The luamplib package

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Abstract

Package to have METAPOST code typeset directly in a document with LuaTEX.

1 Documentation

This package aims at providing a simple way to typeset directly METAPOST code in a document with LuaTEX. LuaTEX is built with the Lua **mplib** library, that runs METAPOST code. This package is basically a wrapper for the Lua **mplib** functions and some TEX functions to have the output of the **mplib** functions in the pdf.

Using this package is easy: in Plain, type your METAPOST code between the macros `\mplibcode` and `\endmplibcode`, and in LATEX in the `mplibcode` environment.

The resulting METAPOST figures are put in a TEX `hbox` with dimensions adjusted to the METAPOST code.

The code of luamplib is basically from the `luatex-mplib.lua` and `luatex-mplib.tex` files from ConTEXt. They have been adapted to LATEX and Plain by Elie Roux and Philipp Gesang and new functionalities have been added by Kim Dohyun. The most notable changes are:

- possibility to use `btex ... etex` to typeset TEX code. `textext()` is a more versatile macro equivalent to `TEX()` from TEX.**mp**. `TEX()` is also allowed and is a synonym of `textext()`. The argument of **mplib**'s primitive `maketext` will also be processed by the same routine.
- possibility to use `verbatimtex ... etex`, though it's behavior cannot be the same as the stand-alone **mpost**. Of course you cannot include `\documentclass`, `\usepackage` etc. When these TEX commands are found in `verbatimtex ... etex`, the entire code will be ignored. The treatment of `verbatimtex` command has changed a lot since v2.20: see below § 1.1.
- in the past, the package required PDF mode in order to have some output. Starting with version 2.7 it works in DVI mode as well, though DVIPDFMx is the only DVI tool currently supported.

It seems to be convenient to divide the explanations of some more changes and cautions into three parts: TEX, METAPOST, and Lua interfaces.

1.1 TEX

1.1.1 \mplibforcehmode

When this macro is declared, every METAPOST figure box will be typeset in horizontal mode, so \centering, \raggedleft etc will have effects. \mplibnoforcehmode, being default, reverts this setting. (Actually these commands redefine \prependtomplibbox; you can redefine this command with anything suitable before a box.)

1.1.2 \everymplib{...}, \everyendmplib{...}

\everymplib and \everyendmplib redefine the lua table containing METAPOST code which will be automatically inserted at the beginning and ending of each METAPOST code chunk.

```
\everymplib{ beginfig(0); }
\everyendmplib{ endfig; }
\begin{mplibcode}
  % beginfig/endfig not needed
  draw fullcircle scaled 1cm;
\end{mplibcode}
```

1.1.3 \mplibsetformat{plain|metafun}

There are (basically) two formats for METAPOST: *plain* and *metafun*. By default, the *plain* format is used, but you can set the format to be used by future figures at any time using \mplibsetformat{⟨*format name*⟩}.

N.B. As *metafun* is such a complicated format, we cannot support all the functionalities producing special effects provided by *metafun*. At least, however, transparency (actually opacity), shading (gradient colors) and transparency group are fully supported, and outlinetext is supported by our own alternative mpliboutlinetext (see below § 1.2). You can try other effects as well, though we did not fully tested their proper functioning.

transparency (texdoc metafun § 8.2) Transparency is so simple that you can apply it to an object, with *plain* format as well as *metafun*, just by appending withprescript "tr_transparency=⟨*number*⟩" to the sentence. ($0 \leq \langle number \rangle \leq 1$)

From v2.36, withtransparency is available with *plain* as well. See below § 1.2.

shading (texdoc metafun § 8.3) One thing worth mentioning about shading is: when a color expression is given in string type, it is regarded by luamplib as a color expression of TEX side. For instance, when withshadecolors("orange", 2/3red) is given, the first color "orange" will be interpreted as a **color**, **xcolor** or **l3color**'s expression.

From v2.36, shading is available with *plain* format as well with extended functionality. See below § 1.2.

transparency group (texdoc metafun § 8.8) As for transparency group, the current *metafun* document is not correct. The true syntax is:

```
draw <picture>|<path> asgroup <string>
```

where ⟨*string*⟩ should be "" (empty), "isolated", "knockout", or "isolated,knockout". Beware that currently many of the PDF rendering applications, except Adobe Acrobat Reader, cannot properly render the isolated or knockout effect.

Transparency group is available with *plain* format as well, with extended functionality. See below § 1.2.

1.1.4 \mplibnumbersystem{scaled|double|decimal}

Users can choose numbersystem option. The default value is scaled, which can be changed by declaring \mplibnumbersystem{double} or \mplibnumbersystem{decimal}.

1.1.5 \mplibshowlog{enable|disable}

Default: disable. When \mplibshowlog{enable}[1] is declared, log messages returned by the METAPOST process will be printed to the .log file. This is the TEX side interface for luamplib.showlog.

1.1.6 \mpliblegacybehavior{enable|disable}

By default, \mpliblegacybehavior{enable} is already declared for backward compatibility, in which case TEX code in verbatimtex ... etex that comes just before beginfig() will be inserted before the following METAPOST figure box. In this way, each figure box can be freely moved horizontally or vertically. Also, a box number can be assigned to a figure box, allowing it to be reused later.

```
\mplibcode
verbatimtex \moveright 3cm etex; beginfig(0); ... endfig;
verbatimtex \leavevmode etex; beginfig(1); ... endfig;
verbatimtex \leavevmode\lower 1ex etex; beginfig(2); ... endfig;
verbatimtex \endgraf\moveright 1cm etex; beginfig(3); ... endfig;
\endmplibcode
```

N.B. \endgraf should be used instead of \par inside verbatimtex ... etex.

On the other hand, TEX code in verbatimtex ... etex between beginfig() and endfig will be inserted after flushing out the METAPOST figure. As shown in the example below, VerbatimTeX() is a synonym of verbatimtex ... etex.

```
\mplibcode
  D := sqrt(2)**7;
  beginfig(0);
  draw fullcircle scaled D;
  VerbatimTeX("\gdef\Dia{" & decimal D & "}");
  endfig;
\endmplibcode
diameter: \Dia bp.
```

By contrast, when \mpliblegacybehavior{disable} is declared, any verbatimtex ... etex will be executed, along with btex ... etex, sequentially one by one. So, some TEX code in verbatimtex ... etex will have effects on following btex ... etex codes.

```
\begin{mplibcode}
  beginfig(0);
```

[1] As for user's setting, enable, true and yes are identical; disable, false and no are identical.

```
  draw btex ABC etex;
  verbatimtex \bfseries etex;
  draw btex DEF etex shifted (1cm,0); % bold face
  draw btex GHI etex shifted (2cm,0); % bold face
  endfig;
\end{mplibcode}
```

1.1.7 \mplibtextextlabel{enable|disable}

Default: disable. \mplibtextextlabel{enable} enables the labels typeset via textext instead of infont operator. So, label("my text",origin) thereafter is exactly the same as label(textext("my text"),origin).

N.B. In the background, luamplib redefines infont operator so that the right side argument (the font part) is totally ignored. Therefore the left side arguemnt (the text part) will be typeset with the current TEX font.

From v2.35, however, the redefinition of infont operator has been revised: when the character code of the text argument is less than 32 (control characters), or is equal to 35 (#), 36 ($), 37 (%), 38 (&), 92 (\), 94 (^), 95 (_), 123 ({), 125 (}), 126 (~) or 127 (DEL), the original infont operator will be used instead of textext operator so that the font part will be honored. Despite the revision, please take care of char operator in the text argument, as this might bring unpermitted characters into TEX.

1.1.8 \mplibcodeinherit{enable|disable}

Default: disable. \mplibcodeinherit{enable} enables the inheritance of variables, constants, and macros defined by previous METAPOST code chunks. On the contrary, \mplibcodeinherit{disable} will make each code chunk being treated as an independent instance, never affected by previous code chunks.

1.1.9 Separate METAPOST instances

luamplib v2.22 has added the support for several named METAPOST instances in LATEX mplibcode environment. Plain TEX users also can use this functionality. The syntax for LATEX is:

```
\begin{mplibcode}[instanceName]
  % some mp code
\end{mplibcode}
```

The behavior is as follows.

- All the variables and functions are shared only among all the environments belonging to the same instance.
- \mplibcodeinherit only affects environments with no instance name set (since if a name is set, the code is intended to be reused at some point).
- btex ... etex boxes are also shared and do not require \mplibglobaltextext.
- When an instance names is set, respective \currentmpinstancename is set as well.

In parellel with this functionality, we support optional argument of instance name for \everymplib and \everyendmplib, affecting only those mplibcode environments of the same

name. Unnamed \everymplib affects not only those instances with no name, but also those with name but with no corresponding \everymplib. The syntax is:

```
\everymplib[instanceName]{...}
\everyendmplib[instanceName]{...}
```

1.1.10 \mplibglobaltextext{enable|disable}

Default: disable. Formerly, to inherit btex ... etex boxes as well as other METAPOST macros, variables and constants, it was necessary to declare \mplibglobaltextext{enable} in advance. But from v2.27, this is implicitly enabled when \mplibcodeinherit is enabled. This optional command still remains mostly for backward compatibility.

```
\mplibcodeinherit{enable}
%\mplibglobaltextext{enable}
\everymplib{ beginfig(0);} \everyendmplib{ endfig;}
\mplibcode
  label(btex $\sqrt{2}$ etex, origin);
  draw fullcircle scaled 20;
  picture pic; pic := currentpicture;
\endmplibcode
\mplibcode
  currentpicture := pic scaled 2;
\endmplibcode
```

1.1.11 \mplibverbatim{enable|disable}

Default: disable. Users can issue \mplibverbatim{enable}, after which the contents of mplibcode environment will be read verbatim. As a result, except for \mpdim and \mpcolor (see below), all other TEX commands outside of the btex or verbatimtex ... etex are not expanded and will be fed literally to the mplib library.

1.1.12 \mpdim{...}

Besides other TEX commands, \mpdim is specially allowed in the mplibcode environment. This feature is inpired by gmp package authored by Enrico Gregorio. Please refer to the manual of gmp package for details.

```
\begin{mplibcode}
  beginfig(1)
  draw origin--(.6\mpdim{\linewidth},0) withpen pencircle scaled 4
  dashed evenly scaled 4 withcolor \mpcolor{orange};
  endfig;
\end{mplibcode}
```

1.1.13 \mpcolor[...]{...}

With \mpcolor command, color names or expressions of color, xcolor and l3color module/packages can be used in the mplibcode environment (after withcolor operator). See the example above. The optional [...] denotes the option of xcolor's \color command. For spot colors, l3color (in PDF/DVI mode), colorspace, spotcolor (in PDF mode) and xespotcolor (in DVI mode) packages are supported as well.

1.1.14 \mpfig ... \endmpfig

Besides the mplibcode environment (for LaTeX) and \mplibcode ... \endmplibcode (for Plain), we also provide unexpandable TeX macros \mpfig ... \endmpfig and its starred version \mpfig* ... \endmpfig to save typing toil. The former is roughly the same as follows:

```
\begin{mplibcode}[@mpfig]
beginfig(0)
token list declared by \everymplib[@mpfig]
...
token list declared by \everyendmplib[@mpfig]
endfig;
\end{mplibcode}
```

and the starred version is roughly the same as follows:

```
\begin{mplibcode}[@mpfig]
...
\end{mplibcode}
```

In these macros \mpliblegacybehavior{disable} is forcibly declared. Again, as both share the same instance name, METAPOST codes are inherited among them. A simple example:

```
\everymplib[@mpfig]{ drawoptions(withcolor .5[red,white]); }
\mpfig* input boxes \endmpfig
\mpfig
  circleit.a(btex Box 1 etex); drawboxed(a);
\endmpfig
```

The instance name (default: @mpfig) can be changed by redefining \mpfiginstancename, after which a new **mplib** instance will start and code inheritance too will begin anew. \let\mpfiginstancename\empty will prevent code inheritance if \mplibcodeinherit{true} is not declared.

1.1.15 About cache files

To support btex ... etex in external .mp files, luamplib inspects the content of each and every .mp file and makes caches if nececcsary, before returning their paths to LuaTeX's **mplib** library. This could waste the compilation time, as most .mp files do not contain btex ... etex commands. So luamplib provides macros as follows, so that users can give instructions about files that do not require this functionality.

- \mplibmakenocache{⟨*filename*⟩[,⟨*filename*⟩,...]}
- \mplibcancelnocache{⟨*filename*⟩[,⟨*filename*⟩,...]}

where ⟨*filename*⟩ is a filename excluding .mp extension. Note that .mp files under $TEXMFMAIN/metapost/base and $TEXMFMAIN/metapost/context/base are already registered by default.

By default, cache files will be stored in $TEXMFVAR/luamplib_cache or, if it's not available (mostly not writable), in the directory where output files are saved: to be specific, $TEXMF_OUTPUT_DIRECTORY/luamplib_cache, ./luamplib_cache, $TEXMFOUTPUT/luamplib_cache, and ., in this order. $TEXMF_OUTPUT_DIRECTORY is normally the value of --output-directory command-line option.

Users can change this behavior by the command \mplibcachedir{⟨*directory path*⟩}, where tilde (~) is interpreted as the user's home directory (on a windows machine as well). As backslashes (\) should be escaped by users, it would be easier to use slashes (/) instead.

1.1.16 About figure box metric

Notice that, after each figure is processed, the macro \MPwidth stores the width value of the latest figure; \MPheight, the height value. Incidentally, also note that \MPllx, \MPlly, \MPurx, and \MPury store the bounding box information of the latest figure without the unit bp.

1.1.17 luamplib.cfg

At the end of package loading, luamplib searches luamplib.cfg and, if found, reads the file in automatically. Frequently used settings such as \everymplib, \mplibforcehmode or \mplibcodeinherit are suitable for going into this file.

1.1.18 Tagged PDF

When **tagpdf** package is loaded and activated, mplibcode environment accepts additional options for tagged PDF. The code related to this functionality is currently in experimental stage, not guaranteeing backward compatibility. Like the LaTeX's picture environment, available optional keys are tag, alt, actualtext, artifact, debug and correct-BBox (texdoc latex-lab-graphic). Additionally, luamplib provides its own text key.

tag=... You can choose a tag name, default value being Figure. BBox info will be added automatically to the PDF unless the value is text or false. When the value is false, tagging is deactivated.

debug draws bounding box of the figure for checking, which you can correct by correct-BBox key with space-separated four dimen values.

alt=... sets an alternative text of the figure as given. This key is needed for ordinary METAPOST figures. You can give alternative text within METAPOST code as well: VerbatimTeX ("\mplibalttext{...}");

actualtext=... starts a Span tag implicitly and sets an actual text as given. Horizontal mode is forced by \noindent command. BBox info will not be added. This key is intended for figures which can be represented by a character or a small sequence of characters. You can give actual text within METAPOST code as well: VerbatimTeX ("\mplibactualtext{...}");

artifact starts an artifact MC (marked content). BBox info will not be added. This key is intended for decorative figures which have no semantic quality.

text starts an artifact MC and enables tagging on textext (the same as btex ... etex) boxes. Horizontal mode is forced by \noindent command. BBox info will not be added. This key is intended for figures made mostly of textext boxes. Inside text-keyed figures, reusing textext boxes is strongly discouraged.

These keys are provided also for \mpfig and \usemplibgroup (see below) commands.

```
\begin{mplibcode}[myInstanceName, alt=figure drawing a circle]
...
\end{mplibcode}

\mpfig[alt=figure drawing a square box]
...
\endmpfig

\usemplibgroup[alt=figure drawing a triangle]{...}

\mppattern{...}          % see below
  \mpfig[tag=false]      % do not tag this figure
  ...
  \endmpfig
\endmppattern
```

As for the instance name of mplibcode environment, instance=... or instancename=... is also allowed in addition to the raw instance name as shown above.

1.2 MetaPost

1.2.1 mplibdimen(...), mplibcolor(...)

These are METAPOST interfaces for the TEX commands \mpdim and \mpcolor (see above). For example, mplibdimen("\linewidth") is basically the same as \mpdim{\linewidth}, and mplibcolor("red!50") is basically the same as \mpcolor{red!50}. The difference is that these METAPOST operators can also be used in external .mp files, which cannot have TEX commands outside of the btex or verbatimtex ... etex.

1.2.2 mplibtexcolor ..., mplibrgbtexcolor ...

mplibtexcolor, which accepts a string argument, is a METAPOST operator that converts a TEX color expression to a METAPOST color expression, that can be used anywhere color expression is expected as well as after the withcolor operator. For instance:

```
color col;
col := mplibtexcolor "olive!50";
```

But the result may vary in its color model (gray/rgb/cmyk) according to the given TEX color. (Spot colors are forced to cmyk model, so this operator is not recommended for spot colors.) Therefore the example shown above would raise a METAPOST error: cmykcolor col; should have been declared. By contrast, mplibrgbtexcolor ⟨*string*⟩ always returns rgb model expressions.

1.2.3 mplibgraphictext ...

mplibgraphictext is a METAPOST operator, the effect of which is similar to that of ConTEXt's graphictext or our own mpliboutlinetext (see below). However the syntax is somewhat different.

```
mplibgraphictext "Funny"
  fakebold 2.3                       % fontspec option
  drawcolor .7blue fillcolor "red!50" % color expressions
```

fakebold, drawcolor and fillcolor are optional; default values are 2, "black" and "white" respectively. When the color expressions are given in string type, they are regarded as color, xcolor or l3color's expressions. All from mplibgraphictext to the end of sentence will compose an anonymous picture, which can be drawn or assigned to a variable. Incidentally, withdrawcolor and withfillcolor are synonyms of drawcolor and fillcolor, hopefully to be compatible with graphictext.

N.B. In some cases, mplibgraphictext will produce better results than ConTEXt or even than our own mpliboutlinetext, especially when processing complicated TEX code such as the vertical writing in Chinese or Japanese. However, because the implementation is quite different from others, there are some limitations such that you can't apply shading (gradient colors) to the text with withshademethod from *metafun*. (But this limitation is now lifted by the introduction of withshadingmethod. See below.) Again, in DVI mode, unicode-math package is needed for math formula, as we cannot embolden type1 fonts in DVI mode.

1.2.4 mplibglyph ... of ...

From v2.30, we provide a new METAPOST operator mplibglyph, which returns a METAPOST picture containing outline paths of a glyph in opentype, truetype or type1 fonts. When a type1 font is specified, METAPOST primitive glyph will be called.

```
mplibglyph 50  of \fontid\font          % slot 50 of current font
mplibglyph "Q" of "TU/TeXGyrePagella(0)/m/n/10"    % font csname
mplibglyph "Q" of "texgyrepagella-regular.otf"     % raw filename
mplibglyph "Q" of "Times.ttc(2)"                   % subfont number
mplibglyph "Q" of "SourceHanSansK-VF.otf[Regular]" % instance name
```

Both arguments before and after of "of" can be either a number or a string. Number arguments are regarded as a glyph slot (GID) and a font id number, repectively. String argument at the left side is regarded as a glyph name in the font or a unicode character. String argument at the right side is regarded as a TEX font csname (without backslash) or the raw filename of a font. When it is a font filename, a number within parentheses after the filename denotes a subfont number (starting from zero) of a TTC font; a string within brackets denotes an instance name of a variable font.

1.2.5 mplibdrawglyph ...

The picture returned by mplibglyph will be quite similar to the result of glyph primitive in its structure. So, METAPOST's draw command will fill the inner path of the picture with the background color. In contrast, mplibdrawglyph ⟨*picture*⟩ command fills the paths according to the nonzero winding number rule. As a result, for instance, the area surrounded by inner path of "O" will remain transparent.

☞ To apply the nonzero winding number rule to a picture containing paths, luamplib appends withpostscript "collect" to the paths except the last one in the picture. If you want the even-odd rule instead, you can, with *plain* format as well, additionally declare withpostscript "evenodd" to the last path in the picture.

1.2.6 mpliboutlinetext (...)

From v2.31, a new METAPOST operator mpliboutlinetext is available, which mimicks *metafun*'s outlinetext. So the syntax is the same: see the *metafun* manual § 8.7

(texdoc metafun). A simple example:

```
draw mpliboutlinetext.b ("$\sqrt{2+\alpha}$")
    (withcolor \mpcolor{red!50})
    (withpen pencircle scaled .2 withcolor red)
    scaled 2 ;
```

After the process, mpliboutlinepic[] and mpliboutlinenum will be preserved as global variables; mpliboutlinepic[1] ... mpliboutlinepic[mpliboutlinenum] will be an array of images each of which containing a glyph or a rule.

N.B. As Unicode grapheme cluster is not considered in the array, a unit that must be a single cluster might be separated apart.

1.2.7 \mppattern{...} ... \endmppattern, ... withpattern ...

TEX macros \mppattern{⟨*name*⟩} ... \endmppattern define a tiling pattern associated with the ⟨*name*⟩. METAPOST operator withpattern, the syntax being ⟨*path*⟩ | ⟨*textual picture*⟩ withpattern ⟨*string*⟩, will return a METAPOST picture which fills the given path or text with a tiling pattern of the ⟨*name*⟩ by replicating it horizontally and vertically. The *textual picture* here means any text typeset by TEX, mostly the result of the btex command (though technically this is not a true textual picture) or the infont operator.

An example:

```
\mppattern{mypatt}              % or \begin{mppattern}{mypatt}
  [                             % options: see below
    xstep = 10,
    ystep = 12,
    matrix = {0, 1, -1, 0},     % or "0 1 -1 0"
  ]
  \mpfig                        % or any other TeX code,
    draw (origin--(1,1))
      scaled 10
      withcolor 1/3[blue,white]
      ;
    draw (up--right)
      scaled 10
      withcolor 1/3[red,white]
      ;
  \endmpfig
\endmppattern                   % or \end{mppattern}

\mpfig
  draw fullcircle scaled 90
    withpostscript "collect"
    ;
  draw fullcircle scaled 200
    withpattern "mypatt"
    withpen pencircle scaled 1
    withcolor \mpcolor{red!50!blue!50}
    withpostscript "evenodd"
    ;
\endmpfig
```

The available options are listed in Table 1.

Table 1: options for \mppattern

Key	Value Type	Explanation
xstep	*number*	horizontal spacing between pattern cells
ystep	*number*	vertical spacing between pattern cells
xshift	*number*	horizontal shifting of pattern cells
yshift	*number*	vertical shifting of pattern cells
bbox	*table* or *string*	llx, lly, urx, ury values*
matrix	*table* or *string*	xx, yx, xy, yy values* or MP transform code
resources	*string*	PDF resources if needed
colored or coloured	*boolean*	false for uncolored pattern. default: true

* in string type, numbers are separated by spaces

For the sake of convenience, the width and height values of tiling patterns will be written down into the log file. (depth is always zero.) Users can refer to them for option setting.

As for matrix option, METAPOST code such as 'rotated 30 slanted .2' is allowed as well as string or table of four numbers. You can also set xshift and yshift values by using 'shifted' operator. But when xshift or yshift option is explicitly given, they have precedence over the effect of 'shifted' operator.

When you use special effects such as transparency in a pattern, resources option is needed: for instance, resources="/ExtGState 1 0 R". However, as luamplib automatically includes the resources of the current page, this option is not needed in most cases.

Option colored=false (coloured is a synonym of colored) will generate an uncolored pattern which shall have no color at all. Uncolored pattern will be painted later by the color of a METAPOST object. An example:

```
\begin{mppattern}{pattnocolor}
  [
    colored = false,
    matrix = "slanted .3 rotated 30",
  ]
  \tiny\TeX
\end{mppattern}

\begin{mplibcode}
  beginfig(1)
  picture tex;
  tex = mpliboutlinetext.p ("\bfseries \TeX");
  for i=1 upto mpliboutlinenum:
    j:=0;
    for item within mpliboutlinepic[i]:
      j:=j+1;
      draw pathpart item scaled 10
      if j < length mpliboutlinepic[i]:
          withpostscript "collect"
      else:
          withpattern "pattnocolor"
          withpen pencircle scaled 1/2
          withcolor (i/4)[red,blue]          % paints the pattern
      fi;
    endfor
```

```
  endfor
  endfig;
\end{mplibcode}
```

A much simpler and efficient way to obtain a similar result (without colorful characters in this example) is to give a *textual picture* as the operand of `withpattern`:

```
\begin{mplibcode}
  beginfig(2)
  picture pic;
  pic = mplibgraphictext "\bfseries\TeX"
          fakebold 1/2
          fillcolor 1/3[red,blue]           % paints the pattern
          drawcolor 2/3[red,blue]
          scaled 10 ;
  draw pic withpattern "pattnocolor" ;
  endfig;
\end{mplibcode}
```

1.2.8 ... withfademethod ...

This is a METAPOST operator which makes the color of an object gradiently transparent. The syntax is ⟨*path*⟩ | ⟨*picture*⟩ `withfademethod` ⟨*string*⟩, the latter being either `"linear"` or `"circular"`. Though it is similar to the `withshademethod` from *metafun*, the differences are: (1) the operand of `withfademethod` can be a picture as well as a path; (2) you cannot make gradient colors, but can only make gradient opacity.

Related macros to control optional values are:

`withfadeopacity` (*number, number*) sets the starting opacity and the ending opacity, default value being `(1,0)`. '`1`' denotes full color; '`0`' full transparency.

`withfadevector` (*pair, pair*) sets the starting and ending points. Default value in the linear mode is `(llcorner p, lrcorner p)`, where `p` is the operand, meaning that fading starts from the left edge and ends at the right edge. Default value in the circular mode is `(center p, center p)`, which means centers of both starting and ending circles are the center of the bounding box.

`withfadecenter` is a synonym of `withfadevector`.

`withfaderadius` (*number, number*) sets the radii of starting and ending circles. This is no-op in the linear mode. Default value is `(0, abs(center p - urcorner p))`, meaning that fading starts from the center and ends at the four corners of the bounding box.

`withfadebbox` (*pair, pair*) sets the bounding box of the fading area, default value being `(llcorner p, urcorner p)`. Though this option is not needed in most cases, there could be cases when users want to explicitly control the bounding box. Particularly, see the description below on the analogous macro `withgroupbbox`.

An example:

```
\mpfig
  picture mill;
  mill = btex \includegraphics[width=100bp]{mill} etex;
  draw mill
```

```
    withfademethod  "circular"
    withfadecenter  (center mill, center mill)
    withfaderadius  (20, 50)
    withfadeopacity (1, 0)
    ;
\endmpfig
```

1.2.9 ... asgroup ...

As said before, transparency group is available with *plain* as well as *metafun* format. The syntax is exactly the same: ⟨*picture*⟩ | ⟨*path*⟩ `asgroup "" | "isolated" | "knockout" | "isolated,knockout"`, which will return a METAPOST picture. It is called *Transparency Group* because the objects contained in the group are composited to produce a single object, so that outer transparency effect, if any, will be applied to the group as a whole, not to the individual objects cumulatively.

The additional feature provided by luamplib is that you can reuse the group as many times as you want in the TEX code or in other METAPOST code chunks, with infinitesimal increase in the size of PDF file. For this functionality we provide TEX and METAPOST macros as follows:

`withgroupname` ⟨*string*⟩ associates a transparency group with the given name. When this is not appended to the sentence with `asgroup` operator, the default group name '`lastmplibgroup`' will be used.

`\usemplibgroup{`⟨*name*⟩`}` is a TEX command to reuse a transparency group of the name once used. Note that the position of the group will be origin-based: in other words, lower-left corner of the group will be shifted to the origin.

`usemplibgroup` ⟨*string*⟩ is a METAPOST command which will add a transparency group of the name to the `currentpicture`. Contrary to the TEX command just mentioned, the position of the group is the same as the original transparency group.

`withgroupbbox (`*pair*`,`*pair*`)` sets the bounding box of the transparency group, default value being `(llcorner p, urcorner p)`. This option might be needed especially when you draw with a thick pen a path that touches the boundary; you would probably want to append to the sentence '`withgroupbbox (bot lft llcorner p, top rt urcorner p)`', supposing that the pen was selected by the `pickup` command.

An example showing the difference between the TEX and METAPOST commands:

```
\mpfig
  draw image(
    fill fullcircle scaled 100 shifted 25right withcolor blue;
    fill fullcircle scaled 100 withcolor red ;
  ) asgroup ""
    withgroupname "mygroup";
  draw (left--right) scaled 10;
  draw (up--down) scaled 10;
\endmpfig

\noindent
\clap{\vrule width 20pt height .25pt depth .25pt}%
\clap{\vrule width .5pt height 10pt depth 10pt}%
\usemplibgroup{mygroup}
```

Table 2: options for \mplibgroup

Key	Value Type	Explanation
asgroup	*string*	"", "isolated", "knockout", or "isolated,knockout"
bbox	*table* or *string*	llx, lly, urx, ury values*
matrix	*table* or *string*	xx, yx, xy, yy values* or MP transform code
resources	*string*	PDF resources if needed

* in string type, numbers are separated by spaces

```
\mpfig
  usemplibgroup "mygroup" rotated 15
    withtransparency (1, 0.5) ;
  draw (left--right) scaled 10;
  draw (up--down) scaled 10;
\endmpfig
```

Also note that normally the reused transparency groups are not affected by outer color commands. However, if you have made the original transparency group using withoutcolor command, colors will have effects on the uncolored objects in the group.

1.2.10 \mplibgroup{...} ... \endmplibgroup

These TEX macros are described here in this subsection, as they are deeply related to the asgroup operator. Users can define a transparency group or a normal *form XObject* with these macros from TEX side. The syntax is similar to the \mppattern command (see above). An example:

```
\mplibgroup{mygrx}                % or \begin{mplibgroup}{mygrx}
  [                               % options: see below
    asgroup="",
  ]
  \mpfig                          % or any other TeX code
    pickup pencircle scaled 10;
    draw (left--right) scaled 30 rotated 45 ;
    draw (left--right) scaled 30 rotated -45 ;
  \endmpfig
\endmplibgroup                    % or \end{mplibgroup}

\usemplibgroup{mygrx}

\mpfig
  usemplibgroup "mygrx" scaled 1.5
    withtransparency (1, 0.5) ;
\endmpfig
```

Availabe options, much fewer than those for \mppattern, are listed in Table 2. Again, the width/height/depth values of the mplibgroup will be written down into the log file.

When asgroup option, including empty string, is not given, a normal form XObject will be generated rather than a transparency group. Thus the individual objects, not the XObject as a whole, will be affected by outer transparency command.

As shown in the example, you can reuse the mplibgroup once defined using the TEX command \usemplibgroup or the METAPOST command usemplibgroup. The behavior of

these commands is the same as that described above, excepting that mplibgroup made by TEX code (not by METAPOST code) respects original height and depth.

1.2.11 ... withtransparency ...

`withtransparency(`*number* | *string*, *number*`)` is provided for *plain* format as well. The first argument accepts a number or a name of alternative transparency methods (see `texdoc metafun` § 8.2 Figure 8.1). The second argument accepts a number denoting opacity.

```
fill fullcircle scaled 10
    withcolor red
    withtransparency (1, 0.5)          % or ("normal", 0.5)
    ;
```

1.2.12 ... withshadingmethod ...

The syntax is exactly the same as *metafun*'s new shading method (`texdoc metafun` § 8.3.3), except that the 'shade' contained in each and every macro name has changed to 'shading' in luamplib: for instance, while `withshademethod` is a macro name which only works with *metafun* format, the equivalent provided by luamplib, `withshadingmethod`, works with *plain* as well. Other differences to the *metafun*'s and some cautions are:

- *textual pictures* (pictures made by `btex ... etex`, `textext`, `maketext`, `mplibgraphictext`, `TEX`, `infont`, etc) as well as paths can have shading effect.

  ```
  draw btex \bfseries\TeX etex scaled 10
      withshadingmethod "linear"
      withshadingcolors (red,blue) ;
  ```

- When you give shading effect to a picture made by 'infont' operator, the result of `withshadingvector` will be the same as that of `withshadingdirection`, as luamplib considers only the bounding box of the picture.

- Inside tiling pattern cells (see above), you shall not give shading effect to pictures (paths are OK). Anyway, that is the current phase of development.

Macros provided by luamplib are:

⟨*path*⟩ | ⟨*textual picture*⟩ `withshadingmethod` ⟨*string*⟩ where ⟨*string*⟩ shall be `"linear"` or `"circular"`. This is the only 'must' item to get shading effect; all the macros below are optional.

`withshadingvector` ⟨*pair*⟩ Starting and ending points (as time value) on the path.

`withshadingdirection` ⟨*pair*⟩ Starting and ending points (as time value) on the bounding box. Default value: `(0,2)`

`withshadingorigin` ⟨*pair*⟩ The center of starting and ending circles. Default value: `center p`

`withshadingradius` ⟨*pair*⟩ Radii of starting and ending circles. This is no-op in linear mode. Default value: `(0, abs(center p - urcorner p))`

`withshadingfactor` ⟨*number*⟩ Multiplier of the radii. This is no-op in linear mode. Default value: `1.2`

`withshadingcenter` ⟨*pair*⟩ Values for shifting starting center. For instance, `(0,0)` means that center of starting circle is `center p`; `(1,1)` means `urcorner p`.

`withshadingtransform` ⟨*string*⟩ where ⟨*string*⟩ shall be `"yes"` (respect transform) or `"no"` (ignore transform). Default value: `"no"` for pictures made by `infont` operator; `"yes"` for all other cases.

`withshadingdomain` ⟨*pair*⟩ Limiting values of parametric variable that varies on the axis of color gradient. Default value: `(0,1)`

`withshadingstep (...)` for combined shading of more than two colors.

`withshadingfraction` ⟨*number*⟩ Fractional number of each shading step. Only meaningful with `withshadingstep`.

`withshadingcolors (`*color expr*, *color expr*`)` Starting and ending colors. Default value: `(white,black)`

1.2.13 `mpliblength ...`

`mpliblength` ⟨*string*⟩ returns the number of unicode characters in the string. This is a unicode-aware version equivalent to the METAPOST primitive `length`, but accepts only a string-type argument. For instance, `mpliblength "abçdéf"` returns `6`, not `8`.

1.2.14 `mplibsubstring ... of ...`

`mplibsubstring` ⟨*pair*⟩ `of` ⟨*string*⟩ is a unicode-aware version equivalent to the METAPOST's `substring ... of ...` primitive. The syntax is the same as the latter. For instance, `mplibsubstring (2,5) of "abçdéf"` returns `"çdé"`, and `mplibsubstring (5,2) of "abçdéf"` returns `"édç"`.

1.3 Lua

1.3.1 `runscript ...`

Using the primitive `runscript` ⟨*string*⟩, you can run a Lua code chunk from METAPOST side and get some METAPOST code returned by Lua if you want. As the functionality is provided by the **mplib** library itself, luamplib does not have much to say about it.

One thing is worth mentioning, however: if you return a Lua *table* to the METAPOST process, it is automatically converted to a relevant METAPOST value type such as pair, color, cmykcolor or transform. So users can save some extra toil of converting a table to a string, though it's not a big deal. For instance, `runscript "return {1,0,0}"` will give you the METAPOST color expression `(1,0,0)` automatically.

1.3.2 Lua table `luamplib.instances`

Users can access the Lua table containing **mplib** instances, `luamplib.instances`, through which METAPOST variables are also easily accessible from Lua side, as documented in LuaTEX manual § 11.2.8.4 (`texdoc luatex`). The following will print `false`, `3.0`, `MetaPost` and the knots and the cyclicity of the path `unitsquare`, consecutively.

```
\begin{mplibcode}[instance1]
  boolean b; b = 1 > 2;
  numeric n; n = 3;
```

Table 3: elements in luamplib table (partial)

Key	Type	Related TEX macro
codeinherit	*boolean*	\mplibcodeinherit
everyendmplib	*table*	\everyendmplib
everymplib	*table*	\everymplib
getcachedir	*function* (⟨*string*⟩)	\mplibcachedir
globaltextext	*boolean*	\mplibglobaltextext
legacyverbatimtex	*boolean*	\mpliblegacybehavior
noneedtoreplace	*table*	\mplibmakenocache
numbersystem	*string*	\mplibnumbersystem
setformat	*function* (⟨*string*⟩)	\mplibsetformat
showlog	*boolean*	\mplibshowlog
textextlabel	*boolean*	\mplibtextextlabel
verbatiminput	*boolean*	\mplibverbatim

```
  string s; s = "MetaPost";
  path p; p = unitsquare;
\end{mplibcode}

\directlua{
  local instance1 = luamplib.instances.instance1
  print( instance1:get_boolean "b" )
  print( instance1:get_number  "n" )
  print( instance1:get_string  "s" )
  local t = instance1:get_path "p"
  for k,v in pairs(t) do
    print(k, type(v)=='table' and table.concat(v,' ') or v)
  end
}
```

1.3.3 Lua function `luamplib.process_mplibcode`

Users can execute a METAPOST code chunk from Lua side by using this function:

```
luamplib.process_mplibcode (<string> metapost code, <string> instance name)
```

The second argument cannot be absent, but can be an empty string (`""`) which means that it has no instance name.

Some other elements in the luamplib namespace, listed in Table 3, can have effects on the process of process_mplibcode.

2 Implementation

2.1 Lua module

```
1
2 luatexbase.provides_module {
3   name          = "luamplib",
4   version       = "2.37.0",
5   date          = "2025/02/06",
6   description   = "Lua package to typeset Metapost with LuaTeX's MPLib.",
```

```
}

```

Use the `luamplib` namespace, since `mplib` is for the METAPOST library itself. ConTEXt uses `metapost`.

```
luamplib          = luamplib or { }
local luamplib    = luamplib

local format, abs = string.format, math.abs

```

Use our own function for warn/info/err.

```
local function termorlog (target, text, kind)
  if text then
    local mod, write, append = "luamplib", texio.write_nl, texio.write
    kind = kind
        or target == "term" and "Warning (more info in the log)"
        or target == "log" and "Info"
        or target == "term and log" and "Warning"
        or "Error"
    target = kind == "Error" and "term and log" or target
    local t = text:explode"\n+"
    write(target, format("Module %s %s:", mod, kind))
    if #t == 1 then
      append(target, format(" %s", t[1]))
    else
      for _,line in ipairs(t) do
        write(target, line)
      end
      write(target, format("(%s)     ", mod))
    end
    append(target, format(" on input line %s", tex.inputlineno))
    write(target, "")
    if kind == "Error" then error() end
  end
end
local function warn (...) -- beware '%' symbol
  termorlog("term and log", select("#",...) > 1 and format(...) or ...)
end
local function info (...)
  termorlog("log", select("#",...) > 1 and format(...) or ...)
end
local function err (...)
  termorlog("error", select("#",...) > 1 and format(...) or ...)
end

luamplib.showlog  = luamplib.showlog or false

```

This module is a stripped down version of libraries that are used by ConTEXt. Provide a few “shortcuts” expected by the code.

```
local tableconcat = table.concat
local tableinsert = table.insert
local tableunpack = table.unpack
local texsprint   = tex.sprint
local texgettoks  = tex.gettoks
```

```
local texgetbox   = tex.getbox
local texruntoks  = tex.runtoks
if not texruntoks then
  err("Your LuaTeX version is too old. Please upgrade it to the latest")
end
local is_defined  = token.is_defined
local get_macro   = token.get_macro
local mplib = require ('mplib')
local kpse  = require ('kpse')
local lfs   = require ('lfs')
local lfsattributes = lfs.attributes
local lfsisdir      = lfs.isdir
local lfsmkdir      = lfs.mkdir
local lfstouch      = lfs.touch
local ioopen        = io.open

```

Some helper functions, prepared for the case when `l-file` etc is not loaded.

```
local file = file or { }
local replacesuffix = file.replacesuffix or function(filename, suffix)
  return (filename:gsub("%.[%a%d]+$","")) .. "." .. suffix
end
local is_writable = file.is_writable or function(name)
  if lfsisdir(name) then
    name = name .. "/_luam_plib_temp_file_"
    local fh = ioopen(name,"w")
    if fh then
      fh:close(); os.remove(name)
      return true
    end
  end
end
local mk_full_path = lfs.mkdirp or lfs.mkdirs or function(path)
  local full = ""
  for sub in path:gmatch("(/*[^\\/]+)") do
    full = full .. sub
    lfsmkdir(full)
  end
end

```

`btex ... etex` in input `.mp` files will be replaced in finder. Because of the limitation of **mplib** regarding `make_text`, we might have to make cache files modified from input files.

```
local luamplibtime = lfsattributes(kpse.find_file"luamplib.lua", "modification")
local currenttime = os.time()
local outputdir, cachedir
if lfstouch then
  for i,v in ipairs{'TEXMFVAR','TEXMF_OUTPUT_DIRECTORY','.','TEXMFOUTPUT'} do
    local var = i == 3 and v or kpse.var_value(v)
    if var and var ~= "" then
      for _,vv in next, var:explode(os.type == "unix" and ":" or ";") do
        local dir = format("%s/%s",vv,"luamplib_cache")
        if not lfsisdir(dir) then
          mk_full_path(dir)
        end
```

```
        if is_writable(dir) then
          outputdir = dir
          break
        end
      end
      if outputdir then break end
    end
  end
end
outputdir = outputdir or '.'
function luamplib.getcachedir(dir)
  dir = dir:gsub("##","#")
  dir = dir:gsub("^~",
    os.type == "windows" and os.getenv("UserProfile") or os.getenv("HOME"))
  if lfstouch and dir then
    if lfsisdir(dir) then
      if is_writable(dir) then
        cachedir = dir
      else
        warn("Directory '%s' is not writable!", dir)
      end
    else
      warn("Directory '%s' does not exist!", dir)
    end
  end
end
```

Some basic METAPOST files not necessary to make cache files.

```
local noneedtoreplace = {
  ["boxes.mp"] = true, --  ["format.mp"] = true,
  ["graph.mp"] = true, ["marith.mp"] = true, ["mfplain.mp"] = true,
  ["mpost.mp"] = true, ["plain.mp"] = true, ["rboxes.mp"] = true,
  ["sarith.mp"] = true, ["string.mp"] = true, -- ["TEX.mp"] = true,
  ["metafun.mp"] = true, ["metafun.mpiv"] = true, ["mp-abck.mpiv"] = true,
  ["mp-apos.mpiv"] = true, ["mp-asnc.mpiv"] = true, ["mp-bare.mpiv"] = true,
  ["mp-base.mpiv"] = true, ["mp-blob.mpiv"] = true, ["mp-butt.mpiv"] = true,
  ["mp-char.mpiv"] = true, ["mp-chem.mpiv"] = true, ["mp-core.mpiv"] = true,
  ["mp-crop.mpiv"] = true, ["mp-figs.mpiv"] = true, ["mp-form.mpiv"] = true,
  ["mp-func.mpiv"] = true, ["mp-grap.mpiv"] = true, ["mp-grid.mpiv"] = true,
  ["mp-grph.mpiv"] = true, ["mp-idea.mpiv"] = true, ["mp-luas.mpiv"] = true,
  ["mp-mlib.mpiv"] = true, ["mp-node.mpiv"] = true, ["mp-page.mpiv"] = true,
  ["mp-shap.mpiv"] = true, ["mp-step.mpiv"] = true, ["mp-text.mpiv"] = true,
  ["mp-tool.mpiv"] = true, ["mp-cont.mpiv"] = true,
}
luamplib.noneedtoreplace = noneedtoreplace
```

`format.mp` is much complicated, so specially treated.

```
local function replaceformatmp(file,newfile,ofmodify)
  local fh = ioopen(file,"r")
  if not fh then return file end
  local data = fh:read("*all"); fh:close()
  fh = ioopen(newfile,"w")
  if not fh then return file end
  fh:write(
    "let normalinfont = infont;\n",
```

```
    "primarydef str infont name = rawtextext(str) enddef;\n",
    data,
    "vardef Fmant_(expr x) = rawtextext(decimal abs x) enddef;\n",
    "vardef Fexp_(expr x) = rawtextext(\"$^{\"&decimal x&\"}$\") enddef;\n",
    "let infont = normalinfont;\n"
  ); fh:close()
  lfstouch(newfile,currenttime,ofmodify)
  return newfile
end
```

Replace btex ... etex and verbatimtex ... etex in input files, if needed.

```
local name_b = "%f[%a_]"
local name_e = "%f[^%a_]"
local btex_etex = name_b.."btex"..name_e.."%s*(.-)%s*"..name_b.."etex"..name_e
local verbatimtex_etex = name_b.."verbatimtex"..name_e.."%s*(.-)%s*"..name_b.."etex"..name_e
local function replaceinputmpfile (name,file)
  local ofmodify = lfsattributes(file,"modification")
  if not ofmodify then return file end
  local newfile = name:gsub("%W","_")
  newfile = format("%s/luamplib_input_%s", cachedir or outputdir, newfile)
  if newfile and luamplibtime then
    local nf = lfsattributes(newfile)
    if nf and nf.mode == "file" and
      ofmodify == nf.modification and luamplibtime < nf.access then
      return nf.size == 0 and file or newfile
    end
  end
  if name == "format.mp" then return replaceformatmp(file,newfile,ofmodify) end
  local fh = ioopen(file,"r")
  if not fh then return file end
  local data = fh:read("*all"); fh:close()
```

"etex" must be preceded by a space and followed by a space or semicolon as specified in LuaTEX manual, which is not the case of standalone METAPOST though.

```
  local count,cnt = 0,0
  data, cnt = data:gsub(btex_etex, "btex %1 etex ") -- space
  count = count + cnt
  data, cnt = data:gsub(verbatimtex_etex, "verbatimtex %1 etex;") -- semicolon
  count = count + cnt
  if count == 0 then
    noneedtoreplace[name] = true
    fh = ioopen(newfile,"w");
    if fh then
      fh:close()
      lfstouch(newfile,currenttime,ofmodify)
    end
    return file
  end
  fh = ioopen(newfile,"w")
  if not fh then return file end
  fh:write(data); fh:close()
  lfstouch(newfile,currenttime,ofmodify)
  return newfile
end

```

As the finder function for **mplib**, use the kpse library and make it behave like as if METAPOST was used. And replace `.mp` files with cache files if needed. See also #74, #97.

```
local mpkpse
do
  local exe = 0
  while arg[exe-1] do
    exe = exe-1
  end
  mpkpse = kpse.new(arg[exe], "mpost")
end
local special_ftype = {
  pfb = "type1 fonts",
  enc = "enc files",
}
function luamplib.finder (name, mode, ftype)
  if mode == "w" then
    if name and name ~= "mpout.log" then
      kpse.record_output_file(name) -- recorder
    end
    return name
  else
    ftype = special_ftype[ftype] or ftype
    local file = mpkpse:find_file(name,ftype)
    if file then
      if lfstouch and ftype == "mp" and not noneedtoreplace[name] then
        file = replaceinputmpfile(name,file)
      end
    else
      file = mpkpse:find_file(name, name:match("%a+$"))
    end
    if file then
      kpse.record_input_file(file) -- recorder
    end
    return file
  end
end

```

Create and load **mplib** instances. We do not support ancient version of **mplib** any more. (Don't know which version of **mplib** started to support `make_text` and `run_script`; let the users find it.)

```
local preamble = [[
  boolean mplib ; mplib := true ;
  let dump = endinput ;
  let normalfontsize = fontsize;
  input %s ;
]]
```

plain or *metafun*, though we cannot support *metafun* format fully.

```
local currentformat = "plain"
function luamplib.setformat (name)
  currentformat = name
end
```

v2.9 has introduced the concept of "code inherit"

```
luamplib.codeinherit = false
```

```
local mplibinstances = {}
luamplib.instances = mplibinstances
local has_instancename = false
local function reporterror (result, prevlog)
  if not result then
    err("no result object returned")
  else
    local t, e, l = result.term, result.error, result.log
```

log has more information than term, so log first (2021/08/02)

```
    local log = l or t or "no-term"
    log = log:gsub("%(Please type a command or say `end'%)","",):gsub("\n+","\n")
    if result.status > 0 then
      local first = log:match"(.-\n! .-)\n! "
      if first then
        termorlog("term", first)
        termorlog("log", log, "Warning")
      else
        warn(log)
      end
      if result.status > 1 then
        err(e or "see above messages")
      end
    elseif prevlog then
      log = prevlog..log
```

v2.6.1: now luamplib does not disregard `show` command, even when `luamplib.showlog` is false. Incidentally, it does not raise error nor prints an info, even if output has no figure.

```
      local show = log:match"\n>>? .+"
      if show then
        termorlog("term", show, "Info (more info in the log)")
        info(log)
      elseif luamplib.showlog and log:find"%g" then
        info(log)
      end
    end
    return log
  end
end
```

`lualibs-os.lua` installs a randomseed. When this file is not loaded, we should explicitly seed a unique integer to get random randomseed for each run.

```
if not math.initialseed then math.randomseed(currenttime) end
local function luamplibload (name)
  local mpx = mplib.new {
    ini_version = true,
    find_file   = luamplib.finder,
```

Make use of `make_text` and `run_script`, which will co-operate with LuaTEX's `tex.runtoks` or other Lua functions. And we provide `numbersystem` option since v2.4. See https://github.com/lualatex/luamplib/issues/21.

```
    make_text   = luamplib.maketext,
    run_script  = luamplib.runscript,
    math_mode   = luamplib.numbersystem,
    job_name    = tex.jobname,
    random_seed = math.random(4095),
```

```
    extensions  = 1,
  }
```

Append our own METAPOST preamble to the preamble above.

```
  local preamble = tableconcat{
    format(preamble, replacesuffix(name,"mp")),
    luamplib.preambles.mplibcode,
    luamplib.legacyverbatimtex and luamplib.preambles.legacyverbatimtex or "",
    luamplib.textextlabel and luamplib.preambles.textextlabel or "",
  }
  local result, log
  if not mpx then
    result = { status = 99, error = "out of memory"}
  else
    result = mpx:execute(preamble)
  end
  log = reporterror(result)
  return mpx, result, log
end
```

Here, excute each mplibcode data, ie \begin{mplibcode} ... \end{mplibcode}.

```
local function process (data, instancename)
  local currfmt
  if instancename and instancename ~= "" then
    currfmt = instancename
    has_instancename = true
  else
    currfmt = tableconcat{
      currentformat,
      luamplib.numbersystem or "scaled",
      tostring(luamplib.textextlabel),
      tostring(luamplib.legacyverbatimtex),
    }
    has_instancename = false
  end
  local mpx = mplibinstances[currfmt]
  local standalone = not (has_instancename or luamplib.codeinherit)
  if mpx and standalone then
    mpx:finish()
  end
  local log = ""
  if standalone or not mpx then
    mpx, _, log = luamplibload(currentformat)
    mplibinstances[currfmt] = mpx
  end
  local converted, result = false, {}
  if mpx and data then
    result = mpx:execute(data)
    local log = reporterror(result, log)
    if log then
      if result.fig then
        converted = luamplib.convert(result)
      end
    end
  else
```

```
    err"Mem file unloadable. Maybe generated with a different version of mplib?"
  end
  return converted, result
end

```

dvipdfmx is supported, though nobody seems to use it.

```
local pdfmode = tex.outputmode > 0

```

make_text and some run_script uses LuaTEX's tex.runtoks.

```
local catlatex = luatexbase.registernumber("catcodetable@latex")
local catat11  = luatexbase.registernumber("catcodetable@atletter")
```

tex.scantoks sometimes fail to read catcode properly, especially \#, \&, or \%. After some experiment, we dropped using it. Instead, a function containing tex.sprint seems to work nicely.

```
local function run_tex_code (str, cat)
  texruntoks(function() texsprint(cat or catlatex, str) end)
end
```

Prepare textext box number containers, locals and globals. localid can be any number. They are local anyway. The number will be reset at the start of a new code chunk. Global boxes will use \newbox command in tex.runtoks process. This is the same when codeinherit is true. Boxes in instances with name will also be global, so that their tex boxes can be shared among instances of the same name.

```
local texboxes = { globalid = 0, localid = 4096 }
```

For conversion of sp to bp.

```
local factor = 65536*(7227/7200)
local textext_fmt = 'image(addto currentpicture doublepath unitsquare \z
  xscaled %f yscaled %f shifted (0,-%f) \z
  withprescript "mplibtexboxid=%i:%f:%f")'
local function process_tex_text (str, maketext)
  if str then
    if not maketext then str = str:gsub("\r.-$","") end
    local global = (has_instancename or luamplib.globaltextext or luamplib.codeinherit)
                   and "\\global" or ""
    local tex_box_id
    if global == "" then
      tex_box_id = texboxes.localid + 1
      texboxes.localid = tex_box_id
    else
      local boxid = texboxes.globalid + 1
      texboxes.globalid = boxid
      run_tex_code(format([[\expandafter\newbox\csname luamplib.box.%s\endcsname]], boxid))
      tex_box_id = tex.getcount'allocationnumber'
    end
    run_tex_code(format("\\luamplibtagtextbegin{%i}%s\\setbox%i\\hbox{%s}\\luamplibtagtextend", tex_box_id, global,
    local box = texgetbox(tex_box_id)
    local wd  = box.width  / factor
    local ht  = box.height / factor
    local dp  = box.depth  / factor
    return textext_fmt:format(wd, ht+dp, dp, tex_box_id, wd, ht+dp)
  end
  return ""
end
```

Make color or xcolor's color expressions usable, with \mpcolor or mplibcolor. These commands should be used with graphical objects. Attempt to support l3color as well.

```
local mplibcolorfmt = {
  xcolor = tableconcat{
    [[\begingroup\let\XC@mcolor\relax]],
    [[\def\set@color{\global\mplibtmptoks\expandafter{\current@color}}]],
    [[\color%s\endgroup]],
  },
  l3color = tableconcat{
    [[\begingroup\def\__color_select:N#1{\expandafter\__color_select:nn#1}]],
    [[\def\__color_backend_select:nn#1#2{\global\mplibtmptoks{#1 #2}}]],
    [[\def\__kernel_backend_literal:e#1{\global\mplibtmptoks\expandafter{\expanded{#1}}}]],
    [[\color_select:n%s\endgroup]],
  },
}
local colfmt = is_defined'color_select:n' and "l3color" or "xcolor"
if colfmt == "l3color" then
  run_tex_code{
    "\\newcatcodetable\\luamplibcctabexplat",
    "\\begingroup",
    "\\catcode`@=11 ",
    "\\catcode`_=11 ",
    "\\catcode`:=11 ",
    "\\savecatcodetable\\luamplibcctabexplat",
    "\\endgroup",
  }
end
local ccexplat = luatexbase.registernumber"luamplibcctabexplat"
local function process_color (str)
  if str then
    if not str:find("%b{}") then
      str = format("{%s}",str)
    end
    local myfmt = mplibcolorfmt[colfmt]
    if colfmt == "l3color" and is_defined"color" then
      if str:find("%b[]") then
        myfmt = mplibcolorfmt.xcolor
      else
        for _,v in ipairs(str:match"{(.+)}":explode"!") do
          if not v:find("^%s*%d+%s*$") then
            local pp = get_macro(format("l__color_named_%s_prop",v))
            if not pp or pp == "" then
              myfmt = mplibcolorfmt.xcolor
              break
            end
          end
        end
      end
    end
    run_tex_code(myfmt:format(str), ccexplat or catat11)
    local t = texgettoks"mplibtmptoks"
    if not pdfmode and not t:find"^pdf" then
      t = t:gsub("%a+ (.+)","pdf:bc [%1]")
```

```
    end
    return format('1 withprescript "mpliboverridecolor=%s"', t)
  end
  return ""
end

```

for \mpdim or mplibdimen

```
local function process_dimen (str)
  if str then
    str = str:gsub("{(.+)}","%1")
    run_tex_code(format([[\mplibtmptoks\expandafter{\the\dimexpr %s\relax}]], str))
    return format("begingroup %s endgroup", texgettoks"mplibtmptoks")
  end
  return ""
end

```

Newly introduced method of processing verbatimtex ... etex. This function is used when \mpliblegacybehavior{false} is declared.

```
local function process_verbatimtex_text (str)
  if str then
    run_tex_code(str)
  end
  return ""
end

```

For legacy verbatimtex process. verbatimtex ... etex before beginfig() is not ignored, but the TEX code is inserted just before the mplib box. And TEX code inside beginfig() ... endfig is inserted after the mplib box.

```
local tex_code_pre_mplib = {}
luamplib.figid = 1
luamplib.in_the_fig = false
local function process_verbatimtex_prefig (str)
  if str then
    tex_code_pre_mplib[luamplib.figid] = str
  end
  return ""
end
local function process_verbatimtex_infig (str)
  if str then
    return format('special "postmplibverbtex=%s";', str)
  end
  return ""
end

local runscript_funcs = {
  luamplibtext    = process_tex_text,
  luamplibcolor   = process_color,
  luamplibdimen   = process_dimen,
  luamplibprefig  = process_verbatimtex_prefig,
  luamplibinfig   = process_verbatimtex_infig,
  luamplibverbtex = process_verbatimtex_text,
}

```

For *metafun* format. see issue #79.

```
mp = mp or {}
local mp = mp
mp.mf_path_reset = mp.mf_path_reset or function() end
mp.mf_finish_saving_data = mp.mf_finish_saving_data or function() end
mp.report = mp.report or info
```

metafun 2021-03-09 changes crashes luamplib.

```
catcodes = catcodes or {}
local catcodes = catcodes
catcodes.numbers = catcodes.numbers or {}
catcodes.numbers.ctxcatcodes = catcodes.numbers.ctxcatcodes or catlatex
catcodes.numbers.texcatcodes = catcodes.numbers.texcatcodes or catlatex
catcodes.numbers.luacatcodes = catcodes.numbers.luacatcodes or catlatex
catcodes.numbers.notcatcodes = catcodes.numbers.notcatcodes or catlatex
catcodes.numbers.vrbcatcodes = catcodes.numbers.vrbcatcodes or catlatex
catcodes.numbers.prtcatcodes = catcodes.numbers.prtcatcodes or catlatex
catcodes.numbers.txtcatcodes = catcodes.numbers.txtcatcodes or catlatex

```

A function from ConTEXt general.

```
local function mpprint(buffer,...)
  for i=1,select("#",...) do
    local value = select(i,...)
    if value ~= nil then
      local t = type(value)
      if t == "number" then
        buffer[#buffer+1] = format("%.16f",value)
      elseif t == "string" then
        buffer[#buffer+1] = value
      elseif t == "table" then
        buffer[#buffer+1] = "(" .. tableconcat(value,",") .. ")"
      else -- boolean or whatever
        buffer[#buffer+1] = tostring(value)
      end
    end
  end
end
function luamplib.runscript (code)
  local id, str = code:match("(.-){(.*)}")
  if id and str then
    local f = runscript_funcs[id]
    if f then
      local t = f(str)
      if t then return t end
    end
  end
  local f = loadstring(code)
  if type(f) == "function" then
    local buffer = {}
    function mp.print(...)
      mpprint(buffer,...)
    end
    local res = {f()}
    buffer = tableconcat(buffer)
```

```
    if buffer and buffer ~= "" then
      return buffer
    end
    buffer = {}
    mpprint(buffer, tableunpack(res))
    return tableconcat(buffer)
  end
  return ""
end

```

make_text must be one liner, so comment sign is not allowed.

```
local function protecttexcontents (str)
  return str:gsub("\\%%", "\0PerCent\0")
            :gsub("%%.-\n", "")
            :gsub("%%.-$",  "")
            :gsub("%zPerCent%z", "\\%%")
            :gsub("\r.-$",  "")
            :gsub("%s+", " ")
end
luamplib.legacyverbatimtex = true
function luamplib.maketext (str, what)
  if str and str ~= "" then
    str = protecttexcontents(str)
    if what == 1 then
      if not str:find("\\documentclass"..name_e) and
         not str:find("\\begin%s*{document}") and
         not str:find("\\documentstyle"..name_e) and
         not str:find("\\usepackage"..name_e) then
        if luamplib.legacyverbatimtex then
          if luamplib.in_the_fig then
            return process_verbatimtex_infig(str)
          else
            return process_verbatimtex_prefig(str)
          end
        else
          return process_verbatimtex_text(str)
        end
      end
    else
      return process_tex_text(str, true) -- bool is for 'char13'
    end
  end
  return ""
end

```

luamplib's METAPOST color operators

```
local function colorsplit (res)
  local t, tt = { }, res:gsub("[%[%]]","",2):explode()
  local be = tt[1]:find"^%d" and 1 or 2
  for i=be, #tt do
    if not tonumber(tt[i]) then break end
    t[#t+1] = tt[i]
  end
```

```
  return t
end

luamplib.gettexcolor = function (str, rgb)
  local res = process_color(str):match'"mpliboverridecolor=(.+)"'
  if res:find" cs " or res:find"@pdf.obj" then
    if not rgb then
      warn("%s is a spot color. Forced to CMYK", str)
    end
    run_tex_code({
      "\\color_export:nnN{",
      str,
      "}{",
      rgb and "space-sep-rgb" or "space-sep-cmyk",
      "}\\mplib_@tempa",
    },ccexplat)
    return get_macro"mplib_@tempa":explode()
  end
  local t = colorsplit(res)
  if #t == 3 or not rgb then return t end
  if #t == 4 then
    return { 1 - math.min(1,t[1]+t[4]), 1 - math.min(1,t[2]+t[4]), 1 - math.min(1,t[3]+t[4]) }
  end
  return { t[1], t[1], t[1] }
end

luamplib.shadecolor = function (str)
  local res = process_color(str):match'"mpliboverridecolor=(.+)"'
  if res:find" cs " or res:find"@pdf.obj" then -- spot color shade: l3 only
```

An example of spot color shading:

```
\DocumentMetadata{ }
\documentclass{article}
\usepackage{luamplib}
\ExplSyntaxOn
\color_model_new:nnn { pantone3005 }
  { Separation }
  {
    name = PANTONE~3005~U ,
    alternative-model = cmyk ,
    alternative-values = {1, 0.56, 0, 0}
  }
  \color_set:nnn{spotA}{pantone3005}{1}
  \color_set:nnn{spotB}{pantone3005}{0.6}
\color_model_new:nnn { pantone1215 }
  { Separation }
  {
    name = PANTONE~1215~U ,
    alternative-model = cmyk ,
    alternative-values = {0, 0.15, 0.51, 0}
  }
  \color_set:nnn{spotC}{pantone1215}{1}
\color_model_new:nnn { pantone2040 }
  { Separation }
  {
```

```
    name = PANTONE~2040~U ,
    alternative-model = cmyk ,
    alternative-values = {0, 0.28, 0.21, 0.04}
  }
  \color_set:nnn{spotD}{pantone2040}{1}
\ExplSyntaxOff
\begin{document}
\begin{mplibcode}
beginfig(1)
  fill unitsquare xscaled \mpdim\textwidth yscaled 1cm
       withshadingmethod "linear"
       withshadingvector (0,1)
       withshadingstep (
           withshadingfraction .5
           withshadingcolors ("spotB","spotC")
       )
       withshadingstep (
           withshadingfraction 1
           withshadingcolors ("spotC","spotD")
       )
  ;
endfig;
\end{mplibcode}
\end{document}
```

another one: user-defined DeviceN colorspace

```
\DocumentMetadata{ }
\documentclass{article}
\usepackage{luamplib}
\ExplSyntaxOn
\color_model_new:nnn { pantone1215 }
  { Separation }
  {
    name = PANTONE~1215~U ,
    alternative-model = cmyk ,
    alternative-values = {0, 0.15, 0.51, 0}
  }
\color_model_new:nnn { pantone+black }
  { DeviceN }
  { names = {pantone1215,black} }
\color_set:nnn{purepantone}{pantone+black}{1,0}
\color_set:nnn{pureblack}  {pantone+black}{0,1}
\ExplSyntaxOff
\begin{document}
\mpfig
fill unitsquare xscaled \mpdim{\textwidth} yscaled 30
    withshadingmethod "linear"
    withshadingcolors ("purepantone","pureblack")
    ;
\endmpfig
\end{document}
```

```
617    run_tex_code({
618      [[\color_export:nnN{]], str, [[}{backend}\mplib_@tempa]],
```

```
    },ccexplat)
    local name, value = get_macro'mplib_@tempa':match'{(.-)}{(.-)}'
    local t, obj = res:explode()
    if pdfmode then
      obj = format("%s 0 R", ltx.pdf.object_id( t[1]:sub(2,-1) ))
    else
      obj = t[2]
    end
    return format('(1) withprescript"mplib_spotcolor=%s:%s:%s"', value,obj,name)
  end
  return colorsplit(res)
end

```

Remove trailing zeros for smaller PDF

```
local decimals = "%.%d+"
local function rmzeros(str) return str:gsub("%.?0+$","") end

```

luamplib's mplibgraphictext operator

```
local emboldenfonts = { }
local function getemboldenwidth (curr, fakebold)
  local width = emboldenfonts.width
  if not width then
    local f
    local function getglyph(n)
      while n do
        if n.head then
          getglyph(n.head)
        elseif n.font and n.font > 0 then
          f = n.font; break
        end
        n = node.getnext(n)
      end
    end
    getglyph(curr)
    width = font.getcopy(f or font.current()).size * fakebold / factor * 10
    emboldenfonts.width = width
  end
  return width
end
local function getrulewhatsit (line, wd, ht, dp)
  line, wd, ht, dp = line/1000, wd/factor, ht/factor, dp/factor
  local pl
  local fmt = "%f w %f %f %f %f re %s"
  if pdfmode then
    pl = node.new("whatsit","pdf_literal")
    pl.mode = 0
  else
    fmt = "pdf:content "..fmt
    pl = node.new("whatsit","special")
  end
  pl.data = fmt:format(line, 0, -dp, wd, ht+dp, "B") :gsub(decimals,rmzeros)
  local ss = node.new"glue"
  node.setglue(ss, 0, 65536, 65536, 2, 2)
```

```
  pl.next = ss
  return pl
end
local function getrulemetric (box, curr, bp)
  local running = -1073741824
  local wd,ht,dp = curr.width, curr.height, curr.depth
  wd = wd == running and box.width  or wd
  ht = ht == running and box.height or ht
  dp = dp == running and box.depth  or dp
  if bp then
    return wd/factor, ht/factor, dp/factor
  end
  return wd, ht, dp
end
local function embolden (box, curr, fakebold)
  local head = curr
  while curr do
    if curr.head then
      curr.head = embolden(curr, curr.head, fakebold)
    elseif curr.replace then
      curr.replace = embolden(box, curr.replace, fakebold)
    elseif curr.leader then
      if curr.leader.head then
        curr.leader.head = embolden(curr.leader, curr.leader.head, fakebold)
      elseif curr.leader.id == node.id"rule" then
        local glue = node.effective_glue(curr, box)
        local line = getemboldenwidth(curr, fakebold)
        local wd,ht,dp = getrulemetric(box, curr.leader)
        if box.id == node.id"hlist" then
          wd = glue
        else
          ht, dp = 0, glue
        end
        local pl = getrulewhatsit(line, wd, ht, dp)
        local pack = box.id == node.id"hlist" and node.hpack or node.vpack
        local list = pack(pl, glue, "exactly")
        head = node.insert_after(head, curr, list)
        head, curr = node.remove(head, curr)
      end
    elseif curr.id == node.id"rule" and curr.subtype == 0 then
      local line = getemboldenwidth(curr, fakebold)
      local wd,ht,dp = getrulemetric(box, curr)
      if box.id == node.id"vlist" then
        ht, dp = 0, ht+dp
      end
      local pl = getrulewhatsit(line, wd, ht, dp)
      local list
      if box.id == node.id"hlist" then
        list = node.hpack(pl, wd, "exactly")
      else
        list = node.vpack(pl, ht+dp, "exactly")
      end
      head = node.insert_after(head, curr, list)
      head, curr = node.remove(head, curr)
```

```
724     elseif curr.id == node.id"glyph" and curr.font > 0 then
725       local f = curr.font
726       local key = format("%s:%s",f,fakebold)
727       local i = emboldenfonts[key]
728       if not i then
729         local ft = font.getfont(f) or font.getcopy(f)
730         if pdfmode then
731           width = ft.size * fakebold / factor * 10
732           emboldenfonts.width = width
733           ft.mode, ft.width = 2, width
734           i = font.define(ft)
735         else
736           if ft.format ~= "opentype" and ft.format ~= "truetype" then
737             goto skip_type1
738           end
739           local name = ft.name:gsub('"','''):gsub(';$','')
740           name = format('%s;embolden=%s;',name,fakebold)
741           _, i = fonts.constructors.readanddefine(name,ft.size)
742         end
743         emboldenfonts[key] = i
744       end
745       curr.font = i
746     end
747     ::skip_type1::
748     curr = node.getnext(curr)
749   end
750   return head
751 end
752 local function graphictextcolor (col, filldraw)
753   if col:find"^[%d%.:]+$" then
754     col = col:explode":"
755     for i=1,#col do
756       col[i] = format("%.3f", col[i])
757     end
758     if pdfmode then
759       local op = #col == 4 and "k" or #col == 3 and "rg" or "g"
760       col[#col+1] = filldraw == "fill" and op or op:upper()
761       return tableconcat(col," ")
762     end
763     return format("[%s]", tableconcat(col," "))
764   end
765   col = process_color(col):match'"mpliboverridecolor=(.+)"'
766   if pdfmode then
767     local t, tt = col:explode(), { }
768     local b = filldraw == "fill" and 1 or #t/2+1
769     local e = b == 1 and #t/2 or #t
770     for i=b,e do
771       tt[#tt+1] = t[i]
772     end
773     return tableconcat(tt," ")
774   end
775   return col:gsub("^.- ","")
776 end
777 luamplib.graphictext = function (text, fakebold, fc, dc)
```

```
  local fmt = process_tex_text(text):sub(1,-2)
  local id = tonumber(fmt:match"mplibtexboxid=(%d+):")
  emboldenfonts.width = nil
  local box = texgetbox(id)
  box.head = embolden(box, box.head, fakebold)
  local fill = graphictextcolor(fc,"fill")
  local draw = graphictextcolor(dc,"draw")
  local bc = pdfmode and "" or "pdf:bc "
  return format('%s withprescript "mpliboverridecolor=%s%s %s")', fmt, bc, fill, draw)
end

```

luamplib's mplibglyph operator

```
local function mperr (str)
  return format("hide(errmessage %q)", str)
end
local function getangle (a,b,c)
  local r = math.deg(math.atan(c.y-b.y, c.x-b.x) - math.atan(b.y-a.y, b.x-a.x))
  if r > 180 then
    r = r - 360
  elseif r < -180 then
    r = r + 360
  end
  return r
end
local function turning (t)
  local r, n = 0, #t
  for i=1,2 do
    tableinsert(t, t[i])
  end
  for i=1,n do
    r = r + getangle(t[i], t[i+1], t[i+2])
  end
  return r/360
end
local function glyphimage(t, fmt)
  local q,p,r = {{},{}}
  for i,v in ipairs(t) do
    local cmd = v[#v]
    if cmd == "m" then
      p = {format('(%s,%s)',v[1],v[2])}
      r = {{x=v[1],y=v[2]}}
    else
      local nt = t[i+1]
      local last = not nt or nt[#nt] == "m"
      if cmd == "l" then
        local pt = t[i-1]
        local seco = pt[#pt] == "m"
        if (last or seco) and r[1].x == v[1] and r[1].y == v[2] then
        else
          tableinsert(p, format('--(%s,%s)',v[1],v[2]))
          tableinsert(r, {x=v[1],y=v[2]})
        end
        if last then
          tableinsert(p, '--cycle')
```

```
      end
    elseif cmd == "c" then
      tableinsert(p, format('..controls(%s,%s)and(%s,%s)',v[1],v[2],v[3],v[4]))
      if last and r[1].x == v[5] and r[1].y == v[6] then
        tableinsert(p, '..cycle')
      else
        tableinsert(p, format('..(%s,%s)',v[5],v[6]))
        if last then
          tableinsert(p, '--cycle')
        end
        tableinsert(r, {x=v[5],y=v[6]})
      end
    else
      return mperr"unknown operator"
    end
    if last then
      tableinsert(q[ turning(r) > 0 and 1 or 2 ], tableconcat(p))
    end
  end
end
r = { }
if fmt == "opentype" then
  for _,v in ipairs(q[1]) do
    tableinsert(r, format('addto currentpicture contour %s;',v))
  end
  for _,v in ipairs(q[2]) do
    tableinsert(r, format('addto currentpicture contour %s withcolor background;',v))
  end
else
  for _,v in ipairs(q[2]) do
    tableinsert(r, format('addto currentpicture contour %s;',v))
  end
  for _,v in ipairs(q[1]) do
    tableinsert(r, format('addto currentpicture contour %s withcolor background;',v))
  end
end
return format('image(%s)', tableconcat(r))
end
if not table.tofile then require"lualibs-lpeg"; require"lualibs-table"; end
function luamplib.glyph (f, c)
  local filename, subfont, instance, kind, shapedata
  local fid = tonumber(f) or font.id(f)
  if fid > 0 then
    local fontdata = font.getfont(fid) or font.getcopy(fid)
    filename, subfont, kind = fontdata.filename, fontdata.subfont, fontdata.format
    instance = fontdata.specification and fontdata.specification.instance
    filename = filename and filename:gsub("^harfloaded:","")
  else
    local name
    f = f:match"^%s*(.+)%s*$"
    name, subfont, instance = f:match"(.+)%((%d+)%)%[(.-)%]$"
    if not name then
      name, instance = f:match"(.+)%[(.-)%]$" -- SourceHanSansK-VF.otf[Heavy]
    end
```

```
  if not name then
    name, subfont = f:match"(.+)%((%d+)%)$" -- Times.ttc(2)
  end
  name = name or f
  subfont = (subfont or 0)+1
  instance = instance and instance:lower()
  for _,ftype in ipairs{"opentype", "truetype"} do
    filename = kpse.find_file(name, ftype.." fonts")
    if filename then
      kind = ftype; break
    end
  end
end
if kind ~= "opentype" and kind ~= "truetype" then
  f = fid and fid > 0 and tex.fontname(fid) or f
  if kpse.find_file(f, "tfm") then
    return format("glyph %s of %q", tonumber(c) or format("%q",c), f)
  else
    return mperr"font not found"
  end
end
local time = lfsattributes(filename,"modification")
local k = format("shapes_%s(%s)[%s]", filename, subfont or "", instance or "")
local h = format(string.rep('%02x', 256/8), string.byte(sha2.digest256(k), 1, -1))
local newname = format("%s/%s.lua", cachedir or outputdir, h)
local newtime = lfsattributes(newname,"modification") or 0
if time == newtime then
  shapedata = require(newname)
end
if not shapedata then
  shapedata = fonts and fonts.handlers.otf.readers.loadshapes(filename,subfont,instance)
  if not shapedata then return mperr"loadshapes() failed. luaotfload not loaded?" end
  table.tofile(newname, shapedata, "return")
  lfstouch(newname, time, time)
end
local gid = tonumber(c)
if not gid then
  local uni = utf8.codepoint(c)
  for i,v in pairs(shapedata.glyphs) do
    if c == v.name or uni == v.unicode then
      gid = i; break
    end
  end
end
if not gid then return mperr"cannot get GID (glyph id)" end
local fac = 1000 / (shapedata.units or 1000)
local t = shapedata.glyphs[gid].segments
if not t then return "image()" end
for i,v in ipairs(t) do
  if type(v) == "table" then
    for ii,vv in ipairs(v) do
      if type(vv) == "number" then
        t[i][ii] = format("%.0f", vv * fac)
      end
```

```
      end
    end
  end
  kind = shapedata.format or kind
  return glyphimage(t, kind)
end

```

mpliboutlinetext : based on mkiv's font-mps.lua

```
local rulefmt = "mpliboutlinepic[%i]:=image(addto currentpicture contour \z
  unitsquare shifted - center unitsquare;) xscaled %f yscaled %f shifted (%f,%f);"
local outline_horz, outline_vert
function outline_vert (res, box, curr, xshift, yshift)
  local b2u = box.dir == "LTL"
  local dy = (b2u and -box.depth or box.height)/factor
  local ody = dy
  while curr do
    if curr.id == node.id"rule" then
      local wd, ht, dp = getrulemetric(box, curr, true)
      local hd = ht + dp
      if hd ~= 0 then
        dy = dy + (b2u and dp or -ht)
        if wd ~= 0 and curr.subtype == 0 then
          res[#res+1] = rulefmt:format(#res+1, wd, hd, xshift+wd/2, yshift+dy+(ht-dp)/2)
        end
        dy = dy + (b2u and ht or -dp)
      end
    elseif curr.id == node.id"glue" then
      local vwidth = node.effective_glue(curr,box)/factor
      if curr.leader then
        local curr, kind = curr.leader, curr.subtype
        if curr.id == node.id"rule" then
          local wd = getrulemetric(box, curr, true)
          if wd ~= 0 then
            local hd = vwidth
            local dy = dy + (b2u and 0 or -hd)
            if hd ~= 0 and curr.subtype == 0 then
              res[#res+1] = rulefmt:format(#res+1, wd, hd, xshift+wd/2, yshift+dy+hd/2)
            end
          end
        elseif curr.head then
          local hd = (curr.height + curr.depth)/factor
          if hd <= vwidth then
            local dy, n, iy = dy, 0, 0
            if kind == 100 or kind == 103 then -- todo: gleaders
              local ady = abs(ody - dy)
              local ndy = math.ceil(ady / hd) * hd
              local diff = ndy - ady
              n = math.floor((vwidth-diff) / hd)
              dy = dy + (b2u and diff or -diff)
            else
              n = math.floor(vwidth / hd)
              if kind == 101 then
                local side = vwidth % hd / 2
                dy = dy + (b2u and side or -side)
```

```
992               elseif kind == 102 then
993                 iy = vwidth % hd / (n+1)
994                 dy = dy + (b2u and iy or -iy)
995               end
996             end
997             dy = dy + (b2u and curr.depth or -curr.height)/factor
998             hd = b2u and hd or -hd
999             iy = b2u and iy or -iy
1000            local func = curr.id == node.id"hlist" and outline_horz or outline_vert
1001            for i=1,n do
1002              res = func(res, curr, curr.head, xshift+curr.shift/factor, yshift+dy)
1003              dy = dy + hd + iy
1004            end
1005          end
1006        end
1007      end
1008      dy = dy + (b2u and vwidth or -vwidth)
1009    elseif curr.id == node.id"kern" then
1010      dy = dy + curr.kern/factor * (b2u and 1 or -1)
1011    elseif curr.id == node.id"vlist" then
1012      dy = dy + (b2u and curr.depth or -curr.height)/factor
1013      res = outline_vert(res, curr, curr.head, xshift+curr.shift/factor, yshift+dy)
1014      dy = dy + (b2u and curr.height or -curr.depth)/factor
1015    elseif curr.id == node.id"hlist" then
1016      dy = dy + (b2u and curr.depth or -curr.height)/factor
1017      res = outline_horz(res, curr, curr.head, xshift+curr.shift/factor, yshift+dy)
1018      dy = dy + (b2u and curr.height or -curr.depth)/factor
1019    end
1020    curr = node.getnext(curr)
1021  end
1022  return res
1023 end
1024 function outline_horz (res, box, curr, xshift, yshift, discwd)
1025   local r2l = box.dir == "TRT"
1026   local dx = r2l and (discwd or box.width/factor) or 0
1027   local dirs = { { dir = r2l, dx = dx } }
1028   while curr do
1029     if curr.id == node.id"dir" then
1030       local sign, dir = curr.dir:match"(.)(...)"
1031       local level, newdir = curr.level, r2l
1032       if sign == "+" then
1033         newdir = dir == "TRT"
1034         if r2l ~= newdir then
1035           local n = node.getnext(curr)
1036           while n do
1037             if n.id == node.id"dir" and n.level+1 == level then break end
1038             n = node.getnext(n)
1039           end
1040           n = n or node.tail(curr)
1041           dx = dx + node.rangedimensions(box, curr, n)/factor * (newdir and 1 or -1)
1042         end
1043         dirs[level] = { dir = r2l, dx = dx }
1044       else
1045         local level = level + 1
```

```
      newdir = dirs[level].dir
      if r2l ~= newdir then
        dx = dirs[level].dx
      end
    end
    r2l = newdir
  elseif curr.char and curr.font and curr.font > 0 then
    local ft = font.getfont(curr.font) or font.getcopy(curr.font)
    local gid = ft.characters[curr.char].index or curr.char
    local scale = ft.size / factor / 1000
    local slant   = (ft.slant or 0)/1000
    local extend  = (ft.extend or 1000)/1000
    local squeeze = (ft.squeeze or 1000)/1000
    local expand  = 1 + (curr.expansion_factor or 0)/1000000
    local xscale = scale * extend * expand
    local yscale = scale * squeeze
    dx = dx - (r2l and curr.width/factor*expand or 0)
    local xpos = dx + xshift + (curr.xoffset or 0)/factor
    local ypos = yshift + (curr.yoffset or 0)/factor
    local vertical = ft.shared and ft.shared.features.vertical and "rotated 90" or ""
    if vertical ~= "" then -- luatexko
      for _,v in ipairs(ft.characters[curr.char].commands or { }) do
        if v[1] == "down" then
          ypos = ypos - v[2] / factor
        elseif v[1] == "right" then
          xpos = xpos + v[2] / factor
        else
          break
        end
      end
    end
    local image
    if ft.format == "opentype" or ft.format == "truetype" then
      image = luamplib.glyph(curr.font, gid)
    else
      local name, scale = ft.name, 1
      local vf = font.read_vf(name, ft.size)
      if vf and vf.characters[gid] then
        local cmds = vf.characters[gid].commands or {}
        for _,v in ipairs(cmds) do
          if v[1] == "char" then
            gid = v[2]
          elseif v[1] == "font" and vf.fonts[v[2]] then
            name  = vf.fonts[v[2]].name
            scale = vf.fonts[v[2]].size / ft.size
          end
        end
      end
      image = format("glyph %s of %q scaled %f", gid, name, scale)
    end
    res[#res+1] = format("mpliboutlinepic[%i]:=%s xscaled %f yscaled %f slanted %f %s shifted (%f,%f);",
                         #res+1, image, xscale, yscale, slant, vertical, xpos, ypos)
    dx = dx + (r2l and 0 or curr.width/factor*expand)
  elseif curr.replace then
```

```
    local width = node.dimensions(curr.replace)/factor
    dx = dx - (r2l and width or 0)
    res = outline_horz(res, box, curr.replace, xshift+dx, yshift, width)
    dx = dx + (r2l and 0 or width)
  elseif curr.id == node.id"rule" then
    local wd, ht, dp = getrulemetric(box, curr, true)
    if wd ~= 0 then
      local hd = ht + dp
      dx = dx - (r2l and wd or 0)
      if hd ~= 0 and curr.subtype == 0 then
        res[#res+1] = rulefmt:format(#res+1, wd, hd, xshift+dx+wd/2, yshift+(ht-dp)/2)
      end
      dx = dx + (r2l and 0 or wd)
    end
  elseif curr.id == node.id"glue" then
    local width = node.effective_glue(curr, box)/factor
    dx = dx - (r2l and width or 0)
    if curr.leader then
      local curr, kind = curr.leader, curr.subtype
      if curr.id == node.id"rule" then
        local wd, ht, dp = getrulemetric(box, curr, true)
        local hd = ht + dp
        if hd ~= 0 then
          wd = width
          if wd ~= 0 and curr.subtype == 0 then
            res[#res+1] = rulefmt:format(#res+1, wd, hd, xshift+dx+wd/2, yshift+(ht-dp)/2)
          end
        end
      elseif curr.head then
        local wd = curr.width/factor
        if wd <= width then
          local dx = r2l and dx+width or dx
          local n, ix = 0, 0
          if kind == 100 or kind == 103 then -- todo: gleaders
            local adx = abs(dx-dirs[1].dx)
            local ndx = math.ceil(adx / wd) * wd
            local diff = ndx - adx
            n = math.floor((width-diff) / wd)
            dx = dx + (r2l and -diff-wd or diff)
          else
            n = math.floor(width / wd)
            if kind == 101 then
              local side = width % wd /2
              dx = dx + (r2l and -side-wd or side)
            elseif kind == 102 then
              ix = width % wd / (n+1)
              dx = dx + (r2l and -ix-wd or ix)
            end
          end
          wd = r2l and -wd or wd
          ix = r2l and -ix or ix
          local func = curr.id == node.id"hlist" and outline_horz or outline_vert
          for i=1,n do
            res = func(res, curr, curr.head, xshift+dx, yshift-curr.shift/factor)
```

```
              dx = dx + wd + ix
            end
          end
        end
      end
      dx = dx + (r2l and 0 or width)
    elseif curr.id == node.id"kern" then
      dx = dx + curr.kern/factor * (r2l and -1 or 1)
    elseif curr.id == node.id"math" then
      dx = dx + curr.surround/factor * (r2l and -1 or 1)
    elseif curr.id == node.id"vlist" then
      dx = dx - (r2l and curr.width/factor or 0)
      res = outline_vert(res, curr, curr.head, xshift+dx, yshift-curr.shift/factor)
      dx = dx + (r2l and 0 or curr.width/factor)
    elseif curr.id == node.id"hlist" then
      dx = dx - (r2l and curr.width/factor or 0)
      res = outline_horz(res, curr, curr.head, xshift+dx, yshift-curr.shift/factor)
      dx = dx + (r2l and 0 or curr.width/factor)
    end
    curr = node.getnext(curr)
  end
  return res
end
function luamplib.outlinetext (text)
  local fmt = process_tex_text(text)
  local id  = tonumber(fmt:match"mplibtexboxid=(%d+):")
  local box = texgetbox(id)
  local res = outline_horz({ }, box, box.head, 0, 0)
  if #res == 0 then res = { "mpliboutlinepic[1]:=image();" } end
  return tableconcat(res) .. format("mpliboutlinenum:=%i;", #res)
end

```

lua function for `mplibsubstring ... of ...`

```
function luamplib.utf8substring (s,b,e)
  local t, tt, step = { }, { }
  for _, c in utf8.codes(s) do
    table.insert(t, utf8.char(c))
  end
  if b <= e then
    b, step = b+1, 1
  else
    e, step = e+1, -1
  end
  for i = b, e, step do
    table.insert(tt, t[i])
  end
  s = table.concat(tt):gsub('"','"&ditto&"')
  return string.format('"%s"', s)
end

```

Our METAPOST preambles

```
luamplib.preambles = {
  mplibcode = [[
```

```
texscriptmode := 2;
def rawtextext (expr t) = runscript("luamplibtext{"&t&"}") enddef;
def mplibcolor (expr t) = runscript("luamplibcolor{"&t&"}") enddef;
def mplibdimen (expr t) = runscript("luamplibdimen{"&t&"}") enddef;
def VerbatimTeX (expr t) = runscript("luamplibverbtex{"&t&"}") enddef;
if known context_mlib:
  defaultfont := "cmtt10";
  let infont = normalinfont;
  let fontsize = normalfontsize;
  vardef thelabel@#(expr p,z) =
    if string p :
      thelabel@#(p infont defaultfont scaled defaultscale,z)
    else :
      p shifted (z + labeloffset*mfun_laboff@# -
        (mfun_labxf@#*lrcorner p + mfun_labyf@#*ulcorner p +
        (1-mfun_labxf@#-mfun_labyf@#)*llcorner p))
    fi
  enddef;
else:
  vardef textext@# (text t) = rawtextext (t) enddef;
  def message expr t =
    if string t: runscript("mp.report[=["&t&"]=]") else: errmessage "Not a string" fi
  enddef;
  def withtransparency (expr a, t) =
    withprescript "tr_alternative=" & if numeric a: decimal fi a
    withprescript "tr_transparency=" & decimal t
  enddef;
  vardef ddecimal primary p =
    decimal xpart p & " " & decimal ypart p
  enddef;
  vardef boundingbox primary p =
    if (path p) or (picture p) :
      llcorner p -- lrcorner p -- urcorner p -- ulcorner p
    else :
      origin
    fi -- cycle
  enddef;
fi
def resolvedcolor(expr s) =
  runscript("return luamplib.shadecolor('"& s &"')")
enddef;
def colordecimals primary c =
  if cmykcolor c:
    decimal cyanpart c & ":" & decimal magentapart c & ":" &
    decimal yellowpart c & ":" & decimal blackpart c
  elseif rgbcolor c:
    decimal redpart c & ":" & decimal greenpart c & ":" & decimal bluepart c
  elseif string c:
    if known graphictextpic: c else: colordecimals resolvedcolor(c) fi
  else:
    decimal c
  fi
enddef;
def externalfigure primary filename =
```

```
  draw rawtextext("\includegraphics{"& filename &"}")
enddef;
def TEX = textext enddef;
def mplibtexcolor primary c =
  runscript("return luamplib.gettexcolor('"& c &"')")
enddef;
def mplibrgbtexcolor primary c =
  runscript("return luamplib.gettexcolor('"& c &"','rgb')")
enddef;
def mplibgraphictext primary t =
  begingroup;
  mplibgraphictext_ (t)
enddef;
def mplibgraphictext_ (expr t) text rest =
  save fakebold, scale, fillcolor, drawcolor, withfillcolor, withdrawcolor,
    fb, fc, dc, graphictextpic;
  picture graphictextpic; graphictextpic := nullpicture;
  numeric fb; string fc, dc; fb:=2; fc:="white"; dc:="black";
  let scale = scaled;
  def fakebold  primary c = hide(fb:=c;) enddef;
  def fillcolor primary c = hide(fc:=colordecimals c;) enddef;
  def drawcolor primary c = hide(dc:=colordecimals c;) enddef;
  let withfillcolor = fillcolor; let withdrawcolor = drawcolor;
  addto graphictextpic doublepath origin rest; graphictextpic:=nullpicture;
  def fakebold  primary c = enddef;
  let fillcolor = fakebold; let drawcolor = fakebold;
  let withfillcolor = fillcolor; let withdrawcolor = drawcolor;
  image(draw runscript("return luamplib.graphictext([===["&t&"]===],"
    & decimal fb &",'"& fc &"','"& dc &"')") rest;)
  endgroup;
enddef;
def mplibglyph expr c of f =
  runscript (
    "return luamplib.glyph('"
    & if numeric f: decimal fi f
    & "','"
    & if numeric c: decimal fi c
    & "')"
  )
enddef;
def mplibdrawglyph expr g =
  draw image(
    save i; numeric i; i:=0;
    for item within g:
      i := i+1;
      fill pathpart item
      if i < length g: withpostscript "collect" fi;
    endfor
  )
enddef;
def mplib_do_outline_text_set_b (text f) (text d) text r =
  def mplib_do_outline_options_f = f enddef;
  def mplib_do_outline_options_d = d enddef;
  def mplib_do_outline_options_r = r enddef;
```

```
enddef;
def mplib_do_outline_text_set_f (text f) text r =
  def mplib_do_outline_options_f = f enddef;
  def mplib_do_outline_options_r = r enddef;
enddef;
def mplib_do_outline_text_set_u (text f) text r =
  def mplib_do_outline_options_f = f enddef;
enddef;
def mplib_do_outline_text_set_d (text d) text r =
  def mplib_do_outline_options_d = d enddef;
  def mplib_do_outline_options_r = r enddef;
enddef;
def mplib_do_outline_text_set_r (text d) (text f) text r =
  def mplib_do_outline_options_d = d enddef;
  def mplib_do_outline_options_f = f enddef;
  def mplib_do_outline_options_r = r enddef;
enddef;
def mplib_do_outline_text_set_n text r =
  def mplib_do_outline_options_r = r enddef;
enddef;
def mplib_do_outline_text_set_p = enddef;
def mplib_fill_outline_text =
  for n=1 upto mpliboutlinenum:
    i:=0;
    for item within mpliboutlinepic[n]:
      i:=i+1;
      fill pathpart item mplib_do_outline_options_f withpen pencircle scaled 0
      if (n<mpliboutlinenum) or (i<length mpliboutlinepic[n]): withpostscript "collect"; fi
    endfor
  endfor
enddef;
def mplib_draw_outline_text =
  for n=1 upto mpliboutlinenum:
    for item within mpliboutlinepic[n]:
      draw pathpart item mplib_do_outline_options_d;
    endfor
  endfor
enddef;
def mplib_filldraw_outline_text =
  for n=1 upto mpliboutlinenum:
    i:=0;
    for item within mpliboutlinepic[n]:
      i:=i+1;
      if (n<mpliboutlinenum) or (i<length mpliboutlinepic[n]):
        fill pathpart item mplib_do_outline_options_f withpostscript "collect";
      else:
        draw pathpart item mplib_do_outline_options_f withpostscript "both";
      fi
    endfor
  endfor
enddef;
vardef mpliboutlinetext@# (expr t) text rest =
  save kind; string kind; kind := str @#;
  save i; numeric i;
```

```
  picture mpliboutlinepic[]; numeric mpliboutlinenum;
  def mplib_do_outline_options_d = enddef;
  def mplib_do_outline_options_f = enddef;
  def mplib_do_outline_options_r = enddef;
  runscript("return luamplib.outlinetext[===["&t&"]===]");
  image ( addto currentpicture also image (
    if kind = "f":
      mplib_do_outline_text_set_f rest;
      mplib_fill_outline_text;
    elseif kind = "d":
      mplib_do_outline_text_set_d rest;
      mplib_draw_outline_text;
    elseif kind = "b":
      mplib_do_outline_text_set_b rest;
      mplib_fill_outline_text;
      mplib_draw_outline_text;
    elseif kind = "u":
      mplib_do_outline_text_set_u rest;
      mplib_filldraw_outline_text;
    elseif kind = "r":
      mplib_do_outline_text_set_r rest;
      mplib_draw_outline_text;
      mplib_fill_outline_text;
    elseif kind = "p":
      mplib_do_outline_text_set_p;
      mplib_draw_outline_text;
    else:
      mplib_do_outline_text_set_n rest;
      mplib_fill_outline_text;
    fi;
  ) mplib_do_outline_options_r; )
enddef ;
primarydef t withpattern p =
  image(
    if cycle t:
      fill
    else:
      draw
    fi
    t withprescript "mplibpattern=" & if numeric p: decimal fi p; )
enddef;
vardef mplibtransformmatrix (text e) =
  save t; transform t;
  t = identity e;
  runscript("luamplib.transformmatrix = {"
  & decimal xxpart t & ","
  & decimal yxpart t & ","
  & decimal xypart t & ","
  & decimal yypart t & ","
  & decimal xpart  t & ","
  & decimal ypart  t & ","
  & "}");
enddef;
primarydef p withfademethod s =
```

```
  if picture p:
    image(
      draw p;
      draw center p withprescript "mplibfadestate=stop";
    )
  else:
    p withprescript "mplibfadestate=stop"
  fi
    withprescript "mplibfadetype=" & s
    withprescript "mplibfadebbox=" &
      decimal (xpart llcorner p -1/4) & ":" &
      decimal (ypart llcorner p -1/4) & ":" &
      decimal (xpart urcorner p +1/4) & ":" &
      decimal (ypart urcorner p +1/4)
enddef;
def withfadeopacity (expr a,b) =
  withprescript "mplibfadeopacity=" &
    decimal a & ":" &
    decimal b
enddef;
def withfadevector (expr a,b) =
  withprescript "mplibfadevector=" &
    decimal xpart a & ":" &
    decimal ypart a & ":" &
    decimal xpart b & ":" &
    decimal ypart b
enddef;
let withfadecenter = withfadevector;
def withfaderadius (expr a,b) =
  withprescript "mplibfaderadius=" &
    decimal a & ":" &
    decimal b
enddef;
def withfadebbox (expr a,b) =
  withprescript "mplibfadebbox=" &
    decimal xpart a & ":" &
    decimal ypart a & ":" &
    decimal xpart b & ":" &
    decimal ypart b
enddef;
primarydef p asgroup s =
  image(
    draw center p
      withprescript "mplibgroupbbox=" &
        decimal (xpart llcorner p -1/4) & ":" &
        decimal (ypart llcorner p -1/4) & ":" &
        decimal (xpart urcorner p +1/4) & ":" &
        decimal (ypart urcorner p +1/4)
      withprescript "gr_state=start"
      withprescript "gr_type=" & s;
    draw p;
    draw center p withprescript "gr_state=stop";
  )
enddef;
```

```
def withgroupbbox (expr a,b) =
  withprescript "mplibgroupbbox=" &
    decimal xpart a & ":" &
    decimal ypart a & ":" &
    decimal xpart b & ":" &
    decimal ypart b
enddef;
def withgroupname expr s =
  withprescript "mplibgroupname=" & s
enddef;
def usemplibgroup primary s =
  draw maketext("\csname luamplib.group." & s & "\endcsname")
    shifted runscript("return luamplib.trgroupshifts['" & s & "']")
enddef;
path    mplib_shade_path ;
numeric mplib_shade_step ; mplib_shade_step := 0 ;
numeric mplib_shade_fx, mplib_shade_fy ;
numeric mplib_shade_lx, mplib_shade_ly ;
numeric mplib_shade_nx, mplib_shade_ny ;
numeric mplib_shade_dx, mplib_shade_dy ;
numeric mplib_shade_tx, mplib_shade_ty ;
primarydef p withshadingmethod m =
  p
  if picture p :
    withprescript "sh_operand_type=picture"
    if textual p:
      withprescript "sh_transform=no"
      mplib_with_shade_method (boundingbox p, m)
    else:
      withprescript "sh_transform=yes"
      mplib_with_shade_method (pathpart p, m)
    fi
  else :
    withprescript "sh_transform=yes"
    mplib_with_shade_method (p, m)
  fi
enddef;
def mplib_with_shade_method (expr p, m) =
  hide(mplib_with_shade_method_analyze(p))
  withprescript "sh_domain=0 1"
  withprescript "sh_color=into"
  withprescript "sh_color_a=" & colordecimals white
  withprescript "sh_color_b=" & colordecimals black
  withprescript "sh_first=" & ddecimal point 0 of p
  withprescript "sh_set_x=" & ddecimal (mplib_shade_nx,mplib_shade_lx)
  withprescript "sh_set_y=" & ddecimal (mplib_shade_ny,mplib_shade_ly)
  if m = "linear" :
    withprescript "sh_type=linear"
    withprescript "sh_factor=1"
    withprescript "sh_center_a=" & ddecimal llcorner p
    withprescript "sh_center_b=" & ddecimal urcorner p
  else :
    withprescript "sh_type=circular"
    withprescript "sh_factor=1.2"
```

```
    withprescript "sh_center_a=" & ddecimal center p
    withprescript "sh_center_b=" & ddecimal center p
    withprescript "sh_radius_a=" & decimal 0
    withprescript "sh_radius_b=" & decimal mplib_max_radius(p)
  fi
enddef;
def mplib_with_shade_method_analyze(expr p) =
  mplib_shade_path := p ;
  mplib_shade_step := 1 ;
  mplib_shade_fx   := xpart point 0 of p ;
  mplib_shade_fy   := ypart point 0 of p ;
  mplib_shade_lx   := mplib_shade_fx ;
  mplib_shade_ly   := mplib_shade_fy ;
  mplib_shade_nx   := 0 ;
  mplib_shade_ny   := 0 ;
  mplib_shade_dx   := abs(mplib_shade_fx - mplib_shade_lx) ;
  mplib_shade_dy   := abs(mplib_shade_fy - mplib_shade_ly) ;
  for i=1 upto length(p) :
    mplib_shade_tx := abs(mplib_shade_fx - xpart point i of p) ;
    mplib_shade_ty := abs(mplib_shade_fy - ypart point i of p) ;
    if mplib_shade_tx > mplib_shade_dx :
      mplib_shade_nx := i + 1 ;
      mplib_shade_lx := xpart point i of p ;
      mplib_shade_dx := mplib_shade_tx ;
    fi ;
    if mplib_shade_ty > mplib_shade_dy :
      mplib_shade_ny := i + 1 ;
      mplib_shade_ly := ypart point i of p ;
      mplib_shade_dy := mplib_shade_ty ;
    fi ;
  endfor ;
enddef;
vardef mplib_max_radius(expr p) =
  max (
    (xpart center   p - xpart llcorner p) ++ (ypart center   p - ypart llcorner p),
    (xpart center   p - xpart ulcorner p) ++ (ypart ulcorner p - ypart center   p),
    (xpart lrcorner p - xpart center   p) ++ (ypart center   p - ypart lrcorner p),
    (xpart urcorner p - xpart center   p) ++ (ypart urcorner p - ypart center   p)
  )
enddef;
def withshadingstep (text t) =
  hide(mplib_shade_step := mplib_shade_step + 1 ;)
  withprescript "sh_step=" & decimal mplib_shade_step
  t
enddef;
def withshadingradius expr a =
  withprescript "sh_radius_a=" & decimal (xpart a)
  withprescript "sh_radius_b=" & decimal (ypart a)
enddef;
def withshadingorigin expr a =
  withprescript "sh_center_a=" & ddecimal a
  withprescript "sh_center_b=" & ddecimal a
enddef;
def withshadingvector expr a =
```

```
  withprescript "sh_center_a=" & ddecimal (point xpart a of mplib_shade_path)
  withprescript "sh_center_b=" & ddecimal (point ypart a of mplib_shade_path)
enddef;
def withshadingdirection expr a =
  withprescript "sh_center_a=" & ddecimal (point xpart a of boundingbox(mplib_shade_path))
  withprescript "sh_center_b=" & ddecimal (point ypart a of boundingbox(mplib_shade_path))
enddef;
def withshadingtransform expr a =
  withprescript "sh_transform=" & a
enddef;
def withshadingcenter expr a =
  withprescript "sh_center_a=" & ddecimal (
    center mplib_shade_path shifted (
      xpart a * xpart (lrcorner mplib_shade_path - llcorner mplib_shade_path)/2,
      ypart a * ypart (urcorner mplib_shade_path - lrcorner mplib_shade_path)/2
    )
  )
enddef;
def withshadingdomain expr d =
  withprescript "sh_domain=" & ddecimal d
enddef;
def withshadingfactor expr f =
  withprescript "sh_factor=" & decimal f
enddef;
def withshadingfraction expr a =
  if mplib_shade_step > 0 :
    withprescript "sh_fraction_" & decimal mplib_shade_step & "=" & decimal a
  fi
enddef;
def withshadingcolors (expr a, b) =
  if mplib_shade_step > 0 :
    withprescript "sh_color=into"
    withprescript "sh_color_a_" & decimal mplib_shade_step & "=" & colordecimals a
    withprescript "sh_color_b_" & decimal mplib_shade_step & "=" & colordecimals b
  else :
    withprescript "sh_color=into"
    withprescript "sh_color_a=" & colordecimals a
    withprescript "sh_color_b=" & colordecimals b
  fi
enddef;
def mpliblength primary t =
  runscript("return utf8.len[===[" & t & "]===]")
enddef;
def mplibsubstring expr p of t =
  runscript("return luamplib.utf8substring([===[" & t & "]===],"
    & decimal xpart p & ","
    & decimal ypart p & ")")
enddef;
]],
  legacyverbatimtex = [[
def specialVerbatimTeX (text t) = runscript("luamplibprefig{"&t&"}") enddef;
def normalVerbatimTeX  (text t) = runscript("luamplibinfig{"&t&"}") enddef;
let VerbatimTeX = specialVerbatimTeX;
extra_beginfig := extra_beginfig & " let VerbatimTeX = normalVerbatimTeX;"&
```

```
  "runscript(" &ditto& "luamplib.in_the_fig=true" &ditto& ");";
extra_endfig := extra_endfig & " let VerbatimTeX = specialVerbatimTeX;"&
  "runscript(" &ditto&
  "if luamplib.in_the_fig then luamplib.figid=luamplib.figid+1 end "&
  "luamplib.in_the_fig=false" &ditto& ");";
]],
  textextlabel = [[
let luampliboriginalinfont = infont;
primarydef s infont f =
  if   (s < char 32)
    or (s = char 35) % #
    or (s = char 36) % $
    or (s = char 37) % %
    or (s = char 38) % &
    or (s = char 92) % \
    or (s = char 94) % ^
    or (s = char 95) % _
    or (s = char 123) % {
    or (s = char 125) % }
    or (s = char 126) % ~
    or (s = char 127) :
    s luampliboriginalinfont f
  else :
    rawtextext(s)
  fi
enddef;
def fontsize expr f =
  begingroup
  save size; numeric size;
  size := mplibdimen("1em");
  if size = 0: 10pt else: size fi
  endgroup
enddef;
]],
}
```

When `\mplibverbatim` is enabled, do not expand `mplibcode` data.

```
luamplib.verbatiminput = false
```

Do not expand `btex ... etex`, `verbatimtex ... etex`, and string expressions.

```
local function protect_expansion (str)
  if str then
    str = str:gsub("\\","!!!Control!!!")
              :gsub("%%","!!!Comment!!!")
              :gsub("#", "!!!HashSign!!!")
              :gsub("{", "!!!LBrace!!!")
              :gsub("}", "!!!RBrace!!!")
    return format("\\unexpanded{%s}",str)
  end
end
local function unprotect_expansion (str)
  if str then
    return str:gsub("!!!Control!!!", "\\")
               :gsub("!!!Comment!!!", "%%")
```

```
              :gsub("!!!HashSign!!!","#")
              :gsub("!!!LBrace!!!",  "{")
              :gsub("!!!RBrace!!!",  "}")
  end
end
luamplib.everymplib    = setmetatable({ [""] = "" },{ __index = function(t) return t[""] end })
luamplib.everyendmplib = setmetatable({ [""] = "" },{ __index = function(t) return t[""] end })
function luamplib.process_mplibcode (data, instancename)
  texboxes.localid = 4096
```

This is needed for legacy behavior

```
  if luamplib.legacyverbatimtex then
    luamplib.figid, tex_code_pre_mplib = 1, {}
  end
  local everymplib    = luamplib.everymplib[instancename]
  local everyendmplib = luamplib.everyendmplib[instancename]
  data = format("\n%s\n%s\n%s\n",everymplib, data, everyendmplib)
  :gsub("\r","\n")
```

These five lines are needed for `mplibverbatim` mode.

```
  if luamplib.verbatiminput then
    data = data:gsub("\\mpcolor%s+(.-%b{})","mplibcolor(\"%1\")")
    :gsub("\\mpdim%s+(%b{})", "mplibdimen(\"%1\")")
    :gsub("\\mpdim%s+(\\%a+)","mplibdimen(\"%1\")")
    :gsub(btex_etex, "btex %1 etex ")
    :gsub(verbatimtex_etex, "verbatimtex %1 etex;")
```

If not `mplibverbatim`, expand `mplibcode` data, so that users can use TEX codes in it. It has turned out that no comment sign is allowed.

```
  else
    data = data:gsub(btex_etex, function(str)
      return format("btex %s etex ", protect_expansion(str)) -- space
    end)
    :gsub(verbatimtex_etex, function(str)
      return format("verbatimtex %s etex;", protect_expansion(str)) -- semicolon
    end)
    :gsub("\".-\"", protect_expansion)
    :gsub("\\%%", "\0PerCent\0")
    :gsub("%%.-\n","\n")
    :gsub("%zPerCent%z", "\\%%")
    run_tex_code(format("\\mplibtmptoks\\expandafter{\\expanded{%s}}",data))
    data = texgettoks"mplibtmptoks"
```

Next line to address issue #55

```
    :gsub("##", "#")
    :gsub("\".-\"", unprotect_expansion)
    :gsub(btex_etex, function(str)
      return format("btex %s etex", unprotect_expansion(str))
    end)
    :gsub(verbatimtex_etex, function(str)
      return format("verbatimtex %s etex", unprotect_expansion(str))
    end)
  end
  process(data, instancename)
end
```

For parsing prescript materials.

```
local function script2table(s)
  local t = {}
  for _,i in ipairs(s:explode("\13+")) do
    local k,v = i:match("(.-)=(.*)") -- v may contain = or empty.
    if k and v and k ~= "" and not t[k] then
      t[k] = v
    end
  end
  return t
end

```

pdfliterals will be stored in figcontents table, and written to pdf in one go at the end of the flushing figure. Subtable post is for the legacy behavior.

```
local figcontents = { post = { } }
local function put2output(a,...)
  figcontents[#figcontents+1] = type(a) == "string" and format(a,...) or a
end
local function pdf_startfigure(n,llx,lly,urx,ury)
  put2output("\\mplibstarttoPDF{%f}{%f}{%f}{%f}",llx,lly,urx,ury)
end
local function pdf_stopfigure()
  put2output("\\mplibstoptoPDF")
end
```

tex.sprint with catcode regime -2, as sometimes # gets doubled in the argument of pdfliteral.

```
local function pdf_literalcode (...)
  put2output{ -2, (format(...) :gsub(decimals,rmzeros)) }
end
local start_pdf_code = pdfmode
  and function() pdf_literalcode"q" end
  or  function() put2output"\\special{pdf:bcontent}" end
local stop_pdf_code = pdfmode
  and function() pdf_literalcode"Q" end
  or  function() put2output"\\special{pdf:econtent}" end

```

Now we process hboxes created from btex ... etex or textext(...) or TEX(...), all being the same internally.

```
local function put_tex_boxes (object,prescript)
  local box = prescript.mplibtexboxid:explode":"
  local n,tw,th = box[1],tonumber(box[2]),tonumber(box[3])
  if n and tw and th then
    local op = object.path
    local first, second, fourth = op[1], op[2], op[4]
    local tx, ty = first.x_coord, first.y_coord
    local sx, rx, ry, sy = 1, 0, 0, 1
    if tw ~= 0 then
      sx = (second.x_coord - tx)/tw
      rx = (second.y_coord - ty)/tw
      if sx == 0 then sx = 0.00001 end
    end
    if th ~= 0 then
```

```
      sy = (fourth.y_coord - ty)/th
      ry = (fourth.x_coord - tx)/th
      if sy == 0 then sy = 0.00001 end
    end
    start_pdf_code()
    pdf_literalcode("%f %f %f %f %f %f cm",sx,rx,ry,sy,tx,ty)
    put2output("\\mplibputtextbox{%i}",n)
    stop_pdf_code()
  end
end
```

Colors

```
local prev_override_color
local function do_preobj_CR(object,prescript)
  if object.postscript == "collect" then return end
  local override = prescript and prescript.mpliboverridecolor
  if override then
    if pdfmode then
      pdf_literalcode(override)
      override = nil
    else
      put2output("\\special{%s}",override)
      prev_override_color = override
    end
  else
    local cs = object.color
    if cs and #cs > 0 then
      pdf_literalcode(luamplib.colorconverter(cs))
      prev_override_color = nil
    elseif not pdfmode then
      override = prev_override_color
      if override then
        put2output("\\special{%s}",override)
      end
    end
  end
  return override
end
```

For transparency and shading

```
local pdfmanagement = is_defined'pdfmanagement_add:nnn'
local pdfobjs, pdfetcs = {}, {}
pdfetcs.pgfextgs = "pgf@sys@addpdfresource@extgs@plain"
pdfetcs.pgfpattern = "pgf@sys@addpdfresource@patterns@plain"
pdfetcs.pgfcolorspace = "pgf@sys@addpdfresource@colorspaces@plain"
local function update_pdfobjs (os, stream)
  local key = os
  if stream then key = key..stream end
  local on = key and pdfobjs[key]
  if on then
    return on,false
  end
  if pdfmode then
```

```
    if stream then
      on = pdf.immediateobj("stream",stream,os)
    elseif os then
      on = pdf.immediateobj(os)
    else
      on = pdf.reserveobj()
    end
  else
    on = pdfetcs.cnt or 1
    if stream then
      texsprint(format("\\special{pdf:stream @mplibpdfobj%s (%s) <<%s>>}",on,stream,os))
    elseif os then
      texsprint(format("\\special{pdf:obj @mplibpdfobj%s %s}",on,os))
    else
      texsprint(format("\\special{pdf:obj @mplibpdfobj%s <<>>}",on))
    end
    pdfetcs.cnt = on + 1
  end
  if key then
    pdfobjs[key] = on
  end
  return on,true
end
pdfetcs.resfmt = pdfmode and "%s 0 R" or "@mplibpdfobj%s"
if pdfmode then
  pdfetcs.getpageres = pdf.getpageresources or function() return pdf.pageresources end
  local getpageres = pdfetcs.getpageres
  local setpageres = pdf.setpageresources or function(s) pdf.pageresources = s end
  local initialize_resources = function (name)
    local tabname = format("%s_res",name)
    pdfetcs[tabname] = { }
    if luatexbase.callbacktypes.finish_pdffile then -- ltluatex
      local obj = pdf.reserveobj()
      setpageres(format("%s/%s %i 0 R", getpageres() or "", name, obj))
      luatexbase.add_to_callback("finish_pdffile", function()
        pdf.immediateobj(obj, format("<<%s>>", tableconcat(pdfetcs[tabname])))
      end,
      format("luamplib.%s.finish_pdffile",name))
    end
  end
  pdfetcs.fallback_update_resources = function (name, res)
    local tabname = format("%s_res",name)
    if not pdfetcs[tabname] then
      initialize_resources(name)
    end
    if luatexbase.callbacktypes.finish_pdffile then
      local t = pdfetcs[tabname]
      t[#t+1] = res
    else
      local tpr, n = getpageres() or "", 0
      tpr, n = tpr:gsub(format("/%s<<",name), "%1"..res)
      if n == 0 then
        tpr = format("%s/%s<<%s>>", tpr, name, res)
      end
```

```
      setpageres(tpr)
    end
  end
else
  texsprint {
    "\\luamplibatfirstshipout{",
    "\\special{pdf:obj @MPlibTr<<>>}",
    "\\special{pdf:obj @MPlibSh<<>>}",
    "\\special{pdf:obj @MPlibCS<<>>}",
    "\\special{pdf:obj @MPlibPt<<>>}}",
  }
  pdfetcs.resadded = { }
  pdfetcs.fallback_update_resources = function (name,res,obj)
    texsprint{"\\special{pdf:put ", obj, " <<", res, ">>}"}
    if not pdfetcs.resadded[name] then
      texsprint{"\\luamplibateveryshipout{\\special{pdf:put @resources <</", name, " ", obj, ">>}}"}
      pdfetcs.resadded[name] = obj
    end
  end
end
```

Transparency

```
local transparancy_modes = { [0] = "Normal",
  "Normal",       "Multiply",     "Screen",       "Overlay",
  "SoftLight",    "HardLight",    "ColorDodge",   "ColorBurn",
  "Darken",       "Lighten",      "Difference",   "Exclusion",
  "Hue",          "Saturation",   "Color",        "Luminosity",
  "Compatible",
  normal     = "Normal",     multiply   = "Multiply",   screen    = "Screen",
  overlay    = "Overlay",    softlight  = "SoftLight",  hardlight = "HardLight",
  colordodge = "ColorDodge", colorburn  = "ColorBurn",  darken    = "Darken",
  lighten    = "Lighten",    difference = "Difference", exclusion = "Exclusion",
  hue        = "Hue",        saturation = "Saturation", color     = "Color",
  luminosity = "Luminosity", compatible = "Compatible",
}
local function add_extgs_resources (on, new)
  local key = format("MPlibTr%s", on)
  if new then
    local val = format(pdfetcs.resfmt, on)
    if pdfmanagement then
      texsprint {
        "\\csname pdfmanagement_add:nnn\\endcsname{Page/Resources/ExtGState}{", key, "}{", val, "}"
      }
    else
      local tr = format("/%s %s", key, val)
      if is_defined(pdfetcs.pgfextgs) then
        texsprint { "\\csname ", pdfetcs.pgfextgs, "\\endcsname{", tr, "}" }
      elseif is_defined"TRP@list" then
        texsprint(catat11,{
          [[\if@filesw\immediate\write\@auxout{]],
          [[\string\g@addto@macro\string\TRP@list{]],
          tr,
          [[}}\fi]],
        })
```

```
        if not get_macro"TRP@list":find(tr) then
          texsprint(catat11,[[\global\TRP@reruntrue]])
        end
      else
        pdfetcs.fallback_update_resources("ExtGState",tr,"@MPlibTr")
      end
    end
  end
  return key
end
local function do_preobj_TR(object,prescript)
  if object.postscript == "collect" then return end
  local opaq = prescript and prescript.tr_transparency
  if opaq then
    local key, on, os, new
    local mode = prescript.tr_alternative or 1
    mode = transparency_modes[tonumber(mode) or mode:lower()]
    if not mode then
      mode = prescript.tr_alternative
      warn("unsupported blend mode: '%s'", mode)
    end
    opaq = format("%.3f", opaq) :gsub(decimals,rmzeros)
    for i,v in ipairs{ {mode,opaq},{"Normal",1} } do
      os = format("<</BM/%s/ca %s/CA %s/AIS false>>",v[1],v[2],v[2])
      on, new = update_pdfobjs(os)
      key = add_extgs_resources(on,new)
      if i == 1 then
        pdf_literalcode("/%s gs",key)
      else
        return format("/%s gs",key)
      end
    end
  end
end

```

Shading with *metafun* format.

```
local function sh_pdfpageresources(shtype,domain,colorspace,ca,cb,coordinates,steps,fractions)
  for _,v in ipairs{ca,cb} do
    for i,vv in ipairs(v) do
      for ii,vvv in ipairs(vv) do
        v[i][ii] = tonumber(vvv) and format("%.3f",vvv) or vvv
      end
    end
  end
  local fun2fmt,os = "<</FunctionType 2/Domain[%s]/C0[%s]/C1[%s]/N 1>>"
  if steps > 1 then
    local list,bounds,encode = { },{ },{ }
    for i=1,steps do
      if i < steps then
        bounds[i] = format("%.3f", fractions[i] or 1)
      end
      encode[2*i-1] = 0
      encode[2*i]   = 1
      os = fun2fmt:format(domain,tableconcat(ca[i],' '),tableconcat(cb[i],' '))
```

```
      :gsub(decimals,rmzeros)
    list[i] = format(pdfetcs.resfmt, update_pdfobjs(os))
  end
  os = tableconcat {
    "<</FunctionType 3",
    format("/Bounds[%s]",    tableconcat(bounds,' ')),
    format("/Encode[%s]",    tableconcat(encode,' ')),
    format("/Functions[%s]", tableconcat(list,  ' ')),
    format("/Domain[%s]>>",  domain),
  } :gsub(decimals,rmzeros)
else
  os = fun2fmt:format(domain,tableconcat(ca[1],' '),tableconcat(cb[1],' '))
    :gsub(decimals,rmzeros)
end
local objref = format(pdfetcs.resfmt, update_pdfobjs(os))
os = tableconcat {
  format("<</ShadingType %i", shtype),
  format("/ColorSpace %s",    colorspace),
  format("/Function %s",      objref),
  format("/Coords[%s]",       coordinates),
  "/Extend[true true]/AntiAlias true>>",
} :gsub(decimals,rmzeros)
local on, new = update_pdfobjs(os)
if new then
  local key, val = format("MPlibSh%s", on), format(pdfetcs.resfmt, on)
  if pdfmanagement then
    texsprint {
      "\\csname pdfmanagement_add:nnn\\endcsname{Page/Resources/Shading}{", key, "}{", val, "}"
    }
  else
    local res = format("/%s %s", key, val)
    pdfetcs.fallback_update_resources("Shading",res,"@MPlibSh")
  end
end
return on
end
local function color_normalize(ca,cb)
if #cb == 1 then
  if #ca == 4 then
    cb[1], cb[2], cb[3], cb[4] = 0, 0, 0, 1-cb[1]
  else -- #ca = 3
    cb[1], cb[2], cb[3] = cb[1], cb[1], cb[1]
  end
elseif #cb == 3 then -- #ca == 4
  cb[1], cb[2], cb[3], cb[4] = 1-cb[1], 1-cb[2], 1-cb[3], 0
end
end
pdfetcs.clrspcs = setmetatable({ }, { __index = function(t,names)
run_tex_code({
  [[\color_model_new:nnn]],
  format("{mplibcolorspace_%s}", names:gsub(",","_")),
  format("{DeviceN}{names={%s}}", names),
  [[\edef\mplib_@tempa{\pdf_object_ref_last:}]],
}, ccexplat)
```

```
  local colorspace = get_macro'mplib_@tempa'
  t[names] = colorspace
  return colorspace
end })
local function do_preobj_SH(object,prescript)
  local shade_no
  local sh_type = prescript and prescript.sh_type
  if not sh_type then
    return
  else
    local domain  = prescript.sh_domain or "0 1"
    local centera = (prescript.sh_center_a or "0 0"):explode()
    local centerb = (prescript.sh_center_b or "0 0"):explode()
    local transform = prescript.sh_transform == "yes"
    local sx,sy,sr,dx,dy = 1,1,1,0,0
    if transform then
      local first = (prescript.sh_first or "0 0"):explode()
      local setx  = (prescript.sh_set_x or "0 0"):explode()
      local sety  = (prescript.sh_set_y or "0 0"):explode()
      local x,y = tonumber(setx[1]) or 0, tonumber(sety[1]) or 0
      if x ~= 0 and y ~= 0 then
        local path = object.path
        local path1x = path[1].x_coord
        local path1y = path[1].y_coord
        local path2x = path[x].x_coord
        local path2y = path[y].y_coord
        local dxa = path2x - path1x
        local dya = path2y - path1y
        local dxb = setx[2] - first[1]
        local dyb = sety[2] - first[2]
        if dxa ~= 0 and dya ~= 0 and dxb ~= 0 and dyb ~= 0 then
          sx = dxa / dxb ; if sx < 0 then sx = - sx end
          sy = dya / dyb ; if sy < 0 then sy = - sy end
          sr = math.sqrt(sx^2 + sy^2)
          dx = path1x - sx*first[1]
          dy = path1y - sy*first[2]
        end
      end
    end
    local ca, cb, colorspace, steps, fractions
    ca = { (prescript.sh_color_a_1 or prescript.sh_color_a or "0"):explode":" }
    cb = { (prescript.sh_color_b_1 or prescript.sh_color_b or "1"):explode":" }
    steps = tonumber(prescript.sh_step) or 1
    if steps > 1 then
      fractions = { prescript.sh_fraction_1 or 0 }
      for i=2,steps do
        fractions[i] = prescript[format("sh_fraction_%i",i)] or (i/steps)
        ca[i] = (prescript[format("sh_color_a_%i",i)] or "0"):explode":"
        cb[i] = (prescript[format("sh_color_b_%i",i)] or "1"):explode":"
      end
    end
    if prescript.mplib_spotcolor then
      ca, cb = { }, { }
      local names, pos, objref = { }, -1, ""
```

```
    local script = object.prescript:explode"\13+"
    for i=#script,1,-1 do
      if script[i]:find"mplib_spotcolor" then
        local t, name, value = script[i]:explode"="[2]:explode":"
        value, objref, name = t[1], t[2], t[3]
        if not names[name] then
          pos = pos+1
          names[name] = pos
          names[#names+1] = name
        end
        t = { }
        for j=1,names[name] do t[#t+1] = 0 end
        t[#t+1] = value
        tableinsert(#ca == #cb and ca or cb, t)
      end
    end
    for _,t in ipairs{ca,cb} do
      for _,tt in ipairs(t) do
        for i=1,#names-#tt do tt[#tt+1] = 0 end
      end
    end
    if #names == 1 then
      colorspace = objref
    else
      colorspace = pdfetcs.clrspcs[ tableconcat(names,",") ]
    end
  else
    local model = 0
    for _,t in ipairs{ca,cb} do
      for _,tt in ipairs(t) do
        model = model > #tt and model or #tt
      end
    end
    for _,t in ipairs{ca,cb} do
      for _,tt in ipairs(t) do
        if #tt < model then
          color_normalize(model == 4 and {1,1,1,1} or {1,1,1},tt)
        end
      end
    end
    colorspace = model == 4 and "/DeviceCMYK"
              or model == 3 and "/DeviceRGB"
              or model == 1 and "/DeviceGray"
              or err"unknown color model"
  end
  if sh_type == "linear" then
    local coordinates = format("%f %f %f %f",
      dx + sx*centera[1], dy + sy*centera[2],
      dx + sx*centerb[1], dy + sy*centerb[2])
    shade_no = sh_pdfpageresources(2,domain,colorspace,ca,cb,coordinates,steps,fractions)
  elseif sh_type == "circular" then
    local factor = prescript.sh_factor or 1
    local radiusa = factor * prescript.sh_radius_a
    local radiusb = factor * prescript.sh_radius_b
```

```
      local coordinates = format("%f %f %f %f %f %f",
        dx + sx*centera[1], dy + sy*centera[2], sr*radiusa,
        dx + sx*centerb[1], dy + sy*centerb[2], sr*radiusb)
      shade_no = sh_pdfpageresources(3,domain,colorspace,ca,cb,coordinates,steps,fractions)
    else
      err"unknown shading type"
    end
  end
  return shade_no
end

```

Shading Patterns: much similar to the metafun's shade, but we can apply shading to textual pictures as well as paths.

```
local function add_pattern_resources (key, val)
  if pdfmanagement then
    texsprint {
      "\\csname pdfmanagement_add:nnn\\endcsname{Page/Resources/Pattern}{", key, "}{", val, "}"
    }
  else
    local res = format("/%s %s", key, val)
    if is_defined(pdfetcs.pgfpattern) then
      texsprint { "\\csname ", pdfetcs.pgfpattern, "\\endcsname{", res, "}" }
    else
      pdfetcs.fallback_update_resources("Pattern",res,"@MPlibPt")
    end
  end
end
function luamplib.dolatelua (on, os)
  local h, v = pdf.getpos()
  h = format("%f", h/factor) :gsub(decimals,rmzeros)
  v = format("%f", v/factor) :gsub(decimals,rmzeros)
  if pdfmode then
    pdf.obj(on, format("<<%s/Matrix[1 0 0 1 %s %s]>>", os, h, v))
    pdf.refobj(on)
  else
    local shift = os:explode()
    if tonumber(h) ~= tonumber(shift[1]) or tonumber(v) ~= tonumber(shift[2]) then
      warn([[Add 'withprescript "sh_matrixshift=%s %s"' to the picture shading]], h, v)
    end
  end
end
local function do_preobj_shading (object, prescript)
  if not prescript or not prescript.sh_operand_type then return end
  local on = do_preobj_SH(object, prescript)
  local os = format("/PatternType 2/Shading %s", format(pdfetcs.resfmt, on))
  on = update_pdfobjs()
  if pdfmode then
    put2output(tableconcat{ "\\latelua{ luamplib.dolatelua(",on,",[[",os,"]]) }" })
  else
```

Why `@xpos` `@ypos` do not work properly???
Anyway, this seems to be needed for proper functioning:

```
\pagewidth=\paperwidth
```

```
\pageheight=\paperheight
\special{papersize=\the\paperwidth,\the\paperheight}
```

```
    if is_defined"RecordProperties" then
      put2output(tableconcat{
        "\\csname tex_savepos:D\\endcsname\\RecordProperties{luamplib/getpos/",on,"}{xpos,ypos}\z
        \\special{pdf:put @mplibpdfobj",on," <<",os,"/Matrix[1 0 0 1 \z
        \\csname dim_to_decimal_in_bp:n\\endcsname{\\RefProperty{luamplib/getpos/",on,"}{xpos}sp} \z
        \\csname dim_to_decimal_in_bp:n\\endcsname{\\RefProperty{luamplib/getpos/",on,"}{ypos}sp}\z
        ]>>}"
      })
    else
      local shift = prescript.sh_matrixshift or "0 0"
      texsprint{ "\\special{pdf:put @mplibpdfobj",on," <<",os,"/Matrix[1 0 0 1 ",shift,"]>>}" }
      put2output(tableconcat{ "\\latelua{ luamplib.dolatelua(",on,",[[",shift,"]]) }" })
    end
  end
  local key, val = format("MPlibPt%s", on), format(pdfetcs.resfmt, on)
  add_pattern_resources(key,val)
  pdf_literalcode("/Pattern cs/%s scn", key)
```

To avoid possible double execution, once by Pattern gs, once by Sh operator.

```
  prescript.sh_type = nil
end
```

Tiling Patterns

```
pdfetcs.patterns = { }
local function gather_resources (optres)
  local t, do_pattern = { }, not optres
  local names = {"ExtGState","ColorSpace","Shading"}
  if do_pattern then
    names[#names+1] = "Pattern"
  end
  if pdfmode then
    if pdfmanagement then
      for _,v in ipairs(names) do
        local pp = get_macro(format("g__pdfdict_/g__pdf_Core/Page/Resources/%s_prop",v))
        if pp and pp:find"__prop_pair" then
          t[#t+1] = format("/%s %s 0 R", v, ltx.pdf.object_id("__pdf/Page/Resources/"..v))
        end
      end
    else
      local res = pdfetcs.getpageres() or ""
      run_tex_code[[\mplibtmptoks\expandafter{\the\pdfvariable pageresources}]]
      res = res .. texgettoks'mplibtmptoks'
      if do_pattern then return res end
      res = res:explode"/+"
      for _,v in ipairs(res) do
        v = v:match"^%s*(.-)%s*$"
        if not v:find"Pattern" and not optres:find(v) then
          t[#t+1] = "/" .. v
        end
      end
    end
```

```
  else
    if pdfmanagement then
      for _,v in ipairs(names) do
        local pp = get_macro(format("g__pdfdict_/g__pdf_Core/Page/Resources/%s_prop",v))
        if pp and pp:find"__prop_pair" then
          run_tex_code {
            "\\mplibtmptoks\\expanded{{",
            format("/%s \\csname pdf_object_ref:n\\endcsname{__pdf/Page/Resources/%s}",v,v),
            "}}",
          }
          t[#t+1] = texgettoks'mplibtmptoks'
        end
      end
    elseif is_defined(pdfetcs.pgfextgs) then
      run_tex_code ({
        "\\mplibtmptoks\\expanded{{",
        "\\ifpgf@sys@pdf@extgs@exists /ExtGState @pgfextgs\\fi",
        "\\ifpgf@sys@pdf@colorspaces@exists /ColorSpace @pgfcolorspaces\\fi",
        do_pattern and "\\ifpgf@sys@pdf@patterns@exists /Pattern @pgfpatterns \\fi" or "",
        "}}",
      }, catat11)
      t[#t+1] = texgettoks'mplibtmptoks'
    else
      for _,v in ipairs(names) do
        local vv = pdfetcs.resadded[v]
        if vv then
          t[#t+1] = format("/%s %s", v, vv)
        end
      end
    end
  end
  return tableconcat(t)
end
function luamplib.registerpattern ( boxid, name, opts )
  local box = texgetbox(boxid)
  local wd = format("%.3f",box.width/factor)
  local hd = format("%.3f",(box.height+box.depth)/factor)
  info("w/h/d of pattern '%s': %s 0", name, format("%s %s",wd, hd):gsub(decimals,rmzeros))
  if opts.xstep == 0 then opts.xstep = nil end
  if opts.ystep == 0 then opts.ystep = nil end
  if opts.colored == nil then
    opts.colored = opts.coloured
    if opts.colored == nil then
      opts.colored = true
    end
  end
  if type(opts.matrix) == "table" then opts.matrix = tableconcat(opts.matrix," ") end
  if type(opts.bbox) == "table" then opts.bbox = tableconcat(opts.bbox," ") end
  if opts.matrix and opts.matrix:find"%a" then
    local data = format("mplibtransformmatrix(%s);",opts.matrix)
    process(data,"@mplibtransformmatrix")
    local t = luamplib.transformmatrix
    opts.matrix = format("%f %f %f %f", t[1], t[2], t[3], t[4])
    opts.xshift = opts.xshift or format("%f",t[5])
```

```
2302    opts.yshift = opts.yshift or format("%f",t[6])
2303  end
2304  local attr = {
2305    "/Type/Pattern",
2306    "/PatternType 1",
2307    format("/PaintType %i", opts.colored and 1 or 2),
2308    "/TilingType 2",
2309    format("/XStep %s", opts.xstep or wd),
2310    format("/YStep %s", opts.ystep or hd),
2311    format("/Matrix[%s %s %s]", opts.matrix or "1 0 0 1", opts.xshift or 0, opts.yshift or 0),
2312  }
2313  local optres = opts.resources or ""
2314  optres = optres .. gather_resources(optres)
2315  local patterns = pdfetcs.patterns
2316  if pdfmode then
2317    if opts.bbox then
2318      attr[#attr+1] = format("/BBox[%s]", opts.bbox)
2319    end
2320    attr = tableconcat(attr) :gsub(decimals,rmzeros)
2321    local index = tex.saveboxresource(boxid, attr, optres, true, opts.bbox and 4 or 1)
2322    patterns[name] = { id = index, colored = opts.colored }
2323  else
2324    local cnt = #patterns + 1
2325    local objname = "@mplibpattern" .. cnt
2326    local metric = format("bbox %s", opts.bbox or format("0 0 %s %s",wd,hd))
2327    texsprint {
2328      "\\expandafter\\newbox\\csname luamplib.patternbox.", cnt, "\\endcsname",
2329      "\\global\\setbox\\csname luamplib.patternbox.", cnt, "\\endcsname",
2330      "\\hbox{\\unhbox ", boxid, "}\\luamplibatnextshipout{",
2331      "\\special{pdf:bcontent}",
2332      "\\special{pdf:bxobj ", objname, " ", metric, "}",
2333      "\\raise\\dp\\csname luamplib.patternbox.", cnt, "\\endcsname",
2334      "\\box\\csname luamplib.patternbox.", cnt, "\\endcsname",
2335      "\\special{pdf:put @resources <<", optres, ">>}",
2336      "\\special{pdf:exobj <<", tableconcat(attr), ">>}",
2337      "\\special{pdf:econtent}}",
2338    }
2339    patterns[cnt] = objname
2340    patterns[name] = { id = cnt, colored = opts.colored }
2341  end
2342 end
2343 local function pattern_colorspace (cs)
2344  local on, new = update_pdfobjs(format("[/Pattern %s]", cs))
2345  if new then
2346    local key, val = format("MPlibCS%i",on), format(pdfetcs.resfmt,on)
2347    if pdfmanagement then
2348      texsprint {
2349        "\\csname pdfmanagement_add:nnn\\endcsname{Page/Resources/ColorSpace}{", key, "}{", val, "}"
2350      }
2351    else
2352      local res = format("/%s %s", key, val)
2353      if is_defined(pdfetcs.pgfcolorspace) then
2354        texsprint { "\\csname ", pdfetcs.pgfcolorspace, "\\endcsname{", res, "}" }
2355      else
```

```
        pdfetcs.fallback_update_resources("ColorSpace",res,"@MPlibCS")
      end
    end
  end
  return on
end
local function do_preobj_PAT(object, prescript)
  local name = prescript and prescript.mplibpattern
  if not name then return end
  local patterns = pdfetcs.patterns
  local patt = patterns[name]
  local index = patt and patt.id or err("cannot get pattern object '%s'", name)
  local key = format("MPlibPt%s",index)
  if patt.colored then
    pdf_literalcode("/Pattern cs /%s scn", key)
  else
    local color = prescript.mpliboverridecolor
    if not color then
      local t = object.color
      color = t and #t>0 and luamplib.colorconverter(t)
    end
    if not color then return end
    local cs
    if color:find" cs " or color:find"@pdf.obj" then
      local t = color:explode()
      if pdfmode then
        cs = format("%s 0 R", ltx.pdf.object_id( t[1]:sub(2,-1) ))
        color = t[3]
      else
        cs = t[2]
        color = t[3]:match"%[(.+)%]"
      end
    else
      local t = colorsplit(color)
      cs = #t == 4 and "/DeviceCMYK" or #t == 3 and "/DeviceRGB" or "/DeviceGray"
      color = tableconcat(t," ")
    end
    pdf_literalcode("/MPlibCS%i cs %s /%s scn", pattern_colorspace(cs), color, key)
  end
  if not patt.done then
    local val = pdfmode and format("%s 0 R",index) or patterns[index]
    add_pattern_resources(key,val)
  end
  patt.done = true
end

```

Fading

```
pdfetcs.fading = { }
local function do_preobj_FADE (object, prescript)
  local fd_type = prescript and prescript.mplibfadetype
  local fd_stop = prescript and prescript.mplibfadestate
  if not fd_type then
    return fd_stop -- returns "stop" (if picture) or nil
  end
```

```
local bbox = prescript.mplibfadebbox:explode":"
local dx, dy = -bbox[1], -bbox[2]
local vec = prescript.mplibfadevector; vec = vec and vec:explode":"
if not vec then
  if fd_type == "linear" then
    vec = {bbox[1], bbox[2], bbox[3], bbox[2]} -- left to right
  else
    local centerx, centery = (bbox[1]+bbox[3])/2, (bbox[2]+bbox[4])/2
    vec = {centerx, centery, centerx, centery} -- center for both circles
  end
end
local coords = { vec[1]+dx, vec[2]+dy, vec[3]+dx, vec[4]+dy }
if fd_type == "linear" then
  coords = format("%f %f %f %f", tableunpack(coords))
elseif fd_type == "circular" then
  local width, height = bbox[3]-bbox[1], bbox[4]-bbox[2]
  local radius = (prescript.mplibfaderadius or "0:"..math.sqrt(width^2+height^2)/2):explode":"
  tableinsert(coords, 3, radius[1])
  tableinsert(coords, radius[2])
  coords = format("%f %f %f %f %f %f", tableunpack(coords))
else
  err("unknown fading method '%s'", fd_type)
end
fd_type = fd_type == "linear" and 2 or 3
local opaq = (prescript.mplibfadeopacity or "1:0"):explode":"
local on, os, new
on = sh_pdfpageresources(fd_type, "0 1", "/DeviceGray", {{opaq[1]}}, {{opaq[2]}}, coords, 1)
os = format("<</PatternType 2/Shading %s>>", format(pdfetcs.resfmt, on))
on = update_pdfobjs(os)
bbox = format("0 0 %f %f", bbox[3]+dx, bbox[4]+dy)
local streamtext = format("q /Pattern cs/MPlibFd%s scn %s re f Q", on, bbox)
  :gsub(decimals,rmzeros)
os = format("<</Pattern<</MPlibFd%s %s>>>>", on, format(pdfetcs.resfmt, on))
on = update_pdfobjs(os)
local resources = format(pdfetcs.resfmt, on)
on = update_pdfobjs"<</S/Transparency/CS/DeviceGray>>"
local attr = tableconcat{
  "/Subtype/Form",
  "/BBox[", bbox, "]",
  "/Matrix[1 0 0 1 ", format("%f %f", -dx,-dy), "]",
  "/Resources ", resources,
  "/Group ", format(pdfetcs.resfmt, on),
} :gsub(decimals,rmzeros)
on = update_pdfobjs(attr, streamtext)
os = "<</SMask<</S/Luminosity/G " .. format(pdfetcs.resfmt, on) .. ">>>>"
on, new = update_pdfobjs(os)
local key = add_extgs_resources(on,new)
start_pdf_code()
pdf_literalcode("/%s gs", key)
if fd_stop then return "standalone" end
return "start"
end
```

Transparency Group

```
pdfetcs.tr_group = { shifts = { } }
luamplib.trgroupshifts = pdfetcs.tr_group.shifts
local function do_preobj_GRP (object, prescript)
  local grstate = prescript and prescript.gr_state
  if not grstate then return end
  local trgroup = pdfetcs.tr_group
  if grstate == "start" then
    trgroup.name = prescript.mplibgroupname or "lastmplibgroup"
    trgroup.isolated, trgroup.knockout = false, false
    for _,v in ipairs(prescript.gr_type:explode",+") do
      trgroup[v] = true
    end
    trgroup.bbox = prescript.mplibgroupbbox:explode":"
    put2output[[\begingroup\setbox\mplibscratchbox\hbox\bgroup]]
  elseif grstate == "stop" then
    local llx,lly,urx,ury = tableunpack(trgroup.bbox)
    put2output(tableconcat{
      "\\egroup",
      format("\\wd\\mplibscratchbox %fbp", urx-llx),
      format("\\ht\\mplibscratchbox %fbp", ury-lly),
      "\\dp\\mplibscratchbox 0pt",
    })
    local grattr = format("/Group<</S/Transparency/I %s/K %s>>",trgroup.isolated,trgroup.knockout)
    local res = gather_resources()
    local bbox = format("%f %f %f %f", llx,lly,urx,ury) :gsub(decimals,rmzeros)
    if pdfmode then
      put2output(tableconcat{
        "\\saveboxresource type 2 attr{/Type/XObject/Subtype/Form/FormType 1",
        "/BBox[", bbox, "]", grattr, "} resources{", res, "}\\mplibscratchbox",
        "\\luamplibtagasgroupbegin",
        [[\setbox\mplibscratchbox\hbox{\useboxresource\lastsavedboxresourceindex}]],
        [[\wd\mplibscratchbox 0pt\ht\mplibscratchbox 0pt\dp\mplibscratchbox 0pt]],
        [[\box\mplibscratchbox]],
        "\\luamplibtagasgroupend",
        "\\endgroup",
        "\\expandafter\\xdef\\csname luamplib.group.", trgroup.name, "\\endcsname{",
        "\\setbox\\mplibscratchbox\\hbox{\\hskip",-llx,"bp\\raise",-lly,"bp\\hbox{",
        "\\useboxresource \\the\\lastsavedboxresourceindex",
        "}}\\wd\\mplibscratchbox",urx-llx,"bp\\ht\\mplibscratchbox",ury-lly,"bp",
        "\\box\\mplibscratchbox}",
      })
    else
      trgroup.cnt = (trgroup.cnt or 0) + 1
      local objname = format("@mplibtrgr%s", trgroup.cnt)
      put2output(tableconcat{
        "\\special{pdf:bxobj ", objname, " bbox ", bbox, "}",
        "\\unhbox\\mplibscratchbox",
        "\\special{pdf:put @resources <<", res, ">>}",
        "\\special{pdf:exobj <<", grattr, ">>}",
        "\\special{pdf:uxobj ", objname, "}",
        "\\endgroup",
      })
      token.set_macro("luamplib.group."..trgroup.name, tableconcat{
```

```
        "\\setbox\\mplibscratchbox\\hbox{\\hskip",-llx,"bp\\raise",-lly,"bp\\hbox{",
        "\\special{pdf:uxobj ", objname, "}",
        "}}\\wd\\mplibscratchbox",urx-llx,"bp\\ht\\mplibscratchbox",ury-lly,"bp",
        "\\box\\mplibscratchbox",
      }, "global")
    end
    trgroup.shifts[trgroup.name] = { llx, lly }
  end
  return grstate
end
function luamplib.registergroup (boxid, name, opts)
  local box = texgetbox(boxid)
  local wd, ht, dp = node.getwhd(box)
  local res = (opts.resources or "") .. gather_resources()
  local attr = { "/Type/XObject/Subtype/Form/FormType 1" }
  if type(opts.matrix) == "table" then opts.matrix = tableconcat(opts.matrix," ") end
  if type(opts.bbox) == "table" then opts.bbox = tableconcat(opts.bbox," ") end
  if opts.matrix and opts.matrix:find"%a" then
    local data = format("mplibtransformmatrix(%s);",opts.matrix)
    process(data,"@mplibtransformmatrix")
    opts.matrix = format("%f %f %f %f %f %f",tableunpack(luamplib.transformmatrix))
  end
  local grtype = 3
  if opts.bbox then
    attr[#attr+1] = format("/BBox[%s]", opts.bbox)
    grtype = 2
  end
  if opts.matrix then
    attr[#attr+1] = format("/Matrix[%s]", opts.matrix)
    grtype = opts.bbox and 4 or 1
  end
  if opts.asgroup then
    local t = { isolated = false, knockout = false }
    for _,v in ipairs(opts.asgroup:explode",+") do t[v] = true end
    attr[#attr+1] = format("/Group<</S/Transparency/I %s/K %s>>", t.isolated, t.knockout)
  end
  local trgroup = pdfetcs.tr_group
  trgroup.shifts[name] = { get_macro'MPllx', get_macro'MPlly' }
  local whd
  if pdfmode then
    attr = tableconcat(attr) :gsub(decimals,rmzeros)
    local index = tex.saveboxresource(boxid, attr, res, true, grtype)
    token.set_macro("luamplib.group."..name, tableconcat{
      "\\useboxresource ", index,
    }, "global")
    whd = format("%.3f %.3f 0", wd/factor, (ht+dp)/factor) :gsub(decimals,rmzeros)
  else
    trgroup.cnt = (trgroup.cnt or 0) + 1
    local objname = format("@mplibtrgr%s", trgroup.cnt)
    texsprint {
      "\\expandafter\\newbox\\csname luamplib.groupbox.", trgroup.cnt, "\\endcsname",
      "\\global\\setbox\\csname luamplib.groupbox.", trgroup.cnt, "\\endcsname",
      "\\hbox{\\unhbox ", boxid, "}\\luamplibatnextshipout{",
      "\\special{pdf:bcontent}",
```

```
      "\\special{pdf:bxobj ", objname, " width ", wd, "sp height ", ht, "sp depth ", dp, "sp}",
      "\\unhbox\\csname luamplib.groupbox.", trgroup.cnt, "\\endcsname",
      "\\special{pdf:put @resources <<", res, ">>}",
      "\\special{pdf:exobj <<", tableconcat(attr), ">>}",
      "\\special{pdf:econtent}}",
    }
    token.set_macro("luamplib.group."..name, tableconcat{
      "\\setbox\\mplibscratchbox\\hbox{\\special{pdf:uxobj ", objname, "}}",
      "\\wd\\mplibscratchbox ", wd, "sp",
      "\\ht\\mplibscratchbox ", ht, "sp",
      "\\dp\\mplibscratchbox ", dp, "sp",
      "\\box\\mplibscratchbox",
    }, "global")
    whd = format("%.3f %.3f %.3f", wd/factor, ht/factor, dp/factor) :gsub(decimals,rmzeros)
  end
  info("w/h/d of group '%s': %s", name, whd)
end

local function stop_special_effects(fade,opaq,over)
  if fade then -- fading
    stop_pdf_code()
  end
  if opaq then -- opacity
    pdf_literalcode(opaq)
  end
  if over then -- color
    put2output"\\special{pdf:ec}"
  end
end

```

Codes below for inserting PDF lieterals are mostly from ConTeXt general, with small changes when needed.

```
local function getobjects(result,figure,f)
  return figure:objects()
end

function luamplib.convert (result, flusher)
  luamplib.flush(result, flusher)
  return true -- done
end

local function pdf_textfigure(font,size,text,width,height,depth)
  text = text:gsub(".",function(c)
    return format("\\hbox{\\char%i}",string.byte(c)) -- kerning happens in metapost : false
  end)
  put2output("\\mplibtextext{%s}{%f}{%s}{%s}{%s}",font,size,text,0,0)
end

local bend_tolerance = 131/65536

local rx, sx, sy, ry, tx, ty, divider = 1, 0, 0, 1, 0, 0, 1

local function pen_characteristics(object)
```

```
  local t = mplib.pen_info(object)
  rx, ry, sx, sy, tx, ty = t.rx, t.ry, t.sx, t.sy, t.tx, t.ty
  divider = sx*sy - rx*ry
  return not (sx==1 and rx==0 and ry==0 and sy==1 and tx==0 and ty==0), t.width
end

local function concat(px, py) -- no tx, ty here
  return (sy*px-ry*py)/divider,(sx*py-rx*px)/divider
end

local function curved(ith,pth)
  local d = pth.left_x - ith.right_x
  if abs(ith.right_x - ith.x_coord - d) <= bend_tolerance and abs(pth.x_coord - pth.left_x - d) <= bend_tolerance t
    d = pth.left_y - ith.right_y
    if abs(ith.right_y - ith.y_coord - d) <= bend_tolerance and abs(pth.y_coord - pth.left_y - d) <= bend_tolerance
      return false
    end
  end
  return true
end

local function flushnormalpath(path,open)
  local pth, ith
  for i=1,#path do
    pth = path[i]
    if not ith then
      pdf_literalcode("%f %f m",pth.x_coord,pth.y_coord)
    elseif curved(ith,pth) then
      pdf_literalcode("%f %f %f %f %f %f c",ith.right_x,ith.right_y,pth.left_x,pth.left_y,pth.x_coord,pth.y_coord)
    else
      pdf_literalcode("%f %f l",pth.x_coord,pth.y_coord)
    end
    ith = pth
  end
  if not open then
    local one = path[1]
    if curved(pth,one) then
      pdf_literalcode("%f %f %f %f %f %f c",pth.right_x,pth.right_y,one.left_x,one.left_y,one.x_coord,one.y_coord )
    else
      pdf_literalcode("%f %f l",one.x_coord,one.y_coord)
    end
  elseif #path == 1 then -- special case .. draw point
    local one = path[1]
    pdf_literalcode("%f %f l",one.x_coord,one.y_coord)
  end
end

local function flushconcatpath(path,open)
  pdf_literalcode("%f %f %f %f %f %f cm", sx, rx, ry, sy, tx ,ty)
  local pth, ith
  for i=1,#path do
    pth = path[i]
    if not ith then
      pdf_literalcode("%f %f m",concat(pth.x_coord,pth.y_coord))
```

```
    elseif curved(ith,pth) then
      local a, b = concat(ith.right_x,ith.right_y)
      local c, d = concat(pth.left_x,pth.left_y)
      pdf_literalcode("%f %f %f %f %f %f c",a,b,c,d,concat(pth.x_coord, pth.y_coord))
    else
      pdf_literalcode("%f %f l",concat(pth.x_coord, pth.y_coord))
    end
    ith = pth
  end
  if not open then
    local one = path[1]
    if curved(pth,one) then
      local a, b = concat(pth.right_x,pth.right_y)
      local c, d = concat(one.left_x,one.left_y)
      pdf_literalcode("%f %f %f %f %f %f c",a,b,c,d,concat(one.x_coord, one.y_coord))
    else
      pdf_literalcode("%f %f l",concat(one.x_coord,one.y_coord))
    end
  elseif #path == 1 then -- special case .. draw point
    local one = path[1]
    pdf_literalcode("%f %f l",concat(one.x_coord,one.y_coord))
  end
end

```

Finally, flush figures by inserting PDF literals.

```
function luamplib.flush (result,flusher)
  if result then
    local figures = result.fig
    if figures then
      for f=1, #figures do
        info("flushing figure %s",f)
        local figure = figures[f]
        local objects = getobjects(result,figure,f)
        local fignum = tonumber(figure:filename():match("([%d]+)$") or figure:charcode() or 0)
        local miterlimit, linecap, linejoin, dashed = -1, -1, -1, false
        local bbox = figure:boundingbox()
        local llx, lly, urx, ury = bbox[1], bbox[2], bbox[3], bbox[4] -- faster than unpack
        if urx < llx then
```

luamplib silently ignores this invalid figure for those that do not contain `beginfig ... endfig`. (issue #70) Original code of ConTeXt general was:

```
-- invalid
pdf_startfigure(fignum,0,0,0,0)
pdf_stopfigure()
```

```
        else
```

For legacy behavior, insert 'pre-fig' TEX code here.

```
          if tex_code_pre_mplib[f] then
            put2output(tex_code_pre_mplib[f])
          end
          pdf_startfigure(fignum,llx,lly,urx,ury)
          start_pdf_code()
          if objects then
```

```
2718            local savedpath = nil
2719            local savedhtap = nil
2720            for o=1,#objects do
2721              local object       = objects[o]
2722              local objecttype   = object.type
```

The following 10 lines are part of btex...etex patch. Again, colors are processed at this stage.

```
2723              local prescript    = object.prescript
2724              prescript = prescript and script2table(prescript) -- prescript is now a table
2725              local cr_over = do_preobj_CR(object,prescript) -- color
2726              local tr_opaq = do_preobj_TR(object,prescript) -- opacity
2727              local fading_ = do_preobj_FADE(object,prescript) -- fading
2728              local trgroup = do_preobj_GRP(object,prescript) -- transparency group
2729              local pattern_ = do_preobj_PAT(object,prescript) -- tiling pattern
2730              local shading_ = do_preobj_shading(object,prescript) -- shading pattern
2731              if prescript and prescript.mplibtexboxid then
2732                put_tex_boxes(object,prescript)
2733              elseif objecttype == "start_bounds" or objecttype == "stop_bounds" then --skip
2734              elseif objecttype == "start_clip" then
2735                local evenodd = not object.istext and object.postscript == "evenodd"
2736                start_pdf_code()
2737                flushnormalpath(object.path,false)
2738                pdf_literalcode(evenodd and "W* n" or "W n")
2739              elseif objecttype == "stop_clip" then
2740                stop_pdf_code()
2741                miterlimit, linecap, linejoin, dashed = -1, -1, -1, false
2742              elseif objecttype == "special" then
```

Collect TEX codes that will be executed after flushing. Legacy behavior.

```
2743                if prescript and prescript.postmplibverbtex then
2744                  figcontents.post[#figcontents.post+1] = prescript.postmplibverbtex
2745                end
2746              elseif objecttype == "text" then
2747                local ot = object.transform -- 3,4,5,6,1,2
2748                start_pdf_code()
2749                pdf_literalcode("%f %f %f %f %f %f cm",ot[3],ot[4],ot[5],ot[6],ot[1],ot[2])
2750                pdf_textfigure(object.font,object.dsize,object.text,object.width,object.height,object.depth)
2751                stop_pdf_code()
2752              elseif not trgroup and fading_ ~= "stop" then
2753                local evenodd, collect, both = false, false, false
2754                local postscript = object.postscript
2755                if not object.istext then
2756                  if postscript == "evenodd" then
2757                    evenodd = true
2758                  elseif postscript == "collect" then
2759                    collect = true
2760                  elseif postscript == "both" then
2761                    both = true
2762                  elseif postscript == "eoboth" then
2763                    evenodd = true
2764                    both    = true
2765                  end
2766                end
2767                if collect then
```

```
            if not savedpath then
              savedpath = { object.path or false }
              savedhtap = { object.htap or false }
            else
              savedpath[#savedpath+1] = object.path or false
              savedhtap[#savedhtap+1] = object.htap or false
            end
          else
```

Removed from ConTeXt general: color stuff.

```
            local ml = object.miterlimit
            if ml and ml ~= miterlimit then
              miterlimit = ml
              pdf_literalcode("%f M",ml)
            end
            local lj = object.linejoin
            if lj and lj ~= linejoin then
              linejoin = lj
              pdf_literalcode("%i j",lj)
            end
            local lc = object.linecap
            if lc and lc ~= linecap then
              linecap = lc
              pdf_literalcode("%i J",lc)
            end
            local dl = object.dash
            if dl then
              local d = format("[%s] %f d",tableconcat(dl.dashes or {}," "),dl.offset)
              if d ~= dashed then
                dashed = d
                pdf_literalcode(dashed)
              end
            elseif dashed then
              pdf_literalcode("[] 0 d")
              dashed = false
            end
            local path = object.path
            local transformed, penwidth = false, 1
            local open = path and path[1].left_type and path[#path].right_type
            local pen = object.pen
            if pen then
              if pen.type == 'elliptical' then
                transformed, penwidth = pen_characteristics(object) -- boolean, value
                pdf_literalcode("%f w",penwidth)
                if objecttype == 'fill' then
                  objecttype = 'both'
                end
              else -- calculated by mplib itself
                objecttype = 'fill'
              end
            end
```

Added : shading

```
            local shade_no = do_preobj_SH(object,prescript) -- shading
            if shade_no then
```

```
      pdf_literalcode"q /Pattern cs"
      objecttype = false
    end
    if transformed then
      start_pdf_code()
    end
    if path then
      if savedpath then
        for i=1,#savedpath do
          local path = savedpath[i]
          if transformed then
            flushconcatpath(path,open)
          else
            flushnormalpath(path,open)
          end
        end
        savedpath = nil
      end
      if transformed then
        flushconcatpath(path,open)
      else
        flushnormalpath(path,open)
      end
      if objecttype == "fill" then
        pdf_literalcode(evenodd and "h f*" or "h f")
      elseif objecttype == "outline" then
        if both then
          pdf_literalcode(evenodd and "h B*" or "h B")
        else
          pdf_literalcode(open and "S" or "h S")
        end
      elseif objecttype == "both" then
        pdf_literalcode(evenodd and "h B*" or "h B")
      end
    end
    if transformed then
      stop_pdf_code()
    end
    local path = object.htap
```

How can we generate an htap object? Please let us know if you have succeeded.

```
    if path then
      if transformed then
        start_pdf_code()
      end
      if savedhtap then
        for i=1,#savedhtap do
          local path = savedhtap[i]
          if transformed then
            flushconcatpath(path,open)
          else
            flushnormalpath(path,open)
          end
        end
        savedhtap = nil
```

```
                  evenodd   = true
                end
                if transformed then
                  flushconcatpath(path,open)
                else
                  flushnormalpath(path,open)
                end
                if objecttype == "fill" then
                  pdf_literalcode(evenodd and "h f*" or "h f")
                elseif objecttype == "outline" then
                  pdf_literalcode(open and "S" or "h S")
                elseif objecttype == "both" then
                  pdf_literalcode(evenodd and "h B*" or "h B")
                end
                if transformed then
                  stop_pdf_code()
                end
              end
```

Added to ConTeXt general: post-object colors and shading stuff. We should beware the `q ... Q` scope.

```
              if shade_no then -- shading
                pdf_literalcode("W%s n /MPlibSh%s sh Q",evenodd and "*" or "",shade_no)
              end
            end
          end
          if fading_ == "start" then
            pdfetcs.fading.specialeffects = {fading_, tr_opaq, cr_over}
          elseif trgroup == "start" then
            pdfetcs.tr_group.specialeffects = {fading_, tr_opaq, cr_over}
          elseif fading_ == "stop" then
            local se = pdfetcs.fading.specialeffects
            if se then stop_special_effects(se[1], se[2], se[3]) end
          elseif trgroup == "stop" then
            local se = pdfetcs.tr_group.specialeffects
            if se then stop_special_effects(se[1], se[2], se[3]) end
          else
            stop_special_effects(fading_, tr_opaq, cr_over)
          end
          if fading_ or trgroup then -- extgs resetted
            miterlimit, linecap, linejoin, dashed = -1, -1, -1, false
          end
        end
      end
      stop_pdf_code()
      pdf_stopfigure()
```

output collected materials to PDF, plus legacy `verbatimtex` code.

```
      for _,v in ipairs(figcontents) do
        if type(v) == "table" then
          texsprint"\\mplibtoPDF{"; texsprint(v[1], v[2]); texsprint"}"
        else
          texsprint(v)
        end
      end
```

```
          if #figcontents.post > 0 then texsprint(figcontents.post) end
          figcontents = { post = { } }
        end
      end
    end
  end
end

function luamplib.colorconverter (cr)
  local n = #cr
  if n == 4 then
    local c, m, y, k = cr[1], cr[2], cr[3], cr[4]
    return format("%.3f %.3f %.3f %.3f k %.3f %.3f %.3f %.3f K",c,m,y,k,c,m,y,k), "0 g 0 G"
  elseif n == 3 then
    local r, g, b = cr[1], cr[2], cr[3]
    return format("%.3f %.3f %.3f rg %.3f %.3f %.3f RG",r,g,b,r,g,b), "0 g 0 G"
  else
    local s = cr[1]
    return format("%.3f g %.3f G",s,s), "0 g 0 G"
  end
end
```

2.2 TEX package

First we need to load some packages.

```
\ifcsname ProvidesPackage\endcsname
```

We need LaTeX 2024-06-01 as we use `ltx.pdf.object_id` when pdfmanagement is loaded. But as fp package does not accept an option, we do not append the date option.

```
  \NeedsTeXFormat{LaTeX2e}
  \ProvidesPackage{luamplib}
    [2025/02/06 v2.37.0 mplib package for LuaTeX]
\fi
\ifdefined\newluafunction\else
  \input ltluatex
\fi
```

In DVI mode, a new XObject (mppattern, mplibgroup) must be encapsulated in an `\hbox`. But this should not affect typesetting. So we use Hook mechanism provided by LaTeX kernel. In Plain, atbegshi.sty is loaded.

```
\ifnum\outputmode=0
  \ifdefined\AddToHookNext
    \def\luamplibatnextshipout{\AddToHookNext{shipout/background}}
    \def\luamplibatfirstshipout{\AddToHook{shipout/firstpage}}
    \def\luamplibateveryshipout{\AddToHook{shipout/background}}
  \else
    \input atbegshi.sty
    \def\luamplibatnextshipout#1{\AtBeginShipoutNext{\AtBeginShipoutAddToBox{#1}}}
    \let\luamplibatfirstshipout\AtBeginShipoutFirst
    \def\luamplibateveryshipout#1{\AtBeginShipout{\AtBeginShipoutAddToBox{#1}}}
  \fi
\fi
```

Loading of lua code.

```
\directlua{require("luamplib")}
```

legacy commands. Seems we don't need it, but no harm.

```
\ifx\pdfoutput\undefined
  \let\pdfoutput\outputmode
\fi
\ifx\pdfliteral\undefined
  \protected\def\pdfliteral{\pdfextension literal}
\fi
```

Set the format for METAPOST.

```
\def\mplibsetformat#1{\directlua{luamplib.setformat("#1")}}
```

luamplib works in both PDF and DVI mode, but only DVIPDFMx is supported currently among a number of DVI tools. So we output a info.

```
\ifnum\pdfoutput>0
  \let\mplibtoPDF\pdfliteral
\else
  \def\mplibtoPDF#1{\special{pdf:literal direct #1}}
  \ifcsname PackageInfo\endcsname
    \PackageInfo{luamplib}{only dvipdfmx is supported currently}
  \else
    \immediate\write-1{luamplib Info: only dvipdfmx is supported currently}
  \fi
\fi
```

To make mplibcode typeset always in horizontal mode.

```
\def\mplibforcehmode{\let\prependtomplibbox\leavevmode}
\def\mplibnoforcehmode{\let\prependtomplibbox\relax}
\mplibnoforcehmode
```

Catcode. We want to allow comment sign in mplibcode.

```
\def\mplibsetupcatcodes{%
  %catcode`\{=12 %catcode`\}=12
  \catcode`\#=12 \catcode`\^=12 \catcode`\~=12 \catcode`\_=12
  \catcode`\&=12 \catcode`\$=12 \catcode`\%=12 \catcode`\^^M=12
}
```

Make btex...etex box zero-metric.

```
\def\mplibputtextbox#1{\vbox to 0pt{\vss\hbox to 0pt{\raise\dp#1\copy#1\hss}}}
```

use Transparency Group

```
\protected\def\usemplibgroup#1#{\usemplibgroupmain}
\def\usemplibgroupmain#1{%
  \mplibstarttousemplibgroup
  \csname luamplib.group.#1\endcsname
  \mplibstoptousemplibgroup
}
\def\mplibstarttousemplibgroup{\prependtomplibbox\hbox dir TLT\bgroup}
\def\mplibstoptousemplibgroup{\egroup}
\protected\def\mplibgroup#1{%
  \begingroup
  \def\MPllx{0}\def\MPlly{0}%
  \def\mplibgroupname{#1}%
  \mplibgroupgetnexttok
}
\def\mplibgroupgetnexttok{\futurelet\nexttok\mplibgroupbranch}
\def\mplibgroupskipspace{\afterassignment\mplibgroupgetnexttok\let\nexttok= }
```

```
\def\mplibgroupbranch{%
  \ifx [\nexttok
    \expandafter\mplibgroupopts
  \else
    \ifx\mplibsptoken\nexttok
      \expandafter\expandafter\expandafter\mplibgroupskipspace
    \else
      \let\mplibgroupoptions\empty
      \expandafter\expandafter\expandafter\mplibgroupmain
    \fi
  \fi
}
\def\mplibgroupopts[#1]{\def\mplibgroupoptions{#1}\mplibgroupmain}
\def\mplibgroupmain{\setbox\mplibscratchbox\hbox\bgroup\ignorespaces}
\protected\def\endmplibgroup{\egroup
  \directlua{ luamplib.registergroup(
    \the\mplibscratchbox, '\mplibgroupname', {\mplibgroupoptions}
  )}%
  \endgroup
}
```

Patterns

```
{\def\:{\global\let\mplibsptoken= } \: }
\protected\def\mppattern#1{%
  \begingroup
  \def\mplibpatternname{#1}%
  \mplibpatterngetnexttok
}
\def\mplibpatterngetnexttok{\futurelet\nexttok\mplibpatternbranch}
\def\mplibpatternskipspace{\afterassignment\mplibpatterngetnexttok\let\nexttok= }
\def\mplibpatternbranch{%
  \ifx [\nexttok
    \expandafter\mplibpatternopts
  \else
    \ifx\mplibsptoken\nexttok
      \expandafter\expandafter\expandafter\mplibpatternskipspace
    \else
      \let\mplibpatternoptions\empty
      \expandafter\expandafter\expandafter\mplibpatternmain
    \fi
  \fi
}
\def\mplibpatternopts[#1]{%
  \def\mplibpatternoptions{#1}%
  \mplibpatternmain
}
\def\mplibpatternmain{%
  \setbox\mplibscratchbox\hbox\bgroup\ignorespaces
}
\protected\def\endmppattern{%
  \egroup
  \directlua{ luamplib.registerpattern(
    \the\mplibscratchbox, '\mplibpatternname', {\mplibpatternoptions}
  )}%
  \endgroup
```

```
}
```

simple way to use mplib: `\mpfig draw fullcircle scaled 10; \endmpfig`

```
\def\mpfiginstancename{@mpfig}
\protected\def\mpfig{%
  \begingroup
  \futurelet\nexttok\mplibmpfigbranch
}
\def\mplibmpfigbranch{%
  \ifx *\nexttok
    \expandafter\mplibprempfig
  \else
    \ifx [\nexttok
      \expandafter\expandafter\expandafter\mplibgobbleoptsmpfig
    \else
      \expandafter\expandafter\expandafter\mplibmainmpfig
    \fi
  \fi
}
\def\mplibgobbleoptsmpfig[#1]{\mplibmainmpfig}
\def\mplibmainmpfig{%
  \begingroup
  \mplibsetupcatcodes
  \mplibdomainmpfig
}
\long\def\mplibdomainmpfig#1\endmpfig{%
  \endgroup
  \directlua{
    local legacy = luamplib.legacyverbatimtex
    local everympfig = luamplib.everymplib["\mpfiginstancename"] or ""
    local everyendmpfig = luamplib.everyendmplib["\mpfiginstancename"] or ""
    luamplib.legacyverbatimtex = false
    luamplib.everymplib["\mpfiginstancename"] = ""
    luamplib.everyendmplib["\mpfiginstancename"] = ""
    luamplib.process_mplibcode(
    "beginfig(0) "..everympfig.." "..[===[\unexpanded{#1}]===].." "..everyendmpfig.." endfig;",
    "\mpfiginstancename")
    luamplib.legacyverbatimtex = legacy
    luamplib.everymplib["\mpfiginstancename"] = everympfig
    luamplib.everyendmplib["\mpfiginstancename"] = everyendmpfig
  }%
  \endgroup
}
\def\mplibprempfig#1{%
  \begingroup
  \mplibsetupcatcodes
  \mplibdoprempfig
}
\long\def\mplibdoprempfig#1\endmpfig{%
  \endgroup
  \directlua{
    local legacy = luamplib.legacyverbatimtex
    local everympfig = luamplib.everymplib["\mpfiginstancename"]
    local everyendmpfig = luamplib.everyendmplib["\mpfiginstancename"]
    luamplib.legacyverbatimtex = false
```

```
    luamplib.everymplib["\mpfiginstancename"] = ""
    luamplib.everyendmplib["\mpfiginstancename"] = ""
    luamplib.process_mplibcode([===[\unexpanded{#1}]===],"\mpfiginstancename")
    luamplib.legacyverbatimtex = legacy
    luamplib.everymplib["\mpfiginstancename"] = everympfig
    luamplib.everyendmplib["\mpfiginstancename"] = everyendmpfig
  }%
  \endgroup
}
\protected\def\endmpfig{endmpfig}
```

The Plain-specific stuff.

```
\unless\ifcsname ver@luamplib.sty\endcsname
  \def\mplibcodegetinstancename[#1]{\xdef\currentmpinstancename{#1}\mplibcodeindeed}
  \protected\def\mplibcode{%
    \begingroup
    \futurelet\nexttok\mplibcodebranch
  }
  \def\mplibcodebranch{%
    \ifx [\nexttok
      \expandafter\mplibcodegetinstancename
    \else
      \global\let\currentmpinstancename\empty
      \expandafter\mplibcodeindeed
    \fi
  }
  \def\mplibcodeindeed{%
    \begingroup
    \mplibsetupcatcodes
    \mplibdocode
  }
  \long\def\mplibdocode#1\endmplibcode{%
    \endgroup
    \directlua{luamplib.process_mplibcode([===[\unexpanded{#1}]===],"\currentmpinstancename")}%
    \endgroup
  }
  \protected\def\endmplibcode{endmplibcode}
\else
```

The LaTeX-specific part: a new environment.

```
  \newenvironment{mplibcode}[1][]{%
    \xdef\currentmpinstancename{#1}%
    \mplibtmptoks{}\ltxdomplibcode
  }{}
  \def\ltxdomplibcode{%
    \begingroup
    \mplibsetupcatcodes
    \ltxdomplibcodeindeed
  }
  \def\mplib@mplibcode{mplibcode}
  \long\def\ltxdomplibcodeindeed#1\end#2{%
    \endgroup
    \mplibtmptoks\expandafter{\the\mplibtmptoks#1}%
    \def\mplibtemp@a{#2}%
    \ifx\mplib@mplibcode\mplibtemp@a
```

```
      \directlua{luamplib.process_mplibcode([===[\the\mplibtmptoks]===],"\currentmpinstancename")}%
      \end{mplibcode}%
    \else
      \mplibtmptoks\expandafter{\the\mplibtmptoks\end{#2}}%
      \expandafter\ltxdomplibcode
    \fi
  }
\fi
```

User settings.

```
\def\mplibshowlog#1{\directlua{
    local s = string.lower("#1")
    if s == "enable" or s == "true" or s == "yes" then
      luamplib.showlog = true
    else
      luamplib.showlog = false
    end
}}
\def\mpliblegacybehavior#1{\directlua{
    local s = string.lower("#1")
    if s == "enable" or s == "true" or s == "yes" then
      luamplib.legacyverbatimtex = true
    else
      luamplib.legacyverbatimtex = false
    end
}}
\def\mplibverbatim#1{\directlua{
    local s = string.lower("#1")
    if s == "enable" or s == "true" or s == "yes" then
      luamplib.verbatiminput = true
    else
      luamplib.verbatiminput = false
    end
}}
\newtoks\mplibtmptoks
```

\everymplib & \everyendmplib: macros resetting luamplib.every(end)mplib tables

```
\ifcsname ver@luamplib.sty\endcsname
  \protected\def\everymplib{%
    \begingroup
    \mplibsetupcatcodes
    \mplibdoeverymplib
  }
  \protected\def\everyendmplib{%
    \begingroup
    \mplibsetupcatcodes
    \mplibdoeveryendmplib
  }
  \newcommand\mplibdoeverymplib[2][]{%
    \endgroup
    \directlua{
      luamplib.everymplib["#1"] = [===[\unexpanded{#2}]===]
    }%
  }
  \newcommand\mplibdoeveryendmplib[2][]{%
```

```
    \endgroup
    \directlua{
      luamplib.everyendmplib["#1"] = [===[\unexpanded{#2}]===]
    }%
  }
\else
  \def\mplibgetinstancename[#1]{\def\currentmpinstancename{#1}}
  \protected\def\everymplib#1#{%
    \ifx\empty#1\empty \mplibgetinstancename[]\else \mplibgetinstancename#1\fi
    \begingroup
    \mplibsetupcatcodes
    \mplibdoeverymplib
  }
  \long\def\mplibdoeverymplib#1{%
    \endgroup
    \directlua{
      luamplib.everymplib["\currentmpinstancename"] = [===[\unexpanded{#1}]===]
    }%
  }
  \protected\def\everyendmplib#1#{%
    \ifx\empty#1\empty \mplibgetinstancename[]\else \mplibgetinstancename#1\fi
    \begingroup
    \mplibsetupcatcodes
    \mplibdoeveryendmplib
  }
  \long\def\mplibdoeveryendmplib#1{%
    \endgroup
    \directlua{
      luamplib.everyendmplib["\currentmpinstancename"] = [===[\unexpanded{#1}]===]
    }%
  }
\fi
```

Allow TEX dimen/color macros. Now `runscript` does the job, so the following lines are not needed for most cases.

```
\def\mpdim#1{ runscript("luamplibdimen{#1}") }
\def\mpcolor#1#{\domplibcolor{#1}}
\def\domplibcolor#1#2{ runscript("luamplibcolor{#1{#2}}") }
```

mplib's number system. Now `binary` has gone away.

```
\def\mplibnumbersystem#1{\directlua{
  local t = "#1"
  if t == "binary" then t = "decimal" end
  luamplib.numbersystem = t
}}
```

Settings for `.mp` cache files.

```
\def\mplibmakenocache#1{\mplibdomakenocache #1,*,}
\def\mplibdomakenocache#1,{%
  \ifx\empty#1\empty
    \expandafter\mplibdomakenocache
  \else
    \ifx*#1\else
      \directlua{luamplib.noneedtoreplace["#1.mp"]=true}%
      \expandafter\expandafter\expandafter\mplibdomakenocache
```

```
    \fi
  \fi
}
\def\mplibcancelnocache#1{\mplibdocancelnocache #1,*,}
\def\mplibdocancelnocache#1,{%
  \ifx\empty#1\empty
    \expandafter\mplibdocancelnocache
  \else
    \ifx*#1\else
      \directlua{luamplib.noneedtoreplace["#1.mp"]=false}%
      \expandafter\expandafter\expandafter\mplibdocancelnocache
    \fi
  \fi
}
\def\mplibcachedir#1{\directlua{luamplib.getcachedir("\unexpanded{#1}")}}
```

More user settings.

```
\def\mplibtextextlabel#1{\directlua{
    local s = string.lower("#1")
    if s == "enable" or s == "true" or s == "yes" then
      luamplib.textextlabel = true
    else
      luamplib.textextlabel = false
    end
}}
\def\mplibcodeinherit#1{\directlua{
    local s = string.lower("#1")
    if s == "enable" or s == "true" or s == "yes" then
      luamplib.codeinherit = true
    else
      luamplib.codeinherit = false
    end
}}
\def\mplibglobaltextext#1{\directlua{
    local s = string.lower("#1")
    if s == "enable" or s == "true" or s == "yes" then
      luamplib.globaltextext = true
    else
      luamplib.globaltextext = false
    end
}}
```

The followings are from ConTeXt general, mostly.

We use a dedicated scratchbox.

```
\ifx\mplibscratchbox\undefined \newbox\mplibscratchbox \fi
```

We encapsulate the literals.

```
\def\mplibstarttoPDF#1#2#3#4{%
  \prependtomplibbox
  \hbox dir TLT\bgroup
  \xdef\MPllx{#1}\xdef\MPlly{#2}%
  \xdef\MPurx{#3}\xdef\MPury{#4}%
  \xdef\MPwidth{\the\dimexpr#3bp-#1bp\relax}%
  \xdef\MPheight{\the\dimexpr#4bp-#2bp\relax}%
  \parskip0pt%
```

```
  \leftskip0pt%
  \parindent0pt%
  \everypar{}%
  \setbox\mplibscratchbox\vbox\bgroup
  \noindent
}
\def\mplibstoptoPDF{%
  \par
  \egroup %
  \setbox\mplibscratchbox\hbox %
    {\hskip-\MPllx bp%
     \raise-\MPlly bp%
     \box\mplibscratchbox}%
  \setbox\mplibscratchbox\vbox to \MPheight
    {\vfill
     \hsize\MPwidth
     \wd\mplibscratchbox0pt%
     \ht\mplibscratchbox0pt%
     \dp\mplibscratchbox0pt%
     \box\mplibscratchbox}%
  \wd\mplibscratchbox\MPwidth
  \ht\mplibscratchbox\MPheight
  \box\mplibscratchbox
  \egroup
}
```

Text items have a special handler.

```
\def\mplibtextext#1#2#3#4#5{%
  \begingroup
  \setbox\mplibscratchbox\hbox
    {\font\temp=#1 at #2bp%
     \temp
     #3}%
  \setbox\mplibscratchbox\hbox
    {\hskip#4 bp%
     \raise#5 bp%
     \box\mplibscratchbox}%
  \wd\mplibscratchbox0pt%
  \ht\mplibscratchbox0pt%
  \dp\mplibscratchbox0pt%
  \box\mplibscratchbox
  \endgroup
}
```

Input `luamplib.cfg` when it exists.

```
\openin0=luamplib.cfg
\ifeof0 \else
  \closein0
  \input luamplib.cfg
\fi
```

Code for **tagpdf**

```
\def\luamplibtagtextbegin#1{}
\let\luamplibtagtextend\relax
\let\luamplibtagasgroupbegin\relax
```

```
\let\luamplibtagasgroupend\relax
\ifcsname SuspendTagging\endcsname\else\endinput\fi
\ifcsname ver@tagpdf.sty\endcsname \else
  \ExplSyntaxOn
  \keys_define:nn{luamplib/notag}
    {
      ,alt          .code:n = { }
      ,actualtext   .code:n = { }
      ,artifact     .code:n = { }
      ,text         .code:n = { }
      ,correct-BBox .code:n = { }
      ,tag          .code:n = { }
      ,debug        .code:n = { }
      ,instance     .code:n = { \tl_gset:Nn \currentmpinstancename {#1} }
      ,instancename .meta:n = { instance = {#1} }
      ,unknown      .code:n = { \tl_gset:Ne \currentmpinstancename {\l_keys_key_str} }
    }
  \RenewDocumentCommand\mplibcode{O{}}
    {
      \tl_gset_eq:NN \currentmpinstancename \c_empty_tl
      \keys_set:ne{luamplib/notag}{#1}
      \mplibtmptoks{}\ltxdomplibcode
    }
  \ExplSyntaxOff
  \let\mplibalttext \luamplibtagtextbegin
  \let\mplibactualtext \mplibalttext
  \endinput\fi
\let\mplibstarttoPDForiginal\mplibstarttoPDF
\let\mplibstoptoPDForiginal\mplibstoptoPDF
\let\mplibputtextboxoriginal\mplibputtextbox
\let\mplibstarttousemplibgrouporiginal\mplibstarttousemplibgroup
\let\mplibstoptousemplibgrouporiginal\mplibstoptousemplibgroup
\ExplSyntaxOn
\tl_new:N \l__luamplib_tag_alt_tl
\tl_new:N \l__luamplib_tag_alt_dflt_tl
\tl_set:Nn\l__luamplib_tag_alt_dflt_tl {metapost~figure}
\tl_new:N \l__luamplib_tag_actual_tl
\tl_new:N \l__luamplib_tag_struct_tl
\tl_set:Nn\l__luamplib_tag_struct_tl {Figure}
\bool_new:N \l__luamplib_tag_usetext_bool
\bool_new:N \l__luamplib_tag_BBox_bool
\bool_set_true:N \l__luamplib_tag_BBox_bool
\seq_new:N\l__luamplib_tag_bboxcorr_seq
\bool_new:N\l__luamplib_tag_bboxcorr_bool
\bool_new:N \l__luamplib_tag_debug_bool
\tl_new:N \l__luamplib_BBox_label_tl
\tl_new:N \l__luamplib_BBox_llx_tl
\tl_new:N \l__luamplib_BBox_lly_tl
\tl_new:N \l__luamplib_BBox_urx_tl
\tl_new:N \l__luamplib_BBox_ury_tl
\cs_set_nopar:Npn \luamplibtagtextbegin #1
{
  \bool_if:NTF \l__luamplib_tag_usetext_bool
  {
```

```
    \tag_mc_end_push:
    \tag_mc_begin:n{}
    \tag_struct_begin:n{tag=NonStruct,stash}
    \def\myboxnum{#1}
    \edef\mystructnum{\tag_get:n{struct_num}}
    \edef\statebeforebox{\inteval{\tag_get:n{struct_counter}+\tag_get:n{mc_counter}}}
  }
  {
    \tag_if_active:TF
      { \bool_set_true:N \l_tmpa_bool }
      { \bool_set_false:N \l_tmpa_bool }
    \SuspendTagging{luamplib.textext}
  }
}
\cs_set_nopar:Npn \luamplibtagtextend
{
  \bool_if:NTF \l__luamplib_tag_usetext_bool
  {
    \edef\stateafterbox{\inteval{\tag_get:n{struct_counter}+\tag_get:n{mc_counter}}}
    \tag_if_active:T {
      \int_compare:nNnTF
      {\stateafterbox}
      =
      {\statebeforebox}
      { \cs_gset_nopar:cpe {luamplib.notagbox.\myboxnum} {\mystructnum} }
      { \cs_gset_nopar:cpe {luamplib.tagbox.\myboxnum} {\mystructnum} }
    }
    \tag_struct_end:
    \tag_mc_end:
    \tag_mc_begin_pop:n{}
  }
  {
    \bool_if:NT \l_tmpa_bool
      { \ResumeTagging{luamplib.textext} }
  }
}
\msg_new:nnn {luamplib}{figure-text-reuse}
{
  textext~box~#1~probably~is~incorrectly~tagged.\\
  Reusing~a~box~in~text-keyed~figures~is~strongly~discouraged.
}
\cs_set_nopar:Npn \mplibputtextbox #1
{
  \vbox to 0pt{\vss\hbox to 0pt{%
    \bool_if:NTF \l__luamplib_tag_usetext_bool
    {
      \ResumeTagging{luamplib.puttextbox}
      \tag_mc_end:
      \cs_if_exist:cTF {luamplib.tagbox.#1}
      {
        \tag_struct_use_num:n {\csname luamplib.tagbox.#1\endcsname}
        \raise\dp#1\copy#1
      }
      {
```

```
        \cs_if_exist:cF {luamplib.notagbox.#1}
        {
          \msg_warning:nnn{luamplib}{figure-text-reuse}{#1}
        }
        \tag_mc_begin:n{}
        \int_set:Nn \l_tmpa_int {#1}
        \tag_mc_reset_box:N \l_tmpa_int
        \raise\dp#1\copy#1
        \tag_mc_end:
      }
      \tag_mc_begin:n{artifact}
    }
    {
      \int_set:Nn \l_tmpa_int {#1}
      \tag_mc_reset_box:N \l_tmpa_int
      \raise\dp#1\copy#1
    }
  \hss}}
}
\cs_new_nopar:Npn \__luamplib_tagging_begin_figure:
{
  \tag_if_active:T
  {
    \tag_mc_end_push:
    \tl_if_empty:NT\l__luamplib_tag_alt_tl
    {
      \msg_warning:nne{luamplib}{alt-text-missing}{\l__luamplib_tag_alt_dflt_tl}
      \tl_set:Ne\l__luamplib_tag_alt_tl {\l__luamplib_tag_alt_dflt_tl}
    }
    \tag_struct_begin:n
    {
      tag=\l__luamplib_tag_struct_tl,
      alt=\l__luamplib_tag_alt_tl,
    }
    \tag_mc_begin:n{}
  }
}
\cs_new_nopar:Npn \__luamplib_tagging_end_figure:
{
  \tag_if_active:T
  {
    \tag_mc_end:
    \tag_struct_end:
    \tag_mc_begin_pop:n{}
  }
}
\cs_new_nopar:Npn \__luamplib_tagging_begin_actualtext:
{
  \tag_if_active:T
  {
    \tag_mc_end_push:
    \tag_struct_begin:n
    {
      tag=Span,
```

```
      actualtext=\l__luamplib_tag_actual_tl,
    }
    \tag_mc_begin:n{}
  }
}
\cs_set_eq:NN \__luamplib_tagging_end_actualtext: \__luamplib_tagging_end_figure:
\cs_new_nopar:Npn \__luamplib_tagging_begin_artifact:
{
  \tag_if_active:T
  {
    \tag_mc_end_push:
    \tag_mc_begin:n{artifact}
  }
}
\cs_new_nopar:Npn \__luamplib_tagging_end_artifact:
{
  \tag_if_active:T
  {
    \tag_mc_end:
    \tag_mc_begin_pop:n{}
  }
}
\cs_set_eq:NN \luamplibtaggingbegin \__luamplib_tagging_begin_figure:
\cs_set_eq:NN \luamplibtaggingend \__luamplib_tagging_end_figure:
\keys_define:nn{luamplib/tag}
  {
    ,alt .code:n =
      {
        \tl_set:Ne\l__luamplib_tag_alt_tl{\text_purify:n{#1}}
      }
    ,actualtext .code:n =
      {
        \bool_set_false:N \l__luamplib_tag_BBox_bool
        \tl_set:Ne\l__luamplib_tag_actual_tl{\text_purify:n{#1}}
        \cs_set_eq:NN \luamplibtaggingbegin \__luamplib_tagging_begin_actualtext:
        \cs_set_eq:NN \luamplibtaggingend \__luamplib_tagging_end_actualtext:
        \tag_if_active:T {\noindent}
      }
    ,artifact .code:n =
      {
        \bool_set_false:N \l__luamplib_tag_BBox_bool
        \cs_set_eq:NN \luamplibtaggingbegin \__luamplib_tagging_begin_artifact:
        \cs_set_eq:NN \luamplibtaggingend \__luamplib_tagging_end_artifact:
      }
    ,text .code:n =
      {
        \bool_set_false:N \l__luamplib_tag_BBox_bool
        \bool_set_true:N  \l__luamplib_tag_usetext_bool
        \cs_set_eq:NN \luamplibtaggingbegin \__luamplib_tagging_begin_artifact:
        \cs_set_eq:NN \luamplibtaggingend \__luamplib_tagging_end_artifact:
        \tag_if_active:T {\noindent}
      }
    ,tag .code:n =
      {
```

```
      \str_case:nnF {#1}
        {
          {text}
          {
            \bool_set_false:N \l__luamplib_tag_BBox_bool
            \bool_set_true:N  \l__luamplib_tag_usetext_bool
            \cs_set_eq:NN \luamplibtaggingbegin \__luamplib_tagging_begin_artifact:
            \cs_set_eq:NN \luamplibtaggingend \__luamplib_tagging_end_artifact:
            \tag_if_active:T {\noindent}
          }
          {false}
          {
            \SuspendTagging{luamplib.tagfalse}
          }
        }
        {
          \tl_set:Nn\l__luamplib_tag_struct_tl{#1}
        }
    }
  ,correct-BBox .code:n =
    {
      \bool_set_true:N \l__luamplib_tag_bboxcorr_bool
      \seq_set_split:Nnn \l__luamplib_tag_bboxcorr_seq{~}{#1~0pt~0pt~0pt~0pt}
    }
  ,debug .code:n =
    { \bool_set_true:N \l__luamplib_tag_debug_bool }
  ,instance .code:n =
    { \tl_gset:Nn \currentmpinstancename {#1} }
  ,instancename .meta:n = { instance = {#1} }
  ,unknown .code:n =
    { \tl_gset:Ne \currentmpinstancename {\l_keys_key_str} }
}
\cs_new_nopar:Npn \luamplibtaggingBBox
{
  \bool_lazy_and:nnT
  {\tag_if_active_p:}
  {\l__luamplib_tag_BBox_bool}
  {
    \tl_set:Ne \l__luamplib_BBox_label_tl {luamplib.BBox.\tag_get:n{struct_num}}
    \tex_savepos:D
    \property_record:ee{\l__luamplib_BBox_label_tl}{xpos,ypos,abspage}
    \tl_set:Ne \l__luamplib_BBox_llx_tl
      {
        \dim_to_decimal_in_bp:n
        { \property_ref:een {\l__luamplib_BBox_label_tl}{xpos}{0}sp }
      }
    \tl_set:Ne \l__luamplib_BBox_lly_tl
      {
        \dim_to_decimal_in_bp:n
        { \property_ref:een {\l__luamplib_BBox_label_tl}{ypos}{0}sp - \dp\mplibscratchbox }
      }
    \tl_set:Ne \l__luamplib_BBox_urx_tl
      {
        \dim_to_decimal_in_bp:n
```

```
      { \l__luamplib_BBox_llx_tl bp + \wd\mplibscratchbox }
    }
  \tl_set:Ne \l__luamplib_BBox_ury_tl
    {
      \dim_to_decimal_in_bp:n
      { \l__luamplib_BBox_lly_tl bp + \ht\mplibscratchbox + \dp\mplibscratchbox }
    }
  \bool_if:NT \l__luamplib_tag_bboxcorr_bool
    {
      \tl_set:Ne \l__luamplib_BBox_llx_tl
        {
          \fp_eval:n
          {
            \l__luamplib_BBox_llx_tl
            +
            \dim_to_decimal_in_bp:n {\seq_item:Nn \l__luamplib_tag_bboxcorr_seq {1} }
          }
        }
      \tl_set:Ne \l__luamplib_BBox_lly_tl
        {
          \fp_eval:n
          {
            \l__luamplib_BBox_lly_tl
            +
            \dim_to_decimal_in_bp:n {\seq_item:Nn \l__luamplib_tag_bboxcorr_seq {2} }
          }
        }
      \tl_set:Ne \l__luamplib_BBox_urx_tl
        {
          \fp_eval:n
          {
            \l__luamplib_BBox_urx_tl
            +
            \dim_to_decimal_in_bp:n {\seq_item:Nn \l__luamplib_tag_bboxcorr_seq {3} }
          }
        }
      \tl_set:Ne \l__luamplib_BBox_ury_tl
        {
          \fp_eval:n
          {
            \l__luamplib_BBox_ury_tl
            +
            \dim_to_decimal_in_bp:n {\seq_item:Nn \l__luamplib_tag_bboxcorr_seq {4} }
          }
        }
    }
  \prop_gput:cne
    { g__tag_struct_\tag_get:n{struct_num}_prop }
    {A}
    {
      << /O /Layout /BBox [
        \l__luamplib_BBox_llx_tl\c_space_tl
        \l__luamplib_BBox_lly_tl\c_space_tl
        \l__luamplib_BBox_urx_tl\c_space_tl
```

```
          \l__luamplib_BBox_ury_tl
        ] >>
      }
    \bool_if:NT \l__luamplib_tag_debug_bool
      {
        \iow_log:e
          {
            luamplib/tag/debug:~BBox~of~structure~\tag_get:n{struct_num}~is~
            \l__luamplib_BBox_llx_tl\c_space_tl
            \l__luamplib_BBox_lly_tl\c_space_tl
            \l__luamplib_BBox_urx_tl\c_space_tl
            \l__luamplib_BBox_ury_tl
          }
        \use:e
        {
          \exp_not:N\AddToHookNext{shipout/foreground}
          {
            \exp_not:N\int_compare:nNnT
            {\exp_not:N\g_shipout_readonly_int}
            =
            {\property_ref:een{\l__luamplib_BBox_label_tl}{abspage}{0}}
            {
              \exp_not:N\put
              (\l__luamplib_BBox_llx_tl bp, \dim_eval:n{\l__luamplib_BBox_lly_tl bp -\paperheight})
              {
                \exp_not:N\opacity_select:n{0.5} \exp_not:N\color_select:n{red}
                \exp_not:N\rule
                  {\dim_eval:n {\l__luamplib_BBox_urx_tl bp - \l__luamplib_BBox_llx_tl bp}}
                  {\dim_eval:n {\l__luamplib_BBox_ury_tl bp - \l__luamplib_BBox_lly_tl bp}}
              }
            }
          }
        }
      }
  }
}
\cs_set_nopar:Npn \luamplibtagasgroupbegin
{
  \bool_if:NT \l__luamplib_tag_usetext_bool
  {
    \ResumeTagging{luamplib.asgroup}
    \tag_mc_begin:n{}
  }
}
\cs_set_nopar:Npn \luamplibtagasgroupend
{
  \bool_if:NT \l__luamplib_tag_usetext_bool
  {
    \tag_mc_end:
    \SuspendTagging{luamplib.asgroup}
  }
}
\cs_set_nopar:Npn \mplibstarttousemplibgroup
{
```

```
  \prependtomplibbox\hbox dir TLT\bgroup
  \luamplibtaggingbegin
  \setbox\mplibscratchbox\hbox\bgroup
  \bool_if:NT \l__luamplib_tag_usetext_bool
  {
    \tag_mc_end:
    \tag_mc_begin:n{}
  }
}
\cs_set_nopar:Npn \mplibstoptousemplibgroup
{
  \bool_if:NT \l__luamplib_tag_usetext_bool
  {
    \tag_mc_end:
    \tag_mc_begin:n{artifact}
  }
  \egroup
  \luamplibtaggingBBox
  \unhbox\mplibscratchbox
  \luamplibtaggingend
  \egroup
}
\cs_set_nopar:Npn \mplibstarttoPDF #1 #2 #3 #4
  {
    \prependtomplibbox
    \hbox dir TLT\bgroup
    \luamplibtaggingbegin % begin tagging
    \xdef\MPllx{#1}\xdef\MPlly{#2}%
    \xdef\MPurx{#3}\xdef\MPury{#4}%
    \xdef\MPwidth{\the\dimexpr#3bp-#1bp\relax}%
    \xdef\MPheight{\the\dimexpr#4bp-#2bp\relax}%
    \parskip0pt
    \leftskip0pt
    \parindent0pt
    \everypar{}%
    \setbox\mplibscratchbox\vbox\bgroup
    \SuspendTagging{luamplib.mplibtopdf}% stop tag inside figure
    \noindent
  }
\cs_set_nopar:Npn \mplibstoptoPDF
  {
    \par
    \egroup
    \setbox\mplibscratchbox\hbox
      {\hskip-\MPllx bp
       \raise-\MPlly bp
       \box\mplibscratchbox}%
    \setbox\mplibscratchbox\vbox to \MPheight
      {\vfill
       \hsize\MPwidth
       \wd\mplibscratchbox0pt
       \ht\mplibscratchbox0pt
       \dp\mplibscratchbox0pt
       \box\mplibscratchbox}%
```

```
    \wd\mplibscratchbox\MPwidth
    \ht\mplibscratchbox\MPheight
    \luamplibtaggingBBox % BBox
    \box\mplibscratchbox
    \luamplibtaggingend % end tagging
    \egroup
  }
\RenewDocumentCommand\mplibcode{O{}}
  {
    \msg_set:nnn {luamplib}{alt-text-missing}
    {
      Alternative~text~for~mplibcode~is~missing.\\
      Using~the~default~value~'##1'~instead.
    }
    \tl_gset_eq:NN \currentmpinstancename \c_empty_tl
    \keys_set:ne{luamplib/tag}{#1}
    \tl_if_empty:NF \currentmpinstancename
      { \tl_set:Nn\l__luamplib_tag_alt_dflt_tl {metapost~figure~\currentmpinstancename} }
    \mplibtmptoks{}\ltxdomplibcode
  }
\RenewDocumentCommand\mpfig{s O{}}
  {
    \begingroup
    \IfBooleanTF{#1}
    {\mplibprempfig *}
    {
      \msg_set:nnn {luamplib}{alt-text-missing}
      {
        Alternative~text~for~mpfig~is~missing.\\
        Using~the~default~value~'##1'~instead.
      }
      \keys_set:ne{luamplib/tag}{#2}
      \tl_if_empty:NF \mpfiginstancename
        { \tl_set:Nn\l__luamplib_tag_alt_dflt_tl {metapost~figure~\mpfiginstancename} }
      \mplibmainmpfig
    }
  }
\RenewDocumentCommand\usemplibgroup{O{} m}
  {
    \begingroup
    \msg_set:nnn {luamplib}{alt-text-missing}
    {
      Alternative~text~for~usemplibgroup~is~missing.\\
      Using~the~default~value~'##1'~instead.
    }
    \keys_set:ne{luamplib/tag}{#1}
    \tl_set:Nn\l__luamplib_tag_alt_dflt_tl {metapost~figure~#2}
    \mplibstarttousemplibgroup
    \csname luamplib.group.#2\endcsname
    \mplibstoptousemplibgroup
    \endgroup
  }
\cs_new_nopar:Npn \mplibalttext #1
{
```

```
  \tl_set:Ne \l__luamplib_tag_alt_tl {\text_purify:n{#1}}
}
\cs_new_nopar:Npn \mplibactualtext #1
{
  \tl_set:Ne \l__luamplib_tag_actual_tl {\text_purify:n{#1}}
}
\ExplSyntaxOff
```

That's all folks!

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```
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```

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```
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Gnomovision comes with ABSOLUTELY NO WARRANTY; for details
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tain conditions; type `show c' for details.
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```
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