

The `pict2e` package*

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Abstract

This package was described in the 2nd edition of “L^AT_EX: A Document Preparation System”, but the L^AT_EX project team declined to produce the package. For a long time, L^AT_EX has included a “`pict2e` package” that merely produced an apologetic error message.

The new package extends the existing L^AT_EX `picture` environment, using the familiar technique (cf. the `graphics` and `color` packages) of driver files. In the user-level part of this documentation there is a fair number of examples of use, showing where things are improved by comparison with the Standard L^AT_EX `picture` environment.

Contents

1	Introduction	2
2	Usage	3
2.1	Package options	3
2.1.1	Driver options	3
2.1.2	Other options	3
2.1.3	Debugging options	3
2.2	Configuration file	4
2.3	Details: Changes to user-level commands	4
2.3.1	Line	4
2.3.2	Vector	5
2.3.3	Circle and Dot	6
2.3.4	Oval	7
2.3.5	Bezier Curves	8
2.4	Extensions	9
2.4.1	Circle arcs	9
2.4.2	Line, Vector, polyline, polyvector, and polygon	9
2.4.3	Path commands	9
2.4.4	Ends of paths, joins of subpaths	10
3	Implementation	13
3.1	Initialisation	13
3.2	Preliminaries	13
3.3	Option processing	13
3.4	Output driver check	15
3.5	Mode check	15
3.6	Graphics operators	16
3.7	Low-level operations	17

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3.7.1	Collecting the graphics instructions and handling the output	17
3.7.2	Auxilliary macros	18
3.8	Medium-level operations	18
3.8.1	Transformations	18
3.8.2	Path definitions	19
3.9	“Pythagorean Addition” and Division	20
3.10	High-level operations	22
3.10.1	Line	23
3.10.2	Vector	23
3.10.3	Circle and Dot	26
3.10.4	Oval	28
3.10.5	Quadratic Bezier Curve	30
3.10.6	Circle arcs	31
3.10.7	Line, Vector, polyline, polyvector, and polygon	32
3.10.8	Path commands	33
3.10.9	Ends of paths, joins of subpaths	34
3.11	Commands from other packages	34
3.11.1	Package <code>e bezier</code>	34
3.11.2	Other packages	34
3.12	Mode ‘original’	35
3.13	Final clean-up	35

List of Figures

1	Line	5
2	Vector	6
3	Vector: shape variants of the arrow-heads	7
4	Circle and Dot	7
5	Oval: Radius argument for <code>\oval</code> vs. <code>\maxovalrad</code>	8
6	Oval: Radius argument for <code>\oval: length</code> vs. <code>number</code>	11
7	Quadratic Bezier curves	12
8	Cubic Bezier curves	12
9	Quadratic (green) and Cubic Bezier curves	12
10	\LaTeX -like implementation of <code>\vector</code>	25
11	PSTricks-like implementation of <code>\vector</code>	26
12	Auxillary macro <code>\pIIE@qcircle</code> —draw a quarter circle	27

1 Introduction

Here’s a quote from the obsolete original official version of the `pict2e` package (1993–2003):

The package `pict2e` that is mentioned in the 2nd edition of “ \LaTeX : A Document Preparation System” has not yet been produced. It is unlikely that the \LaTeX 3 Project Team will ever produce this package thus we would be very happy if someone else creates it.

:-) Finally, someone has produced a working implementation of the `pict2e` package.

This package redefines some of the drawing commands of the \LaTeX `picture` environment. Like the `graphics` and `color` packages, it uses driver files.

Currently there are only back-ends for PostScript and PDF. (Other output formats may be added in the future.)

Note/Warning:

- Documentation has been written somewhat “hastily” and may be inaccurate.
- The status of this package is currently somewhere between “beta” and “release” ... Users and package programmers should *not* rely on *any* feature sported by the internal commands. (Especially, the internal control sequence names may change without notice in future versions of this package.)

2 Usage

To use the `pict2e` package, you put a `\usepackage[optionlist]{pict2e}` instruction in the preamble of your document. Likewise, class or package writers just say `\RequirePackage[optionlist]{pict2e}` in an appropriate place in their class or package file. (Nothing unusual here.)

Like the `graphics` and `color` packages, the `pict2e` package supports a configuration file (see Section 2.2).

2.1 Package options

2.1.1 Driver options

driver	notes	driver	notes
<code>dvips</code>	x	<code>oztex</code>	(x)
<code>xdvi</code>	x	<code>dvipsone</code>	x?
<code>pdftex</code>	x	<code>dviwindo</code>	x?
<code>vtex</code>	x	<code>dvipdf</code>	x?
<code>dvipdfm</code>	x	<code>textures</code>	x?
<code>dvipdfmx</code>	x	<code>pctexps</code>	x?
<code>xetex</code>	x	<code>pctex32</code>	x?
<code>luatex (> 0.85)</code>	x		

x = supported; (x) = supported but untested;

x? = not yet implemented

The driver options are (mostly) implemented by means of definition files (`p2e-driver.def`). For details, see file `p2e-drivers.dtx`.

Note: You should specify the same driver for `pict2e` you use with the `graphics/x` and `color` packages. Otherwise, things may go haywire.

2.1.2 Other options

Currently, there are two options that allow you to choose between variants of the arrows-heads generated by the `\vector` command. See Figure 3 in Section 2.3.2 for the difference.

option	meaning
<code>ltxarrows</code>	Draw L ^A T _E X style vectors (default).
<code>pstarrows</code>	Draw P ^S T _r icks style vectors.

2.1.3 Debugging options

These options are (mainly) for development and testing purposes.

option	meaning
<code>original</code>	Suppresses the new definitions.
<code>debug</code>	Suppresses the compressing of pdf _T E _X output; marks the <code>pict2e</code> generated code in the output files.
<code>hide</code>	Suppresses all graphics output from <code>pict2e</code> .

2.2 Configuration file

Similar to the `graphics` and `color` packages, in most cases it is not necessary to give a driver option explicitly with the `\usepackage` (or `\RequirePackage`) command, if a suitable configuration file `pict2e.cfg` is present on your system (see the example file `pict2e-example.cfg`). On many systems it may be sufficient to copy `pict2e-example.cfg` to `pict2e.cfg`; on others you might need to modify your copy to suit your system.

2.3 Details: Changes to user-level commands

This section describes the improvements of the new implementation of (some of) the `picture` commands. For details, look up “`pict2e` package” in the index of the \LaTeX manual [1].

Here’s a collection of quotes relevant to the `pict2e` package from the \LaTeX manual [1].

From [1, p. 118]:

However, the `pict2e` package uses device-driver support to provide enhanced versions of these commands that remove some of their restrictions. The enhanced commands can draw straight lines and arrows of any slope, circles of any size, and lines (straight and curved) of any thickness.

From [1, p. 179]:

`pict2e` Defines enhanced versions of the `picture` environment commands that remove restrictions on the line slope, circle radius, and line thickness.

From [1, pp. 221–223]:

`\qbezier`

(With the `pict2e` package, there is no limit to the number of points plotted.)

`\line` and `\vector` Slopes $|x|, |y| \leq 6$ or 4, with no common divisor except ± 1 :

(These restrictions are eliminated by the `pict2e` package.)

`\line` and `\vector` Smallest horizontal extent of sloped lines and vectors that can be drawn:

(This does not apply when the `pict2e` package is loaded.)

`\circle` and `\circle*` Largest circles and disks that can be drawn:

(With the `pict2e` package, any size circle or disk can be drawn.)

`\oval` [$\langle rad \rangle$]:

An explicit `rad` argument can be used only with the `pict2e` package; the default value is the radius of the largest quarter-circle \LaTeX can draw without the `pict2e` package.

2.3.1 Line

`\line` `\line(\langle X, Y \rangle)\{\langle LEN \rangle\}`

In the Standard \LaTeX implementation the slope arguments ($\langle X, Y \rangle$) are restricted to integers in the range $-6 \leq X, Y \leq +6$, with no common divisors except ± 1 . (I.e., X and Y must be relatively prime.) Furthermore, only horizontal and vertical lines can assume arbitrary thickness; sloped lines are restricted to the widths given by the `\thinlines` and `\thicklines` declarations (i.e., 0.4pt and 0.8pt, respectively).

From [1, p. 222]:

These restrictions are eliminated by the `pict2e` package.

However, to avoid overflow of \TeX ’s `dimens`, the slope arguments are real numbers in the range $-16383 \leq X, Y \leq +16383$. It is usually not a good idea to use slope arguments with the absolute value less than 10^{-4} (the best accuracy is obtained if you use multiples of arguments

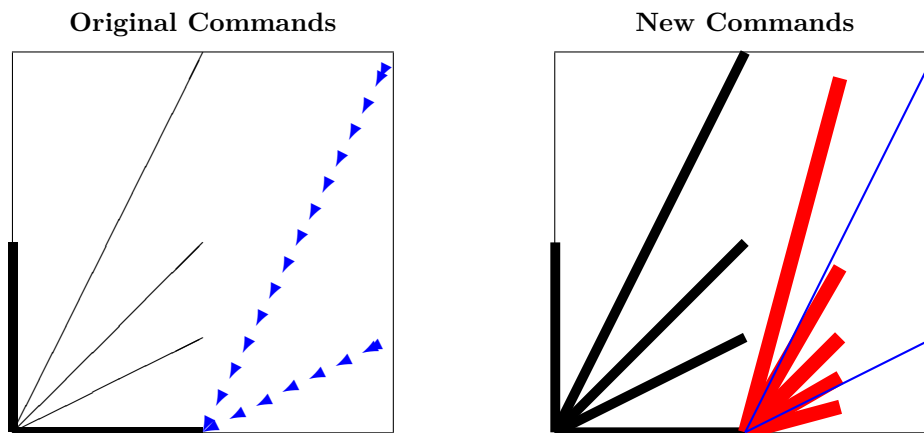


Figure 1: Line

such that you eliminate as much decimal parts as possible). The slope greater than 16384 cannot be obtained.

Furthermore, unlike the Standard \LaTeX implementation, which silently converts the “impossible” slope to a vertical line extending in the upward direction $((0, 0) \mapsto (0, 1))$, the `pict2e` package now treats this as an error.

In the Standard \LaTeX implementation the horizontal extent of sloped lines must be at least 10 pt.

From [1, p. 222]:

This does not apply when the `pict2e` package is loaded.

Figure 1 shows the difference between the old and new implementations: The black lines in the left half of each picture all have slopes that conform to the restrictions of Standard \LaTeX . However, with the new implementation of `pict2e` sloped lines may assume any arbitrary width given by the `\linethickness` declaration. The right half demonstrates that now arbitrary slopes are possible.

The blue lines represent “illegal” slopes specifications, i.e., with common divisors. Note the funny effect Standard \LaTeX produces in such cases. (In \LaTeX releases prior to 2003/12/01, some such “illegal” slopes might even lead to infinite loops! Cf. problem report latex/3570.)

The new implementation imposes no restriction with respect to line thickness, minimal horizontal extent, and slope.

The red lines correspond to angles of 15° , 30° , 45° , 60° , and 75° , respectively. This was achieved by multiplying the sine and cosine of each angle by 1000 and rounding to the nearest integer, like this:

```
\put(50,0){\line(966,259){25}}
\put(50,0){\line(866,500){25}}
\put(50,0){\line(707,707){25}}
\put(50,0){\line(500,866){25}}
\put(50,0){\line(259,966){25}}
```

2.3.2 Vector

`\vector` `\vector(\langle X, Y \rangle){\langle LEN \rangle}`

In the Standard \LaTeX implementation the slope arguments $(\langle X, Y \rangle)$ are restricted to integers in the range $-4 \leq X, Y \leq +4$, with no common divisors except ± 1 . (I.e., X and Y must be relatively prime.) Furthermore, arrow heads come only in two shapes, corresponding to the `\thinlines` and `\thicklines` declarations. (There’s also a flaw: the lines will be printed over the arrow heads. See vertical vector in Figure 2.)

From [1, p. 222]:

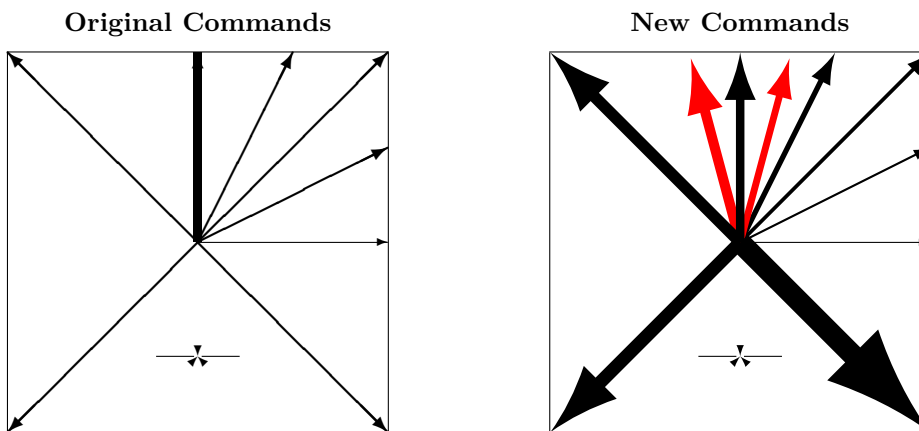


Figure 2: Vector

These restrictions are eliminated by the `pict2e` package.

However, to avoid overflow of $\text{T}_{\text{E}}\text{X}$'s dimen arithmetic, the current implementation restricts the slope arguments to real numbers in the range $-1000 \leq X, Y \leq +1000$, which should be enough. It is usually not a good idea to use slope arguments with the absolute value less than 10^{-4} (the best accuracy is obtained if you use multiples of arguments such that you eliminate as much decimal parts as possible). The slope greater than 16384 cannot be obtained.

Furthermore, unlike the Standard $\text{L}^{\text{A}}\text{T}_{\text{E}}\text{X}$ implementation, which silently converts the “impossible” slope to a vertical vector extending in the upward direction $((0, 0) \mapsto (0, 1))$, the `pict2e` package now treats this as an error.

In the Standard $\text{L}^{\text{A}}\text{T}_{\text{E}}\text{X}$ implementation the horizontal extent of sloped vectors must be at least 10 pt.

From [1, p. 222]:

This does not apply when the `pict2e` package is loaded.

Figure 2 shows the difference between the old and new implementations: The black arrows all have “legal” slopes. The red arrows have slope arguments out of the range permitted by Standard $\text{L}^{\text{A}}\text{T}_{\text{E}}\text{X}$. Slope arguments that are “illegal” in Standard $\text{L}^{\text{A}}\text{T}_{\text{E}}\text{X}$ produce results similar to those with the `\line` command (this has not been demonstrated here).

The new implementation imposes no restriction with respect to line thickness, minimal horizontal extent, and slope.

As with Standard $\text{L}^{\text{A}}\text{T}_{\text{E}}\text{X}$, the arrow head will always be drawn. In particular, only the arrow head will be drawn, if the total length of the arrow is less than the length of the arrow head. See right hand side of Figure 3.

The current version of the `pict2e` package offers two variants for the shape of the arrow heads, controlled by package options. One variant tries to mimic the fonts used in the Standard $\text{L}^{\text{A}}\text{T}_{\text{E}}\text{X}$ implementation (package option `ltxarrows`, the default; see Figure 3, top row), though it is difficult to extrapolate from just two design sizes. The other one is implemented like the arrows of the `PSTricks` package [8] (package option `pstarrows`; see Figure 3, bottom row).

2.3.3 Circle and Dot

```
\circle \circle{\DIAM}
\circle* \circle*{\DIAM}
```

The (hollow) circles and disks (filled circles) of the Standard $\text{L}^{\text{A}}\text{T}_{\text{E}}\text{X}$ implementation had severe restrictions on the number of different diameters and maximum diameters available.

From [1, p. 222]:

With the `pict2e` package, any size circle or disk can be drawn.

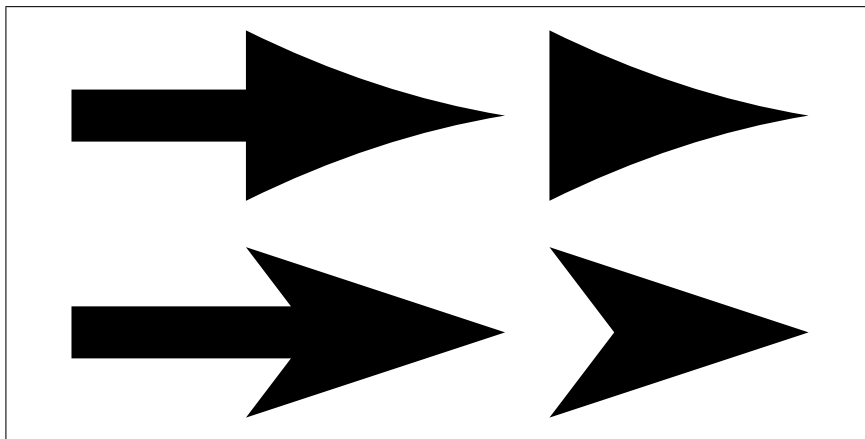


Figure 3: Vector: shape variants of the arrow-heads. Top: L^AT_EX style vectors. Bottom: PSTricks style vectors.

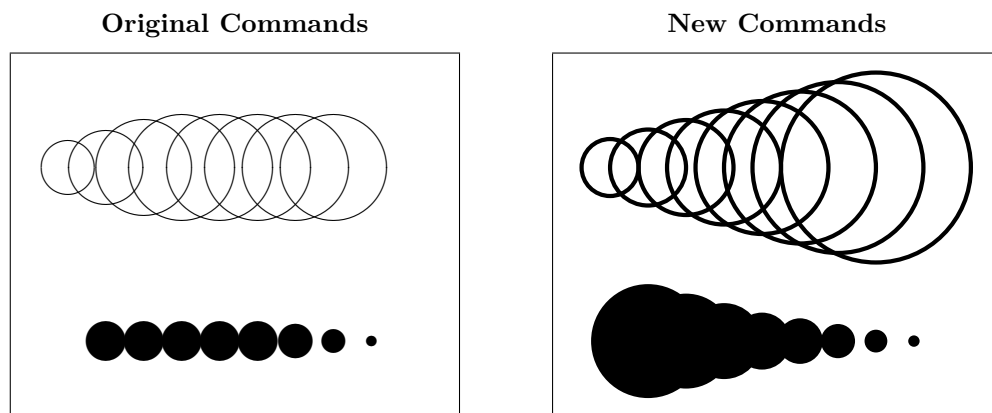


Figure 4: Circle and Dot

With the new implementation there are no more restrictions to the diameter argument. (However, negative diameters are now trapped as an error.)

Furthermore, hollow circles (like sloped lines) can now be drawn with any line thickness. Figure 4 shows the difference.

2.3.4 Oval

`\oval` `\oval[$\langle rad \rangle$]($\langle X, Y \rangle$)[$\langle POS \rangle$]`

In the Standard L^AT_EX implementation, the user has no control over the shape of an oval besides its size, since its corners would always consist of the “quarter circles of the largest possible radius less than or equal to *rad*” [1, p. 223].

From [1, p. 223]:

An explicit rad argument can be used only with the pict2e package; the default value is the radius of the largest quarter-circle L^AT_EX can draw without the pict2e package.

This default value is 20 pt, a length. However, in an early reimplemention of the picture commands [5], there is such an optional argument too, but it is given as a mere number, to be multiplied by `\unitlength`.

Since both alternatives may make sense, we left the choice to the user. (See Figure 6 for the differences.) I.e., this implementation of `\oval` will “auto-detect” whether its [$\langle rad \rangle$]

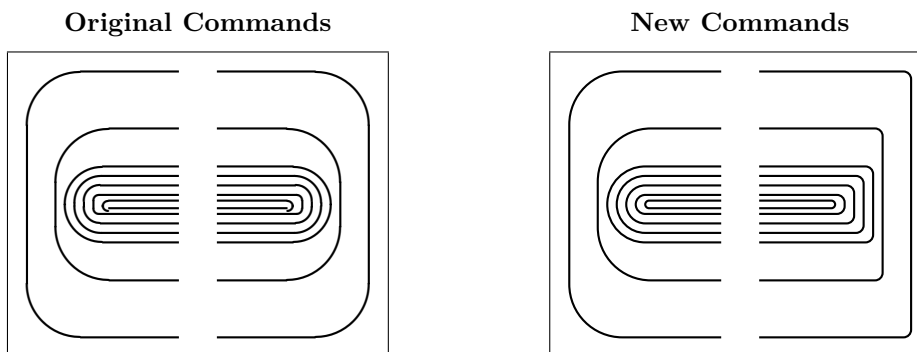


Figure 5: Oval: Radius argument for `\oval` vs. `\maxovalrad`

`\maxovalrad` argument is a length or a number. Furthermore, the default value is not hard-wired either; the user may access it under the moniker `\maxovalrad`, by the means of `\renewcommand*`. (Names or values of length and counter registers may be given as well, both as an explicit [*rad*] argument and when redefining `\maxovalrad`.)

(Both [*rad*] and the default value `\maxovalrad` are ignored in “standard L^AT_EX mode”).

The behaviour of `\oval` in the absence of the [*rad*] argument is shown in Figure 5, left half of each picture. Note that in the Standard L^AT_EX implementation there is a minimum radius as well (innermost “salami” is “broken”). In the right half of each picture, a [*rad*] argument has been used: it has no effect with the original `\oval` command.

Both [*rad*] and `\maxovalrad` may be given as an explicit (rigid) length (i.e., with unit) or as a number. In the latter case the value is used as a factor to multiply by `\unitlength`. (A length or counter register will do as well, of course.)

If a number is given, the rounded corners of an oval will scale according to the current value of `\unitlength`. (See Figure 6, first row.)

If a length is specified, the rounded corners of an oval will be the same regardless of the current value of `\unitlength`. (See Figure 6, second row.)

The default value is 20 pt as specified for the [*rad*] argument of `\oval` by the L^AT_EX manual [1, p. 223]. (See Figure 6, third row.)

2.3.5 Bezier Curves

`\bezier` `\bezier{<N>}<(AX,AY)><(BX,BY)><(CX,CY)>`

`\qbezier` `\qbezier[<N>]<(AX,AY)><(BX,BY)><(CX,CY)>`

`\cbezier` `\cbezier[<N>]<(AX,AY)><(BX,BY)><(CX,CY)><(DX,DY)>`

`\qbeziermax` In Standard L^AT_EX, the *N* argument specifies the number of points to plot: *N* + 1 for a positive integer *N*, appropriate number (at most `\qbeziermax`) for *N* = 0 or if the optional argument is missing. With L^AT_EX versions prior to 2003/12/01, the quadratic Bezier curves plotted by this package will not match those of the Standard L^AT_EX implementation exactly, due to a bug in positioning the dots used to produce a curve (cf. latex/3566).

`\bezier` is the obsolescent variant from the old `bezier` package of vintage L^AT_EX2.09.

The `\cbezier` command draws a cubic Bezier curve; see [3]. (This is not mentioned in [1] and has been added to the package deliberately.)

From [1, p. 221–223]:

With the `pict2e` package, there is no limit to the number of points plotted.

More accurately, if the optional argument is absent or is 0, the `pict2e` package uses primitive operators of the output (back-end) format to draw a full curve.

2.4 Extensions

This section describe new commands that extend the possibilities of the `picture` environment. It is not our aim to create a powerful collection of macros (like `pstricks` or `tikz`). The main goal of this package is to eliminate the limitations of the standard `picture` commands. But this is done by PostScript and PDF operators that might be easily used for user-level commands and hence significantly improve the drawing possibilities.

2.4.1 Circle arcs

```
\arc \arc[ $\langle ANGLE1, ANGLE2 \rangle$ ]{ $\langle RAD \rangle$ }
\arc* \arc*[ $\langle ANGLE1, ANGLE2 \rangle$ ]{ $\langle RAD \rangle$ }
```

These commands are generalizations of `\circle` and `\circle*` commands except that the radius instead of the diameter is given. The optional argument is a comma separated pair of angles given in degrees (implicit value is $[0, 360]$). The arc starts at the point given by $ANGLE1$. If $ANGLE2$ is greater than $ANGLE1$ the arc is drawn in the positive orientation (anticlockwise), if the $ANGLE2$ is smaller than $ANGLE1$ the arc is drawn in the negative orientation (clockwise). The angle of the arc is the absolute value the difference of $ANGLE1$ and $ANGLE2$. Hence the pair $[-10, 80]$ gives the same arc as $[80, -10]$ (a quarter of a circle) while the pairs $[80, 350]$ and $[350, 80]$ give the complementary arc.

In fact, the arc is approximated by cubic Bezier curves with an inaccuracy smaller than 0.0003 (it seems to be sufficiently good).

If `\squarecap` is active then `\arc{ $\langle RAD \rangle$ }` produces a circle with a square.

An equivalent `\pIIearc` to `\arc` is defined to solve possible conflicts with other packages.

2.4.2 Line, Vector, polyline, polyvector, and polygon

```
\Line \Line( $\langle X1, Y1 \rangle$ )( $\langle X2, Y2 \rangle$ )
\polyline \polyline( $\langle X1, Y1 \rangle$ )( $\langle X2, Y2 \rangle$ )... ( $\langle Xn, Yn \rangle$ )
\Vector \Vector( $\langle X1, Y1 \rangle$ )( $\langle X2, Y2 \rangle$ )
\polyvector \polyvector( $\langle X1, Y1 \rangle$ )( $\langle X2, Y2 \rangle$ )... ( $\langle Xn, Yn \rangle$ )
\polygon \polygon( $\langle X1, Y1 \rangle$ )( $\langle X2, Y2 \rangle$ )... ( $\langle Xn, Yn \rangle$ )
\polygon* \polygon*( $\langle X1, Y1 \rangle$ )( $\langle X2, Y2 \rangle$ )... ( $\langle Xn, Yn \rangle$ )
```

A natural way how to describe a line segment is to give the coordinates of the endpoints. The syntax of the `\line`/`\vector` is different because the lines in the standard `picture` environment are made from small line segments of a limited number of slopes given in a font. However, this package changes the `\line` command computing the coordinates of the endpoints and using an internal macro for drawing a line segment with given endpoints. Hence it would be crazy do not use this possibility directly. This is done by the commands `\Line` and `\Vector`. The commands `\polyline` and `\polyvector` draws a stroken line/vector connecting points with given coordinates. The command `\polygon` draws a polygon with given vertices, the star variant gives filled polygon. At least two points should be given.

These command need not be used within a `\put` command (if the coordinates are absolute).

2.4.3 Path commands

```
\moveto \moveto( $\langle X, Y \rangle$ )
\lineto \lineto( $\langle X, Y \rangle$ )
\curveto \curveto( $\langle X2, Y2 \rangle$ )( $\langle X3, Y3 \rangle$ )( $\langle X4, Y4 \rangle$ )
\circlearc \circlearc[ $\langle N \rangle$ ]{ $\langle X \rangle$ }{ $\langle Y \rangle$ }{ $\langle RAD \rangle$ }{ $\langle ANGLE1 \rangle$ }{ $\langle ANGLE2 \rangle$ }
```

These commands directly correspond to the PostScript and PDF path operators. You start defining a path giving its initial point by `\moveto`. Then you can consecutively add a line segment to a given point by `\lineto`, a cubic Bezier curve by `\curveto` (two control points and the endpoint are given) or an arc by `\circlearc` (mandatory parameters are coordinates of the center, radius, initial and final angle).

Drawing arcs is a bit more complicated. There is a special operator only in PostScript (not in PDF) but also in PostScript it is approximated by cubic Bezier curves. Here we use common definition for PostScript and PDF. The arc is drawn such that the initial point given by the initial angle is rotated by $ANGLE2 - ANGLE1$ (anticlockwise for positive value and clockwise for negative value) after reducing this difference to the interval $[-720, 720]$. Implicitly (the optional parameter $N = 0$) before drawing an arc a `\lineto` to the initial point of the arc is added. For $N = 1$ `\moveto` instead of `\lineto` is executed—it is useful if you start the path by an arc and do not want to compute and set the initial point. For $N = 2$ the `\lineto` before drawing the arc is omitted—it leads to a bit shorter code for the path but you should be sure that the already defined part of the path ends precisely at the initial point of the arc.

`\closepath` The command `\closepath` is equivalent to `\lineto` to the initial point of the path. After defining paths you might use either `\strokepath` to draw them or, for closed paths, `\fillpath` to draw an area bounded by them.

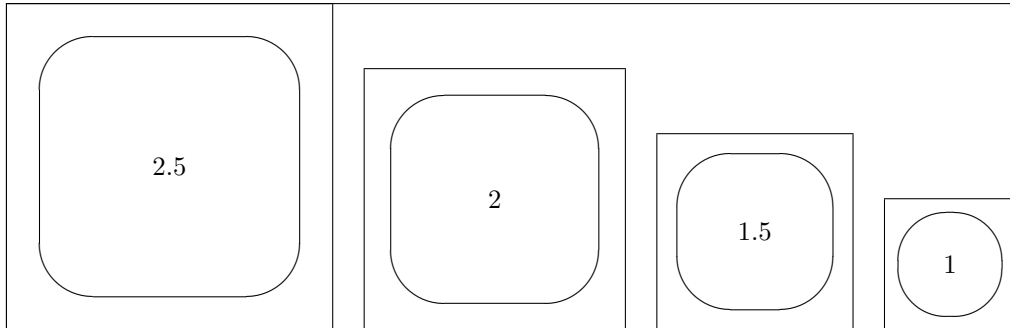
The path construction need not be used within a `\put` command (if the coordinates are absolute).

2.4.4 Ends of paths, joins of subpaths

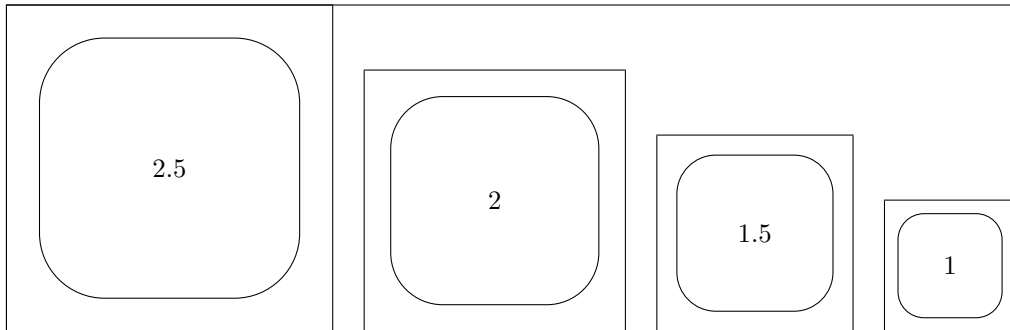
`\buttcap` The shape of ends of paths is controlled by the following commands: `\buttcap` (implicit) define the end as a line segment, `\roundcap` adds a halfdisc, `\squarecap` adds a halfsquare. `\squarecap` While `\squarecap` is ignored for the path with zero length, `\roundcap` places a disc to the given point. These commands do not apply to `\vector` and to closed paths (`\circle`, full `\oval`, parameter, path constructions ended by `\closepath`).

`\miterjoin` The shape of joins of subpaths is controlled by the following commands: `\miterjoin` (implicit) might be defined in such a way that “boundaries” of subpaths are prolonged until they intersect (it might be a rather long distance for lines with a small angle between them); `\roundjoin` corresponds to `\roundcap` for both subpaths; `\beveljoin` adds a convex hull of terminal line segments of both subpaths.

Original Commands, [$\langle rad \rangle$] or $\backslash\maxovalrad$ ignored



New Commands, [$\langle rad \rangle$] or $\backslash\maxovalrad$ depends on $\backslash\unitlength$



New Commands, [$\langle rad \rangle$] or $\backslash\maxovalrad$ a fixed length

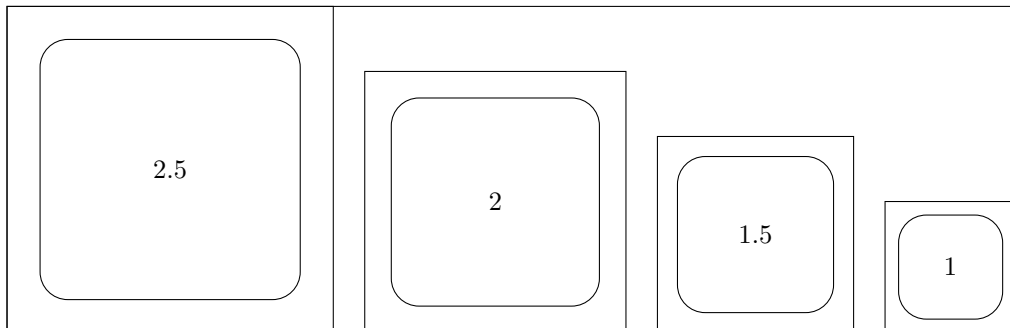


Figure 6: Oval: Radius argument for $\backslash\oval$: length vs. number. The number at the centre of each oval gives the relative value of $\backslash\unitlength$.

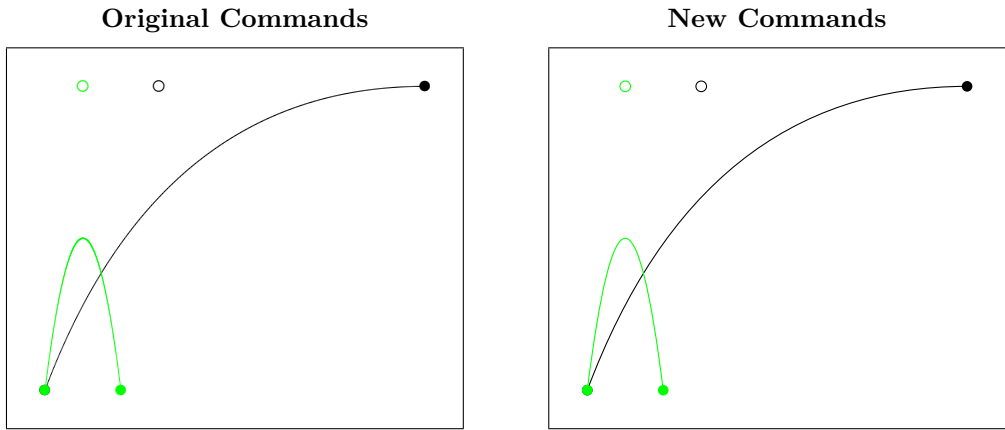


Figure 7: Quadratic Bezier curves

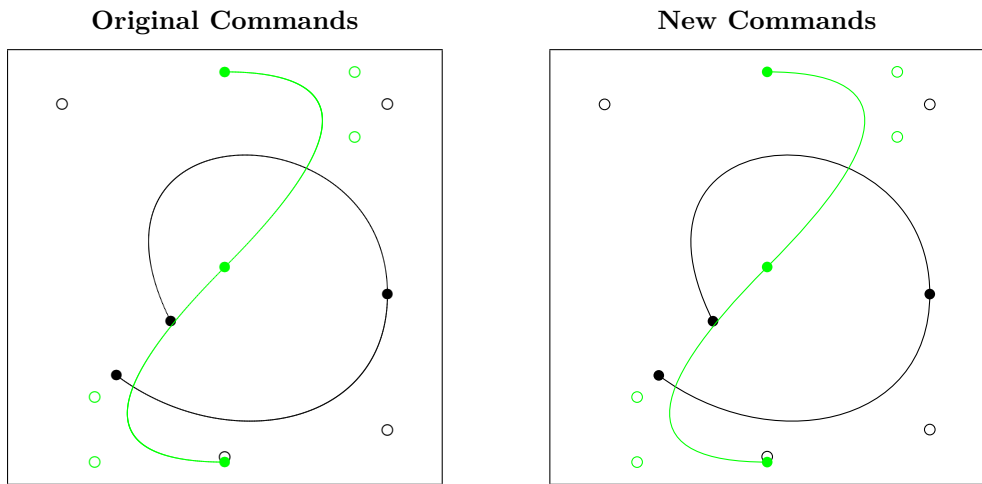


Figure 8: Cubic Bezier curves

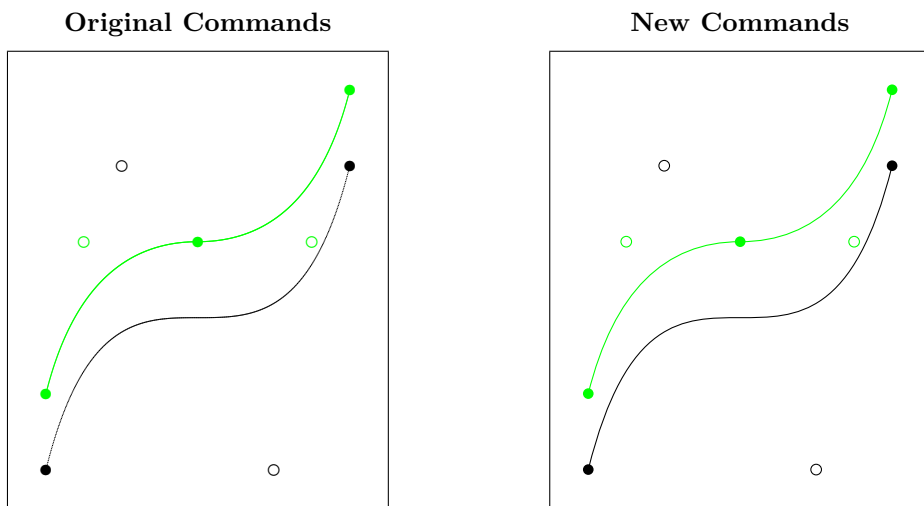


Figure 9: Quadratic (green) and Cubic Bezier curves

3 Implementation

Unlike other packages that have reimplemented or extended some of the commands from Standard L^AT_EX’s `picture` environment, we do not use special fonts, nor draw arbitrary shapes by the means of myriads of small (point) characters, nor do we use sophisticated programming in some back-end programming language.

In its present state, this implementation supports just PostScript and PDF as back-end formats. It just calculates the necessary control points and uses primitive path drawing operators.

```
1 <*package>
```

3.1 Initialisation

`\Gin@codes` First we save the catcodes of some characters, and set them to fixed values whilst this file is being read. (This is done in almost the same manner as in the `graphics` and `color` packages. Alas, we don’t need nor want to have `*` as part of control sequence names, so we omit it here.)

```
2 \edef\Gin@codes{%
3 \catcode'\noexpand\^^A\the\catcode'\^^A\relax
4 \catcode'\noexpand\" \the\catcode'\\" \relax
5 % \catcode'\noexpand*\the\catcode'\*\relax
6 \catcode'\noexpand!\the\catcode'\!\relax
7 \catcode'\noexpand:\the\catcode'\:\relax}

8 \catcode'\^^A=\catcode'\%
9 \@makeother\"%
10 % \catcode'\*=11
11 \@makeother\!%
12 \@makeother\:%
```

3.2 Preliminaries

`\pIIE@mode` The first two of these commands determine how the `pict2e` package works internally; they should be defined properly by the `p2e-⟨driver⟩.def` files. (See file `p2e-drivers.dtx` for details and sample implementations.)

`\pIIE@code`
`\Gin@driver`

The latter command is well known from the `graphics` and `color` packages from the Standard L^AT_EX graphics bundle; it should be set by a package option—most likely in a (system dependent) configuration file `pict2e.cfg`. (File `p2e-drivers.dtx` contains an example configuration file suitable for the `teLEX` and `TEXlive` distributions; it will be extracted as `pict2e-example.cfg`.)

```
13 \newcommand*\pIIE@mode{-1}
14 \newcommand*\pIIE@code[1]{}
15 \providecommand*\Gin@driver{}
```

`\pIIE@tempa` At times, we need some temporary storage bins. However, we only use some macros and do not allocate any new registers; the “superfluous” ones from the `picture` module of the kernel (`ltpictur.dtx`) and the general scratch registers should suffice.

`\pIIE@tempb`
`\pIIE@tempc`

```
16 \newcommand*\pIIE@tempa{}
17 \newcommand*\pIIE@tempb{}
18 \newcommand*\pIIE@tempc{}
```

3.3 Option processing

The driver options are not much of a surprise: they are similar to those of the `graphics` and `color` packages.

```
19 \DeclareOption{dvips}{\def\Gin@driver{dvips.def}}
20 \DeclareOption{xdvi}{\ExecuteOptions{dvips}}
```

```

21 \DeclareOption{dvipdf}{\def\Gin@driver{dvipdf.def}}
22 \DeclareOption{dvipdfm}{\def\Gin@driver{dvipdfm.def}}
23 \DeclareOption{dvipdfmx}{\def\Gin@driver{dvipdfmx.def}}
24 \DeclareOption{pdftex}{\def\Gin@driver{pdftex.def}}
25 \DeclareOption{luatex}{\def\Gin@driver{luatex.def}}
26 \DeclareOption{xetex}{\def\Gin@driver{xetex.def}}
27 \DeclareOption{dvipsone}{\def\Gin@driver{dvipsone.def}}
28 \DeclareOption{dviwindo}{\ExecuteOptions{dvipsone}}
29 \DeclareOption{oztex}{\ExecuteOptions{dvips}}
30 \DeclareOption{textures}{\def\Gin@driver{textures.def}}
31 \DeclareOption{pctexps}{\def\Gin@driver{pctexps.def}}
32 \DeclareOption{pctex32}{\def\Gin@driver{pctex32.def}}
33 \DeclareOption{vtex}{\def\Gin@driver{vtex.def}}

```

Request “original” L^AT_EX mode.

```
34 \DeclareOption{original}{\def\pIIE@mode{0}}
```

`\ifpIIE@pdfliteral@ok` Check, whether if `\pIIE@pdfliteral` is given in the driver file or `\pdfliteral` available
`\pIIE@pdfliteral` directly.

```

35 \newif\ifpIIE@pdfliteral@ok
36 \pIIE@pdfliteral@oktrue
37 \ifx\pIIE@pdfliteral\@undefined
38   \ifx\pdfliteral\@undefined
39     \pIIE@pdfliteral@okfalse
40     \def\pIIE@pdfliteral#1{%
41       \PackageWarning{pict2e}{pdfliteral not supported}%
42     }%
43   \else
44     \let\pIIE@pdfliteral\pdfliteral
45   \fi
46 \fi

```

`\pIIE@buttcap` Do `\buttcap` only if available.

```

47 \def\pIIE@buttcap{%
48   \ifpIIE@pdfliteral@ok
49     \buttcap
50   \fi
51 }

```

`\pIIE@FAL` Some macros to parametrize the shape of the vector outline. The following values are “hand
`\pIIE@FAW` optimized” with the aim of emulating L^AT_EX-style arrows. They also seem suitable for our
`\pIIE@CAW` PSTricks-style arrows. See Figures 10 and 11.

```

\pIIE@FAI 52 \newcommand*\pIIE@FAL{1.52}%
          53 \newcommand*\pIIE@FAW{3.2}%
          54 \newcommand*\pIIE@CAW{1.5pt}%
          55 \newcommand*\pIIE@FAI{0.25}%

```

`\ltxarrows` The following user-level macros can be used to change the arrow style (L^AT_EX-style is the
`\pstarrows` default).

```

56 \newcommand*\ltxarrows{%
57   \let\pIIE@vector=\pIIE@vector@ltx
58 }
59 \newcommand*\pstarrows{%
60   \let\pIIE@vector=\pIIE@vector@pst
61 }

62 \DeclareOption{ltxarrows}{\AtEndOfPackage{ltxarrows}}
63 \DeclareOption{pstarrows}{\AtEndOfPackage{pstarrows}}

```

```

\pIIE@debug@comment This makes debugging easier.
64 \newcommand*\pIIE@debug@comment{}
65 \DeclareOption{debug}{%
66 \def\pIIE@debug@comment{^^J^^J\@percentchar\space >> pict2e <<<^^J}%
67 \begingroup
68 \ifundefined{pdfcompresslevel}{\global\pdfcompresslevel\z@}%
69 \endgroup}

```

A special variant of debugging. (Obsolescent? Once used for performance measurements: arctan vs. pyth-add versions of `\vector`.)

```

70 \DeclareOption{hide}{\AtEndOfPackage{%
71 % \def\pIIE@code#1{}%
72 \let\pIIE@code\@gobble
73 }}

```

Unknown options default to mode “original.”

```

74 \DeclareOption*\ExecuteOptions{original}

```

By default, arrows are in the L^AT_EX style.

```

75 \ExecuteOptions{ltxarrows}

```

Like the `graphics` and `color` packages, we support a configuration file. (See file `p2e-drivers.dtx` for details and an example.)

```

76 \InputIfFileExists{pict2e.cfg}{-}{-}

```

This now should make clear which “mode” and “code” we should use.

```

77 \ProcessOptions\relax

```

3.4 Output driver check

```

78 \ifnum\pIIE@mode=\z@
79 \PackageInfo{pict2e}{Package option ‘original’ requested}
80 \else

```

This code fragment is more or less cloned from the `graphics` and `color` packages.

```

81 \if!\Gin@driver!
82 \PackageError{pict2e}
83 {No driver specified at all}
84 {You should make a default driver option in a file\MessageBreak
85 pict2e.cfg\MessageBreak eg: \protect\ExecuteOptions{dvips}}%
86 \else
87 \PackageInfo{pict2e}{Driver file: \Gin@driver}
88 \@ifundefined{ver@\Gin@driver}{\input{\Gin@driver}}{-}
89 \PackageInfo{pict2e}{Driver file for pict2e: p2e-\Gin@driver}
90 \InputIfFileExists{p2e-\Gin@driver}{-}{-}%
91 \PackageError{pict2e}%
92 {Driver file ‘p2e-\Gin@driver’ not found}%
93 {Q: Is the file properly installed? A: No!}
94 \fi
95 \fi

```

3.5 Mode check

For PostScript and PDF modes.

```

96 \ifnum\pIIE@mode>\z@
97 \ifnum\pIIE@mode<\thr@@
98 \RequirePackage{trig}

```

```

\pIIE@oldline Saved versions of some macros. (Or dummy definitions.)
\pIIE@old@sline 99 \let\pIIE@oldline\line
\pIIE@old@vector 100 \let\pIIE@old@sline\@sline
\pIIE@old@circle
\pIIE@old@dot
\pIIE@old@bezier
\pIIE@old@cbezier
\pIIE@old@oval
\pIIE@old@oval

```

```

101 \let\pIIE@oldvector\vector
102 \let\pIIE@old@circle\@circle
103 \let\pIIE@old@dot\@dot
104 \let\pIIE@old@bezier\@bezier
105 \AtBeginDocument{%
106   \ifundefined{@cbezier}{%
107     \def\pIIE@old@cbezier[#1](#2,#3)(#4,#5)(#6,#7)(#8,#9){}%
108     }\let\pIIE@old@cbezier\@cbezier}}
109 \let\pIIE@oldoval\oval
110 \let\pIIE@old@oval\@oval

```

`\OriginalPictureCmds` Switches back to the original definitions; for testing and demonstration purposes only.

```

111 \newcommand*\OriginalPictureCmds{%
112   \let\@sline\pIIE@old@sline
113   \let\line\pIIE@oldline
114   \let\vector\pIIE@oldvector
115   \let\@circle\pIIE@old@circle
116   \let\@dot\pIIE@old@dot
117   \let\@bezier\pIIE@old@bezier
118   \let\@cbezier\pIIE@old@cbezier
119   \renewcommand*\oval[1][\pIIE@oldoval]{%
120     \let\@oval\pIIE@old@oval
121   }

```

Overambitious drivers.

```

122 \else
123   \PackageError{pict2e}
124     {Unsupported mode (\pIIE@mode) specified}
125     {The driver you specified requested a mode\MessageBreak
126       not supported by this version of this package}
127 \fi

```

Incapable drivers.

```

128 \else
129   \ifnum\pIIE@mode<\z@
130     \PackageError{pict2e}
131       {No suitable driver specified}
132       {You should make a default driver option in a file\MessageBreak
133         pict2e.cfg\MessageBreak eg: \protect\ExecuteOptions{dvips}}
134 \fi
135 \fi

```

Big switch, completed near the end of the package (see page 35).

```

136 \ifnum\pIIE@mode>\z@

```

3.6 Graphics operators

The following definitions allow the PostScript and PDF operations below to share some of the code.

```

137 \ifcase\pIIE@mode\relax

```

```

\pIIE@moveto@op PostScript
\pIIE@lineto@op 138 \or
\pIIE@setlinewidth@op 139 \newcommand*\pIIE@moveto@op{moveto}
\pIIE@stroke@op 140 \newcommand*\pIIE@lineto@op{lineto}
\pIIE@fill@op 141 \newcommand*\pIIE@setlinewidth@op{setlinewidth}
\pIIE@curveto@op 142 \newcommand*\pIIE@stroke@op{stroke}
\pIIE@concat@op 143 \newcommand*\pIIE@fill@op{fill}
\pIIE@closepath@op 144 \newcommand*\pIIE@curveto@op{curveto}

```



```

145 \newcommand*\pIIE@concat@op{concat}
146 \newcommand*\pIIE@closepath@op{closepath}

```

```

\pIIE@moveto@op PDF
\pIIE@lineto@op 147 \or
\pIIE@setlinewidth@op 148 \newcommand*\pIIE@moveto@op{m}
\pIIE@stroke@op 149 \newcommand*\pIIE@lineto@op{l}
\pIIE@fill@op 150 \newcommand*\pIIE@setlinewidth@op{w}
\pIIE@curveto@op 151 \newcommand*\pIIE@stroke@op{S}
\pIIE@concat@op 152 \newcommand*\pIIE@fill@op{f}
\pIIE@closepath@op 153 \newcommand*\pIIE@curveto@op{c}
154 \newcommand*\pIIE@concat@op{cm}
155 \newcommand*\pIIE@closepath@op{h}

```

(Currently, there are no other modes.)

```
156 \fi
```

3.7 Low-level operations

3.7.1 Collecting the graphics instructions and handling the output

```

\pIIE@GRAPH We collect all PostScript/PDF output code for a single picture object in a token register.
\pIIE@addtoGraph 157 \ifdefinable\pIIE@GRAPH{\newtoks\pIIE@GRAPH}
158 \newcommand*\pIIE@addtoGraph[1]{%
159 \begingroup
160 \edef\x{\the\pIIE@GRAPH\space#1}%
161 \global\pIIE@GRAPH\expandafter\x}%
162 \endgroup}

```

```

\pIIE@fillGraph The path will either be filled ...
163 \newcommand*\pIIE@fillGraph{\begingroup \@tempwattrue\pIIE@drawGraph}

```

```

\pIIE@strokeGraph ... or stroked.
164 \newcommand*\pIIE@strokeGraph{\begingroup \@tempwafalse\pIIE@drawGraph}

```

```

\pIIE@drawGraph Common code. When we are done with collecting the path of the picture object, we output
the contents of the token register.
165 \newcommand*\pIIE@drawGraph{%
166 \edef\x{\pIIE@debug@comment\space

```

Instead of scaling individual coordinates, we scale the graph as a whole (pt→bp); see Section 3.8.1.

```

167 \pIIE@scale@PTtoBP}%
168 \if@tempwa
169 \edef\y{\pIIE@fill@op}%
170 \else
171 \edef\x{\x\space
172 \strip@pt\@wholewidth\space\pIIE@setlinewidth@op
173 \pIIE@linecap\pIIE@linejoin\space}%
174 \edef\y{\pIIE@stroke@op}%
175 \fi
176 \expandafter\pIIE@code\expandafter{%
177 \expandafter\x\the\pIIE@GRAPH\space\y}%

```

Clear the graph and the current point after output.

```

178 \global\pIIE@GRAPH{}\xdef\pIIE@CPx{}\xdef\pIIE@CPy{}%
179 \endgroup}

```

3.7.2 Auxilliary macros

The following macros save us a plethora of tokens in subsequent code.

Note that since we are using `\@tempdima` and `\@tempdimb` both here and in medium-level macros below, we must be careful not to spoil their values.

`\pIIE@CPx` The lengths (coordinates) given as arguments will be stored as “real” numbers using the common trick; i.e., they are put in ‘dimen’ registers, scaled by 2^{16} . At the same time, we remember the “current point.” (Not strictly necessary for PostScript, but for some operations in PDF, e.g., *rcurveto* emulation.)

```
180 \newcommand*\pIIE@CPx{} \newcommand*\pIIE@CPy{}
181 \newcommand*\pIIE@add@CP[2]{%
182   \begingroup
183     \@tempdima#1\xdef\pIIE@CPx{\the\@tempdima}%
184     \@tempdimb#2\xdef\pIIE@CPy{\the\@tempdimb}%
185     \pIIE@addtoGraph{\strip@pt\@tempdima\space\strip@pt\@tempdimb}%
186   \endgroup}
```

`\pIIE@add@nums` Similar, but does not set the “current point.” Values need not be coordinates (e.g., may be scaling factors, etc.).

```
187 \newcommand*\pIIE@add@nums[2]{%
188   \begingroup
189     \@tempdima#1\relax
190     \@tempdimb#2\relax
191     \pIIE@addtoGraph{\strip@pt\@tempdima\space\strip@pt\@tempdimb}%
192   \endgroup}
```

`\pIIE@add@num` Likewise, for a single argument.

```
193 \newcommand*\pIIE@add@num[1]{%
194   \begingroup
195     \@tempdima#1\relax
196     \pIIE@addtoGraph{\strip@pt\@tempdima}%
197   \endgroup}
```

3.8 Medium-level operations

3.8.1 Transformations

Transformation operators; not all are currently used. (Hence, some are untested.)

`\pIIE@PTtoBP` Scaling factor, used below. “pt→bp” ($72/72.27 \approx 0.99626401$). Note the trailing space! (Don’t delete it, it saves us some tokens.)

```
198 \newcommand*\pIIE@PTtoBP{0.99626401 }
199 \ifcase\pIIE@mode\relax
```

`\pIIE@concat` PostScript: Use some operators directly.

```
\pIIE@translate 200 \or
\pIIE@rotate 201 \newcommand*\pIIE@concat[6]{%
\pIIE@scale 202   \begingroup
\pIIE@scale@PTtoBP 203     \pIIE@addtoGraph{[]}%
204     \@tempdima#1\relax \@tempdimb#2\relax
205     \pIIE@add@nums\@tempdima\@tempdimb
206     \@tempdima#3\relax \@tempdimb#4\relax
207     \pIIE@add@nums\@tempdima\@tempdimb
208     \@tempdima#5\relax \@tempdimb#6\relax
209     \pIIE@add@nums\@tempdima\@tempdimb
210     \pIIE@addtoGraph{} \pIIE@concat@op}%
```

```

211     \endgroup}
212     \newcommand*\pIIE@translate[2]{\pIIE@add@nums{#1}{#2}\pIIE@addtoGraph{translate}}
213     \newcommand*\pIIE@rotate[1]{\pIIE@add@num{#1}\pIIE@addtoGraph{rotate}}
214     \newcommand*\pIIE@scale[2]{\pIIE@add@nums{#1}{#2}\pIIE@addtoGraph{scale}}
215     \newcommand*\pIIE@scale@PTtoBP{\pIIE@PTtoBP \pIIE@PTtoBP scale}

\pIIE@concat PDF: Emulate. :-(
\pIIE@translate 216 \or
\pIIE@rotate 217 \newcommand*\pIIE@concat[6]{%
\pIIE@scale 218 \begingroup
\pIIE@scale@PTtoBP 219 \@tempdima#1\relax \@tempdimb#2\relax
220 \pIIE@add@nums\@tempdima\@tempdimb
221 \@tempdima#3\relax \@tempdimb#4\relax
222 \pIIE@add@nums\@tempdima\@tempdimb
223 \@tempdima#5\relax \@tempdimb#6\relax
224 \pIIE@add@nums\@tempdima\@tempdimb
225 \pIIE@addtoGraph\pIIE@concat@op
226 \endgroup}
227 \newcommand*\pIIE@translate[2]{\pIIE@concat\p@z@z@\p@{#1}{#2}}
228 \newcommand*\pIIE@rotate[1]{%
229 \begingroup
230 \@tempdima#1\relax
231 \edef\pIIE@tempa{\strip@pt\@tempdima}%
232 \CalculateSin\pIIE@tempa
233 \CalculateCos\pIIE@tempa
234 \edef\pIIE@tempb{\UseSin\pIIE@tempa}%
235 \edef\pIIE@tempc{\UseCos\pIIE@tempa}%
236 \pIIE@concat{\pIIE@tempc\p@}{\pIIE@tempb\p@}%
237 {-\pIIE@tempb\p@}{\pIIE@tempc\p@}\z@\z@
238 \endgroup}
239 \newcommand*\pIIE@scale[2]{\pIIE@concat{#1}\z@\z@{#2}\z@\z@}
240 \newcommand*\pIIE@scale@PTtoBP{\pIIE@PTtoBP 0 0 \pIIE@PTtoBP 0 0 \pIIE@concat@op}

```

(Currently, there are no other modes.)

```
241 \fi
```

3.8.2 Path definitions

\pIIE@moveto Simple things ...

```
242 \newcommand*\pIIE@moveto[2]{%
243 \pIIE@add@CP{#1}{#2}\pIIE@addtoGraph\pIIE@moveto@op}
```

\pIIE@lineto ... have to be defined, too.

```
244 \newcommand*\pIIE@lineto[2]{%
245 \pIIE@add@CP{#1}{#2}\pIIE@addtoGraph\pIIE@lineto@op}
```

We'll use \pIIE@rcurveto to draw quarter circles. (\circle and \oval).

```
246 \ifcase\pIIE@mode\relax
```

\pIIE@rcurveto PostScript: Use the "rcurveto" operator directly.

```
247 \or
248 \newcommand*\pIIE@rcurveto[6]{%
249 \begingroup
250 \@tempdima#1\relax \@tempdimb#2\relax
251 \pIIE@add@nums\@tempdima\@tempdimb
252 \@tempdima#3\relax \@tempdimb#4\relax
253 \pIIE@add@nums\@tempdima\@tempdimb
254 \@tempdima#5\relax \@tempdimb#6\relax
```

```

255     \pIe@add@CP\@tempdima\@tempdimb
256     \pIe@addtoGraph{rcurveto}%
257     \endgroup}

```

`\pIe@rcurveto` PDF: It’s necessary to emulate the PostScript operator “rcurveto”. For this, the “current point” must be known, i.e., all macros which change the “current point” must set `\pIe@CPx` and `\pIe@CPy`.

```

258     \or
259     \newcommand*\pIe@rcurveto[6]{%
260     \begingroup
261     \@tempdima#1\advance\@tempdima\pIe@CPx\relax
262     \@tempdimb#2\advance\@tempdimb\pIe@CPy\relax
263     \pIe@add@nums\@tempdima\@tempdimb
264     \@tempdima#3\advance\@tempdima\pIe@CPx\relax
265     \@tempdimb#4\advance\@tempdimb\pIe@CPy\relax
266     \pIe@add@nums\@tempdima\@tempdimb
267     \@tempdima#5\advance\@tempdima\pIe@CPx\relax
268     \@tempdimb#6\advance\@tempdimb\pIe@CPy\relax
269     \pIe@add@CP\@tempdima\@tempdimb
270     \pIe@addtoGraph\pIe@rcurveto@op
271     \endgroup}

```

(Currently, there are no other modes.)

```
272 \fi
```

`\pIe@curveto` This is currently only used for Bezier curves and for drawing the heads of L^AT_EX-like arrows. Note: It’s the same for PostScript and PDF.

```

273 \newcommand*\pIe@curveto[6]{%
274 \begingroup
275 \@tempdima#1\relax \@tempdimb#2\relax
276 \pIe@add@nums\@tempdima\@tempdimb
277 \@tempdima#3\relax \@tempdimb#4\relax
278 \pIe@add@nums\@tempdima\@tempdimb
279 \@tempdima#5\relax \@tempdimb#6\relax
280 \pIe@add@CP\@tempdima\@tempdimb
281 \pIe@addtoGraph\pIe@curveto@op
282 \endgroup}

```

`\pIe@closepath`

```
283 \newcommand*\pIe@closepath{\pIe@addtoGraph\pIe@closepath@op}
```

3.9 “Pythagorean Addition” and Division

`\pIe@pyth` This algorithm is copied from the P_TC_TE_X package [4] by Michael Wichura, with his permission. Here is his description:

Suppose $x > 0, y > 0$. Put $s = x + y$. Let $z = (x^2 + y^2)^{1/2}$. Then $z = s \times f$, where

$$f = (t^2 + (1 - t)^2)^{1/2} = ((1 + \tau^2)/2)^{1/2}$$

and $t = x/s$ and $\tau = 2(t - 1/2)$.

```

284 \newcommand*\pIe@pyth[3]{%
285 \begingroup
286 \@tempdima=#1\relax
\@tempdima = abs(x)
287 \ifnum\@tempdima<z\@tempdima=-\@tempdima\fi
288 \@tempdimb=#2\relax

```

```

\@tempdimb = abs(y)
289     \ifnum\@tempdimb<\z@\@tempdimb=-\@tempdimb\fi
\@tempdimb = s = abs(x) + abs(y)
290     \advance\@tempdimb\@tempdima
291     \ifnum\@tempdimb=\z@
\@tempdimc = z =  $\sqrt{x^2 + y^2}$ 
292     \@tempdimc=\z@
293     \else
\@tempdima =  $8 \times \text{abs}(x)$ 
294     \multiply\@tempdima 8\relax
\@tempdimc =  $8t = 8 \times \text{abs}(x)/s$ 
295     \pIIe@divide\@tempdima\@tempdimb\@tempdimc
\@tempdimc =  $4\tau = (8t - 4)$ 
296     \advance\@tempdimc -4pt
297     \multiply\@tempdimc 2
298     \edef\pIIe@tempa{\strip@pt\@tempdimc}%
\@tempdima =  $(8\tau)^2$ 
299     \@tempdima=\pIIe@tempa\@tempdimc
\@tempdima =  $[64 + (8\tau)^2]/2 = (8f)^2$ 
300     \advance\@tempdima 64pt
301     \divide\@tempdima 2\relax
initial guess at  $\sqrt{u}$ 
302     \@dashdim=7pt
\@dashdim =  $\sqrt{u}$ 
303     \pIIe@@pyth\pIIe@@pyth\pIIe@@pyth
304     \edef\pIIe@tempa{\strip@pt\@dashdim}%
305     \@tempdimc=\pIIe@tempa\@tempdimb
\@tempdimc =  $z = (8f) \times s/8$ 
306     \global\divide\@tempdimc 8
307     \fi
308     \edef\x{\endgroup#3=\the\@tempdimc}%
309     \x}

\pIIe@@pyth \@dashdim =  $g \leftarrow (g + u/g)/2$ 
310 \newcommand*\pIIe@@pyth{%
311 \pIIe@divide\@tempdima\@dashdim\@tempdimc
312 \advance\@dashdim\@tempdimc
313 \divide\@dashdim\tw@}

\pIIe@divide The following macro for division is a slight modification of the macro from curve2e by Claudio
Beccari with his permission. Real numbers are represented as dimens in pt.
314 \newcommand*\pIIe@divide[3]{%
All definitions inside a group.
315 \begingroup
316 \dimendef\Numer=254\relax \dimendef\Denom=252\relax
317 \countdef\Num=254\relax \countdef\Den=252\relax
318 \countdef\I=250\relax \countdef\Numb=248\relax
319 \Numer #1\relax \Denom #2\relax
Make numerator and denominator nonnegative, save sign.
320 \ifdim\Denom<\z@ \Denom -\Denom \Numer=-\Numer \fi
321 \ifdim\Numer<\z@ \def\sign{-}\Numer=-\Numer \else \def\sign{}\fi

```

Use `\maxdimen` for $x/0$ (this should not appear).

```

322   \ifdim\Denom=\z@
323     \edef\Q{\strip@pt\maxdimen}%
324     \PackageWarning{pict2e}%
325       {Division by 0, \sign\strip@pt\maxdimen\space used}{}%
326   \else

```

Converse to integers and find integer part of the ratio. If it is too large (dimension overflow), use `\maxdimen` otherwise find the remainder and start the iteration process to find 6 digits of the decimal expression.

```

327     \Num=\Numer \Den=\Denom
328     \Numb=\Num \divide\Numb\Den
329     \ifnum\Numb>16383
330       \edef\Q{\strip@pt\maxdimen}%
331       \PackageWarning{pict2e}%
332         {Division overflow, \sign\strip@pt\maxdimen\space used}{}%
333     \else
334       \edef\Q{\number\Numb.}%
335       \multiply \Numb\Den \advance\Num -\Numb
336       \I=6\relax
337       \@whilenum \I>\z@ \do{\pIIe@@divide\advance\I\m@ne}%
338     \fi
339   \fi

```

A useful trick to define #3 outside the group without using `\global` (if the macro is used inside another group.)

```

340   \edef\tempd{\noexpand\endgroup\noexpand#3=\sign\Q\p@}%
341   \tempd}

```

`\pIIe@@divide` Iteration macro for finding decimal expression of the ratio. `\Num` is the remainder of the previous division, `\Den` is the denominator (both are integers).

```

342   \def\pIIe@@divide{%

```

Reduce both numerator and denominator if necessary to avoid overflow in the next step.

```

343     \@whilenum \Num>214748364 \do{\divide\Num\tw@ \divide\Den\tw@}%

```

Find the next digit of the decimal expression.

```

344     \multiply \Num 10
345     \Numb=\Num \divide\Numb\Den
346     \edef\Q{\Q\number\Numb}%

```

Find the remainder.

```

347     \multiply \Numb\Den \advance \Num -\Numb

```

Stop the iteration if the remainder is zero.

```

348     \ifnum\Num>\z@\else\I=0\fi}

```

3.10 High-level operations

`\pIIe@checkslopeargs` Common code for `\line` and `\vector`.

```

349   \newcommand*\pIIe@checkslopeargsline[2]{%
350     \pIIe@checkslopeargs{#1}{#2}{16383}}
351   \newcommand*\pIIe@checkslopeargsvector[2]{%
352     \pIIe@checkslopeargs{#1}{#2}{1000}}
353   \newcommand*\pIIe@checkslopeargs[3]{%
354     \edef\@tempa{#1}\expandafter\pIIe@checkslopearg\@tempa.:{#3}%
355     \edef\@tempa{#2}\expandafter\pIIe@checkslopearg\@tempa.:{#3}%

```

A bit incompatible with Standard L^AT_EX: slope (0,0) raises an error.

```

356     \ifdim #1\p@=\z@ \ifdim #2\p@=\z@ \@badlinearg \fi\fi}

```

```

357 \def\pIIE@checkslopearg #1.#2:#3{%
358   \def\tempa{#1}%
359   \ifx\tempa\empty\def\tempa{0}\fi
360   \ifx\tempa\space\def\tempa{0}\fi
361   \ifnum\ifnum\tempa<z@-\fi\tempa>#3 \@badlinearg \fi}
362 \def\@badlinearg{\PackageError
363   {pict2e}{Bad \protect\line\space or \protect\vector\space argument}{}}

```

3.10.1 Line

`\line` `\line($\langle x,y \rangle$){\mathit{l}_x}`:

```

364 \def\line(#1,#2)#3{%
365   \begingroup
366   \pIIE@checkslopeargsline{#1}{#2}%
367   \@tempdima=#1pt\relax \@tempdimb=#2pt\relax
368   \@linelen #3\unitlength
369   \ifdim\@linelen<z@ \@badlinearg \else
370     \pIIE@sline
371     \pIIE@moveto\z@\z@
372     \pIIE@lineto\@xdim\@ydim
373     \pIIE@strokeGraph

```

Simulated bounding box

```

374   \box\@tempboxa
375   \fi
376   \endgroup}

```

`\pIIE@sline` Common code for `\line` and `\vector`.

```

377 \newcommand*\pIIE@sline{%

```

Calculation of the endpoints `\@xdim`, `\@ydim` (used for `\line` only).

```

378   \ifdim\@tempdima=z@
379     \ifdim\@tempdimb<z@\@linelen-\@linelen\fi
380     \@ydim=\@linelen
381     \@xdim=z@
382   \else
383     \ifdim\@tempdima<z@\@linelen-\@linelen\fi
384     \ifdim\@tempdimb=z@
385       \@xdim=\@linelen
386       \@ydim=z@
387     \else
388       \pIIE@divide\@tempdimb\@tempdima\dimen@
389       \@ydim=\strip@pt\dimen@\@linelen
390       \@xdim=\@linelen
391     \fi
392   \fi

```

Prepare a box that can be used as a bounding box for `\line` and `\vector` to achieve the same behavior as standard L^AT_EX outside of a picture environment.

```

393   \@ovxx=\ifnum\@xdim=z@ \z@\else\@linelen\fi
394   \@ovyy=\ifnum\@ydim<z@ \z@\else\@ydim\fi
395   \@ovdy=\ifnum\@ydim<z@ -\@ydim\else\z@\fi
396   \setbox\@tempboxa\hbox{%
397     \vrule\@height \@ovyy \@depth \@ovdy \@width \z@
398     \vrule\@height \z@ \@depth \z@ \@width \@ovxx}}

```

3.10.2 Vector

`\vector` Unlike `\line`, `\vector` must be redefined, because the kernel version checks for illegal slope arguments.

`\vector<(x,y)>{<l_x>}`: Instead of calculating $\theta = \arctan \frac{y}{x}$, we use “pythagorean addition” [4] to determine $s = \sqrt{x^2 + y^2}$ and to obtain the length of the vector $l = l_x \cdot \frac{s}{x}$ and the values of $\sin \theta = \frac{y}{s}$ and $\cos \theta = \frac{x}{s}$ for the rotation of the coordinate system.

```

399 \def\vector(#1,#2)#3{%
400   \begingroup
401   \pIIE@checkslopeargsvector{#1}{#2}%
402   \@tempdima=#1pt\relax \@tempdimb=#2pt\relax
403   \@linelen#3\unitlength
404   \ifdim\@linelen<\z@ \@badlinearg \else
405     \pIIE@sline
406     \@linelen#3\unitlength
407     \pIIE@pyth{\@tempdima}{\@tempdimb}\dimen@
408     \ifdim\@tempdima=\z@ \else
409       \ifdim\@tempdimb=\z@ \else

```

This calculation is only necessary, if the vector is actually sloped.

```

410       \pIIE@divide\dimen@{\@tempdima}\@xdim
411       \@linelen\strip@pt\@xdim\@linelen
412       \ifdim\@linelen<\z@\@linelen-\@linelen\fi
413     \fi
414   \fi

```

sin θ and cos θ

```

415   \pIIE@divide{\@tempdimb}\dimen@\@ydim
416   \pIIE@divide{\@tempdima}\dimen@\@xdim

```

Rotate the following vector/arrow outlines by angle θ :

cos θ sin θ -sin θ cos θ 0 0

```

417   \pIIE@concat\@xdim\@ydim{-\@ydim}\@xdim\z@\z@

```

Internal command to draw the outline of the vector/arrow.

```

418   \pIIE@vector
419   \pIIE@fillGraph
Simulated bounding box
420   \box\@tempboxa
421   \fi
422   \endgroup}

```

`\pIIE@vector` This command should be `\def`'ed or `\let` to a macro that generates the vector's outline path. Now initialized by package options, via `\AtEndOfPackage`.

```

423   \newcommand*\pIIE@vector{}

```

L^AT_EX version The arrows drawn by the variant generated by the `ltxarrows` package option are modeled after those in the fonts used by the Standard L^AT_EX version of the picture commands (`ltpictur.dtx`). See Figure 10.

`\pIIE@vector@ltx` The arrow outline. (Not yet quite the same as with L^AT_EX's fonts.)

Problem: Extrapolation. There are only two design sizes (thicknesses) for L^AT_EX's line drawing fonts. Where can we go from there?

Note that only the arrow head will be drawn, if the length argument of the `\vector` command is smaller than the calculated length of the arrow head.

```

424   \newcommand*\pIIE@vector@ltx{%
425     \@ydim\pIIE@FAW\@wholewidth \advance\@ydim\pIIE@CAW\relax
426     \@ovxx\pIIE@FAL\@ydim
427     \@xdim\@linelen \advance\@xdim-\@ovxx
428     \divide\@ydim\tw@
429     \divide\@ovxx\tw@ \advance\@ovxx\@xdim
430     \@ovyy\@ydim
431     \divide\@ovyy\tw@ \advance\@ovyy-\pIIE@FAI\@ydim

```

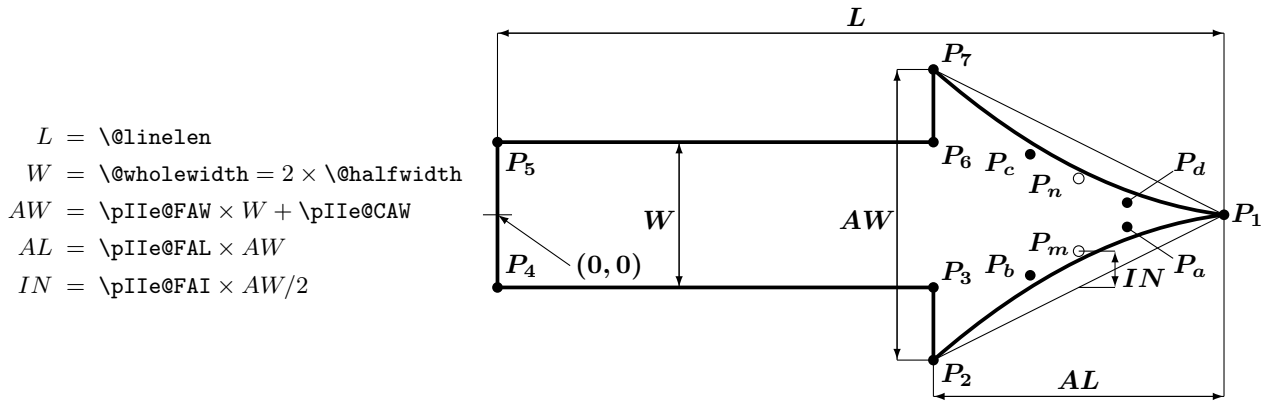



Figure 10: Sketch of the path drawn by the \LaTeX -like implementation of \vector . (Note: We are using the redefined macros of \pict2e !)

```

432   \pIIE@bezier@QtoC\@linelen\@ovxx\@ovro
433   \pIIE@bezier@QtoC\z@\@ovyy\@ovri
       $P_d = P_1 + 1/3(P_n - P_1)$ 
434   \pIIE@bezier@QtoC\@xdim\@ovxx\@clnwd
435   \pIIE@bezier@QtoC\@ydim\@ovyy\@clnht
       $P_c = P_7 + 1/3(P_n - P_7)$ 
       $P_1$ 
436   \pIIE@moveto\@linelen\z@
       $P_a P_b P_2$ 
437   \pIIE@curveto\@ovro{-\@ovri}\@clnwd{-\@clnht}\@xdim{-\@ydim}%
438   \ifdim\@xdim>\z@
       $P_3$ 
439   \pIIE@lineto\@xdim{-\@halfwidth}%
       $P_4$ 
440   \pIIE@lineto\z@{-\@halfwidth}%
       $P_5$ 
441   \pIIE@lineto\z@\@halfwidth}%
       $P_6$ 
442   \pIIE@lineto\@xdim\@halfwidth}%
443   \fi
       $P_7$ 
444   \pIIE@lineto\@xdim\@ydim
       $P_c P_d P_1$ 
445   \pIIE@curveto\@clnwd\@clnht\@ovro\@ovri\@linelen\z@}

```

PSTricks version The arrows drawn by the variant generated by the \pstarrows package option are modeled after those in the \pstricks package [8]. See Figure 11.

\pIIE@vector@pst The arrow outline. Note that only the arrowhead will be drawn, if the length argument of the \vector command is smaller than the calculated length of the arrow head.

```

446   \newcommand*\pIIE@vector@pst{%
447     \@ydim\pIIE@FAW\@wholewidth \advance\@ydim\pIIE@CAW\relax
448     \@ovxx\pIIE@FAL\@ydim
449     \@xdim\@linelen \advance\@xdim-\@ovxx

```

$L = \text{\@linelen}$
 $W = \text{\@wholewidth} = 2 \times \text{\@halfwidth}$
 $AW = \text{\pIIE@FAW} \times W + \text{\pIIE@CAW}$
 $AL = \text{\pIIE@FAL} \times AW$
 $IN = \text{\pIIE@FAI} \times AL$

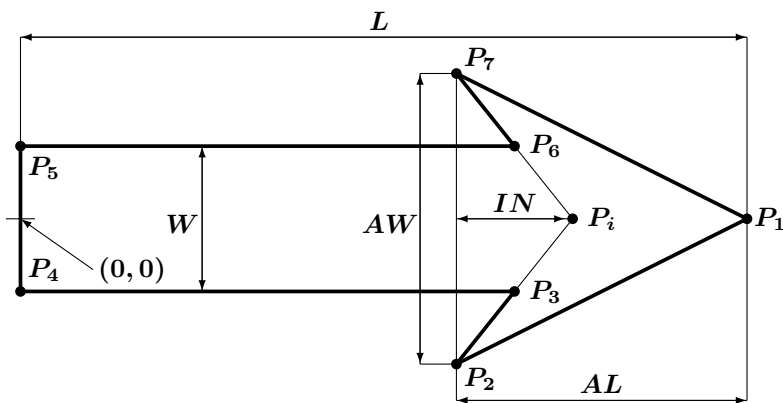


Figure 11: Sketch of the path drawn by the PSTricks-like implementation of `\vector`. (Note: We are using the redefined macros of `pict2e!`)

```

450 \divide\@ydim\tw@
451 \@ovyy\@ydim \advance\@ovyy-\@halfwidth
452 \@ovdx\pIIE@FAI\@ovxx
453 \pIIE@divide\@ovdx\@ydim\@tempdimc
454 \@ovxx\strip@pt\@ovyy\@tempdimc
455 \advance\@ovxx\@xdim
456 \advance\@ovdx\@xdim
      P1
457 \pIIE@moveto\@linelen\z@
      P2
458 \pIIE@lineto\@xdim{-\@ydim}%
459 \ifdim\@xdim>\z@
      P3
460 \pIIE@lineto\@ovxx{-\@halfwidth}%
      P4
461 \pIIE@lineto\z@{-\@halfwidth}%
      P5
462 \pIIE@lineto\z@\@halfwidth}%
      P6
463 \pIIE@lineto\@ovxx\@halfwidth}%
464 \else
      Pi
465 \pIIE@lineto\@ovdx\z@
466 \fi
      P7
467 \pIIE@lineto\@xdim\@ydim
      P1
468 \pIIE@lineto\@linelen\z@}

```

3.10.3 Circle and Dot

`\@circle` The circle will either be stroked ...

```

469 \def\@circle#1{\begingroup \@tempwafalse\pIIE@circ{#1}}

```

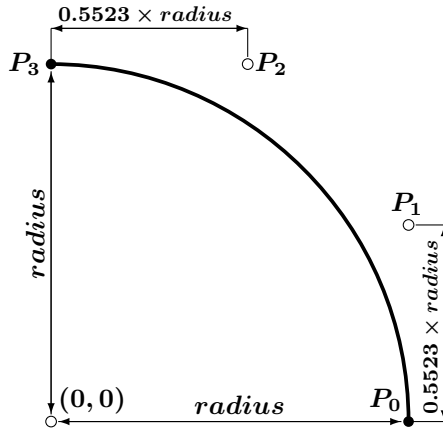


Figure 12: Sketch of the quarter circle path drawn by `\pIIE@qcircle` (NE quarter)

`\@dot` ... or filled.

```
470 \def\@dot#1{\begingroup \@tempwattrue\pIIE@circ{#1}}
```

`\pIIE@circ` Common code.

```
471 \newcommand*\pIIE@circ[1]{%
```

We need the radius instead of the diameter. Unlike Standard L^AT_EX, we check for negative or zero diameter argument.

```
472 \@tempdima#1\unitlength
473 \ifdim\@tempdima<\z@ \pIIE@badcircarg \fi
474 \divide\@tempdima\tw@
475 \pIIE@circle\@tempdima
```

With the current state of affairs, we could use `\pIIE@drawGraph` directly; but that would possibly be a case of premature optimisation. (Note to ourselves: Use of the `@tempswa` switch both here and inside `quarter-circle!` Hence a group is necessary there.)

```
476 \if@tempswa \pIIE@fillGraph \else \buttcap \pIIE@strokeGraph \fi
477 \endgroup}
```

`\pIIE@circle` Approximate a full circle by four quarter circles, use the standard shape of ends.

```
478 \newcommand*\pIIE@circle[1]{%
479 \pIIE@qcircle[1]\z@{#1}\pIIE@qcircle \@ne{#1}%
480 \pIIE@qcircle \tw@{#1}\pIIE@qcircle\thr@@{#1}\pIIE@closepath}
```

`\pIIE@qcircle` Approximate a quarter circle, using cubic Bezier splines.

`#1=Switch` (0=no ‘moveto’, 1=‘moveto’), `#2=Quadrant No.`, `#3=Radius`.

0 = 1st Quadrant (NE) 1 = 2nd Quadrant (NW)

2 = 3rd Quadrant (SW) 3 = 4th Quadrant (SE)

(PostScript: We could use the `arc` operator!)

0.55228474983 = “magic number” (see [3]).

Sacrifice a save level (otherwise a private “switch” macro were necessary!)

```
481 \newcommand*\pIIE@qcircle[3][0]{%
482 \begingroup
483 \@ovro#3\relax \@ovri0.55228474983\@ovro
484 \@tempdimc\@ovri \advance\@tempdimc-\@ovro
485 \ifnum#1>\z@ \@tempwattrue \else \@tempswafalse \fi
486 \ifcase#2\relax
NE
487 \pIIE@qcircle\@ovro\z@\z@\@ovri\@tempdimc\@ovro{-\@ovro}\@ovro
488 \or
```

```

NW
489     \pIIE@@qcircle\z@\@ovro{-\@ovri}\z@{-\@ovro}\@tempdimc{-\@ovro}{-\@ovro}%
490     \or
SW
491     \pIIE@@qcircle{-\@ovro}\z@\z@{-\@ovri}{-\@tempdimc}{-\@ovro}\@ovro{-\@ovro}%
492     \or
SE
493     \pIIE@@qcircle\z@{-\@ovro}\@ovri\z@\@ovro{-\@tempdimc}\@ovro\@ovro
494     \fi
495     \endgroup}

```

`\pIIE@@qcircle` Ancillary macro; saves us some tokens above.

Note: Use of `rcurveto` instead of `curveto` makes it possible (or at least much easier) to re-use this macro for the rounded corners of ovals.

```

496 \newcommand*\pIIE@@qcircle[8]{%
497   \if@tempswa\pIIE@moveto{#1}{#2}\fi \pIIE@rcurveto{#3}{#4}{#5}{#6}{#7}{#8}}

```

`\pIIE@badcircarg` Obvious cousin to `\@badlinearg` from the L^AT_EX kernel.

```

498 \newcommand*\pIIE@badcircarg{%
499   \PackageError{pict2e}%
500   {Illegal argument in \protect\circle(*), \protect\oval, \protect\arc(*) or
501   \protect\circlearc.}%
502   {The radius of a circle, dot, arc or oval corner must be greater than zero.}}%

```

3.10.4 Oval

`\maxovalrad` User level command, may be redefined by `\renewcommand*`. It may be given as an explicit (rigid) length (i.e., with unit) or as a number. In the latter case it is used as a factor to be multiplied by `\unitlength`. (dimen and count registers should work, too.) The default value is 20 pt as specified for the [*rad*] argument of `\oval` by the L^AT_EX manual [1, p. 223].

```

503 \newcommand*\maxovalrad{20pt}

```

`\pIIE@defaultUL` The aforementioned behaviour seems necessary, since [1, p. 223] does not specify explicitly whether the [*rad*] argument should be given in terms of `\unitlength` or as an absolute length. To implement this feature, we borrow from the `graphics` package: See `\Gin@defaultbp` and `\Gin@def@bp` from `graphics.dtx`.

```

504 \newcommand*\pIIE@defaultUL[2]{%
505   \afterassignment\pIIE@def@UL\dimen@#2\unitlength\relax{#1}{#2}}

```

However, things are simpler in our case, since we always need the value stored in `\dimen@`. Hence, we could/should omit the unnecessary argument!?)

```

506 \newcommand*\pIIE@def@UL{}
507 \def\pIIE@def@UL#1\relax#2#3{%
508 %   \if!#1!%
509 %     \def#2{#3}% \edef ?
510 %   \else
511 %     \edef#2{\strip@pt\dimen@}%
512 %   \fi
513   \edef#2{\the\dimen@}}

```

`\oval` The variant of `\oval` defined here takes an additional optional argument, which specifies the maximum radius of the rounded corners (default = 20 pt, as given above). Unlike Standard L^AT_EX, we check for negative or zero radius argument. `\pIIE@maxovalrad` is the internal variant of `\maxovalrad`.

```

514 \newcommand*\pIIE@maxovalrad{}
515 \newcommand*\pIIE@oval{}

```

```

516 \def\pIe@oval#1(#2,#3){\ifnextchar[{\@oval(#2,#3)}{\@oval(#2,#3)[]}]
517 \renewcommand*\oval[1][\maxovalrad]{%
518 \begingroup \pIe@defaultUL\pIe@maxovalrad{#1}%
519 \ifdim\pIe@maxovalrad<\z@ \pIe@badcircarg \fi
Can't close the group here, since arguments must be parsed.
520 \pIe@oval}

```

`\@oval` (This is called in turn by the saved original.)

```

521 \def\@oval(#1,#2)[#3]{%
In analogy to circles, we need only half of the size value.
522 \@ovxx#1\unitlength \divide\@ovxx\tw@
523 \@ovyy#2\unitlength \divide\@ovyy\tw@
524 \@tempdimc \ifdim\@ovyy>\@ovxx \@ovxx \else \@ovyy \fi
525 \ifdim\pIe@maxovalrad<\@tempdimc \@tempdimc\pIe@maxovalrad\relax \fi
Subtract the radius of the corners to get coordinates for the straight line segments.
526 \@xdim\@ovxx \advance\@xdim-\@tempdimc
527 \@ydim\@ovyy \advance\@ydim-\@tempdimc
Determine which parts of the oval we have to draw.
528 \pIe@get@quadrants{#3}%
For the whole oval remove use the standard shape of ends.
529 \ifnum15=\@tempcnta \pIe@buttcap \fi
"@tempswa = false" means, that we have to suppress the 'moveto' in the following quadrant.
530 \@tempswatrue
The following isn't strictly necessary, but yields a single (unfragmented) path even for [r]
(right half of oval only). Useful for future extensions.
Bits 3 and 0 set? (SE/NE)
531 \ifnum9=\@tempcnta
532 \pIe@qoval\z@{-\@ovyy}{\@xdim}{-\@ovyy}\thr@@\@tempdimc\@ovxx\z@
Bit 0 set! (NE)
533 \@tempcnta\@ne
534 \fi
Bit 0 set? (NE)
535 \pIe@qoval\@ovxx\z@\@ovxx\@ydim\z@\@tempdimc\z@\@ovyy
Bit 1 set? (NW)
536 \pIe@qoval\z@\@ovyy{-\@xdim}\@ovyy\@ne\@tempdimc{-\@ovxx}\z@
Bit 2 set? (SW)
537 \pIe@qoval{-\@ovxx}\z@{-\@ovxx}{-\@ydim}\tw@\@tempdimc\z@{-\@ovyy}%
Bit 3 set? (SE)
538 \pIe@qoval\z@{-\@ovyy}{\@xdim}{-\@ovyy}\thr@@\@tempdimc\@ovxx\z@
Now we've finished, draw the oval and finally close the group opened by \@oval above.
539 \pIe@strokeGraph
540 \endgroup}

```

`\pIe@qoval` Ancillary macro; saves us some tokens above.
(PostScript: We could use the `arc` or `arcto` operator!)

```

541 \newcommand*\pIe@qoval[8]{%
542 % \end{macrocode}
543 % Bit set?
544 % \begin{macrocode}
545 \ifodd\@tempcnta
546 \if@tempswa\pIe@moveto{#1}{#2}\fi

```

```

547     \pIe@lineto{#3}{#4}\pIe@qcircle{#5}{#6}\pIe@lineto{#7}{#8}%
548     \@tempwafalse
549     \else
550     \@tempwattrue
551     \fi

```

Shift by one bit.

```

552     \divide\@tempcnta\tw@}

```

`\pIe@get@quadrants` According to the parameter (`tlbr`) bits are set in `\@tempcnta`:

```

0 = 1st Quadrant (NE)      1 = 2nd Quadrant (NW)
2 = 3rd Quadrant (SW)     3 = 4th Quadrant (SE)

```

(Cf. `\@oval` and `\@ovvert` in the L^AT_EX kernel.) We abuse `\@setfpsbit` from the float processing modules of the kernel.

```

553 \newcommand*\pIe@get@quadrants[1]{%
554   \@ovttrue \@ovbtrue \@ovltrue \@ovrtrue \@tempcnta\z@
555   \@tfor\reserved@a:=#1\do{\csname @ov\reserved@a false\endcsname}%
556   \if@ovr \if@ovb\@setfpsbit2\fi \if@ovt\@setfpsbit4\fi \fi
557   \if@ovl \if@ovb\@setfpsbit1\fi \if@ovt\@setfpsbit8\fi \fi}

```

3.10.5 Quadratic Bezier Curve

`\@bezier` If `#1=0` the primitive operators of the (back-end) format are used. The kernel version of `\@bezier` uses `\put` internally, which features `\killglue` and `\ignorespaces` commands in turn (at the beginning and end, respectively). Since we don't use `\put`, we have to add the latter commands by hand.

```

558 \def\@bezier#1(#2,#3)(#4,#5)(#6,#7){%
559   \ifnum #1=\z@

```

$$P_0 = (\#2, \#3) \quad P_m = (\#4, \#5) \quad P_3 = (\#6, \#7)$$

```

560     \@killglue
561     \begingroup
562     \@ovxx#2\unitlength \@ovyy#3\unitlength
563     \@ovdx#4\unitlength \@ovdy#5\unitlength
564     \@xdim#6\unitlength \@ydim#7\unitlength

```

$$P_1 = P_m + 1/3(P_0 - P_m)$$

```

565     \pIe@bezier@QtoC\@ovxx\@ovdx\@ovro
566     \pIe@bezier@QtoC\@ovyy\@ovdy\@ovri

```

$$P_2 = P_m + 1/3(P_3 - P_m)$$

```

567     \pIe@bezier@QtoC\@xdim\@ovdx\@clnwd
568     \pIe@bezier@QtoC\@ydim\@ovdy\@clnht

```

$$(P_{0x}, P_{0y})$$

```

569     \pIe@moveto\@ovxx\@ovyy

```

$$(P_{1x}, P_{1y}) \quad (P_{2x}, P_{2y}) \quad (P_{3x}, P_{3y})$$

```

570     \pIe@curveto\@ovro\@ovri\@clnwd\@clnht\@xdim\@ydim

```

```

571     \pIe@strokeGraph

```

```

572     \endgroup

```

```

573     \ignorespaces

```

```

574     \else

```

```

575     \pIe@old@bezier{#1}(\#2,\#3)(\#4,\#5)(\#6,\#7)

```

```

576     \fi}

```

`\pIe@bezier@QtoC` Ancillary macro; saves us some tokens above.

Transformation: quadratic bezier parameters \rightarrow cubic bezier parameters.

(Missing: Reference for mathematical formula. Or is this trivial?)

```

577 \newcommand*\pIe@bezier@QtoC[3]{%

```

```

578 \@tempdimc#1\relax \advance\@tempdimc-#2\relax
579 \divide\@tempdimc\thr@@ \advance\@tempdimc #2\relax
580 #3\@tempdimc}

```

3.10.6 Circle arcs

We need some auxiliary dimensions.

```

581 \ifx\undefined\@arclen \newdimen\@arclen \fi
582 \ifx\undefined\@arcrad \newdimen\@arcrad \fi
583 \ifx\undefined\@tempdimd \newdimen\@tempdimd \fi

```

`\pIIE@arc` #1: 0 (implicit) if we connect arc with a current point, 1 if we start drawing by this arc, 2 if we continue drawing. Other parameters: coordinates of the center (dimensions), radius (dimension), initial and final angle. If the final angle is greater than the initial angle, we “draw” in the positive sense (anticlockwise) otherwise in the negative sense (clockwise). First we check whether the radius is not negative and reduce the rotation to the interval $[-720, 720]$.

```

584 \newcommand*\pIIE@arc[6][0]{%
585 \@arcrad #4\relax
586 \ifdim \@arcrad<\z@ \pIIE@badcircarg \else
587 \@arclen #6\p@ \advance\@arclen -#5\p@
588 \ifdim \@arclen<\z@ \def\sign{-}\else\def\sign{}\fi
589 \ifdim \sign\@arclen>720\p@
590 \PackageWarning {pict2e}{The arc angle is reduced to -720..720}%
591 \@whiledim \sign\@arclen>720\p@ \do {\advance\@arclen-\sign360\p@}%
592 \@tempdima #5\p@ \advance\@tempdima \@arclen
593 \edef\@angleend{\strip@pt\@tempdima}%
594 \pIIE@arc{#1}{#2}{#3}{#4}{#5}{\@angleend}%
595 \else
596 \pIIE@arc{#1}{#2}{#3}{#4}{#5}{#6}%
597 \fi
598 \fi}

```

If the angle (its absolute value) is too large, the arc is recursively divided into 2 parts until the angle is at most 90 degrees.

```

599 \newcommand*\pIIE@@arc[6]{%
600 \begingroup
601 \ifdim \sign\@arclen>90\p@
602 \divide\@arclen 2
603 \@tempdima #5\p@ \advance\@tempdima \@arclen
604 \edef\@anglemid{\strip@pt\@tempdima}%
605 \def\@temp{\pIIE@arc{#1}{#2}{#3}{#4}{#5}}%
606 \expandafter\@temp\expandafter{\@anglemid}%
607 \def\@temp{\pIIE@arc{2}{#2}{#3}{#4}}%
608 \expandafter\@temp\expandafter{\@anglemid}{#6}%
609 \else

```

We approximate the arc by a Bezier curve. First we calculate the coordinates of the initial point:

```

610 \CalculateSin{#5}\CalculateCos{#5}%
611 \@tempdima\UseCos{#5}\@arcrad \advance\@tempdima #2\relax
612 \@tempdimb\UseSin{#5}\@arcrad \advance\@tempdimb #3\relax

```

The coordinates are added to the path if and how necessary:

```

613 \ifcase #1\relax
614 \pIIE@lineto\@tempdima\@tempdimb
615 \or \pIIE@moveto\@tempdima\@tempdimb
616 \or
617 \else \PackageWarning {pict2e}{
618 {Illegal obligatory argument in \protect\circlearc.}}%
619 \fi

```

The distance of control points from the endpoints is $\frac{4}{3}r \tan \frac{\varphi}{4}$ (φ is the angle and r is the radius of the arc).

```
620     \@tempdimc \@arclen \divide \@tempdimc \@iv
621     \edef \@angle{\strip@pt \@tempdimc}\CalculateTan{\@angle}%
622     \@linelen\UseTan{\@angle}\@arcrad \@linelen4\@linelen \divide \@linelen\thr@@
```

Coordinates of the first control point, added to the path:

```
623     \advance \@tempdima-\UseSin{#5}\@linelen
624     \advance \@tempdimb \UseCos{#5}\@linelen
625     \pIIE@add@nums \@tempdima \@tempdimb
```

Coordinates of the endpoint:

```
626     \CalculateSin{#6}\CalculateCos{#6}%
627     \@tempdima \UseCos{#6}\@arcrad \advance \@tempdima #2\relax
628     \@tempdimb \UseSin{#6}\@arcrad \advance \@tempdimb #3\relax
```

Coordinates of the second control point:

```
629     \@tempdimc \UseSin{#6}\@linelen \advance \@tempdimc \@tempdima
630     \@tempdimd-\UseCos{#6}\@linelen \advance \@tempdimd \@tempdimb
```

Adding the second control point and the endpoint to the path

```
631     \pIIE@add@nums \@tempdimc \@tempdimd
632     \pIIE@add@CP \@tempdima \@tempdimb
633     \pIIE@addtoGraph \pIIE@curveto@op
634     \fi
635     \endgroup}
```

`\arc` The `\arc` command generalizes (except that the radius instead of the diameter is used) the standard `\circle` adding as an obligatory first parameter comma separated pair of angles (initial and final). We start with `\pIIEarc` to avoid conflicts with other packages.

```
636 \newcommand*\pIIEarc
637   {\@ifstar{\@tempswatrue\pIIE@arc@}{\@tempswafalse\pIIE@arc@}}
638 \newcommand*\pIIE@arc@[2][0,360]{\pIIE@arc@@{#1}{#2}}
639 \def\pIIE@arc@@{#1,#2}#3{%
640   \if@tempswa
641     \pIIE@moveto\z@\z@
642     \pIIE@arc{\z@}{\z@}{#3\unitlength}{#1}{#2}%
643     \pIIE@closepath\pIIE@fillGraph
644   \else
645     \pIIE@arc[1]{\z@}{\z@}{#3\unitlength}{#1}{#2}%
646     \pIIE@strokeGraph
647   \fi}
648 \ifx\undefined\arc
649 \else
650   \PackageWarning{pict2e}{\protect\arc\space redefined}%
651 \fi
652 \let\arc\pIIEarc
```

3.10.7 Line, Vector, polyline, polyvector, and polygon

`\Line` We use recursive macros for `\polyline`, `\polyvector`, and `\polygon`.

```
\polyline 653 \let\lp@r(\let\vp@r)
\Vector 654 \def\Line(#1,#2)(#3,#4){\polyline(#1,#2)(#3,#4)}
\polyvector 655 \def\polyline(#1,#2){%
\polygon 656   \@killglue
657   \pIIE@moveto{#1\unitlength}{#2\unitlength}%
658   \@ifnextchar\lp@r{\@polyline}{\PackageWarning{pict2e}%
659     {Polygonal lines require at least two vertices!}%
660     \ignorespaces}}
661 \def\@polyline(#1,#2){%
```



```

662 \pIIE@lineto{#1\unitlength}{#2\unitlength}%
663 \ifnextchar\lp@r{\@polyline}{\pIIE@strokeGraph\ignorespaces}}
664 \def\Vector(#1,#2)(#3,#4){\polyvector(#1,#2)(#3,#4)}
665 \def\polyvector(#1,#2){%
666 \@killglue
667 \ifnextchar\lp@r{\begingroup\@polyvector(#1,#2)}{%
668 \PackageWarning{pict2e}%
669 {Polygonal vectors require at least two vertices!}\ignorespaces}}
670 \def\@polyvector(#1,#2)(#3,#4){%

```

See the similar definition for `\vector` (3.10.2)

```

671 \@xdim#1\unitlength \@tempdima=#3\unitlength
672 \@ydim#2\unitlength \@tempdimb=#4\unitlength
673 \advance\@tempdima-\@xdim \advance\@tempdimb-\@ydim
674 \ifdim\@tempdima=\z@ \@linelen\@tempdimb \else
675 \ifdim\@tempdimb=\z@ \@linelen\@tempdima \else
676 \pIIE@pyth\@tempdima\@tempdimb\@linelen
677 \fi
678 \fi
679 \ifdim\@linelen<\z@ \@linelen-\@linelen\fi
680 \pIIE@divide{\@tempdima}\@linelen\@ovxx
681 \pIIE@divide{\@tempdimb}\@linelen\@ovyy

```

Note the shift to the previous point in addition to the rotation.

```

682 \pIIE@concat\@ovxx\@ovyy{-\@ovyy}\@ovxx\@xdim\@ydim
683 \pIIE@vector \pIIE@fillGraph
684 \ifnextchar\lp@r{\@polyvector(#3,#4)}{\endgroup\ignorespaces}}
685 \def\polygon{%
686 \@killglue
687 \ifstar{\begingroup\@tempswatruet\@polygon}%
688 {\begingroup\@tempswafalset\@polygon}}
689 \def\@polygon(#1,#2){%
690 \pIIE@moveto{#1\unitlength}{#2\unitlength}%
691 \ifnextchar\lp@r{\@@polygon}{\PackageWarning{pict2e}%
692 {Polygons require at least two vertices!}%
693 \ignorespaces}}
694 \def\@@polygon(#1,#2){\pIIE@lineto{#1\unitlength}{#2\unitlength}%
695 \ifnextchar\lp@r{\@@polygon}{\pIIE@closepath
696 \if@tempswa\pIIE@fillGraph\else\pIIE@strokeGraph\fi
697 \endgroup
698 \ignorespaces}}

```

3.10.8 Path commands

```

\moveto Direct access to path constructions in PostScript and PDF.
\lineto 699 \def\moveto(#1,#2){%
\curveto 700 \@killglue
\circlearc 701 \pIIE@moveto{#1\unitlength}{#2\unitlength}%
\closepath 702 \ignorespaces}
\strokepath 703 \def\lineto(#1,#2){%
\fillpath 704 \@killglue
705 \pIIE@lineto{#1\unitlength}{#2\unitlength}%
706 \ignorespaces}
707 \def\curveto(#1,#2)(#3,#4)(#5,#6){%
708 \@killglue
709 \pIIE@curveto{#1\unitlength}{#2\unitlength}{#3\unitlength}{#4\unitlength}%
710 {#5\unitlength}{#6\unitlength}%
711 \ignorespaces}
712 \newcommand*\circlearc[6][0]{%
713 \@killglue

```

```

714 \pIIE@arc[#1]{#2\unitlength}{#3\unitlength}{#4\unitlength}{#5}{#6}%
715 \ignorespaces}
716 \def\closepath{\pIIE@closepath}
717 \def\strokepath{\pIIE@strokeGraph}
718 \def\fillpath{\pIIE@fillGraph}

```

3.10.9 Ends of paths, joins of subpaths

`\buttcap` Ends of paths and joins of subpaths in PostScript and PDF.

```

\roundcap 719 \ifcase\pIIE@mode\relax
\squarecap 720 \or
\miterjoin 721 \newcommand*\pIIE@linecap@op{setlinecap}
\roundjoin 722 \newcommand*\pIIE@linejoin@op{setlinejoin}
\beveljoin 723 \or
724 \newcommand*\pIIE@linecap@op{J}
725 \newcommand*\pIIE@linejoin@op{j}
726 \fi
727 \def\pIIE@linecap{}
728 \def\pIIE@linejoin{}
729 \def\buttcap{\edef\pIIE@linecap{ 0 \pIIE@linecap@op}}
730 \def\roundcap{\edef\pIIE@linecap{ 1 \pIIE@linecap@op}}
731 \def\squarecap{\edef\pIIE@linecap{ 2 \pIIE@linecap@op}}
732 \def\miterjoin{\edef\pIIE@linejoin{ 0 \pIIE@linejoin@op}}
733 \def\roundjoin{\edef\pIIE@linejoin{ 1 \pIIE@linejoin@op}}
734 \def\beveljoin{\edef\pIIE@linejoin{ 2 \pIIE@linejoin@op}}

```

3.11 Commands from other packages

3.11.1 Package `ebezier`

One feature from [3].

`\cbezier` #1, the maximum number of points to use, is simply ignored, as well as `\qbeziermax`.
`\@cbezier` Like the kernel version of `\@bezier`, the original version of `\@cbezier` uses `\put` internally,
`\pIIE@@cbezier` which features `\killglue` and `\ignorespaces` commands in turn (at the beginning and end, respectively). Since we don't use `\put`, we have to add the latter commands by hand.

Original head of the macro:

```
\def\cbezier{\@ifnextchar [{\@cbezier}{\@cbezier[0]}}
```

Changed analogous to the L^AT_EX kernel's `\qbezier` and `\bezier`:

```

735 \AtBeginDocument{\@ifundefined{cbezier}{\newcommand}{\renewcommand}*%
736 \cbezier[2][0]{\pIIE@@cbezier[#1]#2}%
737 \@ifdefinable\pIIE@@cbezier{}%
738 \def\pIIE@@cbezier#1#2(#3)#4(#5)#6({\@cbezier#1)(#3)(#5){}%
739 \def\@cbezier[#1](#2,#3)(#4,#5)(#6,#7)(#8,#9){%
740 \@killglue
741 \pIIE@moveto{#2\unitlength}{#3\unitlength}%
742 \pIIE@curveto{#4\unitlength}{#5\unitlength}%
743 {#6\unitlength}{#7\unitlength}{#8\unitlength}{#9\unitlength}%
744 \pIIE@strokeGraph
745 \ignorespaces}%
746 }

```

3.11.2 Other packages

Other macros from various packages may be included in future versions of this package.

3.12 Mode ‘original’

Other branch of the big switch, started near the beginning of the code (see page 16).

```
747 \else

\oval Gobble the new optional argument and continue with saved version. \maxovalrad is there to
\maxovalrad avoid error messages in case the user’s document redefines it with \renewcommand*. Likewise,
\OriginalPictureCmds \OriginalPictureCmds is only needed for test documents.

748 \renewcommand*\oval[1] [] {\pIIe@oldoval}
749 \newcommand*\maxovalrad{20pt}
750 \newcommand*\OriginalPictureCmds{}
751 \fi
```

3.13 Final clean-up

Restore Catcodes.

```
752 \Gin@codes
753 \let\Gin@codes\relax
754 </package>
```

Acknowledgements

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Finally we thank the members of The $\text{L}\text{A}\text{T}\text{E}\text{X}$ Team for taking the time to evaluate our new implementation of the picture mode commands, and eventually accepting it as the “official” *pict2e* package, as well as providing the *README* file.

References

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Change History

v0.1a	General: First version. (RN)	1	v0.1y	<code>\pIie@vector@ltx</code> : First implementation. (RN,HjG)	24
v0.1d	<code>\pIie@drawGraph</code> : “gsave/grestore” added. (RN)	17	v0.2h	<code>\pIie@badcircarg</code> : New error message. (RN,HjG)	28
v0.1g	<code>\pIie@circle</code> : Changed code (using <code>\pIie@add@qcircle</code>). (HjG,RN) . . .	27	<code>\pIie@circ</code> : Check for negative or zero diameter argument (RN,HjG)	27	
	<code>\pIie@drawGraph</code> : “gsave/grestore” removed. (RN)	17	<code>\pIie@def@UL</code> : Check for negative or zero radius argument (RN,HjG)	28	
v0.1h	<code>\pIie@addtoGraph</code> : Added newline code (to be improved eventually). (RN,HjG)	17	v0.2j	General: First release to CTAN (2004/02/19 v0.2j). (LaTeX Team) . . .	1
v0.1i	<code>\pIie@drawGraph</code> : “gsave/grestore” restored for PDF (see ‘p2e-drivers.dtx’). (RN)	17	v0.2k	General: Better control for indexing temporary registers while debugging (HjG)	1
v0.1t	<code>\pIie@get@quadrants</code> : Rename <code>\pIie@get@ovalquadrants</code> to <code>\pIie@get@quadrants</code> (RN)	30		Better control over funny pagestyle while debugging (HjG)	1
v0.1u	<code>\@bezier</code> : Change calculation of cubic bezier parameters to use less tokens (HjG)	30	v0.2l	<code>\line</code> : Macro added (RN/HjG)	23
	<code>\pIie@qcircle</code> : New ancillary macro (HjG)	28		General: Even better control over funny pagestyle while debugging (RN)	1
	<code>\pIie@add@CP</code> : Rename <code>\pIie@add@XY</code> to <code>\pIie@add@CP</code> (HjG)	18	v0.2n	<code>\pIie@circ</code> : Allow zero diameter (RN/HjG)	27
	<code>\pIie@bezier@QtoC</code> : New ancillary macro (HjG)	30		<code>\pIie@def@UL</code> : Moved radius test to <code>\oval</code> , where it belongs (RN/HjG) . . .	28
	<code>\pIie@drawGraph</code> : Clear current point after output (HjG)	17		<code>\pIie@oval</code> : Allow zero diameter (RN/HjG)	28
	<code>\pIie@qcircle</code> : Change coding of quadrant number to match bit number in <code>\pIie@get@quadrants</code> (HjG)	27		Moved radius test from <code>\pIie@def@UL</code> (RN/HjG)	28
	<code>\pIie@qoval</code> : New ancillary macro (HjG)	29		General: Second release to CTAN (2004/04/22 v0.2n). (RN/HjG)	1
	<code>\pIie@vector</code> : New ancillary macro (HjG)	24	v0.2o	<code>\@bezier</code> : Supply <code>\ignorespaces</code> to match kernel version (HjG)	30
	<code>\pIie@vector@ltx</code> : New ancillary macro (HjG)	24		<code>\@cbezier</code> : Supply <code>\ignorespaces</code> to match kernel version (HjG)	34
	<code>\pIie@vector@pst</code> : New ancillary macro (HjG)	25		<code>\Gin@codes</code> : Save and restore catcodes (HjG)	13
v0.1v	<code>\pIie@qcircle</code> : Exchange <code>\@xdim</code> and <code>\@ydim</code> to <code>\@ovri</code> and <code>\@ovro</code> (HjG)	27		<code>\line</code> : Use <code>\pIie@checkslopeargs</code> (HjG)	23
v0.1w	<code>\pIie@qoval</code> : Rename <code>\pIie@oval</code> to <code>\pIie@qoval</code> (HjG)	29		<code>\vector</code> : Use <code>\pIie@checkslopeargs</code> (HjG)	24
	General: Index use of temporary registers while debugging (HjG)	1		General: Third release to CTAN (2004/06/25 v0.2o). (RN/HjG)	1
v0.1x	<code>\pIie@FAI</code> : Introduce “inset”. (RN,HjG)	14	v0.2p	<code>\@bezier</code> : <code>\@killglue</code> added. (RN) . . .	30
				<code>\@cbezier</code> : <code>\@killglue</code> added. (RN) . . .	34
				General: Fourth release to CTAN (2004/07/28 v0.2p). (RN)	1
			v0.2q	General: Fourth release to CTAN (2004/08/06 v0.2q). (RN/HjG)	1

v0.2r	<code>\pIIE@pyth</code> : Two wrong global assignments changed. (RN)	20	v0.3a	<code>\pIIE@circle</code> : Changed code, <code>closepath</code> seems to be necessary.	27
v0.2t	<code>\line</code> : All lines by <code>\@sline</code> (JT)	23	General: 11th release to CTAN (2016/01/09 v0.3a). (JT)	1	
v0.2u	General: Fifth release to CTAN (2008/06/29 v0.2u). (JT)	1	v0.3b	General: 12th release to CTAN (2016/02/05 v0.3b). (RN)	1
v0.2v	General: Sixth release to CTAN (2008/07/19 v0.2v). (JT)	1	New option ‘ <code>luatex</code> ’ (RN)	13	
v0.2w	General: Seventh release to CTAN (2008/07/19 v0.2w). (JT)	1	v0.3c	<code>\pIIE@checkslopeargs</code> : <code>\edef</code> for parameters stored in macros – suggested by Phelype Oleinik (RN)	22
v0.2x	General: Eighth release to CTAN (2009/08/08 v0.2x). (JT)	1	v0.3d	<code>\pIIE@oval</code> : Allow spaces after the first optional Argument suggested by FMI (RN)	28
v0.2y	General: Ninth release to CTAN (2011/04/05 v0.2y). (JT)	1	<code>\pIIE@sline</code> : Simulated bounding boxes for <code>\line</code> and <code>\vector</code> suggested by Donald Arseneau (RN)	23	
v0.2z	General: 10th release to CTAN (2011/04/05 v0.2z). (JT)	1	<code>\pstarrows</code> : New user-level macros <code>\ltxarrows</code> and <code>\pstarrows</code> . (RN)	14	
			v0.3e	General: Added <code>\Vector</code> and <code>\polyvector</code> suggested by FMI. (RN)	32

Index

Numbers written in *italic* refer to the page where the corresponding entry is described; numbers underlined refer to the code line of the definition; numbers in *roman* refer to the code lines where the entry is used.

Symbols		A
<code>\!</code>	<code>\ifnextchar</code>	<code>\arc</code>
<code>\"</code>	663, 667, 684, 691, 695	<code>\arc*</code>
<code>\%</code>	<code>\@ifstar</code>	
<code>*</code>	637, 687	
<code>\:</code>	<code>\@killglue</code>	
<code>\@@polygon</code>	560, 656, 666, 686,	
<code>\@angle</code>	700, 704, 708, 713, 740	
<code>\@angleend</code>	<code>\@makeoether</code>	
<code>\@anglemid</code>	9, 11, 12	
<code>\@arclen</code>	<code>\@oval</code>	
587, 588, 589, 591,	110, 120, 516, <u>521</u>	
592, 601, 602, 603, 620	<code>\@polygon</code>	
<code>\@arcrad</code>	687, 688, 689	
611, 612, 622, 627, 628	<code>\@polyline</code>	
<code>\@badlinearg</code>	<code>\@polyvector</code>	
356, 361, 362, 369, 404	<code>\@setfpsbit</code>	
<code>\@bezier</code>	556, 557	
<code>\@cbezier</code>	<code>\@sline</code>	
<code>\@circle</code>	100, 112	
<code>\@depth</code>	<code>\@temp</code>	
<code>\@dot</code>	605, 606, 607, 608	
<code>\@gobble</code>	<code>\@tempa</code>	
<code>\@height</code>	354,	
	355, 358, 359, 360, 361	
	<code>\@tempboxa</code>	
	374, 396, 420	
	<code>\@tempdimd</code>	
	583, 630, 631	
	<code>\@undefined</code>	
	37, 38	
	<code>\@whiledim</code>	
	591	
	<code>\@whilenum</code>	
	337, 343	
	<code>\@width</code>	
	397, 398	
	<code>\^</code>	
	3, 8	
		B
		<code>\begin</code>
		544
		<code>\beveljoin</code>
		10, <u>719</u>
		<code>\bezier</code>
		8
		<code>\box</code>
		374, 420
		<code>\buttcap</code>
		10, 49, 476, <u>719</u>
		C
		<code>\CalculateCos</code>
		233, 610, 626
		<code>\CalculateSin</code>
		232, 610, 626
		<code>\CalculateTan</code>
		621
		<code>\catcode</code>
		3, 4, 5, 6, 7, 8, 10
		<code>\cbezier</code>
		8, <u>735</u>
		<code>\circle</code>
		6, 500
		<code>\circle*</code>
		6
		<code>\circlearc</code>
		9, 501, 618, <u>699</u>
		<code>\closepath</code>
		10, <u>699</u>
		<code>\countdef</code>
		317, 318
		<code>\curveto</code>
		9, <u>699</u>

D	O	<code>\pIe@curveto</code> 273 , 437 , 445 , 570 , 709 , 742
<code>\Den</code> 317 , 327 , 328 , 335 , 343 , 345 , 347	<code>\OriginalPictureCmds</code> 111 , 748	<code>\pIe@curveto@op</code> 138 , 147 , 270 , 281 , 633
<code>\Denom</code> 316 , 319 , 320 , 322 , 327	<code>\oval</code> 7 , 109 , 119 , 500 , 514 , 748	<code>\pIe@debug@comment</code> 64 , 166
<code>\dimendef</code> 316	P	<code>\pIe@def@UL</code> 504
E	<code>\pdfliteral</code> 38 , 44	<code>\pIe@defaultUL</code> 504 , 518
<code>\empty</code> 359	<code>\pIe@@arc</code> 594 , 596 , 599 , 605 , 607	<code>\pIe@divide</code> 295 , 311 , 314 , 388 , 410 , 415 , 416 , 453 , 680 , 681
<code>\end</code> 542	<code>\pIe@@cbezier</code> 735	<code>\pIe@drawGraph</code> 163 , 164 , 165
F	<code>\pIe@@divide</code> 337 , 342	<code>\pIe@FAI</code> 52 , 431 , 452
<code>\fillpath</code> 10 , 699	<code>\pIe@@pyth</code> 303 , 310	<code>\pIe@FAL</code> 52 , 426 , 448
G	<code>\pIe@@qcircle</code> 487 , 489 , 491 , 493 , 496	<code>\pIe@FAW</code> 52 , 425 , 447
<code>\Gin@codes</code> 2 , 752 , 753	<code>\pIe@add@CP</code> 180 , 243 , 245 , 255 , 269 , 280 , 632	<code>\pIe@fill@op</code> 138 , 147 , 169
<code>\Gin@driver</code> 13 , 19 , 21 , 22 , 23 , 24 , 25 , 26 , 27 , 30 , 31 , 32 , 33 , 81 , 87 , 88 , 89 , 90 , 92	<code>\pIe@add@num</code> 193 , 213	<code>\pIe@fill@Graph</code> 163 , 419 , 476 , 643 , 683 , 696 , 718
H	<code>\pIe@add@nums</code> 187 , 205 , 207 , 209 , 212 , 214 , 220 , 222 , 224 , 251 , 253 , 263 , 266 , 276 , 278 , 625 , 631	<code>\pIe@get@quadrants</code> 528 , 553
<code>\hbox</code> 396	<code>\pIe@addtoGraph</code> 157 , 185 , 191 , 196 , 203 , 210 , 212 , 213 , 214 , 225 , 243 , 245 , 256 , 270 , 281 , 283 , 633	<code>\pIe@GRAPH</code> 157 , 177 , 178
I	<code>\pIe@arc</code> 584 , 642 , 645 , 714	<code>\pIe@linecap</code> 173 , 727 , 729 , 730 , 731
<code>\I</code> 318 , 336 , 337 , 348	<code>\pIe@arc@</code> 637 , 638	<code>\pIe@linecap@op</code> 721 , 724 , 729 , 730 , 731
<code>\ifpIe@pdfliteral@ok</code> 35 , 48	<code>\pIe@arc@@</code> 638 , 639	<code>\pIe@linejoin</code> 173 , 728 , 732 , 733 , 734
<code>\ifx</code> 37 , 38 , 359 , 360 , 581 , 582 , 583 , 648	<code>\pIe@badcircarg</code> 473 , 498 , 519 , 586	<code>\pIe@linejoin@op</code> 722 , 725 , 732 , 733 , 734
<code>\ignorespaces</code> 573 , 660 , 663 , 669 , 684 , 693 , 698 , 702 , 706 , 711 , 715 , 745	<code>\pIe@bezier@Qtoc</code> 432 , 433 , 434 , 435 , 565 , 566 , 567 , 568 , 577	<code>\pIe@lineto</code> 244 , 372 , 439 , 440 , 441 , 442 , 444 , 458 , 460 , 461 , 462 , 463 , 465 , 467 , 468 , 547 , 614 , 662 , 694 , 705
L	<code>\pIe@buttcap</code> 47 , 529	<code>\pIe@lineto@op</code> 138 , 147 , 245
<code>\Line</code> 9 , 653	<code>\pIe@CAW</code> 52 , 425 , 447	<code>\pIe@maxovalrad</code> 514 , 525
<code>\line</code> 4 , 99 , 113 , 363 , 364	<code>\pIe@checkslopearg</code> 354 , 355 , 357	<code>\pIe@mode</code> 13 , 34 , 78 , 96 , 97 , 124 , 129 , 136 , 137 , 199 , 246 , 719
<code>\lineto</code> 9 , 699	<code>\pIe@checkslopeargs</code> 349	<code>\pIe@moveto</code> 242 , 371 , 436 , 457 , 497 , 546 , 569 , 615 , 641 , 657 , 690 , 701 , 741
<code>\lp@r</code> 653 , 658 , 663 , 667 , 684 , 691 , 695	<code>\pIe@checkslopeargsline</code> 349 , 366	<code>\pIe@moveto@op</code> 138 , 147 , 243
<code>\ltxarrows</code> 56 , 62	<code>\pIe@checkslopeargsvector</code> 351 , 401	<code>\pIe@old@bezier</code> 99 , 118
M	<code>\pIe@circ</code> 469 , 470 , 471	<code>\pIe@old@circle</code> 99 , 115
<code>\m@ne</code> 337	<code>\pIe@circle</code> 475 , 478	<code>\pIe@old@dot</code> 99 , 116
<code>\maxdimen</code> 323 , 325 , 330 , 332	<code>\pIe@closepath</code> 283 , 480 , 643 , 695 , 716	<code>\pIe@old@oval</code> 99 , 120
<code>\maxovalrad</code> 8 , 503 , 517 , 748	<code>\pIe@closepath@op</code> 138 , 147 , 283	<code>\pIe@old@sline</code> 99 , 112
<code>\miterjoin</code> 10 , 719	<code>\pIe@code</code> 13 , 71 , 72 , 176	<code>\pIe@old@line</code> 99 , 113
<code>\moveto</code> 9 , 699	<code>\pIe@concat</code> 200 , 216 , 417 , 682	<code>\pIe@old@oval</code> 99 , 119 , 748
N	<code>\pIe@concat@op</code> 138 , 147 , 210 , 225 , 240	<code>\pIe@old@vector</code> 99 , 114
<code>\newdimen</code> 581 , 582 , 583	<code>\pIe@CPx</code> 178 , 180 , 261 , 264 , 267	<code>\pIe@oval</code> 514
<code>\newif</code> 35	<code>\pIe@CPy</code> 178 , 180 , 262 , 265 , 268	<code>\pIe@pdfliteral</code> 35
<code>\Num</code> 317 , 327 , 328 , 335 , 343 , 344 , 345 , 347 , 348		<code>\pIe@pdfliteral@okfalse</code> 39
<code>\Numb</code> 318 , 328 , 329 , 334 , 335 , 345 , 346 , 347		<code>\pIe@pdfliteral@oktrue</code> 36
<code>\number</code> 334 , 346		<code>\pIe@PTtoBP</code> 198 , 215 , 240
<code>\Numer</code> 316 , 319 , 320 , 321 , 327		<code>\pIe@pyth</code> 284 , 407 , 676

<code>\pIIE@qcircle</code>	<code>\pIIE@translate</code> .. 200 , 216	S
. 479 , 480 , 481 , 547	<code>\pIIE@vector</code>	<code>\setbox</code> 396
<code>\pIIE@qoval</code> 532 , 57 , 60 , 418 , 423 , 683	<code>\sign</code> 321 , 325 , 332 ,
535 , 536 , 537 , 538 , 541	<code>\pIIE@vector@ltx</code> .. 57 , 424	340 , 588 , 589 , 591 , 601
<code>\pIIE@rcurveto</code> 247 , 258 , 497	<code>\pIIE@vector@pst</code> .. 60 , 446	<code>\squarecap</code> 10 , 719
<code>\pIIE@rotate</code> 200 , 216	<code>\pIIE@arc</code> 636 , 652	<code>\strokepath</code> 10 , 699
<code>\pIIE@scale</code> 200 , 216	<code>\polygon</code> 9 , 653	
<code>\pIIE@scale@PTtoBP</code>	<code>\polygon*</code> 9	T
. 167 , 200 , 216	<code>\polyline</code> 9 , 653	<code>\tempend</code> 340 , 341
<code>\pIIE@setlinewidth@op</code>	<code>\polyvector</code> 9 , 653	
. 138 , 147 , 172	<code>\pstarrows</code> 56 , 63	U
<code>\pIIE@sline</code> 370 , 377 , 405		<code>\undefined</code> 581 , 582 , 583 , 648
<code>\pIIE@stroke@op</code> 138 , 147 , 174	Q	<code>\UseCos</code> 235 , 611 , 624 , 627 , 630
<code>\pIIE@strokeGraph</code> . 164 ,	<code>\Q</code> 323 , 330 , 334 , 340 , 346	<code>\UseSin</code> 234 , 612 , 623 , 628 , 629
373 , 476 , 539 , 571 ,	<code>\qbezier</code> 8	<code>\UseTan</code> 622
646 , 663 , 696 , 717 , 744	<code>\qbeziermax</code> 8	
<code>\pIIE@tempa</code> 16 ,		V
231 , 232 , 233 , 234 ,	R	<code>\Vector</code> 9 , 653
235 , 298 , 299 , 304 , 305	<code>\roundcap</code> 10 , 719	<code>\vector</code> 5 , 101 , 114 , 363 , 399
<code>\pIIE@tempb</code> 16 , 234 , 236 , 237	<code>\roundjoin</code> 10 , 719	<code>\vrule</code> 397 , 398
<code>\pIIE@tempc</code> 16 , 235 , 236 , 237	<code>\rp@r</code> 653	