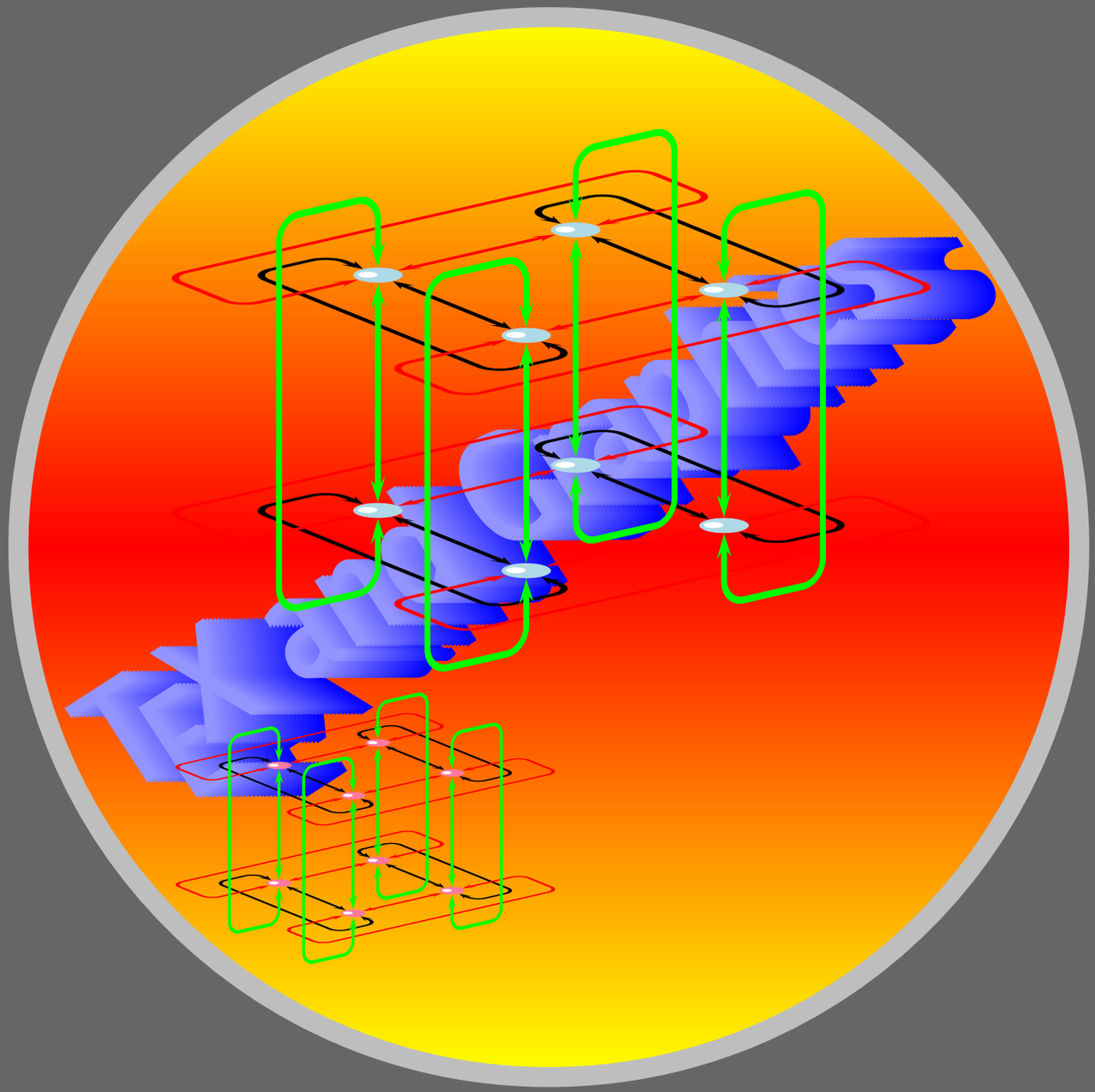

Custom Graphics

Simple customization
Higher level customization

Online LaTeX Tutorial
Part II – Graphics
PSTricks

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8. Custom Graphics

We've seen in previous chapters the wide array of graphics objects available off-the-shelf in PSTricks. In this chapter we'll take a look at some methods of creating our own graphics objects. We've also seen how we can produce variants of such predefined objects by tweaking their default parameter settings. The first level of customization is to save such variants as new objects and then reuse them.

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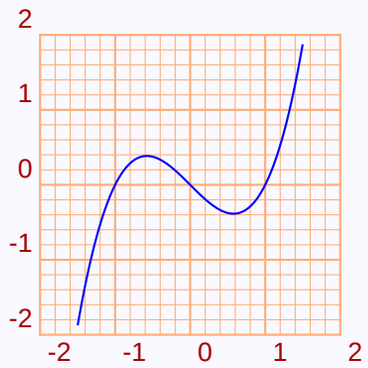
8.1. Simple customization

If a certain graphics object in PSTricks is repeatedly used with some custom parameter settings, we can save the tedium in typing in these values by saving it under a new name. (This also comes in handy to make changes in a consistent manner, if we happen to change our mind later).

8.1.1. New objects

You may have noticed that many of our examples contain a colored grid like the one below:

```
\begin{pspicture}(-2,-2)(2,2)
  \psgrid[gridcolor=Apricot,%
          gridlabelcolor=Mahogany,%
          subgridcolor=Apricot]
  \psplot[plotstyle=curve,%
          linecolor=Blue]%
         {-1.5}{1.5}{x 3 exp x sub}
\end{pspicture}
```



Since the same grid is used in all the examples, it'd be nice if we can avoid the tedium of typing all the parameter settings again and again; and its where the command `\newpsobject` comes in handy. Thus by defining

```
\newpsobject{colgrid}%
            {psgrid}%
            {gridcolor=Apricot,%
             gridlabelcolor=Mahogany,%
             subgridcolor=Apricot}
```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we can use `\colgrid` every time we need the grid of these specifications.

The syntax of the general command is:

```
\newpsobject{name}%
            {object}%
            {parameter1=value1}%
             parameter1=value1
             ............}
```

Where *name* is the name we give to the variant object (such as `colgrid` in the example above), *object* is the name of the graphics object predefined in PSTricks that we want to tweak (such as `psgrid` in the example) and *Parameter1*, *parameter2* are the parameters whose values we set by assigning values *value1*, *value2* and so on.

Once an object is defined using `\newpsobject`, we can change its parameters the usual way by enclosing the new values within square brackets. The examples below illustrates this:

```
\newpsobject{bigdots}%
            {psdots}%
            {dotsize=1 0,%
             linecolor=Red}
\begin{pspicture}(-0.5,-0.5)(1.5,1.37)
  \bigdots(0,0)(1,0)(0.5,0.866)
\end{pspicture}

\vspace{1cm}

\begin{pspicture}(-0.5,-0.5)(1.5,1.37)
  \bigdots[linecolor=Green](0,0)
  \bigdots[linecolor=Blue](1,0)
  \bigdots(0.5,0.866)
\end{pspicture}
```

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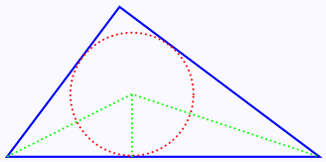
8.1.2. New styles

We can also freeze certain parameter values under a new name using the command `\newpsstyle` and then use it with various graphics objects, as in the example below:

```
\newpsstyle{newdots}%
           {linestyle=dotted,%
            dotsep=1pt,%
            linecolor=Green}

\psset{unit=0.5cm}
\begin{pspicture}(0,-0.5)(8.33,4.5)
  \pspolygon[linecolor=Blue](0,0)(8.33,0)(3,4)
  \psline[style=newdots](0,0)(3.33,1.67)(8.33,0)
  \psline[style=newdots](3.33,1.67)(3.33,0)
  \pscircle[style=newdots,linecolor=Red](3.33,1.67){1.67}
  \end{pspicture}
```



The syntax of the general command is

```
\newpsstyle{name}%
           {parameter1=value1}%
            parameter1=value1
            ... ... ... ... }
```

Note that any parameter value set in `\newpsstyle` can be changed the usual way, as seen in the `\pscircle` of the above example.

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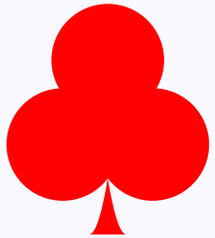
8.2. Higher level customization

Apart from creating variant objects by merely tweaking the parameter settings of predefined objects, PSTricks also allows us to create our own graphics objects by combining predefined objects in various ways, using the command `\pscustom`. Let's look at an example to see this command in action. Suppose (for whatever reason), we want to draw a red `club suit` shown below:



Drawing the top part is easy, using our `\bigdots`, of the first section.

```
\psset{unit=1.5cm}
\begin{pspicture}(-1,-1)(2,1.5)
  \bigdots(0,0)(0.8,0)(0.4,0.75)
\end{pspicture}
```

Next we draw the stem. The *shape* of the stem—it can be scaled to the needed *size* later—can be drawn using two parabolic arcs and a line segment as shown below:

We've included the arrows to show the *direction* of drawing. The code for producing this (without the arrows) is shown below:

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```
\begin{pspicture}(-1,-1)(1,0)
  \psplot{-1}{0}{x 1 add 2 exp 1 sub}
  \psplot{0}{1}{x 1 sub 2 exp 1 sub}
  \psline(1,-1)(-1,-1)
\end{pspicture}
```

So far, so good; but how do we *color* this? This is where `\pscustom` steps in. Look at the code and the output shown below:

```
\begin{pspicture}(-1,-1)(1,0)
  \pscustom[fillstyle=solid,%
            fillcolor=Red,%
            linestyle=none]{%
             \psplot{-1}{0}{x 1 add 2 exp 1 sub}
             \psplot{0}{1}{x 1 sub 2 exp 1 sub}
             \psline(1,-1)(-1,-1)}
\end{pspicture}
```

Now it's only a question of scaling the stem we've created and pasting at the bottom of the circles, to make our picture:

```
\psset{unit=1.5cm}
\begin{pspicture}(-1,-1)(2,2)
  \bigdots(0,0)(0.8,0)(0.4,0.75)
  \rput(0.4,-0.3){%
    \pscustom[xunit=0.25cm,%
              yunit=0.75cm,%
              linestyle=none,%
              fillstyle=solid,%
              fillcolor=Red]{%
                \psplot{-1}{0}{x 1 add 2 exp 1 sub}
                \psplot{0}{1}{x 1 sub 2 exp 1 sub}
                \psline(1,-1)(-1,-1)}}
\end{pspicture}
```

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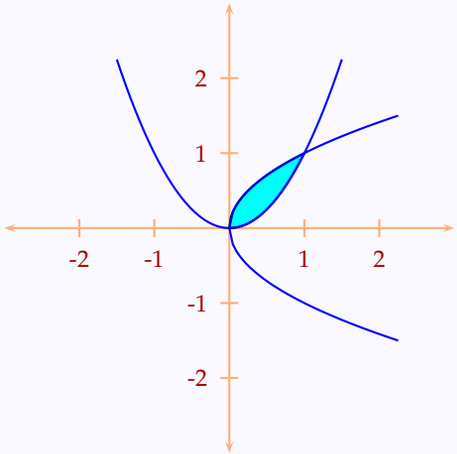
Let's now take a closer look at the `\pscustom` command. In the above example, this command helped us to create our "stem" as a new graphics object, which could be subjected to the various parameter settings, as with a regular PSTricks object. This is highly useful in highlighting the region between two curves as in the example below:

```
\renewcommand{\pshlabel}[1]{\small\color{Mahogany}#1}
\renewcommand{\psvlabel}[1]{\small\color{Mahogany}#1}
\begin{pspicture}(-3,-3)(3,3)
  \colaxes(0,0)(-3,-3)(3,3)
  \pscustom[fillstyle=solid,fillcolor=Cyan]{%
    \psplot{0}{1}{x 2 exp}
    \psplot{1}{0}{x sqrt}}
  \psset{linecolor=Blue}
  \psplot{-1.5}{1.5}{x 2 exp}
  \psplot{0}{2.25}{x sqrt}
  \psplot{0}{2.25}{x sqrt neg}
\end{pspicture}
```

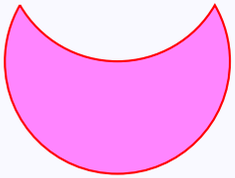


Note that `\colaxes` is not a native PSTricks command but is set by

```
\newpsobject{colaxes}{psaxes}{linecolor=Apricot,arrows=<->}
```

8.2.1. Of paths and points

As another example, suppose we want to draw a crescent like the one below:



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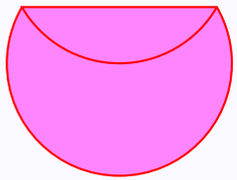
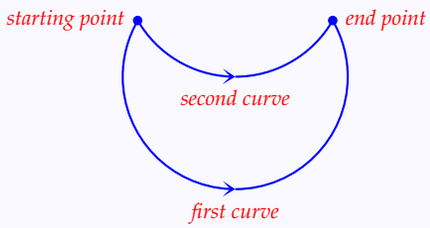
Armed with our (little) knowledge of the `\pscustom`, suppose we try

```
\begin{pspicture}(-1.5,-1.5)(1.5,1.5)
  \pscustom[fillstyle=solid,%
            fillcolor=Lavender,%
            linecolor=Red]{%
              \psarc(0,0){1.5}{150}{30}
              \psarc(0,1.5){1.5}{210}{330}}
\end{pspicture}
```

We get



To analyze this seemingly strange behavior, we must look at the way PSTricks (more precisely, PostScript) draws pictures. First recall that the command `\psarc` draws an arc of a circle in the *counter-clockwise direction*, so that our code above give instructions to draw curves as shown below:



In PostScript parlance, a curve is called a *path* and once a path is instructed to be drawn, the point where the path ends is called *current point*. So, when we say

`\psarc(0,0){1.5}{150}{30}`

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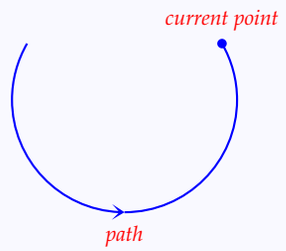
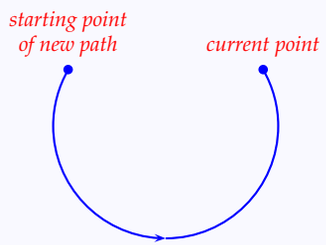
this is the state we are in:



The starting point of the second path to be drawn by `\psarc(0,1.5){1.5}{210}{330}` is the beginning of the first path:



The point to note (no pun!) is that here, the beginning of the new path is *not* the current point. Now comes the rub: *by default*, `\pscustom` *joins the current point with the beginning of a new path*. So

```
\begin{pspicture}(-1.5,-1.5)(1.5,1.5)
  \pscustom[linecolor=Blue]{%
    \psarc(0,0){1.5}{150}{30}
    \psarc(0,1.5){1.5}{210}{330}}
\end{pspicture}
```

produces (without the arrows)

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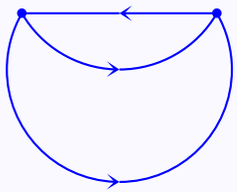


(Do you see why our earlier construction with `\pscustom` worked? There we had three paths, *with the beginning of each path the same as the current point*).

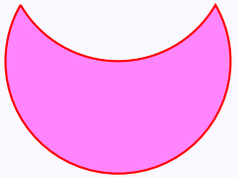
So, what's the way out? PSTricks also has a command `\psarcn` ("n" for negative) which draws the arc of a circle in the *clockwise* direction. Thus `\psarc(0,0){1.5}{210}{330}` and `\psarcn(0,0){1.5}{330}{210}` produce the same curve, but *drawn* in opposite directions:

`\psarc(0,0){1.5}{210}{330}`

`\psarcn(0,0){1.5}{330}{210}`

Now we can easily draw the crescent:

```
\begin{pspicture}(-1.5,-2)(1.5,0.5)
  \pscustom[fillstyle=solid,%
            fillcolor=Lavender,%
            linecolor=Red]{%
              \psarc(0,0){1.5}{150}{30}
              \psarcn(0,1.5){1.5}{330}{210}}
\end{pspicture}
```



Here's another example, using `\psarcn`

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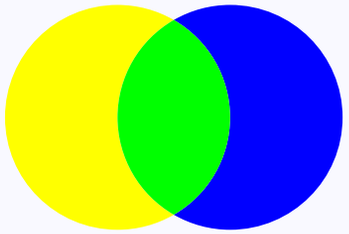
```
\psset{unit=1.5cm}
\begin{pspicture}(0,-1)(3,1)
  \psset{linestyle=none,fillstyle=solid}
  \pscustom[fillcolor=Yellow]{%
    \psarc(1,0){1}{60}{-60}
    \psarcn(2,0){1}{240}{120}}
  \pscustom[fillcolor=Blue]{%
    \psarc(2,0){1}{240}{120}
    \psarcn(1,0){1}{60}{-60}}
  \pscustom[fillcolor=Green]{%
    \psarc(1,0){1}{-60}{60}
    \psarc(2,0){1}{120}{240}}
 \end{pspicture}
```



The (default) behavior of PSTricks in joining the current point to the beginning of the new path can sometimes be of advantage. For example, in our construction of a "stem" earlier, we need not explicitly mention the "base", using`\psline`, if the two curves are specified to be drawn in suitable directions:

```
\begin{pspicture}(-1,-1)(1,0)
  \pscustom[linestyle=none,%
            fillstyle=solid,%
            fillcolor=Red]{%
              \psplot{0}{-1}{x 1 add 2 exp 1 sub}
              \psplot{1}{0}{x 1 sub 2 exp 1 sub}}
\end{pspicture}
```

8.2.2. Current point again

Another feature to note is that the paths drawn by `\psline` and `\pscurve` make use of the current point as the first point; so also does `\psplot` with

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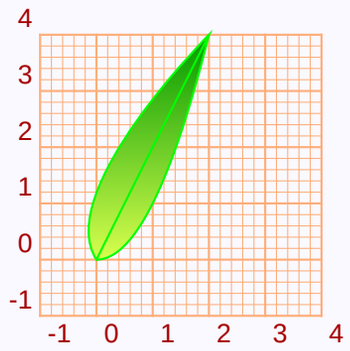
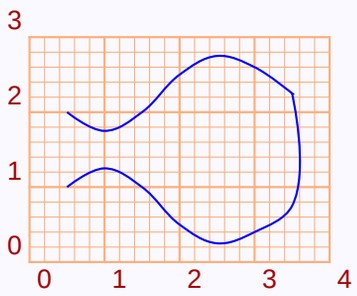
plotstyle=curve and \psbezier with only three points specified. Look at these examples:

```
\psset{unit=0.75cm}
\begin{pspicture}(-1,-1.5)(4,4.5)
  \colgrid(-1,-1)(4,4)
  \pscustom[linecolor=Green,%
            fillstyle=gradient,%
            gradbegin=OliveGreen,%
            gradend=GreenYellow,%
            gradmidpoint=1]{%
              \psline(0,0)(2,4)
              \psplot[plotstyle=curve]{0}{2}{x 2 exp}}
\end{pspicture}
```




```
\begin{pspicture}(0,-0.5)(4,3.5)
  \colgrid(0,0)(4,3)
  \pscustom[linecolor=Blue]{%
    \pscurve(0.5,2)(1,1.75)(1.5,2)(2,2.5)%
            (2.5,2.75)(3,2.6)(3.5,2.25)
    \pscurve(3.5,0.75)(3,0.4)(2.5,0.25)%
            (2,0.5)(1.5,1)(1,1.25)(0.5,1)}
\end{pspicture}
```



8.2.3. Lifting the pen

The behavior of the commands such as \psline toward the current point can be modified by setting the parameter liftpen, which can take values 0, 1 or 2. The default value is 0 and this corresponds to the (default) behavior of

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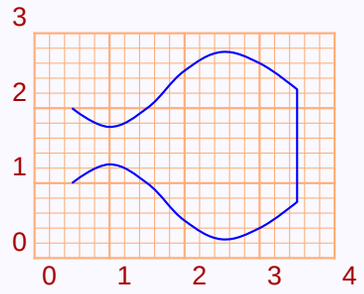
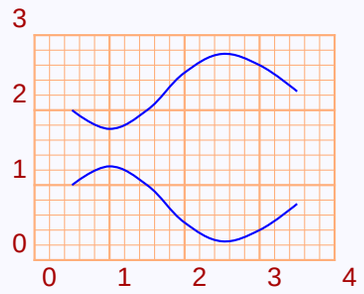
treating the current point as the first point. With `liftpen=1`, the current point is not treated as the first point, but a line is drawn from the current point to the first point of the path, as with the other path drawing commands:

```
\begin{pspicture}(0,-0.5)(4,3.5)
  \colgrid(0,0)(4,3)
  \pscustom[linecolor=Blue]{%
    \pscurve(0.5,2)(1,1.75)(1.5,2)(2,2.5)%
            (2.5,2.75)(3,2.6)(3.5,2.25)
    \pscurve[liftpen=1]%
            (3.5,0.75)(3,0.4)(2.5,0.25)%
            (2,0.5)(1.5,1)(1,1.25)(0.5,1)}
\end{pspicture}
```



With `liftpen=2`, the current point is not taken as the first point, nor is a line drawn from the current point to the first point of the path:

```
\begin{pspicture}(0,-0.5)(4,3.5)
  \colgrid(0,0)(4,3)
  \pscustom[linecolor=Blue]{%
    \pscurve(0.5,2)(1,1.75)(1.5,2)(2,2.5)%
            (2.5,2.75)(3,2.6)(3.5,2.25)
    \pscurve[liftpen=2]%
            (3.5,0.75)(3,0.4)(2.5,0.25)%
            (2,0.5)(1.5,1)(1,1.25)(0.5,1)}
\end{pspicture}
```



The pictures below show the last three pictures above with the parameter settings `\fillstyle=solid` and `\fillcolor=Cyan` for the `\pscustom` command:

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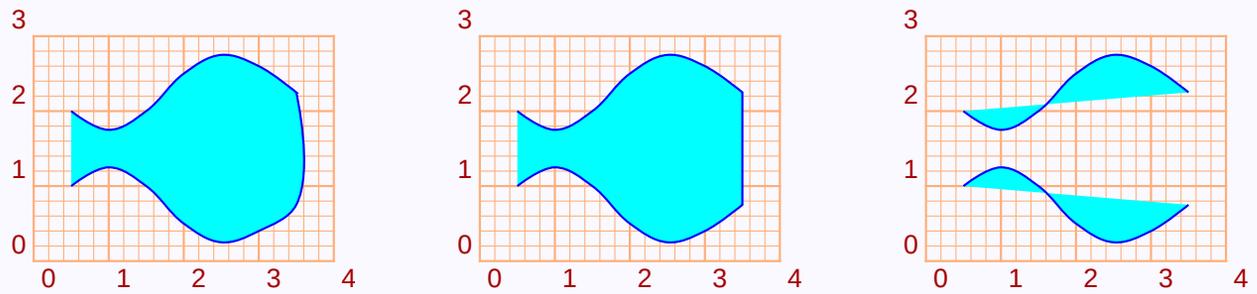

`liftpen=0` `liftpen=1` `liftpen=2`

The last picture may need some explanation; note that when we instruct an "open" curve to be "filled", then the first and the last points are joined to make a closed region, which is then filled.

8.2.4. Other tricks

Before discussing some other techniques, we must take a closer look at the way PostScript handles graphics. When we give instructions to draw a path in PostScript, it is not immediately drawn; we will also have to give instructions to draw it, or *stroke* it in PostScript terminology. Again, we will have to give explicit commands to *fill* a region. The command `\pscustom` automatically does the stroking and filling at the end, subject to the various `linestyle` and `fillstyle` options. But within `\pscustom` we ourselves can stroke or fill using the commands `\stroke` or `\fill`. We can also use the command `\newpath` to clear the current path and current point. Look at the example below:

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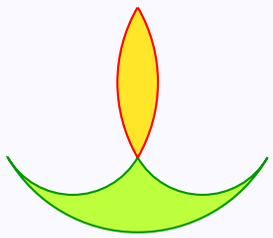
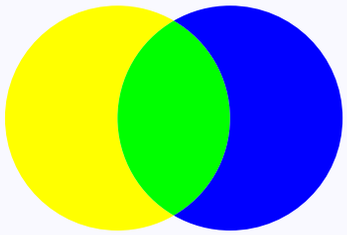
```
\begin{pspicture}(-2,-2)(2,2)
  \pscustom[linestyle=none]{%
    \psarcn(0.865,-0.5){1}{330}{210}
    \psarcn(-0.865,-0.5){1}{330}{210}
    \psarc(0,0){2}{210}{330}
    \fill[fillstyle=solid,fillcolor=SpringGreen]
    \stroke[linestyle=solid,linecolor=OliveGreen]
    \newpath
    \psarc(1.73,0){2}{150}{210}
    \psarc(-1.73,0){2}{-30}{30}
    \fill[fillstyle=solid,fillcolor=Goldenrod]
    \stroke[linestyle=solid,linecolor=Red]}
\end{pspicture}
```



Here's one of our earlier examples, coded using a single `\pscustom` instead of the three used earlier:

```
\psset{unit=1.5cm}
\begin{pspicture}(0,-1)(3,1)
  \pscustom[linestyle=none]{%
    \psarc(1,0){1}{60}{-60}
    \psarcn(2,0){1}{240}{120}
    \fill[fillstyle=solid,fillcolor=Yellow]
    \newpath
    \psarc(1,0){1}{-60}{60}
    \psarc(2,0){1}{120}{240}
    \fill[fillstyle=solid,fillcolor=Green]
    \newpath
    \psarc(2,0){1}{240}{120}
    \psarcn(1,0){1}{60}{-60}
    \fill[fillstyle=solid,fillcolor=Blue]}
\end{pspicture}
```



Now suppose we want to produce something like this:

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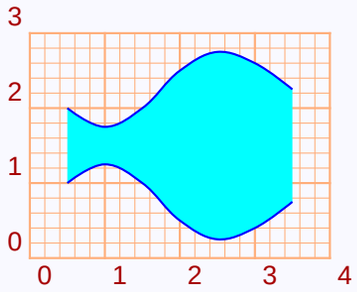
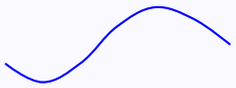
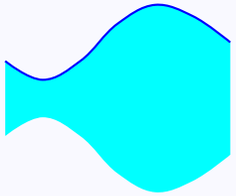


As the previous examples show, tweaking the `liftpen` values is of no use here, since in all these the curves are connected, one way or the other. Let's first list what we want to do:

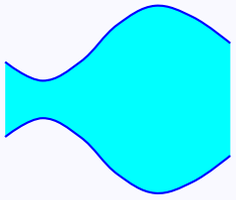
1. Draw the first curve



2. Give instructions to draw the second curve, with `liftpen=1`, without actually stroking it, and instructions to fill the region between the curves



3. Draw the the second curve with `liftpen=2`, but no filling.



We know how to do Steps 1 and 3 above; it's Step 2 that is tricky; we use the pair of commands `\gsave...\grestore` to do the job. Let's see them in action:

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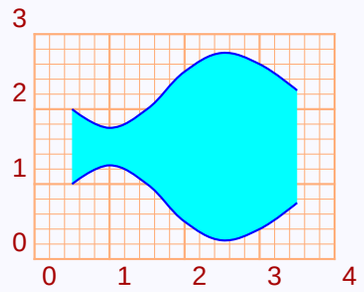
```
\begin{pspicture}(0,-1)(4,3)
  \colgrid(0,0)(4,3)
  \pscustom[linecolor=Blue]{%
    \pscurve(0.5,2)(1,1.75)(1.5,2)(2,2.5)%
            (2.5,2.75)(3,2.6)(3.5,2.25)
    \gsave
    \pscurve[liftpen=1]%
            (3.5,0.75)(3,0.4)(2.5,0.25)%
            (2,0.5)(1.5,1)(1,1.25)(0.5,1)
    \fill[fillstyle=solid,%
          fillcolor=Cyan]
    \grestore
    \pscurve[liftpen=2]%
            (3.5,0.75)(3,0.4)(2.5,0.25)%
            (2,0.5)(1.5,1)(1,1.25)(0.5,1)}
 \end{pspicture}
```



As can be seen from this code, the implementation of Step 2 is done within the `\gsave...\grestore` command. We've noted that PostScript strokes or fills a path only on explicit instructions to do so and `\pscustom` automatically strokes or fills a path at the end. Within the commands `\gsave...\grestore` however, `\pscustom` does not stroke or fill a path, unless told. (In PostScript, the command `gsave` saves the *current graphics state*, such as the current path, current point, color, linewidth and so on to a *stack* and `grestore` restores the saved state.) Thus in the example above, the code within this command pair does exactly what we want to do in Step 2 above.

Here's another example using `\gsave...\grestore`

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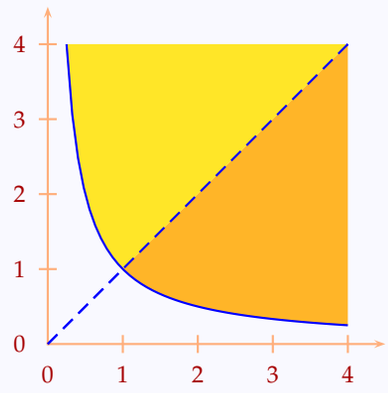
```
\renewcommand{\pshlabel}[1]{\small\color{Mahogany}#1}
\renewcommand{\psvlabel}[1]{\small\color{Mahogany}#1}
\begin{pspicture}(0,0)(4.5,4.5)
  \colaxes(4.5,4.5)
  \pscustom[linecolor=Blue,%
            linestyle=dashed]{%
              \psline(0,0)(4,4)
              \stroke
              \gsave
                \psplot[liftpen=1]%
                       {0.25}{1}{1 x div}
                \fill[fillstyle=solid,%
                      fillcolor=Goldenrod]
              \grestore
              \gsave
                \psplot[liftpen=1]%
                       {4}{1}{1 x div}
                \fill[fillstyle=solid,%
                      fillcolor=Dandelion]
              \grestore}
    \psplot[linecolor=Blue]%
           {0.25}{4}{1 x div}
  \end{pspicture}
```



Within `\pscustom` we can also use the command `\moveto` to move the current point to a point with specified coordinates.

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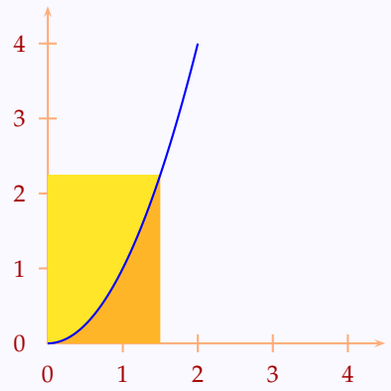
```
\renewcommand{\pshlabel}[1]{\small\color{Mahogany}#1}
\renewcommand{\psvlabel}[1]{\small\color{Mahogany}#1}
\begin{pspicture}(0,0)(4.5,4.5)
  \colaxes(4.5,4.5)
  \pscustom[linecolor=Blue]{%
    \psplot{0}{1.5}{x 2 exp}
    \gsave
      \psline(0,2.25)
      \fill[fillstyle=solid,%
            fillcolor=Goldenrod]
    \grestore
    \gsave
      \psline(1.5,0)
      \fill[fillstyle=solid,%
            fillcolor=Dandelion]
    \grestore
    \moveto(1.5,2.25)
    \psplot{1.5}{2}{x 2 exp}}
  \end{pspicture}
```



Within `\pscustom`, we can also transform the coordinate system in certain ways. For example, the command `\translate` can be used to shift the coordinate axes (parallel to themselves) to a new point, as in the example below:

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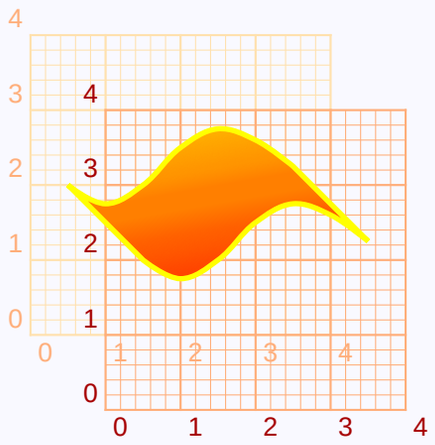
```
\begin{pspicture}(0,-1.5)(5,4.5)
  \pscustom[style=mystyle]{%
    \pscurve(0.5,2)(1,1.75)(1.5,2)(2,2.5)%
            (2.5,2.75)(3,2.6)(3.5,2.25)
    \translate(1,-1)
    \pscurve[liftpen=1]%
       (3.5,2.25)(3,2.6)(2.5,2.75)%
       (2,2.5)(1.5,2)(1,1.75)(0.5,2)
    \closepath}
\end{pspicture}
```



Here, the style named `mystyle` is set as

```
\newpsstyle{mystyle}%
           {linestyle=solid,%
            linewidth=2pt,%
            linecolor=Yellow,%
            fillstyle=gradient,%
            gradbegin=Yellow,%
            gradend=Red,%
            gradangle=10,%
            gradmidpoint=1}
```

We have also drawn two coordinate grids, the lighter one showing the original system and the darker one showing the changed system, the codes of which are not shown in the example.

We can also use (within `\pscustom`) the command `\scale` to scale the coordinate axes. It takes two numbers as arguments, the x-axis scaled by the first number and the y-axis scaled by the second number, as in this example:

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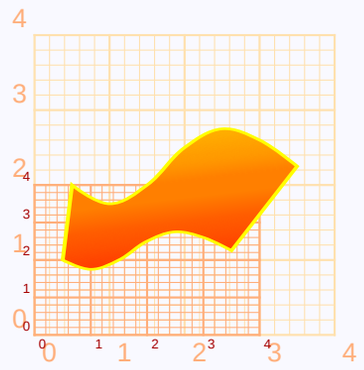
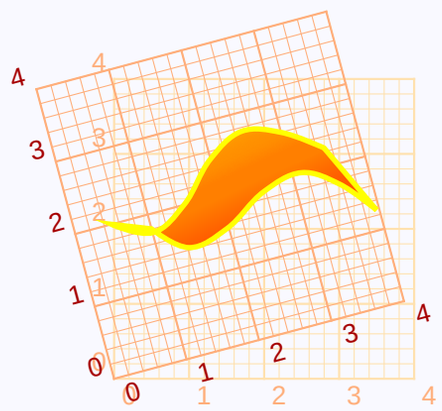
```
\begin{pspicture}(0,-1)(4,4.5)
  \pscustom[style=mystyle]{%
    \pscurve(0.5,2)(1,1.75)(1.5,2)(2,2.5)%
            (2.5,2.75)(3,2.6)(3.5,2.25)
    \scale{0.75 0.5}
    \pscurve[liftpen=1]%
      (3.5,2.25)(3,2.6) (2.5,2.75)%
      (2,2.5)(1.5,2)(1,1.75)(0.5,2)
    \closepath}
\end{pspicture}
```



If both axes are to be scaled by the same factor, we need only specify this number only once within the `\scale` command.

The command `\rotate` (surprise!) rotates the axes by the angle specified in degrees, as in the example below:

```
\begin{pspicture}(-2,-1)(4,5)
  \pscustom[style=mystyle]{%
    \pscurve(0.5,2)(1,1.75)(1.5,2)(2,2.5)%
            (2.5,2.75)(3,2.6)(3.5,2.25)
    \rotate{15}
    \pscurve[liftpen=1]%
            (3.5,2.25)(3,2.6) (2.5,2.75)%
            (2,2.5)(1.5,2)(1,1.75)(0.5,2)
    \closepath}
\end{pspicture}
```



The coordinate axes can be interchanged with the `\swapaxes` command.

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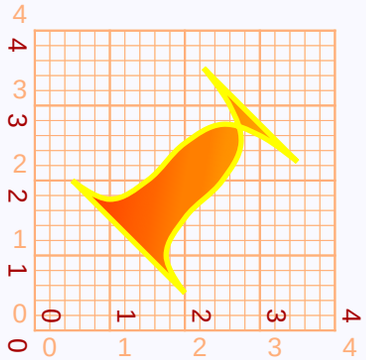
```
\begin{pspicture}(0,-1)(4,4.5)
  \palecolgrid(0,0)(4,4)
  \rput{-90}{\colgrid[xunit=-1cm,yunit=1cm](0,0)(4,4)}
  \pscustom[style=mystyle]{%
    \pscurve(0.5,2)(1,1.75)(1.5,2)(2,2.5)%
            (2.5,2.75)(3,2.6)(3.5,2.25)
    \swapaxes
    \pscurve[liftpen=1]%
            (3.5,2.25)(3,2.6) (2.5,2.75)%
            (2,2.5)(1.5,2)(1,1.75)(0.5,2)
    \closepath}
\end{pspicture}
```



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