The luamplib package

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Abstract

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

1 Documentation

This packages 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 (in Lua) for the Lua `mplib` functions and some TEX functions to have the output of the `mplib` functions in the pdf.

In the past, the package required PDF mode in order to output something. Starting with version 2.7 it works in DVI mode as well, though DVIPDFMx is the only DVI tool currently supported.

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

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 code is 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, new functionalities have been added by Kim Dohyun. The changes are:

- a LATEX environment
- all TEX macros start by `mplib`
- use of luatexbase for errors, warnings and declaration
- 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 synomym of `textext()`.

  N.B. Since v2.5, `btex ... etex` input from external `mp` files will also be processed by luamplib.

  N.B. Since v2.20, `verbatimtex ... etex` from external `mp` files will be also processed by luamplib. Warning: This is a change from previous version.

Some more changes and cautions are:

\mplibforcehmode When this macro is declared, every mplibcode 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 define this command with anything suitable before a box.)

\mpliblegacybehavior{enable} By default, \mpliblegacybehavior{enable} is already declared, in which case a verbatimtex ... etex that comes just before beginfig() is not ignored, but the TEX code will be inserted before the following mplib hbox. Using this command, each mplib box can be freely moved horizontally and/or vertically. Also, a box number might be assigned to mplib box, allowing it to be reused later (see test files).

```
\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.

By contrast, TEX code in VerbatimTeX(...) or verbatimtex ... etex between beginfig() and endfig will be inserted after flushing out the mplib figure.

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

\mpliblegacybehavior{disable} If \mpliblegacybehavior{disabled} is declared by user, 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 btex ... etex codes that follows.

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

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

`\everymplib`, `\everyendmplib` Since v2.3, new macros `\everymplib` and `\everyendmplib` redefine the lua table containing MetaPost code which will be automatically inserted at the beginning and ending of each `mplibcode`.

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

`\mpdim` Since v2.3, `\mpdim` and other raw TEX commands are allowed inside mplib code. This feature is inpired by gmp.sty authored by Enrico Gregorio. Please refer the manual of gmp package for details.

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

N.B. Users should not use the protected variant of `btex ... etex` as provided by gmp package. As **luamplib** automatically protects TEX code inbetween, `\btex` is not supported here.

`\mpcolor` With `\mpcolor` command, color names or expressions of **color**/**xcolor** packages can be used inside mplibcode enviroment (after `withcolor` operator), though **luamplib** does not automatically load these packages. See the example code above. For spot colors, **(x)spotcolor** (in PDF mode) and **xespotcolor** (in DVI mode) packages are supported as well.

`\mplibnumbersystem` Users can choose `numbersystem` option since v2.4. The default value `scaled` can be changed to `double` or `decimal` by declaring `\mplibnumbersystem{double}` or `\mplibnumbersystem{decimal}`. For details see http://github.com/lualatex/luamplib/issues/21.

Settings regarding cache files To support `btex ... etex` in external `.mp` files, **luamplib** inspects the content of each and every `.mp` input files and makes caches if nececcsary, before returning their paths to LuaTEX's mplib library. This would make the compilation time longer wastefully, as most `.mp` files do not contain `btex ... etex` command. So **luamplib** provides macros as follows, so that users can give instruction about files that do not require this functionality.

- `\mplibmakenocache{<filename>[,<filename>,...]}`

- \mplibcancelnocache{<filename>[,<filename>,...]}

where <filename> is a file name 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, in the same directory as where pdf/dvi output file is saved. This however can be changed 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.

\mplibtextextlabel Starting with v2.6, \mplibtextextlabel{enable} enables string 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. Every string label therefore will be typeset with current TEX font. Also take care of char operator in the left side argument, as this might bring unpermitted characters into TEX.

\mplibcodeinherit Starting with v2.9, \mplibcodeinherit{enable} enables the inheritance of variables, constants, and macros defined by previous mplibcode chunks. On the contrary, the default value \mplibcodeinherit{disable} will make each code chunks being treated as an independent instance, and never affected by previous code chunks.

Separate instances for LATEX environment v2.22 has added the support for several named MetaPost instances in LATEX mplibcode environment. Syntax is like so:

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

Behaviour 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 labels still exist separately and require \mplibglobaltextext.
- When an instance names is set, respective \currentmpinstancename is set.

In parellel with this functionality, v2.23 and after supports 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. Syntax is:

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

\mplibglobaltextext To inherit btex ... etex labels as well as metapost variables, it is necessary to declare \mplibglobaltextext{enable} in advance. On this case, be careful that normal TEX boxes can conflict with btex ... etex boxes, though this would occur very rarely. Notwithstanding the danger, it is a 'must' option to activate \mplibglobaltextext if you want to use graph.mp with \mplibcodeinherit functionality.

```
\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
```

\mplibverbatim Starting with v2.11, users can issue \mplibverbatim{enable}, after which the contents of mplibcode environment will be read verbatim. As a result, except for \mpdim and \mpcolor, all other TEX commands outside btex ... etex or verbatimtex ... etex are not expanded and will be fed literally into the mplib process.

\mplibshowlog When \mplibshowlog{enable} is declared, log messages returned by mplib instance will be printed into the .log file. \mplibshowlog{disable} will revert this functionality. This is a TEX side interface for luamplib.showlog. (v2.20.8)

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 or \mplibforcehmode are suitable for going into this file.

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*⟩}.

2 Implementation

2.1 Lua module

```
1
2 luatexbase.provides_module {
3   name          = "luamplib",
4   version       = "2.23.0",
5   date          = "2022/01/12",
6   description   = "Lua package to typeset Metapost with LuaTeX's MPLib.",
7 }
```

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

local err  = function(...)
  return luatexbase.module_error  ("luamplib", select("#",...) > 1 and format(...) or ...)
end
local warn = function(...)
  return luatexbase.module_warning("luamplib", select("#",...) > 1 and format(...) or ...)
end
local info = function(...)
  return luatexbase.module_info   ("luamplib", select("#",...) > 1 and format(...) or ...)
end
```

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

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

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 imported code.

```
local tableconcat   = table.concat
local texsprint     = tex.sprint
local textprint     = tex.tprint

local texget      = tex.get
local texgettoks  = tex.gettoks
local texgetbox   = tex.getbox
local texruntoks  = tex.runtoks
```

We don't use `tex.scantoks` anymore. See below reagrding `tex.runtoks`.

```
  local texscantoks = tex.scantoks
```

```
if not texruntoks then
  err("Your LuaTeX version is too old. Please upgrade it to the latest")
end

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]+$","")) .. "." .. suffix
end
local stripsuffix = file.stripsuffix or function(filename)
  return (filename:gsub("%.[%a%d]+$",""))
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.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 = kpse.find_file("luamplib.lua")
luamplibtime = luamplibtime and lfsattributes(luamplibtime,"modification")

local currenttime = os.time()

local outputdir
if lfstouch then
  local texmfvar = kpse.expand_var('$TEXMFVAR')
  if texmfvar and texmfvar ~= "" and texmfvar ~= '$TEXMFVAR' then
    for _,dir in next, texmfvar:explode(os.type == "windows" and ";" or ":") do
      if not lfsisdir(dir) then
        mk_full_path(dir)
      end
      if is_writable(dir) then
        local cached = format("%s/luamplib_cache",dir)
        lfsmkdir(cached)
        outputdir = cached
        break
      end
```

```
    end
  end
end
if not outputdir then
  outputdir = "."
  for _,v in ipairs(arg) do
    local t = v:match("%-output%-directory=(.+)")
    if t then
      outputdir = t
      break
    end
  end
end

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
        luamplib.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,
}
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 cachedir = luamplib.cachedir or outputdir
  local newfile = name:gsub("%W","_")
  newfile = cachedir .."/luamplib_input_"..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 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 it 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",
}

local function finder(name, mode, ftype)
  if mode == "w" then
    return name
  else
    ftype = special_ftype[ftype] or ftype
    local file = mpkpse:find_file(name,ftype)
    if file then
      if not lfstouch or ftype ~= "mp" or noneedtoreplace[name] then
        return file
      end
```

```
      return replaceinputmpfile(name,file)
    end
    return mpkpse:find_file(name, name:match("%a+$"))
  end
end
luamplib.finder = finder

```

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.)

```
if tonumber(mplib.version()) <= 1.50 then
  err("luamplib no longer supports mplib v1.50 or lower. "..
  "Please upgrade to the latest version of LuaTeX")
end

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

local logatload
local function reporterror (result, indeed)
  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
      warn(log)
      if result.status > 1 then
        err(e or "see above messages")
      end
    elseif indeed then
      local log = logatload..log
```

v2.6.1: now luamplib does not disregard `show` command, even when `luamplib.showlog` is false. Incidentally, it does not raise error but just prints a warning, even if output has no figure.

```
      if log:find"\n>>" then
        warn(log)
      elseif log:find"%g" then
        if luamplib.showlog then
          info(log)
        elseif not result.fig then
          info(log)
```

```
      end
    end
    logatload = ""
  else
    logatload = log
  end
  return log
 end
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`. And we provide `numbersystem` option since v2.4. Default value "scaled" can be changed by declaring `\mplibnumbersystem{double}` or `\mplibnumbersystem{decimal}`. See https://github.com/lualatex/luamplib/issues/21.

```
  make_text   = luamplib.maketext,
  run_script  = luamplib.runscript,
  math_mode   = luamplib.numbersystem,
  random_seed = math.random(4095),
  extensions  = 1,
 }
```

Append our own MetaPost preamble to the preamble above.

```
 local preamble = preamble .. luamplib.mplibcodepreamble
 if luamplib.legacy_verbatimtex then
  preamble = preamble .. luamplib.legacyverbatimtexpreamble
 end
 if luamplib.textextlabel then
  preamble = preamble .. luamplib.textextlabelpreamble
 end
 local result
 if not mpx then
  result = { status = 99, error = "out of memory"}
 else
  result = mpx:execute(format(preamble, replacesuffix(name,"mp")))
 end
 reporterror(result)
 return mpx, result
end

```

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

```
local currentformat = "plain"

local function setformat (name)
 currentformat = name
end
```

```
luamplib.setformat = setformat

```

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

```
local function process_indeed (mpx, data)
  local converted, result = false, {}
  if mpx and data then
    result = mpx:execute(data)
    local log = reporterror(result, true)
    if log then
      if result.fig then
        converted = luamplib.convert(result)
      else
        warn("No figure output. Maybe no beginfig/endfig")
      end
    end
  else
    err("Mem file unloadable. Maybe generated with a different version of mplib?")
  end
  return converted, result
end

```

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

```
luamplib.codeinherit = false
local mplibinstances = {}

local function process (data, instancename)
```

The workaround of issue #70 seems to be unnecessary, as we use make_text now.

```
  if not data:find(name_b.."beginfig%s*%([%+%-%s]*%d[%.%d%s]*%)") then
    data = data .. "beginfig(-1);endfig;"
  end


  local defaultinstancename = currentformat .. (luamplib.numbersystem or "scaled")
    .. tostring(luamplib.textextlabel) .. tostring(luamplib.legacy_verbatimtex)
  local currfmt = instancename or defaultinstancename
  if #currfmt == 0 then
    currfmt = defaultinstancename
  end
  local mpx = mplibinstances[currfmt]
  local standalone = false
  if currfmt == defaultinstancename then
    standalone = not luamplib.codeinherit
  end
  if mpx and standalone then
    mpx:finish()
  end
  if standalone or not mpx then
    mpx = luamplibload(currentformat)
```

```
    mplibinstances[currfmt] = mpx
  end
  return process_indeed(mpx, data)
end
```

`make_text` and some `run_script` uses LuaTEX's `tex.runtoks`, which made possible running TEX code snippets inside `\directlua`.

```
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.script` seems to work nicely.

```
local function run_tex_code_no_use (str, cat)
  cat = cat or catlatex
  texscantoks("mplibtmptoks", cat, str)
  texruntoks("mplibtmptoks")
end
```

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

Indefinite number of boxes are needed for `btex ... etex`. So starts at somewhat huge number of box registry. Of course, this may conflict with other packages using many many boxes. (When `codeinherit` feature is enabled, boxes must be globally defined.) But I don't know any reliable way to escape this danger.

```
local tex_box_id = 2047
```

For conversion of sp to bp.

```
local factor = 65536*(7227/7200)

local textext_fmt = [[image(addto currentpicture doublepath unitsquare ]]..
  [[xscaled %f yscaled %f shifted (0,-%f) ]]..
  [[withprescript "mplibtexboxid=%i:%f:%f")]]

local function process_tex_text (str)
  if str then
    tex_box_id = tex_box_id + 1
    local global = luamplib.globaltextext and "\\global" or ""
    run_tex_code(format("%s\\setbox%i\\hbox{%s}", global, tex_box_id, str))
    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.

```
local mplibcolor_fmt = [[\begingroup\let\XC@mcolor\relax]]..
  [[\def\set@color{\global\mplibtmptoks\expandafter{\current@color}}]]..
  [[\color %s \endgroup]]

local function process_color (str)
  if str then
    if not str:find("{.-}") then
      str = format("{%s}",str)
    end
    run_tex_code(mplibcolor_fmt:format(str), catat11)
    return format('1 withprescript "MPlibOverrideColor=%s"', texgettoks"mplibtmptoks")
  end
  return ""
end
```

\mpdim is expanded before MPLib process, so code below will not be used for mplibcode data. But who knows anyone would want it in .mp input file. If then, you can say mplibdimen(".5\textwidth") for example.

```
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. 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 legacy_mplibcode_reset ()
  tex_code_pre_mplib = {}
  luamplib.figid = 1
end

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

```

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
    f()
    buffer = tableconcat(buffer)
    if buffer and buffer ~= "" then
      return buffer
    end
    buffer = {}
    mpprint(buffer, f())
    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("%s+", " ")
end

luamplib.legacy_verbatimtex = 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.legacy_verbatimtex 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)
    end
  end
  return ""
end

```

Our MetaPost preambles

```
local mplibcodepreamble = [[
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;
 def graphictext primary filename =
  if (readfrom filename = EOF):
    errmessage "Please prepare '"&filename&"' in advance with"&
    " 'pstoedit -ssp -dt -f mpost yourfile.ps "&filename&"'";
  fi
  closefrom filename;
  def data_mpy_file = filename enddef;
  mfun_do_graphic_text (filename)
 enddef;
else:
 vardef textext@# (text t) = rawtextext (t) enddef;
fi
def externalfigure primary filename =
 draw rawtextext("\includegraphics{"& filename &"}")
enddef;
def TEX = textext enddef;
]]
luamplib.mplibcodepreamble = mplibcodepreamble

local legacyverbatimtexpreamble = [[
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& ");";
]]
luamplib.legacyverbatimtexpreamble = legacyverbatimtexpreamble

local textextlabelpreamble = [[
primarydef s infont f = rawtextext(s) enddef;
def fontsize expr f =
 begingroup
 save size; numeric size;
 size := mplibdimen("1em");
 if size = 0: 10pt else: size fi
 endgroup
enddef;
]]
luamplib.textextlabelpreamble = textextlabelpreamble

```

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    = { [""] = "" }
luamplib.everyendmplib = { [""] = "" }

local function process_mplibcode (data, instancename)
```

This is needed for legacy behavior regarding verbatimtex

```
  legacy_mplibcode_reset()

  local everymplib    = luamplib.everymplib[instancename] or
                        luamplib.everymplib[""]
  local everyendmplib = luamplib.everyendmplib[instancename] or
                        luamplib.everyendmplib[""]
  data = format("\n%s\n%s\n%s\n",everymplib, data, everyendmplib)
  data = data:gsub("\r","\n")

  data = data:gsub("\\mpcolor%s+(.-%b{})","mplibcolor(\"%1\")")
  data = data:gsub("\\mpdim%s+(%b{})", "mplibdimen(\"%1\")")
  data = data:gsub("\\mpdim%s+(\\%a+)","mplibdimen(\"%1\")")

  data = data:gsub(btex_etex, function(str)
    return format("btex %s etex ", -- space
      luamplib.verbatiminput and str or protect_expansion(str))
  end)
  data = data:gsub(verbatimtex_etex, function(str)
    return format("verbatimtex %s etex;", -- semicolon
      luamplib.verbatiminput and str or protect_expansion(str))
```

```
  end)

```

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.

```
  if not luamplib.verbatiminput then
    data = data:gsub("\".-\"", protect_expansion)

    data = data:gsub("\\%%", "\0PerCent\0")
    data = data:gsub("%%.-\n","")
    data = data:gsub("%zPerCent%z", "\\%%")

    run_tex_code(format("\\mplibtmptoks\\expanded{{%s}}",data))
    data = texgettoks"mplibtmptoks"
```

Next line to address issue #55

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

  process(data, instancename)
end
luamplib.process_mplibcode = process_mplibcode

```

For parsing `prescript` materials.

```
local further_split_keys = {
  mplibtexboxid = true,
  sh_color_a    = true,
  sh_color_b    = true,
}

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 ~= "" then
      if further_split_keys[k] then
        t[k] = v:explode(":")
      else
        t[k] = v
      end
    end
  end
  return t
```

```
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

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

local function pdf_startfigure(n,llx,lly,urx,ury)
  texsprint(format("\\mplibstarttoPDF{%f}{%f}{%f}{%f}",llx,lly,urx,ury))
end

local function pdf_stopfigure()
  texsprint("\\mplibstoptoPDF")
end

```

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

```
local function pdf_literalcode(fmt,...) -- table
  textprint({"\\mplibtoPDF{"},{-2,format(fmt,...)},{"}"})
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
  end)
  texsprint(format("\\mplibtextext{%s}{%f}{%s}{%s}{%f}",font,size,text,0,-( 7200/ 7227)/65536*depth))
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 then
    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 th
      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

```

dvipdfmx is supported, though nobody seems to use it.

```
local pdfoutput = tonumber(texget("outputmode")) or tonumber(texget("pdfoutput"))
local pdfmode = pdfoutput > 0

local function start_pdf_code()
  if pdfmode then
    pdf_literalcode("q")
  else
    texsprint("\\special{pdf:bcontent}") -- dvipdfmx
  end
end
local function stop_pdf_code()
  if pdfmode then
    pdf_literalcode("Q")
  else
    texsprint("\\special{pdf:econtent}") -- dvipdfmx
  end
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
  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)
    texsprint(format("\\mplibputtextbox{%i}",n))
    stop_pdf_code()
  end
end
```

Colors and Transparency

```
local pdf_objs = {}
local token, getpageres, setpageres = newtoken or token
local pgf = { bye = "pgfutil@everybye", extgs = "pgf@sys@addpdfresource@extgs@plain" }

if pdfmode then -- repect luaotfload-colors
  getpageres = pdf.getpageresources or function() return pdf.pageresources end
  setpageres = pdf.setpageresources or function(s) pdf.pageresources = s end
else
  texsprint("\\special{pdf:obj @MPlibTr<<>>}",
            "\\special{pdf:obj @MPlibSh<<>>}")
end

local function update_pdfobjs (os)
  local on = pdf_objs[os]
  if on then
    return on,false
  end
  if pdfmode then
    on = pdf.immediateobj(os)
  else
    on = pdf_objs.cnt or 0
    pdf_objs.cnt = on + 1
  end
  pdf_objs[os] = on
  return on,true
end

local transparancy_modes = { [0] = "Normal",
  "Normal",       "Multiply",     "Screen",       "Overlay",
  "SoftLight",    "HardLight",    "ColorDodge",   "ColorBurn",
  "Darken",       "Lighten",      "Difference",   "Exclusion",
```

```
  "Hue",          "Saturation",   "Color",        "Luminosity",
  "Compatible",
}

local function update_tr_res(res,mode,opaq)
  local os = format("<</BM /%s/ca %.3f/CA %.3f/AIS false>>",mode,opaq,opaq)
  local on, new = update_pdfobjs(os)
  if new then
    if pdfmode then
      res = format("%s/MPlibTr%i %i 0 R",res,on,on)
    else
      if pgf.loaded then
        texsprint(format("\\csname %s\\endcsname{/MPlibTr%i%s}", pgf.extgs, on, os))
      else
        texsprint(format("\\special{pdf:put @MPlibTr<</MPlibTr%i%s>>}",on,os))
      end
    end
  end
  return res,on
end

local function tr_pdf_pageresources(mode,opaq)
  if token and pgf.bye and not pgf.loaded then
    pgf.loaded = token.create(pgf.bye).cmdname == "assign_toks"
    pgf.bye    = pgf.loaded and pgf.bye
  end
  local res, on_on, off_on = "", nil, nil
  res, off_on = update_tr_res(res, "Normal", 1)
  res, on_on  = update_tr_res(res, mode, opaq)
  if pdfmode then
    if res ~= "" then
      if pgf.loaded then
        texsprint(format("\\csname %s\\endcsname{%s}", pgf.extgs, res))
      else
        local tpr, n = getpageres() or "", 0
        tpr, n = tpr:gsub("/ExtGState<<", "%1"..res)
        if n == 0 then
          tpr = format("%s/ExtGState<<%s>>", tpr, res)
        end
        setpageres(tpr)
      end
    end
  else
    if not pgf.loaded then
      texsprint(format("\\special{pdf:put @resources<</ExtGState @MPlibTr>>}"))
    end
  end
  return on_on, off_on
end

```

Shading with metafun format. (maybe legacy way)

```
local shading_res

local function shading_initialize ()
  shading_res = {}
  if pdfmode and luatexbase.callbacktypes.finish_pdffile then -- ltluatex
    local shading_obj = pdf.reserveobj()
    setpageres(format("%s/Shading %i 0 R",getpageres() or "",shading_obj))
    luatexbase.add_to_callback("finish_pdffile", function()
      pdf.immediateobj(shading_obj,format("<<%s>>",tableconcat(shading_res)))
      end, "luamplib.finish_pdffile")
    pdf_objs.finishpdf = true
  end
end

local function sh_pdfpageresources(shtype,domain,colorspace,colora,colorb,coordinates)
  if not shading_res then shading_initialize() end
  local os = format("<</FunctionType 2/Domain [ %s ]/C0 [ %s ]/C1 [ %s ]/N 1>>",
                    domain, colora, colorb)
  local funcobj = pdfmode and format("%i 0 R",update_pdfobjs(os)) or os
  os = format("<</ShadingType %i/ColorSpace /%s/Function %s/Coords [ %s ]/Extend [ true true ]/AntiAlias true>>",
              shtype, colorspace, funcobj, coordinates)
  local on, new = update_pdfobjs(os)
  if pdfmode then
    if new then
      local res = format("/MPlibSh%i %i 0 R", on, on)
      if pdf_objs.finishpdf then
        shading_res[#shading_res+1] = res
      else
        local pageres = getpageres() or ""
        if not pageres:find("/Shading<<.*>>") then
          pageres = pageres.."/Shading<<>>"
        end
        pageres = pageres:gsub("/Shading<<","%1"..res)
        setpageres(pageres)
      end
    end
  else
    if new then
      texsprint(format("\\special{pdf:put @MPlibSh<</MPlibSh%i%s>>}",on,os))
    end
    texsprint(format("\\special{pdf:put @resources<</Shading @MPlibSh>>}"))
  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

local prev_override_color

local function do_preobj_color(object,prescript)
```

transparency

```
  local opaq = prescript and prescript.tr_transparency
  local tron_no, troff_no
  if opaq then
    local mode = prescript.tr_alternative or 1
    mode = transparancy_modes[tonumber(mode)]
    tron_no, troff_no = tr_pdf_pageresources(mode,opaq)
    pdf_literalcode("/MPlibTr%i gs",tron_no)
  end
```

color

```
  local override = prescript and prescript.MPlibOverrideColor
  if override then
    if pdfmode then
      pdf_literalcode(override)
      override = nil
    else
      texsprint(format("\\special{color push %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
        texsprint(format("\\special{color push %s}",override))
      end
    end
  end
```

shading

```
  local sh_type = prescript and prescript.sh_type
  if sh_type then
    local domain  = prescript.sh_domain
    local centera = prescript.sh_center_a:explode()
```

```
    local centerb = prescript.sh_center_b:explode()
    for _,t in pairs({centera,centerb}) do
      for i,v in ipairs(t) do
        t[i] = format("%f",v)
      end
    end
    centera = tableconcat(centera," ")
    centerb = tableconcat(centerb," ")
    local colora  = prescript.sh_color_a or {0};
    local colorb  = prescript.sh_color_b or {1};
    for _,t in pairs({colora,colorb}) do
      for i,v in ipairs(t) do
        t[i] = format("%.3f",v)
      end
    end
    if #colora > #colorb then
      color_normalize(colora,colorb)
    elseif #colorb > #colora then
      color_normalize(colorb,colora)
    end
    local colorspace
    if     #colorb == 1 then colorspace = "DeviceGray"
    elseif #colorb == 3 then colorspace = "DeviceRGB"
    elseif #colorb == 4 then colorspace = "DeviceCMYK"
    else   return troff_no,override
    end
    colora = tableconcat(colora, " ")
    colorb = tableconcat(colorb, " ")
    local shade_no
    if sh_type == "linear" then
      local coordinates = tableconcat({centera,centerb}," ")
      shade_no = sh_pdfpageresources(2,domain,colorspace,colora,colorb,coordinates)
    elseif sh_type == "circular" then
      local radiusa = format("%f",prescript.sh_radius_a)
      local radiusb = format("%f",prescript.sh_radius_b)
      local coordinates = tableconcat({centera,radiusa,centerb,radiusb}," ")
      shade_no = sh_pdfpageresources(3,domain,colorspace,colora,colorb,coordinates)
    end
    pdf_literalcode("q /Pattern cs")
    return troff_no,override,shade_no
  end
  return troff_no,override
end

local function do_postobj_color(tr,over,sh)
  if sh then
    pdf_literalcode("W n /MPlibSh%s sh Q",sh)
  end
  if over then
    texsprint("\\special{color pop}")
```

```
  end
  if tr then
    pdf_literalcode("/MPlibTr%i gs",tr)
  end
end
```

Finally, flush figures by inserting PDF literals.

```
local function 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, and prepare a table for 'in-fig' codes.

```
          if tex_code_pre_mplib[f] then
            texsprint(tex_code_pre_mplib[f])
          end
          local TeX_code_bot = {}
          pdf_startfigure(fignum,llx,lly,urx,ury)
          start_pdf_code()
          if objects then
            local savedpath = nil
            local savedhtap = nil
            for o=1,#objects do
              local object       = objects[o]
              local objecttype   = object.type
```

The following 5 lines are part of `btex...etex` patch. Again, colors are processed at this stage.

```
              local prescript    = object.prescript
              prescript = prescript and script2table(prescript) -- prescript is now a table
              local tr_opaq,cr_over,shade_no = do_preobj_color(object,prescript)
```

```
            if prescript and prescript.mplibtexboxid then
              put_tex_boxes(object,prescript)
            elseif objecttype == "start_bounds" or objecttype == "stop_bounds" then --skip
            elseif objecttype == "start_clip" then
              local evenodd = not object.istext and object.postscript == "evenodd"
              start_pdf_code()
              flushnormalpath(object.path,false)
              pdf_literalcode(evenodd and "W* n" or "W n")
            elseif objecttype == "stop_clip" then
              stop_pdf_code()
              miterlimit, linecap, linejoin, dashed = -1, -1, -1, false
            elseif objecttype == "special" then
```

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

```
              if prescript and prescript.postmplibverbtex then
                TeX_code_bot[#TeX_code_bot+1] = prescript.postmplibverbtex
              end
            elseif objecttype == "text" then
              local ot = object.transform -- 3,4,5,6,1,2
              start_pdf_code()
              pdf_literalcode("%f %f %f %f %f %f cm",ot[3],ot[4],ot[5],ot[6],ot[1],ot[2])
              pdf_textfigure(object.font,object.dsize,object.text,object.width,object.height,object.depth)
              stop_pdf_code()
            else
              local evenodd, collect, both = false, false, false
              local postscript = object.postscript
              if not object.istext then
                if postscript == "evenodd" then
                  evenodd = true
                elseif postscript == "collect" then
                  collect = true
                elseif postscript == "both" then
                  both = true
                elseif postscript == "eoboth" then
                  evenodd = true
                  both    = true
                end
              end
              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
                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
  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
```

Change from ConTeXt general: there was color stuffs.

```
    if not shade_no then -- conflict with shading
      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
  end
  if transformed then
    stop_pdf_code()
  end
  local path = object.htap
  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
              end
            end
```

Added to ConTeXt general: color stuff. And execute legacy verbatimtex code.

```
            do_postobj_color(tr_opaq,cr_over,shade_no)
          end
        end
        stop_pdf_code()
        pdf_stopfigure()
        if #TeX_code_bot > 0 then texsprint(TeX_code_bot) end
      end
    end
  end
end
luamplib.flush = flush

local function 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
luamplib.colorconverter = colorconverter
```

2.2 TEX package

First we need to load some packages.

```
\bgroup\expandafter\expandafter\expandafter\egroup
\expandafter\ifx\csname selectfont\endcsname\relax
  \input ltluatex
\else
  \NeedsTeXFormat{LaTeX2e}
```

```
  \ProvidesPackage{luamplib}
    [2022/01/12 v2.23.0 mplib package for LuaTeX]
  \ifx\newluafunction\@undefined
  \input ltluatex
  \fi
\fi
```

Loading of lua code.

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

Support older engine. Seems we don't need it, but no harm.

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

Unfortuantely there are still packages out there that think it is a good idea to manually set `\pdfoutput` which defeats the above branch that defines `\pdfliteral`. To cover that case we need an extra check.

```
\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 warning.

```
\ifnum\pdfoutput>0
  \let\mplibtoPDF\pdfliteral
\else
  \def\mplibtoPDF#1{\special{pdf:literal direct #1}}
  \ifcsname PackageWarning\endcsname
    \PackageWarning{luamplib}{take dvipdfmx path, no support for other dvi tools currently.}
  \else
    \write128{}
    \write128{luamplib Warning: take dvipdfmx path, no support for other dvi tools currently.}
    \write128{}
  \fi
\fi
```

Make `mplibcode` typesetted 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}}}
```

The Plain-specific stuff.

```
\unless\ifcsname ver@luamplib.sty\endcsname
\def\mplibcode{%
  \begingroup
  \begingroup
  \mplibsetupcatcodes
  \mplibdocode
}
\long\def\mplibdocode#1\endmplibcode{%
  \endgroup
  \directlua{luamplib.process_mplibcode([===[\unexpanded{#1}]===],"")}%
  \endgroup
}
\else
```

The LaTeX-specific part: a new environment.

```
\newenvironment{mplibcode}[1][]{%
  \global\def\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.legacy_verbatimtex = true
    else
      luamplib.legacy_verbatimtex = 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

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

```
  \long\def\mplibdoeveryendmplib#1{%
    \endgroup
    \directlua{
      luamplib.everyendmplib[""] = [===[\unexpanded{#1}]===]
    }%
  }
\fi
```

Allow TEX dimen/color macros. Now `runscript` does the job, so the following lines are not needed for most cases. But the macros will be expanded when they are used in another macro.

```
\def\mpdim#1{ mplibdimen("#1") }
\def\mpcolor#1#{\domplibcolor{#1}}
\def\domplibcolor#1#2{ mplibcolor("#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 litterals.

```
\def\mplibstarttoPDF#1#2#3#4{%
  \prependtomplibbox
  \hbox\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{%
  \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
```

That's all folks!

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