The \texttt{xfp} package
Floating Point Unit

The \LaTeX\ Project\textsuperscript{*}

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

\texttt{\fpeval} \texttt{\star}

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 \( \text{sign} x \), negation \( \neg x \), conjunction \( x \& y \), disjunction \( x \mid y \), ternary operator \( x \text{?} y : z \).
- Exponentials: \( \exp x \), \( \ln x \), \( x^y \).
- Integer factorial: \( \text{fact} x \).
- Trigonometry: \( \sin x \), \( \cos x \), \( \tan x \), \( \cot x \), \( \sec x \), \( \csc x \) expecting their arguments in radians, and \( \text{sind} x \), \( \text{cosd} x \), \( \text{tand} x \), \( \text{cotd} x \), \( \text{secd} x \), \( \text{cscd} x \) expecting their arguments in degrees.
- Inverse trigonometric functions: \( \text{asin} x \), \( \text{acos} x \), \( \text{atan} x \), \( \text{acot} x \), \( \text{asec} x \), \( \text{acsc} x \) giving a result in radians, and \( \text{asind} x \), \( \text{acosd} x \), \( \text{atand} x \), \( \text{acotd} x \), \( \text{asecd} x \), \( \text{acscd} x \) giving a result in degrees.
- Extrema: \( \max(x_1, x_2, \ldots) \), \( \min(x_1, x_2, \ldots) \), \( \abs x \).
- Rounding functions, controlled by two optional values, \( n \) (number of places, 0 by default) and \( t \) (behavior on a tie, \texttt{NaN} by default):
  - \( \text{trunc}(x, n) \) rounds towards zero,
  - \( \text{floor}(x, n) \) rounds towards \( -\infty \).

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- `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**: `rand()`, `randint(m, n)`.
- **Constants**: `pi`, `deg` (one degree in radians).
- **Dimensions**, automatically expressed in points, *e.g.*, `pc` is 12.
- **Automatic conversion** (no need for \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.
\[
\text{LaTeX} \text{ can now compute: } \frac{\sin(3.5)}{2} + 2 \cdot 10^{-3} = \fpeval{\sin(3.5)/2 + 2e-3}.
\]

\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.
\[
\text{LaTeX} \text{ can now compute: The sum of the numbers is } \inteval{1 + 2 + 3}.
\]

**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{array}{ll}
\text{E} & \text{I} \\
\edef & 1, 2 \inteval & 2 \\
\text{F} & \text{N} \\
\fpeval & 1 \number & 2 \\
\end{array}