpath_internal_tl`.)

`\g__draw_softpath_corners_bool` Allow for optimised path use.

```

1137 \bool_new:N \g__draw_softpath_corners_bool

```

(End definition for `\g__draw_softpath_corners_bool`.)

`__draw_softpath_add:n`

`__draw_softpath_add:o`

`__draw_softpath_add:x`

```

1138 \cs_new_protected:Npn \__draw_softpath_add:n

```

```

1139 { \tl_build_gput_right:Nn \g__draw_softpath_main_tl }

```

```

1140 \cs_generate_variant:Nn \__draw_softpath_add:n { o, x }

```

(End definition for `__draw_softpath_add:n`.)


```

    \__draw_softpath_use: Using and clearing is trivial.
    \__draw_softpath_clear:
\__draw_softpath_use_clear:
1141 \cs_new_protected:Npn \__draw_softpath_use:
1142 {
1143     \tl_build_get:NN \g__draw_softpath_main_tl \l__draw_softpath_internal_tl
1144     \l__draw_softpath_internal_tl
1145 }
1146 \cs_new_protected:Npn \__draw_softpath_clear:
1147 {
1148     \tl_build_gclear:N \g__draw_softpath_main_tl
1149     \bool_gset_false:N \g__draw_softpath_corners_bool
1150 }
1151 \cs_new_protected:Npn \__draw_softpath_use_clear:
1152 {
1153     \__draw_softpath_use:
1154     \__draw_softpath_clear:
1155 }

(End definition for \__draw_softpath_use:, \__draw_softpath_clear:, and \__draw_softpath_use_
clear:.)

\g__draw_softpath_lastx_dim For tracking the end of the path (to close it).
\g__draw_softpath_lasty_dim
1156 \dim_new:N \g__draw_softpath_lastx_dim
1157 \dim_new:N \g__draw_softpath_lasty_dim

(End definition for \g__draw_softpath_lastx_dim and \g__draw_softpath_lasty_dim.)

\g__draw_softpath_move_bool Track if moving a point should update the close position.
1158 \bool_new:N \g__draw_softpath_move_bool
1159 \bool_gset_true:N \g__draw_softpath_move_bool

(End definition for \g__draw_softpath_move_bool.)

    \__draw_softpath_curveto:nnnnnn The various parts of a path expressed as the appropriate soft path functions.
    \__draw_softpath_lineto:nn
    \__draw_softpath_moveto:nn
    \__draw_softpath_rectangle:nnnn
    \__draw_softpath_roundpoint:nn
    \__draw_softpath_roundpoint:VV
1160 \cs_new_protected:Npn \__draw_softpath_closepath:
1161 {
1162     \__draw_softpath_add:x
1163     {
1164         \__draw_softpath_close_op:nn
1165         { \dim_use:N \g__draw_softpath_lastx_dim }
1166         { \dim_use:N \g__draw_softpath_lasty_dim }
1167     }
1168 }
1169 \cs_new_protected:Npn \__draw_softpath_curveto:nnnnnn #1#2#3#4#5#6
1170 {
1171     \__draw_softpath_add:n
1172     {
1173         \__draw_softpath_curveto_opi:nn {#1} {#2}
1174         \__draw_softpath_curveto_opii:nn {#3} {#4}
1175         \__draw_softpath_curveto_opiii:nn {#5} {#6}
1176     }
1177 }
1178 \cs_new_protected:Npn \__draw_softpath_lineto:nn #1#2
1179 {
1180     \__draw_softpath_add:n
1181     { \__draw_softpath_lineto_op:nn {#1} {#2} }

```

```

1182 }
1183 \cs_new_protected:Npn \__draw_softpath_moveto:nn #1#2
1184 {
1185   \__draw_softpath_add:n
1186   { \__draw_softpath_moveto_op:nn {#1} {#2} }
1187   \bool_if:NT \g__draw_softpath_move_bool
1188   {
1189     \dim_gset:Nn \g__draw_softpath_lastx_dim {#1}
1190     \dim_gset:Nn \g__draw_softpath_lasty_dim {#2}
1191   }
1192 }
1193 \cs_new_protected:Npn \__draw_softpath_rectangle:nnnn #1#2#3#4
1194 {
1195   \__draw_softpath_add:n
1196   {
1197     \__draw_softpath_rectangle_opi:nn {#1} {#2}
1198     \__draw_softpath_rectangle_opii:nn {#3} {#4}
1199   }
1200 }
1201 \cs_new_protected:Npn \__draw_softpath_roundpoint:nn #1#2
1202 {
1203   \__draw_softpath_add:n
1204   { \__draw_softpath_roundpoint_op:nn {#1} {#2} }
1205   \bool_gset_true:N \g__draw_softpath_corners_bool
1206 }
1207 \cs_generate_variant:Nn \__draw_softpath_roundpoint:nn { VV }

```

(End definition for __draw_softpath_curveto:nnnnnn and others.)

```

\__draw_softpath_close_op:nn
  \__draw_softpath_curveto_opi:nn
  \__draw_softpath_curveto_opii:nn
  \__draw_softpath_curveto_opiii:nn
  \__draw_softpath_lineto_op:nn
  \__draw_softpath_moveto_op:nn
  \__draw_softpath_roundpoint_op:nn
  \__draw_softpath_rectangle_opi:nn
  \__draw_softpath_rectangle_opii:nn
\__draw_softpath_curveto_opi:nnNnnNnn
\__draw_softpath_rectangle_opi:nnNnn

```

The markers for operations: all the top-level ones take two arguments. The support tokens for curves have to be different in meaning to a round point, hence being quark-like.

```

1208 \cs_new_protected:Npn \__draw_softpath_close_op:nn #1#2
1209 { \driver_draw_closepath: }
1210 \cs_new_protected:Npn \__draw_softpath_curveto_opi:nn #1#2
1211 { \__draw_softpath_curveto_opi:nnNnnNnn {#1} {#2} }
1212 \cs_new_protected:Npn \__draw_softpath_curveto_opi:nnNnnNnn #1#2#3#4#5#6#7#8
1213 { \driver_draw_curveto:nnnnnn {#1} {#2} {#4} {#5} {#7} {#8} }
1214 \cs_new_protected:Npn \__draw_softpath_curveto_opii:nn #1#2
1215 { \__draw_softpath_curveto_opii:nn }
1216 \cs_new_protected:Npn \__draw_softpath_curveto_opiii:nn #1#2
1217 { \__draw_softpath_curveto_opiii:nn }
1218 \cs_new_protected:Npn \__draw_softpath_lineto_op:nn #1#2
1219 { \driver_draw_lineto:nn {#1} {#2} }
1220 \cs_new_protected:Npn \__draw_softpath_moveto_op:nn #1#2
1221 { \driver_draw_moveto:nn {#1} {#2} }
1222 \cs_new_protected:Npn \__draw_softpath_roundpoint_op:nn #1#2 { }
1223 \cs_new_protected:Npn \__draw_softpath_rectangle_opi:nn #1#2
1224 { \__draw_softpath_rectangle_opi:nnNnn {#1} {#2} }
1225 \cs_new_protected:Npn \__draw_softpath_rectangle_opi:nnNnn #1#2#3#4#5
1226 { \driver_draw_rectangle:nnnn {#1} {#2} {#4} {#5} }
1227 \cs_new_protected:Npn \__draw_softpath_rectangle_opii:nn #1#2 { }

```

(End definition for __draw_softpath_close_op:nn and others.)

5.2 Rounding soft path corners

The aim here is to find corner rounding points and to replace them with arcs of appropriate length. The approach is exactly that in `pgf`: step through, find the corners, find the supporting data, do the rounding.

```

\l__draw_softpath_main_tl For constructing the updated path.
1228 \tl_new:N \l__draw_softpath_main_tl

(End definition for \l__draw_softpath_main_tl.)

\l__draw_softpath_part_tl Data structures.
1229 \tl_new:N \l__draw_softpath_part_tl
1230 \tl_new:N \l__draw_softpath_curve_end_tl

(End definition for \l__draw_softpath_part_tl.)

\l__draw_softpath_lastx_fp Position tracking: the token list data may be entirely empty or set to a co-ordinate.
\l__draw_softpath_lasty_fp 1231 \fp_new:N \l__draw_softpath_lastx_fp
\l__draw_softpath_corneri_dim 1232 \fp_new:N \l__draw_softpath_lasty_fp
\l__draw_softpath_cornerii_dim 1233 \dim_new:N \l__draw_softpath_corneri_dim
\l__draw_softpath_first_tl 1234 \dim_new:N \l__draw_softpath_cornerii_dim
\l__draw_softpath_move_tl 1235 \tl_new:N \l__draw_softpath_first_tl
1236 \tl_new:N \l__draw_softpath_move_tl

(End definition for \l__draw_softpath_lastx_fp and others.)

\c__draw_softpath_arc_fp The magic constant.
1237 \fp_const:Nn \c__draw_softpath_arc_fp { 4/3 * (sqrt(2) - 1) }

(End definition for \c__draw_softpath_arc_fp.)

\__draw_softpath_round_corners: Rounding corners on a path means going through the entire path and adjusting it. As
\__draw_softpath_round_loop:Nnn such, we avoid this entirely if we know there are no corners to deal with. Assuming there
\__draw_softpath_round_action:nn is work to do, we recover the existing path and start a loop.
\__draw_softpath_round_action:Nnn 1238 \cs_new_protected:Npn \__draw_softpath_round_corners:
\__draw_softpath_round_action_curveto:NnnNnn 1239 {
\__draw_softpath_round_action_close: 1240 \bool_if:NT \g__draw_softpath_corners_bool
\__draw_softpath_round_lookahead:NnnNnn 1241 {
\__draw_softpath_round_roundpoint:NnnNnnNnn 1242 \group_begin:
\__draw_softpath_round_calc:nnnNnn 1243 \tl_clear:N \l__draw_softpath_main_tl
\__draw_softpath_round_calc:nnnnnn 1244 \tl_clear:N \l__draw_softpath_part_tl
\__draw_softpath_round_calc:fVnnnn 1245 \fp_zero:N \l__draw_softpath_lastx_fp
\__draw_softpath_round_calc:nnnnw 1246 \fp_zero:N \l__draw_softpath_lasty_fp
\__draw_softpath_round_close:nn 1247 \tl_clear:N \l__draw_softpath_first_tl
\__draw_softpath_round_close:w 1248 \tl_clear:N \l__draw_softpath_move_tl
\__draw_softpath_round_end: 1249 \tl_build_get:NN \g__draw_softpath_main_tl \l__draw_softpath_internal_tl
1250 \exp_after:wN \__draw_softpath_round_loop:Nnn
1251 \l__draw_softpath_internal_tl
1252 \q_recursion_tail ? ?
1253 \q_recursion_stop
1254 \group_end:
1255 }
1256 \bool_gset_false:N \g__draw_softpath_corners_bool
1257 }

```

The loop can take advantage of the fact that all soft path operations are made up of a token followed by two arguments. At this stage, there is a simple split: have we round a round point. If so, is there any actual rounding to be done: if the arcs have come through zero, just ignore it. In cases where we are not at a corner, we simply move along the path, allowing for any new part starting due to a moveto.

```

1258 \cs_new_protected:Npn \__draw_softpath_round_loop:Nnn #1#2#3
1259 {
1260   \quark_if_recursion_tail_stop_do:Nn #1 { \__draw_softpath_round_end: }
1261   \token_if_eq_meaning:NNTF #1 \__draw_softpath_roundpoint_op:nn
1262   { \__draw_softpath_round_action:nn {#2} {#3} }
1263   {
1264     \tl_if_empty:NT \l__draw_softpath_first_tl
1265     { \tl_set:Nn \l__draw_softpath_first_tl { {#2} {#3} } }
1266     \fp_set:Nn \l__draw_softpath_lastx_fp {#2}
1267     \fp_set:Nn \l__draw_softpath_lasty_fp {#3}
1268     \token_if_eq_meaning:NNTF #1 \__draw_softpath_moveto_op:nn
1269     {
1270       \tl_put_right:No \l__draw_softpath_main_tl
1271       \l__draw_softpath_move_tl
1272       \tl_put_right:No \l__draw_softpath_main_tl
1273       \l__draw_softpath_part_tl
1274       \tl_set:Nn \l__draw_softpath_move_tl { #1 {#2} {#3} }
1275       \tl_clear:N \l__draw_softpath_first_tl
1276       \tl_clear:N \l__draw_softpath_part_tl
1277     }
1278     { \tl_put_right:Nn \l__draw_softpath_part_tl { #1 {#2} {#3} } }
1279     \__draw_softpath_round_loop:Nnn
1280   }
1281 }
1282 \cs_new_protected:Npn \__draw_softpath_round_action:nn #1#2
1283 {
1284   \dim_set:Nn \l__draw_softpath_corneri_dim {#1}
1285   \dim_set:Nn \l__draw_softpath_cornerii_dim {#2}
1286   \bool_lazy_and:nnTF
1287   { \dim_compare_p:nNn \l__draw_softpath_corneri_dim = { 0pt } }
1288   { \dim_compare_p:nNn \l__draw_softpath_cornerii_dim = { 0pt } }
1289   { \__draw_softpath_round_loop:Nnn }
1290   { \__draw_softpath_round_action:Nnn }
1291 }

```

We now have a round point to work on and have grabbed the next item in the path. There are only a few cases where we have to do anything. Each of them is picked up by looking for the appropriate action.

```

1292 \cs_new_protected:Npn \__draw_softpath_round_action:Nnn #1#2#3
1293 {
1294   \tl_if_empty:NT \l__draw_softpath_first_tl
1295   { \tl_set:Nn \l__draw_softpath_first_tl { {#2} {#3} } }
1296   \token_if_eq_meaning:NNTF #1 \__draw_softpath_curveto_opi:nn
1297   { \__draw_softpath_round_action_curveto:NnnNnn }
1298   {
1299     \token_if_eq_meaning:NNTF #1 \__draw_softpath_close_op:nn
1300     { \__draw_softpath_round_action_close: }
1301     {
1302       \token_if_eq_meaning:NNTF #1 \__draw_softpath_lineto_op:nn

```

```

1303         { \__draw_softpath_round_lookahead:NnnNnn }
1304         { \__draw_softpath_round_loop:Nnn }
1305     }
1306 }
1307 #1 {#2} {#3}
1308 }

```

For a curve, we collect the two control points then move on to grab the end point and add the curve there: the second control point becomes our starter.

```

1309 \cs_new_protected:Npn \__draw_softpath_round_action_curveto:NnnNnn
1310 #1#2#3#4#5#6
1311 {
1312   \tl_put_right:Nn \l__draw_softpath_part_tl
1313   { #1 {#2} {#3} #4 {#5} {#6} }
1314   \fp_set:Nn \l__draw_softpath_lastx_fp {#5}
1315   \fp_set:Nn \l__draw_softpath_lasty_fp {#6}
1316   \__draw_softpath_round_lookahead:NnnNnn
1317 }
1318 \cs_new_protected:Npn \__draw_softpath_round_action_close:
1319 {
1320   \bool_lazy_and:nnTF
1321   { ! \tl_if_empty_p:N \l__draw_softpath_first_tl }
1322   { ! \tl_if_empty_p:N \l__draw_softpath_move_tl }
1323   {
1324     \exp_after:wN \__draw_softpath_round_close:nn
1325     \l__draw_softpath_first_tl
1326   }
1327   { \__draw_softpath_round_loop:Nnn }
1328 }

```

At this stage we have a current (sub)operation (#1) and the next operation (#4), and can therefore decide whether to round or not. In the case of yet another rounding marker, we have to look a bit further ahead.

```

1329 \cs_new_protected:Npn \__draw_softpath_round_lookahead:NnnNnn #1#2#3#4#5#6
1330 {
1331   \bool_lazy_any:nTF
1332   {
1333     { \token_if_eq_meaning_p:NN #4 \__draw_softpath_lineto_op:nn }
1334     { \token_if_eq_meaning_p:NN #4 \__draw_softpath_curveto_opi:nn }
1335     { \token_if_eq_meaning_p:NN #4 \__draw_softpath_close_op:nn }
1336   }
1337   {
1338     \__draw_softpath_round_calc:nnnNnn
1339     \__draw_softpath_round_loop:Nnn {#5} {#6}
1340   }
1341   {
1342     \token_if_eq_meaning:NNTF #4 \__draw_softpath_roundpoint_op:nn
1343     { \__draw_softpath_round_roundpoint:NnnNnnNnn }
1344     { \__draw_softpath_round_loop:Nnn }
1345   }
1346   #1 {#2} {#3}
1347   #4 {#5} {#6}
1348 }
1349 \cs_new_protected:Npn \__draw_softpath_round_roundpoint:NnnNnnNnn
1350 #1#2#3#4#5#6#7#8#9

```

```

1351 {
1352   \__draw_softpath_round_calc:nnnNnn
1353   \__draw_softpath_round_loop:Nnn
1354   {#8} {#9} #1 {#2} {#3}
1355   #4 {#5} {#6} #7 {#8} {#9}
1356 }

```

We now have all of the data needed to construct a rounded corner: all that is left to do is to work out the detail! At this stage, we have details of where the corner itself is (#4, #5), and where the next point is (#1, #2). There are two types of calculations to do. First, we need to interpolate from those two points in the direction of the corner, in order to work out where the curve we are adding will start and end. From those, plus the points we already have, we work out where the control points will lie. All of this is done in an expansion to avoid multiple calls to `\tl_put_right:Nx`. The end point of the line is worked out up-front and saved: we need that if dealing with a close-path operation.

```

1357 \cs_new_protected:Npn \__draw_softpath_round_calc:nnnNnn #1#2#3#4#5#6
1358 {
1359   \tl_set:Nx \l__draw_softpath_curve_end_tl
1360   {
1361     \draw_point_interpolate_distance:nnn
1362     \l__draw_softpath_cornerii_dim
1363     { #5 , #6 } { #2 , #3 }
1364   }
1365   \tl_put_right:Nx \l__draw_softpath_part_tl
1366   {
1367     \exp_not:N #4
1368     \__draw_softpath_round_calc:fVnnnn
1369     {
1370       \draw_point_interpolate_distance:nnn
1371       \l__draw_softpath_corneri_dim
1372       { #5 , #6 }
1373       {
1374         \l__draw_softpath_lastx_fp ,
1375         \l__draw_softpath_lasty_fp
1376       }
1377     }
1378     \l__draw_softpath_curve_end_tl
1379     {#5} {#6} {#2} {#3}
1380   }
1381   \fp_set:Nn \l__draw_softpath_lastx_fp {#5}
1382   \fp_set:Nn \l__draw_softpath_lasty_fp {#6}
1383   #1
1384 }

```

At this stage we have the two curve end points, but they are in co-ordinate form. So we split them up (with some more reordering).

```

1385 \cs_new:Npn \__draw_softpath_round_calc:nnnnnn #1#2#3#4#5#6
1386 {
1387   \__draw_softpath_round_calc:nnnnw {#3} {#4} {#5} {#6}
1388   #1 \q_mark #2 \q_stop
1389 }
1390 \cs_generate_variant:Nn \__draw_softpath_round_calc:nnnnnn { fV }

```

The calculations themselves are relatively straight-forward, as we use a quadratic Bézier curve.

```

1391 \cs_new:Npn \__draw_softpath_round_calc:nnnnw
1392 #1#2#3#4 #5 , #6 \q_mark #7 , #8 \q_stop
1393 {
1394   {#5} {#6}
1395   \exp_not:N \__draw_softpath_curveto_opi:nn
1396   {
1397     \fp_to_dim:n
1398     { #5 + \c__draw_softpath_arc_fp * ( #1 - #5 ) }
1399   }
1400   {
1401     \fp_to_dim:n
1402     { #6 + \c__draw_softpath_arc_fp * ( #2 - #6 ) }
1403   }
1404   \exp_not:N \__draw_softpath_curveto_opii:nn
1405   {
1406     \fp_to_dim:n
1407     { #7 + \c__draw_softpath_arc_fp * ( #1 - #7 ) }
1408   }
1409   {
1410     \fp_to_dim:n
1411     { #8 + \c__draw_softpath_arc_fp * ( #2 - #8 ) }
1412   }
1413   \exp_not:N \__draw_softpath_curveto_opiii:nn
1414   {#7} {#8}
1415 }

```

To deal with a close-path operation, we need to do some manipulation. It needs to be treated as a line operation for rounding, and then have the close path operation re-added at the point where the curve ends. That means saving the end point in the calculation step (see earlier), and shuffling a lot.

```

1416 \cs_new_protected:Npn \__draw_softpath_round_close:nn #1#2
1417 {
1418   \use:x
1419   {
1420     \__draw_softpath_round_calc:nnnNnn
1421     {
1422       \tl_set:Nx \exp_not:N \l__draw_softpath_move_tl
1423       {
1424         \__draw_softpath_moveto_op:nn
1425         \exp_not:N \exp_after:wN
1426         \exp_not:N \__draw_softpath_round_close:w
1427         \exp_not:N \l__draw_softpath_curve_end_tl
1428         \exp_not:N \q_stop
1429       }
1430       \use:x
1431       {
1432         \exp_not:N \exp_not:N \exp_not:N \use_i:nnnn
1433         {
1434           \__draw_softpath_round_loop:Nnn
1435           \__draw_softpath_close_op:nn
1436           \exp_not:N \exp_after:wN
1437           \exp_not:N \__draw_softpath_round_close:w
1438           \exp_not:N \l__draw_softpath_curve_end_tl
1439           \exp_not:N \q_stop

```

```

1440         }
1441     }
1442 }
1443 {#1} {#2}
1444 \__draw_softpath_lineto_op:nn
1445 \exp_after:wN \use_none:n \l__draw_softpath_move_tl
1446 }
1447 }
1448 \cs_new:Npn \__draw_softpath_round_close:w #1 , #2 \q_stop { {#1} {#2} }

```

Tidy up the parts of the path, complete the built token list and put it back into action.

```

1449 \cs_new_protected:Npn \__draw_softpath_round_end:
1450 {
1451     \tl_put_right:No \l__draw_softpath_main_tl
1452     \l__draw_softpath_move_tl
1453     \tl_put_right:No \l__draw_softpath_main_tl
1454     \l__draw_softpath_part_tl
1455     \tl_build_gclear:N \g__draw_softpath_main_tl
1456     \__draw_softpath_add:o \l__draw_softpath_main_tl
1457 }

```

(End definition for `__draw_softpath_round_corners:` and others.)

```

1458 </initex | package>

```

6 l3draw-state implementation

```

1459 <*initex | package>

```

```

1460 <@@=draw>

```

This sub-module covers more-or-less the same ideas as `pgfcoregraphicstate.code.tex`.

At present, equivalents of the following are currently absent:

- `\pgfsetinnerlinewidth`, `\pgfinnerlinewidth`, `\pgfsetinnerstrokecolor`, `\pgfsetinnerstrokecolor`
- Likely to be added on further work is done on paths/stroking.

`\g__draw_linewidth_dim` Linewidth for strokes: global as the scope for this relies on the graphics state. The inner line width is used for places where two lines are used.

```

1461 \dim_new:N \g__draw_linewidth_dim

```

(End definition for `\g__draw_linewidth_dim`.)

`\l_draw_default_linewidth_dim` A default: this is used at the start of every drawing.

```

1462 \dim_new:N \l_draw_default_linewidth_dim
1463 \dim_set:Nn \l_draw_default_linewidth_dim { 0.4pt }

```

(End definition for `\l_draw_default_linewidth_dim`. This variable is documented on page ??.)

`\draw_linewidth:n` Set the linewidth: we need a wrapper as this has to pass to the driver layer.

```

1464 \cs_new_protected:Npn \draw_linewidth:n #1
1465 {
1466     \dim_gset:Nn \g__draw_linewidth_dim { \fp_to_dim:n {#1} }
1467     \driver_draw_linewidth:n \g__draw_linewidth_dim
1468 }

```

(End definition for `\draw_linewidth:n`. This function is documented on page ??.)

`\draw_dash_pattern:nn` Evaluated all of the list and pass it to the driver layer.

```

1469 \cs_new_protected:Npn \draw_dash_pattern:nn #1#2
1470 {
1471   \group_begin:
1472     \seq_set_from_clist:Nn \l__draw_tmp_seq {#1}
1473     \seq_set_map:Nn \l__draw_tmp_seq \l__draw_tmp_seq
1474       { \fp_to_dim:n {##1} }
1475     \use:x
1476     {
1477       \driver_draw_dash_pattern:nn
1478       { \seq_use:Nn \l__draw_tmp_seq { , } }
1479       { \fp_to_dim:n {#2} }
1480     }
1481   \group_end:
1482 }
1483 \seq_new:N \l__draw_tmp_seq

```

(End definition for \draw_dash_pattern:nn and \l__draw_tmp_seq. This function is documented on page ??.)

`\draw_miterlimit:n` Pass through to the driver layer.

```

1484 \cs_new_protected:Npn \draw_miterlimit:n #1
1485 { \driver_draw_miterlimit:n { \fp_eval:n {#1} } }

```

(End definition for \draw_miterlimit:n. This function is documented on page ??.)

`\draw_cap_but:` All straight wrappers.

```

\draw_cap_rectangle: 1486 \cs_new_protected:Npn \draw_cap_but: { \driver_draw_cap_but: }
\draw_cap_round:      1487 \cs_new_protected:Npn \draw_cap_rectangle: { \driver_draw_cap_rectangle: }
\draw_evenodd_rule:   1488 \cs_new_protected:Npn \draw_cap_round: { \driver_draw_cap_round: }
\draw_nonzero_rule:   1489 \cs_new_protected:Npn \draw_evenodd_rule: { \driver_draw_evenodd_rule: }
\draw_join_bevel:     1490 \cs_new_protected:Npn \draw_nonzero_rule: { \driver_draw_nonzero_rule: }
\draw_join_miter:     1491 \cs_new_protected:Npn \draw_join_bevel: { \driver_draw_join_bevel: }
\draw_join_round:     1492 \cs_new_protected:Npn \draw_join_miter: { \driver_draw_join_miter: }
                     1493 \cs_new_protected:Npn \draw_join_round: { \driver_draw_join_round: }

```

(End definition for \draw_cap_but: and others. These functions are documented on page ??.)

`\l__draw_color_tmp_tl` Scratch space.

```

1494 \tl_new:N \l__draw_color_tmp_tl

```

(End definition for \l__draw_color_tmp_tl.)

`\draw_color:n` Much the same as for core color support but calling the relevant driver-level function.

```

\draw_color_fill:n    1495 \cs_new_eq:NN \draw_color:n \color_select:n
\draw_color_stroke:n  1496 \cs_new_protected:Npn \draw_color_fill:n #1
\__draw_color:nn      1497 { \__draw_color:nn { fill } {#1} }
\__draw_color_aux:nn  1498 \cs_new_protected:Npn \draw_color_stroke:n #1
\__draw_color_aux:Vn  1499 { \__draw_color:nn { stroke } {#1} }
\__draw_color:nw      1500 \cs_new_protected:Npn \__draw_color:nn #1#2
\__draw_select_cmyk:nw 1501 {
\__draw_select_gray:nw 1502   \color_parse:nN {#2} \l__draw_color_tmp_tl
\__draw_select_rgb:nw  1503   \__draw_color_aux:Vn \l__draw_color_tmp_tl {#1}
\__draw_split_select:nw 1504 }
                     1505 \cs_new_protected:Npn \__draw_color_aux:nn #1#2

```

```

1506 { \_draw_color:nw {#2} #1 \q_stop }
1507 \cs_generate_variant:Nn \_draw_color_aux:nn { V }
1508 \cs_new_protected:Npn \_draw_color:nw #1#2 ~ #3 \q_stop
1509 { \use:c { \_draw_color_ #2 :nw } {#1} #3 \q_stop }
1510 \cs_new_protected:Npn \_draw_color_cmyk:nw #1#2 ~ #3 ~ #4 ~ #5 \q_stop
1511 { \use:c { driver_draw_color_ #1 _cmyk:nnnn } {#2} {#3} {#4} {#5} }
1512 \cs_new_protected:Npn \_draw_color_gray:nw #1#2 \q_stop
1513 { \use:c { driver_draw_color_ #1 _gray:n } {#2} }
1514 \cs_new_protected:Npn \_draw_color_rgb:nw #1#2 ~ #3 ~ #4 \q_stop
1515 { \use:c { driver_draw_color_ #1 _rgb:nnn } {#2} {#3} {#4} }
1516 \cs_new_protected:Npn \_draw_color_spot:nw #1#2 ~ #3 \q_stop
1517 { \use:c { driver_draw_color_ #1 _spot:nn } {#2} {#3} }

```

(End definition for `\draw_color:n` and others. These functions are documented on page ??.)

```

1518 </initex | package>

```

7 l3draw-transforms implementation

```

1519 <*initex | package>

```

```

1520 <@@=draw>

```

This sub-module covers more-or-less the same ideas as `pgfcoretransformations.code.tex`. At present, equivalents of the following are currently absent:

- `\pgfgettransform`, `\pgfgettransformentries`: Awaiting use cases.
- `\pgftransformlineattime`, `\pgftransformarcaxesattime`, `\pgftransformcurveattime`: Need to look at the use cases for these to fully understand them.
- `\pgftransformarrow`: Likely to be done when other arrow functions are added.
- `\pgflowlevelsynccm`, `\pgflowlevel`: Likely to be added when use cases are encountered in other parts of the code.

`\l__draw_matrix_active_bool` An internal flag to avoid redundant calculations.

```

1521 \bool_new:N \l__draw_matrix_active_bool

```

(End definition for `\l__draw_matrix_active_bool`.)

`\l__draw_matrix_a_fp` The active matrix and shifts.

```

\l__draw_matrix_b_fp 1522 \fp_new:N \l__draw_matrix_a_fp
\l__draw_matrix_c_fp 1523 \fp_new:N \l__draw_matrix_b_fp
\l__draw_xshift_dim 1524 \fp_new:N \l__draw_matrix_c_fp
\l__draw_yshift_dim 1525 \fp_new:N \l__draw_matrix_d_fp
1526 \dim_new:N \l__draw_xshift_dim
1527 \dim_new:N \l__draw_yshift_dim

```

(End definition for `\l__draw_matrix_a_fp` and others.)

`\draw_transform_matrix_reset`: Fast resetting.

```

\draw_transform_shift_reset: 1528 \cs_new_protected:Npn \draw_transform_matrix_reset:
1529 {
1530   \fp_set:Nn \l__draw_matrix_a_fp { 1 }
1531   \fp_zero:N \l__draw_matrix_b_fp
1532   \fp_zero:N \l__draw_matrix_c_fp

```

```

1533     \fp_set:Nn \l__draw_matrix_d_fp { 1 }
1534   }
1535   \cs_new_protected:Npn \draw_transform_shift_reset:
1536   {
1537     \dim_zero:N \l__draw_xshift_dim
1538     \dim_zero:N \l__draw_yshift_dim
1539   }
1540   \draw_transform_matrix_reset:
1541   \draw_transform_shift_reset:

```

(End definition for \draw_transform_matrix_reset: and \draw_transform_shift_reset:. These functions are documented on page ??.)

\draw_transform_matrix:nnnn Setting the transform matrix is straight-forward, with just a bit of expansion to sort out.
 \draw_transform_shift:n With the mechanism active, the identity matrix is set.

```

\__draw_transform_shift:nn
1542   \cs_new_protected:Npn \draw_transform_matrix:nnnn #1#2#3#4
1543   {
1544     \fp_set:Nn \l__draw_matrix_a_fp {#1}
1545     \fp_set:Nn \l__draw_matrix_b_fp {#2}
1546     \fp_set:Nn \l__draw_matrix_c_fp {#3}
1547     \fp_set:Nn \l__draw_matrix_d_fp {#4}
1548     \bool_lazy_all:nTF
1549     {
1550       { \fp_compare_p:nNn \l__draw_matrix_a_fp = \c_one_fp }
1551       { \fp_compare_p:nNn \l__draw_matrix_b_fp = \c_zero_fp }
1552       { \fp_compare_p:nNn \l__draw_matrix_c_fp = \c_zero_fp }
1553       { \fp_compare_p:nNn \l__draw_matrix_d_fp = \c_one_fp }
1554     }
1555     { \bool_set_false:N \l__draw_matrix_active_bool }
1556     { \bool_set_true:N \l__draw_matrix_active_bool }
1557   }
1558   \cs_new_protected:Npn \draw_transform_shift:n #1
1559   {
1560     \__draw_point_process:nn
1561     { \__draw_transform_shift:nn } {#1}
1562   }
1563   \cs_new_protected:Npn \__draw_transform_shift:nn #1#2
1564   {
1565     \dim_set:Nn \l__draw_xshift_dim {#1}
1566     \dim_set:Nn \l__draw_yshift_dim {#2}
1567   }

```

(End definition for \draw_transform_matrix:nnnn, \draw_transform_shift:n, and __draw_transform_shift:nn. These functions are documented on page ??.)

\draw_transform_matrix_concat:nnnn Much the same story for adding to an existing matrix, with a bit of pre-expansion so
 __draw_transform_concat:nnnn that the calculation uses “frozen” values.

```

\draw_transform_shift_concat:n
1568   \cs_new_protected:Npn \draw_transform_matrix_concat:nnnn #1#2#3#4
\__draw_transform_shift_concat:nn
1569   {
1570     \use:x
1571     {
1572       \__draw_transform_concat:nnnn
1573       { \fp_eval:n {#1} }
1574       { \fp_eval:n {#2} }
1575       { \fp_eval:n {#3} }

```

```

1576         { \fp_eval:n {#4} }
1577     }
1578 }
1579 \cs_new_protected:Npn \__draw_transform_concat:nnnn #1#2#3#4
1580 {
1581     \use:x
1582     {
1583         \draw_transform_matrix:nnnn
1584         { #1 * \l__draw_matrix_a_fp + #2 * \l__draw_matrix_c_fp }
1585         { #1 * \l__draw_matrix_b_fp + #2 * \l__draw_matrix_d_fp }
1586         { #3 * \l__draw_matrix_a_fp + #4 * \l__draw_matrix_c_fp }
1587         { #3 * \l__draw_matrix_b_fp + #4 * \l__draw_matrix_d_fp }
1588     }
1589 }
1590 \cs_new_protected:Npn \draw_transform_shift_concat:n #1
1591 {
1592     \__draw_point_process:nn
1593     { \__draw_transform_shift_concat:nn } {#1}
1594 }
1595 \cs_new_protected:Npn \__draw_transform_shift_concat:nn #1#2
1596 {
1597     \dim_set:Nn \l__draw_xshift_dim { \l__draw_xshift_dim + #1 }
1598     \dim_set:Nn \l__draw_yshift_dim { \l__draw_yshift_dim + #2 }
1599 }

```

(End definition for `\draw_transform_matrix_concat:nnnn` and others. These functions are documented on page ??.)

```

\draw_transform_matrix_invert:
\__draw_transform_invert:n
\__draw_transform_invert:f
\draw_transform_shift_invert:

```

Standard mathematics: calculate the inverse matrix and use that, then undo the shifts.

```

1600 \cs_new_protected:Npn \draw_transform_matrix_invert:
1601 {
1602     \bool_if:NT \l__draw_matrix_active_bool
1603     {
1604         \__draw_transform_invert:f
1605         {
1606             \fp_eval:n
1607             {
1608                 1 /
1609                 (
1610                     \l__draw_matrix_a_fp * \l__draw_matrix_d_fp
1611                     - \l__draw_matrix_b_fp * \l__draw_matrix_c_fp
1612                 )
1613             }
1614         }
1615     }
1616 }
1617 \cs_new_protected:Npn \__draw_transform_invert:n #1
1618 {
1619     \fp_set:Nn \l__draw_matrix_a_fp
1620     { \l__draw_matrix_d_fp * #1 }
1621     \fp_set:Nn \l__draw_matrix_b_fp
1622     { -\l__draw_matrix_b_fp * #1 }
1623     \fp_set:Nn \l__draw_matrix_c_fp
1624     { -\l__draw_matrix_c_fp * #1 }

```

```

1625 \fp_set:Nn \l__draw_matrix_d_fp
1626 { \l__draw_matrix_a_fp * #1 }
1627 }
1628 \cs_generate_variant:Nn \__draw_transform_invert:n { f }
1629 \cs_new_protected:Npn \draw_transform_shift_invert:
1630 {
1631 \dim_set:Nn \l__draw_xshift_dim { -\l__draw_xshift_dim }
1632 \dim_set:Nn \l__draw_yshift_dim { -\l__draw_yshift_dim }
1633 }

```

(End definition for \draw_transform_matrix_invert:, __draw_transform_invert:n, and \draw_transform_shift_invert:.. These functions are documented on page ??.)

\draw_transform_triangle:nnn Simple maths to move the canvas origin to #1 and the two axes to #2 and #3.

```

1634 \cs_new_protected:Npn \draw_transform_triangle:nnn #1#2#3
1635 {
1636 \__draw_point_process:nnn
1637 {
1638 \__draw_point_process:nn
1639 { \__draw_tranform_triangle:nnnnnn }
1640 {#1}
1641 }
1642 {#2} {#3}
1643 }
1644 \cs_new_protected:Npn \__draw_tranform_triangle:nnnnnn #1#2#3#4#5#6
1645 {
1646 \use:x
1647 {
1648 \draw_transform_matrix:nnnn
1649 { #3 - #1 }
1650 { #4 - #2 }
1651 { #5 - #1 }
1652 { #6 - #2 }
1653 \draw_transform_shift:n { #1 , #2 }
1654 }
1655 }

```

(End definition for \draw_transform_triangle:nnn. This function is documented on page ??.)

\draw_transform_scale:n Lots of shortcuts.

```

\draw_transform_xscale:n 1656 \cs_new_protected:Npn \draw_transform_scale:n #1
\draw_transform_yscale:n 1657 { \draw_transform_matrix_concat:nnnn { #1 } { 0 } { 0 } { #1 } }
\draw_transform_xshift:n 1658 \cs_new_protected:Npn \draw_transform_xscale:n #1
\draw_transform_yshift:n 1659 { \draw_transform_matrix_concat:nnnn { #1 } { 0 } { 0 } { 1 } }
\draw_transform_xslant:n 1660 \cs_new_protected:Npn \draw_transform_yscale:n #1
\draw_transform_yslant:n 1661 { \draw_transform_matrix_concat:nnnn { 1 } { 0 } { 0 } { #1 } }
1662 \cs_new_protected:Npn \draw_transform_xshift:n #1
1663 { \draw_transform_shift_concat:n { #1 , 0 } }
1664 \cs_new_protected:Npn \draw_transform_yshift:n #1
1665 { \draw_transform_shift_concat:n { 0 , #1 } }
1666 \cs_new_protected:Npn \draw_transform_xslant:n #1
1667 { \draw_transform_matrix_concat:nnnn { 1 } { 0 } { #1 } { 1 } }
1668 \cs_new_protected:Npn \draw_transform_yslant:n #1
1669 { \draw_transform_matrix_concat:nnnn { 1 } { #1 } { 0 } { 1 } }

```

(End definition for `\draw_transform_scale:n` and others. These functions are documented on page ??.)

`\draw_transform_rotate:n` Slightly more involved: evaluate the angle only once, and the sine and cosine only once.

```

\__draw_transform_rotate:n 1670 \cs_new_protected:Npn \draw_transform_rotate:n #1
\__draw_transform_rotate:f 1671 { \__draw_transform_rotate:f { \fp_eval:n {#1} } }
\__draw_transform_rotate:nn 1672 \cs_new_protected:Npn \__draw_transform_rotate:n #1
\__draw_transform_rotate:ff 1673 {
1674   \__draw_transform_rotate:ff
1675   { \fp_eval:n { cosd(#1) } }
1676   { \fp_eval:n { sind(#1) } }
1677 }
1678 \cs_generate_variant:Nn \__draw_transform_rotate:n { f }
1679 \cs_new_protected:Npn \__draw_transform_rotate:nn #1#2
1680 { \draw_transform_matrix_concat:nnnn {#1} {#2} { -#2 } { #1 } }
1681 \cs_generate_variant:Nn \__draw_transform_rotate:nn { ff }

(End definition for \draw_transform_rotate:n, \__draw_transform_rotate:n, and \__draw_transform_
rotate:nn. This function is documented on page ??.)

1682 </initex | package>

```

Index

The italic numbers denote the pages where the corresponding entry is described, numbers underlined point to the definition, all others indicate the places where it is used.

B	
<code>\begin</code>	847, 851, 875, 878
bool commands:	
<code>\bool_gset_eq:NN</code>	609
<code>\bool_gset_false:N</code>	1149, 1256
<code>\bool_gset_true:N</code>	1159, 1205
<code>\bool_if:NTF</code>	30, 69, 530, 533, 542, 543, 970, 1002, 1187, 1240, 1602
<code>\bool_lazy_all:nTF</code>	1548
<code>\bool_lazy_and:nnTF</code> 61, 526, 1286, 1320	
<code>\bool_lazy_any:nTF</code>	1331
<code>\bool_lazy_or:nnTF</code>	407, 502, 535
<code>\bool_new:N</code>	56, 490, 491, 492, 493, 494, 587, 1026, 1137, 1158, 1521
<code>\bool_set_eq:NN</code>	601
<code>\bool_set_false:N</code>	64, 513, 514, 515, 1555
<code>\bool_set_true:N</code>	65, 519, 550, 554, 555, 1044, 1556
box commands:	
<code>\box_move_down:nn</code>	1070
<code>\box_new:N</code>	1027
<code>\box_set_dp:Nn</code>	1075
<code>\box_set_ht:Nn</code>	1073
<code>\box_set_wd:Nn</code>	1076
<code>\box_use_drop:N</code>	1071, 1079
C	
clist commands:	
<code>\clist_map_inline:nn</code>	516
color commands:	
<code>\color_parse:nN</code>	1502
<code>\color_select:n</code>	1495
cs commands:	
<code>\cs_generate_variant:Nn</code>	263, 456, 489, 634, 646, 653, 661, 696, 715, 722, 730, 737, 746, 752, 764, 767, 785, 807, 815, 821, 846, 860, 874, 895, 930, 949, 962, 1140, 1207, 1390, 1507, 1628, 1678, 1681
<code>\cs_if_exist:NTF</code>	518
<code>\cs_if_exist_use:NTF</code>	246, 255, 521
<code>\cs_new:Npn</code>	360, 370, 380, 390, 626, 632, 635, 637, 644, 647, 649, 651, 654, 655, 657, 659, 662, 664, 669, 678, 688, 697, 703, 708, 716, 723, 731, 738, 747, 753, 759, 765, 768, 774, 783, 786, 796, 801, 808, 816, 822, 832, 838, 852, 861, 867, 879, 881, 890, 920, 922, 931, 936, 950, 952, 954, 963, 968, 995, 1000, 1385, 1391, 1448
<code>\cs_new_eq:NN</code>	1495
<code>\cs_new_protected:Npn</code>	20, 42, 49, 57, 67, 76, 82, 88, 94, 101, 115, 123, 128, 130, 132, 145, 152, 188, 190, 201, 207, 237, 264, 296, 302, 308, 313, 321, 330, 335, 346, 401, 403, 416, 423, 432, 438, 440, 450, 457, 463, 470, 495, 500, 511, 548, 552, 557, 564, 588, 606, 902, 904, 906, 908, 912, 1029, 1036, 1056, 1085, 1092, 1103, 1112, 1120, 1127, 1138, 1141, 1146, 1151, 1160, 1169, 1178, 1183, 1193, 1201, 1208, 1210, 1212, 1214, 1216, 1218, 1220, 1222, 1223, 1225, 1227, 1238, 1258, 1282, 1292, 1309, 1318, 1329, 1349, 1357, 1416, 1449, 1464, 1469, 1484, 1486, 1487, 1488, 1489, 1490, 1491, 1492, 1493, 1496, 1498, 1500, 1505, 1508, 1510, 1512, 1514, 1516, 1528, 1535, 1542, 1558, 1563, 1568, 1579, 1590, 1595, 1600, 1617, 1629, 1634, 1644, 1656, 1658, 1660, 1662, 1664, 1666, 1668, 1670, 1672, 1679
D	
dim commands:	
<code>\dim_abs:n</code>	445, 446
<code>\dim_compare:nNnTF</code> 452, 459, 566, 1060	
<code>\dim_compare_p:nNn</code>	62, 63, 1287, 1288
<code>\dim_eval:n</code>	445, 446
<code>\dim_gset:Nn</code> 22, 24, 26, 28, 32, 34, 36, 38, 44, 45, 46, 47, 51, 52, 568, 1031, 1032, 1033, 1034, 1189, 1190, 1466	
<code>\dim_gset_eq:NN</code>	613, 614, 615, 616, 617, 618, 619, 620, 1095, 1114, 1115, 1116, 1117
<code>\dim_gzero:N</code>	1062, 1063, 1064, 1065
<code>\dim_max:nn</code>	23, 27, 33, 37
<code>\dim_min:nn</code>	25, 29, 35, 39
<code>\dim_new:N</code>	14, 15, 16, 17, 18, 19, 54, 55, 579, 580, 581, 582, 583, 584, 585, 586, 896, 897, 898, 899, 900, 901, 1022, 1023, 1024, 1025, 1082,

1099, 1100, 1101, 1102, 1156, 1157, 1233, 1234, 1461, 1462, 1526, 1527	\draw_path_scope_begin:
\dim_set:Nn . . . . .	. . . . . 588, 1090, 1123
59, 60, 914, 915, 1284, 1285, 1463, 1565, 1566, 1597, 1598, 1631, 1632	\draw_path_scope_end: 588, 1094, 1129
\dim_set_eq:NN	\draw_path_use:n 495
. . . . 591, 592, 593, 594, 595, 596, 597, 598, 1089, 1106, 1107, 1108, 1109	\draw_path_use_clear:n 495
\dim_step_inline:nnnn 472, 480	\draw_point_interpolate_arcaxes:nnnnnn 786
\dim_use:N . . 566, 571, 573, 1165, 1166	\draw_point_interpolate_curve:nnnnn 822
\dim_zero:N 1537, 1538	\draw_point_interpolate_curve:nnnnnn 822
\c_max_dim 44, 45, 46, 47, 566, 1031, 1032, 1033, 1034, 1060	\draw_point_interpolate_curve_ auxi:nnnnnnnn 822
draw commands:	\draw_point_interpolate_curve_ auxii:nnnnnnnn 822
\l_draw_bb_update_bool	\draw_point_interpolate_curve_ auxiii:nnnnnn 822
. 30, 527, 1026, 1044	\draw_point_interpolate_curve_ auxiv:nnnnnn 822
\draw_begin: 1036	\draw_point_interpolate_curve_ auxv:nnw 822
\draw_cap_but: 1051, 1486	\draw_point_interpolate_curve_ auxvi:n 822
\draw_cap_rectangle: 1486	\draw_point_interpolate_curve_ auxvii:nnnnnnnn 822
\draw_cap_round: 1486	\draw_point_interpolate_curve_ auxviii:nnnnnn 822
\draw_color:n 1049, 1495	\draw_point_interpolate_distance:nnn 768, 1361, 1370
\draw_color_fill:n 1495	\draw_point_interpolate_line:nnn 753
\draw_color_stroke:n 1495	\draw_point_intersect_circles:nnnnn 697
\draw_dash_pattern:nn . . 1054, 1469	\draw_point_intersect_lines:nnnn 669
\l_draw_default_linewidth_dim	\draw_point_polar:nn 655
. 1048, 1462	\draw_point_polar:nnn
\draw_end: 1036	. . . . . 271, 279, 284, 290, 655
\draw_evenodd_rule: 1486	\draw_point_transform:n
\draw_join_bevel: 1486	. . . . . 80, 92, 110, 112, 113, 149, 150, 278, 283, 341, 413, 963
\draw_join_miter: 1052, 1486	\draw_point_unit_vector:n . . 662, 781
\draw_join_round: 1486	\draw_point_vec:nn 920
\draw_linewidth:n 1048, 1464	\draw_point_vec:nnn 920
\draw_miterlimit:n 1053, 1484	\draw_point_vec_polar:nn 950
\draw_nonzero_rule: 1050, 1486	\draw_point_vec_polar:nnn 950
\draw_path_arc:nnn 188, 333	\draw_scope_begin: 1085
\draw_path_arc:nnnn 188	\draw_scope_end: 1092
\draw_path_arc_axes:nnnn 330	\draw_suspend_begin: 1120
\draw_path_canvas_curveto:nnn . . 128	\draw_suspend_end: 1120
\draw_path_canvas_lineto:n 128	\draw_transform_matrix:nnnn
\draw_path_canvas_moveto:n 128	. . . . . 1542, 1583, 1648
\draw_path_circle:nn 401	\draw_transform_matrix_concat:nnnn 1568,
\draw_path_close: 123, 429	1657, 1659, 1661, 1667, 1669, 1680
\draw_path_corner_arc:nn 57	\draw_transform_matrix_invert: 1600
\draw_path_curveto:nn 145	
\draw_path_curveto:nnn 76	
\draw_path_ellipse:nnn 335, 402	
\draw_path_grid:nnnn 440	
\draw_path_lineto:n	
. 76, 426, 427, 428, 478, 486	
\draw_path_moveto:n	
. 76, 425, 430, 477, 485	
\draw_path_rectangle:nn 403, 439	
\draw_path_rectangle_corners:nn 432	

\draw_transform_matrix_reset: ...	1045, 1124, 1528	\l__draw_matrix_c_fp	976, 1008, 1522, 1532, 1546, 1552, 1584, 1586, 1611, 1623, 1624
\draw_transform_rotate:n	1670	\l__draw_matrix_d_fp	982, 1013, 1525, 1533, 1547, 1553, 1585, 1587, 1610, 1620, 1625
\draw_transform_scale:n	1656	__draw_path_arc:nnnn	188
\draw_transform_shift:n .. 1542, 1653		__draw_path_arc:nnNnn	188
\draw_transform_shift_concat:n ..	1568, 1663, 1665	\c__draw_path_arc_60_fp	188
\draw_transform_shift_invert: .	1600	\c__draw_path_arc_90_fp	188
\draw_transform_shift_reset: ...	1046, 1125, 1528	__draw_path_arc_add:nnnn	188
\draw_transform_triangle:nnn ...	332, 1634	__draw_path_arc_aux_add:nn	298, 304, 316, 321
\draw_transform_xscale:n	1656	__draw_path_arc_auxi:nnnnNnn	188, 215, 222
\draw_transform_xshift:n	1656	__draw_path_arc_auxii:nnnNnnnn	188
\draw_transform_xslant:n	1656	__draw_path_arc_auxiii:nn	188
\draw_transform_yscale:n	1656	__draw_path_arc_auxiv:nnnn	188
\draw_transform_yshift:n	1656	__draw_path_arc_auxv:nn	188
\draw_transform_yslant:n	1656	__draw_path_arc_auxvi:nn	188
\draw_xvec:n	902, 917	\l__draw_path_arc_delta_fp	188
\draw_yvec:n	902, 918	\l__draw_path_arc_start_fp	188
\draw_zvec:n	902, 919	__draw_path_curveto:nnnn	145
draw internal commands:		__draw_path_curveto:nnnnnn	76, 139, 159, 292, 362, 372, 382, 392
__draw_color:nn	1495	\c__draw_path_curveto_a_fp	145
__draw_color:nw	1495	\c__draw_path_curveto_b_fp	145
__draw_color_aux:nn	1495	__draw_path_ellipse:nnnnnn	335
__draw_color_cmyk:nw	1510	__draw_path_ellipse_arci:nnnnnn	335
__draw_color_gray:nw	1512	__draw_path_ellipse_arci:nnnnnn	335
__draw_color_rgb:nw	1514	__draw_path_ellipse_arci:nnnnnn	335
__draw_color_spot:nw	1516	__draw_path_ellipse_arci:nnnnnn	335
\l__draw_color_tmp_tl 1494, 1502, 1503		__draw_path_ellipse_arci:nnnnnn	335
\l__draw_corner_arc_bool	56, 64, 65, 69, 408	__draw_path_ellipse_arci:nnnnnn	335
\l__draw_corner_xarc_dim 54, 59, 62, 72		__draw_path_ellipse_arci:nnnnnn	335
\l__draw_corner_yarc_dim 54, 60, 63, 73		__draw_path_ellipse_arci:nnnnnn	335
__draw_draw_polar:nnn	655	__draw_path_ellipse_arci:nnnnnn	335
__draw_draw_vec_polar:nnn	953, 954, 962	\c__draw_path_ellipse_fp	335
\l__draw_fill_color_tl	1082	__draw_path_grid_auxi:nnnnnn	440
\g__draw_id_int	1028, 1039	__draw_path_grid_auxii:nnnnnn	440
\g__draw_linewidth_dim	574, 1089, 1095, 1461, 1466, 1467	__draw_path_grid_auxiii:nnnnnn	440
\l__draw_linewidth_dim	1082, 1089, 1095	__draw_path_grid_auxiiii:nnnnnn	440
\l__draw_main_box 1027, 1040, 1067, 1071, 1073, 1075, 1076, 1079		__draw_path_grid_auxiv:nnnnnnnn	440
\l__draw_matrix_a_fp	975, 1007, 1522, 1530, 1544, 1550, 1584, 1586, 1610, 1619, 1626	\g__draw_path_lastx_dim	14, 51, 163, 299, 305, 591, 619
\l__draw_matrix_active_bool	409, 970, 1002, 1521, 1555, 1556, 1602	\l__draw_path_lastx_dim 579, 591, 619	
\l__draw_matrix_b_fp	981, 1012, 1522, 1531, 1545, 1551, 1585, 1587, 1611, 1621, 1622	\g__draw_path_lasty_dim	14, 52, 170, 300, 306, 592, 620
		\l__draw_path_lasty_dim 579, 592, 620	
		__draw_path_lineto:nn	76, 131
		__draw_path_mark_corner:	67, 96, 107, 125, 138, 158, 229
		__draw_path_moveto:nn	76, 129, 350, 358
		__draw_path_rectangle:nnnn	403

_draw_path_rectangle_corners:nnnn	_draw_point_interpolate_curve_-
..... 432	auxii:nnnnnnnnn 834 , 838 , 846
_draw_path_rectangle_corners:nnnnn	_draw_point_interpolate_curve_-
..... 435 , 438	auxiii:nnnnnnn 841 , 852 , 860
_draw_path_rectangle_rounded:nnnn	_draw_point_interpolate_curve_-
..... 403	auxiv:nnnnnnn ... 854 , 855 , 856 , 861
_draw_path_reset_limits:	_draw_point_interpolate_curve_-
..... 20 , 507 , 599 , 1043	auxv:nnw 863 , 867 , 874
\l_draw_path_tmp_tl	_draw_point_interpolate_curve_-
..... 11 , 266 , 292 , 311 , 315 , 319 , 323	auxvi:n 858 , 879
\l_draw_path_tmpa_fp 11 , 154 , 164 , 176	_draw_point_interpolate_curve_-
\l_draw_path_tmpb_fp 11 , 155 , 171 , 180	auxvii:nnnnnnnn 880 , 881
_draw_path_update_last:nn	_draw_point_interpolate_curve_-
..... 49 , 86 , 99 , 121 , 421	auxviii:nnnnnn 883 , 890 , 895
_draw_path_update_limits:nn	_draw_point_interpolate_-
... 20 , 84 , 97 , 117 , 118 , 119 , 418 , 419	distance:nnnn 771 , 774
_draw_path_use:n	_draw_point_interpolate_-
..... 495	distance:nnnnn 768 , 778
_draw_path_use_action_draw: .. 495	_draw_point_interpolate_-
_draw_path_use_action_fillstroke:	distance:nnnnnn 768
..... 495	_draw_point_interpolate_line_-
\l_draw_path_use_bb_bool 493	aux:nnnnn 753
\l_draw_path_use_clear_bool 493 , 530	_draw_point_interpolate_line_-
\l_draw_path_use_clip_bool	aux:nnnnnn 753
..... 490 , 513 , 533	_draw_point_intersect_circles_-
\l_draw_path_use_fill_bool	auxi:nnnnnnnn 697
..... 490 , 514 , 536 , 542 , 554	_draw_point_intersect_circles_-
_draw_path_use_stroke_bb: ... 495	auxii:nnnnnnnn 697
_draw_path_use_stroke_bb_-	_draw_point_intersect_circles_-
aux:NnN 495	auxiii:nnnnnnnn 697
\l_draw_path_use_stroke_bool	_draw_point_intersect_circles_-
..... 490 , 515 , 528 , 537 , 543 , 550 , 555	auxiv:nnnnnnnn 697
\g_draw_path_xmax_dim	_draw_point_intersect_circles_-
..... 16 , 22 , 23 , 44 , 593 , 615	auxv:nnnnnnnnnn 697
\l_draw_path_xmax_dim . 579 , 593 , 615	_draw_point_intersect_circles_-
\g_draw_path_xmin_dim	auxvi:nnnnnnnn 697
..... 16 , 24 , 25 , 45 , 594 , 616	_draw_point_intersect_circles_-
\l_draw_path_xmin_dim . 579 , 594 , 616	auxvii:nnnnnnnn 697
\g_draw_path_ymax_dim	_draw_point_intersect_lines:nnnnnnn
..... 16 , 26 , 27 , 46 , 595 , 617	..... 669
\l_draw_path_ymax_dim . 579 , 595 , 617	_draw_point_intersect_lines_-
\g_draw_path_ymin_dim	aux:nnnnnn 669
..... 16 , 28 , 29 , 47 , 596 , 618	_draw_point_process:nn 78 ,
\l_draw_path_ymin_dim . 579 , 596 , 618	90 , 105 , 129 , 131 , 136 , 267 , 273 ,
_draw_point_interpolate_-	275 , 286 , 339 , 626 , 663 , 770 , 776 ,
arcaxes_auxi:nnnnnnnnnn 786	790 , 910 , 965 , 997 , 1560 , 1592 , 1638
_draw_point_interpolate_-	_draw_point_process:nnn .. 103 ,
arcaxes_auxii:nnnnnnnnnn 786	134 , 147 , 337 , 405 , 434 , 442 , 626 ,
_draw_point_interpolate_-	671 , 673 , 699 , 755 , 788 , 824 , 826 , 1636
arcaxes_auxiii:nnnnnnnn 786	_draw_point_process_auxi:nn . 626
_draw_point_interpolate_-	_draw_point_process_auxii:nw . 626
arcaxes_auxiv:nnnnnnnn 786	_draw_point_process_auxiii:nnn 626
_draw_point_interpolate_curve_-	
auxi:nnnnnnnnnn 827 , 832	

_draw_point_process_auxiv:nw .	626	\l_draw_softpath_first_tl	1231 , 1247 , 1264 ,
_draw_point_to_dim:n	629 , 640 , 641 , 649 , 818 ,		1265 , 1275 , 1294 , 1295 , 1321 , 1325
	892 , 924 , 938 , 956 , 972 , 988 , 1004 , 1017	\l_draw_softpath_internal_tl . . .	1136 , 1143 , 1144 , 1249 , 1251
_draw_point_to_dim_aux:n	649	\g_draw_softpath_lastx_dim	597 , 613 , 1156 , 1165 , 1189
_draw_point_to_dim_aux:w	649	\l_draw_softpath_lastx_dim	585 , 597 , 613
_draw_point_transform:nn	963	\l_draw_softpath_lastx_fp	1231 , 1245 , 1266 , 1314 , 1374 , 1381
_draw_point_transform_noshift:n	270 , 289 , 343 , 344 , 995	\g_draw_softpath_lasty_dim	598 , 614 , 1156 , 1166 , 1190
_draw_point_transform_noshift:nn	995	\l_draw_softpath_lasty_dim	586 , 598 , 614
_draw_point_unit_vector:nn . .	662	\l_draw_softpath_lasty_fp	1231 , 1246 , 1267 , 1315 , 1375 , 1382
_draw_point_vec:nn	920	_draw_softpath_lineto:nn .	98 , 1160
_draw_point_vec:nnn	920	_draw_softpath_lineto_op:nn . . .	1181 , 1208 , 1302 , 1333 , 1444
_draw_point_vec_polar:nnn . . .	950	\g_draw_softpath_main_tl	600 , 1135 , 1139 , 1143 , 1148 , 1249 , 1455
_draw_reset_bb: . . .	1029 , 1042 , 1110	\l_draw_softpath_main_tl	15 , 600 , 612 , 1228 ,
_draw_scope_bb_begin: . .	1103 , 1122		1243 , 1270 , 1272 , 1451 , 1453 , 1456
_draw_scope_bb_end: . . .	1103 , 1130	\g_draw_softpath_move_bool	1158 , 1187
_draw_select_cmyk:nw	1495	\l_draw_softpath_move_tl	1231 , 1248 ,
_draw_select_gray:nw	1495		1271 , 1274 , 1322 , 1422 , 1445 , 1452
_draw_select_rgb:nw	1495	_draw_softpath_moveto:nn .	85 , 1160
_draw_softpath_add:n	612 , 1138 , 1162 ,	_draw_softpath_moveto_op:nn . . .	1186 , 1208 , 1268 , 1424
	1171 , 1180 , 1185 , 1195 , 1203 , 1456	\l_draw_softpath_part_tl	1229 , 1244 ,
\c_draw_softpath_arc_fp	1237 , 1398 , 1402 , 1407 , 1411		1273 , 1276 , 1278 , 1312 , 1365 , 1454
_draw_softpath_clear:	506 , 604 , 608 , 1047 , 1141	_draw_softpath_rectangle:nnnn .	420 , 1160
_draw_softpath_close_op:nn . . .	1164 , 1208 , 1299 , 1335 , 1435	_draw_softpath_rectangle_-	
_draw_softpath_closepath:	126 , 357 , 1160	opi:nn	1197 , 1208
\l_draw_softpath_corneri_dim . . .	1231 , 1284 , 1287 , 1371	_draw_softpath_rectangle_-	
\l_draw_softpath_cornerii_dim . .	1231 , 1285 , 1288 , 1362	opi:nnNnn	1208
\g_draw_softpath_corners_bool . .	603 , 610 , 1137 , 1149 , 1205 , 1240 , 1256	_draw_softpath_rectangle_-	
\l_draw_softpath_corners_bool . .	579 , 602 , 611	opii:nn	1198 , 1208
\l_draw_softpath_curve_end_tl . .	1230 , 1359 , 1378 , 1427 , 1438	_draw_softpath_round_action:nn	1238
_draw_softpath_curveto:nnnnnn .	120 , 1160	_draw_softpath_round_action:Nnn	1238
_draw_softpath_curveto_opi:nn .	1173 , 1208 , 1296 , 1334 , 1395	_draw_softpath_round_action_-	
_draw_softpath_curveto_-		close:	1238
opi:nnNnnNnn	1208	_draw_softpath_round_action_-	
_draw_softpath_curveto_opii:nn	1174 , 1208 , 1404	curveto:NnnNnn	1238
_draw_softpath_curveto_-		_draw_softpath_round_calc:nnnNnn	1238
opiii:nn	1175 , 1208 , 1413		

_draw_softpath_round_calc:nnnnnn	\l_draw_zvec_x_dim	896, 942
. 1238	\l_draw_zvec_y_dim	896, 946
_draw_softpath_round_calc:nnnnw	driver commands:	
. 1238	\driver_draw_begin:	1041
_draw_softpath_round_close:nn	\driver_draw_cap_but:	1486
_draw_softpath_round_close:w	\driver_draw_cap_rectangle: . .	1487
_draw_softpath_round_corners: .	\driver_draw_cap_round:	1488
. 525, 1238	\driver_draw_clip:	534
_draw_softpath_round_end: . .	\driver_draw_closepath:	1209
_draw_softpath_round_lookahead:NnnNnn	\driver_draw_curveto:nnnnnn . .	1213
. 1238	\driver_draw_dash_pattern:nn .	1477
_draw_softpath_round_loop:Nnn	\driver_draw_end:	1058
_draw_softpath_round_roundpoint:NnnNnnNnn	\driver_draw_evenodd_rule: . . .	1489
. 1238	\driver_draw_join_bevel:	1491
_draw_softpath_roundpoint:nn . .	\driver_draw_join_miter:	1492
. 71, 1160	\driver_draw_join_round:	1493
_draw_softpath_roundpoint_-	\driver_draw_lineto:nn	1219
op:nn 1204, 1208, 1261, 1342	\driver_draw_linewidth:n	1467
_draw_softpath_use: 532, 1141	\driver_draw_miterlimit:n	1485
_draw_softpath_use_clear: 531, 1141	\driver_draw_moveto:nn	1221
_draw_split_select:nw 1495	\driver_draw_nonzero_rule: . . .	1490
\l_draw_stroke_color_tl 1082	\driver_draw_rectangle:nnnn . .	1226
\l_draw_tmp_seq 1469	\driver_draw_scope_begin:	1087
_draw_tranform_triangle:nnnnnn	\driver_draw_scope_end:	1097
. 1639, 1644		
_draw_transform_concat:nnnn .	E	
_draw_transform_invert:n . . . 1600	\ERROR	522
_draw_transform_rotate:n . . . 1670	exp commands:	
_draw_transform_rotate:nn . . 1670	\exp_after:wN	
_draw_transform_shift:nn . . . 1542	. . . . . 292, 310, 1250, 1324, 1425, 1436, 1445	
_draw_transform_shift_concat:nn	\exp_not:N 1367, 1395,	
. 1568	. . . . . 1404, 1413, 1422, 1425, 1426, 1427,	
_draw_vec:nn 902	. . . . . 1428, 1432, 1436, 1437, 1438, 1439	
_draw_vec:nnn 902		
\g_draw_xmax_dim 32,	F	
. 33, 1022, 1031, 1062, 1077, 1106, 1114	fp commands:	
\l_draw_xmax_dim . . . 1099, 1106, 1114	\fp_compare:nNnTF	203, 213
\g_draw_xmin_dim 34, 35, 1022, 1032,	\fp_compare_p:nNn	
. 1060, 1063, 1069, 1077, 1107, 1115	. . . . . 1550, 1551, 1552, 1553	
\l_draw_xmin_dim . . . 1099, 1107, 1115	\fp_const:Nn	
\l_draw_xshift_dim . . . . .	. . . . . 186, 187, 328, 329, 400, 1237	
. 977, 991, 1522, 1537, 1565, 1597, 1631	\fp_eval:n 195, 196,	
\l_draw_xvec_x_dim 896, 926, 940, 958	. . . . . 217, 224, 233, 650, 658, 681, 682,	
\l_draw_xvec_y_dim . . . 896, 927, 944	. . . . . 683, 684, 685, 686, 706, 711, 712,	
\g_draw_ymax_dim 36,	. . . . . 719, 726, 727, 734, 741, 743, 756,	
. 37, 1022, 1033, 1064, 1074, 1108, 1116	. . . . . 761, 779, 799, 804, 811, 812, 835,	
\l_draw_ymax_dim . . . 1099, 1108, 1116	. . . . . 842, 864, 865, 884, 885, 886, 887,	
\g_draw_ymin_dim . . . 38, 39, 1022,	. . . . . 921, 934, 953, 1485, 1573, 1574,	
. 1034, 1065, 1070, 1074, 1109, 1117	. . . . . 1575, 1576, 1606, 1671, 1675, 1676	
\l_draw_ymin_dim . . . 1099, 1109, 1117	\fp_new:N 12, 13, 326,	
\l_draw_yshift_dim . . . . .	. . . . . 327, 1231, 1232, 1522, 1523, 1524, 1525	
. 983, 991, 1522, 1538, 1566, 1598, 1632	\fp_set:Nn 154, 155, 209, 210,	
\l_draw_yvec_x_dim . . . 896, 926, 941	. . . . . 293, 294, 1266, 1267, 1314, 1315,	
\l_draw_yvec_y_dim 896, 927, 945, 959		

<code>\tl_clear:N</code> .....	.. 1261, 1268, 1296, 1299, 1302, 1342
266, 1243, 1244, 1247, 1248, 1275, 1276	
<code>\tl_if_blank:nTF</code>	<code>\token_if_eq_meaning_p:NN</code>
497	1333, 1334, 1335
<code>\tl_if_blank_p:n</code>	
503	
<code>\tl_if_empty:N</code>	
1264, 1294	
<code>\tl_if_empty_p:N</code>	
1321, 1322	
<code>\tl_new:N</code> 11, 1083, 1084, 1135, 1136,	
1228, 1229, 1230, 1235, 1236, 1494	
<code>\tl_put_right:Nn</code> .. 319, 323, 1270,	
1272, 1278, 1312, 1365, 1451, 1453	
<code>\tl_set:Nn</code>	
... 315, 1265, 1274, 1295, 1359, 1422	
token commands:	
<code>\token_if_eq_meaning:NNTF</code>	

U

use commands:

<code>\use:N</code>
539, 570, 1509, 1511, 1513, 1515, 1517
<code>\use:n</code>
156, 192, 239,
348, 1418, 1430, 1475, 1570, 1581, 1646
<code>\use_i:nn</code>
16
<code>\use_i:nnnn</code>
1432
<code>\use_ii:nn</code>
16
<code>\use_none:n</code>
1445