PyNomo Documentation

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pyNomo is a python library for making nomographs (or nomograms) that are graphical calculators. Nomographs are defined as a python script that consists in most part of dictionaries.

CHAPTER

ONE

INSTALLATION

pyNomo is a python2 library and thus requires working python installation on the computer. pyNomo stands on the shoulders of (read: requires) the python packages: numpy, scipy and pyx that requires LaTeX-installation.

For editing pyNomo scripts any text browser works but integrated development environment (IDE) for python can speed up developments. Good free IDE alternatives are for example PyCharm community edition and spyder.

1.1 OSX Installation

In OSX Macports is an effective tool to manage open-source software. In the following a MacPorts environment is set for Python and pyNomo. *sudo* runs the commands as super-user and requires it's password to be given.

First install python 2.7

```
$ sudo port install python27
```

One can list available python versions on the system with command

```
$ sudo port select --list python
```

Select MacPorts python 2.7

```
$ sudo port select --set python python27
```

Install python package index tool (pip)

```
$ sudo port install py27-pip
```

and set it active

```
$ port select --set pip pip27
```

Now python environment should be correct to be run from `/opt/local/Library/...`. Now install other required packages.

```
$ sudo port install py27-numpy
$ sudo port install py27-scipy
$ sudo port install py27-pyx
$ sudo pip install pynomo
```

1.2 Linux installation

In Debian Linux distribution and in its derivatives (for example Ubuntu and Raspbian) pynomo can be installed using *apt-get* with the following commands. *sudo* runs the commands as super-user and requires it's password to be given.

```
$ sudo apt-get -y install python
$ sudo apt-get -y install python-pyx
$ sudo apt-get -y install python-pip
$ sudo apt-get -y install python-numpy
$ sudo apt-get -y install python-scipy
$ sudo pip install pynomo
```

1.3 Windows installation

1. Download and install python 2.7.x from www.python.org/downloads/ . pyNomo is not yet compatible with python 3.x.x
2. Download and install MIKTeX LaTeX -distribution from http://miktex.org/download.
3. Download and install numpy from sourceforge.net/projects/numpy.
4. Download and install scipy from sourceforge.net/projects/scipy.
5. Download and install PIL (python imaging library) from http://effbot.org/downloads/. PIL is required by some pyx packages. pynomo might work without PIL.

pyx (python graphics package) installation is more tricky. Either

- Download pyx 0.12.1 (python graphics package) from http://sourceforge.net/projects/pyx/files/pyx/0.12.1/PyX-0.12.1.tar.gz/download
- Uncompress the file *PyX-0.12.1.tar.gz* using for example 7-zip.
- Open command prompt (cmd) and go to the uncompressed folder that contains file *setup.py*.
- run command `python setup.py install`

or cross your fingers and just run:

```
> pip install --allow-external pyx pyx
```

on command prompt with administrative rights.

Finally pyNomo is installed either by downloading installer from http://sourceforge.net/projects/pynomo/ and by running it. Other choice to try is to run:

```
> pip install pynomo
```

on command line. Tedious, huh! If you find simpler Windows recipe, please email it to the maintainer of the project.

1.4 Docker installation

Docker is a platform to create a sandboxed virtualized environments. In the following example

Dockerfile a virtualized Ubuntu is created that has pyNomo installed with all requirements:

```
FROM ubuntu

# Install required packages:
# python, pyx, pip, numpy, scipy, pynomo and their requirements
RUN apt-get update
RUN apt-get -y upgrade
RUN DEBIAN_FRONTEND=noninteractive apt-get -y install python
RUN DEBIAN_FRONTEND=noninteractive apt-get -y install python-pyx
RUN DEBIAN_FRONTEND=noninteractive apt-get -y install python-pip
RUN DEBIAN_FRONTEND=noninteractive apt-get -y install python-numpy
RUN DEBIAN_FRONTEND=noninteractive apt-get -y install python-scipy
RUN DEBIAN_FRONTEND=noninteractive pip install pynomo

# Add /app directory and make it working dir
RUN mkdir -p /app
ADD . /app
WORKDIR /app

# Set the default command to execute -> "python my_pynomo_file.py"
CMD ["python", "my_pynomo_file.py"]
```

Docker container (environment) *my_pynomo_docker* is built in the directory */my_directory_path* that has the file *Dockerfile* with command

```
$ docker build -t my_pynomo_docker .
```

Once environment is built and *my_pynomo_file.py is in directory '/my_directory_path/pdf_py_dir/* one can run

```
$ docker run -i -v /my_directory_path/pdf_py_dir:/app my_pynomo_docker
```

that runs command `python my_pynomo_file.py` inside */app directory* of container that is mapped to directory */my_directory_path/pdf_py_dir* of the host system. That way a folder is used to share the script file and the generated pdf file between host system and the container (virtualized Linux environment).

CHAPTER

TWO

SOFTWARE DOCUMENTATION

Nomographs of PyNomo are constructed by writing a python script that defines the nomograph and calls class Nomographer to build the nomograph.

Nomograph is constructed by defining axis parameters that are used to build a block. Many blocks are possibly aligned with each other and construct the nomograph.

A simple example of pseudocode of typical PyNomo structure is the following:

```
from pynomo.nomographer import * # this loads the needed pynomo class
# define block 1
axis_params_1_for_block_1 = {...}
axis_params_2_for_block_1 = {...}
axis_params_3_for_block_1 = {...}
block_1 = {...}

# define block 2
axis_params_1_for_block_2 = {...}
axis_params_2_for_block_2 = {...}
axis_params_3_for_block_2 = {...}
block_2 = {...}

# define nomograph
main_params={
              'filename':'filename_of_nomograph.pdf',  # filename of output
              'block_params':[block_1,block_2],        # the blocks make the nomograph
              'transformations':[('scale paper',)],    # these make (projective) transformations for the canves
              }
# create nomograph
Nomographer(main_params)
```

It is to be noted that nomograph is defined as python dicts that constitute one dict that is passed to Nomographer class.

2.1 Basic blocks

The following blocks are the core of PyNomo. These are used as easy building blocks for nomograph construction. If these do not suffice one can build as complex nomograph as one wishes by using determinants in type 9.

Type 1	$F_1(u_1) + F_2(u_2) + F_3(u_3) = 0$	Three parallel lines
Type 2	$F_1(u_1) = F_2(u_2)F_3(u_3)$	"N" or "Z"
Type 3	$F_1(u_1) + F_2(u_2) + \cdots + F_N(u_N) = 0$	N parallel lines
Type 4	$\frac{F_1(u_1)}{F_2(u_2)} = \frac{F_3(u_3)}{F_4(u_4)}$	"Proportion"
Type 5	$F_1(v) = F_2(x, u).$	"Contour"
Type 6	$u = u$	"Ladder"
Type 7	$\frac{1}{F_1(u_1)} + \frac{1}{F_2(u_2)} = \frac{1}{F_3(u_3)}$	"Angle"
Type 8	$y = F(u)$	"Single"
Type 9	$\begin{vmatrix} F_1(u_1[,v_1]) & G_1(u_1[,v_1]) & H_1(u_1[,v_1]) \\ F_2(u_2[,v_2]) & G_2(u_2[,v_2]) & H_2(u_2[,v_2]) \\ F_3(u_3[,v_3]) & G_3(u_3[,v_3]) & H_3(u_3[,v_3]) \end{vmatrix} = 0$	"General"
Type 10	$F_1(u) + F_2(v)F_3(w) + F_4(w) = 0$	One curved line

2.2 Axes

Defining axes and their appearance is major work in nomograph construction. Different possibilities are illustrated in examples of axes parameters.

2.3 Combination of blocks

If a nomograph consists of many equations that are aligned, a compound nomograph is constructed.

2.4 Transformations

Scales shall be transformed in order to tune the appearance.

2.5 Manual

Article "“Creating Nomograms with the PyNomo Software”" by Ron Doerfler is a detailed manual for using PyNomo.

CHAPTER

THREE

AXES

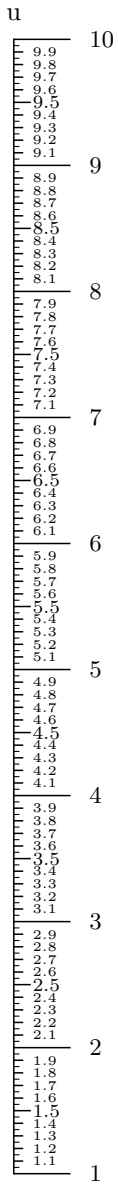
3.1 Axes by example

Axes are fundamental building blocks of nomographs. The following code uses minimal axis definion `N_params` that is rendered as a linear scale illustrated below. The range of values axis represents is defined with keywords `u_min` and `u_max`. `title` sets title string for the axis. Key part of the nomograph is the functional form of the axis. In the example below it is defined with keyword `function` and is given as a function. Different types of blocks assume different keywords of axis functions. For example types 1, 2 and 3 take keyword `function` but type 9 takes either `f`, `g`, `h` or `f_grid`, `g_grid`, `h_grid` keywords. So one have to define axis parameters compatible with the used block type. In the examples below Type 8 is used as block to taking axis definition because it is the simplest one.

3.1.1 Linear scale (`'scale_type':'linear'`)

Here we start with the simplest axis. It has by default scale `'scale_type':'linear'` that is simple linear scale.

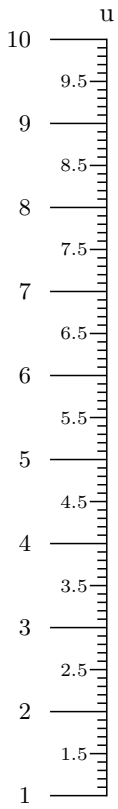
```
# ex_axes_1.py

import sys
sys.path.insert(0, "..")
from pynomo.nomographer import *

# axis definitions
N_params = {'u_min': 1.0,            # axis start value
            'u_max': 10.0,           # axis stop value
            'function': lambda u: u, # axis function
            'title': 'u',            # axis titles
            }

# block definitons defining one block of type 8
block_params = {'block_type': 'type_8',
                'f_params': N_params,
                'width': 5.0,
                'height': 15.0,
                }

# nomograph generation definitions
main_params = {'filename': 'ex_axes_1.pdf',
                'paper_height': 15.0,
                'paper_width': 5.0,
                'block_params': [block_params],
                'transformations': [('scale paper',)]
              }

# actual code that builds the nomograph
Nomographer(main_params)
```



Because the example above looked little too busy or packed, we reduce the ticks by using only three different tick levels `'tick_levels':3` and two tick text levels `'tick_text_levels':2`. Tick side relative to the final drawing is set to left using `'tick_side':'left'`.

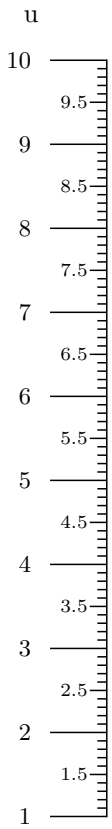
```
# ex_axes_2.py

N_params = {'u_min': 1.0,
            'u_max': 10.0,
            'function': lambda u: u,
            'title': 'u',
            'tick_levels': 3,        # <-
            'tick_text_levels': 2,   # <-
            'tick_side': 'left',     # <-
            }

block_params = {'block_type': 'type_8',
                'f_params': N_params,
                'width': 5.0,
                'height': 10.0,
                }

main_params = {'filename': 'ex_axes_2.pdf',
                'paper_height': 10.0,
                'paper_width': 5.0,
```

```
                'block_params': [block_params],
                'transformations': [('scale paper',)]
               }

Nomographer(main_params)
```



Title position can be shifted in both x- and y-directions. In the following we shift it using key-values `'title_x_shift':-1.0` and `'title_y_shift':0.5`. Units are here centimeters.

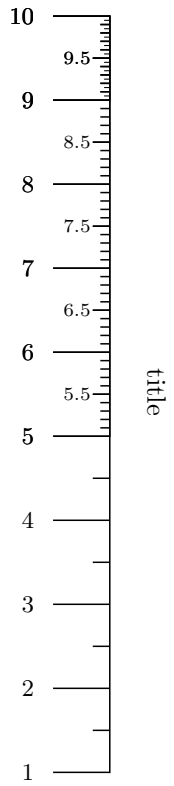
```
# ex_axes_3.py

N_params = {'u_min': 1.0,
            'u_max': 10.0,
            'function': lambda u: u,
            'title': 'u',
            'tick_levels': 3,
            'tick_text_levels': 2,
            'tick_side': 'left',
            'title_x_shift': -1.0,   # <-
            'title_y_shift': 0.5     # <-
            }

block_params = {'block_type': 'type_8',
                'f_params': N_params,
                'width': 5.0,
                'height': 10.0,
                }

main_params = {'filename': 'ex_axes_3.pdf',
               'paper_height': 10.0,
               'paper_width': 5.0,
               'block_params': [block_params],
               'transformations': [('scale paper',)]
               }

Nomographer(main_params)
```



Sometimes single level of axis definitions is not enough. We might want to add more ticks in some additional range of the axis. Keyword `'extra_params'` helps here. Value for this key is an array of dictionaries that modify given params in the given range set by `u_min` and `u_max`. In the following example we define additional ranges with more ticks in ranges 5.0..10.0 and 9.0..10.0. We also draw title this time to center using `'title_draw_center:True`.

```
# ex_axes_4.py

N_params = {'u_min': 1.0,
            'u_max': 10.0,
            'function': lambda u: u,
            'title': 'title',
            'tick_levels': 2,
            'tick_text_levels': 1,
            'tick_side': 'left',
            'title_draw_center': True,                # <-
            'extra_params': [{'u_min': 5.0,           # <- range 1
                              'u_max': 10.0,          # <-
                              'tick_levels': 3,       # <-
                              'tick_text_levels': 2,  # <-
                              },                      # <-
                             {'u_min': 9.0,           # <- range 2
                              'u_max': 10.0,          # <-
                              'tick_levels': 4,       # <-
                              'tick_text_levels': 2,  # <-
                              }                       # <-
                             ]                        # <-
            }
block_params = {'block_type': 'type_8',
                'f_params': N_params,
                'width': 5.0,
                'height': 10.0,
                }
main_params = {'filename': 'ex_axes_4.pdf',
               'paper_height': 10.0,
               'paper_width': 5.0,
               'block_params': [block_params],
               'transformations': [('scale paper',)]
```

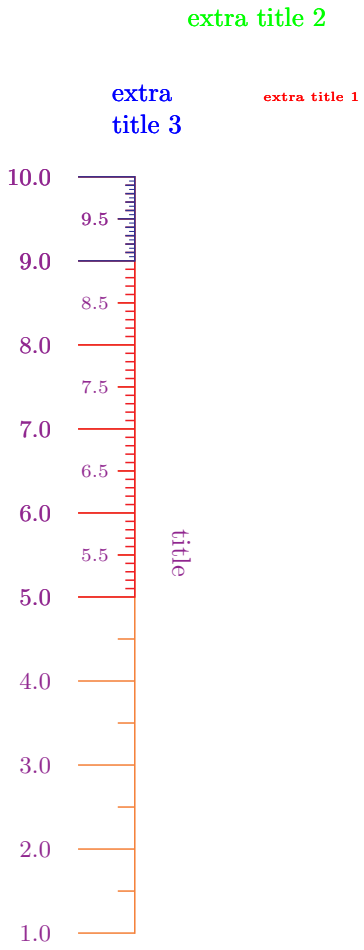
```
            }
Nomographer(main_params)
```



Color can be used to tune visual appearance of the axis. In the following example we tune colors with self-explaining keywords `'axis_color'`, `'text_color'` and `'title_color'`. Additional titles are set by using keyword `'extra_titles'` with value of an array of dictionaries that can take keywords `'dx'` and `'dy'` as relative position to main title. Value of keyword `'text'` `sets the title text and` `'pyx_extra_defs'` can be used to give additional parameters for pyx rendering that is only option in current release. In the example numbers are formatted to have one three digits before comma and and one digit after comma using `'text_format':r"$%3.1f$ "`.

```
# ex_axes_4_1.py

N_params = {'u_min': 1.0,
            'u_max': 10.0,
            'function': lambda u: u,
            'title': 'title',
            'tick_levels': 2,
            'tick_text_levels': 1,
            'tick_side': 'left',
            'title_draw_center': True,
            'text_format': r"$%3.1f$ ",                              # <- format numbers as %3.1f
            'axis_color': color.cmyk.Orange,
            'text_color': color.cmyk.Plum,
            'title_color': color.cmyk.Plum,
            'extra_params': [{'u_min': 5.0,
                              'u_max': 10.0,
                              'tick_levels': 3,
                              'tick_text_levels': 2,
                              'axis_color': color.cmyk.Red,
                              },
                             {'u_min': 9.0,
                              'u_max': 10.0,
                              'tick_levels': 4,
                              'tick_text_levels': 2,
                              'axis_color': color.cmyk.Blue,
```

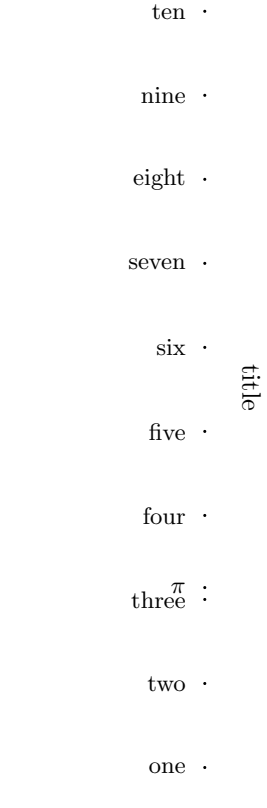
```
                              }
                            ],
            'extra_titles': [{'dx': 1.0,                                        # <- 1st extra title
                              'dy': 1.0,                                        # <-
                              'text': 'extra title 1',                          # <-
                              'width': 5,                                       # <-
                              'pyx_extra_defs': [color.rgb.red, text.size.tiny]   # <-
                              },
                             {'dx': 0.0,                                        # <- 2nd extra title
                              'dy': 2.0,                                        # <-
                              'text': 'extra title 2',                          # <-
                              'width': 5,                                       # <-
                              'pyx_extra_defs': [color.rgb.green]               # <-
                              },
                             {'dx': -1.0,                                       # <- 3rd extra title
                              'dy': 1.0,                                        # <-
                              'text': r"extra  \par title 3",                   # <- \par = newline
                              'width': 5,                                       # <-
                              'pyx_extra_defs': [color.rgb.blue]                # <-
                              }]
            }
block_params = {'block_type': 'type_8',
                'f_params': N_params,
                'width': 5.0,
                'height': 10.0,
                }
main_params = {'filename': 'ex_axes_4_1.pdf',
               'paper_height': 10.0,
               'paper_width': 5.0,
               'block_params': [block_params],
               'transformations': [('scale paper',)]
               }
Nomographer(main_params)
```



3.1.2 Manual point scale (`'scale_type':'manual point'`)

Sometimes axes have to be defined manually. One option is to use manual point scale type with `'scale_type':'manual point'` and define the points as a dict to keyword `'manual_axis_data'`.

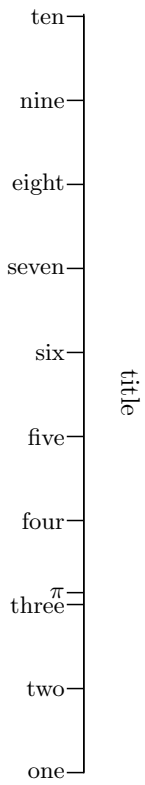
```
# ex_axes_5.py

N_params = {'u_min': 1.0,
            'u_max': 10.0,
            'function': lambda u: u,
            'title': 'title',
            'tick_levels': 2,
            'tick_text_levels': 1,
            'tick_side': 'left',
            'title_draw_center': True,
            'scale_type': 'manual point',        # <- use manual points
            'manual_axis_data': {1.0: 'one',     # <- give point values as keys
                                 2.0: 'two',     # <- and texts as values
                                 3.0: 'three',
                                 3.1415: r'$\pi$',
                                 4.0: 'four',
                                 5.0: 'five',
                                 6.0: 'six',
                                 7.0: 'seven',
                                 8.0: 'eight',
                                 9.0: 'nine',
                                 10.0: 'ten'}
            }
block_params = {'block_type': 'type_8',
                'f_params': N_params,
                'width': 5.0,
                'height': 10.0
                }
main_params = {'filename': 'ex_axes_5.pdf',
               'paper_height': 10.0,
               'paper_width': 5.0,
               'block_params': [block_params],
               'transformations': [('scale paper',)]
               }
Nomographer(main_params)
```



3.1.3 Manual line scale ('scale_type':'manual line')

Similarly other option is to use manual line scale type with 'scale_type':'manual line' that draws main scale line and ticks. Drawn ticks are defined as a dict to keyword 'manual_axis_data' as above example.

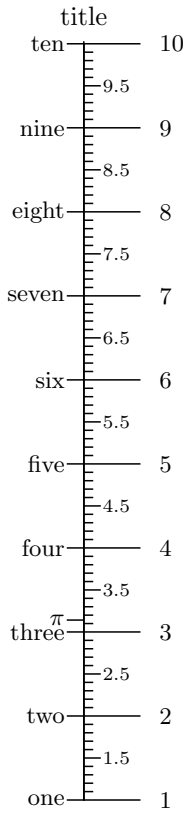
```
# ex_axes_6.py

N_params = {'u_min': 1.0,
            'u_max': 10.0,
            'function': lambda u: u,
            'title': 'title',
            'tick_levels': 2,
            'tick_text_levels': 1,
            'tick_side': 'left',
            'title_draw_center': True,
            'scale_type': 'manual line',     # <-
            'manual_axis_data': {1.0: 'one',
                                 2.0: 'two',
                                 3.0: 'three',
                                 3.1415: r'$\pi$',
                                 4.0: 'four',
                                 5.0: 'five',
                                 6.0: 'six',
                                 7.0: 'seven',
                                 8.0: 'eight',
                                 9.0: 'nine',
                                 10.0: 'ten'}
            }
block_params = {'block_type': 'type_8',
                'f_params': N_params,
                'width': 5.0,
                'height': 10.0,
                }
main_params = {'filename': 'ex_axes_6.pdf',
               'paper_height': 10.0,
               'paper_width': 5.0,
               'block_params': [block_params],
               'transformations': [('scale paper',)]
               }
Nomographer(main_params)
```



Combining manual lines and a linear scale.

```
# ex_axes_7.py

N_params = {'u_min': 1.0,
            'u_max': 10.0,
            'function': lambda u: u,
            'title': 'title',
            'tick_levels': 2,
            'tick_text_levels': 1,
            'tick_side': 'left',
            'scale_type': 'manual line',
            'manual_axis_data': {1.0: 'one',
                                 2.0: 'two',
                                 3.0: 'three',
                                 3.1415: r'$\pi$',
                                 4.0: 'four',
                                 5.0: 'five',
                                 6.0: 'six',
                                 7.0: 'seven',
                                 8.0: 'eight',
                                 9.0: 'nine',
                                 10.0: 'ten'},
            'extra_params': [{'u_min': 1.0,
                              'u_max': 10.0,
                              'scale_type': 'linear',
                              'tick_levels': 3,
                              'tick_text_levels': 2,
                              'tick_side': 'right',
                              }]
            }
block_params = {'block_type': 'type_8',
                'f_params': N_params,
                'width': 5.0,
                'height': 10.0,
                }
main_params = {'filename': 'ex_axes_7.pdf',
               'paper_height': 10.0,
               'paper_width': 5.0,
               'block_params': [block_params],
               'transformations': [('scale paper',)]
```

```
            }
Nomographer(main_params)
```

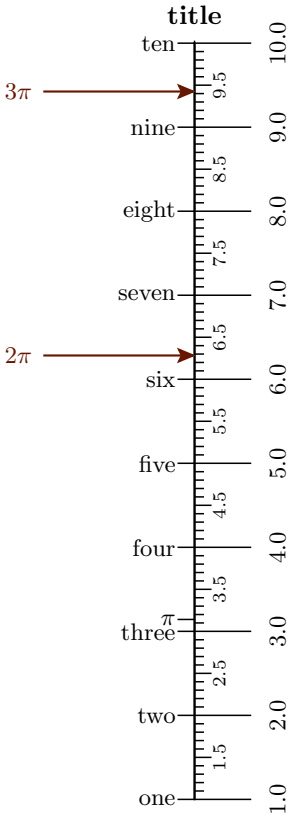


3.1.4 Manual arrows ('scale_type':'manual arrow')

Manual arrows can be used to point values in the scale using arrows.

```
# ex_axes_7_1.py

N_params = {'u_min': 1.0,
            'u_max': 10.0,
            'function': lambda u: u,
            'title': r'\bf title',
            'tick_levels': 2,
            'tick_text_levels': 1,
            'tick_side': 'left',
            'scale_type': 'manual line',
            'manual_axis_data': {1.0: 'one',
                                 2.0: 'two',
                                 3.0: 'three',
                                 3.1415: r'$\pi$',
                                 4.0: 'four',
                                 5.0: 'five',
                                 6.0: 'six',
                                 7.0: 'seven',
                                 8.0: 'eight',
                                 9.0: 'nine',
                                 10.0: 'ten'},
            'extra_params': [{'u_min': 1.0,
                              'u_max': 10.0,
                              'scale_type': 'linear',
                              'tick_levels': 3,
                              'tick_text_levels': 2,
                              'tick_side': 'right',
                              'extra_angle': 90.0,
                              'text_horizontal_align_center': True,
                              'text_format': r"$%2.1f$"},
```

```
                            {'scale_type': 'manual arrow',           # <-
                             'manual_axis_data': {6.2830: r'$2\pi$',
                                                  9.4245: r'$3\pi$'},
                             'arrow_color': color.cmyk.Sepia,
                             'arrow_length': 2.0,
                             'text_color': color.cmyk.Sepia,
                             }]
            }
block_params = {'block_type': 'type_8',
                'f_params': N_params,
                'width': 5.0,
                'height': 10.0,
                }
main_params = {'filename': 'ex_axes_7_1.pdf',
               'paper_height': 10.0,
               'paper_width': 5.0,
               'block_params': [block_params],
               'transformations': [('scale paper',)]
               }
Nomographer(main_params)
```

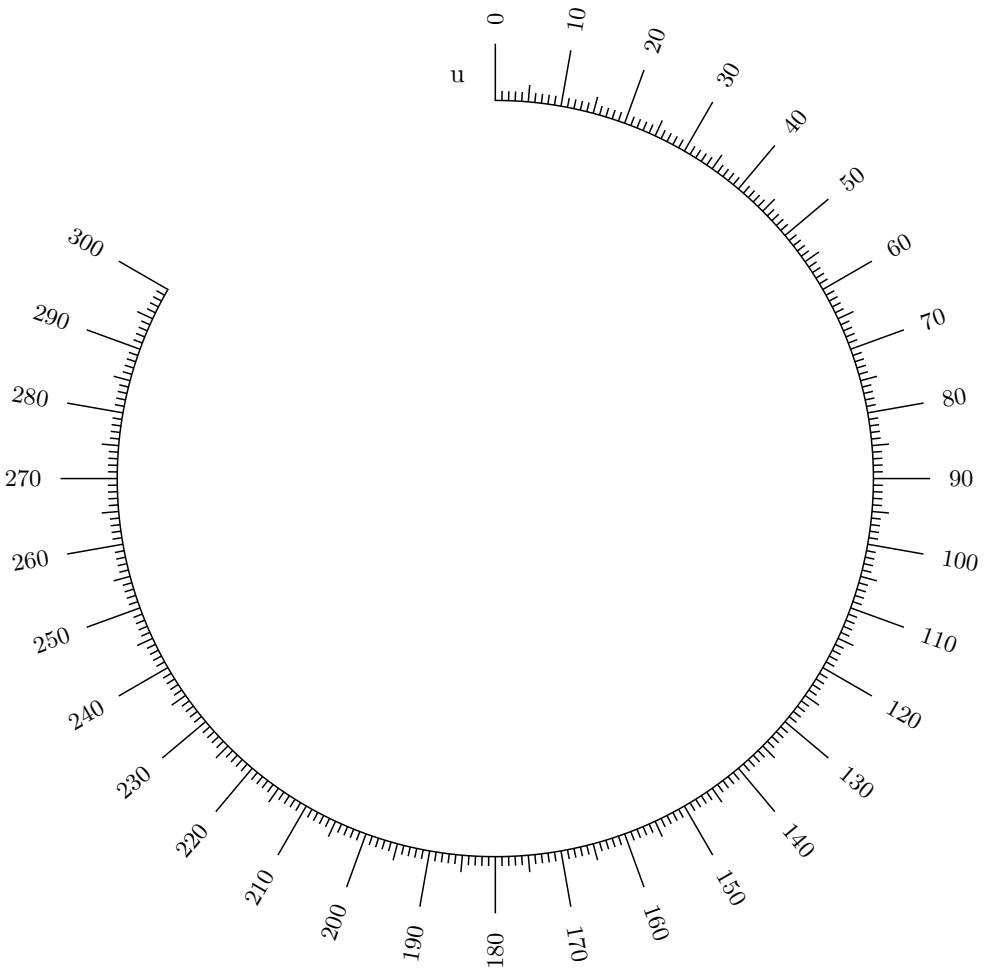


3.1.5 Manual function (’function_x’ and ’function_y’)

If one wants to explicitely draw scale in xy-scace, parameters ’function_x’ and ’function_y’ can be used in conjuction with block type 8. In the following example circular scale is drawn.

```
# ex_axes_8.py

N_params = {'u_min': 0.0,
            'u_max': 300.0,
            'function_x': lambda u: 3 * sin(u / 180.0 * pi),
            'function_y': lambda u: 3 * cos(u / 180.0 * pi),
            'title': 'u',
            'tick_levels': 3,
            'tick_text_levels': 1,
            'title_x_shift': -0.5,
```

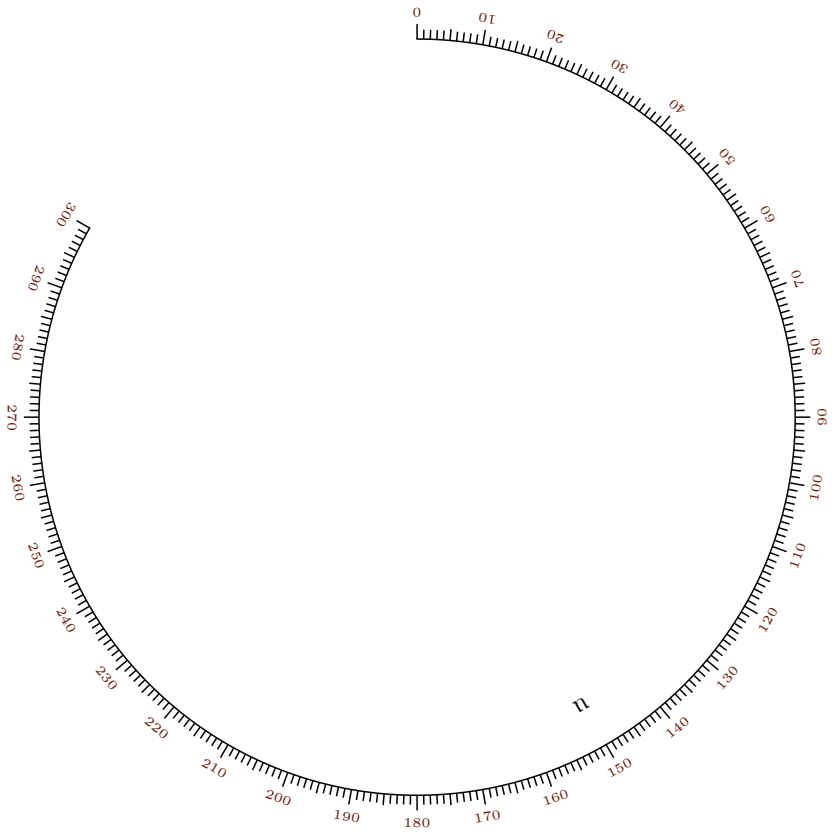
```
            }
block_params = {'block_type': 'type_8',
                'f_params': N_params,
                'width': 5.0,
                'height': 15.0,
                }
main_params = {'filename': 'ex_axes_8.pdf',
               'paper_height': 10.0,
               'paper_width': 10.0,
               'block_params': [block_params],
               'transformations': [('scale paper',)]
               }
Nomographer(main_params)
```



In the following we fine-tune the appearance of the scale. Tick lengths are explicitly given with params `'grid_length_x'` (note name with bad logic), text sizes are tuned with params `'text_size_x'` and distance of text to the scale is set using `'text_distance_x'`. `'full_angle'` parameter allows text to be drawn also upside down and text angle is rotated with `'extra_angle'`.

```
# ex_axes_8_1.py

N_params = {'u_min': 0.0,
            'u_max': 300.0,
            'function_x': lambda u: 3 * sin(u / 180.0 * pi),
            'function_y': lambda u: 3 * cos(u / 180.0 * pi),
            'title': 'u',
            'tick_levels': 3,
            'tick_text_levels': 1,
            'title_x_shift': -0.5,
            'grid_length_0': 0.8/4,
```

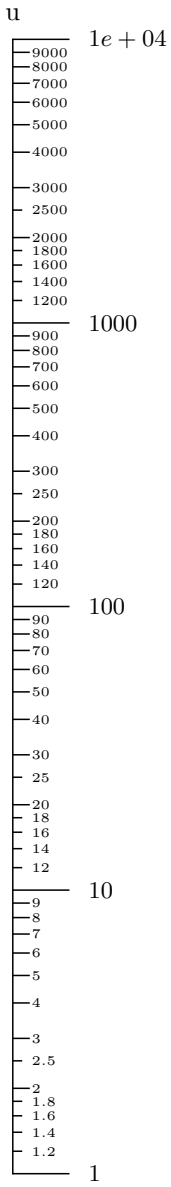
```
            'grid_length_1': 0.6/4,
            'grid_length_2': 0.5/4,
            'grid_length_3': 0.4/4,
            'grid_length_4': 0.3/4,
            'text_size_0': text.size.tiny,
            'text_size_1': text.size.tiny,
            'text_size_2': text.size.tiny,
            'text_size_3': text.size.tiny,
            'text_size_4': text.size.tiny,
            'text_distance_0': 1.2/4,
            'text_distance_1': 1.1/4,
            'text_distance_2': 1.0/4,
            'text_distance_3': 1.0/4,
            'text_distance_4': 1.0/4,
            'title_distance_center': 0.7,
            'title_opposite_tick': True,
            'title_draw_center': True,
            'text_format': "$%3.1f$",
            'full_angle': True,
            'extra_angle': 90.0,
            'text_horizontal_align_center': True,
            'text_format': r"$%2.0f$",
            'text_color': color.cmyk.Sepia,
           }
block_params = {'block_type': 'type_8',
                'f_params': N_params,
                'width': 5.0,
                'height': 15.0,
                }
main_params = {'filename': 'ex_axes_8_1.pdf',
               'paper_height': 10.0,
               'paper_width': 10.0,
               'block_params': [block_params],
               'transformations': [('scale paper',)]
               }
Nomographer(main_params)
```



3.1.6 Linear scale ('scale_type':'log')

Often one needs to use logarithmic functions in scales and 'scale_type':'log' makes some optimizations for this kind of scale appearance.

```
# ex_axes_9.py

N_params = {'u_min': 1.0,
            'u_max': 10000.0,
            'function': lambda u: log(u),
            'title': 'u',
            'scale_type': 'log',
            }
block_params = {'block_type': 'type_8',
                'f_params': N_params,
                'width': 5.0,
                'height': 15.0,
                }
main_params = {'filename': 'ex_axes_9.pdf',
               'paper_height': 15.0,
               'paper_width': 5.0,
               'block_params': [block_params],
               'transformations': [('scale paper',)]
              }
Nomographer(main_params)
```



3.1.7 Smart scales (`'scale_type':'smart linear'`, `'scale_type':'smart log'`)

Linear and log scales just plot ticks and texts as given with params `'tick_levels'` and `'tick_text_levels'`. Often this approach generates busy scales with overlapping texts and too dense ticks. Better approach is to use smart linear scales `'scale_type':'smart linear'` or smart log scales `'scale_type':'smart log'` These scales check that tick and text distances does not go below given thresholds (`'tick_distance_smart'` and `'text_distance_smart'`. TODO: example to use smart scales.

3.2 Common axis params

Table 3.1: Common axis params

parameter	default value	explanation
'ID'	'none'	**String.** To identify the axis.
'tag'	'none'	**String.** To align blocks w.r.t each other along axes with same tag.
'dtag'	'none'	**String.** To double-align blocks w.r.t each other along axes with same tag.
'title'	''	**String.** Axis title.
'title_x_shift'	0.0	**Float.** Title shift in x-direction.
'title_y_shift'	0.25	**Float.** Title shift in y-direction.
'scale_type'	'linear'	**String.** Scale type. Can be 'linear': linear scale. 'log': logarithmic scale. 'smart linear': linear scale with equal spacings. 'smart log': logarithmic scale with equal spacings, can also have negative values. 'manual point': Points and corresponding text positions are given manually in 'manual axis data'. No line is drawn. 'manual line': Ticks and corresponding text positions are given manually in 'manual axis data'.
'tick_levels'	4	**Integer.** How many levels (minor, minor-minor, etc.) of ticks are drawn. Largest effect to 'linear' scale.
'tick_text_levels'	'3'	**Integer.** How many levels (minor, minor-minor, etc.) of texts are drawn. Largest effect to 'linear' scale.
'tick_side'	'right'	**String.** Tick and text side in final paper. Can be: 'right''or ''left'
'reference'	False	**Boolean.** If axis is treated as reference line that is a turning point.
'reference_padding'	'0.2'	**Float.** Fraction of reference line over other lines.
'manual_axis_data'	{}	**Dict.** Manually set tick/point positions and text positions. Could be for example:"{1:'1',3.14:r'pi',5:'5',7:'seven',10:'10'}'
'title_draw_center'	False	**Boolean.** Title is drawn to center of line.
'title_distance_center'	'type_9'	**String.** To double-align blocks w.r.t each other along axes with same tag.
'title_opposite_tick'	True	**Boolean.** Title in opposite direction w.r.t ticks.
'align_func'	lambda u:u	**func(u).** function to align different scales.
'align_x_offset'	0.0	**Float.** If axis is aligned with other axis, this value x offsets final scale.
'align_y_offset'	0.0	**Float.** If axis is aligned with other axis, this value y offsets final scale.
'text_format'	r'$%4.4g$ '	**String.** Format for numbers in scale.

Continued on next page

Table 3.1 – continued from previous page

parameter	default value	explanation
'extra_params'	[{},...]	**Array of Dicts.** List of dictionary of params to be drawn additionally.
'text_distance_#'	x.x	**Float.** where #=0,1,2,3 or 4. Distance of text from scale line. Number corresponds to the level, where 0 is the major tick and 4 is the most minor ticks.
'grid_length_#'	x.x	**Float.** where #=0,1,2,3 or 4. Length of the tick. Number corresponds to the level, where 0 is the major tick and 4 is the most minor ticks.
'text_size_#'	x.x	**Float.** where #=0,1,2,3 or 4. Text size. For example: text.size.small, text.size.scriptsize or text.size.tiny. Number corresponds to the level, where 0 is the major tick and 4 is the most minor ticks.
'text_size_log_#'	x.x	**Float.** where #=0,1 or 2. Text size. For example: text.size.small, text.size.scriptsize or text.size.tiny . Number corresponds to the level, where 0 is the major tick and 2 is the most minor ticks.
'full_angle'	False	**Boolean.** If true, text can be upside down, otherwise +- 90 degrees from horizontal. Good foor example for full circle scales.
'extra_angle'	0.0	**Boolean.** Title is drawn to center of line.
'title_draw_center'	False	**Float.** Angle to rotate tick text from horizontal along tick.
'text_horizontal_align_center'	False	**Boolean.** Aligns tick text horizontally to center. Good when text rotated 90 degrees.
'turn_relative'	False	**Boolean.** Side left or right is relative according to traveling of scale from min to max.
'arrow_size'	0.2	**Float.** Used with arrow scale.
'arrow_length'	1.0	**Float.** Used with arrow scale..
'arrow_color'	color.rgb.black	**Color.** Used with arrow scale.
'axis_color'	color.rgb.black	**Color.** Color of axis.
'text_color'	color.rgb.black	**Color.** Color of tick texts.
'extra_titles'	[]	**Array.** List of extra title dicts for scale. Could be i.e."[{'dx':1.0, 'dy':1.0, 'text':'extra title 1', 'width':5, 'pyx_extra_defs': [color.rgb.red,text.size.Huge]}, {'text': 'extra title 2'}]".

Continued on next page

Table 3.1 – continued from previous page

parameter	default value	explanation
'base_start'	None	**None/Float.** Defines number with 'base_stop' (instead of 'u_min' or 'u_max') to find major tick decades.
'base_stop'	None	**None/Float.** Defines number with 'base_start' (instead of 'u_min' or 'u_max') to find major tick decades.
'tick_distance_smart'	.05	**Float**. Minimum distance between smart ticks.
'text_distance_smart'	.25	**Float**. Minimum distance between smart texts.

CHAPTER

FOUR

MAIN PARAMS

Main params define the top level properties of the nomograph.

4.1 List of main params

Table 4.1: General params

parameter	default value	explanation
'filename'	'pynomo_default.pdf'	**String.** Filename of generated file. .pdf and .eps formats supported.
'paper_height'	20.0	**String.** Height of paper (roughly, ticks and texts extend this).
'paper_width'	20.0	**String.** Width of paper (roughly, ticks and texts extend this).
'block_params'		**Array of Blocks.** List of blocks that make the nomograph.
'transformations'	[('rotate', 0.01), ('scale paper')]	**Array of tuples.** List of transformations to transform nomograph.
'title_str'	''	**String.** Title string of nomograph.
'title_x'	paper_width/2.0	**Float.** Title x-position.
'title_y'	paper_height	**Float.** Title y-position.
'title_box_width'	paper_width/2.2	**Float.** Title box width.
'title_color'	'color.rgb.black'	**Color.** Title color.
'make_grid'	False	**Boolean.** If True, draws grid to help position texts, etc.
'pre_func'	None	**func(context).** PyX function(canvas) to draw under nomograph. Function definition could be:
'post_func'	None	**func(context).** PyX function(canvas) to draw over nomograph. Definiton same as for 'pre_func'.
'debug'	False	**Boolean.** If True, prints dicts of definions.
'extra_texts'	[]	**List of Dicts defining texts.** Defines extra texts. Could be for example:
'isopleth_params'	[{}]	**List of Dicts.** Defines appearance of isopleths. Could be for example:

CHAPTER

FIVE

TYPE REFERENCE

In the following is a reference for the types used in pyNomo.

5.1 Type 1

Type 1 is three parallel lines that have functional relationship:

$$F_1(u_1) + F_2(u_2) + F_3(u_3) = 0$$

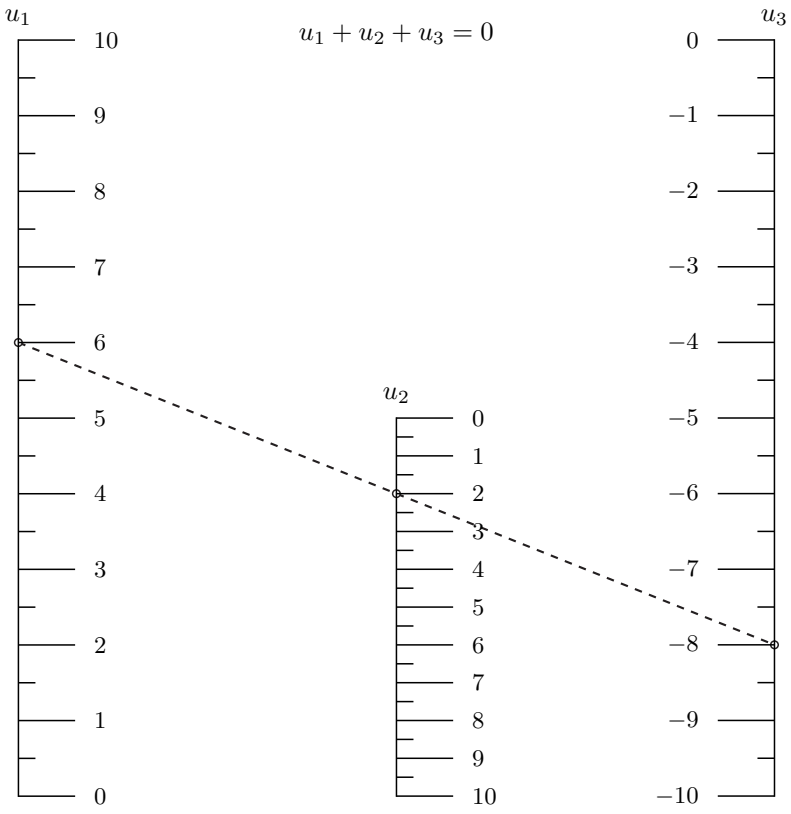
Note, that this kind of function can be transformed to many forms by using type 8 that is a equation given in determinant form. Use of this nomograph is given by the following simple example.

5.1.1 Simple example

This simple example plots nomograph for equation:

$$u_1 + u_2 + u_3 = 0.$$

Generated nomograph



Source code of simple example of type 1

```
"""
    ex_type1_nomo_1.py

    Simple nomogram of type 1: F1+F2+F3=0
"""
import sys
sys.path.insert(0, "..")
#sys.path[:0] = [".."]
from pynomo.nomographer import *

N_params_1={
        'u_min':0.0,
        'u_max':10.0,
        'function':lambda u:u,
        'title':r'$u_1$',
        'tick_levels':2,
        'tick_text_levels':1,
                }

N_params_2={
        'u_min':0.0,
        'u_max':10.0,
        'function':lambda u:u,
        'title':r'$u_2$',
        'tick_levels':2,
        'tick_text_levels':1,
                }

N_params_3={
        'u_min':0.0,
        'u_max':-10.0,
        'function':lambda u:u,
        'title':r'$u_3$',
```

```
        'tick_levels':2,
        'tick_text_levels':1,
                }


block_1_params={
              'block_type':'type_1',
              'width':10.0,
              'height':10.0,
              'f1_params':N_params_1,
              'f2_params':N_params_2,
              'f3_params':N_params_3,
              'isopleth_values':[[6,2,'x']],
              }

main_params={
               'filename':'ex_type1_nomo_1.pdf',
               'paper_height':10.0,
               'paper_width':10.0,
               'block_params':[block_1_params],
               'transformations':[('rotate',0.01),('scale paper',)],
               'title_str':r'$u_1+u_2+u_3=0$',
               'debug':False,
              }
Nomographer(main_params)
```

5.1.2 Parameters for type 1

Axis parameters

Table 5.1: Specific axis parameters for type 1

parameter key	default value	**type**, explanation
`'function'`	–	**func(u).** Function in equation For example `lambda u: u`
`'u_min'`	–	**Float.** Minimum value of function variable.
`'u_max'`	–	**Float.** Maximum value of function variable.

See *Common axis params* for other parameters.

Block parameters

Table 5.2: Specific block parameters for type 9

parameter	default value	explanation
`'block_type'`	`'type_1'`	**String.** This is type 1 block
`'width'`	10.0	**Float.** Block width (to be scaled)
`'height'`	10.0	**Float.** Block height (to be scaled)
`'f1_params'`	–	**Axis params Dict.** Axis params for function f1
`'f2_params'`	–	**Axis params Dict.** Axis params for function f2
`'f3_params'`	–	**Axis params Dict.** Axis params for function f3
`'mirror_x'`	`False`	**Boolean.** If x-axis is mirrored
`'mirror_y'`	`False`	**Boolean.** If y-axis is mirrored
`'proportion'`	`1.0`	**Float.** Factor for spacings between lines
`'isopleth_values'`	`[[]]`	** List of list of isopleth values.** Unknown values are given with strings, e.g. 'x'. An example:`[[0.8, 0.1, 'x'], ['x', 0.2, 1.0]]`

General parameters

See *List of main params* for top level main parameters.

5.2 Type 2

Type 1 is "N" or "Z" nomograph that have functional relationship:

$$F_1(u_1) = F_2(u_2)F_3(u_3)$$

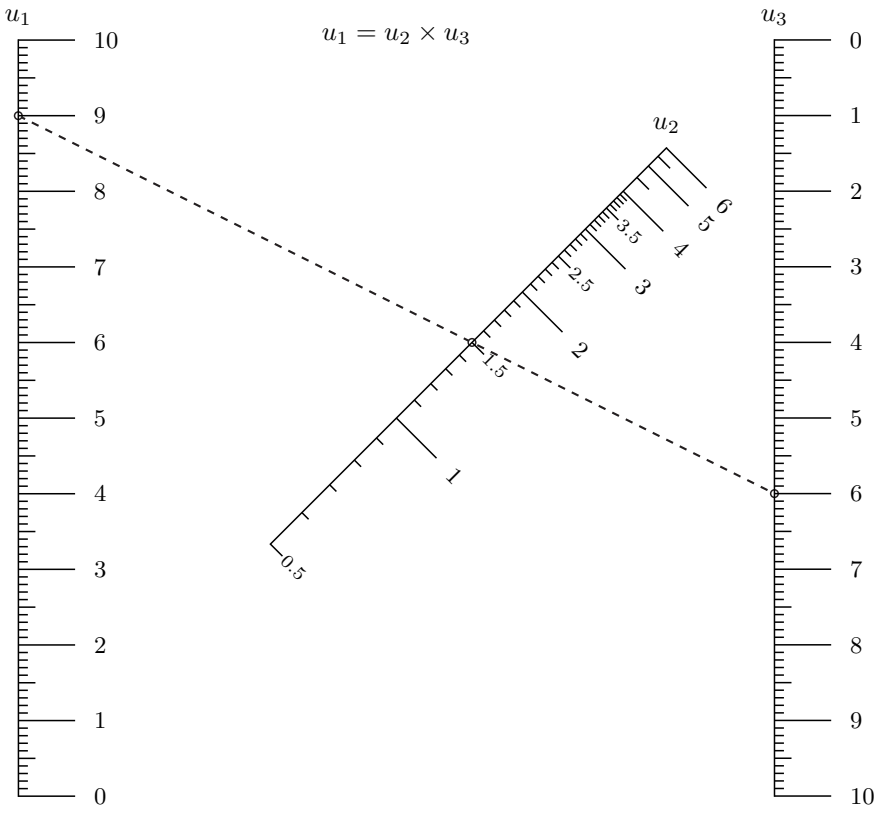
Use of this nomograph is given by the following simple example.

5.2.1 Simple example

This simple example plots nomograph for equation:

$$u_1 = u_2 u_3$$

Generated nomograph



Source code of simple example of type 2

```
"""
    ex_type2_nomo_1.py

    Simple nomogram of type 2: F1=F2*F3
"""
import sys
sys.path.insert(0, "..")
from pynomo.nomographer import *

N_params_1={
        'u_min':0.0,
        'u_max':10.0,
        'function':lambda u:u,
        'title':r'$u_1$',
        'tick_levels':3,
        'tick_text_levels':1,
                }

N_params_2={
        'u_min':0.5,
        'u_max':6.0,
        'function':lambda u:u,
        'title':r'$u_2$',
        'tick_levels':3,
        'tick_text_levels':2,
        'scale_type':'linear smart',
                }

N_params_3={
        'u_min':0.0,
        'u_max':10.0,
        'function':lambda u:u,
        'title':r'$u_3$',
```

```
        'tick_levels':3,
        'tick_text_levels':1,
                }


block_1_params={
              'block_type':'type_2',
              'width':10.0,
              'height':10.0,
              'f1_params':N_params_1,
              'f2_params':N_params_2,
              'f3_params':N_params_3,
              'isopleth_values':[[9,1.5,'x']],
              }

main_params={
               'filename':'ex_type2_nomo_1.pdf',
               'paper_height':10.0,
               'paper_width':10.0,
               'block_params':[block_1_params],
               'transformations':[('rotate',0.01),('scale paper',)],
               'title_str':r'$u_1=u_2\times u_3$'
              }
Nomographer(main_params)
```

5.2.2 Parameters for type 2

Axis parameters

Table 5.3: Specific axis parameters for type 2

parameter key	default value	**type**, explanation
`'function'`	–	**func(u).** Function in equation For example `lambda u: u`
`'u_min'`	–	**Float.** Minimum value of function variable.
`'u_max'`	–	**Float.** Maximum value of function variable.

See *Common axis params* for other parameters.

Block parameters

Table 5.4: Specific block parameters for type 2

parameter	default value	explanation
`'block_type'`	`'type_2'`	**String.** This is type 2 block
`'width'`	10.0	**Float.** Block width (to be scaled)
`'height'`	10.0	**Float.** Block height (to be scaled)
`'f1_params'`	–	**Axis params Dict.** Axis params for function f1
`'f2_params'`	–	**Axis params Dict.** Axis params for function f2
`'f3_params'`	–	**Axis params Dict.** Axis params for function f3
`'mirror_x'`	`False`	**Boolean.** If x-axis is mirrored
`'mirror_y'`	`False`	**Boolean.** If y-axis is mirrored
`'proportion'`	`1.0`	**Float.** Factor for spacings between lines
`'isopleth_values'`	`[[]]`	** List of list of isopleth values.** Unknown values are given with strings, e.g. 'x'. An example:`[[0.8, 0.1, 'x'], ['x', 0.2, 1.0]]`

General parameters

See *List of main params* for top level main parameters.

5.3 Type 3

Type 3 has N parallel lines that have functional relationship:

$$F_1(u_1) + F_2(u_2) + \cdots + F_N(u_N) = 0$$

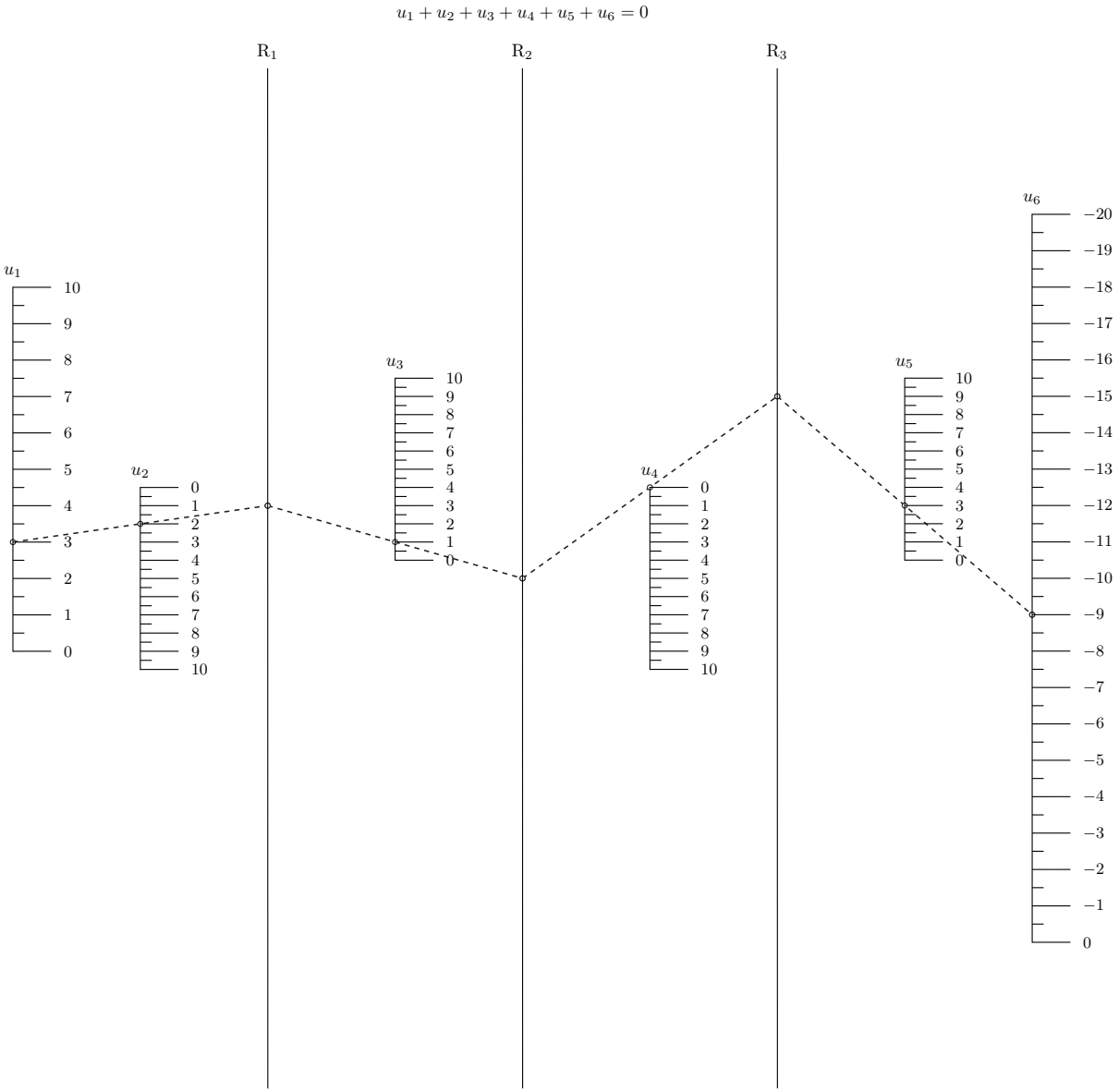
Use of this nomograph is given by the following simple example.

5.3.1 Simple example

This simple example plots nomograph for equation:

$$u_1 + u_2 + u_3 + u_4 + u_5 + u_6 = 0$$

Generated nomograph



Source code of simple example of type 2

```
"""
    ex_type3_nomo_1.py

    Simple nomogram of type 3: F1+F2+...+FN=0
    You should have received a copy of the GNU General Public License
    along with this program.  If not, see <http://www.gnu.org/licenses/>.
"""
import sys
sys.path.insert(0, "..")
from pynomo.nomographer import *

N_params_1={
        'u_min':0.0,
        'u_max':10.0,
        'function':lambda u:u,
        'title':r'$u_1$',
        'tick_levels':2,
        'tick_text_levels':1,
                }
N_params_2={
```

```
        'u_min':0.0,
        'u_max':10.0,
        'function':lambda u:u,
        'title':r'$u_2$',
        'tick_levels':2,
        'tick_text_levels':1,
                }
N_params_3={
        'u_min':0.0,
        'u_max':10.0,
        'function':lambda u:u,
        'title':r'$u_3$',
        'tick_levels':2,
        'tick_text_levels':1,
                }
N_params_4={
        'u_min':0.0,
        'u_max':10.0,
        'function':lambda u:u,
        'title':r'$u_4$',
        'tick_levels':2,
        'tick_text_levels':1,
                }
N_params_5={
        'u_min':0.0,
        'u_max':10.0,
        'function':lambda u:u,
        'title':r'$u_5$',
        'tick_levels':2,
        'tick_text_levels':1,
                }
N_params_6={
        'u_min':-20.0,
        'u_max':0.0,
        'function':lambda u:u,
        'title':r'$u_6$',
        'tick_levels':2,
        'tick_text_levels':1,
        'tick_side':'right',
                }

block_1_params={
             'block_type':'type_3',
             'width':10.0,
             'height':10.0,
             'f_params':[N_params_1,N_params_2,N_params_3,
                         N_params_4,N_params_5,N_params_6],
             'isopleth_values':[[3,2,1,0,3,'x']],
             }

main_params={
              'filename':'ex_type3_nomo_1.pdf',
              'paper_height':20.0,
              'paper_width':20.0,
              'block_params':[block_1_params],
              'transformations':[('rotate',0.01),('scale paper',)],
              'title_str':r'$u_1+u_2+u_3+u_4+u_5+u_6=0$',
              'title_y':21.0,
              }
Nomographer(main_params)
```

5.3.2 Parameters for type 3

Axis parameters

Table 5.5: Specific axis parameters for type 3

parameter key	default value	**type**, explanation
`'function'`	–	**func(u).** Function in equation For example `lambda u: u`
`'u_min'`	–	**Float.** Minimum value of function variable.
`'u_max'`	–	**Float.** Maximum value of function variable.

See *Common axis params* for other parameters.

Block parameters

Table 5.6: Specific block parameters for type 3

parameter	default value	explanation
`'block_type'`	`'type_3'`	**String.** This is type 3 block
`'width'`	10.0	**Float.** Block width (to be scaled)
`'height'`	10.0	**Float.** Block height (to be scaled)
`'f_params'`	–	**List of Axis params Dict.** List of Axis params.
`'mirror_x'`	`False`	**Boolean.** If x-axis is mirrored
`'mirror_y'`	`False`	**Boolean.** If y-axis is mirrored
`'reference_padding'`	`0.2`	**Float.** Additional length to reference axes.
`'reference_titles'`	`[]`	**Array of Strings.** List of reference line titles. For example *['R_1','R_2','R_3']*.
`'reference_color'`	`color.rgb.black`	**Color.** Color of reference lines.
`'isopleth_values'`	`[[]]`	** List of list of isopleth values.** Unknown values are given with strings, e.g. 'x'. An example:`[[0.8,'x',0.7,7.0,9.0],[0.7,0.8,'x',5.0,4.44]`

General parameters

See *List of main params* for top level main parameters.

5.4 Type 4

Type 4 is proportion nomograph that have functional relationship:

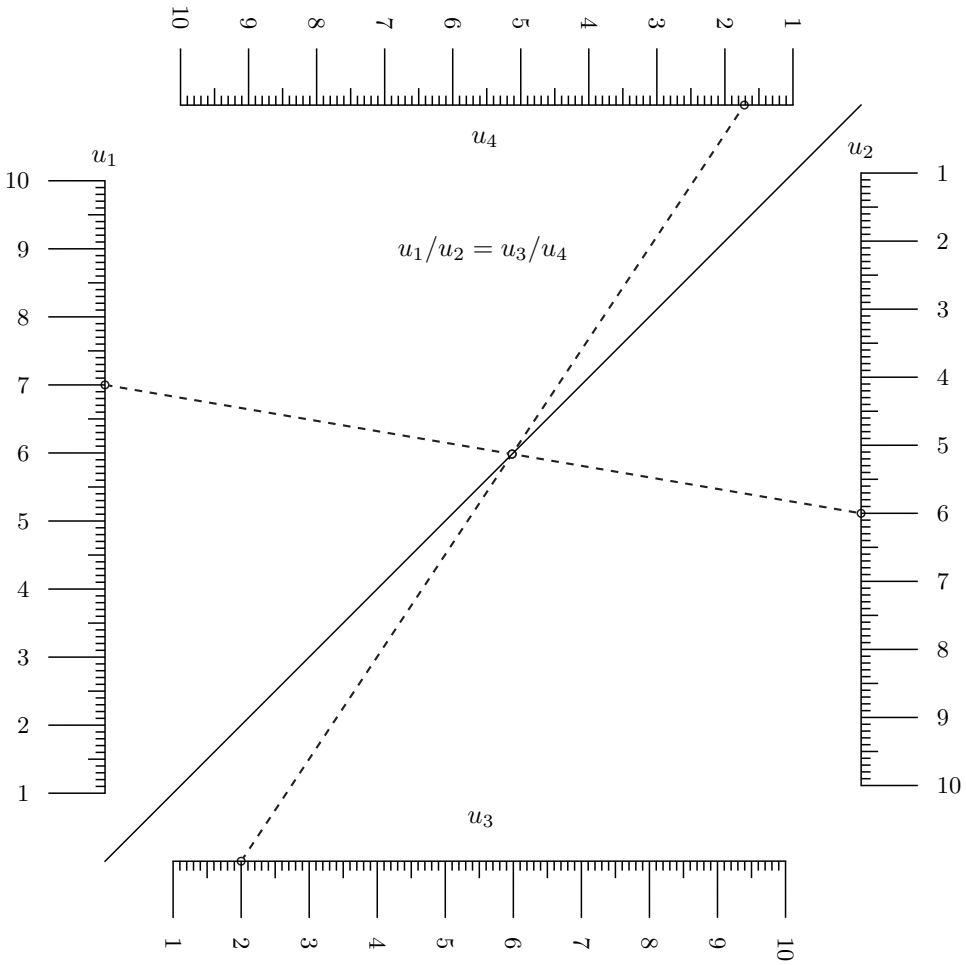
$$\frac{F_1(u_1)}{F_2(u_2)} = \frac{F_3(u_3)}{F_4(u_4)}$$

5.4.1 Simple example

This simple example plots nomograph for equation:

$$u_1/u_2 = u_3/u_4$$

Generated nomograph



Source code of simple example of type 4

```
"""
    ex_type4_nomo_1.py

    Simple nomogram of type 4: F1/F2=F3/F4
"""
import sys
sys.path.insert(0, "..")
from pynomo.nomographer import *

N_params_1={
        'u_min':1.0,
        'u_max':10.0,
        'function':lambda u:u,
        'title':r'$u_1$',
        'tick_levels':3,
        'tick_text_levels':1,
        'tick_side':'left',
```

```
                }
N_params_2={
        'u_min':1.0,
        'u_max':10.0,
        'function':lambda u:u,
        'title':r'$u_2$',
        'tick_levels':3,
        'tick_text_levels':1,
        'tick_side':'right',
                }
N_params_3={
        'u_min':1.0,
        'u_max':10.0,
        'function':lambda u:u,
        'title':r'$u_3$',
        'tick_levels':3,
        'tick_text_levels':1,
        'tick_side':'right',
        'title_draw_center':True,
        'title_opposite_tick':False,
                }
N_params_4={
        'u_min':1.0,
        'u_max':10.0,
        'function':lambda u:u,
        'title':r'$u_4$',
        'tick_levels':3,
        'tick_text_levels':1,
        'tick_side':'left',
        'title_draw_center':True,
        'title_opposite_tick':False,
                }

block_1_params={
                 'block_type':'type_4',
                 'f1_params':N_params_1,
                 'f2_params':N_params_2,
                 'f3_params':N_params_3,
                 'f4_params':N_params_4,
                 'isopleth_values':[[7,6,2,'x']],
                             }

main_params={
               'filename':'ex_type4_nomo_1.pdf',
               'paper_height':10.0,
               'paper_width':10.0,
               'block_params':[block_1_params],
               'transformations':[('rotate',0.01),('scale paper',)],
               'title_str':r'$u_1/u_2=u_3/u_4$',
               'title_y':8.0,
              }
Nomographer(main_params)
```

5.4.2 Parameters for type 4

Axis parameters

Table 5.7: Specific axis parameters for type 4

parameter key	default value	**type**, explanation
`'function'`	–	**func(u).** Function in equation For example `lambda u: u`
`'u_min'`	–	**Float.** Minimum value of function variable.
`'u_max'`	–	**Float.** Maximum value of function variable.

See *Common axis params* for other parameters.

Block parameters

Table 5.8: Specific block parameters for type 4

parameter	default value	explanation
`'block_type'`	`'type_4'`	**String.** This is type 4 block
`'width'`	10.0	**Float.** Block width (to be scaled)
`'height'`	10.0	**Float.** Block height (to be scaled)
`'f1_params'`	–	**Axis params Dict.** Axis params for function f1
`'f2_params'`	–	**Axis params Dict.** Axis params for function f2
`'f3_params'`	–	**Axis params Dict.** Axis params for function f3
`'f4_params'`	–	**Axis params Dict.** Axis params for function f4
`'mirror_x'`	`False`	**Boolean.** If x-axis is mirrored
`'mirror_y'`	`False`	**Boolean.** If y-axis is mirrored
`'padding'`	`0.9`	**Float.** How much axis extend w.r.t. width/height.
`'float_axis'`	`'F1 or F2'`	**Strings.** If given 'F1 or F2', then scaling is according to them, otherwise according to F3 and F4.
`'reference_color'`	`color.rgb.black`	**Color.** Color of reference lines.
`'isopleth_values'`	`[[]]`	** List of list of isopleth values.** Unknown values are given with strings, e.g. 'x'. An example:`[[0.8,'x',0.7,0.5],[0.7,0.8,'x',0.3]]`

General parameters

See *List of main params* for top level main parameters.

5.5 Type 5

Type 5 is graphing block that has functional relationship:

$$F_1(u) = F_2(x, v).$$

This type of block is used commonly in nomographs that have an equation in form

$$f_a(a_1, a_2, a_3, ...) = f_b(u, v)$$

and :math:‘f_b(u,v) cannot be represented as line-nomograph. Typically equation above is written as pair of equations:

$$f_a(a_1, a_2, a_3, ...) = x$$

and

$$f_b(u, v) = x.$$

This equation is written in form

$$F_1(u) = F_2(x, v).$$

in order to construct this contour block. In reality block consists of horizontal lines:

$$F_1(u) = y$$

and contour lines

$$F_2(x, v) = y,$$

where x and y are the coordinates of canvas. Coordinate x is reference with name wd in block parameters and it holds

$$x = f_{wd}(wd).$$

Note: Type 5 is a very complex (say stupid) way to make basic graphs. In the future versions of pynomo a more simple way for graphs will be implemented.

5.5.1 Simple example

In the following example

$$F_1(u) = u$$

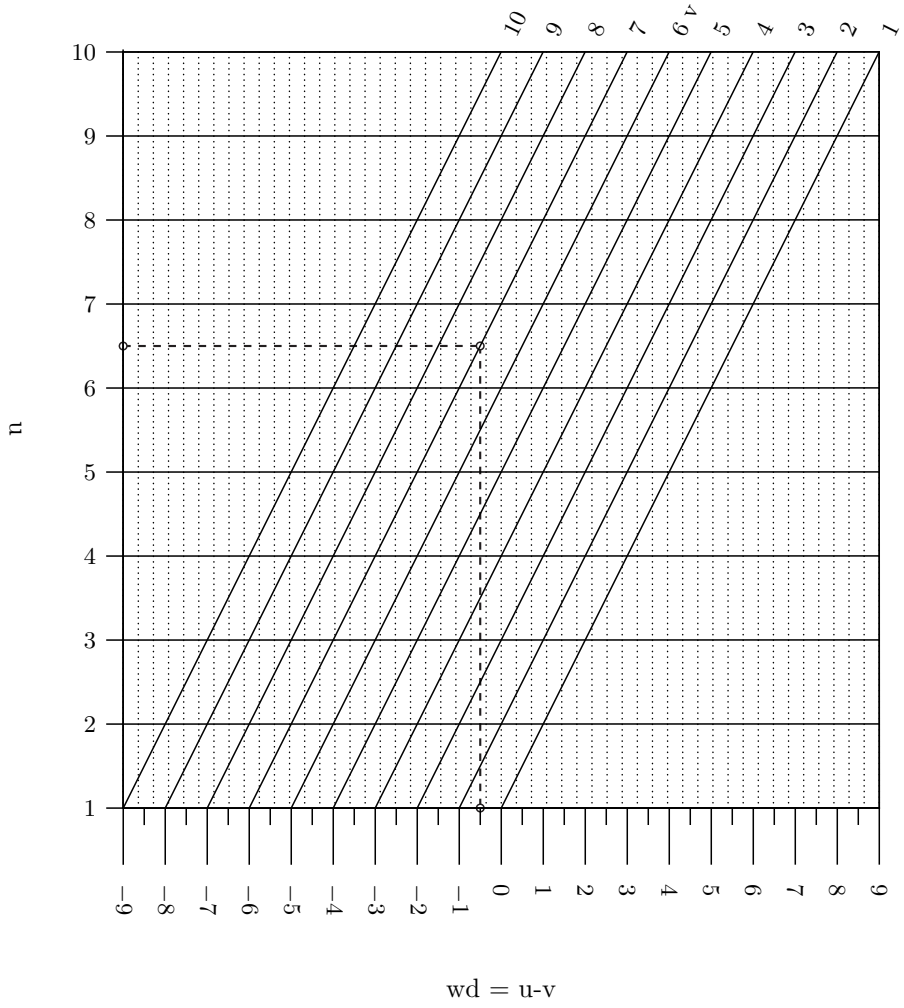
and

$$F_2(wd, v) = wd + v.$$

Thus the original equation is

$$wd = u - v.$$

Generated nomograph



Source code of simple example of type 5

```
"""
    ex_type5_nomo_1.py

    Simple nomogram of type 5.
"""
import sys
sys.path.insert(0, "..")
from pynomo.nomographer import *



block_params={
   'block_type':'type_5',
   'u_func':lambda u:u,
   'v_func':lambda x,v:x+v,
   'u_values':[1.0,2.0,3.0,4.0,5.0,6.0,7.0,8.0,9.0,10.0],
   'v_values':[1.0,2.0,3.0,4.0,5.0,6.0,7.0,8.0,9.0,10.0],
   'wd_tick_levels':2,
   'wd_tick_text_levels':1,
   'wd_tick_side':'right',
   'wd_title':'wd = u-v',
   'u_title':'u',
   'v_title':'v',
   'wd_title_opposite_tick':True,
   'wd_title_distance_center':2.5,
```

```
   'isopleth_values':[[6.5,7,'x']],
 }


main_params={
               'filename':'ex_type5_nomo_1.pdf',
               'paper_height':10.0,
               'paper_width':10.0,
               'block_params':[block_params],
               'transformations':[('rotate',0.01),('scale paper',)]
               }

Nomographer(main_params)
```

5.5.2 Parameters for type 5

Axis parameters

No specific axis parameters. Everything is defined in block.

Block parameters

Table 5.9: Specific block parameters for type 4

parameter	default value	explanation
'block_type'	'type_5'	**String.** This is type 5 block.
'width'	10.0	**Float.** Block width (to be scaled)
'height'	10.0	**Float.** Block height (to be scaled)
'mirror_x'	False	**Boolean.** If x-axis is mirrored
'mirror_y'	False	**Boolean.** If y-axis is mirrored
'u_func'	–	**func(u).** u function. For example "lambda u:u'
'v_func'	–	**func(u,v).** v function. For example `lambda x,v: x+v`
'wd_func'	–	**func(wd).** wd func. For example `lambda wd: wd`
'wd_func_inv'	–	**func(wd).** Inverse of wd-func. For example `lambda wd: wd`
'u_values'	–	**List of Floats.** List of plotted u values. For example *[1.0,2.0,3.0,4.0,5.0,6.0,7.0,8.0,9.0,10.0]'*.
'u_tag'	'none'	**String.** To align blocks w.r.t each other along axes with same tag.
'u_title'	''	**String.** Axis title.
'u_title_x_shift'	0.0	**Float.** Title shift in x-direction.
'u_title_y_shift'	0.25	**Float.** Title shift in y-direction.

Continued on next page

Table 5.9 – continued from previous page

parameter	default value	explanation
'u_scale_type'	'linear'	**String.** Scale type. Can be 'linear': linear scale. 'log': logarithmic scale. 'smart linear': linear scale with equal spacings. 'smart log': logarithmic scale with equal spacings, can also have negative values. 'manual point': Points and corresponding text positions are given manually in 'manual axis data'. No line is drawn. 'manual line': Ticks and corresponding text positions are given manually in 'manual axis data'.
'u_tick_levels'	4	**Integer.** How many levels (minor, minor-minor, etc.) of ticks are drawn. Largest effect to 'linear' scale.
'u_tick_text_levels'	'3'	**Integer.** How many levels (minor, minor-minor, etc.) of texts are drawn. Largest effect to 'linear' scale.
'u_tick_side'	'right'	**String.** Tick and text side in final paper. Can be: 'right''or '''left'
'u_reference'	False	**Boolean.** If axis is treated as reference line that is a turning point.
'u_reference_padding'	'0.2'	**Float.** Fraction of reference line over other lines.
'u_manual_axis_data'	{}	**Dict.** Manually set tick/point positions and text positions. Could be for example:"{1:'1',3.14:r'pi',5:'5',7:'seven',10:'10'}'
'u_title_draw_center'	False	**Boolean.** Title is drawn to center of line.
'u_title_distance_center'	'type_9'	**String.** To double-align blocks w.r.t each other along axes with same tag.
'u_title_opposite_tick'	True	**Boolean.** Title in opposite direction w.r.t ticks.
'u_align_func'	lambda u:u	**func(u).** function to align different scales.
'u_align_x_offset'	0.0	**Float.** If axis is aligned with other axis, this value x offsets final scale.
'u_align_y_offset'	0.0	**Float.** If axis is aligned with other axis, this value y offsets final scale.
'u_text_format'	r'$%4.4g$ '	**String.** Format for numbers in scale.
'u_extra_params'	[{},...]	**Array of Dicts.** List of dictionary of params to be drawn additionally.
'u_text_distance_#'	x.x	**Float.** where #=0,1,2,3 or 4. Distance of text from scale line. Number corresponds to the level, where 0 is the major tick and 4 is the most minor ticks.
'u_grid_length_#'	x.x	**Float.** where #=0,1,2,3 or 4. Length of the tick. Number corresponds to the level, where 0 is the major tick and 4 is the most minor ticks.

Continued on next page

Table 5.9 – continued from previous page

parameter	default value	explanation
'u_text_size_#'	x.x	**Float.** where #=0,1,2,3 or 4. Text size. For example: text.size.small, text.size.scriptsize or text.size.tiny. Number corresponds to the level, where 0 is the major tick and 4 is the most minor ticks.
'u_text_size_log_#'	x.x	**Float.** where #=0,1 or 2. Text size. For example: text.size.small, text.size.scriptsize or text.size.tiny . Number corresponds to the level, where 0 is the major tick and 2 is the most minor ticks.
'u_full_angle'	False	**Boolean.** If true, text can be upside down, otherwise +- 90 degrees from horizontal. Good foor example for full circle scales.
'u_extra_angle'	0.0	**Boolean.** Title is drawn to center of line.
'u_text_horizontal_align_center'	False	**Boolean.** Aligns tick text horizontally to center. Good when text rotated 90 degrees.
'u_axis_color'	color.rgb.black	**Color.** Color of axis.
'u_text_color'	color.rgb.black	**Color.** Color of tick texts.
'v_values'	–	**List of Floats.** List of plotted v values. For example *[1.0,2.0,3.0,4.0,5.0,6.0,7.0,8.0,9.0,10.0]'*.
'v_title'	''	**String.** Axis title.
'v_title_draw_center'	False	**Boolean.** Title is drawn to center of line.
'v_title_distance_center'	'type_9'	**String.** To double-align blocks w.r.t each other along axes with same tag.
'v_title_opposite_tick'	True	**Boolean.** Title in opposite direction w.r.t ticks.
'wd_tag'	'none'	**String.** To align blocks w.r.t each other along axes with same tag.
'wd_title'	''	**String.** Axis title.
'wd_title_x_shift'	0.0	**Float.** Title shift in x-direction.
'wd_title_y_shift'	0.25	**Float.** Title shift in y-direction.
'wd_scale_type'	'linear'	**String.** Scale type. Can be 'linear': linear scale. 'log': logarithmic scale. 'smart linear': linear scale with equal spacings. 'smart log': logarithmic scale with equal spacings, can also have negative values. 'manual point': Points and corresponding text positions are given manually in 'manual axis data'. No line is drawn. 'manual line': Ticks and corresponding text positions are given manually in 'manual axis data'.

Continued on next page

Table 5.9 – continued from previous page

parameter	default value	explanation
'wd_tick_levels'	4	**Integer.** How many levels (minor, minor-minor, etc.) of ticks are drawn. Largest effect to 'linear' scale.
'wd_tick_text_levels'	'3'	**Integer.** How many levels (minor, minor-minor, etc.) of texts are drawn. Largest effect to 'linear' scale.
'wd_tick_side'	'right'	**String.** Tick and text side in final paper. Can be: 'right''or ''left'
'wd_reference'	False	**Boolean.** If axis is treated as reference line that is a turning point.
'wd_reference_padding'	'0.2'	**Float.** Fraction of reference line over other lines.
'wd_manual_axis_data'	{}	**Dict.** Manually set tick/point positions and text positions. Could be for example:"{1:'1',3.14:r'pi',5:'5',7:'seven',10:'10'}'
'wd_title_draw_center'	False	**Boolean.** Title is drawn to center of line.
'wd_title_distance_center'	'type_9'	**String.** To double-align blocks w.r.t each other along axes with same tag.
'wd_title_opposite_tick'	True	**Boolean.** Title in opposite direction w.r.t ticks.
'wd_align_func'	lambda u:u	**func(u).** function to align different scales.
'wd_align_x_offset'	0.0	**Float.** If axis is aligned with other axis, this value x offsets final scale.
'wd_align_y_offset'	0.0	**Float.** If axis is aligned with other axis, this value y offsets final scale.
'wd_text_format'	r'$%4.4g$ '	**String.** Format for numbers in scale.
'wd_extra_params'	[{},...]	**Array of Dicts.** List of dictionary of params to be drawn additionally.
'wd_text_distance_#'	x.x	**Float.** where #=0,1,2,3 or 4. Distance of text from scale line. Number corresponds to the level, where 0 is the major tick and 4 is the most minor ticks.
'wd_grid_length_#'	x.x	**Float.** where #=0,1,2,3 or 4. Length of the tick. Number corresponds to the level, where 0 is the major tick and 4 is the most minor ticks.
'wd_text_size_#'	x.x	**Float.** where #=0,1,2,3 or 4. Text size. For example: text.size.small, text.size.scriptsize or text.size.tiny. Number corresponds to the level, where 0 is the major tick and 4 is the most minor ticks.

Continued on next page

Table 5.9 – continued from previous page

parameter	default value	explanation
'wd_text_size_log_#'	x.x	**Float.** where #=0,1 or 2. Text size. For example: text.size.small, text.size.scriptsize or text.size.tiny . Number corresponds to the level, where 0 is the major tick and 2 is the most minor ticks.
'wd_full_angle'	False	**Boolean.** If true, text can be upside down, otherwise +- 90 degrees from horizontal. Good foor example for full circle scales.
'wd_extra_angle'	0.0	**Boolean.** Title is drawn to center of line.
'wd_text_horizontal_alignment'	False	**Boolean.** Aligns tick text horizontally to center. Good when text rotated 90 degrees.
'wd_axis_color'	color.rgb.black	**Color.** Color of axis.
'wd_text_color'	color.rgb.black	**Color.** Color of tick texts.
'isopleth_values'	[[]]	** List of list of isopleth values.** Unknown values are given with strings, e.g. 'x'. An example:[[0.8,'x',0.7],[0.7,0.8,'x']]

General parameters

See *List of main params* for top level main parameters.

5.6 Type 6

Type 6 is ladder nomograph:

$$u = u.$$

In practice this means that if one axis has for example y-position as

$$y = f_1(u)$$

and it was desirable to have

$$y = f_2(u)$$

in order to connect blocks together, one uses ladder to make the transformation.

Note: Ladders are not beautiful and should be used only when no other solution exist.

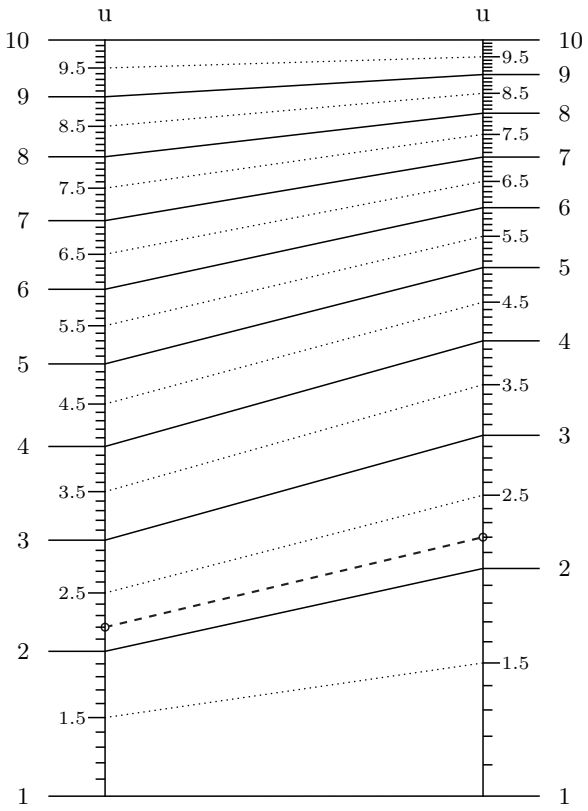
5.6.1 Simple example

This simple example plots nomograph for equation:

$$u = u,$$

where linear scale is converted to a logarithmic scale.

Generated nomograph



Source code of simple example of type6

```
"""
    ex_type6_nomo_1.py

    Simple nomogram of type 6.
"""
import sys
sys.path.insert(0, "..")
from pynomo.nomographer import *

N_params_1={
        'u_min':1.0,
        'u_max':10.0,
        'function':lambda u:u**0.5,
        'title':'u',
        'tick_levels':3,
        'tick_text_levels':2,
        'tick_side':'left',
        }

N_params_2={
        'u_min':1.0,
        'u_max':10.0,
        'function':lambda u:log(u),
        'title':'u',
        'tick_levels':3,
        'tick_text_levels':2,
        }

block_params={
              'block_type':'type_6',
              'f1_params':N_params_1,
              'f2_params':N_params_2,
              'width':5.0,
```

```
                'height':10.0,
                'isopleth_values':[[2.2,'x']],
                #'curve_const':0.01
                        }

main_params={
                'filename':'ex_type6_nomo_1.pdf',
                'paper_height':10.0,
                'paper_width':5.0,
                'block_params':[block_params],
                'transformations':[('rotate',0.01),('scale paper',)]
                }

Nomographer(main_params)
```

5.6.2 Parameters for type 6

Axis parameters

Table 5.10: Specific axis parameters for type 6

parameter key	default value	**type**, explanation
`'function'`	–	**func(u).** Function in equation For example `lambda u: u`
`'u_min'`	–	**Float.** Minimum value of function variable.
`'u_max'`	–	**Float.** Maximum value of function variable.

See *Common axis params* for other parameters.

Block parameters

Table 5.11: Specific block parameters for type 6

parameter	default value	explanation
'block_type'	'type_6'	**String.** This is type 6 block.
'type'	'parallel'	**String.** Can be either 'parallel'‘‘or ‘‘'orthogonal'.
'x_empty'	0.2	**Float.** If orthogonal, how much fractional space before start of x-axis.
'y_empty'	0.2	**Float.** If orthogonal, how much fractional space before start of y-axis.
'curve_const'	0.0	**Float.** Sets the lenght of angle of Bezier curve. low value = straigh line, high value = curved line.
'width'	10.0	**Float.** Block width (to be scaled)
'height'	10.0	**Float.** Block height (to be scaled)
'f1_params'	–	**Axis params Dict.** Axis params for function f1
'f2_params'	–	**Axis params Dict.** Axis params for function f2
'mirror_x'	False	**Boolean.** If x-axis is mirrored
'mirror_y'	False	**Boolean.** If y-axis is mirrored
'ladder_color'	color.rgb.black	**Color.** Ladder color.
'isopleth_values'	[[]]	** List of list of isopleth values.** Unknown values are given with strings, e.g. ‘x’. An example:[[0.8,'x'],[0.7,'x']]

General parameters

See *List of main params* for top level main parameters.

5.7 Type 7

Type 7 is “angle” nomograph that has functional relationship:

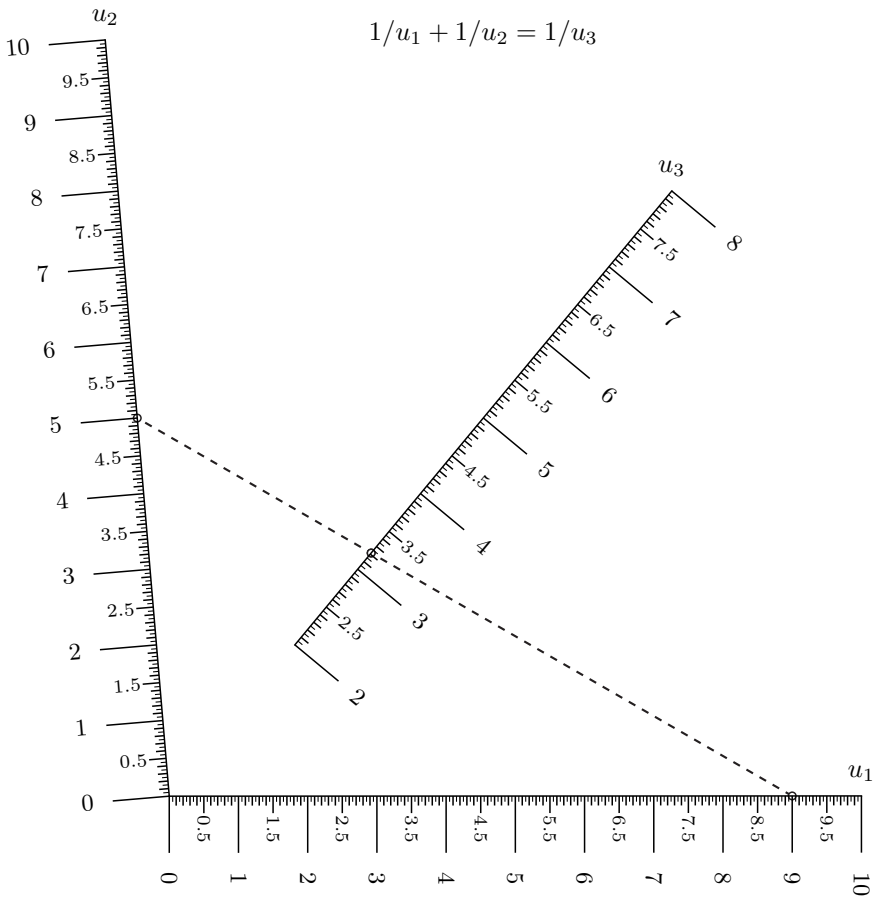
$$\frac{1}{F_1(u_1)} + \frac{1}{F_2(u_2)} = \frac{1}{F_3(u_3)}$$

5.7.1 Simple example

This simple example plots nomograph for equation:

$$1/u_1 + 1/u_2 = 1/u_3$$

Generated nomograph



Source code of simple example of type 2

5.7.2 Parameters for type 7

Axis parameters

Table 5.12: Specific axis parameters for type 7

parameter key	default value	**type**, explanation
`'function'`	–	**func(u).** Function in equation For example `lambda u: u`
`'u_min'`	–	**Float.** Minimum value of function variable.
`'u_max'`	–	**Float.** Maximum value of function variable.

See *Common axis params* for other parameters.

Block parameters

Table 5.13: Specific block parameters for type 7

parameter	default value	explanation
'block_type'	'type_4'	**String.** This is type 7 block
'width'	10.0	**Float.** Block width (to be scaled)
'height'	10.0	**Float.** Block height (to be scaled)
'f1_params'	–	**Axis params Dict.** Axis params for function f1
'f2_params'	–	**Axis params Dict.** Axis params for function f2
'f3_params'	–	**Axis params Dict.** Axis params for function f3
'mirror_x'	False	**Boolean.** If x-axis is mirrored
'mirror_y'	False	**Boolean.** If y-axis is mirrored
'angle_u'	45.0	**Float.** Angle between u1 and u3. Note: later transformations may alter the angle.
'angle_v'	45.0	**Float.** Angle between u2 and u3. Note: later transformations may alter the angle.
'isopleth_values'	[[]]	** List of list of isopleth values.** Unknown values are given with strings, e.g. 'x'. An example:[[0.8,'x',0.7],[0.7,0.8,'x']]

General parameters

See *List of main params* for top level main parameters.

5.8 Type 8

Type 8 is single nomograph:

$$y = F(u)$$

or

$$x = F_x(u),$$

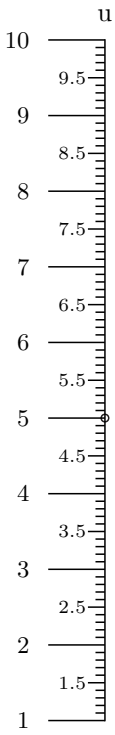
$$y = F_y(u).$$

x and y are coordinates of canvas. Often this block is used for construction of dual-scales to existing scales.

5.8.1 Simple example

This simple example plots single vertical scale.

Generated nomograph



Source code of simple example of type 8

```
"""
    ex_type8_nomo_1.py

    Simple nomogram of type 8.
"""
import sys
sys.path.insert(0, "..")
from pynomo.nomographer import *

N_params_1={
        'u_min':1.0,
        'u_max':10.0,
        'function':lambda u:u,
        'title':'u',
        'tick_levels':3,
        'tick_text_levels':2,
        'tick_side':'left',
        }

block_params={
               'block_type':'type_8',
               'f_params':N_params_1,
               'width':5.0,
               'height':10.0,
               'isopleth_values':[[5]]
                      }

main_params={
               'filename':'ex_type8_nomo_1.pdf',
               'paper_height':10.0,
               'paper_width':5.0,
               'block_params':[block_params],
               'transformations':[]
               }

Nomographer(main_params)
```

5.8.2 Parameters for type 8

Axis parameters

Table 5.14: Specific axis parameters for type 8

parameter key	default value	**type**, explanation
`'function'`	–	**func(u).** Function in equation. For example `lambda u: u`.
`'u_min'`	–	**Float.** Minimum value of function variable.
`'u_max'`	–	**Float.** Maximum value of function variable.
`'function_x'`	–	**func(u).** x-position in function. If used 'function_y' must be defined. For example `lambda u: u`.
`'function_y'`	–	**func(u).** y-position in function. If used 'function_x' must be defined. Overrides 'function'. For example `lambda u: u`.

See *Common axis params* for other parameters.

Block parameters

Table 5.15: Specific block parameters for type 8

parameter	default value	explanation
`'block_type'`	`'type_8'`	**String.** This is type 8 block
`'width'`	10.0	**Float.** Block width (to be scaled)
`'height'`	10.0	**Float.** Block height (to be scaled)
`'f1_params'`	–	**Axis params Dict.** Axis params for function f1
`'f2_params'`	–	**Axis params Dict.** Axis params for function f2
`'f3_params'`	–	**Axis params Dict.** Axis params for function f3
`'f4_params'`	–	**Axis params Dict.** Axis params for function f4
`'mirror_x'`	`False`	**Boolean.** If x-axis is mirrored
`'mirror_y'`	`False`	**Boolean.** If y-axis is mirrored
`'padding'`	`0.9`	**Float.** How much axis extend w.r.t. width/height.
`'float_axis'`	`'F1 or F2'`	**Strings.** If given 'F1 or F2', then scaling is according to them, otherwise according to F3 and F4.
`'reference_color'`	`color.rgb.black`	**Color.** Color of reference lines.
`'isopleth_values'`	`[[]]`	** List of list of isopleth values.** Unknown values are given with strings, e.g. 'x'. An example:`[[0.8,'x',0.7,0.5], [0.7,0.8,'x',0.3]]`

General parameters

See *List of main params* for top level main parameters.

5.9 Type 9

Type 9 is "general determinant" nomograph that has functional relationship:

$$\begin{vmatrix} F_1(u_1[,v_1]) & G_1(u_1[,v_1]) & H_1(u_1[,v_1]) \\ F_2(u_2[,v_2]) & G_2(u_2[,v_2]) & H_2(u_2[,v_2]) \\ F_3(u_3[,v_3]) & G_3(u_3[,v_3]) & H_3(u_3[,v_3]) \end{vmatrix} = 0.$$

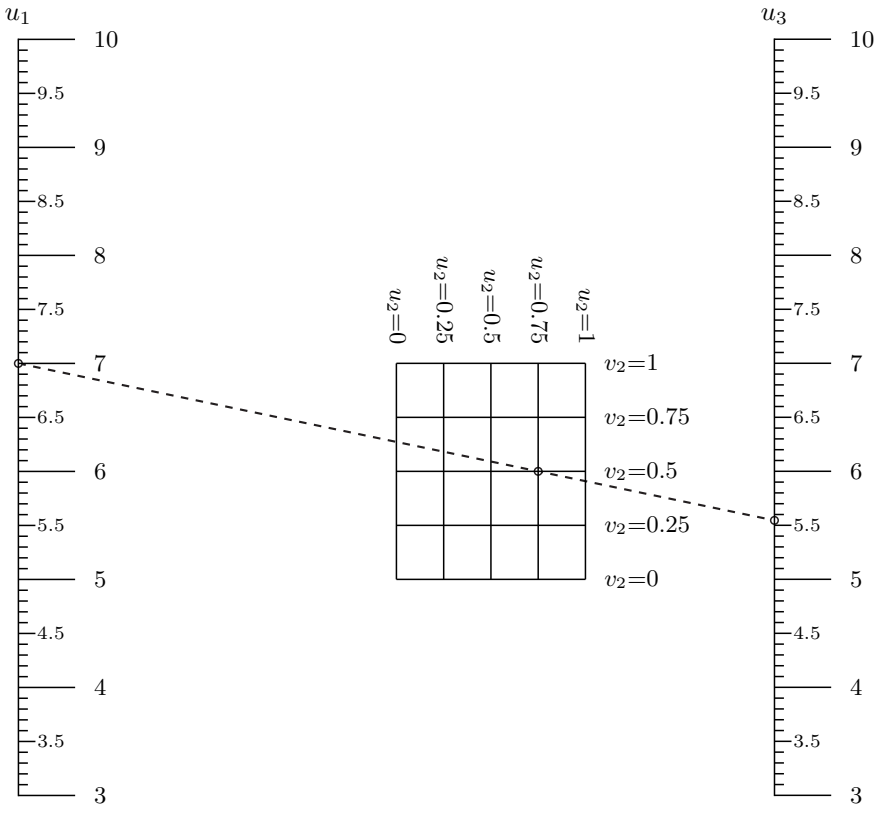
This is the basic building block for line nomographs. Notation $u[,v]$ is to be understood such that if v is defined ´, a grid is constructed for the row, otherwise a normal scale with variable u.

5.9.1 Simple example

This simple example plots nomograph for equation in determinant form:

$$\begin{vmatrix} 0 & u_1 & 1 \\ u_2+2 & 2v_2+5 & 1 \\ 4 & u_3 & 1 \end{vmatrix} = 0$$

Generated nomograph



Source code of simple example of type 9

```
"""
    ex_type9_nomo_1.py

    Simple nomogram of type 9: determinant
"""
import sys
sys.path.insert(0, "..")
from pynomo.nomographer import *

N_params_1={
            'u_min':3.0,
            'u_max':10.0,
            'f':lambda u:0,
            'g':lambda u:u,
            'h':lambda u:1.0,
            'title':r'$u_1$',
            'scale_type':'linear',
            'tick_levels':3,
            'tick_text_levels':2,
            'grid':False}

N_params_2={
        'u_min':0.0, # for alignment
        'u_max':1.0,  # for alignment
        'f_grid':lambda u,v:u+2.0,
        'g_grid':lambda u,v:2*v+5.0,
        'h_grid':lambda u,v:1.0,
        'u_start':0.0,
        'u_stop':1.0,
        'v_start':0.0,
        'v_stop':1.0,
        'u_values':[0.0,0.25,0.5,0.75,1.0],
        'v_values':[0.0,0.25,0.5,0.75,1.0],
        'grid':True,
        'text_prefix_u':r'$u_2$=',
        'text_prefix_v':r'$v_2$=',
        }

N_params_3={
            'u_min':3.0,
            'u_max':10.0,
            'f':lambda u:4.0,
            'g':lambda u:u,
            'h':lambda u:1.0,
            'title':r'$u_3$',
            'scale_type':'linear',
            'tick_levels':3,
            'tick_text_levels':2,
            'grid':False
            }

block_params={
             'block_type':'type_9',
             'f1_params':N_params_1,
             'f2_params':N_params_2,
             'f3_params':N_params_3,
             'transform_ini':False,
             'isopleth_values':[[7,[0.75,0.5],'x']]
             }

main_params={
              'filename':'ex_type9_nomo_1.pdf',
              'paper_height':10.0,
              'paper_width':10.0,
              'block_params':[block_params],
              'transformations':[('rotate',0.01),('scale paper',)]
              }
Nomographer(main_params)
```

5.9.2 Parameters for type 9

Axis parameters

Table 5.16: Specific axis parameters for type 9 grid axis

parameter key	default value	**type**, explanation
`'grid'`	–	**Bool.** `True` because this is grid.
`'f'`	–	**func(u,v).** F function in determinant. For example `lambda u,v:u+v`
`'g'`	–	**func(u,v).** G function in determinant. For example `lambda u,v:u+v`
`'h'`	–	**func(u,v).** H function in determinant. For example `lambda u,v:u+v`
`'u_start'`	–	u start when drawing v=const line
`'u_stop'`	–	u stop when drawing v=const line
`'v_start'`	–	v start when drawing u=const line
`'v_stop'`	–	v stop when drawing u=const line
`'u_values'`	–	List of grid lines u=const. For example `[0.0,0.25,0.5,0.75,1.0]`
`'v_values'`	–	List of grid lines v=const. For example ‘‘[0.0,0.25,0.5,0.75,1.0]‘
`'text_prefix_u'`	–	Text prefix for u before value
`'text_prefix_v'`	–	Text prefix for v before value
`'v_texts_u_start'`	`False`	If v-texts are in u start side
`'v_texts_u_stop'`	`True`	If v-texts are in u stop side
`'u_texts_v_start'`	`False`	If u-texts are in v start side
`'u_texts_v_stop'`	`True`	If u-texts are in v stop side
`'u_line_color'`	`color.rgb.black`	**Color.** u line color
`'v_line_color'`	`color.rgb.black`	**Color.** v line color
`'u_text_color'`	`color.rgb.black`	**Color.** u text color
`'v_text_color'`	`color.rgb.black`	**Color.** v text color
`'text_distance'`	0.25	**Float.** Text distance
`'circles'`	`False`	**Boolean.** If marker circles to crossings
`'extra_params'`	–	**List of Dicts.** List of params to be drawn.

See *Common axis params* for other parameters.

Block parameters

Table 5.17: Specific block parameters for type 9

parameter	default value	explanation
`'block_type'`	`'type_9'`	**String.** This is type 9 block
`'width'`	10.0	**Float.** Block width (to be scaled)
`'height'`	10.0	**Float.** Block height (to be scaled)
`'f1_params'`	–	**Axis params Dict.** Axis params for function f1
`'f2_params'`	–	**Axis params Dict.** Axis params for function f2
`'f3_params'`	–	**Axis params Dict.** Axis params for function f3
`'mirror_x'`	`False`	**Boolean.** If x-axis is mirrored
`'mirror_y'`	`False`	**Boolean.** If y-axis is mirrored
`'transform_ini'`	`False`	**Boolean.** If row 1 and row 3 end and start are to be transformed to be in rectangle corners. If True, be sure that 'u_min_trafo' and 'u_max_trafo' are defined.
`'isopleth_values'`	`[[]]`	** List of list of isopleth values.** Grid values are given with tuple (a,b) and are not solved. Unknown values are given with strings, e.g. 'x'. An example:`[[0.8,(0.1,0.2),'x'], ['x',(0.1,0.2),1.0]]`

General parameters

See *List of main params* for top level main parameters.

5.10 Type 10

Type 10 is nomograph that has one curved line. It has functional relationship:

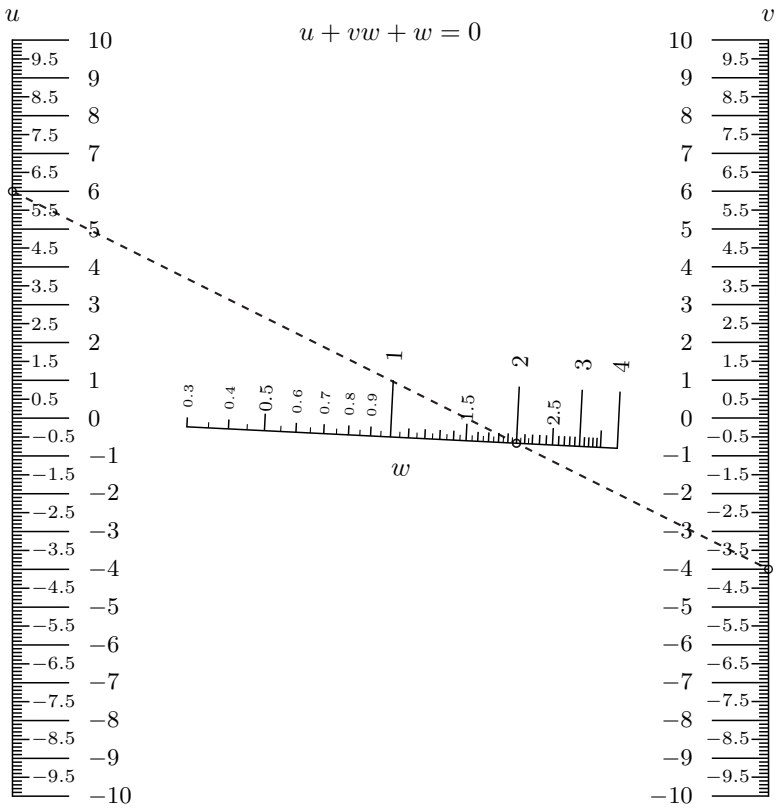
$$F_1(u) + F_2(v)F_3(w) + F_4(w) = 0.$$

5.10.1 Simple example

This simple example plots nomograph for equation:

$$u + vw + w = 0.$$

Generated nomograph



Source code of simple example of type 10

```
"""
    ex_type10_nomo_1.py

    Simple nomogram of type 7: F1(u)+F2(v)*F3(w)+F4(w)=0
    along with this program.  If not, see <http://www.gnu.org/licenses/>.
"""
import sys
sys.path.insert(0, "..")
from pynomo.nomographer import *

N_params_1={
        'u_min':-10.0,
        'u_max':10.0,
        'function':lambda u:u,
        'title':r'$u$',
        'tick_levels':3,
        'tick_text_levels':2,
                }

N_params_2={
        'u_min':-10.0,
        'u_max':10.0,
        'function':lambda u:u,
        'title':r'$v$',
        'tick_levels':3,
        'tick_text_levels':2,
        'tick_side':'left',
                }

N_params_3={
        'u_min':0.3,
        'u_max':4.0,
        'function_3':lambda u:u,
```

```
        'function_4':lambda u:u,
        'title':r'$w$',
        'tick_levels':4,
        'tick_text_levels':3,
        'scale_type':'linear smart',
        'title_draw_center':True,
               }

block_1_params={
             'block_type':'type_10',
             'width':10.0,
             'height':10.0,
             'f1_params':N_params_1,
             'f2_params':N_params_2,
             'f3_params':N_params_3,
             'isopleth_values':[[6,-4,'x']]
             }

main_params={
              'filename':'ex_type10_nomo_1.pdf',
              'paper_height':10.0,
              'paper_width':10.0,
              'block_params':[block_1_params],
              'transformations':[('rotate',0.01),('scale paper',)],
              'title_str':r'$u+vw+w=0$'
              }
Nomographer(main_params)
```

5.10.2 Parameters for type 10

Axis parameters

Table 5.18: Specific axis parameters for type 10

parameter key	default value	**type**, explanation
'function'	–	**func(u).** Function in the equation for F_1 and F_2.$Forexample"lambdau : u$‘
'function_3'	–	**func(u).** Function in the equation for F_3. For example `lambda u: u`
'function_4'	–	**func(u).** Function in the equation for F_4. For example `lambda u: u`
'u_min'	–	**Float.** Minimum value of function variable.
'u_max'	–	**Float.** Maximum value of function variable.

See *Common axis params* for other parameters.

Block parameters

Table 5.19: Specific block parameters for type 10

parameter	default value	explanation
'block_type'	'type_10'	**String.** This is type 10 block
'width'	10.0	**Float.** Block width (to be scaled)
'height'	10.0	**Float.** Block height (to be scaled)
'f1_params'	–	**Axis params Dict.** Axis params for function f1
'f2_params'	–	**Axis params Dict.** Axis params for function f2
'f3_params'	–	**Axis params Dict.** Axis params for function f3
'f4_params'	–	**Axis params Dict.** Axis params for function f4
'mirror_x'	False	**Boolean.** If x-axis is mirrored
'mirror_y'	False	**Boolean.** If y-axis is mirrored
'padding'	0.9	**Float.** How much axis extend w.r.t. width/height.
'float_axis'	'F1 or F2'	**Strings.** If given 'F1 or F2', then scaling is according to them, otherwise according to F3 and F4.
'reference_color'	color.rgb.black	**Color.** Color of reference lines.
'isopleth_values'	[[]]	** List of list of isopleth values.** Unknown values are given with strings, e.g. 'x'. An example:[[0.8,'x',0.7,0.5],[0.7,0.8,'x',0.3]]

General parameters

See *List of main params* for top level main parameters.

CHAPTER

SIX

EXAMPLES

In the following are listed examples to show nomographs possibilities. Also is explained the background for the cases and underlying math for the nomograph construction. Source code shows the implementation.

6.1 Example: Amortized loan calculator

6.1.1 Theory and background

This approach of constructing an amortized loan calculator is similar to one in Ref. [1]_

Equation for amortized loan [2]_ is:

$$\frac{a}{A} = \frac{\frac{p}{100\times 12}}{1-\frac{1}{(1+\frac{p}{100\times 12})^{12n}}},$$

where A is the amount of loan, a is monthly payment amount, p interest rate per year (monthly interest rate is taken as $p/12$) [1] and n is number of years for payment.

This equation of four variables is probably impossible to present with line and grid nomographs. For this reason a "Type 5" contour nomogram is constructed of the right hand side of the equation and left hand equation is just N-nomogram (Type 2). The two equations for nomogram construction are:

$$x = \frac{a}{A}$$

and

$$x = \frac{\frac{p}{100\times 12}}{1-\frac{1}{(1+\frac{p}{100\times 12})^{12n}}}.$$

In practice x is the x-coordinate of the canvas where nomogram is constructed.

Right hand side of equation

By defining coordinates x and y:

$$x = \frac{\frac{p}{100\times 12}}{1-\frac{1}{(1+\frac{p}{100\times 12})^{12n}}},$$

$y = 12n,$ we may solve y in terms of x and n:

[1] http://en.wikipedia.org/wiki/Annual_percentage_rate#Does_not_represent_the_total_cost_of_borrowing

$y = \frac{\log(\frac{x}{x-\frac{p}{100\times12}})}{\log(1+\frac{p}{100\times12})}$

The previous two equations are of correct form

$y = f_1(v)$

and

$y = f_2(x, u)$

for type 5 nomogram. For compressing time axis (y-axis), we transform $y \to \log y$ and find

$y = \log\left(\frac{\log(\frac{x}{x-\frac{p}{100\times12}})}{\log(1+\frac{p}{100\times12})}\right)$

$y = \log(12n).$

Left hand side of equation

Left hand side of equation

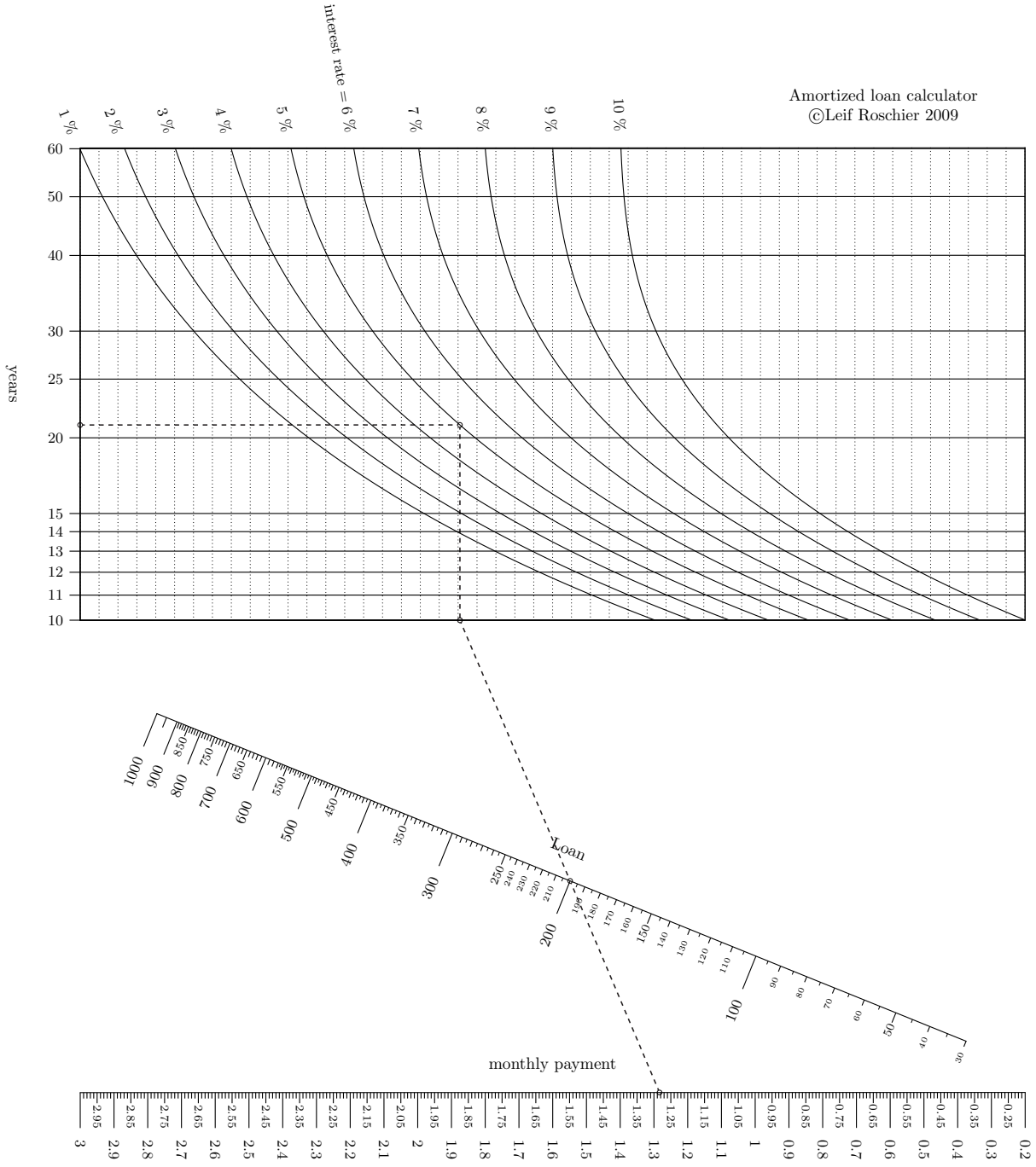
$x = \frac{a}{A}$

is just N-nomogram

$F_1(u_1) = F_2(u_2)F_3(u_3)$

References

6.1.2 Generated nomograph



6.1.3 Source code

```
"""
    ex_amortized_loan.py

    Amortized loan calculator
"""
import sys
sys.path.insert(0, "..")
from pynomo.nomographer import *

# Type 5 contour
```

```
def f1(x,u):
    return log(log(x/(x-u/(100.0*12.0)))/log(1+u/(100.0*12.0)))

block_1_params={
            'width':10.0,
           'height':5.0,
           'block_type':'type_5',
           'u_func':lambda u:log(u*12.0),
           'v_func':f1,
           'u_values':[10.0,11.0,12.0,13.0,14.0,15.0,20.0,25.0,30.0,40.0,50.0,60.0],
           'v_values':[1.0,2.0,3.0,4.0,5.0,6.0,7.0,8.0,9.0,10.0],
           'wd_tag':'A',
           'u_title':'years',
           'v_title':r'interest rate = ',
           'u_text_format':r"$%3.0f$ ",
           'v_text_format':r"$%3.0f$ \%% ",
           'isopleth_values':[[21,5,'x']]
             }

# this is non-obvious trick to find bottom edge coordinates of the grid in order
# to align it with N nomogram
block1_dummy=Nomo_Block_Type_5(mirror_x=False)
block1_dummy.define_block(block_1_params)
block1_dummy.set_block()

# Let's define the N-nomogram
N_params_3={
        'u_min':block1_dummy.grid_box.params_wd['u_min'],
        'u_max':block1_dummy.grid_box.params_wd['u_max'],
        'function':lambda u:u,
        'title':'',
        'tag':'A',
        'tick_side':'right',
        'tick_levels':2,
        'tick_text_levels':2,
        'reference':False,
        'tick_levels':0,
        'tick_text_levels':0,
        'title_draw_center':True
                }
N_params_2={
        'u_min':30.0,
        'u_max':1000.0,
        'function':lambda u:u,
        'title':'Loan',
        'tag':'none',
        'tick_side':'left',
        'tick_levels':4,
        'tick_text_levels':3,
        'title_draw_center':True,
       #'text_format':r"$%3.0f$ ",
        'scale_type':'linear smart',
                }
N_params_1={
        'u_min':0.2,
        'u_max':3.0,
        'function':lambda u:u,
        'title':'monthly payment',
        'tag':'none',
        'tick_side':'right',
        'tick_levels':3,
        'tick_text_levels':2,
        'title_draw_center':True
                }

block_2_params={
             'block_type':'type_2',
             'width':10.0,
             'height':20.0,
             'f1_params':N_params_1,
             'f2_params':N_params_2,
             'f3_params':N_params_3,
```

```
            'isopleth_values':[['x',200,'x']]
            }

main_params={
             'filename':'amortized_loan.pdf',
             'paper_height':20.0,
             'paper_width':20.0,
             'block_params':[block_1_params,block_2_params],
             'transformations':[('rotate',0.01),('scale paper',)],
               'title_str':r'Amortized loan calculator    \copyright    Leif Roschier  2009',
               'title_x': 17,
               'title_y': 21,
               'title_box_width': 5
             }
Nomographer(main_params)
```

6.2 Example Photography exposure

6.2.1 Theory and background

This example illustrates how exposure in photography depends on factors: latitude, time of day, day of year, weather, composition. It relates these to camera settings: film speed (e.g. ISO 100), aperture and shutter speed. The mathematical approach and model is taken from book written by V. Setälä. [1]_ This book illustrates the approach as nomographs but they are different compared with the one generatated here. Book uses shadow length, but we break shadow length into time, date and latitude via solar zenith angle.

The basic equation in Setälä (pp.492-494) can be extracted and written as

$$FS - L - A - W + C + T = 0 \tag{6.1}$$

where parameters of (6.1) are listed below:

FS	Film speed	DIN value that equals $10\log(S) + 1$,where S is ISO FILM speed
T	shutter time	$10\log\left(\frac{t}{1/10}\right)$
A	aperture	$10\log\left(\frac{N^2}{3.2^2}\right)$
L	shadow length (in steps)	two times (shadow length)/(person length) $= 2\arctan(\phi)$, where ϕ is solar zenith angle.
W	weather	Clear sky, Cumulus clouds: 0, Clear sky: 1, Sun through clouds: 3, Sky light gray: 6, Sky dark gray: 9, Thunder-clouds cover sky: 12
C	Composition	Person under trees: -6, Inside forest : -4, Person in shadow of wall : -1, Person at open place; alley under trees : 2, Buildings; street : 5, Landscape and front matter : 7, Open landscape : 9, Snow landscape and front matter; beach : 11,Snow field; open sea : 13, Clouds : 15

It is to be noted that Setälä has stops ten times base-10 logarithmic. Today we think stops in base-2 logarithmic.

Shadow lenght

Calculation of shadow length as a function of day of year, time of day and latitude is according to [2]_. Following equations are used. For fractional year (without time information) we take

$\gamma = (day - 1 + 0.5)2\pi/365.$

For time offset (eqtime) we use equation (in minutes)

$TO = 229.18(0.000075 + 0.001868\cos(\gamma) - 0.032077\sin(\gamma) - 0.014615\cos(2\gamma) - 0.040849\sin(2\gamma))$

to calculate that error is below 17 minutes for time axis. We assume that sun is at heightest point at noon and this is the error and approximation. We calculate stops in logarithmic scale and in this case we do not need very accurate equations for time. For declination we use equation

and for hour angle

$ha = (60h + \overline{TO})/4 - 180.$

Solar zenith angle (ϕ), latitude (LAT), declination (D) and hour angle (ha) are connected with equation:

$\cos(\phi) = \sin(LAT)sin(D) + \cos(LAT)\cos(D)\cos(ha).$

This is in our desired form as a function of hour (h), day (day), latitude (LAT), solar zenith angle (ϕ):

$\cos(\phi) = \sin(LAT)sin(D(\gamma(day))) + \cos(LAT)\cos(D(\gamma(day)))\cos(ha(h))\,.$

In practice illuminance of flat surface on earth depends on solar zenith angle as $\cos(\phi)$. Setälä uses shadow length that is easily measurable, but scales incorrectly, as value is proportional to $\tan(\phi)$. Also Setälä sums linear value with logarithmic ones as a practical approximation. To correct these assumptions, here we assume that values for shadow length 1 and 10 for Setälä are reasonable, and an equation that scales logarithmically is found:

$L = 0.33766 - 13.656\log 10(\cos(\phi))$

that gives $L = 1$ for $\phi = 26.565 = \arctan(1/2)$ and $L = 10$ for $\phi = 78.69 = \arctan(10/2)$.

6.2.2 Construction of the nomograph

The presented equation is the following:

$$FS - \{0.33766 - 13.656\log_{10}[\sin(LAT)\sin(D(\gamma(day))) + \cos(LAT)\cos(D(\gamma(day)))\cos(ha(h))]\} \\ -A - W + C + T = 0.$$

In order to construct the nomograph, we split the equation into four blocks and an additional block to present values as EV100.

Table 6.1: Main equation split into blocks for the nomograph.

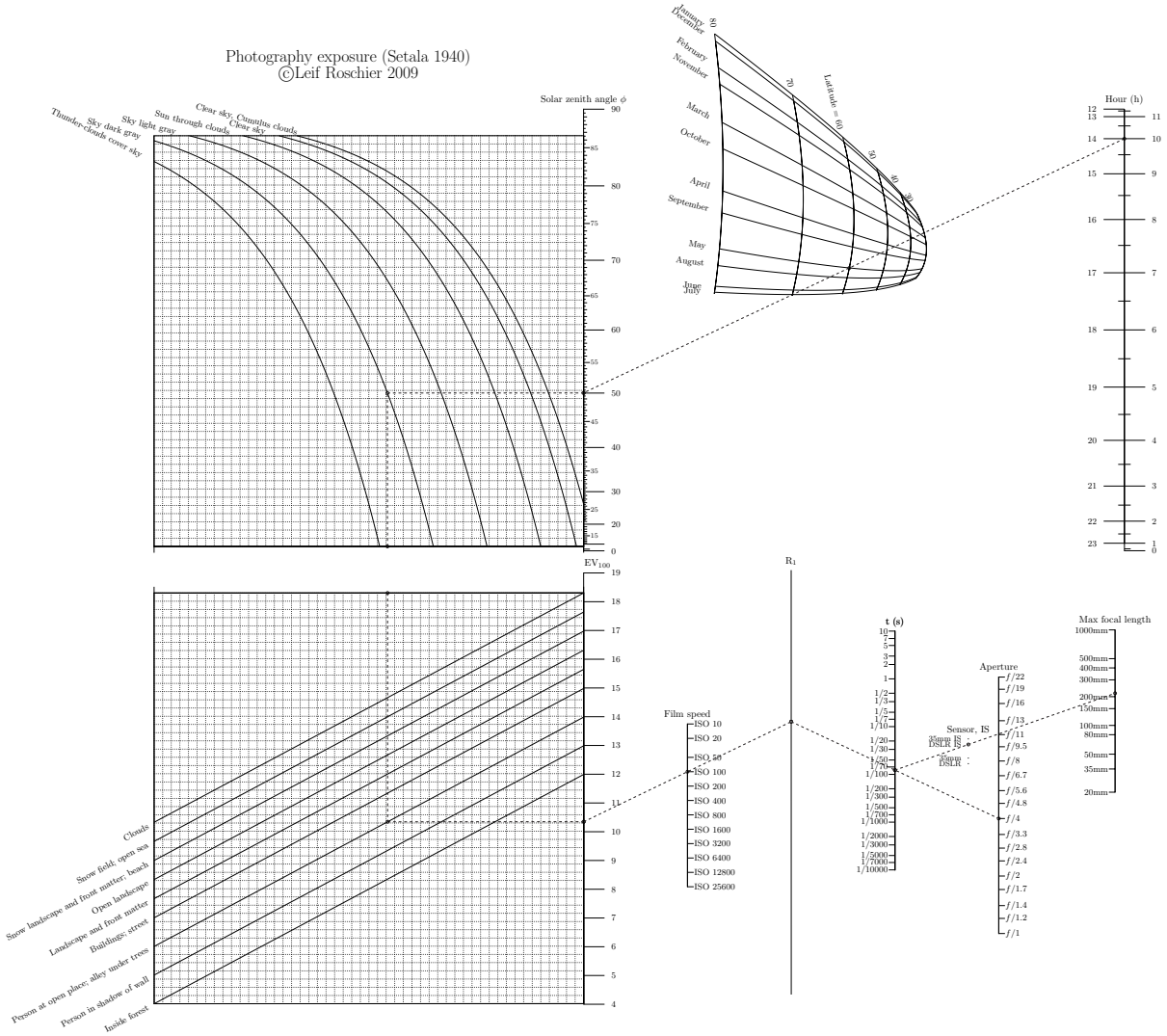
Explanation	Type
$x_1 \equiv \cos(\phi) = \sin(LAT)sin(D(\gamma(day))) + \cos(LAT)\cos(D(\gamma(day)))\cos(ha(h))$ formed into determinant: $\begin{vmatrix} 0 & \cos(\phi) & 1 \\ \frac{\cos(LAT)\cos(D(\gamma(day)))}{1+(\cos(LAT)\cos(D(\gamma(day))))} & \frac{\sin(LAT)\sin(D(\gamma(day)))}{1+(\cos(LAT)\cos(D(\gamma(day))))} & 1 \\ 1 & -\cos(ha(h)) & 1 \end{vmatrix} = 0$	Type 9
$C_1 \equiv L + W = 0.006918 - 13.656\log_{10}(x_1) + W$ split into two equations for contour construction: $y_1 = C_1$ $y_1 = 0.006918 - 13.656\log_{10}(x_1) + W$	Type 5
$C_2 \equiv L + W + C = C_1 + C$ split into two equations for contour construction: $y_2 = C_2$ $y_2 = C_1 + C$	Type 5
$C_2 = FS - A + T$ equals $C_2 - (10\log_{10}(S) + 1.0) + 10\log_{10}\left(\frac{N^2}{3.2^2}\right) - 10\log_{10}\left(\frac{1/t_i}{1/10}\right) = 0,$ where $t_i \equiv 1/t$ is inverse shutter time.	Type 3

Continued on next page

Table 6.1 – continued from previous page

Explanation	Type
Additional EV100 scale by using relation $$C_2 = (-EV_{100} + 13.654)/0.3322$$	Type 8
Maximum focal length calculator according to equation $$t_i/f = FL$$ written as $$-10\log_{10}\left(\frac{1/t_i}{1/10}\right) - 10\log_{10}\left(\frac{f}{10}\right) - 10\log_{10}(FL) = 0$$ in order to align correctly with previous equation. The values for the factor f are: DSLR (3/2), 35mm (1), DSLR image stabilization (3/8) and 35mm image stabilization (1/8).	Type 1

6.2.3 Generated nomograph



6.2.4 Source code

```
"""
    ex_photo_exposure.py

    Photgraph exposure.
"""
import sys
sys.path.insert(0, "..")
from pynomo.nomographer import *
"""
functions for solartime taken from solareqns.pdf from
http://www.srrb.noaa.gov/highlights/sunrise/solareqns.PDF
"""


# fractional year
def gamma(day):
    return 2 * pi / 365.0 * (day - 1 + 0.5)
# equation of time


def eq_time(day):
    gamma0 = gamma(day)
    return 229.18 * (0.000075 + 0.001868 * cos(gamma0) - 0.032077 * sin(gamma0)\
                     - 0.014615 * cos(2 * gamma0) - 0.040849 * sin(2 * gamma0))
```

```
25
26  # mean correction, with constant correction we make less than 17 minutes  error
27  # in time axis
28  temp_a = arange(0, 365.0, 0.1)
29  temp_b = eq_time(temp_a)
30  correction = mean(temp_b) # this is 0.0171885 minutes
31
32
33  # declination
34  def eq_declination(day):
35      g0 = gamma(day)
36      return 0.006918 - 0.399912 * cos(g0) + 0.070257 * sin(g0) - 0.006758 * cos(2 * g0)\
37              + 0.000907 * sin(2 * g0) - 0.002697 * cos(3 * g0) + 0.00148 * sin(3 * g0)
38
39
40  def f1(dummy):
41      return 0.0
42
43
44  def g1(fii):
45      return cos(fii*pi/180.0)
46
47
48  def f2(lat, day):
49      dec = eq_declination(day)
50      return (cos(lat * pi / 180.0) * cos(dec)) / (1.0 + (cos(lat * pi / 180.0) * cos(dec)))
51
52
53  def g2(lat, day):
54      dec = eq_declination(day)  # in radians
55      return (sin(lat * pi / 180.0) * sin(dec)) / (1.0 + (cos(lat * pi / 180.0) * cos(dec)))
56
57
58  def f3(dummy):
59      return 1
60
61
62  def g3(h):
63      hr = (h * 60.0 + correction) / 4.0 - 180.0
64      return -1.0 * cos(hr * pi / 180.0)
65
66  days_in_month = (31, 28, 31, 30, 31, 30, 31, 31, 30, 31, 30, 31)
67  times1=[]
68  for idx in range(0, 12):
69      times1.append(sum(days_in_month[0:idx])+1)
70
71  time_titles = ['January', 'February', 'March', 'April', 'May', 'June',
72                 'July', 'August', 'September', 'October', 'November', 'December']
73
74  phi_params = {'u_min': 0.0,
75                'u_max': 90.0,
76                'u_min_trafo': 0.0,
77                'u_max_trafo': 90.0,
78                'f': f1,
79                'g': g1,
80                'h': lambda u: 1.0,
81                'title': r'Solar zenith angle $\phi$',
82                'title_x_shift': 0.0,
83                'title_y_shift': 0.25,
84                'scale_type': 'linear smart',
85                'tick_levels': 4,
86                'tick_text_levels': 2,
87                'tick_side': 'right',
88                'tag': 'phi',
89                'grid': False,
90                }
91  time_params = {'u_min': 0.0,
92                 'u_max': 23.0,
93                 'u_min_trafo': 0.0,
94                 'u_max_trafo': 12.0,
95                 'f': f3,
96                 'g': g3,
97                 'h':lambda u: 1.0,
```

```
                'title': r'Hour (h)',
                'title_x_shift': 0.0,
                'title_y_shift': 0.25,
                'scale_type': 'linear',
                'tick_levels': 2,
                'tick_text_levels': 1,
                'tick_side': 'right',
                'tag': 'none',
                'grid': False,
                }
lat_day_params = {'ID': 'none',  # to identify the axis
                  'tag': 'none',  # for aligning block wrt others
                  'title': 'Grid',
                  'title_x_shift': 0.0,
                  'title_y_shift': 0.25,
                  'title_distance_center': 0.5,
                  'title_opposite_tick': True,
                  'u_min': 20.0,  # for alignment
                  'u_max': 80.0,  # for alignment
                  'f_grid': f2,
                  'g_grid': g2,
                  'h_grid': lambda u, v: 1.0,
                  'u_start': 30.0,
                  'u_stop': 80.0,
                  'v_start': times1[0],  # day
                  'v_stop': times1[-1],
                  'u_values': [30.0, 40.0, 50.0, 60.0, 70.0, 80.0],
                  'u_texts': ['30', '40', '50', 'Latitude = 60', '70', '80'],
                  'v_values': times1,
                  'v_texts': time_titles,
                  'grid': True,
                  'text_prefix_u': r'',
                  'text_prefix_v': r'',
                  'text_distance': 0.5,
                  'v_texts_u_start': False,
                  'v_texts_u_stop': True,
                  'u_texts_v_start': False,
                  'u_texts_v_stop': True,
                  }
block_params = {'block_type': 'type_9',
                'f1_params': phi_params,
                'f2_params': lat_day_params,
                'f3_params': time_params,
                'transform_ini': True,
                'isopleth_values': [['x', [60, times1[4]], 14.0]]
                }


# limiting functions are to avoid NaN in contour construction that uses optimization
def limit_xx(x):
    x1 = x
    return x1


def limit_x(x):
    x1 = x
    return x1

const_A = 0.33766
const_B = -13.656

block_params_weather = {'block_type': 'type_5',
                        'u_func': lambda u: u,
                        'v_func':lambda x, v: const_A + const_B * log10(limit_x(x)) + v,
                        'u_values': [1.0, 25.0],
                        'u_manual_axis_data': {1.0: '',
                                               25.0: ''},
                        'v_values': [0.0, 1.0, 3.0, 6.0, 9.0, 12.0],
                        'v_manual_axis_data': {0.0: ['Clear sky, Cumulus clouds',
                                                     {'x_corr': 0.5,
                                                      'y_corr': 0.0,
                                                      'draw_line': False}],
```

```
                                          1.0: 'Clear sky',
                                          3.0: 'Sun through clouds',
                                          6.0: 'Sky light gray',
                                          9.0: 'Sky dark gray',
                                          12.0: 'Thunder-clouds cover sky'},
                       'v_text_distance': 0.5,
                       'wd_tick_levels': 0,
                       'wd_tick_text_levels': 0,
                       'wd_tick_side': 'right',
                       'wd_title': '',
                       'manual_x_scale': True,
                       'x_min': 0.06,
                       'x_max': 0.99,
                       'u_title': '',
                       'v_title': '',
                       'wd_title_opposite_tick': True,
                       'wd_title_distance_center': 2.5,
                       'wd_align_func': lambda L: acos(limit_xx(10.0**((L - const_A) / const_B))) * 180.0 / pi,  # phi as L
                       'wd_func': lambda L: 10.0**((L - const_A) / const_B),  # x as L
                       'wd_func_inv': lambda x: const_A+const_B * log10(x),  # L as x
                       'wd_tag': 'phi',
                       'mirror_y': True,
                       'mirror_x': False,
                       'width': 10.0,
                       'height': 10.0,
                       'u_scale_opposite': True,
                       'u_tag': 'AA',
                       'horizontal_guides': True,
                       'isopleth_values': [['x', 9.0, 'x']],
                       }
block_params_scene = {'block_type': 'type_5',
                      'u_func': lambda u: u,
                      'v_func': lambda x, v: x + v,
                      'u_values': [1.0, 25.0],
                      'u_manual_axis_data': {1.0: '',
                                             25.0: ''},
                      'u_tag': 'AA',
                      'wd_tag': 'EV',
                      'v_values': [-4.0, -1.0, 2.0, 5.0, 7.0, 9.0, 11.0, 13.0, 15.0],
                      'v_manual_axis_data': {-6.0: 'Person under trees',
                                             -4.0: 'Inside forest',
                                             -1.0: 'Person in shadow of wall',
                                             2.0: 'Person at open place; alley under trees',
                                             5.0: 'Buildings; street',
                                             7.0: 'Landscape and front matter',
                                             9.0: 'Open landscape',
                                             11.0: 'Snow landscape and front matter; beach',
                                             13.0: 'Snow field; open sea',
                                             15.0: 'Clouds',
                                             },
                      'wd_tick_levels': 0,
                      'wd_tick_text_levels': 0,
                      'wd_tick_side': 'right',
                      'wd_title': '',
                      'u_title': '',
                      'v_title': '',
                      'wd_title_opposite_tick': True,
                      'wd_title_distance_center': 2.5,
                      'mirror_x': True,
                      'horizontal_guides': True,
                      'u_align_y_offset': -0.9,
                      'isopleth_values': [['x', 2.0, 'x']],
                      }
camera_params_1 = {'u_min': -10.0,
                   'u_max': 15.0,
                   'function': lambda u: u,
                   'title': r'',
                   'tick_levels': 0,
                   'tick_text_levels': 0,
                   'tag': 'EV',
                   }
camera_params_2 = {'u_min': 10.0,
```

```
                    'u_max': 25600.0,
                    'function': lambda S: -(10 * log10(S) + 1.0),
                    'title': r'Film speed',
                    'manual_axis_data': {10.0: 'ISO 10',
                                         20.0: 'ISO 20',
                                         50.0: 'ISO 50',
                                         100.0: 'ISO 100',
                                         200.0: 'ISO 200',
                                         400.0: 'ISO 400',
                                         800.0: 'ISO 800',
                                         1600.0: 'ISO 1600',
                                         3200.0: 'ISO 3200',
                                         6400.0: 'ISO 6400',
                                         12800.0: 'ISO 12800',
                                         25600.0: 'ISO 25600',
                                         },
                    'scale_type': 'manual line'
                    }
camera_params_3 = {'u_min': 0.1,
                    'u_max': 10000.0,
                    'function': lambda t: -10 * log10((1.0 / t) / (1.0 / 10.0)) - 30,
                    'manual_axis_data': {1/10.0: '10',
                                         1/7.0: '7',
                                         1/5.0: '5',
                                         1/3.0: '3',
                                         1/2.0: '2',
                                         1.0: '1',
                                         2.0: '1/2',
                                         3.0: '1/3',
                                         5.0: '1/5',
                                         7.0: '1/7',
                                         10.0: '1/10',
                                         20.0: '1/20',
                                         30.0: '1/30',
                                         50.0: '1/50',
                                         70.0: '1/70',
                                         100.0: '1/100',
                                         200.0: '1/200',
                                         300.0: '1/300',
                                         500.0: '1/500',
                                         700.0: '1/700',
                                         1000.0: '1/1000',
                                         2000.0: '1/2000',
                                         3000.0: '1/3000',
                                         5000.0: '1/5000',
                                         7000.0: '1/7000',
                                         10000.0: '1/10000',
                                  },
                    'scale_type': 'manual line',
                    'title': r't (s)',
                    'text_format': r"1/%3.0f s",
                    'tag': 'shutter',
                    'tick_side': 'left',
                    }
camera_params_4 = {'u_min': 1.0,
                    'u_max': 22.0,
                    'function': lambda N: 10 * log10((N / 3.2)**2) + 30,
                    'manual_axis_data': {1.0: '$f$/1',
                                         1.2: '$f$/1.2',
                                         1.4: '$f$/1.4',
                                         1.7: '$f$/1.7',
                                         2.0: '$f$/2',
                                         2.4: '$f$/2.4',
                                         2.8: '$f$/2.8',
                                         3.3: '$f$/3.3',
                                         4.0: '$f$/4',
                                         4.8: '$f$/4.8',
                                         5.6: '$f$/5.6',
                                         6.7: '$f$/6.7',
                                         8.0: '$f$/8',
                                         9.5: '$f$/9.5',
                                         11.0 :'$f$/11',
```

```
                                        13.0 :'$f$/13',
                                        16.0 :'$f$/16',
                                        19.0 :'$f$/19',
                                        22.0 :'$f$/22',
                                        },
                    'scale_type': 'manual line',
                    'title': r'Aperture',
                    }
block_params_camera = {'block_type': 'type_3',
                       'width': 10.0,
                       'height': 10.0,
                       'f_params': [camera_params_1, camera_params_2, camera_params_3,
                                    camera_params_4],
                       'mirror_x': True,
                       'isopleth_values': [['x', 100.0, 'x', 4.0]],
                       }


def old_EV(EV):  # C2(EV100) in wiki
    return (-EV + 13.654) / 0.3322

EV_para = {'tag': 'EV',
           'u_min': 4.0,
           'u_max': 19.0,
           'function': lambda u: old_EV(u),
           'title': r'EV$_{100}$',
           'tick_levels': 1,
           'tick_text_levels': 1,
           'align_func': old_EV,
           'title_x_shift': 0.5,
           'tick_side': 'right',
           }
EV_block = {'block_type': 'type_8',
            'f_params': EV_para,
            'isopleth_values': [['x']],
            }
# maximum focal length
FL_t_para={'u_min': 0.1,
           'u_max': 10000.0,
           'function': lambda t:-10 * log10((1.0 / t) / (1.0 / 10.0)) - 30,
           'scale_type': 'linear',
           'tick_levels': 0,
           'tick_text_levels': 0,
           'title': r't (s)',
           'text_format': r"1/%3.0f s",
           'tag': 'shutter',
           }
FL_factor_params_2 = {'u_min': 1.0/4.0,
                      'u_max': 3.0/2.0,
                      'function': lambda factor: -10 * log10(factor / 10.0) + 0,
                      'title': r'Sensor, IS',
                      'scale_type': 'manual point',
                      'manual_axis_data': {1.0/(2.0/3.0): 'DSLR',
                                           1.0/(1.0): '35mm',
                                           1.0/(8.0/3.0): 'DSLR IS',
                                           1.0/(4.0): '35mm IS',
                      },
                      'tick_side':'left',
                      'text_size_manual': text.size.footnotesize,  # pyx directive
                      }
FL_fl_params = {'u_min': 20.0,
                'u_max': 1000.0,
                'function': lambda FL:-10 * log10(FL) + 30,
                'title': r'Max focal length',
                'tick_levels': 3,
                'tick_text_levels': 2,
                'tick_side': 'left',
                'scale_type': 'manual line',
                'manual_axis_data': {20.0: '20mm',
                                     35.0: '35mm',
                                     50.0: '50mm',
                                     80.0: '80mm',
```

```
                                    100.0: '100mm',
                                    150.0: '150mm',
                                    200.0: '200mm',
                                    300.0: '300mm',
                                    400.0: '400mm',
                                    500.0: '500mm',
                                    1000.0: '1000mm'}
                }

FL_block_params = {'block_type': 'type_1',
                   'width': 12.0,
                   'height': 10.0,
                   'f1_params': FL_t_para,
                   'f2_params': FL_factor_params_2,
                   'f3_params': FL_fl_params,
                   'mirror_x': True,
                   'proportion': 0.5,
                   'isopleth_values': [['x', 1.0/(8.0/3.0), 'x']],
                   }

main_params = {'filename': ['ex_photo_exposure.pdf', 'ex_photo_exposure.eps'],
               'paper_height': 35.0,
               'paper_width': 35.0,
               'block_params': [block_params, block_params_weather, block_params_scene,
                                block_params_camera, EV_block, FL_block_params],
               'transformations': [('rotate', 0.01), ('scale paper',)],
               'title_x': 7,
               'title_y': 34,
               'title_box_width': 10,
               'title_str': r'\LARGE Photography exposure (Setala 1940) \par \copyright Leif Roschier  2009 '
              }
Nomographer(main_params)
```

CHAPTER

SEVEN

LICENSE

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