SPECTRALSEQUENCES

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The SPECTRALSEQUENCES package is a specialized tool built on top of PGF/Ti*k*Z for drawing spectral sequences. It provides a powerful, concise syntax for specifying the data of a spectral sequence, and then allows the user to print various pages of spectral sequence, automatically choosing which subset of the classes, differentials, and structure lines to display on each page. It also handles most of the details of the layout. At the same time, SPECTRALSEQUENCES is extremely flexible. It is closely integrated with Ti*k*Z to ensure that users can take advantage of as much as possible of its expressive power. It is possible to turn off most of the automated layout features and draw replacements using Ti*k*Z commands. SPECTRALSEQUENCES also has a carefully designed error reporting system intended to ensure that it is as clear as possible what is going wrong.

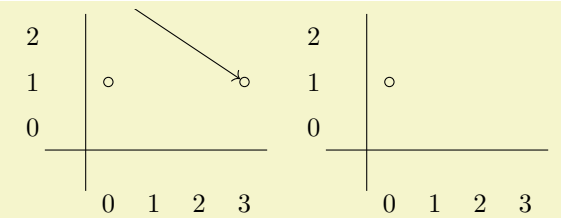
Many thanks to the authors of Ti*k*Z for producing such a wonderful package with such thorough documentation. I would have needed to spend a lot more time reading the Ti*k*Z code if the documentation weren't so excellent. I took ideas or code or both from tikzcd (part of the code for turning quotes into class or edge labels), PGFPLOTS (axes labels), and sseq (the grid styles, the stack). I lifted a fair amount of code from tex stack exchange. Thanks to Eric Peterson for being a very early adopter and reporting many bugs, to Eva Belmont for many productive conversations and for the idea of adding the stack traces for errors and to Vishal Arul and Catherine Ray for helpful suggestions. Also thanks to all my friends, family, and acquaintances listened to me talk about LaTeX programming even though they probably found it dreadfully boring.

Contents

1 Introduction

The SPECTRALSEQUENCES package consists of two main environments – the `{sseqdata}` environment, which specifies the data for a named spectral sequence diagram, and the `{sseqpage}` environment, which prints a single page of a spectral sequence diagram. The `\printpage` command is also available as a synonym for a `{sseqpage}` environment with an empty body.

Here is a basic example:




```
\begin{sseqdata}[ name = ex1, scale = 0.6,
                  cohomological Serre grading ]
\class(0,0)
\class(0,2)
\class(3,0)
\class(3,2)
\d3(0,2)
\end{sseqdata}
\printpage[ name = ex1, page = 3 ]  \quad
\printpage[ name = ex1, page = 4 ]
```

`\begin{sseqdata}[ name = ex1, cohomological Serre grading]` starts the declaration of the data of a spectral sequence named `ex1` whose page `r` differentials go `r` to the right and down `r − 1` – that is, it has cohomological Serre grading. Then we specify four classes and one page 3 differential, and we ask SPECTRALSEQUENCES to print the third and fourth pages of the spectral sequence. Note that on the fourth page, the source and target of the differential have disappeared.

1.1 A warning about fragile macros

All the data in a SPECTRALSEQUENCES environment is stored and used later. As a result, most of the SPECTRALSEQUENCES commands currently cannot tolerate fragile macros. Unfortunately, it is impossible for SPECTRALSEQUENCES to warn you about this situation – if you use a fragile command in a place that it doesn't belong, the result will be an incomprehensible error message. If you are getting nonsense error messages, this is probably why. The solution is to convert fragile macros into robust ones. See here for more information.

2 The Environments

`\begin{sseqdata}[`⟨*options*⟩`]`
⟨*environment contents*⟩
`\end{sseqdata}`

The `{sseqdata}` environment is for storing a spectral sequence to be printed later. This environment is intended for circumstances where you want to print multiple pages of the same spectral sequence. When using the `{sseqdata}` environment, you must use the `name` option to tell SPECTRALSEQUENCES where to store the spectral sequence so that you can access it later.

`\begin{sseqpage}[`⟨*options*⟩`]`
⟨*environment contents*⟩
`\end{sseqpage}`

This environment is used for printing a page of existing spectral sequence that was already specified using the `{sseqdata}` environment. The body of the environment adds local changes – classes, differentials, structure lines, and arbitrary TikZ options that are by default only printed on this particular page. The `{sseqpage}` environment can also be used to print a standalone page of a spectral sequence – that is, if you only want to print a single page of the spectral sequence, you can skip using the `{sseqdata}` environment.

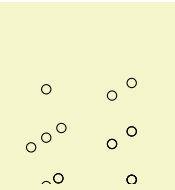
\printpage[⟨*options*⟩]

This command prints a single page of an existing spectral sequence as-is. This is equivalent to a {sseqpage} environment with an empty body.

3 The main commands

\class[⟨*options*⟩](⟨*x*⟩,⟨*y*⟩)

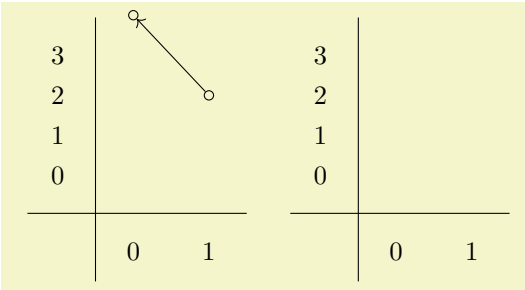
This places a class at (x,y) where x and y are integers. If multiple classes occur at the same position, SPECTRALSEQUENCES will automatically arrange them in a pre-specified pattern. This pattern may be altered using the class pattern option.



```
\begin{sseqpage}[ no axes, ymirror, yscale = 0.8 ]
\class(0,0)
\class(1,0) \class(1,0)
\class(0,1) \class(0,1) \class(0,1)
\class(1,1) \class(1,1) \class(1,1) \class(1,1)
\class(0,2) \class(0,2) \class(0,2) \class(0,2) \class(0,2)
\class(1,2) \class(1,2) \class(1,2) \class(1,2) \class(1,2) \class(1,2)
\end{sseqpage}
```

The effect of the \class command is to print a Ti*k*Z node on a range of pages. Any option that would work for a Ti*k*Z \node command will also work in the same way for the \class, \replaceclass, and \classoptions commands.

If a class is the source or the target of a differential on a certain page, then the page of the class is set to that page, and the class is only rendered on pages up to that number:

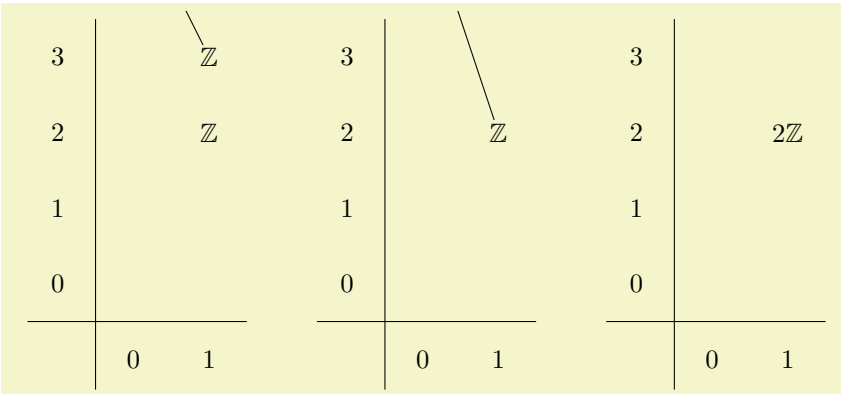



```
\begin{sseqdata}[ name = class example,
                  Adams grading,
                  yscale = 0.53 ]
\class(1,0)
\class(0,2)
\class(0,3)
\d2(1,0)
\end{sseqdata}
\printpage[ name = class example, page = 2 ]
\quad
\printpage[ name = class example, page = 3 ]
```

See the class options section for a list of the sort of options available for classes.

\replaceclass[⟨*options*⟩](⟨*x*⟩,⟨*y*⟩,⟨*n*⟩)
\replaceclass[⟨*options*⟩](⟨*classname*⟩)

After a class is the source or target of a differential, it disappears on the next page. However, some differentials are not injective or not surjective. Using the command \replaceclass causes a new symbol to appear on the page after a class supported or accepted a differential (or both). If there are multiple classes at the coordinate (x,y) you may specify which using an integer or a tag *n*. By default, this command will affect the first class placed in that position. You can also provide the name of a class.



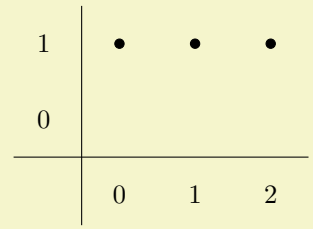
```
\begin{sseqdata}[name = replace class example, Adams grading, classes = {draw = none } ]
\class["\mathbb{Z}"](0,3)
\class["\mathbb{Z}"](1,1)
\class["\mathbb{Z}"](1,0)
\d["\cdot 2"]2(1,1)
\replaceclass["\mathbb{Z}/2"](0,3)
\d[->]3(1,0)
\replaceclass["2\mathbb{Z}"](1,0)
\end{sseqdata}
\printpage[ name = replace class example, page = 2 ] \qquad
\printpage[ name = replace class example, page = 3 ] \qquad
\printpage[ name = replace class example, page = 4 ]
```

Note that this will not restore any structlines coming into or off of the class, if you want the structlines to persist, you must call `\structline` again (or use the structline `page` option)

`\classoptions`[⟨*options*⟩](⟨*x*⟩,⟨*y*⟩,⟨*n*⟩)
`\classoptions`[⟨*options*⟩](⟨*classname*⟩)

This adds options to an existing class. This can be used in a `{sseqpage}` environment to modify the appearance of a class for just one drawing of the spectral sequence, for instance to highlight it for discussion purposes.

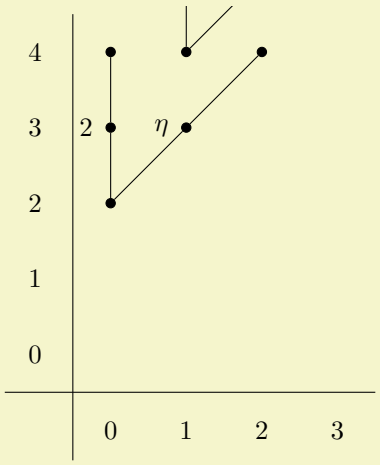
If there are multiple classes at the coordinate `(x,y)` you may specify which using an integer or a `tag` *n*. By default, this command will affect the first class placed in that position. You can also provide the `name` of a class.



The red class is the problem

```
\begin{sseqdata}[ name = class options example,
                  classes = fill ]
\class(2,1)
\foreach \x in {0,...,2} \foreach \y in {0,1} {
    \class(\x,\y)
}
\end{sseqdata}
\begin{sseqpage}[ name = class options example,
                  right clip padding = 0.6cm ]
\classoptions[red](2,1,2) % Only is red on this page!
\node[ background, text width = 10em ] at (0.3,-2.2)
    {\textup{The red class is the problem}};
\end{sseqpage}
```

Another reason to use this is to give a label to one instance of a class that shows up in a loop or a command defined using `\NewSseqGroup`:




```
\NewSseqGroup\mygroup {} {
    \class(0,0)
    \class(0,1)
    \class(0,2)
    \class(1,1)
    \class(2,2)
    \structline(0,0)(0,1)
    \structline(0,1)(0,2)
    \structline(0,0)(1,1)
    \structline(1,1)(2,2)
}
\begin{sseqpage}[ classes = fill, class labels = { left = 0.3em } ]
\mygroup(0,0)
\mygroup(1,2)
\classoptions["2"](0,1)
\classoptions["\eta"](1,1)
\end{sseqpage}
```

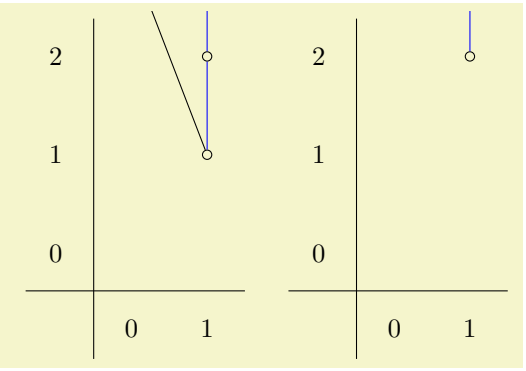
See the class options section for a list of the sort of options available for classes.

`\d`[⟨*options*⟩]⟨*page*⟩(⟨*x*⟩,⟨*y*⟩,⟨*source n*⟩,⟨*target n*⟩)
`\d`[⟨*options*⟩]⟨*page*⟩(⟨*source name*⟩,⟨*target n*⟩)

`\d[`⟨*options*⟩`]`⟨*page*⟩`(`⟨*source coordinate*⟩`)(`⟨*target coordinate*⟩`)`

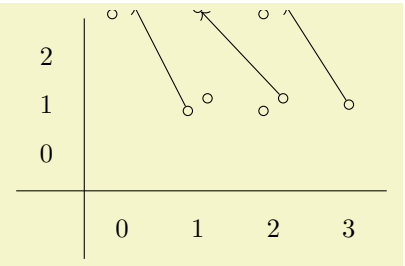
Calling `\d`⟨*page*⟩`(`⟨*x*⟩`,`⟨*y*⟩`)` creates a differential starting at `(`⟨*x*⟩`,`⟨*y*⟩`)` of length determined by the specified page. In order to use the `\d` command like this, you must first specify the `degree` of the differentials as an option to the `{sseqdata}` or `{sseqpage}` environment. The degree indicates how far to the right and how far up a page `r` differential will go as a function of `r`. If there is a page `r` differential, on page `r + 1`, the source, target, and any `\structline`s connected to the source and target of the differential disappear.

If there are multiple nodes in the source or target, you may specify which one the differential should go to using an index or tag for ⟨*source n*⟩ or ⟨*target n*⟩. It is also possible to provide the name of the source coordinate and an optional target, or to separately provide the source and target coordinate, either as names or as `(`⟨*x*⟩`,`⟨*y*⟩`,`⟨*n*⟩`)`. Using `\d` with explicit source and target coordinates works even if you did not provide a `degree` to the spectral sequence. If you did provide a `degree`, then SPECTRALSEQUENCES will check whether the difference between the source and target is appropriate for a differential of a given page, and if not it will throw an error. If this is undesirable, you can use the `lax degree` option.



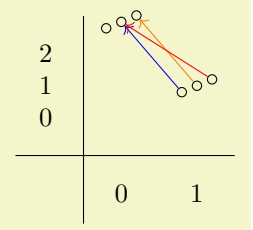

```
\begin{sseqdata}[ name = d example, degree = {-1}{#1},
                  struct lines = blue, yscale = 1.3 ]
\class(0,2)
\class(1,2)
\class(1,1)
\class(1,0)
\structline(1,2)(0,2)
\structline(1,2)(1,1)
\structline(1,1)(1,0)
\d2(1,0)
\end{sseqdata}
\printpage[ name = d example, page = 2 ] \quad
\printpage[ name = d example, page = 3 ]
```

If there are multiple nodes in the source or target coordinate, then there is a funny syntax for indicating which one should be the source and target: `\d`⟨*page*⟩`(`⟨*x*⟩`,`⟨*y*⟩`,\sourcen,\targetn)`




```
\begin{sseqpage}[ Adams grading, yscale = 0.8 ]
\class(1,0) \class(1,0)
\class(0,2) \class(0,2)
\d2(1,0,1,2)
\class(2,0) \class(2,0)
\class(1,2)
\d2(2,0,2)
\class(3,0)
\class(2,2) \class(2,2)
\d2(3,0,,2)
\end{sseqpage}
```

Negative indices will count from the most recent class in the coordinate (so `-1` is the most recent, `-2` is the second most recent, etc). You can also use a `tag`, which works better if the situation is complicated.




```
\begin{sseqpage}[ Adams grading, yscale = 0.65 ]
\class(1,0)
\class(0,2) \class(0,2)
\d[blue]2(1,0,-1,-1)
\class(1,0)
\class(0,2)
\d[orange]2(1,0,-1,-1)
\class(1,0)
\d[red]2(1,0,-1,-2)
\end{sseqpage}
```

`\doptions[`⟨*options*⟩`]`⟨*page*⟩`(`⟨*x*⟩`,`⟨*y*⟩`,`⟨*source n*⟩`,`⟨*target n*⟩`)`
`\doptions[`⟨*options*⟩`]`⟨*page*⟩`(`⟨*source name*⟩`,`⟨*target n*⟩`)`
`\doptions[`⟨*options*⟩`]`⟨*page*⟩`(`⟨*source coordinate*⟩`)(`⟨*target coordinate*⟩`)`

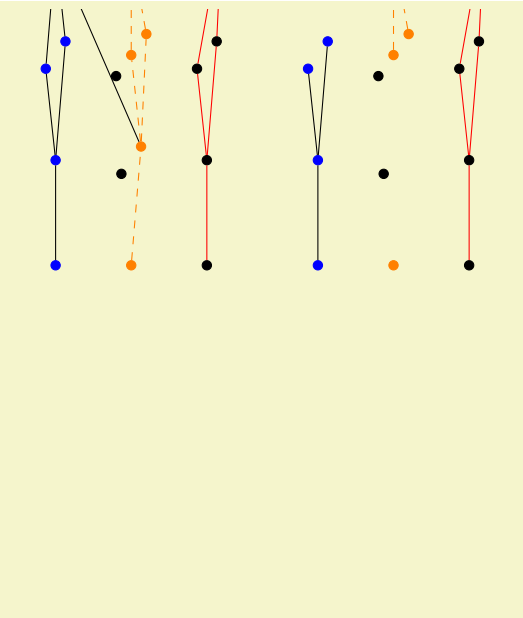
This command adds options to an existing differential, just like `\classoptions` except for differentials. Its syntax is identical to that of `\d`.

`\structline`[⟨*options*⟩](⟨*source coordinate*⟩)(⟨*target coordinate*⟩)

This command creates a structure line from ⟨*source coordinate*⟩ to ⟨*target coordinate*⟩. The source and target coordinates are either of the form (⟨*x*⟩,⟨*y*⟩,⟨*n*⟩) or (⟨*class name*⟩). If there are multiple classes at (x, y), then ⟨*n*⟩ specifies which of the classes at (x, y) the structline starts and ends at – if n is positive, then it counts from the first class in that position, if n is negative, it counts backwards from the most recent. You can also use a `tag` for n.

If the source or target of a structure line is hit by a differential, then on subsequent pages, the structure line disappears.

If the source or target has had multiple generations (i.e., they got hit and you used `\replaceclass`), then the `\structline` will only appear starting on the first page where the current generation of both the source and target are present. If this is undesirable, you can use the `page` option to change it.



```
\DeclareSseqGroup\tower {} {
    \class(0,0)
    \foreach \y in {1,...,5} {
        \class(0,\y)
        \structline(\lastclass1)(\lastclass)
    }
    \class(0,2)
    \structline(0,1,-1)(\lastclass)
    \structline(\lastclass)(0,3,-1)
}
\begin{sseqdata}[ name = structline example,
                  classes = { circle, fill },
                  Adams grading, no axes,
                  yscale = 1.39 ]
\class(1,1) \class(1,2)
\class(2,3) \class(2,3) \class(2,5)
\tower[classes = blue](0,0)
\tower[struct lines = dashed,orange](1,0)
\tower[struct lines = red](2,0)
\d2(1,1,2)
\end{sseqdata}
\printpage[ name = structline example, page = 2 ] \quad
\printpage[ name = structline example, page = 3 ]
```

`\structlineoptions`[⟨*options*⟩](⟨*source coordinate*⟩)(⟨*target coordinate*⟩)

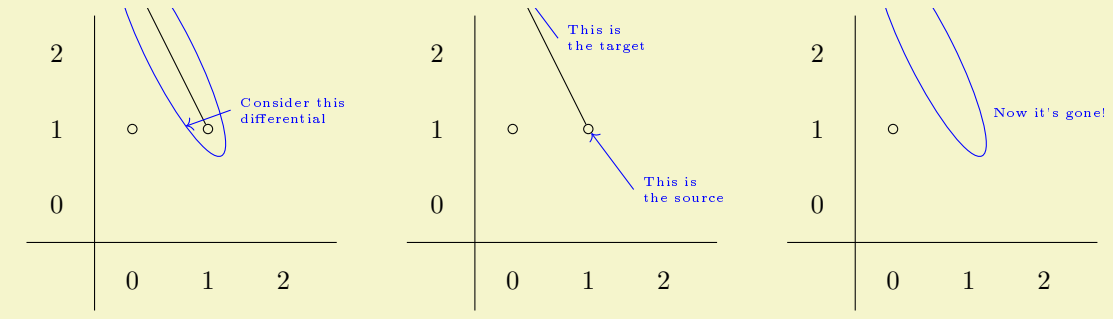
This command adds options to an existing structure line, just like `\classoptions` except for structure lines. Its syntax is identical to `\structline`.

`\circleclasses`[⟨*options*⟩](⟨*source coordinate*⟩)(⟨*target coordinate*⟩)

This command is a lot like `\structline` except that it puts a circle around the classes instead of connecting them with a line. It might take a certain amount of fiddling with options to get `\circleclasses` to produce good results. There is no `\circleclassesoptions` command because it doesn't seem necessary and (more importantly) I didn't feel like making one. Maybe someday I'll put one in.

`\draw`
`\path`
`\node`
`\clip`

Any code that would work in a `{tikzpicture}` environment will also work unchanged in a `{sseqdata}` or `{sseqpage}` environment, with a few minor differences. This is a very flexible way to add arbitrary background or foreground features to the spectral sequence:




```
\begin{sseqdata}[ name = tikz example, Adams grading, math nodes = false,
                  tikz primitives = { blue, font = \tiny, <- }, circle classes = tikz primitive style,
                  x range = {0}{2}, x axis extend end = 2em ]
\class(0,0)
\class(1,0)
\class(0,2)
\d2(1,0)
\end{sseqdata}

\begin{sseqpage}[ name = tikz example ]
\circleclasses[ name path = myellipse, inner sep = 3pt, ellipse ratio = 1.6 ] (1,0) (0,2)
\path[ name path = myline ] (1.3,1.25) -- (0.6,1);
\draw[ name intersections = { of = myellipse and myline } ]
      (intersection-1) to (1.3,1.25) node[ right, text width = 1.6cm ] {Consider this differential};
\end{sseqpage} \qquad

\begin{sseqpage}[ name = tikz example ]
\draw[ xshift = 1 ] (0,0) to (0.6,0.2) node[ right, text width = 1.1cm ] {This is the source};
\draw[ yshift = 2 ] (0,0) to (0.6,0.2) node[ right, text width = 1.1cm ] {This is the target};
\end{sseqpage} \qquad

\begin{sseqpage}[ page = 3, name = tikz example ]
\circleclasses[ name path = myellipse, inner sep = 3pt, ellipse ratio = 1.6 ] (1,0)(0,2)
\node[ right, font = \tiny ] at (1.2,1.2) {Now it's gone!};
\end{sseqpage}
```

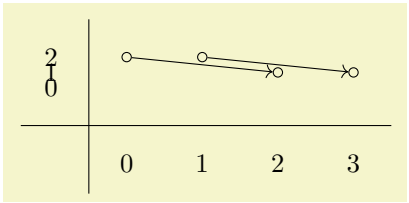
4 Options for the main commands

4.1 Universal options

The following options work with all of the drawing commands in this package, including `\class`, `\d`, and `\structline`, their friends `\replaceclass`, `\classoptions`, `\doptions`, and `\structlines`, as well as with Ti*k*Z primitives.

`xshift` = ⟨*integer*⟩
`yshift` = ⟨*integer*⟩

Shifts by integer values are the only coordinate changes that are allowed to be applied to `\class`, `\d`, `\structline`, their relatives, or to a `{scope}` environment that contains any of these commands. These shift commands help with reusing code. For instance:




```
\begin{sseqpage}[ cohomological Serre grading, yscale = 0.45 ]
\foreach \x in {0,1} \foreach \y in {0,1} {
    \begin{scope}[ xshift = \x, yshift = \y ]
    \class(2,0)
    \class(0,1)
    \d2(0,1)
    \end{scope}
}
\end{sseqpage}
```

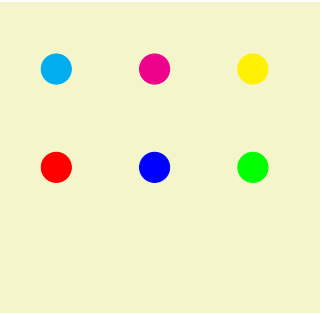
This code segment is very useful so SPECTRALSEQUENCES has the command `\NewSseqGroup` which to make code like this more convenient. The following code produces the same output as above:

```
\NewSseqGroup\examplegroup {} {
    \class(2,0)
    \class(0,1)
    \d2(0,1)
}
\begin{sseqpage}
\examplegroup(0,0)
\examplegroup(0,1)
\examplegroup(1,0)
\examplegroup(1,1)
\end{sseqpage}
```

A word of warning: the behavior of `xshift` in SPECTRALSEQUENCES is incompatible with the normal behavior of `xshift` in Ti*k*Z. For some reason, saying `xshift = 1` in Ti*k*Z does not shift the coordinate `(0,0)` to the coordinate `(1,0)` – instead it shifts by 1pt. In SPECTRALSEQUENCES , saying `xshift = 1` moves the coordinate `(0,0)` to the coordinate `(1,0)`. This includes Ti*k*Z primitives: saying `\draw[ xshift = 1 ] (0,0) -- (1,0);` inside a `{sseqdata}` or `{sseqpage}` environment is the same as saying `\draw(1,0) -- (2,0);` despite the fact that this is not the case in the `{tikzpicture}` environment.

Colors

These come from the LaTeX color package via Ti*k*Z, so see the color package documentation for more information.

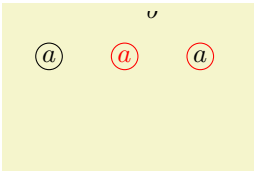


```
\begin{sseqpage}[ classes = {fill,inner sep = 0.4em},
                  no axes, scale = 1.3 ]
\class[red](0,0)
\class[blue](1,0)
\class[green](2,0)
\class[cyan](0,1)
\class[magenta](1,1)
\class[yellow](2,1)
\class[blue!50!red](0,2) % a 50-50 blend of blue and red
\class[green!30!yellow](1,2) % 70% green, 30% yellow
\class[blue!50!black](2,2)
\end{sseqpage}
```

"⟨*text*⟩"⟨*options*⟩

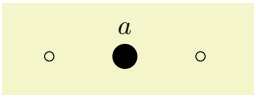
Specify a label for a class, a differential, or a structure line. This uses the Ti*k*Z quotes syntax. The options include anything you might pass as an option to a Ti*k*Z node, including arbitrary coordinate transforms, colors, opacity options, shapes, fill, draw, etc. The behavior is a little different depending on whether you use it on a class or on a differential or struct line.

For a class, the ⟨*text*⟩ is placed in the position `inside` the node by default – in effect, the ⟨*text*⟩ becomes the label text of the node (so saying `\class["label text"](0,0)` causes a similar effect to saying `\node at (0,0) {label text};`). There are other position options such as `left`, `above left`, etc which cause the label text to be placed in a separate node positioned appropriately. If the placement is above, left, etc, then any option that you may pass to a Ti*k*Z node will also work for the label, including general coordinate transformations. If the placement is "inside", then the only relevant ⟨*options*⟩ are those that alter the appearance of text, such as opacity and color.



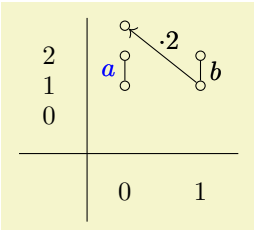
```
\begin{sseqpage}[ classes = { minimum width = width("a") + 0.5em }, no axes ]
\class["a"](0,0)
\class["a",red](1,0)
\class["a" black,red](2,0)
\class["b" above](0,1)
\class["b" {below right,yshift = 0.1cm}](1,1)
\class["a" {above right = {1em}}](2,1)
\end{sseqpage}
```

You can adjust the default behavior of class labels using the `labels` style option or its relatives `class labels`, `inner class labels` or `outer class labels`. Note that it is also possible to give a label to a `\node` this way, although the behavior is slightly different. In particular, the label defaults to the `above` position instead of going in the `\node` text by default. Also, this won't respect the various label style options like `labels`, etc.



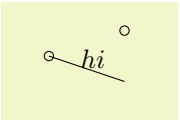

```
\begin{sseqpage}[ no axes ]
\class(0,0)
\class(2,0)
\node[circle,fill,"a"] at (1,0) {};
\end{sseqpage}
```

For either a `\structline` or a `\class` the label normally goes on the right side of the edge. The special `'` option makes it go in the opposite position from the default. I imitated the label handling in the tikzcd package, so if you use tikzcd, this should be familiar.



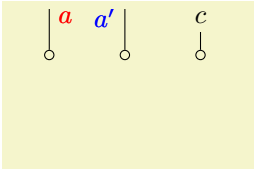

```
\begin{sseqpage}[ Adams grading, yscale = 0.63 ]
\class(0,0)
\class(0,1)
\class(0,2)
\structline["a"' blue](0,0)(0,1)
\class(1,0)
\class(1,1)
\structline["b"](1,0)(1,1)
\d[ "\cdot 2" { pos = 0.7, yshift = -5pt } ] 2 (1,0)
\end{sseqpage}
```

You can use the style options `labels`, `edge labels`, `differential labels`, and `struct line labels` to adjust the styling of edge labels. For instance, if you would prefer for the labels to default to the left hand side of the edge rather than the right hand side, you could say `edge labels = {auto = left}`. You can also use quotes to label edges drawn with TikZ primitives:




```
\begin{sseqpage}[ yscale = 0.58, no axes ]
\class(0,0)
\class(1,1)
\draw (1,0) to["hi"'{ pos = 0.7, yshift = -0.5em }] (0,1);
\end{sseqpage}
```

The special option "description," stolen from tikzcd, places the label on top of the edge. In order to make this option work correctly, if the background coolor is not the default white, you must inform sseqpages about this using the key `background color` = ⟨*color*⟩. In this document, the background color is called *graphicbackground*.




```
\begin{sseqpage}[ no axes, background color = graphicbackground ]
\foreach \x in {0,1,2} \foreach \y in {0,1} {
    \class(\x,\y)
}
\structline["a" red](0,0)(0,1)
\structline["a'"'blue,"b"{yshift = 1em}](1,0)(1,1)
\structline["c" description](2,0)(2,1)
\end{sseqpage}
```

4.2 Options for \class

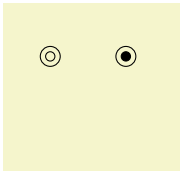
Because the main job of the `\class` command is to print a TikZ `\node` on the appropriate pages of the spectral sequence, most options that would work for a TikZ node also work for the commands `\class`, `\replaceclass`, and `\classoptions`. Here are a few that you might care about:

A TikZ shape

If you give the name of a TikZ shape, the class node will be of that shape. The standard TikZ shapes are `circle` and `rectangle`. SPECTRALSEQUENCES defines two new shapes:

`circlen` = ⟨*n*⟩

This draws n concentric circles. It's intended for indicating a $\mathbb{Z}/p^n$ summand. For large values of n the result isn't all that appealing.

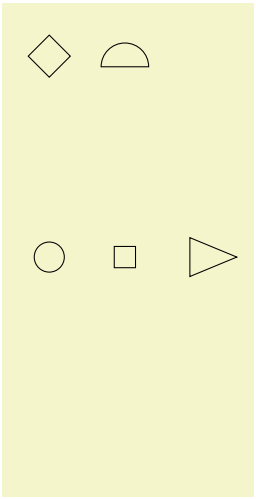


```
\begin{sseqpage}[ no axes ]
\class[circlen = 2](0,0)
\class[circlen = 2,fill](1,0)
\class[circlen = 3](0,1)
\class[circlen = 4](1,1)
\end{sseqpage}
```

newellipse
ellipse ratio = ⟨*ratio*⟩

This shape is used for `\circleclasses`. It's a variant on the `ellipse` shape that gives more control over the ellipse's aspect ratio.

There are many more Ti*k*Z shapes in the shapes library, which you can load using the command `\usetikzlibrary{shapes}`. The following are some examples:

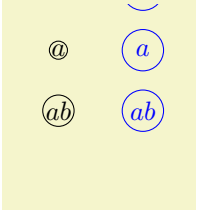


```
\begin{sseqpage}[ no axes, classes = { inner sep = 0.4em },
                  class placement transform = { scale = 2 },
                  yscale = 1.63 ]
\class(0,0)
\class[isosceles triangle](2,0)
\class[rectangle](1,0)
\class[diamond](0,1)
\class[semicircle](1,1)
\class[regular polygon, regular polygon sides = 5](2,2)
\class[regular polygon, regular polygon sides = 6](2,2)
\class[regular polygon, regular polygon sides = 7](2,2)
\class[regular polygon, regular polygon sides = 8](2,2)
\end{sseqpage}
```

See the Ti*k*Z manual for more information.

minimum width = ⟨*dimension*⟩
minimum height = ⟨*dimension*⟩
minimum size = ⟨*dimension*⟩
inner sep = ⟨*dimension*⟩
outer sep = ⟨*dimension*⟩

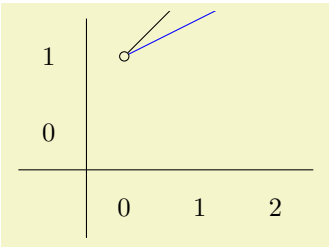
These options control the size of a node. This is typically useful to make the size of nodes consistent independent of the size of their label text. For instance:



```
\begin{sseqdata}[ name = minimum width example, no axes, yscale = 0.8 ]
\class["ab"](0,0)
\class["a"](0,1)
\class(0,2)
\end{sseqdata}
\printpage[ name = minimum width example ]
\printpage[ name = minimum width example,
  change classes = { blue, minimum width = width("ab") + 0.5em } ]
```

name = ⟨*node name*⟩

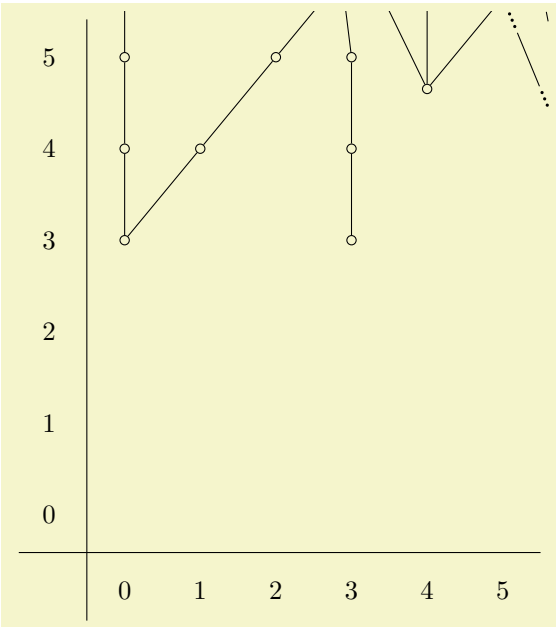
The `\class` command makes a Ti*k*Z node on appropriate pages. You can refer to this node using Ti*k*Z commands by using coordinates. Using the `name` option, you can give the node a second shorter name. One potential benefit to this is that it is immune to coordinate transformations. For example, in the following code, `xshift` does not apply to the nodes specified by `(id)` and `(eta)` but does apply to the coordinate specified by `(1,1)`:




```
\begin{sseqpage}
\class[name = id](0,0)
\class[name = eta](1,1)
\class(2,1)
\draw[xshift = 1] (id) -- (eta);
\draw[xshift = 1,blue] (id) -- (1,1);
\end{sseqpage}
```

`tag` = ⟨*tag*⟩

This key adds a tag to the current class. Tags are used for identifying which of multiple classes in the same position you are referring to. They are useful when you have groups of related classes and want a family of differentials connecting them. For instance:

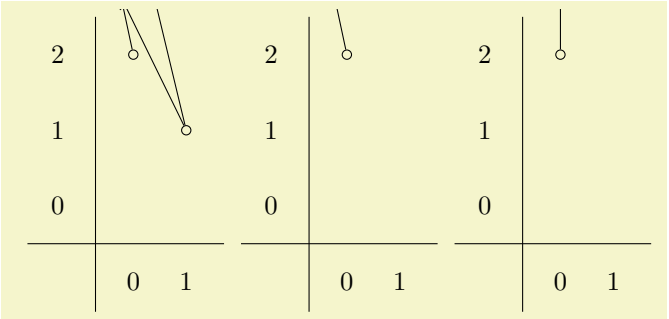



```
\DeclareSseqGroup\tower {} {
    \class(0,0)
    \foreach \i in {1,...,11} {
        \class(0,\i)
        \structline(0,\i-1,-1)(0,\i,-1)
    }
}
\NewSseqGroup\hvee {} {
    \tower(0,0)
    \foreach \i in {1,...,11} {
        \class(\i,\i)
        \structline(\i-1,\i-1,-1)(\i,\i,-1)
    }
}
\begin{sseqpage}[ degree = {-1}{1}, yscale = 1.1,
                  x range = {0}{5}, y range = {0}{5} ]
\tower(3,0)
\hvee[tag = id](0,0)
\hvee[tag = h21](4,2)
\foreach \n in {0,...,5} {
    \d2(4+\n,2+\n,h21,id)
}
\end{sseqpage}
```

We want each differential to go from the `h21` vee to the `id` vee, independent of which classes are in the same position of the two vees. The easy way to accomplish this is by giving tags to each of the two vees.

`offset` = {(⟨*x offset*⟩,⟨*y offset*⟩)}

By default, a class uses the offset specified by `class pattern`. Occasionally this is undesirable. In this case, you can specify the offset for a particular class by hand. For example if the sum of two classes is hit by a differential, it looks better for the class replacing them to be centered:



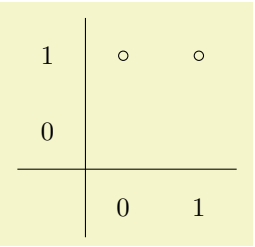

```
\begin{sseqdata}[ name = offset example,
    xscale = 0.7,
    Adams grading,
    class placement transform = {scale = 1.8} ]
\class(0,1)
\class(0,2)\class(0,2)
\draw(0,1)--(0,2);
\class(1,0)
\d2(1,0,,1)
\d2(1,0,,2)
\replaceclass(0,2)
\end{sseqdata}
\printpage[name = offset example, page=2]
\printpage[name = offset example, page=3]
\begin{sseqpage}[name = offset example, page=3]
\classoptions[offset = {(0,0)}](0,2)
\end{sseqpage}
```

`tooltip` = ⟨*text*⟩

This key generates a "tooltip" over the given class. That is, if you hover your mouse over it, a little window will popup with the tooltip text. This is particularly useful to give the coordinates or names of classes in large diagrams where it may be hard to tell from looking at the picture what position the class is in, or there may not be room to supply names to classes.

The tooltip is made using the `\pdftooltip` command from the `pdfcomment` package. This cannot handle math, but it will print math expressions into tex input form. Not all pdf viewers will display the tooltip correctly. If this concerns you, the command `\sseqtooltip` is used to produce the tooltip, and you can redefine it as any other command that takes `\sseqtooltip{`⟨*text*⟩`}{`⟨*tooltip text*⟩`}` and produces a tooltip. For instance, on this stack exchange post, there is code that supposedly produces tooltips that work with Evince. I have not tested whether it works by itself or whether it works with my package, but you could. You could potentially figure out how to get math to work in tooltips too – if you find a satisfactory method, please let me know.

Anyways, here's an example:

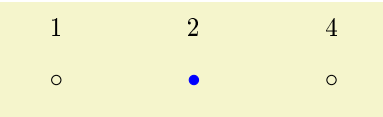



```
\begin{sseqpage}[classes = {tooltip = {(|xcoord,|ycoord)}}]
\class(0,0)
\class(0,1)
\class(1,0)
\class(1,1)
\end{sseqpage}
```

There's another example at the beginning of the section on the class stack.

`page` = ⟨*page*⟩`--`⟨*page max*⟩
`generation` = ⟨*generation*⟩`--`⟨*generation max*⟩

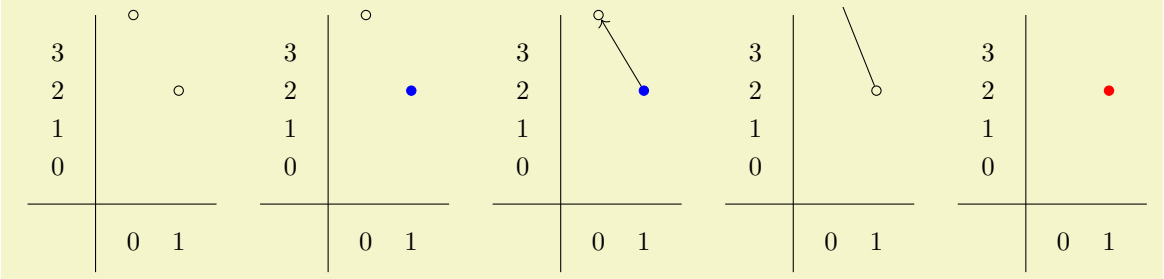
These options only work in `\classoptions`. The `page` option gives a range of pages for which the options apply to. If only one page is specified, it is the minimum page and the option applies to all larger pages.




```
\begin{sseqdata}[ name = page_example, no axes,
    title = |page, title style = {yshift = -0.5cm} ]
\class(0,0)
\classoptions[page = {2-3},fill,blue](0,0)
\end{sseqdata}

\printpage[ name = page_example, page = 1 ] \qquad
\printpage[ name = page_example, page = 2 ] \qquad
\printpage[ name = page_example, page = 4 ]
```

A "generation" of a class is the interval from one call of `\class` or `\replaceclass` to the page on which it next supports or is hit by a differential. By default the `\classoptions` command adds options only to the most recent generation of the class in a `{sseqdata}` environment, or on the generation appropriate to the current page in a `{sseqpage}` environment. Using the `generation` option allows you to provide a single generation or range of generations of the class that the options should apply to. The first generation is generation 0, and the most recent generation is generation -1. Larger negative values count backwards.



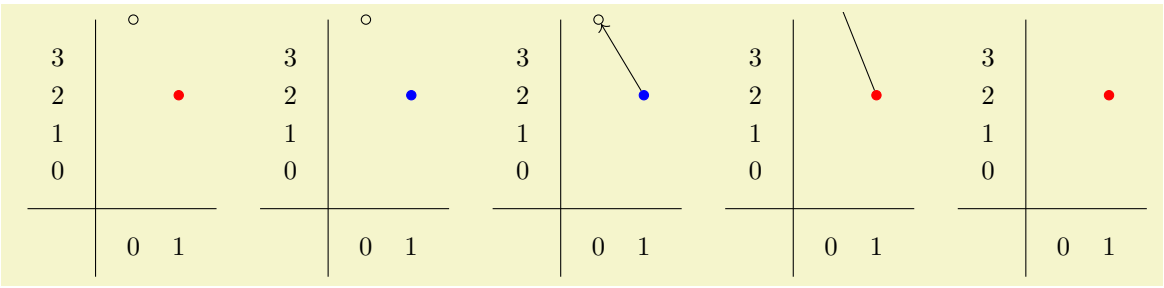
```
\begin{sseqdata}[ name = page_example2, Adams grading, xscale = 0.6, yscale = 0.5 ]
\class(0,2)\class(1,0)
\d2(1,0)
\replaceclass(1,0)
\class(0,3)
\d3(1,0)
\replaceclass(1,0)
\classoptions[fill,red](1,0) % (a) applies to most recent (last) generation.
\end{sseqdata}

\printpage[ name = page_example2, page = 1 ] % generation 0 of (1,0), not styled
\quad
\begin{sseqpage}[ name = page_example2, page = 1, keep changes ]
\classoptions[fill,blue](1,0) % (b) applies to the generation present on page 1, that is, generation 0.
\end{sseqpage} \quad

% generation 0 of (1,0), so class is blue from (b)
\printpage[ name = page_example2, page = 2 ] \quad

% generation 1 of (1,0), class is not styled
\printpage[ name = page_example2, page = 3 ] \quad

% generation 2 of (1,0), class is red from (a)
\printpage[ name = page_example2, page = 4 ]
```




```
\begin{sseqdata}[ name = page_example2, Adams grading,update existing ]
% (c) applies to all generations, overwrites (b) and (a):
\classoptions[fill, red, generation = 0 -- -1](1,0)
\end{sseqdata}

\printpage[ name = page_example2, page = 1 ]% generation 0 of (1,0), so class is red
\quad
\begin{sseqpage}[ name = page_example2, page = 1, keep changes ]
\classoptions[fill,blue](1,0) % (d) applies to the generation present on page 1, that is, generation 0.
\end{sseqpage} \quad

% generation 0 of (1,0), class is blue from (d)
\printpage[ name = page_example2,page = 2 ] \quad

% generation 1 of (1,0), class is red from (c)
\printpage[ name = page_example2, page = 3 ]
\quad
\printpage[ name = page_example2, page = 4 ] % generation 2 of (1,0), class is red from (c)
```

\xcoord
\ycoord

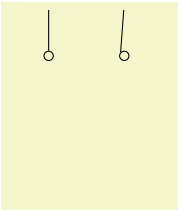
These commands represent the `x` and `y` coordinate of the current class when used in class options. The only use I have for them is in the `tooltip` option, but maybe there is some other purpose for them.

4.3 Options for \d and \structline

Because the main job of the `\d` and `\structline` commands is to print an edge on the appropriate pages of the spectral sequence, most Ti*k*Z options that you could apply to a Ti*k*Z "to" operator (as in `\draw (x1,y1) to (x2,y2);`) can be applied to both `\d` and `\structline`. Some such options are as follows:

source anchor = ⟨*anchor*⟩
target anchor = ⟨*anchor*⟩

Because you can't use the normal Ti*k*Z mechanism for specifying the source and target anchors, SPECTRALSEQUENCES has these two keys for `\d` and `\structline`:



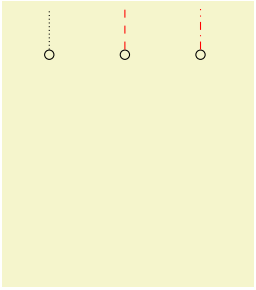
```
\begin{sseqpage}[ no axes, yscale = 1.24 ]
\foreach \x in {0,1} \foreach \y in {0,1} {
    \class(\x,\y)
}
\structline(0,0)(0,1)
\structline[ source anchor = north west, target anchor = -30 ](1,0)(1,1)
\end{sseqpage}
```

shorten > = ⟨*distance*⟩
shorten < = ⟨*distance*⟩

These behave exactly like the corresponding options from Ti*k*Z , shortening the end and beginning of the edge respectively. Note that you can lengthen the edge by shortening by a negative amount.

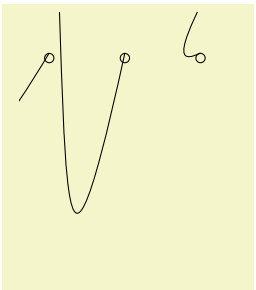
Dash patterns:

See the Ti*k*Z manual for a complete explanation of the dash pattern related options. Some examples:



```
\begin{sseqpage}[ no axes, yscale = 1.6 ]
\foreach \x in {0,1,2} \foreach \y in {0,1} {
    \class(\x,\y)
}
\structline[densely dotted](0,0)(0,1)
\structline[dashed,red, "a"](1,0)(1,1)
\structline[dash dot,red, "a" black](2,0)(2,1)
\end{sseqpage}
```

bend left = ⟨*angle*⟩
bend right = ⟨*angle*⟩
in = ⟨*anchor*⟩
out = ⟨*anchor*⟩



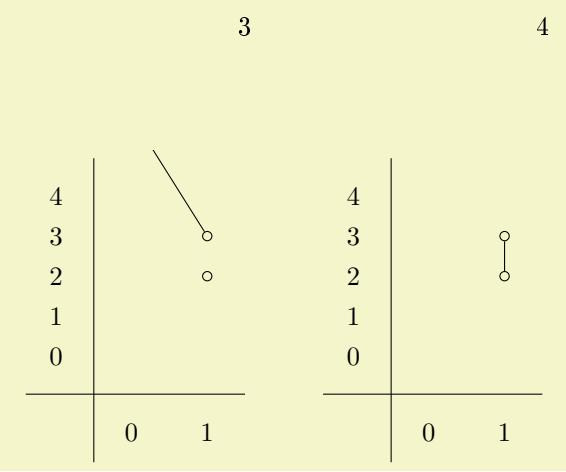
```
\begin{sseqpage}[no axes,yscale = 1.6]
\foreach \x in {0,1,2} \foreach \y in {0,1} {
    \class(\x,\y)
}
\structline[bend left = 20](0,0)(0,1)
\structline[bend right = 20](1,0)(1,1)
\structline[in = 20,out = north](2,0)(2,1)
\end{sseqpage}
```

invisible

This key is only for `\d`. It prevents a differential from being drawn at all. The typical reason you might want this is so that you can draw your own differential using Ti*k*Z commands. See `\getdtarget` for an example of this.

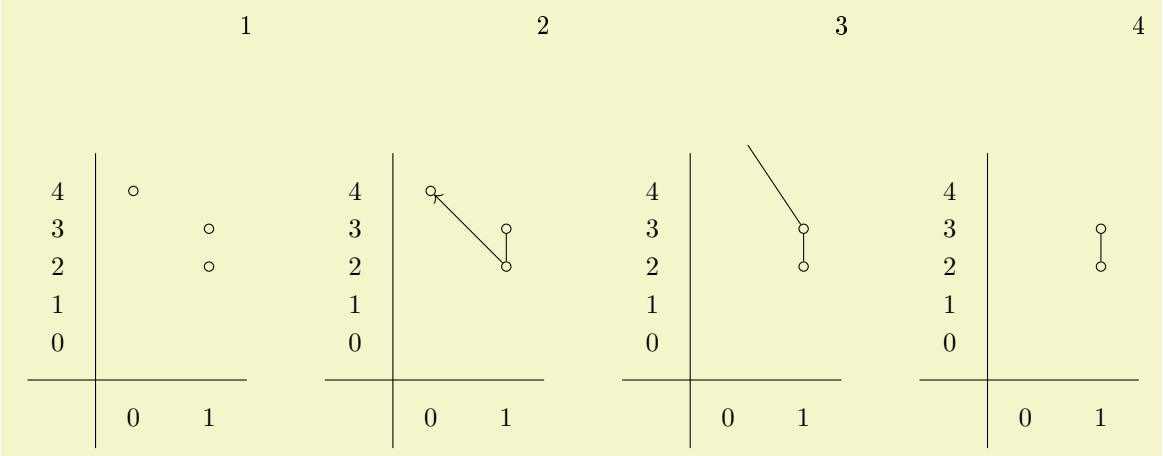
page = ⟨*page*⟩--⟨*page max*⟩

This key is only for \structline and \structlineoptions. By default, the \structline command only adds a structline starting on the page where the most recent generation of the source or target is born:




```
\begin{sseqdata}[ name = structpage example,
                  title = |page, yscale = 0.53 ]
\class(0,2)
\class(0,4)
\class(1,0)
\class(1,1)
\d2(1,0)(0,2)
\d3(1,1)(0,4)
\replaceclass(1,0)
\replaceclass(1,1)
\structline(1,0)(1,1)
\end{sseqdata}
\printpage[name = structpage example,page = 3]
\qquad
\printpage[name = structpage example,page = 4]
```

By specifying a page number, you can adjust which page the \structline starts on:



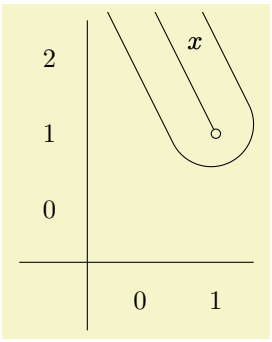

```
\begin{sseqdata}[ name = structpage example2, title = |page, yscale = 0.5 ]
\class(0,2)
\class(0,4)
\class(1,0)
\class(1,1)
\d2(1,0)(0,2)
\d3(1,1)(0,4)
\replaceclass(1,0)
\replaceclass(1,1)
\structline[page = 2](1,0)(1,1)
\end{sseqdata}
\printpage[name = structpage example2,page = 1]
\qquad
\printpage[name = structpage example2,page = 2]
\qquad
\printpage[name = structpage example2,page = 3]
\qquad
\printpage[name = structpage example2,page = 4]
```

Similarly, for \structlineoptions you can specify a minimum page on which to apply the options, or a range of pages.

4.4 Options for \circleclass

fit = ⟨*coordinates or nodes*⟩

The `\circleclasses` command uses the TikZ fitting library. Sometimes it's desirable to make the resulting node fit extra things, for example a label. It doesn't necessarily end up looking great though.




```
\begin{sseqpage}[Adams grading,axes gap = 0.7cm]
\class(0,2)
\class(1,0)
% Fit in the label x and also a symmetric invisible label to maintain symmetry
\d["x"{name = x},"x"'{name = x',opacity = 0}]2(1,0)
\circleclasses[fit = (x)(x'),rounded rectangle](1,0)(0,2)
\end{sseqpage}
```

`rounded rectangle`

You can put a shape as an option and it will change the shape of the node drawn by `\circleclasses`. Any shape will do, but I think that an `ellipse` or `rounded rectangle` are the only particularly appealing options.

`ellipse ratio` = ⟨*ratio*⟩ (initially `1.2`)

By default, the shape drawn by `\circleclasses` is a "newelipse" which is a custom defined shape that respects the option `elipse ratio` which roughly controls how long and skinny versus short and fat the ellipse is. If you find that the ellipse is too long, try a larger value of this option, and conversely if it's too fat try a smaller value. If no value is satisfactory, try out the `rounded rectangle` shape. (This is stolen from the following stack exchange answer: https://tex.stackexchange.com/a/24621.)

`class style`
`permanent cycle style`
`transient cycle style`
`this page class style`
`differential style`
`struct line style`

See the corresponding entry in the TikZ primitives section.

`page` = ⟨*page*⟩--⟨*page max*⟩

By default, the ellipse will be drawn on the same set of pages that a structline between the two classes would be drawn on. This specifies a range of pages for the ellipse to be drawn. Note that unlike with structlines, you can instruct `\circleclasses` to draw the shape even on pages where one or both of the classes that it is fitting are dead.

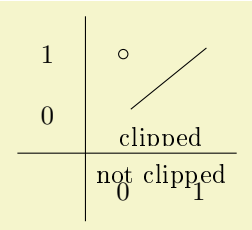
4.5 Options for TikZ primitives

`background`

This key instructs SPECTRALSEQUENCES to put the current TikZ primitive in the background. The way that the spectral sequence is printed is as follows:

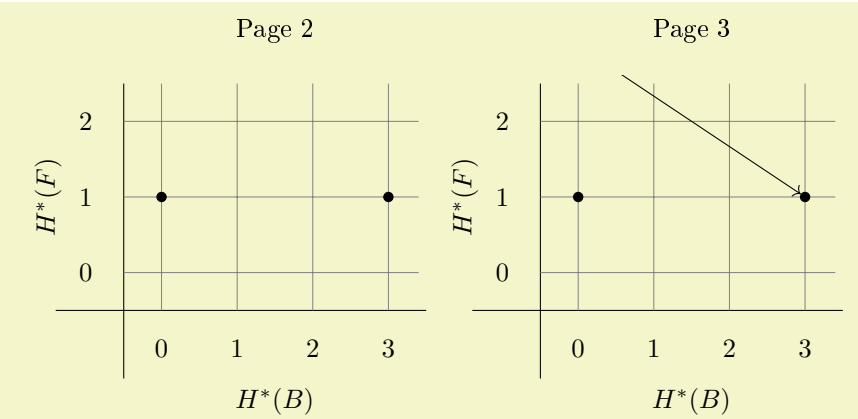
- The title, axes, axes ticks, and axes labels are printed (the appropriate steps are skipped when the `no title`, `no axes`, `no ticks`, or `no labels` keys are used or if no title or axes labels are provided).
- The TikZ background paths are printed.
- The clipping is inserted (unless the `no clip` key is used).
- All foreground elements (classes, differentials, structlines, and normal TikZ paths) are printed.

In particular, this means that foreground TikZ paths can be clipped by the standard clipping, but background paths that are outside of the clipping expand the size of the TikZ picture.



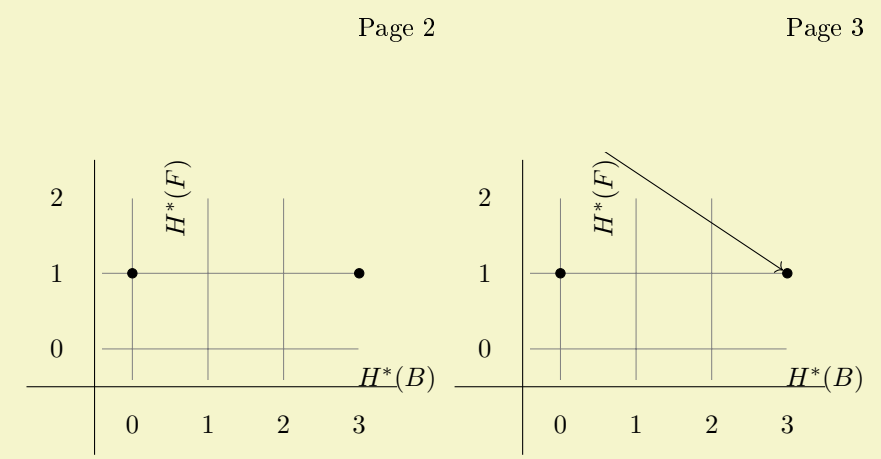

```
\begin{sseqpage}[no ticks,yscale = 0.9,math nodes = false]
\class(0,0)
\class(1,1)
\begin{scope}[background]
\draw(0.1,0.1)--(1.1,1.1);
\end{scope}
\node[background] at (0.5,-1) {not clipped};
\node at (0.5,-0.4) {clipped};
\end{sseqpage}
```

Here is an example where TikZ labels with the `background` key are used to add labels and a grid. Note that this styling is easier to make using the `title`, `x label`, `y label`, and `grid` options.




```
\begin{sseqdata}[ name = tikz background example, cohomological Serre grading, classes = fill ]
\begin{scope}[background]
\node at (\xmax/2,\ymax+1.2) {\textup{Page \page}};
\node at (\xmax/2,-1.7) {H^*(B)};
\node[rotate = 90] at (-1.5,\ymax/2) {H^*(F)};
\draw[step = 1cm, gray, very thin] (\xmin-0.5,\ymin-0.5) grid (\xmax+0.4,\ymax+0.5);
\end{scope}
\class(0,0)
\class(3,0)
\class(0,2)
\class(3,2)
\d3(0,2)
\end{sseqdata}
\printpage[name = tikz background example, page = 2]
\printpage[name = tikz background example, page = 3]
```

For this particular use case, it's probably better to use `title`, `x label`, and `y label`:



```
\begin{sseqdata}[ name = tikz background example2, cohomological Serre grading, classes = fill,
                  grid = go, title = { Page \page }, x label = { $H^*(B)$ }, y label = { $H^*(F)$ },
                  x label style = { yshift = 10pt}, y label style = { xshift = 10pt } ]
\class(0,0)
\class(3,0)
\class(0,2)
\class(3,2)
\d3(0,2)
\end{sseqdata}
\printpage[name = tikz background example2, page = 2]
\printpage[name = tikz background example2, page = 3]
```

But if you need more flexible labeling, you'll likely want to use tikz primitives with `background`. See `example_KF3.tex` for an instance where this key is useful.

`page constraint` = ⟨*predicate*⟩
`page constraint or` = ⟨*predicate*⟩

This places a constraint on the pages in which the Ti*k*Z primitive is printed. This predicate should look something like `(\page< = 4) && (\page> = 3)`. The predicate is anded together with any previous predicates, so that you can use this as an option for a `{scope}` and again for the individual Ti*k*Z primitive.

`\isalive`(⟨*coordinate*⟩)
`\isalive`{(⟨*coordinate 1*⟩)⋯(⟨*coordinate n*⟩)}

This command can only be used with `page constraint`. Saying

`page constraint = {(`⟨*x*⟩, ⟨*y*⟩, ⟨*index*⟩`)}`

will print the Ti*k*Z primitive only on pages where the specified class is alive. Saying

`page constraint = {\isalive(`⟨*coordinate 1*⟩`)` ⋯ `(`⟨*coordinate n*⟩`)}`

is equivalent to

`page constraint = {\isalive(`⟨*coordinate 1*⟩`)` `&&` ⋯ `&& \isalive(`⟨*coordinate n*⟩`)}`

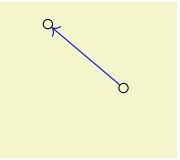
Writing

`\draw[page constraint = {\isalive(1,0)(2,2)}](1,0)--(2,2);`

is the same as `\structline(1,0)(2,2)`, except that you can't later use `\structlineoptions` on it (and it won't have the `struct lines` style applied).

`class style`
`permanent cycle style`
`transient cycle style`
`this page class style`
`differential style`
`struct line style`

These classes apply the styling of the corresponding element to your Ti*k*Z commands.



```
\begin{sseqpage}[ differentials = blue, yscale = 0.65, no axes ]
\class(0,2)
\class(1,0)
% This will be styled as if it were a differential
\draw[differential style] (1,0) -- (0,2);
\end{sseqpage}
```

See `\getdtarget` for a more natural example.

5 Miscellaneous commands

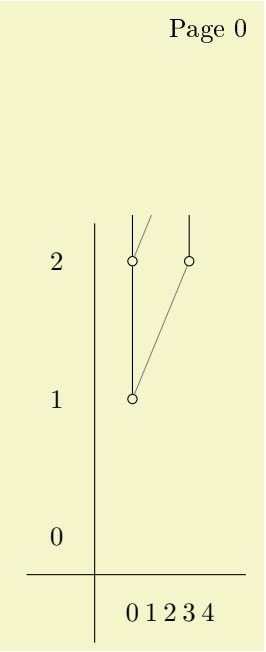
`\sseqset`{⟨*keys*⟩}

The `\sseqset` command is for adjusting the global options for all spectral sequences in the current scope, or for applying options to the rest of the current spectral sequence. For instance, if most of the spectral sequences in the current document are going to be Adams graded, you can say `\sseqset{Adams grading}` and all future spectral sequences in the current scope will have Adams grading (unless you specify a different grading explicitly). As another example, `\sseqset{no axes}` will suppress axes from spectral sequences in the current scope. Note that defaults only apply to new `{sseqdata}` environments or to unnamed `{sseqpage}` environments; they won't apply to existing spectral sequences.

You can also use `\sseqset` to create styles to be used in spectral sequences.

`.global sseq style` = ⟨*keys*⟩
`.global sseq append style` = ⟨*keys*⟩
`.sseq style` = ⟨*keys*⟩
`.sseq append style` = ⟨*keys*⟩

These handlers create reusable styles to be used in spectral sequences. If this style is a set of global options, then use the `.global sseq style` handler, whereas if it is supposed to be applied to individual features (classes, differentials, struct lines, circle classes, and tikz primitives) then use the `.sseq style` handler.

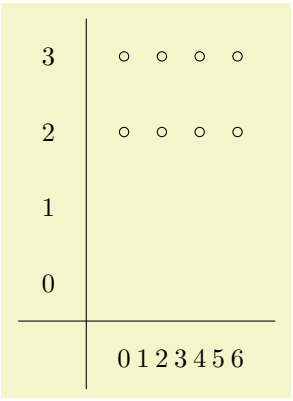



```
\sseqset{
    mysseq/.style = {
        Adams grading, title = Page \page,
        x range = {0}{4}, y range = {0}{2},
        xscale = 0.5, yscale = 1.35
    },
    htwostruct/.sseq style = { gray, thin }
}
\begin{sseqpage}[ mysseq ]
\class(0,0) \class(0,1) \class(0,2) \class(0,3)
\class(3,1) \class(3,2) \class(3,3)
\structline(0,0)(0,1) \structline(0,1)(0,2) \structline(0,2)(0,3)
\structline(3,1)(3,2) \structline(3,2)(3,3)
\structline[htwostruct](0,0)(3,1)
\structline[htwostruct](0,1)(3,2)
\structline[htwostruct](0,2)(3,3)
\end{sseqpage}
```

`\foreach`

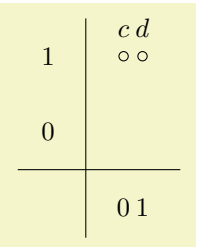
This command is from Ti*k*Z and works in pretty much the same way in SPECTRALSEQUENCES, though with slightly better variants. The `\foreach` command is very flexible and has a lot of variants. The basic usage is `\foreach \x in {`⟨*xmin*⟩`,...,`⟨*xmax*⟩`} {`⟨*loop body*⟩`}` which will execute ⟨*loop body*⟩ with `\x` set to each value between ⟨*xmin*⟩ and ⟨*xmax*⟩ inclusive. If you want a step greater than 1, try `\foreach \x in {`⟨*xmin*⟩`,`⟨*xmin*⟩`+`⟨*xstep*⟩`,...,`⟨*xmax*⟩`} {`⟨*loop body*⟩`}`.

If you need to do multiple loops with a common body, you can just stack the `\foreach` commands:




```
\begin{sseqpage}[xscale=0.5]
\foreach \x in {0,2,...,6}
\foreach \y in {0,...,3}{
    \class(\x,\y)
}
\end{sseqpage}
```

You can also loop through tuples, for instance:



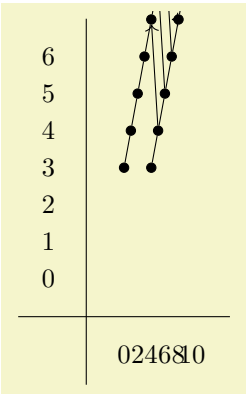

```
\begin{sseqpage}[xscale=0.5]
\foreach \x/\y/\label in {0/1/a,1/1/b,0/0/c,1/0/d}{
    \class["\label" above](\x,\y)
}
\end{sseqpage}
```

See the last example for `normalize monomial` for a better example of this usage.

There are tons of other things you can do with `\foreach`, though I haven't yet found need for them in combination with SPECTRALSEQUENCES. See the TikZ manual for more details.

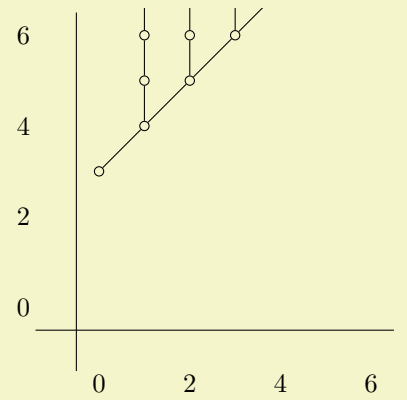
`\Do{`⟨*iterations*⟩`}`⟨*loop body*⟩
`\DoUntilOutOfBounds`⟨*loop body*⟩
`\DoUntilOutOfBoundsThenNMore{`⟨*extra iterations*⟩`}`⟨*loop body*⟩
`\iteration`

The one use case that `\foreach` doesn't cover all that well is if you want the loop to always repeat until the features you are drawing go off the page. This is what `\DoUntilOutOfBounds` and `\DoUntilOutOfBoundsThenNMore` are for. These help ensure that if you change the range of your diagram, infinite families will automatically be drawn correctly without the need to adjust a bunch of loop bounds. The purpose of `\DoUntilOutOfBoundsThenNMore` is for towers that are receiving a differential. If your spectral sequence is Adams graded, and a tower is receiving a d_r differential from another tower, you should use `\DoUntilOutOfBoundsThenNMore{r}`:




```
\begin{sseqpage}[
    Adams grading, classes = fill,
    x range = {0}{10}, y range = {0}{6},
    x tick step = 2,
    xscale = 0.3,yscale = 0.7,
    run off differentials = {->}
]
\class(0,0)
\DoUntilOutOfBoundsThenNMore{3}{
    \class(\lastx+1,\lasty+1)
    \structline
}
\class(4,0)
\DoUntilOutOfBounds{
    \class(\lastx+1,\lasty+1)
    \structline
    \d3(\lastclass)
}
\end{sseqpage}
```

You can also nest `\DoUntilOutOfBounds` reasonably:




```
\begin{sseqpage}[
    x range = {0}{6}, y range = {0}{6},
    tick step = 2,
    scale = 0.6
]
\class(0,0)
\DoUntilOutOfBounds{
    \class(\lastx+1,\lasty+1)
    \structline
    \DoUntilOutOfBounds{
        \class(\lastx,\lasty+1)
        \structline
    }
}
\end{sseqpage}
```

One important difference between `\foreach` and the `\Do` family of commands is that `\Do` has no effect on the stack. This is in order to ensure that they nest properly.

Note that if you are using these commands and you are planning to draw several pictures of the diagram with restricted range, you need to specify a range for the `{sseqdata}` that contains all of the ranges of pages that you want to draw. If you then want to set a smaller default range, use `{sseqpage}`with `keep changes`.

The `\Do` command is less general than `\foreach`; the purpose is to provide a syntax for stack-based looping that is similar to `\DoUntilOutOfBounds` but with a fixed range. So `\Do{n}{`⟨*loop body*⟩`}` repeats ⟨*loop body*⟩ `n` times. The assumption is that the loop body draws something relative to the position of the `\lastclass`.

If you need to know how many iterations one of these three commands has gone through, this is stored in the variable `\iteration`.

`\sseqerrortowarning`⟨*error-name*⟩

Turns the error with the given name into a warning. An error message will start by saying `"error-name"`. This is the name you need to put into this command.

`\sseqnormalizemonomial`

This command simplifies a monomial by combining like variables and removing bases that are raised to the 0th power, removing exponents of 1, removing 1's, and replacing the empty monomial with 1. It outputs its result into `\processedlabel`. This command is specifically meant to be used as a value for `class label handler`, so see the example there for the actual purpose. The exponents must be integers or else it will misbehave.

$1, \quad x^2y, \quad x_2^4$

```
\sseqnormalizemonomial{x^0y^0} $\processedlabel$, \quad
\sseqnormalizemonomial{x^3yx^{-1}z^0} $\processedlabel$, \quad
\sseqnormalizemonomial{1x_2^2x^2_2} $\processedlabel$
```

`\NewSseqCommand\`⟨*command*⟩`{`⟨*argspec*⟩`}{`⟨*body*⟩`}`
`\DeclareSseqCommand\`⟨*command*⟩`{`⟨*argspec*⟩`}{`⟨*body*⟩`}`

The xparse package provides these very powerful commands for defining macros. They are used internally to the SPECTRALSEQUENCES package to define `\class`, `\d`, etc. To help you create variants of these commands, I will record here the argument specifications for each of them. See the xparse manual for a better explanation and more information.

To make a command like `\class`, you can use the argument specification `O{}r()`. The argument type `O{`⟨*default*⟩`}` stands for a bracket delimited optional argument with default value ⟨*default*⟩. In this case, we've specified the default to be empty. `r()` stands for a "required" argument delimited by `(` and `)`. In the command definition, access the optional argument with `#1` and the coordinate with `#2`.

#1 = {key = value}; #2 = {x,y}

#1 = {}; #2 = {1,2,3}

```
\DeclareDocumentCommand\demo{ O{} r() }
    {  \#1 = \textcolor{purple}{\{#1\}};
       \#2 = \textcolor{purple}{\{#2\}} }
\hbox{\demo[key = value](x,y)}
\bigskip
\hbox{\demo(1,2,3)}
```

If you want to separate out the coordinates into different arguments, you can use `O{}u(u,u)`. The argument type `u` stands for "until" and scans up until the next instance of the given character. So in this case, `#1` is of argument type `O` which is an option list, `#2` corresponds to the `u(` which is a throw-away argument, then `#3` corresponds to `u,` and contains the `x` coordinate, and `#4` corresponds to `u)` and contains the `y` coordinate. Note however that this will not match balanced parenthetical expressions.

#1 = {hi}; #3 = {x}; #4 = {y}

#1 = {}; #3 = {1}; #4 = {2}

#1 = {}; #3 = {(1+1)*2}; #4 = {2}

#1 = {}; #3 = {1}; #4 = {(1+1} *2)

```
\DeclareDocumentCommand\demo{ O{} u( u, u)}
    {  \#1 = \textcolor{purple}{\{#1\}};
       \#3 = \textcolor{purple}{\{#3\}};
       \#4 = \textcolor{purple}{\{#4\}}  }
\hbox{\demo[hi](x,y)}
\bigskip
\hbox{\demo(1,2)}
\bigskip
\hbox{\demo((1+1)*2,2)}
\bigskip
\hbox{\demo(1,(1+1)*2)} % uh-oh -- *2) is left off!
```

You can specify an optional argument delimited by parentheses using `d()`. Use the commands `\IfNoValueTF`, `\IfNoValueT`, and `\IfNoValueF` to test whether the user provided a value.

#1 = {hi}; #2 = {x,y}

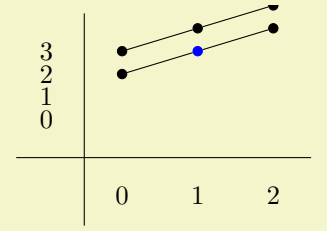
#1 = {options}; #2 = {no value}

#1 = {}; #2 = {1,2}

#1 = {}; #2 = {no value}

```
\DeclareDocumentCommand\demo{ O{} d() } {
       \#1 = \textcolor{purple}{\{#1\}};
       \#2 = \textcolor{purple}{
              \{\IfNoValueTF{#2}{no value}{#2}\} }
}
\hbox{\demo[hi](x,y)}
\bigskip
\hbox{\demo[options]}
\bigskip
\hbox{\demo(1,2)}
\bigskip
\hbox{\demo}
```

An example where this is actually useful:




```
\DeclareSseqCommand\etaclass{ O{} d() }{
    \IfNoValueF{#2}{ \pushstack(#2) }
    \class[#1] (\lastx+1, \lasty+1)
    \structline (\lastclass) (\lastclass1)
}
\begin{sseqpage}[ classes = fill, yscale = 0.55 ]
\class(0,0)
\class(0,1)
\etaclass\etaclass
\etaclass[blue](0,0)\etaclass
\end{sseqpage}
```

The `\d` command has argument specification `O{} U( r()`. The argument type `U` is special to SPECTRALSEQUENCES, and is a variant of until that reinserts the delimiting token. This allows the `(` token to also delimit the beginning of the `r()` argument. Note that the argument type `U` is specially added by SPECTRALSEQUENCES and might be removed in the future if the LaTeX3 team yells at me or something.

#1 = {opts}; #2 = {page}; #3 = {x,y}

#1 = {}; #2 = {5}; #3 = {x,y}

```
\DeclareDocumentCommand \demo{  O{} U( r() }
    {  \#1 = \textcolor{purple}{\{#1\}};
       \#2 = \textcolor{purple}{\{#2\}};
       \#3 = \textcolor{purple}{\{#3\}}  }
\hbox{\demo[opts]page(x,y)}
\bigskip
\hbox{\demo5(x,y)}
```

The `\structline` and `\changeclasses` commands have argument specification `O{}r()r()`.

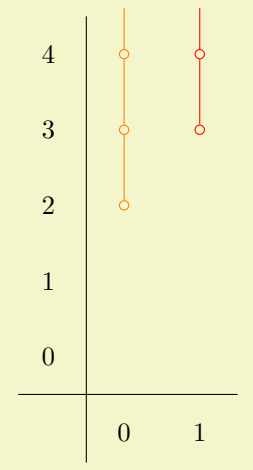
#1 = {hi}; #2 = {x,y}; #3 = {x',y'}

#1 = {}; #2 = {x,y,2}; #3 = {x',y',-1}

```
\DeclareDocumentCommand\demo{ O{} r() r() }
    {  \#1 = \textcolor{purple}{\{#1\}};
       \#2 = \textcolor{purple}{\{#2\}};
       \#3 = \textcolor{purple}{\{#3\}}  }
\hbox{\demo[hi](x,y)(x',y')}
\bigskip
\hbox{\demo(x,y,2)(x',y',-1)}
```

\NewSseqGroup\⟨*command*⟩{⟨*argspec*⟩}{⟨*body*⟩}
\DeclareSseqGroup\⟨*command*⟩{⟨*argspec*⟩}{⟨*body*⟩}

So that calling `\mygroup(x,y)` prints the whole group shifted to start at (x, y) instead of (0, 0). For instance:



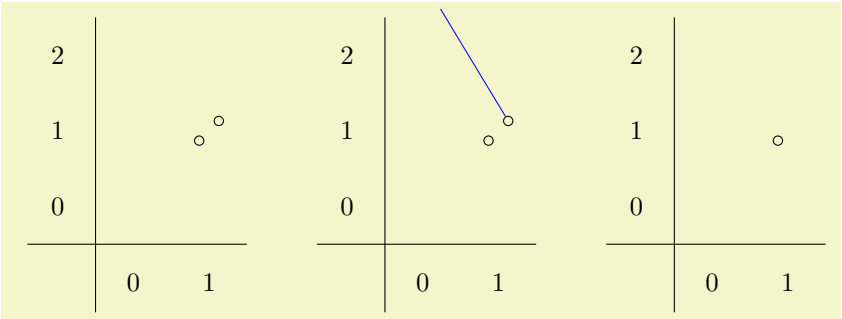

```
\DeclareSseqGroup\tower {m} {
    \class(0,0)
    \foreach \n in {1,...,#1} {
        \class(0,\n)
        \structline(0,\n-1)(0,\n)
    }
}
\begin{sseqpage}
\tower[orange](0,0){4}
\tower[red](1,1){2}
\end{sseqpage}
```

\sseqparseint\⟨*macro*⟩{⟨*integer expression*⟩}

Stores the result of evaluating an integer expression into \⟨*macro*⟩. An integer expression consists of `+`, `-`, `*`, `/`, parentheses, and macros that expand to more of the same. The exact rules regarding what is a valid expression are pretty much what you would expect.

\getdtarget{⟨*macro*⟩}{⟨*page*⟩}(⟨*source coordinate*⟩)

Sets ⟨*macro*⟩ equal to the coordinates of the target position of a length ⟨*page*⟩ differential starting at ⟨*source coordinate*⟩. This helps to make commands that draw fancy differentials. For instance, consider the following example, suggested by Catherine Ray:



```
% O{}u(u) is the arg-spec for \d, O{}u(u)mm looks like \d with two extra mandatory arguments
\NewSseqCommand\twods{ O{} U( r() m m }{
    \getdtarget\target#2{#3}            % Store the target position in \target
    \nameclass{source}(#3)              % naming the classes gives us a speed boost
    \nameclass{target1}(\target,#4)     % by preventing sseqpages from reparsing the coordinate
    \nameclass{target2}(\target,#5)     % it also makes the code easier to read
%
    \circleclasses[ differential style, #1,
          name path = circ, page = #2-#2 ]
               (target1)(target2)           % Circle the classes, use differential style
%
    \d[invisible]#2(source)(target1)    % don't draw anything, but record source and targets as hit.
    \d[invisible]#2(source)(target2)
%
    \path(target1)--(target2)
               coordinate[midway](midpt);% put a coordinate in the center of the two classes
    \path[name path = lin] (source) -- (midpt);% save path from start to midpoint
%
    % draw line in "differential style" from start to intersection point of circ and lin
    \draw[ differential style, #1, page constraint= { \page == #2 },
          name intersections = { of = circ and lin } ]
               (source) -- (intersection-1);
}
\begin{sseqdata}[ name = cathex, Adams grading, differentials = { blue } ]
\class(0,2)
\class(0,2)
\class(1,0)\class(1,0)

\twods2(1,0,-1){1}{2}
\end{sseqdata}
\printpage[ name = cathex, page = 1 ]
\qquad
\printpage[ name = cathex, page = 2 ]
\qquad
\printpage[ name = cathex, page = 3 ]
```

\nameclass{⟨*name*⟩}(⟨*coordinate*⟩)

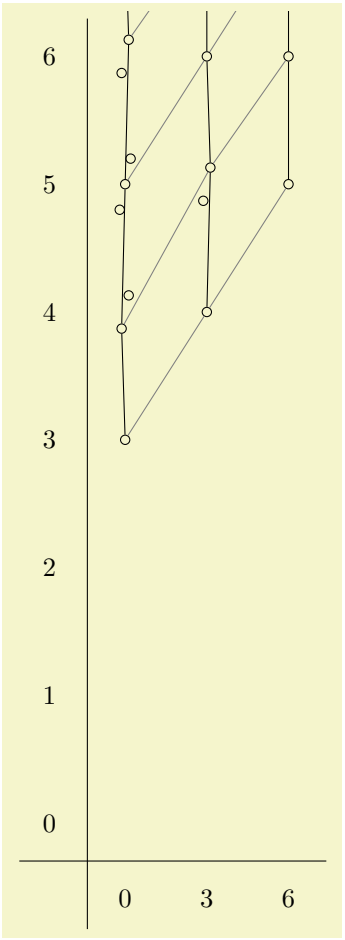
The \nameclass command gives a name to a class. It's similar to saying \doptions[name = ⟨*name*⟩], but faster. It's also similar to saying \pushstack(⟨*coordinate*⟩). Giving temporary names to coordinates that you are going to use repeatedly makes the code easier to read and is faster (though this only matters in very large diagrams). See \getdtarget for an example.

\tagclass{⟨*tag*⟩}(⟨*coordinate*⟩)

The \tagclass command gives a tag to a class. It's similar to saying \doptions[tag = ⟨*name*⟩], but faster. See example_tmfmayss.tex for a use case for this.

\gettag\⟨*somecontrolsequence*⟩(⟨*coordinate*⟩)

The \gettag command finds the most recent tag applied to the coordinate and stores it into the command. This is useful for connecting groups of nodes. For example, consider the following code, inspired by example_tmfmayss.tex.




```
\DeclareSseqCommand \tower { O{} } {
    \begin{scope}[#1]
    \foreach\i in {1,...,7}{
        \class(\lastx,\lasty+1)
        \structline(\lastclass1)(\lastclass)
    }
    \end{scope}
    \restorestack
}
\DeclareSseqCommand \htwotower { O{} d() } {
    \IfNoValueF{#2}{
        \pushstack(#2)
    }
    \begin{scope}[#1]
    \gettag\thetag(\lastclass)
    \class(\lastx+3,\lasty+1)
    \structline[gray](\lastclass)(\lastclass1)
    \savestack
    \foreach\i in {1,...,7}{
        \class(\lastx,\lasty+1)
        \structline(\lastclass1)(\lastclass)
        \structline[gray](\lastx-3,\lasty-1,\thetag)(\lastclass)
    }
    \restorestack
    \end{scope}
}
\begin{sseqpage}[ y range = {0}{6}, x tick step = 3,
    xscale=0.6, yscale=1.3 ]
\class(0,2) \class(0,3) \class(3,2)
\class[tag=h_0^i](0,0)
\tower[tag=h_0^i]
\class(0,2) \class(0,1)

\htwotower[tag=h_2 h_0^i](0,0)
\htwotower[tag=h_2 h_0^i]
\end{sseqpage}
```

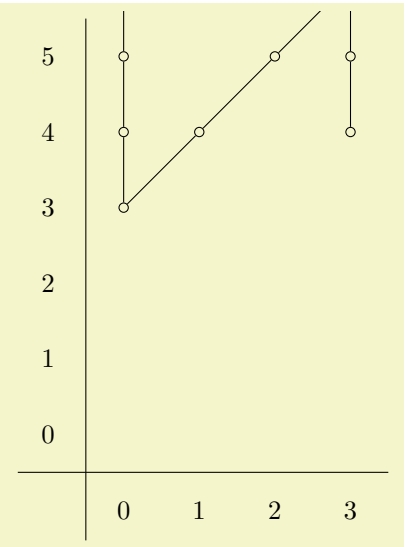
5.1 The Class Stack

The class stack is a linked list of the classes in the order that they are produced that SPECTRALSEQUENCES maintains. I've only recently implemented this feature, so it is more liable to change in the future than other things. Whenever you use the `\class` function, the class you added is pushed onto the stack. Here's an example that demonstrates basic usage:

The following commands are used to access the stack:

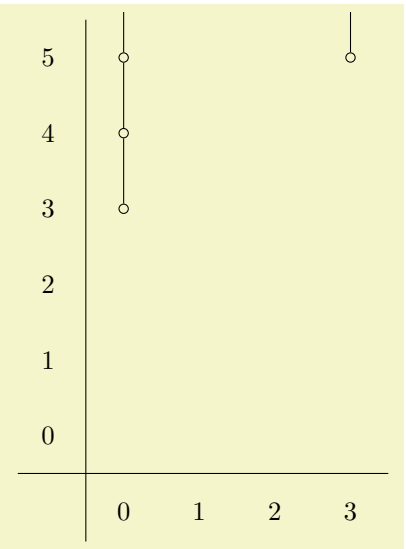
`\lastx`⟨n⟩
`\lasty`⟨n⟩
`\lastclass`⟨n⟩

The commands `\lastx` and `\lasty` evaluate to the `x` and `y` position, respectively, of the nth class on the stack. If $n = 0$ you can leave it off. The command `\lastclass` evaluates to the coordinate of the most recent class on the stack. This is useful for writing turtle-style code:




```
\DeclareSseqCommand \etaclass {}{
    \class(\lastx+1,\lasty+1)
    \structline(\lastclass1)(\lastclass)
}
\DeclareSseqCommand \divtwoclass {}{
    \class(\lastx,\lasty-1)
    \structline(\lastclass1)(\lastclass)
}
\begin{sseqpage}
\class(0,0)
\savestack
\foreach \y in { 1,...,5 }{
    \class(0,\y)
    \structline(\lastclass1)(\lastclass)
}
\restorestack
\etaclass\etaclass\etaclass
\divtwoclass\divtwoclass
\end{sseqpage}
```

You can use `\lastx` and `\lasty` in other contexts than in the body of a SPECTRALSEQUENCES command, most notably inside `\sseqparseint` (they also go fine inside `\pgfmathparse` if you need it or one of its siblings). For instance, consider the following tower command:




```
\DeclareSseqCommand \tower { } {
    \savestack
    \sseqparseint\numclasses{\ymax-\lasty0}
    \foreach \n in {1,...,\numclasses}{
        \class(\lastx,\lasty+1)
        \structline(\lastclass1)(\lastclass)
    }
    \restorestack
}
\begin{sseqpage}[y range = {0}{5}]
\class(0,0)\tower
\class(1,3)\tower
\class(3,2)\tower
\end{sseqpage}
```

`\pushstack`(⟨*coordinate*⟩)

This adds a class to the top of the stack. The coordinate is specified using the same syntax as a coordinate for `\structline` or `\replaceclass`.

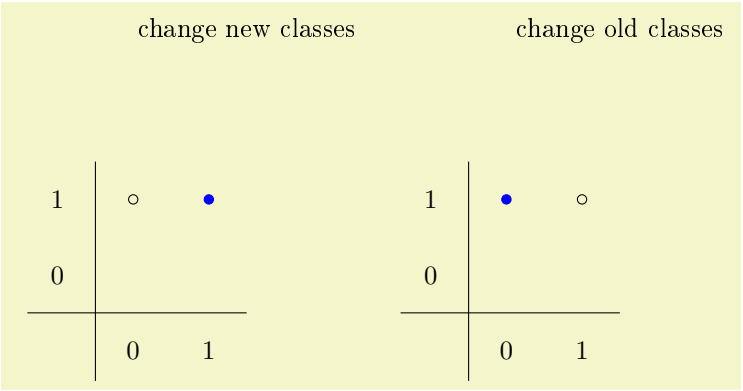
`\savestack`
`\restorestack`

This saves and reverts the stack. Saves nest. Most frequently, you will want to use these at the start and end of a command.

6 Styles

The SPECTRALSEQUENCES package has a large number of styles which control the appearance of specific components (e.g., classes, differentials, or structlines) of a spectral sequence. Each style has two corresponding keys: `classes` and `change classes`. Saying `classes = {`⟨*keys*⟩`}` adds the keys to the list of options used

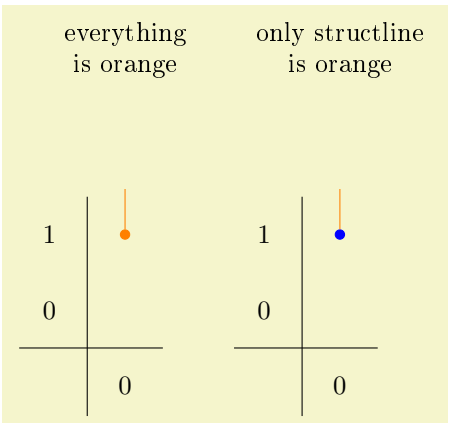
to style every future class, whereas `change classes = {`⟨*keys*⟩`}` only makes sense in a `{sseqpage}` environment, and temporarily overwrites the list of options. Note that `change classes` only applies to classes that existed before the current page, and that even with the `keep changes` option, the `change classes` options are local to the current page. Compare:




```
\begin{sseqdata}[ name = stylesex ]
\class(0,0)\class(1,1)
\end{sseqdata}
\begin{sseqpage}[ name = stylesex,
                  classes = { fill, blue },
                  title = change new classes ]
\class(0,1)\class(1,0)
\end{sseqpage}
\quad
\begin{sseqpage}[ name = stylesex,
                  change classes = { fill, blue },
                  title = change old classes ]
\class(0,1)\class(1,0)
\end{sseqpage}
```

You can modify these styles outside of a spectral sequence or inside it using `\sseqset`, you can modify them as options to the `{sseqdata}` and `{sseqpage}` environments, or you can modify them as arguments to the `{scope}` environment.

In cases where the same drawing feature is affected by multiple of these styles, the more specific style takes precedence. For instance, for a class that is the source or target of a differential on the current page, the precedence order from lowest to highest goes: `sseq style`, `class style`, `transient cycle style`, `this page cycle style`, and then any options from scopes in the order they appear, and any local options (the options that come right with the class, e.g., `\class[local options](x,y)`). If you don't want the options to your scopes to override more specific styles, use `sseq`:



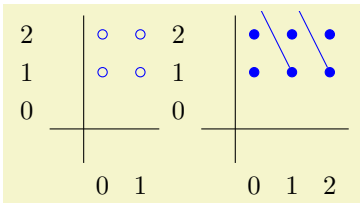

```
\begin{sseqpage}[ classes = { blue, fill },
   title style = { align = center, text width = 2.4cm },
   title = { everything is orange } ]
\begin{scope}[orange]
\class(0,0) \class(0,1)
\structline(0,0)(0,1)
\end{scope}
\end{sseqpage}

\begin{sseqpage}[ classes = { blue, fill },
   title style = { align = center, text width = 2.4cm },
   title = { only structline is orange } ]
\begin{scope}[ sseq = orange ]
\class(0,0) \class(0,1)
\structline(0,0)(0,1)
\end{scope}
\end{sseqpage}
```

Throughout, "class" and "cycle" are synonyms.

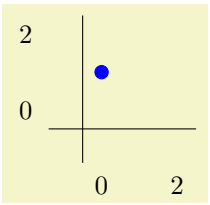
`sseqs` = {⟨*keys*⟩}
`change sseqs` = {⟨*keys*⟩}
`sseq` = {⟨*keys*⟩}
`change sseq` = {⟨*keys*⟩}

This passes options to all features in all future spectral sequences in the current scope. Note that for many global options you can set a default directly by saying `\sseqset{key = {`⟨*value*⟩`}}` and this is in some cases preferable.




```
% Applies to both of the following sseqs:
\sseqset{ sseqs = { blue, scale = 0.5 } }%
\begin{sseqpage}
\foreach \x in {0,1}
\foreach \y in {0,1,2} {
    \class(\x,\y)
}
\end{sseqpage}
\begin{sseqpage}[ Adams grading, classes = fill ]
\foreach \x in {0,1,2}
\foreach \y in {0,1,2} {
    \class(\x,\y)
}
\d2(1,0)
\d2(2,0)
\end{sseqpage}
```

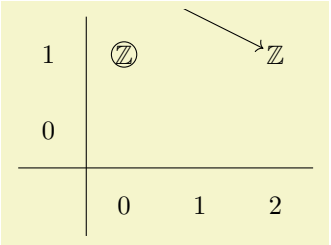
`classes` = {⟨*keys*⟩}
`cycles` = {⟨*keys*⟩}
`change classes` = {⟨*keys*⟩}
`change cycles` = {⟨*keys*⟩}




```
\begin{sseqpage}[ classes = { blue, fill, minimum width = 0.5em },
                  scale = 0.5, x tick step = 2, y tick step = 2 ]
\class(0,0)
\class(2,2)
\end{sseqpage}
```

`permanent classes` = {⟨*keys*⟩}
`permanent cycles` = {⟨*keys*⟩}
`change permanent classes` = {⟨*keys*⟩}
`change permanent cycles` = {⟨*keys*⟩}

These options change the appearance of all permanent cycles (e.g., those classes which never support or are hit by a differential). For instance, we can circle the permanent cycles automatically. In the following example, note that because `permanent cycles` is more specific than `classes`, the `permanent cycles = {draw}` command takes precedence over the `classes = {draw = none}` command and the permanent cycle nodes are drawn.

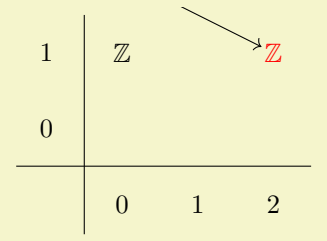



```
\begin{sseqpage}[ cohomological Serre grading,
                  classes = { draw = none },
                  permanent cycles = {draw} ]
\foreach \x in {0,2} \foreach \y in {0,1} {
    \class["\mathbb{Z}"](\x,\y)
}
\d2(0,1)
\end{sseqpage}
```

`transient classes` = {⟨*keys*⟩}
`transient cycles` = {⟨*keys*⟩}

change transient classes = {⟨keys⟩}
change transient cycles = {⟨keys⟩}

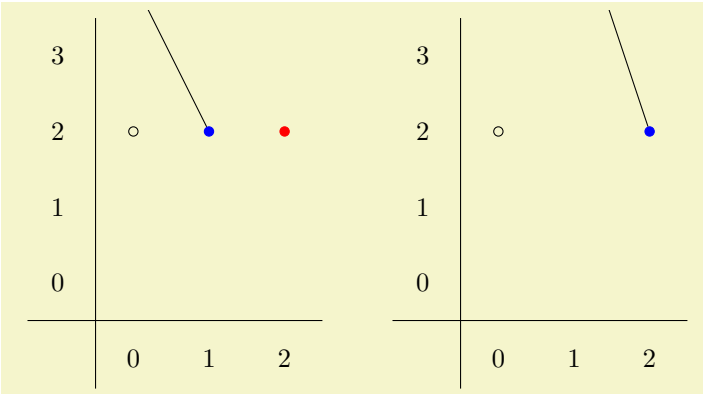
These options change the appearance of all transient cycles (e.g., those classes which eventually support or are hit by a differential). Again, this takes precedence over the `classes` option.




```
\begin{sseqpage}[ cohomological Serre grading,
                  classes = { draw = none },
                  transient cycles = red ]
\foreach \x in {0,2} \foreach \y in {0,1} {
    \class["\mathbb{Z}"](\x,\y)
}
\d2(0,1)
\end{sseqpage}
```

this page classes = {⟨keys⟩}
this page cycles = {⟨keys⟩}
change this page classes = {⟨keys⟩}
change this page cycles = {⟨keys⟩}

These options change the appearance of all cycles which support or are hit by a differential on this page. Any class that is hit on the current page is also a transient cycle, and so `this page classes` takes precedence over `transient cycles`




```
\begin{sseqdata}[ name = this page cycles example, Adams grading,
                  transient cycles = { red, fill }, this page cycles = { blue } ]
\class(0,0)
\class(0,2) \class(1,0)
\class(1,3) \class(2,0)
\d2(1,0) \d3(2,0)
\end{sseqdata}
\printpage[ name = this page cycles example, page = 2 ] \qquad
\printpage[ name = this page cycles example, page = 3 ]
```

edges = {⟨keys⟩}
differentials = {⟨keys⟩}
struct lines = {⟨keys⟩}
change edges = {⟨keys⟩}
change differentials = {⟨keys⟩}
change struct lines = {⟨keys⟩}

The `edges` key applies to both differentials and structure lines. The `differentials` and `struct lines` keys both take precedence over `edges`.

this page struct lines = {⟨keys⟩}
change this page struct lines = {⟨keys⟩}

This style applies to structure lines whose source or target is hit on the current page. It takes precedence over `struct lines`.

`tikz primitives` = {⟨*keys*⟩}
`change tikz primitives` = {⟨*keys*⟩}

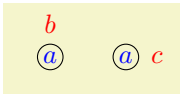
Applies to all TikZ primitives.

`labels` = {⟨*keys*⟩}
`change labels` = {⟨*keys*⟩}

This style applies to labels on classes, differentials, and structlines. All the more specific label styles take precedence over it.

`class labels` = {⟨*keys*⟩}
`inner class labels` = {⟨*keys*⟩}
`outer class labels` = {⟨*keys*⟩}
`change class labels` = {⟨*keys*⟩}
`change inner class labels` = {⟨*keys*⟩}
`change outer class labels` = {⟨*keys*⟩}

Inner class labels specifically applies to class labels that are inside the node, outer class labels specifically applies to ones outside it:




```
\begin{sseqpage}[ no axes, classes = { inner sep = 1pt },
    label distance=2pt,
    outer class labels = { red },
    inner class labels = { blue } ]
\class["a", "b" above](0,0)
\class["a", "c" right](1,0)
\end{sseqpage}
```

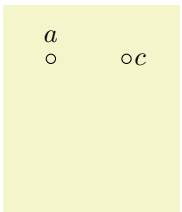
`edge labels` = {⟨*keys*⟩}
`differential labels` = {⟨*keys*⟩}
`struct line labels` = {⟨*keys*⟩}
`change edge labels` = {⟨*keys*⟩}
`change differential labels` = {⟨*keys*⟩}
`change struct line labels` = {⟨*keys*⟩}

6.1 Style-like options

The options are not styles, but can be modified in the same set of places (namely, anywhere):

`label distance` = ⟨*dimension*⟩

This sets the default distance from a class to an outer label. There are also variants like `above label distance` corresponding to `above`, `below`, `left`, `right`, `above left`, `above right`, `below left`, and `below right`.



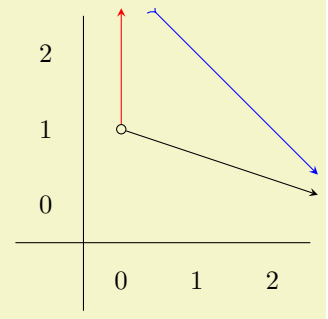

```
\begin{sseqpage}[ label distance = 0.3em,
                  right label distance = 0em,
                  no axes,yscale = 1.25 ]
\class["a" above](0,0)
\class["b" above right](0,1)
\class["c" right](1,0)
\class["c" {right = 1em}](1,1)
\end{sseqpage}
```

`run off` = ⟨*start tip*⟩–⟨*end tip*⟩
`run off struct lines` = ⟨*start tip*⟩–⟨*end tip*⟩ (initially `...-...`)

`run off differentials` = ⟨*start tip*⟩–⟨*end tip*⟩ (initially `...-...`)

Change the default behavior of run off edges for either all edges, just struct lines, or just differentials respectively. Local arrowhead options override this.

If an edge runs off the edge of the clipping, sseqpages automatically add an arrowhead to indicate that the edge continues. This option controls which arrow head is added if the start or end of an edge runs off the page.

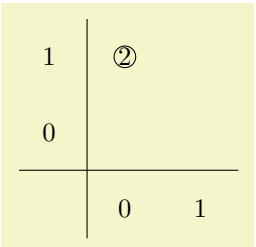



```
\begin{sseqpage}[ x range = {0}{2}, y range = {0}{2},
                  draw orphan edges, run off = >-stealth ]
\class(0,0)
\class(3,0) \class(0,3)
\structline(0,0)(3,0)
\structline[red](0,0)(0,3)
\structline[blue](3,0)(0,3)
\end{sseqpage}
```

`class label handler` = ⟨*function*⟩

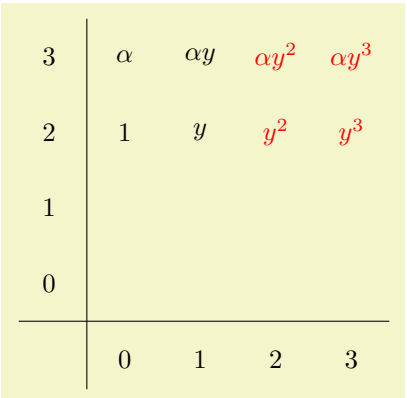
The value of `class label handler` is a function that is applied to all labels before displaying them. It should put its output into `\processedlabel`. This is intended to help with code reusability. Because these handlers may crash or have annoying side-effects on some input, you may want to toggle the value of this command on and off. To turn this off for the rest of the current spectral sequence you can say `\sseqset{class label handler = {}}`. You can also use the `class label handler` key in a `{scope}`.

The main function SPECTRALSEQUENCES provides for use here is `\sseqnormalizemonomial{#1}`. This makes it convenient to translate expressions with polynomial labels. You can write your own handlers if your TEX programming skills are sufficient. Let me know if there are any other functions that you want here, and if you implement them yourself, please send me your implementation. Here is an example of a function that evaluates an arithmetic expression:




```
\begin{sseqpage}[
    class label handler = { \sseqparseint\processedlabel{#1} }
]
\class["1+1"](0,0)
\class["1+2*(1+3*(4-1))"](1,1)
\end{sseqpage}
```

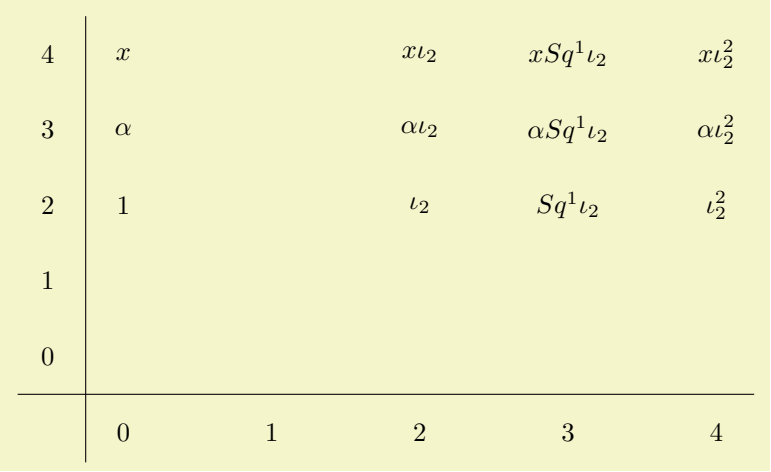
Here's an example using `\sseqnormalizemonomial`:




```
\NewSseqGroup \test {m} {
    \class["1#1"](0,0)
    \class["\alpha#1"](0,1)
    \class["y#1"](1,0)
    \class["\alpha y#1"](1,1)
}
\begin{sseqpage}[
    class label handler = { \sseqnormalizemonomial{#1} },
    classes = { draw = none }, class labels = { font = \small } ]
\test{}
\test[red](2,0){y^2}
\test[orange](2,2){\alpha^2y^2}
\test[blue](0,2){\alpha^2}
\end{sseqpage}
```

Here is another example which demonstrates a useful idiom for drawing Serre spectral sequences. For a more complete example, see `example_KF3n.tex`. Note the use of braces in `{Sq^1\iota_2}`. Without

braces, `\sseqnormalizemonomial` will simplify `Sq^1xSq^2x` into $S^2q^3x^2$, which is obviously undesirable, so the correct way to input this is `{Sq^1x}{Sq^2x}`. Unfortunately, `\foreach` strips a pair of braces from its arguments, so you need to put two pairs of braces.




```
\begin{sseqpage}[
  xscale = 1.4,
  classes = { draw = none },
  class label handler = {\sseqnormalizemonomial{#1}} ]

\foreach \x/\xlabel in
  { 0/1, 2/\iota_2, 3/{{Sq^1\iota_2}}, 4/\iota_2^2 }
\foreach \y/\ylabel in
  { 0/1, 1/\alpha, 2/x, 3/\alpha x, 4/x^2 }
{
    \class["\ylabel\xlabel"] (\x,\y)
}
\end{sseqpage}
```

7 Global options

These options can only be set at the beginning of a `{sseqdata}` or `{sseqpage}` environment. When it makes sense, you can also set a default value using `\sseqset`. Generally, these options either modify the plot style or the logic for the spectral sequence.

`name` = ⟨*sseq name*⟩

This option must be used with the `{sseqdata}` environment where it indicates the name of the spectral sequence, which will be used with the `{sseqpage}` environment or `\printpage` command to draw the spectral sequence. The name used in a `{sseqdata}` environment must be new unless the environment is used with the `update existing` key in which case the `{sseqdata}` environment will add to the existing spectral sequence. It is optional when used with `{sseqpage}` , and if included the name given must be the name of an existing spectral sequence.

`page` = ⟨*page number*⟩ (initially 0)

This key is for `{sseqpage}` and `\printpage`. It specifies which page of the spectral sequence is to be printed. On page r, all `\class`es that are not hit by differentials on pages less than r will be printed, as well as all `\structline`s whose source and target classes are both printed on page r, and all differentials of length exactly r. The special value `page = 0` prints all classes, differentials, and structure lines.

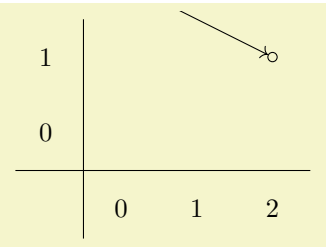
`degree` = {⟨*x degree*⟩}{⟨*y degree*⟩}
`cohomological Serre grading`
`homological Serre grading`

Adams grading

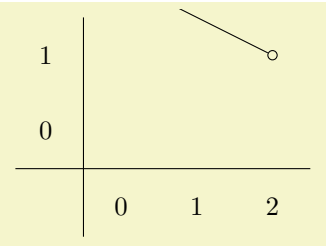
Specifies the degree of differentials. The ⟨*x degree*⟩ and ⟨*y degree*⟩ should both be mathematical expressions in one variable `#1` that evaluate to integers on any input. They specify the `x` and `y` displacement of a page `#1` differential. In practice, they will be linear expressions with `#1` coefficient 1, -1, or 0.

The `degree` option must be given before placing any differentials. It can be specified at the beginning of the `{sseqdata}` environment, at the beginning of the `{sseqpage}` environment if it is being used as a standalone page, or as a default by saying `\sseqset{degree = {`⟨*x degree*⟩`}{`⟨*y degree*⟩`}}` or `\sseqset{Adams grading}` outside of the `{sseqdata}` and SPECTRALSEQUENCES environments.

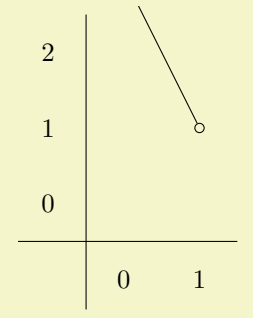
You can make a named grading convention by saying `\sseqset{my grading/.sseq grading = {`⟨*x degree*⟩`}{`⟨*y degree*⟩`}}`. Then later passing `my grading` to a spectral sequence is equivalent to saying `degree = {`⟨*x degree*⟩`}{`⟨*y degree*⟩`}`. The following grading conventions exist by default:




```
% equivalent to degree = {#1}{1-#1}:
\begin{sseqpage}[ cohomological Serre grading ]
\class(0,1)
\class(2,0)
\d2(0,1)
\end{sseqpage}
```




```
% equivalent to degree = {-#1}{#1-1}:
\begin{sseqpage}[ homological Serre grading ]
\class(0,1)
\class(2,0)
\d2(2,0)
\end{sseqpage}
```

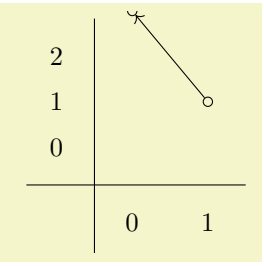



```
% equivalent to degree = {-1}{#1-1}:
\begin{sseqpage}[ Adams grading ]
\class(0,2)
\class(1,0)
\d2(1,0)
\end{sseqpage}
```

strict degree
lax degree

If the degree is strict, then latex will throw an error if you try to specify a differential that doesn't have the proper grading. The degree is strict by default.

```
\begin{sseqdata}[ name = laxdegree, Adams grading ]
\class(0,2)
\class(1,0)
\d3(1,0)(0,2) % Error: differential does not respect grading.
              % Target should be in position (0,3) but instead it is (0,2)...
\end{sseqdata}
```



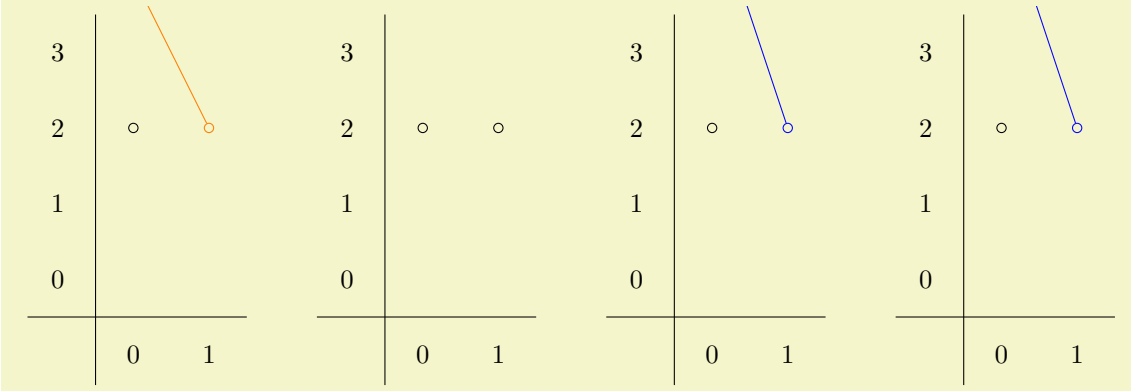

```
\begin{sseqdata}[ name = laxdegree, Adams grading, lax degree, yscale = 0.6 ]
\class(0,2)
\class(1,0)
\d3(1,0)(0,2) % No error because degree checking is off
\end{sseqdata}
\printpage[ name = laxdegree, page = 3 ]
```

update existing

This key is only for the {sseqdata} environment. It specifies that the current {sseqdata} environment is adding data to an existing spectral sequence. If you don't pass this key, then giving a {sseqdata} environment the same name as a different {sseqdata} environment will cause an error. This is intended to help you avoid accidentally reusing the same name.

keep changes = ⟨*boolean*⟩ (default true)(initially false)

This option is only for the {sseqpage} environment, and only works when a name is provided. This option specifies that all of the commands in the current {sseqpage} environment should be carried forward to future pages of the same named spectral sequence. For example:




```
\begin{sseqdata}[ name = keep changes example, Adams grading, y range = {0}{3} ]
\class(0,0)
\class(1,0)
\end{sseqdata}

\begin{sseqpage}[ name = keep changes example, sseq = orange ]
\class(0,2)
\class(1,2)
\classoptions[orange](1,0)
\d2(1,0)
\end{sseqpage} \qquad

\printpage[ name = keep changes example, page = 2 ] \qquad

\begin{sseqpage}[ name = keep changes example, sseq = blue, keep changes ]
\class(0,3)
\class(1,3)
\classoptions[blue](1,0)
\d3(1,0)
\end{sseqpage} \qquad

\printpage[ name = keep changes example, page = 3 ]
```

Note that the orange classes and differential do not persist because the keep changes option is not set in the first {sseqpage} environment, but the blue classes and differential do, since the keep changes option is set in the second {sseqpage} environment.

no differentials

`draw differentials`

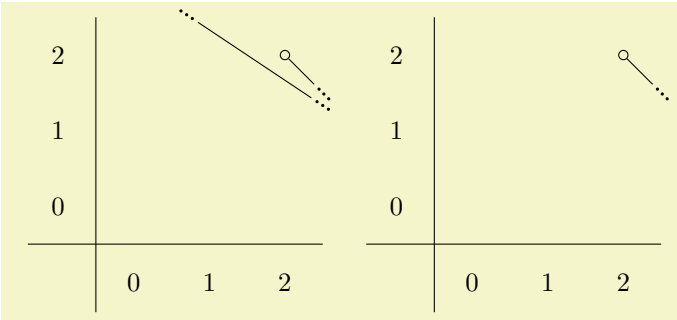
The option `no differentials` suppresses all of the differentials on the current page, whereas `draw differentials` causes the page appropriate differentials to be drawn. This is useful for explaining how the computation of a spectral sequence goes, or if you want to display one of the edges of the spectral sequence, like in `example_KF3n.tex`.

`no struct lines`
`draw struct lines`

The option `no struct lines` suppresses all of the structure lines on the current page, whereas the option `draw struct lines` causes the page appropriate structure lines to be drawn.

`no orphan edges`
`draw orphan edges`

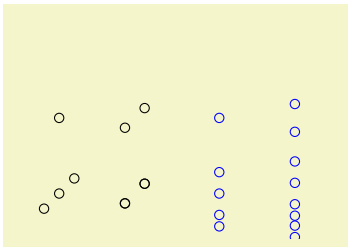
An edge is an "orphan" if both its source and target lie off the page. By default these are drawn, but with the option `no orphan edges` they are not. If the option `no orphan edges` has been set, `draw orphan edges` undoes it.




```
\begin{sseqdata}[
    name = orphan edges example,
    cohomological Serre grading,
    x range = {0}{2}, y range = {0}{2} ]
\class(0,3) \class(3,1)
\d3(0,3)
\class(2,1) \class(4,0)
\d2(2,1)
\end{sseqdata}
\printpage[ name = orphan edges example ]
\quad
\printpage[ name = orphan edges example,
            no orphan edges ]
```

`class pattern` = ⟨*class pattern name*⟩ (initially `standard`)

This key specifies the arrangement of multiple classes at the same coordinate. The default value is `standard`.



```
\begin{sseqdata}[ name = class pattern example, no axes, ymirror ]
\class(0,0)
\class(1,0) \class(1,0)
\class(0,1) \class(0,1) \class(0,1)
\class(1,1) \class(1,1) \class(1,1) \class(1,1)
\class(0,2) \class(0,2) \class(0,2) \class(0,2) \class(0,2)
\class(1,2) \class(1,2) \class(1,2) \class(1,2) \class(1,2) \class(1,2)
\end{sseqdata}

\printpage[ name = class pattern example, class pattern = standard ]
\printpage[ name = class pattern example, change classes = blue,
    class pattern = linear, class placement transform = { rotate = 45 } ]
```

You can add new class patterns using `\sseqnewclasspattern`:

`\sseqnewclasspattern`{⟨*class pattern name*⟩}{⟨*offsets*⟩}

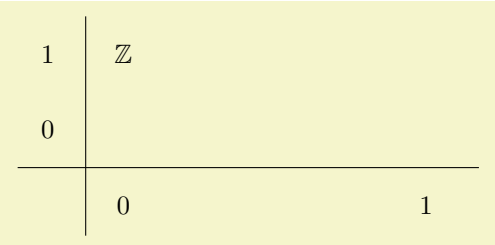
Creates a new class pattern. For example, the `linear` class pattern is created using the command:

```
\sseqnewclasspattern{linear}{
    (0,0);
    (-0.13,0)(0.13,0);
    (-0.2,0)(0,0)(0.2,0);
    (-0.3,0)(-0.1,0)(0.1,0)(0.3,0);
    (-0.4,0)(-0.2,0)(0,0)(0.2,0)(0.4,0);
    (-0.5,0)(-0.3,0)(-0.1,0)(0.1,0)(0.3,0)(0.5,0);
}
```

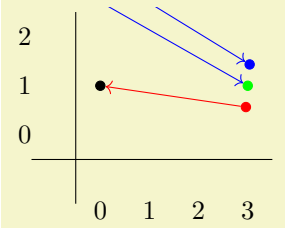
For instance the third row indicates that if there are three classes at the position `(x,y)` they should be printed at `(x-0.2,y)`, `(x,y)`, and `(x+0.2,y)`. You can give as many rows as you like; SPECTRALSEQUENCES will throw an error if there are more classes in any position than the maximum number that your class pattern can handle – for instance, the `linear` class pattern can handle up to six classes based on this definition.

`class placement transform` = {⟨*transform keys*⟩}, add class placement transform = {⟨*transform keys*⟩}

The option `class placement transform` allows the user to specify a TikZ coordinate transform to adjust the relative position of multiple nodes in the same (x, y) position. The `class placement transform` key overrides the previous value of transformations, the `add class placement transform` just adds the new transformation to the end of the list. This coordinate transform can only involve rotation and scaling, no translation. Specifying a scaling factor helps if the nodes are too large and overlap. In some cases a rotation makes it easier to see which class is the target of a differential.



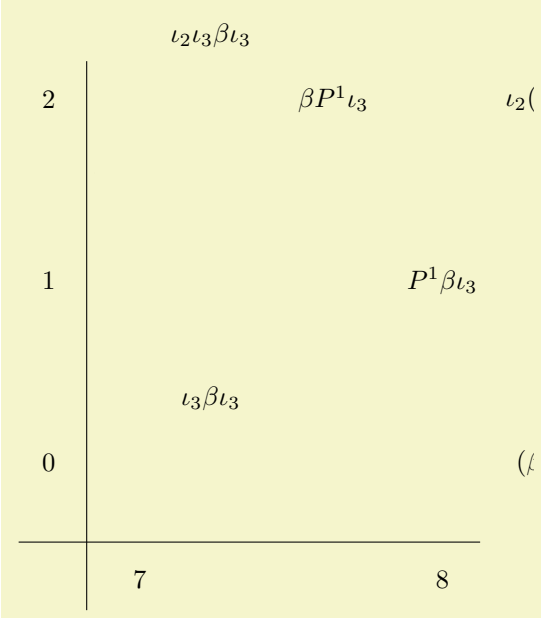

```
\begin{sseqpage}[ class placement transform = { xscale = 3 },
                  class pattern = linear,
                  classes = { draw = none },
                  xscale = 2, x axis extend end = 0.7cm ]
\class["\mathbb{Z}"](0,0)
\class["\mathbb{Z}/2"](1,1)
\class["\mathbb{Z}/3"](1,1)
\end{sseqpage}
```




```
\begin{sseqpage}[ class placement transform = { rotate = 40 },
                  cohomological Serre grading, scale = 0.65,
                  classes = fill, differentials = blue ]
\class(0,0)
\class(0,2)\class(0,2)
\class[red](3,0)\class[green](3,0)\class[blue](3,0)

\d3(0,2,1,2)
\d3(0,2,-1,-1)
\draw[->,red](3,0,1)--(0,0);
\end{sseqpage}
```

With multiple large class names, the best option is to arrange the classes vertically:




```
\begin{sseqpage}[ classes = {draw = none }, xscale = 2, yscale=1.55,
    class pattern = linear,
    class placement transform = { scale = 3, rotate = 90 },
    right clip padding = 20pt, top clip padding = 20pt,
    x axis gap = 30pt, y axis gap = 20pt ]
\class["\iota_3\beta\iota_3"](7,0)
\class["P^1\iota_3"](7,0)

\class["\iota_2\iota_3\beta\iota_3"](7,2)
\class["\iota_2P^1\iota_3"](7,2)

\class["(\beta\iota_3)^2"](8,0)
\class["P^1\beta\iota_3"](8,0)
\class["\beta P^1\iota_3"](8,0)

\class["\iota_2(\beta\iota_3)^2"](8,2)
\class["\iota_2P^1\beta\iota_3"](8,2)
\class["\iota_2\beta P^1\iota_3"](8,2)
\end{sseqpage}
```

`math nodes` = ⟨*boolean*⟩ (default `true`)(`initially true`)

This key instructs SPECTRALSEQUENCES to put all labels in math mode automatically.

7.1 Global Coordinate Transformations

Of the normal Ti*k*Z coordinate transformations, only the following can be applied to a sseq diagram:

`scale` = ⟨*factor*⟩
`xscale` = ⟨*factor*⟩
`yscale` = ⟨*factor*⟩
`xmirror`
`ymirror`

Scale the diagram by ⟨*factor*⟩. Under normal circumstances, you can tell Ti*k*Z to mirror a diagram by saying, for instance, `xscale = -1`, but SPECTRALSEQUENCES needs to be aware that the diagram has been mirrored in order to draw the axes correctly. Thus, if you want to mirror a spectral sequence, use the `xmirror` and `ymirror` options as appropriate.

`rotate` = ⟨*angle*⟩

It probably won't look great if you pick an angle that isn't a multiple of 90 degrees.

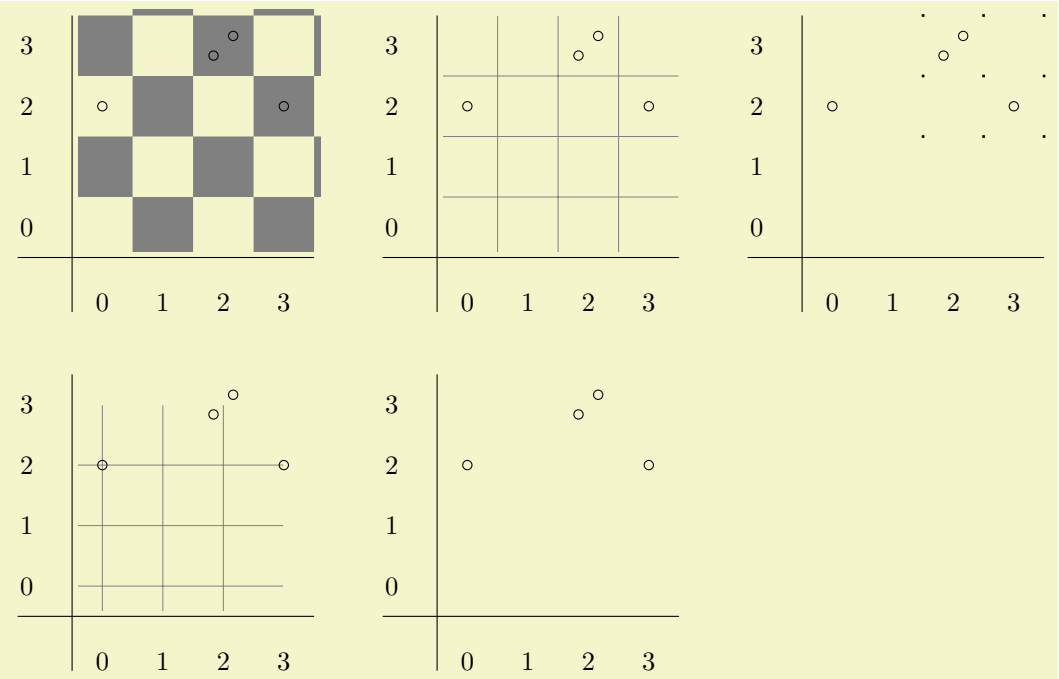
7.2 Plot Options and Axes Style

`x range` = {⟨*x min*⟩}{⟨*x max*⟩}
`y range` = {⟨*y min*⟩}{⟨*y max*⟩}

These options set the x range (respectively y range) to be a specific interval. By default, if no range is specified then the range is chosen to fit all the classes. If an x range is specified but no y range, then the y range is chosen to fit all the classes that lie inside the specified x range, and vice versa. The values must be integers – if you want to extend the x axis a noninteger amount, try using `x axis start extend` or `x axis end extend`.

`grid` = {⟨*grid style*⟩}

Makes SPECTRALSEQUENCES draw a grid. The grid styles and a significant part of the code that produces them were stolen from the sseq package.

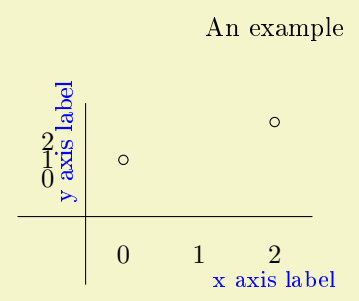



```
\begin{sseqdata}[ name = grid example, scale = 0.8 ]
\class(0,0)
\class(3,0)
\class(2,1)\class(2,1)
\class(1,2)\class(1,2)\class(1,2)
\class(0,3)
\class(3,3)
\end{sseqdata}
\hbox{
\printpage[ name = grid example, grid = chess ]
\qquad
\printpage[ name = grid example, grid = crossword ]
\qquad
\printpage[ name = grid example, grid = dots ]
}
\vskip20pt
\hbox{
\printpage[ name = grid example, grid = go ]
\qquad
\printpage[ name = grid example, grid = none ]
}
```

It is possible to make your own grid style by defining the command `\sseq@grid@yourgridname` to draw a grid.

`title` = ⟨*text*⟩

`title style` = ⟨*keys*⟩
`x label` = ⟨*text*⟩
`y label` = ⟨*text*⟩
`x label style` = ⟨*keys*⟩
`y label style` = ⟨*keys*⟩
`label style` = ⟨*keys*⟩




```
\begin{sseqpage}[ title = { An example }, yscale = 0.5,
    x label = { x axis label },
    y label = { y axis label },
    label style = { blue, font = \small },
    x label style = { yshift = 5pt },
    ]
\class(0,0)
\class(2,2)
\end{sseqpage}
```

`no title`
`draw title`
`no x label`
`no y label`
`no labels`
`draw x label`
`draw y label`
`draw labels`

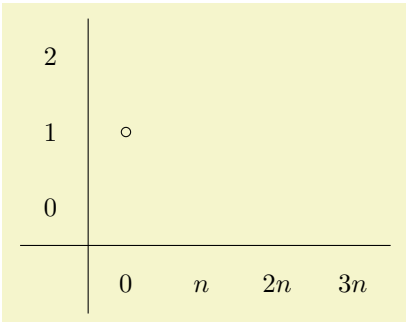
Suppress or unsuppress the title, x label, y label, or both x and y labels, respectively.

`no x axis`
`no y axis`
`no axes`
`draw x axis`
`draw y axis`
`draw axes`

Suppress the axis. Also suppresses axes ticks. If there is a title or axes labels they will still be drawn. You can draw your own axes using Ti*k*Z inside a `{scope}` environment with the `background` key.

`no x ticks`
`no y ticks`
`no ticks`
`draw x ticks`
`draw y ticks`
`draw ticks`

Suppress axes ticks (the numbers next to the axes). Only matters if axes are drawn. You can make your own ticks using Ti*k*Z inside a `{scope}` environment with the `background` key. For instance, you might want to label the axes as 0, n, $2n$, ... You can achieve this as follows: (you can also use `x tick handler`).




```
\begin{sseqpage}[ no x ticks, x range = {0}{3} ]
\begin{scope}[ background ]
    \node at (0,\ymin - 1) {0};
    % \vphantom is fragile so we have to throw in an extra \protect
    \node at (1,\ymin - 1) {\protect\vphantom{2}n};
\foreach \n in {2,..., \xmax}{
    \node at (\n,\ymin - 1) {\n n};
}
\end{scope}
\class(0,0)
\class(3,2)
\end{sseqpage}
```

`x tick step` = ⟨*positive integer*⟩ (initially 1)
`y tick step` = ⟨*positive integer*⟩ (initially 1)
`tick step` = ⟨*positive integer*⟩ (initially 1)

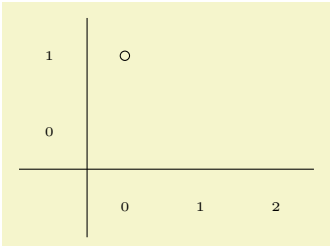
Sets the interval between labels.

`x tick offset` = ⟨*integer*⟩ (initially 0)
`y tick offset` = ⟨*integer*⟩ (initially 0)
`tick offset` = ⟨*integer*⟩ (initially 0)

Sets the label offset – by default the ticks will always be the set of numbers that are 0 mod ⟨*tick step*⟩. Change it so that the ticks are the set of numbers that are ⟨*tick offset*⟩ mod ⟨*tick step*⟩.

`x tick style` = {⟨*keys*⟩}
`y tick style` = {⟨*keys*⟩}
`tick style` = {⟨*keys*⟩}

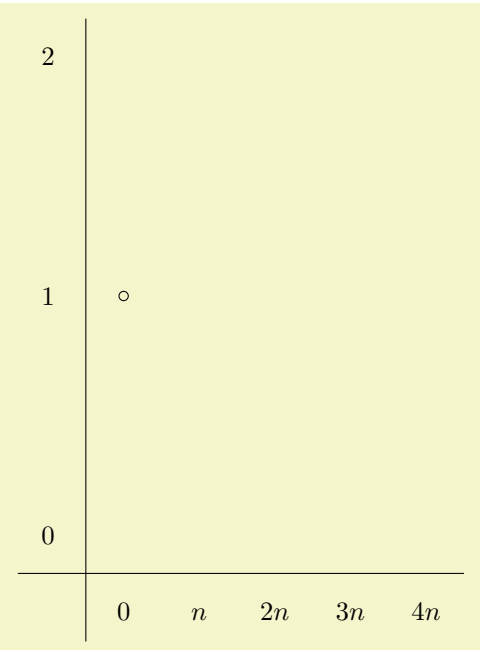
Change the tick style:




```
\begin{sseqpage}[ tick style = { blue, font = \tiny } ]
\class(0,0) \class(2,1)
\end{sseqpage}
```

`x tick handler` = ⟨*function*⟩ (initially #1)
`y tick handler` = ⟨*function*⟩ (initially #1)
`tick handler` = ⟨*function*⟩ (initially #1)

The value for `x tick handler` should be a function that takes in the current `x` value and outputs the appropriate tick. Correspondingly with `y tick handler`. The `tick handler` key sets both.




```
\begin{sseqpage}[ x range = {0}{4}, yscale = 1.78,
    x tick handler = {
        \ifnum#1 = 0\relax
            0
        \else
            \ifnum#1 = 1\relax
                % \vphantom is fragile so we \protect it
                \protect\vphantom{2}n
            \else
                #1n
            \fi
        \fi
    }
]
\class(0,0)
\class(4,2)
\end{sseqpage}
```

7.3 Layout

`x axis style` = ⟨*style*⟩ (initially `border`)
`y axis style` = ⟨*style*⟩ (initially `border`)
`axes style` = ⟨*style*⟩ (initially `border`)

The ⟨*style*⟩ is either `border` or `center`. The `border` option puts the axes on the bottom and left of the picture; the center option by default places the axes at `x` = `y` = 0. This option is only worth using for multi-quadrant spectral sequences. See `example_KRAHSS.tex` and `example_KUHFPSS.tex` for examples where this is used.

`x axis origin` = ⟨*x value*⟩ (initially 0)
`y axis origin` = ⟨*y value*⟩ (initially 0)

If you use `axes style` = *`center`*, these keys change the position of the axes. Otherwise, they are ignored.

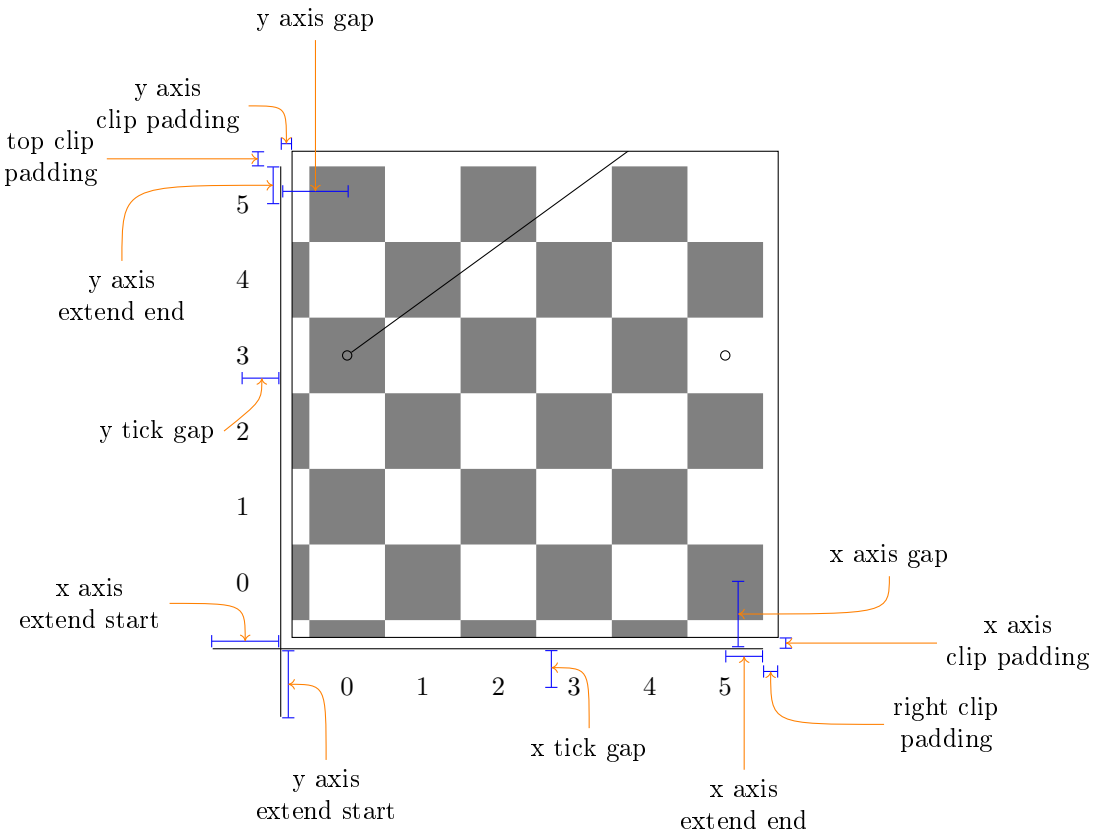
`x axis gap` = ⟨*dimension*⟩ (initially `0.5cm`)
`y axis gap` = ⟨*dimension*⟩ (initially `0.5cm`)
`axes gap` = ⟨*dimension*⟩ (initially `0.5cm`)

`x tick gap` = ⟨*dimension*⟩ (initially `0.5cm`)
`y tick gap` = ⟨*dimension*⟩ (initially `0.5cm`)

`x axis start extend` = ⟨*dimension*⟩ (initially `0.5cm`)
`y axis start extend` = ⟨*dimension*⟩ (initially `0.5cm`)
`x axis extend end` = ⟨*dimension*⟩ (initially `0.9cm`)
`y axis extend end` = ⟨*dimension*⟩ (initially `0.9cm`)

`x axis clip padding` = ⟨*dimension*⟩ (initially `0.1cm`)
`y axis clip padding` = ⟨*dimension*⟩ (initially `0.1cm`)

`right clip padding` = ⟨*dimension*⟩ (initially `0.1cm`)
`left clip padding` = ⟨*dimension*⟩ (initially `0.4cm`)
`top clip padding` = ⟨*dimension*⟩ (initially `0.1cm`)
`bottom clip padding` = ⟨*dimension*⟩ (initially `0.4cm`)



`custom clip` = ⟨*clip path*⟩

Give a custom clipping. The clipping specified must be in the form of a valid Ti*k*Z path, for instance `\clip (0,0) rectangle (10,10);`. This clipping is also applied to any grid and is used to draw ellipses on appropriate differentials or struct lines that go out of bounds and to determine whether a differential or struct line is an "orphan". It is not applied to any background elements, which is important because these are often used for axes labels and such that should lie outside of the clipping region. Weird things can happen with out of range edges if use this option with an oddly shaped path.

`clip` = ⟨*boolean*⟩ (default `true`)(`initially true`)

If this is false the spectral sequence won't be clipped. I'm not really sure why you would want that, but there might be some use case. Setting this to be false is not fully supported, and it's possible that weird things will happen with some of the edges that go out of range.

`rotate labels` = ⟨*boolean*⟩ (default `true`)(`initially false`)

If you use `rotate = 90` but also want the labels rotated (so that the whole diagram is sideways) use this key.