PSTricks is distributed with a much more general loop macro, called \texttt{multido}. You must input the file \texttt{multido.tex} or \texttt{multido.sty}. See the documentation \texttt{multido.doc} for details. Here is a sample of what you can do:

\begin{pspicture}(-3.4,-3.4)(3.4,3.4)
\newgray{mygray}{0} % Initialize 'mygray' for benefit
\psset{fillstyle=solid,fillcolor=mygray} % of this line.
\SpecialCoor
\degrees[1.1]
\multido{\n=0.0+.1}{11}{%
\newgray{mygray}{\n}
\rput{\n}{\pswedge{3}{-.05}{.05}}
\uput{3.2}[\n](0,0){\small \n}}
\end{pspicture}

All of these loop macros can be nested.

26 Axes

The axes command described in this section is defined in \texttt{pst-plot.tex} / \texttt{pst-plot.sty}, which you must input first. \texttt{pst-plot.tex}, in turn, will automatically input \texttt{multido.tex}, which is used for putting the labels on the axes.
The macro for making axes is:

\[ \texttt{\textbackslash psaxes\{par\}[arrows](x0,y0)(x1,y1)(x2,y2)} \]

The coordinates must be Cartesian coordinates. They work the same way as with \texttt{\textbackslash psgrid}. That is, if we imagine that the axes are enclosed in a rectangle, \((x1,y1)\) and \((x2,y2)\) are opposing corners of the rectangle. (I.e., the x-axis extends from \(x1\) to \(x2\) and the y-axis extends from \(y1\) to \(y2\).) The axes intersect at \((x0,y0)\). For example:

\[
\texttt{\textbackslash psaxes[linewidth=1.2pt,labels=none, ticks=none]{<->}(2,1)(0,0)(4,3)}
\]

If \((x0,y0)\) is omitted, then the origin is \((x1,y1)\). If both \((x0,y0)\) and \((x1,y1)\) are omitted, \((0,0)\) is used as the default. For example, when the axes enclose a single orthont, only \((x2,y2)\) is needed:

\[
\texttt{\textbackslash psaxes{-}\textbackslash{\textbackslash{\textbackslash{\textbackslash(4,2)}}}}
\]

Labels (numbers) are put next to the axes, on the same side as \(x1\) and \(y1\). Thus, if we enclose a different orthont, the numbers end up in the right place:

\[
\texttt{\textbackslash psaxes{-}\textbackslash{\textbackslash{\textbackslash(4,-2)}}}
\]

Also, if you set the \texttt{arrows} parameter, the first arrow is used for the tips at \(x1\) and \(y1\), while the second arrow is used for the tips at \(x2\) and \(y2\). Thus, in the preceding examples, the arrowheads ended up in the right place too.\footnote{Including a first arrow in these examples would have had no effect because arrows are never drawn at the origin.}
When the axes don’t just enclose an orthont, that is, when the origin is not at a corner, there is some discretion as to where the numbers should go. The rules for positioning the numbers and arrows described above still apply, and so you can position the numbers as you please by switching $y_1$ and $y_2$, or $x_1$ and $x_2$. For example, compare

\[
\text{\psaxes{<->}(0,0)(-2.5,0)(2.5,2.5)}
\]

with what we get when $x_1$ and $x_2$ are switched:

\[
\text{\psaxes{<->}(0,0)(2.5,0)(-2.5,2.5)}
\]

\text{\psaxes} puts the ticks and numbers on the axes at regular intervals, using the following parameters:

<table>
<thead>
<tr>
<th>Horizontal</th>
<th>Vertical</th>
<th>Dflt</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$O_x=\text{num}$</td>
<td>$O_y=\text{num}$</td>
<td>0</td>
<td>Label at origin.</td>
</tr>
<tr>
<td>$D_x=\text{num}$</td>
<td>$D_y=\text{num}$</td>
<td>1</td>
<td>Label increment.</td>
</tr>
<tr>
<td>$d_x=\text{dim}$</td>
<td>$o_y=\text{dim}$</td>
<td>0pt</td>
<td>Dist btwn labels.</td>
</tr>
</tbody>
</table>

When $d_x$ is 0, $D_x \times \text{\psxunit}$ is used instead, and similarly for $d_y$. Hence, the default values of 0pt for $d_x$ and $d_y$ are not as peculiar as they seem.

You have to be very careful when setting $O_x$, $D_x$, $O_y$ and $D_y$ to non-integer values. \text{multido.tex} increments the labels using rudimentary fixed-point arithmetic, and it will come up with the wrong answer unless $O_x$ and $D_x$, or $O_y$ and $D_y$, have the same number of digits to the right of the decimal. The only exception is that $O_x$ or $O_y$ can always be an integer, even if $D_x$ or $D_y$ is not. (The converse does not work, however.)\textsuperscript{13}

\textsuperscript{13}For example, $O_x=1.0$ and $D_x=1.4$ is okay, as is $O_x=1$ and $D_x=1.4$, but $O_x=1.4$ and $D_x=1$, or $O_x=1.4$ and $D_x=1.15$, is not okay. If you get this wrong, \textsc{PSTricks} won’t complain, but you won’t get the right labels either.
Note that \textbackslash psaxes’s first coordinate argument determines the physical position of the origin, but it doesn’t affect the label at the origin. E.g., if the origin is at (1,1), the origin is still labeled 0 along each axis, unless you explicitly change $Ox$ and $Oy$. For example:

```
\psaxes[Ox=-2]([-2,0)(2,3])
```

The ticks and labels use a few other parameters as well:

\begin{itemize}
\item \textbf{labels=\textit{all/x/y/none}} \hspace{1cm} \textbf{Default: all}
  \begin{itemize}
  \item To specify whether labels appear on both axes, the x-axis, the y-axis, or neither.
  \end{itemize}
\item \textbf{showorigin=true/false} \hspace{1cm} \textbf{Default: true}
  \begin{itemize}
  \item If true, then labels are placed at the origin, as long as the label doesn’t end up on one of the axes. If false, the labels are never placed at the origin.
  \end{itemize}
\item \textbf{ticks=\textit{all/x/y/none}} \hspace{1cm} \textbf{Default: all}
  \begin{itemize}
  \item To specify whether ticks appear on both axes, the x-axis, the y-axis, or neither.
  \end{itemize}
\item \textbf{tickstyle=\textit{full/top/bottom}} \hspace{1cm} \textbf{Default: full}
  \begin{itemize}
  \item For example, if \textbf{tickstyle=top}, then the ticks are only on the side of the axes away from the labels. If \textbf{tickstyle=bottom}, the ticks are on the same side as the labels. \textbf{full} gives ticks extending on both sides.
  \end{itemize}
\item \textbf{ticksize=\textit{dim}} \hspace{1cm} \textbf{Default: 3pt}
  \begin{itemize}
  \item Ticks extend $dim$ above and/or below the axis.
  \end{itemize}
\end{itemize}

The distance between ticks and labels is \textbackslash pslabelsep, which you can change with the \texttt{labelsep} parameter.

The labels are set in the current font (ome of the examples above were preceded by \texttt{small} so that the labels would be smaller). You can do fancy things with the labels by redefining the commands:
\psxlabel
\psylabel

E.g., if you want to change the font of the horizontal labels, but not the vertical labels, try something like

\def\psxlabel#1{\small #1}

You can choose to have a frame instead of axes, or no axes at all (but you still get the ticks and labels), with the parameter:

\textbf{axesstyle=axes/frame/none} \hspace{1cm} \textbf{Default: axes}

The usual linestyle, fillstyle and related parameters apply.

For example:

\begin{center}
\begin{pspicture}(-3,3)
\psaxes[Dx=.5,dx=1,tickstyle=top,axesstyle=frame](-3,3)
\end{pspicture}
\end{center}

The \texttt{psaxes} macro is pretty flexible, but \texttt{PSTricks} contains some other tools for making axes from scratch. E.g., you can use \texttt{psline} and \texttt{psframe} to draw axes and frames, respectively, \texttt{multido} to generate labels (see the documentation for \texttt{multido.tex}), and \texttt{multips} to make ticks.
27 Framed boxes

The macros for framing boxes take their argument, put it in an \hbox, and put a PostScript frame around it. (They are analogous to \TeX’s \fbox). Thus, they are composite objects rather than pure graphics objects. In addition to the graphics parameters for \psframe, these macros use the following parameters:

\textbf{framesep=$dim$} \hspace{1cm} \textbf{Default: 3pt}

Distance between each side of a frame and the enclosed box.

\textbf{boxsep=true/false} \hspace{1cm} \textbf{Default: true}

When true, the box that is produced is the size of the frame or whatever that is drawn around the object. When false, the box that is produced is the size of whatever is inside, and so the frame is “transparent” to \TeX. This parameter only applies to \psframebox, \pscirclebox, and \psovalbox.

Here are the three box-framing macros:

\textbf{\psframebox*[par]{stuff}}

A simple frame (perhaps with rounded corners) is drawn using \psframe. The * option is of particular interest. It generates a solid frame whose color is fillcolor (rather than linecolor, as with the closed graphics objects). Recall that the default value of fillcolor is white, and so this has the effect of blotting out whatever is behind the box. For example,

\begin{verbatim}
\pspolygon[fillcolor=gray,fillstyle=crosshatch*](0,0)(3,0)
(3,2)(2,2)
\put(2,1){\psframebox*[framearc=.3]{Label}}
\end{verbatim}
\psdblframebox*[par]{stuff}
This draws a double frame. It is just a variant of \psframebox, defined by
\newpsobject{psdblframebox}{psframebox}{doublesep=\pslinewidth}

For example,
\psdblframebox*[linewidth=1.5pt]{%\parbox[c]{6cm}{\raggedright A double frame is drawn with the gap between lines equal to doublesep}}

A double frame is drawn with the gap between lines equal to doublesep

\pssshadowbox*[par]{stuff}
This draws a single frame, with a shadow.

\pssshadowbox{\bf Great Idea!!}

You can get the shadow with \psframebox just be setting the shadowsize parameter, but with \psframebox the dimensions of the box won’t reflect the shadow (which may be what you want!).

\pscirclebox*[par]{stuff}
This draws a circle. With boxsep=true, the size of the box is close to but may be larger than the size of the circle. For example:

You are here
\pscirclebox{\begin{tabular}{c} You are \hline here \end{tabular}}

\cput*[par]{angle}{x,y}{stuff}
This combines the functions of \pscirclebox and \rput. It is like \rput{<angle>}(x0,y0){\string\pscirclebox*[<par>]{<stuff>}}

but it is more efficient. Unlike the \rput command, there is no argument for changing the reference point; it is always the center of the box. Instead, there is an optional argument for changing graphics parameters. For example
The command

\psclip{graphics} \ldots \endpsclip

sets the clipping path to the path drawn by the graphics object(s), until the \endpsclip command is reached. \psclip and \endpsclip must be properly nested with respect to \TeX\ grouping. Only pure graphics (those described in Part II and \pscustom) are permitted. An Overfull \hbox warning indicates that the graphics argument contains extraneous output or space. Note that the graphics objects otherwise act as usual, and the \psclip does not otherwise affect the surrounded text. Here is an example:
“One of the best new plays I have seen all year: cool, poetic, ironic …” proclaimed *The Guardian* upon the London premiere of this extraordinary play about a Czech director and his actress wife, confronting exile in America.

If you don’t want the outline to be painted, you need to include `linestyle=none` in the parameter changes. You can actually include more than one graphics object in the argument, in which case the clipping path is set to the intersection of the paths.

\texttt{\textbackslash psclip} can be a useful tool in picture environments. For example, here it is used to shade the region between two curves:

\begin{pspicture}(0,0)(4,4)
\psframe*[linecolor=gray](0,0)(4,4)
\psplot[linewidth=1.5pt]{.5}{4}{2 x div}
\psplot[linewidth=1.5pt]{0}{3}{3 x x mul 3 div sub}
\psaxes(4,4)
\endpspicture

Driver notes: The clipping macros use \texttt{\textbackslash pstverb} and \texttt{\textbackslash pstVerb}. Don’t be surprised if PSTricks’s clipping does not work or causes problem—it is never robust. \texttt{\textbackslash endpsclip} uses \texttt{\textbackslash initclip}. This can interfere with other clipping operations, and especially if the \TeX{} document is converted to an Encapsulated PostScript file. The command \texttt{\textbackslash \textbackslash AltClipMode} causes \texttt{\textbackslash psclip} and \texttt{\textbackslash endpsclip} to use \texttt{\textbackslash gsave} and \texttt{\textbackslash grestore} instead. This bothers some drivers, such as NeXt\TeX{}’s TeXView, especially if \texttt{\textbackslash psclip} and \texttt{\textbackslash endpsclip} do not end up on the same page.

## 29 Rotation and scaling boxes

There are versions of the standard box rotation macros:

\texttt{\textbackslash rotateleft\{stuff\}}
\rotateright{stuff} \rotatedown{stuff}

\textit{stuff} is put in an \texttt{hbox} and then rotated or scaled, leaving the appropriate amount of spaces. Here are a few uninteresting examples:

\Large\bf \rotateleft{Left} \rotatedown{Down} \rotateright{Right}

There are also two box scaling macros:

\texttt{\scalebox{\texttt{num1 num2}}{stuff}}

If you give two numbers in the first argument, \texttt{num1} is used to scale horizontally and \texttt{num2} is used to scale vertically. If you give just one number, the box is scaled by the same in both directions. You can’t scale by zero, but negative numbers are OK, and have the effect of flipping the box around the axis. You never know when you need to do something like \texttt{\scalebox{-1 1}{this}}.

\texttt{\scaleboxto(x,y){stuff}}

This time, the first argument is a (Cartesian) coordinate, and the box is scaled to have width \texttt{x} and height (plus depth) \texttt{y}. If one of the dimensions is 0, the box is scaled by the same amount in both directions. For example:

\scaleboxto(4,2){Big and long}

PSTricks defines LR-box environments for all these box rotation and scaling commands:

\pslongbox{Rotateleft}{\rotateleft} \pslongbox{Rotateright}{\rotateright} \pslongbox{Rotatedown}{\rotatedown} \pslongbox{Scalebox}{\scalebox} \pslongbox{Scaleboxto}{\scaleboxto}

Here is an example where we \texttt{\Rotatedown} for the answers to exercises:
Question: How do Democrats organize a firing squad?

Answer: First they get in a circle, ...
All the commands described in this part are contained in the file \texttt{pst-node.tex/pst-node.sty}.

The node and node connection macros let you connect information and place labels, without knowing the exact position of what you are connecting or of where the lines should connect. These macros are useful for making graphs and trees, mathematical diagrams, linguistic syntax diagrams, and connecting ideas of any kind. They are the trickiest tricks in PStricks!

Although you might use these macros in pictures, positioning and rotating them with \texttt{rput}, you can actually use them anywhere. For example, I might do something like this in a guide about page styles:

\begin{verbatim}
\makeatletter
\gdef\ps@temp{\def\@oddhead{\def\@evenhead{}}
\def\@oddfoot{\small\sf
\ovalnode[boxsep=false]{A}{\rightmark}
nccurve[ncurv=.5,angleB=240,angleA=180,nodesep=6pt][<](){A}{B}
\hfil\thepage}
\let\@evenfoot\@oddfoot}
\makeatother
\thispagestyle{temp}
\end{verbatim}

With the myfooters page style, the name of the current section appears at the bottom of each page.

You can use nodes in math mode and in alignment environments as well. Here is an example of a commutative diagram:
There are three components to the node macros:

**Node definitions** The node definitions let you assign a name and shape to an object. See Section 30.

**Node connections** The node connections connect two nodes, identified by their names. See Section 31.

**Node labels** The node label commands let you affix labels to the node connections. See Section 32.

### 30 Nodes

The name of a node must contain only letters and numbers, and must begin with a letter.

*Warning: Bad node names can cause PostScript errors.*

\begin{array}{c@{\hskip 1cm}c}
\rnode{a}{A} & \rnode{b}{B} & \rnode{c}{C}
\end{array}

\begin{verypsbox}{\scriptstyle}
\ncline{->}{a}{b}\Bput{f}
\ncline{->}{a}{c}\Aput{g}
\ncline[linestyle=dotted]{->}{b}{c}\Aput{h}
\end{verypsbox}

\begin{psset}{nodesep=3pt}
\begin{psnodebox}{\scriptstyle}
\ncline{->}[a]{1}\Bput{f}
\ncline{->}{a}{2}\Aput{g}
\ncline[linestyle=dotted]{->}{2}{c}\Aput{h}
\end{psnodebox}
\end{psset}

\rnode{[refpoint]}{name}{stuff}

This assigns the name to the node, which will have a rectangular shape for the purpose of making connections, with the “center” at the reference point (i.e., node connections will point to the reference point. \rnode was used in the two examples above.

\Rnode(x, y){name}{stuff}

This is like \rnode, but the reference point is calculated differently. It is set to the middle of the box’s baseline, plus \(x, y\). If you omit the \((x, y)\) argument, command

\RnodeRef
is substituted. The default definition of \RnodeRef is 0.7ex. E.g.,
the following are equivalent:

$$\text{\Rnode(0,0.6ex){stuff}}$$
$$\text{\{\def\RnodeRef{0,0.6ex}\Rnode{stuff}}$$

\Rnode is useful when aligning nodes by their baaleines, such as in
commutative diagrams. With \node horizontal node connections
might not be quite horizontal, because of differences in the size
of letters.

\pnode\((x, y)\){name}
This creates a zero dimensional node at the point \((x, y)\) (default
(0,0)).

\cnode*[par]\((x, y)\){radius}{name}
This draws a circle and assigns the name to it.

\circlenode*[par]{name}{stuff}
This is a variant of \pscirclebox that gives the node the shape of
the circle.

\cnodeput*[par]{angle}(x, y){name}{stuff}
This is a variant of \cput that gives the node the shape of the
circle.

\ovalnode*[par]{name}{stuff}
This is a variant of \psovalbox that gives the node the shape of the
ellipse.

The reason that there is no \framenode command is that using \psframe-
box (or \psshadowbox or \psbbox) in the argument of \node
gives the desired result.

31 Node connections

All the node connection commands begin with nc, and they all have the
same syntax:

\langle nodeconnection\rangle\{<par>\}{<arrows>}{<nodeA>}{<nodeB>\}
A line of some sort is drawn from nodeA to nodeB. Some of the node connection commands are a little confusing, but with a little experimentation you will figure them out, and you will be amazed at the things you can do.

The node and point connections can be used with \pscustom. The beginning of the node connection is attached to the current point by a straight line, as with \psarc.\(^\text{14}\)

When we refer to the A and B nodes below, we are referring only to the order in which the names are given as arguments to the node connection macros.

When a node name cannot be found on the same page as the node connection command, you get either no node connection or a nonsense node connection. However, \TeX{} will not report any errors.

The node connections use the following parameters:

- **nodesep=dim**
  
  Default: 0

  The border around the nodes added for the purpose of determining where to connect the lines.

- **offset=dim**
  
  Default: 0

  After the node connection point is calculated, it is shift up for nodeA and down for nodeB by dim, where “up” and “down” assume that the connecting line points to the right from the node.

- **arm=dim**
  
  Default: 10pt

  Some node connections start with a segment of length dim before turning somewhere.

- **angle=angle**
  
  Default: 0

  Some node connections let you specify the angle that the node connection should connect to the node.

- **arcangle=angle**
  
  Default: 8

  This applies only to \ncarc, and is described below.

- **ncurv=num**
  
  Default: .67

  This applies only to \ncurve and \pcurve, and is described below.

\(^\text{14}\)See page 71 if you want to use the nodes as coordinates in other PStricks macros.
**loopsize=dim**  
Default: 1cm

This applies only the `\ncloop` and `\pcloop`, and is described below.

You can set these parameters separately for the two nodes. Just add an `A` or `B` to the parameter name. E.g.

```latex
\psset{nodesepA=3pt, offsetA=5pt, offsetB=3pt, arm=1cm}
```

sets `nodesep` for the `A` node, but leaves the value for the `B` node unchanged, sets `offset` for the `A` and `B` nodes to different values, and sets `arm` for the `A` and `B` nodes to the same value.

Don’t forget that by using the `border` parameter, you can create the impression that one node connection passes over another.

Here is a description of the individual node connection commands:

- **\ncline**\[par\]{arrows}{nodeA}{nodeB}
  
  This draws a straight line between the nodes. Only the `offset` and `nodesep` parameters are used.

  ```latex
  \put[bl](0,0){\rnode{A}{Idea 1}}
  \put[tr](4,3){\ovalnode{B}{Idea 2}}
  \ncline[nodesep=3pt]{<->}{A}{B}
  ```

- **\ncLine**\[par\]{arrows}{nodeA}{nodeB}
  
  This is like `\ncline`, but the labels (with `\put`, etc) are positioned as if the line began and ended at the center of the nodes. This is useful if you have multiple parallel lines and you want the labels to line up, even though the nodes are of varying size, e.g., in commutative diagrams.

  ```latex
  \put[bl](0,0){\rnode{A}{\psframebox{Node A}}}
  \put[tr](4,3){\ovalnode{B}{Node B}}
  \ncLine[angleB=180]{A}{B}
  ```

- **\nccurve**\[par\]{arrows}{nodeA}{nodeB}
  
  This draws a bezier curve between the nodes. It uses the `nodesep`, `offset`, `angle` and `ncurv` parameters.

  ```latex
  \put[bl](0,0){\rnode{A}{\psframebox{Node A}}}
  \put[tr](4,3){\ovalnode{B}{Node B}}
  \ncurve[angleB=180]{A}{B}
  ```

Node connections 62
\ncarc*[par]{arrows}{nodeA}{nodeB}

This is actually a variant of \ncurve. I.e., it also connects the nodes with a bezier curve, using the \nodesep, offset, and ncurv parameters. However, the curve connects to node A at an angle \arcangleA from the line between A and B, and connects to node B at an angle -\arcangleB from the line between B and A. For small, equal values of \angleA and \angleB (e.g., the default value of 8) and with the default value of ncurv, the curve approximates an arc of a circle. \ncarc is a nice way to connect two nodes with two lines.

\ncnodeput(0,0){A}{X}
\ncnodeput(3,2){B}{Y}
\psset{nodesep=3pt}
\ncarc->{(A)(B)}
\ncarc->{(B)(A)}

\ncbar*[par]{arrows}{nodeA}{nodeB}

First, lines are drawn attaching to both nodes at an angle \angleA and of lengths \armA and \armB. Then one of the arms is extended so that when the two are connected, the finished line contains 3 segments meeting at right angles. Generally, the whole line has three straight segments. The value of linearc is used for rounding the corners.

\node{A}[[Connect] some \node{B}{words}!]
\ncbar[nodesep=3pt,angle=-90,**]|*[<]{(A)(B)}

\ncdiag*[par]{arrows}{nodeA}{nodeB}

First, the arms are drawn using \angle and \arm. Then they are connected with a straight line. Generally, the whole line has three straight segments. The value of linearc is used for rounding the corners.

\rput[tl](0,3){\rnode{A}{\psframebox{Node A}}}
\rput[br](4,0){\ovalnode{B}{Node B}}
\ncdiag[angleA=-90,angleB=90,arm=5,linearc=.2](A)(B)
\ncdiagg*[par]{arrows}{nodeA}{nodeB}

This is similar to \ncdiag, but only the arm for node A is drawn. The end of this arm is then connected directly to node B. The connection typically has two segments. The value of linearc is used for rounding the corners.

\node(0,0){4pt}{a}
\rput[l](3,1){\rnode{b}{H}}
\rput[l](3,-1){\rnode{c}{T}}
\ncdiagg[angleA=180,armA=2cm,nodesepA=3pt]{b}{a}
\ncdiagg[angleA=180,armA=2cm,nodesepA=3pt]{c}{a}

\ncangle*[par]{arrows}{nodeA}{nodeB}

The node connection points are determined by angleA and angleB (and nodeseq and offset). Then an arm is drawn for node B using armB. This arm is connected to node A by a right angle, that also meets node A at angle angleA. Generally, the whole line has three straight segments, but it can have fewer. The value of linearc is used for rounding the corners. Simple, right? Here is an example:

\ncangles*[par]{arrows}{nodeA}{nodeB}

This is similar to \ncangle, but both armA and armB are used. The arms are connected by a right angle that meets arm A at a right angle as well. Generally there are four segments (hence one more angle than \ncangle, and hence the s in \ncangles). The value of linearc is used for rounding the corners. Compare this example with the previous one:
\texttt{\textbackslash ncloop*[par]{arrows}{node}A}{node}B\)

The first segment is \texttt{arm}A, then it makes a 90 degree turn to the left, drawing a segment of length \texttt{loopp}size. The next segment is again at a right angle; it connects to \texttt{arm}B. For example:

\begin{verbatim}
\node(a){\psframebox\{\Huge A loop\}}
\ncloop[angleB=180,looppsize=1,arm=.5,linearc=.2]{->}{a}{a}
\end{verbatim}

\texttt{\textbackslash nccircle*[par]{arrows}{node}{radius}\)

This draws a circle from a node to itself. It is the only node connection command of this sort. The circle starts at angle \texttt{angle}A and goes around the node counterclockwise, at a distance \texttt{nodesep}A from the node.

The node connection commands make interesting drawing tools as well, as an alternative to \texttt{\psline} for connecting two points. There are variants of the node connection commands for this purpose. Each begins with \texttt{pc} (for “point connection”) rather than \texttt{nc}. E.g.,

\begin{verbatim}
\pcarc{<->}(3,4)(6,9)
\end{verbatim}

gives the same result as

\begin{verbatim}
\pnode(3,4){A}\pnode(6,9){B}\pcarc{<->}{A}{B}
\end{verbatim}

Only \texttt{\ncLine} and \texttt{\nccircle} do not have \texttt{pc} variants:

\texttt{\textbackslash pcline*[par]{arrows}x1,y1x2,y2}\)

Like \texttt{\ncline}.

\texttt{\textbackslash pccurve*[par]{arrows}x1,y1x2,y2}\)

Like \texttt{\nccurve}.

\texttt{\textbackslash pcarc*[par]{arrows}x1,y1x2,y2}\)

Like \texttt{\ncarc}.

\texttt{\textbackslash pcbar*[par]{arrows}x1,y1x2,y2}\)

Like \texttt{\ncbar}.

\texttt{\textbackslash pcdiag*[par]{arrows}x1,y1x2,y2}\)

Like \texttt{\ncdiag}.
32 Attaching labels to node connections

Now we come to the commands for attaching labels to the node connections. The node label command must come right after the node connection to which the label is to be attached. You can attach more than one label to a node connection, and a label can include more nodes.

The node label commands must end up on the same \TeX{} page as the node connection to which the label corresponds.

The coordinate argument in other PSTricks put commands is a single number in the node label commands: \texttt{(pos)}. This number selects a point on the node connection, roughly according to the following scheme:

Each node connection has potentially one or more segments, including the arms and connecting lines. A number \texttt{pos} between 0 and 1 picks a point on the first segment from node A to B, (fraction \texttt{pos} from the beginning to the end of the segment), a number between 1 and 2 picks a number on the second segment, and so on. Each node connection has its own default value of the positioning coordinate, which is used by some short versions of the label commands.

Here are the details for each node connection:

<table>
<thead>
<tr>
<th>Connection</th>
<th>Segments</th>
<th>Range</th>
<th>Default</th>
</tr>
</thead>
<tbody>
<tr>
<td>\texttt{\textbackslash incline}</td>
<td>1</td>
<td>$0 \leq \texttt{pos} \leq 1$</td>
<td>0.5</td>
</tr>
<tr>
<td>\texttt{\textbackslash incurve}</td>
<td>1</td>
<td>$0 \leq \texttt{pos} \leq 1$</td>
<td>0.5</td>
</tr>
<tr>
<td>\texttt{\textbackslash incarc}</td>
<td>1</td>
<td>$0 \leq \texttt{pos} \leq 1$</td>
<td>0.5</td>
</tr>
<tr>
<td>\texttt{\textbackslash incbar}</td>
<td>3</td>
<td>$0 \leq \texttt{pos} \leq 3$</td>
<td>1.5</td>
</tr>
<tr>
<td>\texttt{\textbackslash incdiag}</td>
<td>3</td>
<td>$0 \leq \texttt{pos} \leq 3$</td>
<td>1.5</td>
</tr>
<tr>
<td>\texttt{\textbackslash incdiagg}</td>
<td>2</td>
<td>$0 \leq \texttt{pos} \leq 2$</td>
<td>0.5</td>
</tr>
<tr>
<td>\texttt{\textbackslash incangle}</td>
<td>3</td>
<td>$0 \leq \texttt{pos} \leq 3$</td>
<td>1.5</td>
</tr>
<tr>
<td>\texttt{\textbackslash incloop}</td>
<td>5</td>
<td>$0 \leq \texttt{pos} \leq 4$</td>
<td>2.5</td>
</tr>
<tr>
<td>\texttt{\textbackslash incircle}</td>
<td>1</td>
<td>$0 \leq \texttt{pos} \leq 1$</td>
<td>0.5</td>
</tr>
</tbody>
</table>

There is another difference between the node label commands and other put commands. In addition to the various ways of specifying the angle...
of rotation for \rput, with the node label commands the angle can be of the form \{angle\}. In this case, the angle is calculated after rotating the coordinate system so that the node connection at the position of the label points to the right (from nodes A to B). E.g., if the angle is \{:U\}, then the label runs parallel to the node connection.

Here are the node label commands:

\[ \text{lput}*[\text{refpoint}][\text{rotation}](\text{pos})\{\text{stuff}} \]

The \text{l} stands for “label”. Here is an example illustrating the use of the optional star and \text{angle} with \text{lput}, as well as the use of the \text{offset} parameter with \text{pcline}:

\begin{verbatim}
\pspolygon(0,0)(4,2)(4,0)
\pcline[\text{offset=12pt}]{|-|}(0,0)(4,2)
\text{lput}*[\text{:U}]{\text{Length}}
\end{verbatim}

(Remember that with the put commands, you can omit the coordinate if you include the angle of rotation. You are likely to use this feature with the node label commands.)

With \text{lput} and \text{rput}, you have a lot of control over the position of the label. E.g.,

\begin{verbatim}
\text{pcline}(0,0)(4,2)
\text{lput}[:U]{\text{\rput[r]{N}(0,.4){\text{label}}}}
\end{verbatim}

puts the label upright on the page, with right side located .4 centimeters “above” the position .5 of the node connection (above if the node connection points to the right). However, the \text{aput} and \text{bput} commands described below handle the most common cases without \text{rput}.15

15There is also an obsolete command \text{Lput} for putting labels next to node connections. The syntax is

\begin{verbatim}
\text{Lput}[@){\text{<labelsep>}}\{<refpoint>\}[@){\text{<rotation>}}(\text{<pos>})\{<stuff>}
\end{verbatim}

It is a combination of \text{Rput} and \text{lput}, equivalent to

\begin{verbatim}
\text{lput}(\text{<pos>})\{\text{\rput[@){\text{<labelsep>}}\{<refpoint>\}[@){\text{<rotation>}}(0,0)\{<stuff>}}
\end{verbatim}

\text{Mput} is a short version of \text{Lput} with no \{rotation\} or \{pos\} argument. \text{Lput} and \text{Mput} remain part of PStricks only for backwards compatibility.
\textbf{\texttt{\textbackslash aput*[labelsep][angle](pos){stuff}}} \\
\textit{stuff} is positioned distance \texttt{pslabelsep above} the node connection, given the convention that node connections point to the right. \texttt{\textbackslash aput} is a node-connection variant of \texttt{\textbackslash put}. For example:

\begin{verbatim}
\pspolygon(0,0)(4,2)(4,0)
\pcline[linestyle=none](0,0)(4,2)
\aput{:U}{Hypotenuse}
\end{verbatim}

\textbf{\texttt{\textbackslash bput*[labelsep][angle](pos){stuff}}} \\
This is like \texttt{\textbackslash aput}, but \textit{stuff} is positioned \textit{below} the node connection.

It is fairly common to want to use the default position and rotation with these node connections, but you have to include at least one of these arguments. Therefore, PStricks contains some variants:

\textbf{\texttt{\textbackslash mput*[refpoint]{stuff}}} \\
\textbf{\texttt{\textbackslash Aput*[labelsep]{stuff}}} \\
\textbf{\texttt{\textbackslash Bput*[labelsep]{stuff}}} \\
of \texttt{\textbackslash put}, \texttt{\textbackslash aput} and \texttt{\textbackslash bput}, respectively, that have no angle or positioning argument. For example:

\begin{verbatim}
\cnode*(0,0){3pt}{A}
\cnode*(4,2){3pt}{B}
\ncline[nodesep=3pt]{A}{B}
\mput*{1}
\end{verbatim}

Here is another:

\begin{verbatim}
\pcline{<->}(0,0)(4,2)
\Aput{Label}
\end{verbatim}

Now we can compare \texttt{\textbackslash ncline} with \texttt{\textbackslash ncLine}, and \texttt{\textbackslash node} with \texttt{\textbackslash Rnode}. First, here is a mathematical diagram with \texttt{\textbackslash ncLine} and \texttt{\textbackslash Rnode}:
Here is the same one, but with `\ncline` and `\rnode` instead:

\[
\begin{array}{cc}
(X-A; N-A) & (\tilde{X}; a) \\
\downarrow & \downarrow \\
(X; N) & (\tilde{X}; N)
\end{array}
\]

Driver notes: The node macros use `\pstVerb` and `\pstverbscale`.
33 Coils and zigzags

The file pst-coil.tex/pst-coil.sty (and optionally the header file pst-coil.pro) defines the following graphics objects for coils and zigzags:

\pscoil*[par]{arrows}(x0,y0)(x1,y1)
\psCoil*[par]{angle1}{angle2}
\pszigzag*[par]{arrows}(x0,y0)(x1,y1)

These graphics objects use the following parameters:

- coilwidth=dim  Default: 1cm
- coilheight=num  Default: 1
- coilarm=dim  Default: .5cm
- coilaspect=angle  Default: 45
- coilinc=angle  Default: 10

All coil and zigzag objects draw a coil or zigzag whose width (diameter) is coilwidth, and with the distance along the axes for each period (360 degrees) equal to coilheight x coilwidth.

Both \pscoil and \psCoil draw a “3D” coil, projected onto the xz-axes. The center of the 3D coil lies on the yz-plane at angle pcoilaspect to the z-axis. The coil is drawn with PostScript’s lineto, joining points that lie at angle coilinc from each other along the coil. Hence, increasing coilinc makes the curve smoother but the printing slower. \pszigzag does not use the coilaspect and coilinc parameters.

\pscoil and \pszigzag connect (x0,y0) and (x1,y1), starting and ending with straight line segments of length coilarmA and coilarmB, resp. Setting coilarm is the same as setting coilarmA and coilarmB.

Here is an example of \pscoil: