The easing Library for pgfmath

Loh Ka-tsun

July 14, 2021

1 Usage

2 Implementation

`\ifeasing@withfpu`
`\easing@divide`

This library uses TEX registers and pgf's mathematical engine for computations.

It is possible that the user is loading this library together with fpu. We save the basic routines from pgfmath so that when this happens, fpu doesn't break everything when it does a switcharoo with the pgfmath macros.

```
\newif\ifeasing@withfpu
\expandafter\ifx\csname pgflibraryfpuifactive\endcsname\relax
\easing@withfpufalse
\else
\easing@withfputrue
\fi
\ifeasing@withfpu
\let\easing@divide\pgfmath@basic@divide@
\let\easing@cos\pgfmath@basic@cos@
\let\easing@exp\pgfmath@basic@exp@
\let\easing@ln\pgfmath@basic@ln@
\else
\let\easing@divide\pgfmathdivide@
\let\easing@cos\pgfmathcos@
\let\easing@exp\pgfmathexp@
\let\easing@ln\pgfmathln@
\fi
```

`\easing@linearstep@ne`
`\easing@linearstep@fixed`
`\easing@linearstep@float`
`\easing@linearstep`

In absence of fpu, the next section of code defines `\easing@linearstep`, which expects as arguments plain numbers (i.e. things that can be assigned to dimension registers). The net effect of `\easing@linearstep{#1}{#2}{#3}` is to set `\pgfmathresult` to $\frac{\#3-\#1}{\#2-\#1}$, clamped to between 0 and 1.

If fpu is loaded, `\easing@linearstep` is instead named `\easing@linearstep@fixed`, and we additionally define `\easing@linearstep@float`, which expects fpu-format floats as arguments. We do not format the output as a float since fpu is smart enough to do that conversion quietly on its own.

The `\easing@linearstep` routine is the first step in the definition of all other routines that compute easing functions.

```
\def\easing@linearstep@ne#1{%
  \begingroup
  \pgf@x#1pt
  \ifdim1pt<\pgf@x\pgf@x 1pt\fi
  \ifdim0pt>\pgf@x\pgf@x 0pt\fi
  \pgfmathreturn\pgf@x
  \endgroup
}%
\expandafter\def
\csname easing@linearstep\ifeasing@withfpu @fixed\fi\endcsname#1#2#3{%
  \begingroup
  \pgf@xa#3pt
  \pgf@xb#2pt
  \pgf@xc#1pt
  \ifdim\pgf@xb=\pgf@xc
  \edef\pgfmathresult{\ifdim\pgf@xa>\pgf@xb 1\else 0\fi}%
  \else
  \advance\pgf@xa-\pgf@xc
  \advance\pgf@xb-\pgf@xc
  \easing@divide{\pgfmath@tonumber\pgf@xa}{\pgfmath@tonumber\pgf@xb}%
  \easing@linearstep@ne\pgfmathresult
  \fi
  \pgfmathsmuggle\pgfmathresult
  \endgroup
}%
\ifeasing@withfpu
\def\easing@linearstep@float#1#2#3{%
  \begingroup
  \pgfmathfloatsubtract{#3}{#1}%
  \edef\pgf@tempa{\pgfmathresult}%
  \pgfmathfloatsubtract{#2}{#1}%
  \edef\pgf@tempb{\pgfmathresult}%
  \pgfmathfloatifflags{\pgf@tempb}{0}{%
    \pgfmathfloatifflags{\pgf@tempa}{-}{%
      \edef\pgfmathresult{0}%
    }{%
      \edef\pgfmathresult{1}%
    }%
  }{%
    \pgfmathfloatdivide\pgf@tempa\pgf@tempb
    \pgfmathfloattofixed{\pgfmathresult}%
    \easing@linearstep@ne\pgfmathresult
  }%
  \pgfmathsmuggle\pgfmathresult
  \endgroup
}%
\def\easing@linearstep#1#2#3{%
  \pgflibraryfpuifactive{%
    \easing@linearstep@float{#1}{#2}{#3}}{%
    \easing@linearstep@fixed{#1}{#2}{#3}}%
}%
\fi
```

`\easing@linearstep@easein@ne`
`\easing@linearstep@easeout@ne`

The linear ease-in and ease-out functions are identitcal to the linear step function. We define the respective macros so as not to surprise the user with their absence.

```
\let\easing@lineareasein\easing@linearstep
\pgfmathdeclarefunction{lineareasein}{3}{%
  \easing@lineareasein{#1}{#2}{#3}}%
\let\easing@lineareaseout\easing@linearstep
\pgfmathdeclarefunction{lineareaseout}{3}{%
  \easing@lineareasein{#1}{#2}{#3}}%
```

the right to make space in the margins:

`\easing@derive@easein@nefromstep@ne`
`\easing@derive@easeout@nefromstep@ne`
`\easing@derive@step@nefromeasein@ne`
`\easing@derive@easeout@nefromeasein@ne`

The pattern in general is that, for each shape, we define the one-parameter version of the step, ease-in, and ease-out routines interpolating between values 0 at 1 at the ends of the unit interval. Then by composing with `\easing@linearstep`, we obtain the three-parameter versions that allow the user to specify the begin and end points of the interpolation.

Most of the time it suffices to define just one of the three one-parameter versions of a shape to be able to infer the form of all three. This is done with the `\easing@derive`–`from`– macros.

```
\def\easing@derive@easein@nefromstep@ne#1{%
  \expandafter\def\csname easing@#1easein@ne\endcsname##1{%
    \begingroup
    \pgf@x##1 pt
    \divide\pgf@x 2
    \csname easing@#1step@ne\endcsname{\pgfmath@tonumber\pgf@x}%
    \pgf@x\pgfmathresult pt
    \multiply\pgf@x 2
    \pgfmathreturn\pgf@x
    \endgroup
  }%
}%
\def\easing@derive@easeout@nefromstep@ne#1{%
  \expandafter\def\csname easing@#1easeout@ne\endcsname##1{%
    \begingroup
    \pgf@x##1 pt
    \divide\pgf@x 2
    \advance\pgf@x 0.5pt
    \csname easing@#1step@ne\endcsname{\pgfmath@tonumber\pgf@x}%
    \pgf@x\pgfmathresult pt
    \multiply\pgf@x 2
    \advance\pgf@x -1pt
    \pgfmathreturn\pgf@x
    \endgroup
  }%
}%
\def\easing@derive@step@nefromeasein@ne#1{%
  \expandafter\def\csname easing@#1step@ne\endcsname##1{%
  \begingroup
    \pgf@x##1 pt
    \multiply\pgf@x 2
    \ifdim\pgf@x<1pt
    \csname easing@#1easein@ne\endcsname{\pgfmath@tonumber\pgf@x}%
    \pgf@x\pgfmathresult pt
    \divide\pgf@x 2
    \else
    \multiply\pgf@x -1
    \advance\pgf@x 2pt
    \csname easing@#1easein@ne\endcsname{\pgfmath@tonumber\pgf@x}%
    \pgf@x\pgfmathresult pt
    \divide\pgf@x 2
    \multiply\pgf@x -1
    \advance\pgf@x 1pt
    \fi
    \pgfmathreturn\pgf@x
    \endgroup
  }%
}%
\def\easing@derive@easeout@nefromeasein@ne#1{%
  \expandafter\def\csname easing@#1easeout@ne\endcsname##1{%
    \begingroup
    \pgf@x##1pt
    \multiply\pgf@x -1
    \advance\pgf@x 1pt
    \csname easing@#1easein@ne\endcsname{\pgfmath@tonumber\pgf@x}%
    \pgf@x\pgfmathresult pt
    \multiply\pgf@x -1
    \advance\pgf@x 1pt
    \pgfmathreturn\pgf@x
    \endgroup
  }%
}
```

`\easing@pgfmathinstall` The three-parameter versions of each routine is installed into the mathematical engine, so that they are available in `\pgfmathparse`.

```
\def\easing@pgfmathinstall#1{%
  \pgfmathdeclarefunction{#1step}{3}{%
    \easing@linearstep{##1}{##2}{##3}%
    \csname easing@#1step@ne\endcsname\pgfmathresult
  }%
  \pgfmathdeclarefunction{#1easein}{3}{%
    \easing@linearstep{##1}{##2}{##3}%
    \csname easing@#1easein@ne\endcsname\pgfmathresult
  }%
  \pgfmathdeclarefunction{#1easeout}{3}{%
    \easing@linearstep{##1}{##2}{##3}%
    \csname easing@#1easeout@ne\endcsname\pgfmathresult
  }%
}%
```

\easing@smoothstep@ne
\easing@smootheasein@ne
\easing@smootheaseout@ne

The smooth shape.

```
\def\easing@smoothstep@ne#1{%
  \begingroup
  \pgf@x#1pt
  \edef\pgf@temp{\pgfmath@tonumber\pgf@x}%
  \multiply\pgf@x-2
  \advance\pgf@x 3pt
  \pgf@x\pgf@temp\pgf@x
  \pgf@x\pgf@temp\pgf@x
  \pgfmathreturn\pgf@x
  \endgroup
}%
\easing@derive@easein@nefromstep@ne{smooth}%
\easing@derive@easeout@nefromstep@ne{smooth}%
\easing@pgfmathinstall{smooth}%
```

\easing@sinestep@ne
\easing@sineeasein@ne
\easing@sineeaseout@ne

The sine shape.

We write down both the easein and step forms of this, since they are simple compared to what would have been obtained by \easing@derive–.

```
\def\easing@sineeasein@ne#1{%
  \begingroup
  \pgf@x#1pt
  \multiply\pgf@x 90
  \easing@cos{\pgfmath@tonumber\pgf@x}%
  \pgf@x\pgfmathresult pt
  \multiply\pgf@x -1
  \advance\pgf@x 1pt
  \pgfmathreturn\pgf@x
  \endgroup
}%
\def\easing@sinestep@ne#1{%
  \begingroup
  \pgf@x#1pt
  \multiply\pgf@x 180
  \easing@cos{\pgfmath@tonumber\pgf@x}%
  \pgf@x\pgfmathresult pt
  \divide\pgf@x 2
  \multiply\pgf@x -1
  \advance\pgf@x 0.5pt
  \pgfmathreturn\pgf@x
  \endgroup
}%
\easing@derive@easeout@nefromeasein@ne{sine}%
\easing@pgfmathinstall{sine}%
```

\easing@powstep@ne
\easing@poweasein@ne
\easing@poweaseout@ne

The pow shape.

Because of some wonkiness in in fpu, instead of invoking the pow function from pgfmath, we compute t^n approximately by computing $e^{n \ln t}$ using ln and exp instead (which is what pgfmath does anyway when the exponent is not an integer.)

```
\pgfkeys{/easing/.is family}%
\pgfkeys{easing,
  pow/exponent/.estore in=\easing@param@pow@exponent,
  pow/exponent/.default=2.4,
  pow/exponent}%
\def\easing@poweasein@ne#1{%
  \begingroup
  \pgf@x#1pt
  \ifdim\pgf@x=0pt
  \edef\pgfmathresult{0}%
  \else
  \easing@ln{#1}%
  \pgf@x\pgfmathresult pt
  \pgf@x\easing@param@pow@exponent\pgf@x
  \easing@exp{\pgfmath@tonumber\pgf@x}%
  \fi
  \pgfmathsmuggle\pgfmathresult
  \endgroup
}%
\easing@derive@easeout@nefromeasein@ne{pow}%
\easing@derive@step@nefromeasein@ne{pow}%
\easing@pgfmathinstall{pow}%
```

\easing@quadstep@ne
\easing@quadeasein@ne
\easing@quadeaseout@ne
\easing@cubicstep@ne
\easing@cubiceasein@ne
\easing@cubiceaseout@ne
\easing@quartstep@ne
\easing@quarteasein@ne
\easing@quarteaseout@ne
\easing@quintstep@ne
\easing@quinteasein@ne
\easing@quinteaseout@ne

The quad–, cubic–, quart–, and quint– routines have explicit definitions. The small integer exponents are computed with TeX registers, which is probably a little faster and more accurate than setting the argument then evaluating the equivalent pow– routine.

```
\def\easing@quadeasein@ne#1{%
  \begingroup
  \pgf@x#1pt
  \edef\pgf@temp{\pgfmath@tonumber\pgf@x}%
  \pgf@x\pgf@temp\pgf@x
  \pgfmathreturn\pgf@x
  \endgroup
}%
\easing@derive@step@nefromeasein@ne{quad}%
\easing@derive@easeout@nefromeasein@ne{quad}%
\easing@pgfmathinstall{quad}%

\def\easing@cubiceasein@ne#1{%
  \begingroup
  \pgf@x#1pt
  \edef\pgf@temp{\pgfmath@tonumber\pgf@x}%
  \pgf@x\pgf@temp\pgf@x
  \pgf@x\pgf@temp\pgf@x
  \pgfmathreturn\pgf@x
  \endgroup
}%
\easing@derive@step@nefromeasein@ne{cubic}%
\easing@derive@easeout@nefromeasein@ne{cubic}%
\easing@pgfmathinstall{cubic}%

\def\easing@quarteasein@ne#1{%
  \begingroup
  \pgf@x#1pt
  \edef\pgf@temp{\pgfmath@tonumber\pgf@x}%
  \pgf@x\pgf@temp\pgf@x
  \pgf@x\pgf@temp\pgf@x
  \pgf@x\pgf@temp\pgf@x
  \pgfmathreturn\pgf@x
  \endgroup
}%
\easing@derive@step@nefromeasein@ne{quart}%
\easing@derive@easeout@nefromeasein@ne{quart}%
\easing@pgfmathinstall{quart}%

\def\easing@quinteasein@ne#1{%
  \begingroup
  \pgf@x#1pt
  \edef\pgf@temp{\pgfmath@tonumber\pgf@x}%
  \pgf@x\pgf@temp\pgf@x
  \pgf@x\pgf@temp\pgf@x
  \pgf@x\pgf@temp\pgf@x
  \pgf@x\pgf@temp\pgf@x
  \pgfmathreturn\pgf@x
  \endgroup
}%
\easing@derive@step@nefromeasein@ne{quint}%
\easing@derive@easeout@nefromeasein@ne{quint}%
\easing@pgfmathinstall{quint}%
```

\easing@backstep@ne
\easing@backeasein@ne
\easing@backeaseout@ne

The back shape.

```
\pgfkeys{easing,
  back/overshoot/.estore in=\easing@param@back@overshoot,
  back/overshoot/.default=1.6,
  back/overshoot}%
\def\easing@backeasein@ne#1{%
  \begingroup
  \pgf@x#1pt
  \edef\pgf@temp{\pgfmath@tonumber\pgf@x}%
  \advance\pgf@x -1pt
  \pgf@x\easing@param@back@overshoot\pgf@x
  \advance\pgf@x\pgf@temp pt
  \pgf@x\pgf@temp\pgf@x
  \pgf@x\pgf@temp\pgf@x
  \pgfmathreturn\pgf@x
  \endgroup
}%
\easing@derive@step@nefromeasein@ne{back}%
\easing@derive@easeout@nefromeasein@ne{back}%
\easing@pgfmathinstall{back}%
```