

# wumpus-core Guide

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## 1 About **wumpus-core**

This guide was last updated for **wumpus-core** version 0.36.0.

**wumpus-core** is a Haskell library for generating 2D vector pictures. It was written with portability as a priority, so it has no dependencies on foreign C libraries. Output to PostScript and SVG (Scalable Vector Graphics) is supported.

**wumpus-core** is rather primitive, the basic drawing objects are paths and text labels. A second library **wumpus-basic** contains code for higher level drawing but it is experimental and the APIs are a long way from stable (it should probably be considered a *technology preview*).

Although **wumpus-core** is heavily inspired by PostScript it avoids PostScript's notion of an (implicit) current point and the movements `lineto`, `moveto` etc., instead **wumpus-core** aims for a more *coordinate free* style.

## 2 Exposed modules

**wumpus-core** exports the following modules:

**Wumpus.Core**. Top-level *shim* module to import all the exposed modules. Some internal data types are also exported as opaque - the implementation is hidden, but the type name is exposed so it can be used in the type signatures of *userland* functions. Typically, where these data types need to be *instantiated* smart constructors are provided.

**Wumpus.Core.AffineTrans**. The standard affine transformations (scaling, rotation, translation) implemented as type classes, with a set of derived operations - reflections about the X or Y axes, rotations through common angles.

**Wumpus.Core.BoundingBox**. Data type representing bounding boxes and operations on them. Bounding boxes are important for Pictures and they support the definition of *picture composition* operators.

**Wumpus.Core.Colour.** A single colour type `RGBi` is supported. This type defines colour as a triple of integers (`Word8`) - black is (0, 0, 0); white is (255, 255, 255). Some named colours are defined, although they are hidden by the top level shim module to avoid name clashes with libraries providing more extensive lists of colours. `Wumpus.Core.Colour` can be imported directly if the named colours are required.

**Wumpus.Core.FontSize.** Various calculations for font size metrics. `wumpus-core` has limited handling of font / character size as it cannot interpret the metrics within font files (doing so would be a huge task). Instead this module provides some metrics based on the Courier mono-spaced font that can be used for rudimentary size calculations on text labels.

**Wumpus.Core.Geometry.** The usual types and operations from affine geometry - points, vectors and 3x3 matrices, also the `DUnit` type family. Essentially this type family is a trick used heavily within `wumpus-core` to avoid annotating class declarations with constraints on the unit - class constraints like `Fractional u` can then be shifted to the instance declaration rather than the class declaration.

**Wumpus.Core.GraphicsState.** Data types modelling the attributes of PostScript's graphics state (stroke style, dash pattern, etc.). Note that `wumpus-core` annotates all primitives - paths, text labels - with their rendering style, the `GraphicsState` here is an internal detail used to generate more efficient PostScript and SVG. The *smaller* types in this module such as `StrokeAttr` are the only ones relevant for the public API.

**Wumpus.Core.OutputPostScript.** Functions to write PostScript or encapsulated PostScript files.

**Wumpus.Core.OutputSVG.** Functions to write SVG files.

**Wumpus.Core.Picture.** Operations to build *pictures* - paths and labels within an affine frame. Generally the functions here are convenience constructors for types from the hidden module `Wumpus.Core.PictureInternal`. The types from `PictureInternal` are exported as opaque signatures by `Wumpus.Core.WumpusTypes`.

**Wumpus.Core.PtSize.** Text size calculations in `Core.FontSize` use points (i.e. 1/72 of an inch). The `PtSize` module is a numeric type to represent them.

**Wumpus.Core.TextEncoder.** Types for handling extended character codes e.g. for accented characters or the Symbol font. Special characters generally have to be escaped in the PostScript and SVG output, this module provides data types for lookup tables between the escaped character code and its PostScript or SVG representation. Text encoders are associated with fonts - glyphs within a font are located by their character name / code. Currently `wumpus-core` has encoders for Latin1 and the Symbol font.

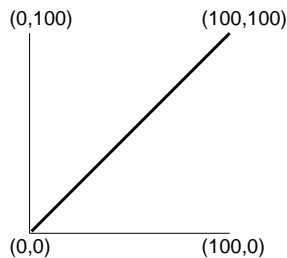


Figure 1: The world frame, with origin at the bottom left.

**Wumpus.Core.TextLatin1.** A instance of the `TextEncoder` type for mapping Latin 1 characters to the PostScript and SVG escape characters. Typically this encoder is associated with the fonts - Helvetica, Courier and Times-Roman.

**Wumpus.Core.TextSymbol.** A instance of the `TextEncoder` type for the Symbol font. Note, unfortunately escape codes for the Symbol font seem to cause problems for some SVG renderers. Chrome appears fine, but Safari and Firefox currently have problems.

**Wumpus.Core.VersionNumber.** Current version number of `wumpus-core` .

**Wumpus.Core.WumpusTypes.** This module collects internal types for Pictures, Paths etc. and presents them as opaque types - i.e. their constructors are hidden.

### 3 Drawing model

`wumpus-core` has two main drawable primitives *paths* and text *labels*, ellipses are also a primitive although this is a concession to efficiency when drawing dots (which would otherwise require 4 to 8 Bezier arcs to describe). Paths are made from straight sections or Bezier curves, they can be open and *stroked* to produce a line; or closed and *stroked*, *filled* or *clipped*. Labels represent a single horizontal line of text - multiple lines must be composed from multiple labels.

Primitives are attributed with drawing styles - font name and size for labels; line width, colour, etc. for paths. Primitives can be grouped to support support hyperlinks in SVG output (so Primitives are not strictly *primitive*). The function `frame` assembles a list of primitives into a `Picture` with the standard affine frame where the origin is at (0,0) and the X and Y axes have the unit bases (i.e. they have a *scaling* value of 1).

`wumpus-core` uses the same picture frame as PostScript where the origin at the bottom left, see Figure 1. This contrasts to SVG where the origin at the top-left. When `wumpus-core` generates SVG, the whole picture is generated within a matrix transformation `[ 1.0, 0.0, 0.0, -1.0, 0.0, 0.0 ]` that changes the picture to use PostScript coordinates. This has the side-effect that text is otherwise

drawn upside down, so `wumpus-core` adds a rectifying transform to each text element.

Once labels and paths are assembled as a *Picture* they are transformable with the usual affine transformations (scaling, rotation, translation).

Graphics properties (e.g colour) are opaque once primitives are assembled into pictures - it is not possible to write a transformation function that turns elements in a picture blue. In some ways this is a limitation - for instance, the `Diagrams` library appears to support some notion of attribute overriding; however avoiding mutable attributes does keep this part of `wumpus-core` conceptually simple. To make a blue or red arrow with `wumpus-core`, one would make drawing colour a parameter of the arrow constructor function.

## 4 Affine transformations

For affine transformations Wumpus uses the `Matrix3'3` data type to represent 3x3 matrices in row-major form. The constructor (`M3'3 a b c d e f g h i`) builds this matrix:

$$\begin{matrix} a & b & c \\ d & e & f \\ g & h & i \end{matrix}$$

Note, in practice the elements *g* and *h* are superfluous. They are included in the data type to make it match the typical representation from geometry texts. Also, typically matrices will be implicitly created with functions from the `Core.Geometry` and `Core.AffineTrans` modules.

For example a translation matrix moving 10 units in the X-axis and 20 in the Y-axis will be encoded as (`M3'3 1.0 0.0 10.0 0.0 1.0 20.0 0.0 0.0 1.0`)

$$\begin{matrix} 1.0 & 0.0 & 10.0 \\ 0.0 & 1.0 & 20.0 \\ 0.0 & 0.0 & 1.0 \end{matrix}$$

Affine transformations on Pictures are communicated to PostScript as `concat` commands. For Pictures, `wumpus-core` performs no transformations itself, delegating all the work to PostScript or SVG. Internally `wumpus-core` transforms the bounding boxes of Pictures - it needs to do this to maintain their size metrics allowing transformed pictures to be composed with picture composition operators like the `picBeside` combinator.

PostScript uses column-major form and uses a six element matrix rather than a nine element one. The translation matrix above would produce this `concat` command:

```
[1.0 0.0 0.0 1.0 10.0 20.0] concat
```

Similarly, it would be communicated to SVG via a `group` element:

```
<g transform="matrix(1.0, 0.0, 0.0, 1.0, 10.0, 20.0)"> ... </g>
```

`wumpus-core` also supports the regular affine transformations on Primitives (the arbitrary matrix transformation `transform` is not supported). Transformations are implicitly interpreted in the standard affine frame - origin at (0,0) and unit scaling vectors for the bases.

For paths, all the transformations are precomputed on the control points before the output is generated. For labels and ellipses the *start point* of the primitive (baseline-left for label, center for ellipse) is transformed by `wumpus-core` and matrix operations are transmitted to PostScript and SVG to transform the actual drawing (`wumpus-core` has no access to the paths that describe character glyphs so it cannot precompute transformations on them).

One consequence of transformations operating on the control points of primitives is that scalings do not scale the tip of the *drawing pen*. If a path is stroked, lifted to a Picture and then scaled the whole graphics state is effectively scaled including the pen tip so the path is drawn with a thicker outline. However, if a path is stroked and then scaled as a Primitive, the drawing pen is not scaled so the path will be drawn with the regular line width.

## 5 Font handling

Font handling is quite primitive in `wumpus-core`. The bounding box of text label is only estimated - based on the length of the label's string rather than the metrics of the individual letters encoded in the font. Accessing the glyph metrics in a font would require a font loader to read TrueType font files. This would be a significant development effort, probably larger than the effort put into `wumpus-core` itself; for `wumpus-core`'s intended use - producing diagrams and pictures rather than high quality text - the primitive font handling is not such a draw back.

In both PostScript and SVG mis-named fonts can cause somewhat inscrutable printing anomalies - usually falling back to a default font but not always. At worst, PostScript may do no subsequent drawing after a font load error. `wumpus-core` uses `scalefont` in the generated PostScript, this semingly works for any integer size and not just the regular font sizes (10, 12, 18, 24, 36).

The following table lists PostScript fonts and their SVG equivalents, the package `wumpus-basic` includes a module `Wumpus.Basic.SafeFonts` encoding the fonts in this list and matching them to their appropriate `TextEncoder`.

PostScript name	SVG name
Times-Roman	Times New Roman
Times-Italic	Times New Roman - style="italic"
Times-Bold	Times New Roman - font-weight="bold"
Times-BoldItalic	Times New Roman - style="italic", font-weight="bold"
Helvetica	Helvetica
Helvetica-Oblique	Helvetica - style="italic"
Helvetica-Bold	Helvetica - font-weight="bold"
Helvetica-Bold-Oblique	Helvetica - style="italic", font-weight="bold"
Courier	Courier New
Courier-Oblique	Courier New - style="italic"
Courier-Bold	Courier New - font-weight="bold"
Courier-Bold-Oblique	Courier New - style="italic", font-weight="bold"
Symbol	Symbol

## 6 Acknowledgments

PostScript is a registered trademark of Adobe Systems Inc.