

# The Black Magic of Floats in $\text{\LaTeX}$

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## Abstract

The behavior of floats can often be confusing for the uninitiated, and yield unexpected results. This document gives a brief overview on the subject, primarily based on Leslie Lamport's  *$\text{\LaTeX}$  – A Document Preparation System* [1].

I will not cover every possible edge case, but present some usage examples and common problem one tends to run into while working with floats.

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Nam dui ligula, fringilla a, euismod sodales, sollicitudin vel, wisi. Morbi auctor lorem non justo. Nam lacus libero, pretium at, lobortis vitae, ultricies et, tellus. Donec aliquet, tortor sed accumsan bibendum, erat ligula aliquet magna, vitae ornare odio metus a mi. Morbi ac orci et nisl hendrerit mollis. Suspendisse ut massa. Cras nec ante. Pellentesque a nulla. Cum sociis natoque penatibus et magnis dis parturient montes, nascetur ridiculus mus. Aliquam tincidunt urna. Nulla ullamcorper vestibulum turpis. Pellentesque cursus luctus mauris.

**Figure 1:** A `figure` environment with placeholder text

**Table 1:** Results for an experiment

EXPERIMENT INPUT	EXPERIMENT OUTPUT
interesting thing	interesting result!
boring thing	mildly surprising result
weird thing	very unexpected result
fascinating thing	machine broke
Xenomorph XX121	dead scientists

## 1 What Are Floats, Anyway?

Normal text is broken by  $\text{\TeX}$  across lines and pages automatically. Some content, such as images, are not well-suited to being split into pieces. That is what floating environments are for: To provide a way to put such content in a place where it does not need to be broken; a way for it to *float* to a suitable location for an optimal overall result.

Two such floating environments are provided by  $\text{\LaTeX}$  by default: The `figure` and the `table`<sup>1</sup> environment. There are packages which define more floating environments (for example, the `listings` packages can let its code listings float, if so desired), or the user may define their own floating environments, if they so wish.

Fundamentally, the only important difference between these environments is how they are captioned and numbered: `figure` environments will get a different caption and number to a `table` environment. However, one may in principle put pretty much anything one desires into either environment. As long as the code itself is valid,  $\text{\LaTeX}$  will not complain. Figure 1 and Table ?? demonstrate this by placing some Lorem Ipsum text inside their environments.

The floating behavior can be demonstrated by the fact that, in the source code of this document, Figure 1 and Table 1 are placed almost right after this sentence. In the resulting document, they may be placed wherever  $\text{\LaTeX}$  deems most suitable<sup>2</sup>.

Because captions are a moving argument (Section 3.5.1 in [1]), fragile commands such as linebreaks inside them must be preceded by `\protect`, as shown in the caption of Figure 2 and the code in Listing 1.

The `\caption` command can only be used inside a floating environment by default. If you require captions for non-floating arguments, there are packages which provide such facilities, as

<sup>1</sup> Because confusion is fun: The `table` environment does not actually typeset a table. That is what `tabular`, `tabularx` and similar environments are for. See [2] for an overview. The `table` environment is merely a floating container intended for containing tabular content.

<sup>2</sup>  $\text{\LaTeX}$  usually tries to place floats either at the top of a page, the bottom of a page, or on a separate page. See 3 for more information.

56	57	58	59	60	61	62	63
48	49	50	51	52	53	54	55
40	41	42	43	44	45	46	47
32	33	34	35	36	37	38	39
24	25	26	27	28	29	30	31
16	17	18	19	20	21	22	23
8	9	10	11	12	13	14	15
0	1	2	3	4	5	6	7

**Figure 2:** One can place arbitrary content inside a `figure` environment, though this does not usually make much sense.

Note that you can also have linebreaks inside a `caption`, like here, but it requires the `\protect` command, and there must be no empty line after the `\\`. See Listing 1 for the code.

well as more caption customisation options, see [3, 4] and Chapter 6 of this document.

## 2 Basic Usage

Listing 1<sup>3</sup> shows the basic code for including an external graphics file inside a `figure` environment and providing a caption to go along with it.

### Figure Environment with External Picture

```
\begin{figure}
  \includegraphics[height=3cm,width=4.5cm]{images/grid8cm.png}
  \caption{%
    One can place arbitrary content inside a figure environment,
    though this does not usually make much sense.\protect\\
    Note that you can also have linebreaks inside a caption,
    like here, but it requires the \textbackslash{}protect
    command, and there must be no empty line after the
    \textbackslash{}textbackslash{}. See Listing \ref{lst:figure} for
    the code.}
  \label{fig:distorted-grid}
\end{figure}
```

**Listing 1:** Code block for including a graphics in a figure and including a forced linebreak in a caption with a `\protect` command

It is often desirable to center a table or a picture, in which case we add a `\centering` directive into the environment, as done in Listing 2<sup>4</sup>.

You may have noticed that the `\caption` is placed above the content for tables and below the picture in a `figure` environment. This is not prescribed by  $\text{\LaTeX}$ , obviously, and will depend on the style guide you're following or your own preferences. All I will say on the subject is that most tables I've seen had their caption above the table and most images had them below the picture.

*What does matter, however, is where the `\label` is put!* In order to pick up the correct number, it must always come either inside the `\caption` command to which it is supposed to be connected, or after it. If you put it before the `\caption` command, the `\label` will pick up whichever counter

<sup>3</sup>Incidentally, Listing 1 is one of those cases where a new type of floating environment has been provided; in this case by the `minted` package.

<sup>4</sup>There exists also a `\begin{center} ... \end{center}` environment. For the curious, some information on the differences between that and `\centering` can be found at [5, 6]

#### Tabular Inside Table, Centered

```
\begin{table}
  \centering
  \caption{Results for an experiment}
  \label{tab:experiment}
  \begin{tabular}{ll}
    \toprule
    \scshape Experiment Input & \scshape Experiment Output \\
    \midrule
    interesting thing          & interesting result!      \\
    boring thing              & mildly surprising result \\
    weird thing               & very unexpected result   \\
    fascinating thing         & machine broke            \\
    Xenomorph XX121           & dead scientists          \\
    \bottomrule
  \end{tabular}
\end{table}
```

Listing 2: Centering a `tabular` environment inside a `table` floating environment. This is the code for Table 1.

was the last active one before the `\caption`, which can be anything (another picture or table or float of some sort, but also a chapter, section or similar). This is a mistake which is easily made and often hard to detect.

Lastly, note the optional argument to the `\caption` command. If it is given, it will be the text for the entry in the `listof...` command. See Listing 3.

#### Optional Argument for `\caption` Command

```
\caption[This is the text for the List of <something> entry]{
  This is the text which goes below/above the float. It can be
  rather long, depending on how much explanation the content
  of the float requires (remember: because a float is not
  necessarily right where you write about its content in the
  main body of text, it might be useful for the reader to
  understand its content without having to go and dig through
  the main text), and in such cases, it does not make sense to
  have the entire text of the caption in the List of entry.}
```

Listing 3: Optional Arguments to the `\caption` command for the List of ... entry.

### 3 Placement Options

Placement options allow you to influence L<sup>A</sup>T<sub>E</sub>X's placement behavior of floats, with more or less vehemence.

*Whatever your preferences, only use placement options once your text is (almost) complete.* Otherwise you will end up needing to change them again and again and again, causing a lot more work. Also, it is quite easily possible to overlook a bad placement option from an earlier version of a document which makes you jump through hoops trying to get the best result even though L<sup>A</sup>T<sub>E</sub>X would actually do the right thing if you would just let it<sup>5</sup>.

#### Placement Options

```
\begin{float type}[loc] body \end{float type}
```

Listing 4: Placement options for floats

Listing 4 contains the basic syntax of a float with placement options. The `loc` argument can be a sequence of one to four letters and an exclamation mark. The meaning of these options is as follows (paraphrased from [1]):

- h** *Here*: at the location in the text where the environment is in the source code. Does not work for double-column floats in two-column documents.
- t** *Top*: at the top of a text page.
- b** *Bottom*: at the bottom of a text page. Does not work for double-column floats in two-column documents.
- p** *Page of floats*: on a separate page containing only floats, but no text.
- !** *Try harder*: tells L<sup>A</sup>T<sub>E</sub>X to try harder to place the float at the earliest possible place in the document allowed by the rest of the argument. The meaning of *try harder* is elaborated in Section 5.

This also overrides a `\suppressfloats` (see below) command for the float to which it belongs.

The default value for `loc`, if it is not specified manually, is `tpb`, meaning L<sup>A</sup>T<sub>E</sub>X may put the float at the top of a text page, the bottom of a text page, or on a separate page containing only floats.

When an optional `loc` argument is given, make sure to specify enough options to allow L<sup>A</sup>T<sub>E</sub>X sufficient flexibility with placing the floats. Otherwise a float and all subsequent floats can end up being saved until the end of a chapter or document, potentially causing T<sub>E</sub>X to run out of memory or producing a result which does not make sense from a document design point of view.

Additionally, there exists the `\suppressfloats[loc]` command. This tells L<sup>A</sup>T<sub>E</sub>X not to put any additional floats on the current page. `loc` can be:

- t** No more figures at the top of the current page.
- b** No more figures at the bottom of the current page.

### 4 Help, My Floats Are Jinxed!

It is probably a good idea to understand how L<sup>A</sup>T<sub>E</sub>X determines how floats are placed. There are six rules which govern this, backed by fifteen parameters. Because rules are rules, and phrasing matters, I will quote [1] verbatim for these:

<sup>5</sup>I am obviously *not* speaking from personal experience here. I am smarter than that, I assure you.

## L<sup>A</sup>T<sub>E</sub>X Float Rules from Lamport [1]

Here are the rules that determine where a figure or table is put:

- It is printed at the earliest place that does not violate subsequent rules, except that an `h` (here) position takes precedence over a `t` (top) position.
- It will not be printed on an earlier page than the place in the text where the figure or table environment appears.
- A figure will not be printed before an earlier figure, and a table will not be printed before an earlier table.<sup>a</sup>
- It may appear only at a position allowed by the `loc` argument, or, if that argument is missing, by the default `tbp` specifier.
- Placement of the figure or table cannot produce an overfull page.
- The page constraints determined by the formatting parameters described below are not violated. However, if a `!` appears in the optional argument, then the constraints for text pages are ignored, and only the ones for float pages (expressed by `\floatpagefraction` and `\dblfloatpagefraction`) apply.

The last three rules are suspended when a `\clearpage`, `\cleardoublepage`, or `\end{document}` command occurs, all unprocessed figures and tables being allowed a `p` option and printed at that point.

---

<sup>a</sup>However, in a two-column page style, a single-column figure can come before an earlier double-column figure, and vice versa.

These rules can sometimes result in unexpected and/or undesired behavior. Some issues which have caused me the occasional headache over the years are:

- *Many floats, not a lot of text.* There is not really much one can do in this case (I would not advise writing more text just for the sake of padding your document's layout). But it can produce odd results, and some experimentation with the placement of floats in the source code, placement options and `\clearpage` may be needed.

Float pages tend to be the most sensible option in this case, at least in my humble opinion. Make sure to allow L<sup>A</sup>T<sub>E</sub>X to place floats on float pages in this case with the `p` placement option.

- *All floats move to the end of a chapter or the document.* As mentioned above, this tends to come about when not enough placement options are specified for a float (yes, a single one suffices to move all subsequent ones). Usually, I would recommend to at least specify `ht`, see [7].
- *Floats are at an inconvenient place.* Despite its best efforts, sometimes L<sup>A</sup>T<sub>E</sub>X's algorithm will simply not produce an optimal result. For example, the text which talks about the content of a float and the corresponding float are inconveniently located. Maybe the reader has to keep flipping a page to read the text for a float and look at the float itself.

In such cases, I would advise one or more of a few things:

- Move the descriptive text to the float's caption.
- Try to relocate the float via placement options.
- Try to relocate the float by moving it in the source code.
- Split the float into several pieces of content and have the corresponding text between them. For example, if you have a float with several plots. Be sensible about this though.
- Some other genius idea which has not yet occurred to me.

## 5 L<sup>A</sup>T<sub>E</sub>X's Dark Magic

You probably do not have to read this section. But for the curious, or the desperate, these are the fifteen style parameters mentioned above. Note that, according to [1], if you're having trouble, it tends to be caused by one of the first seven more likely than not. Again, I shall quote Lamport:

### L<sup>A</sup>T<sub>E</sub>X Float Style Parameters from Lamport [1]

**topnumber** A counter whose value is the maximum number of floats allowed at the top of a text page.

**\topfraction** The maximum fraction of the page that can be occupied by floats at the top of the page. Thus, the value .25 specifies that as much as the top quarter of the page may be devoted to floats. It is changed with **\renewcommand**.

**bottomnumber** Same as **topnumber** except for the bottom of the page.

**\bottomfraction** Same as **\topfraction** except for the bottom of the page.

**totalnumber** A counter whose value is the maximum number of floats that can appear on a single text page, irrespective of their positions.

**\textfraction** The minimum fraction of a text page that must be devoted to text. The other 1- **\textfraction** fraction may be occupied by floats. It is changed with **\renewcommand**.

**\floatpagefraction** The minimum fraction of a float page that must be occupied by floats, limiting the amount of blank space allowed on a float page. It is changed with **\renewcommand**.

**dbltopnumber** The analog of **topnumber** for double-column floats on a two-column page.

**\dbltopfraction** The analog of **\topfraction** for double-column floats on a two-column page.

**\dblfloatpagefraction** The analog of **\floatpagefraction** for a float page of double-column floats.

**\floatsep** The vertical space added between floats that appear at the top or bottom of a text page. It is a rubber length.

**\textfloatsep** The vertical space added between the floats appearing at the top or bottom of a page and the text on that page. It is a rubber length.

**\intextsep** The vertical space placed above and below a float that is put in the middle of the text with the **h** location option. It is a rubber length.

**\dblfloatsep** The analog of **\floatsep** for double-width floats on a two-column page. It is a rubber length.

**\dbltextfloatsep** The analog of **\textfloatsep** for double-width floats on a two-column page. It is a rubber length.

## 6 Alternatives to Using Floats



## 7 References

- [1] Leslie Lamport, Digital Equipment Corporation, “*LaTeX – A Document Preparation System*”, 2nd Edition, 1994, Addison-Wesley Publishing Company.
- [2] Lapo Mori, “*Tables in LaTeX 2<sub>ε</sub>: Packages and Methods*”, The PracTeX Journal, 2007-FEB-20. [Online], <https://www.tug.org/pracjourn/2007-1/mori/mori.pdf>, [Accessed: 2017-MAR-27].
- [3] Comprehensive TeX Archive Network. “*Package caption – Customising captions in floating environments*”. [Online], <http://ctan.org/pkg/caption>, [Accessed: 2017-MAR-26].
- [4] Comprehensive TeX Archive Network. “*Topic caption*”. [Online], <http://ctan.org/topic/caption>, [Accessed: 2017-MAR-26].
- [5] Enrico Gregorio, “*When should we use \begin{center} instead of \centering?*”, [Online], <http://tex.stackexchange.com/a/23653>, [Accessed: 2017-MAR-26].
- [6] stefan, “*TeXBlog – center vs. centering*”. [Online], <http://texblog.net/latex-archive/floats/center-centering/>, [Accessed: 2017-MAR-27].
- [7] Stefan Kottwitz, “*h float specifier changed to ht warning when not attempting to specify a float*”. [Online], <http://tex.stackexchange.com/a/1527>, [Accessed: 2017-MAR-27].