The \texttt{xfp} package
Floating Point Unit

The \LaTeX{} Project\textsuperscript{*}
Released 2021-08-27

This package provides a \LaTeX{}\texttt{2e} document-level interface to the \LaTeX{}\texttt{3} floating point unit (part of \texttt{expl3}). It also provides a parallel integer expression interface for convenience.

The expandable command \texttt{\fpeval} takes as its argument a floating point expression and produces a result using the normal rules of mathematics. As this command is expandable it can be used where \TeX{} requires a number and for example within a low-level \texttt{\edef} operation to give a purely numerical result.

Briefly, the floating point expressions may comprise:

- Basic arithmetic: addition \( x + y \), subtraction \( x - y \), multiplication \( x \ast y \), division \( x/y \), square root \( \sqrt{x} \), and parentheses.
- Comparison operators: \( x < y \), \( x \leq y \), \( x > y \), \( x \neq y \) etc.
- Boolean logic: sign \texttt{sign(} \( x \text{)} \), negation \texttt{!} \( x \text{)} \), conjunction \texttt{x && y} \), disjunction \texttt{x || y} \), ternary operator \( x \text{? } y \text{: } z \).
- Exponentials: \texttt{exp(} \( x \text{)} \), \texttt{ln(} \( x \text{)} \), \( x^y \).
- Integer factorial: \texttt{fact(} \( x \text{)} \).
- Trigonometry: \texttt{sin(} \( x \text{)} \), \texttt{cos(} \( x \text{)} \), \texttt{tan(} \( x \text{)} \), \texttt{cot(} \( x \text{)} \), \texttt{sec(} \( x \text{)} \), \texttt{csc(} \( x \text{)} \) expecting their arguments in radians, and \texttt{sind(} \( x \text{)} \), \texttt{cosd(} \( x \text{)} \), \texttt{tand(} \( x \text{)} \), \texttt{cotd(} \( x \text{)} \), \texttt{secd(} \( x \text{)} \), \texttt{cscd(} \( x \text{)} \) expecting their arguments in degrees.
- Inverse trigonometric functions: \texttt{asin(} \( x \text{)} \), \texttt{acos(} \( x \text{)} \), \texttt{atan(} \( x \text{)} \), \texttt{acot(} \( x \text{)} \), \texttt{asec(} \( x \text{)} \), \texttt{acsc(} \( x \text{)} \) giving a result in radians, and \texttt{asind(} \( x \text{)} \), \texttt{acosd(} \( x \text{)} \), \texttt{atand(} \( x \text{)} \), \texttt{acotd(} \( x \text{)} \), \texttt{asecd(} \( x \text{)} \), \texttt{acscd(} \( x \text{)} \) giving a result in degrees.
- Extrema: \texttt{max(} \( x_1, x_2, \ldots \text{)} \), \texttt{min(} \( x_1, x_2, \ldots \text{)} \), \texttt{abs(} \( x \text{)} \).
- Rounding functions, controlled by two optional values, \texttt{n} (number of places, 0 by default) and \texttt{t} (behavior on a tie, \texttt{NaN} by default):
  - \texttt{trunc(} \( x, n \text{)} \) rounds towards zero,
  - \texttt{floor(} \( x, n \text{)} \) rounds towards \( -\infty \),

\textsuperscript{*}E-mail: latex-team@latex-project.org
- ceil\((x, n)\) rounds towards \(+\infty\),
- round\((x, n, t)\) rounds to the closest value, with ties rounded to an even value by default, towards zero if \(t = 0\), towards \(+\infty\) if \(t > 0\) and towards \(-\infty\) if \(t < 0\).

- Random numbers: \(\text{rand}()\), \(\text{randint}(m, n)\).
- Constants: \(\pi\), \(\text{deg}\) (one degree in radians).
- Dimensions, automatically expressed in points, \(e.g.,\) \(\text{pc}\) is 12.
- Automatic conversion (no need for \(\text{\texttt{number}}\) of integer, dimension, and skip variables to floating points numbers, expressing dimensions in points and ignoring the stretch and shrink components of skips.
- Tuples: \((x_1, \ldots, x_n)\) that can be added together, multiplied or divided by a floating point number, and nested.

An example of use could be the following.

\begin{align*}
\text{LaTeX} & \text{ can now compute: } \frac{\sin(3.5)}{2} + 2\cdot 10^{-3} = \text{\texttt{fpeval}}{\sin(3.5)/2 + 2e-3}.
\end{align*}

\textbf{\textcolor{red}{\texttt{\inteval}}} The expandable command \texttt{\inteval} takes as its argument an integer expression and produces a result using the normal rules of mathematics. The operations recognised are +, -, \(\ast\), and / plus parentheses. Division occurs with \textit{rounding}, and ties are rounded away from zero. As this command is expandable it can be used where \TeX{} requires a number and for example within a low-level \texttt{\edef} operation to give a purely numerical result.

An example of use could be the following.

\begin{align*}
\text{LaTeX} & \text{ can now compute: The sum of the numbers is } \text{\texttt{\inteval}}{1 + 2 + 3}.
\end{align*}

\textbf{Index}

The italic numbers denote the pages where the corresponding entry is described, numbers underlined point to the definition, all others indicate the places where it is used.

\begin{tabular}{llll}
\textbf{E} & & \textbf{I} & \\
\texttt{\edef} & \ldots & 1, 2 & \texttt{\inteval} & \ldots & 2 \\
\textbf{F} & & \textbf{N} & \\
\texttt{\fpeval} & \ldots & 1 & \texttt{\number} & \ldots & 2
\end{tabular}