

COMBINATORIAL GAME SYMBOLS AND NOTATION

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ABSTRACT. The `combgames-symbols` package provides symbols and braces-and-slashes notation for combinatorial game theory. It is based on `combgames` by Raymond Chen, David Wolfe and Aaron N. Siegel. I replaced the old bitmap symbols made in METAFONT with vector graphics made in MetaPost. Board drawings are provided separately by `combgames-tikz`.

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1. INSTALLATION AND A FIRST EXAMPLE

Load `combgames-symbols` for symbols and game notation:

```
\documentclass{article}
\usepackage{combgames-symbols}
\begin{document}
$\cgtripleup + \cg sunny \qqquad \combgame{\{1|0\}}$
\end{document}
```

For a local installation or an Overleaf project, place `combgames-symbols.sty` in the document directory. With pdfLaTeX, also provide the files with extensions `.tfm`, `.map`, `.enc`, and `.pfb`, all with basename `combgames-symbols`. The package loads its font map automatically. With XeLaTeX or LuaLaTeX, provide `combgames-symbols.otf` instead of those four font files. Font-building sources are not needed to compile documents. The TikZ board package is not required.

For documents using the development package, replace `cgt` with `combgames-symbols` in the preamble. The symbol and notation commands retain their names.

2. FONT SYMBOLS

$\uparrow$	<code>\cgup</code>	$\downarrow$	<code>\cgdown</code>	$*$	<code>\cgstar</code>
$\Uparrow$	<code>\cgdoubleup</code>	$\Downarrow$	<code>\cgdoubledown</code>	$-$	<code>\cgneg</code>
$\Uparrow\Uparrow$	<code>\cgtripleup</code>	$\Downarrow\Downarrow$	<code>\cgtripldown</code>	$\star$	<code>\cgfarstar</code>
$\Uparrow\Uparrow\Uparrow$	<code>\cgquadup</code>	$\Downarrow\Downarrow\Downarrow$	<code>\cgquaddown</code>	$\odot$	<code>\cg sunny</code>
$\dagger$	<code>\cgtiny</code>	$\dashv$	<code>\cgminy</code>	$\supset$	<code>\cgloony</code>
$\textcircled{k}$	<code>\cgko</code>	$\textcircled{K}$	<code>\cgKo</code>		
$\overline{\textcircled{k}}$	<code>\cgkobar</code>	$\overline{\textcircled{K}}$	<code>\cgKobar</code>		

TABLE 1. `combgames-symbols` ordinary symbols.

$\triangleleft\!\!\mid$	<code>\cglfuz</code>	$\!\!\mid\!\!\triangleright$	<code>\cggfuz</code>	$\parallel$	<code>\cgfuzzy</code>
$\uparrow\downarrow$	<code>\cgupsum</code>	$\downarrow\uparrow$	<code>\cgdownsum</code>	$\cdot$	<code>\cgnmultiply</code>
				$\bowtie$	<code>\cgbow</code>

TABLE 2. `combgames-symbols` relations (first row) and binary operators (second row).

2.1. Repeated arrows and mathematical spacing. `\cgups{n}` and `\cgdowns{n}` accept nonnegative integers. Zero gives 0; one through four use the individual arrow symbols; larger values use a numerical multiple.

```
\cgups{0},\ \cgups{1},\ \cgups{2},\ \cgups{3},\ \cgups{4},\ \cgups{5}
\qqquad \cgdowns{5}
```

$$0, \uparrow, \Uparrow, \Uparrow\Uparrow, \Uparrow\Uparrow\Uparrow, 5 \cdot \uparrow \quad 5 \cdot \downarrow$$

3. BRACES-AND-SLASHES NOTATION

The command `\combgame` has been updated from the `combgames` package to include angle brackets, denoting scoring games. Use `\<` and `\>` for angle brackets in `\combgame`.

$$\begin{aligned} \text{\combgame}\{\text{\<2||1|0\>}\} & \qquad \langle 2 \parallel 1 \mid 0 \rangle \\ \text{\combgame}\{\text{\{3,\{4||2|1\}\}|||0|||-8\}\} & \qquad \left\{ 3, \{ 4 \parallel 2 \mid 1 \} \parallel\!\!\parallel 0 \parallel\!\!\parallel -8 \right\} \\ \text{\int^T G} = \text{\combgame}\{\text{\{T + \int^T G^L \mid -T + \int^T G^R\}\} & \qquad \int^T G = \left\{ T + \int^T G^L \mid -T + \int^T G^R \right\} \end{aligned}$$

TABLE 3. Example usage of `\combgame`.

- There is also a starred form, `\combgame*`, that suppresses growth of the vertical bars:

$$\begin{aligned} \text{\combgame}\{2|1||0|||-1|||-2\} & \qquad 2 \mid 1 \parallel 0 \parallel\!\!\parallel -1 \parallel\!\!\parallel -2 \\ \text{\combgame*}\{2|1||0|||-1|||-2\} & \qquad 2 \mid 1 \parallel 0 \parallel -1 \parallel -2 \end{aligned}$$

- You should use `\combgame` whenever appropriate, even for simple expressions, since it will typeset the result much more cleanly than otherwise. Compare the following two examples.

$$\begin{aligned} \text{\combgame*}\{\text{\{2||-1|-3\}\} & \qquad \{ 2 \parallel -1 \mid -3 \} & \text{Beautiful!} \\ \text{\{2||-1|-3\}} & \qquad \{ 2 \parallel -1 \mid -3 \} & \text{Hideous!} \end{aligned}$$

- Within the `combgame` argument, the brace commands `\{` and `\}` are redefined to mean `\left\{` and `\right\}`. The old commands are still available as `\lbrace` and `\rbrace`.
- Literal bars depend on when TeX reads the input. In a macro definition or an argument already read by another command, they may have been tokenized before `\combgame` can make them active. If you wish to define macros that refer to `\combgame`, there is an alternative command `\cgslashes{n}` for an n -tuple slash. The commands `\cgslash` and `\cgsslash` are shorthand for $n = 1$ and 2 , respectively. Here's an example:

```
\newcommand\threeswitch[3]
{\combgame{\{#1 \cgsslash #2 \cgslash #3\}}}
Then \threeswitch{2}{1}{0} would typeset
```

$$\{ 2 \parallel 1 \mid 0 \}$$

- You can control the growth of the slashes by setting `\cgslashextension`. The default is 1.5pt. For example:

$$\begin{array}{lcl}
\backslash\text{combgame}\{2|1||0|||-1|||-2\} & 2|1||0|||-1|||-2 & \\
\backslash\text{setlength}\backslash\text{cgslashtextension}\{3\text{pt}\} & & \\
\backslash\text{combgame}\{2|1||0|||-1|||-2\} & 2|1||0|||-1|||-2 &
\end{array}$$

Spacing and scope. The commands `\cgslash`, `\cgsslash`, and `\cgslashes` are only valid inside `\combgame`. Its explicit form `\cgslashes{3}` draws three bars. The math glue `\cgslashtextension` controls the spacing between adjacent bars and defaults to -2μ . Change it with an assignment such as `\cgslashtextension=-1\mu`, preferably in a local group. The starred form removes the extra growth of longer bar groups; it still sizes the bars to their contents. The extra growth controlled by `\cgslashtextension` applies in display style.

4. COMPATIBILITY AND TROUBLESHOOTING

The source-and-result examples follow the original `combgames` manual by Aaron N. Siegel and David Wolfe. This package retains the symbol and braces-and-slashes interfaces, but does not implement the original tree or thermograph facilities. Do not load it together with `combgames`.

If a font or encoding is missing, check that all the files listed in Section 1 are present. The map refers to `combgames-symbols.enc` and `combgames-symbols.pfb`. Use the complete set of renamed font files; files from the development version are not substitutes.

Literal bars in an argument already read by another macro cannot always be made active. Use the explicit slash commands described above.

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