

DCpic v4.3.2

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The Current Maintainer of this work is Pedro Quaresma (`pedro@mat.uc.pt`).

This work consists of the files `dcpic.sty`.

Coimbra, 2009/12/22

Pedro Quaresma

1 History

11/1990 – **Version 1.0**

10/1991 – **Version 1.1**

9/1993 – **Version 1.2** – The distance from the arrow end points and the objects became a fixed number (10units), the distance arguments became optional. A new option for the arrows was introduced.

3/1995 – **Version 1.3** – The distance from the arrow to its label became fixed in 10units. A new option for the arrows was introduced.

7/1996 – **Version 2.1** – A new syntax for the “`mor`” command was introduced.

5/2001 – **Version 3.0** – Implementation of the command `cmor` for curved arrows.

11/2001 – **Versionão 3.1** The arrow’s tips became more \TeX -like.

1/2002 – **Version 3.2** – Introduction of the “Logical specification of diagrams”, the commands “`obj`” and “`mor`” were modified accordingly.

5/2002 – **Version 4.0** – **New syntax, non-compatible with past versions.** The commands `begindc`, `obj`, and `mor` were modified.

3/2003 – **Version 4.1** – New kind of arrows, “surjective arrows”, was added. The drawing of the double tip only works well in the vertical, or horizontal case.

12/2004 - **Version 4.1.1.** – New version for the drawing of surjective arrows, it solves the previous problem with it.

3/2007 - **version 4.2** – Adds the “`providespackage`” directive that was missing. Adds dashed lines, and dotted lines.

5/2008 - **version 4.2.1** – Deleting some counters, trying to avoid the problem “running out of counters”, that occurs because of the use of \PiCTeX and \DcPic (only two...)

8/2008 - **version 4.3** – Thanks to Ruben Debeerst (debeerst@mathematik.uni-kassel.de), he added a new arrow “`equalline`”. After that I decided to add: the `doublearrow`; the `doublearrow` with opposite directions; the null arrow. This last can be used as a simple form of adding new labels.

12/2008 - version 4.3.1 – The comand “id” is internalised (“!id”), it should be that way from the begining because it is not to be used from the outside. The comand “dasharrow” was changed to “dashArrow” to avoid a clash with the AMS command with the same name.

12/2009 - version 4.3.2 – There is a conflict between dcpic.sty and hyperref in current texlive-2009 due to the one letter macro (thanks Thorsten S ;thorsten.schwander@gmail.com;). The “d” changed to “deuc” (Euclidian Distance). The “x” and “y” changed to “xO” “yO”

2 Introduction

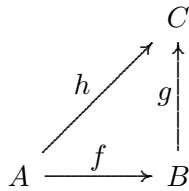
DCpic is a package of $\text{T}_{\text{E}}\text{X}$ [3] macros for graph modelling in a (La) $\text{T}_{\text{E}}\text{X}$ [4] or Con $\text{T}_{\text{E}}\text{X}$ t [5] document. Its distinguishing features are: the use of $\text{P}_{\text{T}}\text{C}_{\text{T}}\text{E}_{\text{X}}$ [7] a powerful graphical engine, and a simple specification syntax. A graph is described in terms of its objects and its edges. The objects are textual elements and the edges can have various straight or curved forms.

A graph [2] in DCpic is a “picture” in $\text{P}_{\text{T}}\text{C}_{\text{T}}\text{E}_{\text{X}}$, in which we place our *objects* and *morphisms* (edges). The user’s commands in DCpic are: `begindc` and `enddc` which establish the coordinate system where the objects will be placed; `obj`, the command which defines the place and the contents of each object; `mor`, and `cmor`, the commands which define the morphisms, linear and curved edges, and its labels.

Until version 3.2 DCpic “Commutative Diagrams in $\text{P}_{\text{T}}\text{C}_{\text{T}}\text{E}_{\text{X}}$ ” was dedicated to commutative diagrams [6] (“**Diagramas Comutativos**” in Portuguese) drawing, that is the reason for the name “obj” (objects) and “mor” (morphism) for the nodes and edges.

Example:

```
\begin{dc}{\commdiag}
  \obj(1,1){A}
  \obj(3,1){B}
  \obj(3,3){C}
  \mor{A}{B}{f}
  \mor{B}{C}{g}
  \mor{A}{C}{h}
\end{dc}
```



Note: all the numeric values should be integer values.

3 Description

3.1 Available commands

The environment:

```
\begin{dc}{#1}[#2]
  #1 - Graph type
    0 = "commdiag", commutative diagram
    1 = "digraph", direct graph
    2 = "undigraph", undirect graph
    3 = "cdigraph", direct graph with incircled objects
    4 = "cundigraph", undirect graph with incircled objects
  (optional) #2 - magnification factor (default value, 30)
\end{dc}
```

Objects:

```
\obj(#1,#2)[#3]{#4}[#5]
  #1 and #2 - coordinates
(optional) #3 - Label, to be used in the morphisms command, if not
              present the #4 will be used for that purpose
  #4 - Object contents
(optional) #5 - placement of the object (default value \north)
    0="\pcent", center
    1="\north", north
    2="\northeast", northeast
    3="\east", east
    4="\southeast", southeast
    5="\south", south
    6="\southwest", southwest
```

```
7="\west", west
8="\northwest", northwest
```

Note: if you omit the #3 argument (label), and the #4 argument is a complex (and long) L^AT_EX command, then this command can crash. In this case you must specify a label (the empty label [], if you do not intend to use the label).

Morphism (linear edges). This commando has two major variants:

1. Starting and Ending objects specification

```
\mor{#1}{#2}[#5,#6]{#7}[#8,#9]
```

As you can see this first form is (intentionally) badly formed, the arguments #3 and #4 are missing (the actual command is correctly formed).

#1 - The starting object reference

#2 - The ending object reference

from this two we will obtain the objects coordinates, and also the dimensions of the enclosing box.

The objects box dimensions are used to do an automatic adjustment of the edge width.

from #1 we obtain (x,y), (#1,#2) in the second form

from #2 we obtain (x',y'), (#3,#4) in the second form

this values will be passed to the command second form

2. Two points coordinates specification

```
\mor(#1,#2)(#3,#4)[#5,#6]{#7}[#8,#9]
```

Now we can describe all the arguments

```
#1 and #2 - coordinates (beginning)
#3 and #4 - coordinates (ending)
(optional)#5,#6 - correction factors (default values, 10 and 10)
#5 - actual beginning of the edge
#6 - actual ending of the edge
#7 - text (morphism label)
(optional)#8,#9
#8 - label placement
1 = \atright, at right, default value
```

```

-1 = \atleft, at left
#9 - edge type
0 = "\solidarrow", default value
1 = "\dashArrow"
2 = "\solidline"
3 = "\dashline"
4 = "\dotline"
5 = "\injectionarrow" - previous value 3 (v.<4.2)
6 = "\aplicationarrow" - previous value 4 (v.<4.2)
7 = "\surjectivearrow" - previous value 5 (v.<4.2)

```

Note: insert a space after the command.

Curved Morphisms (quadratic edges):

```

\cmor(#1) #2(#3,#4){#5}[#6]
#1 - list of points (odd number)
#2 - tip direction
0 = "\pup", pointing up
1 = "\pdown", pointing down
2 = "\pright", pointing right
3 = "\pleft", pointing left
#3 and #4 - coordenates of the label
#5 - morphism label
(optional) #6 - edge type
0 = "\solidarrow", default value
1 = "\dashArrow"
2 = "\solidline"

```

Notes: Insert a space after the command. The space after the list of points is mandatory.

4 Examples

4.1 Different types of lines/arrows

```

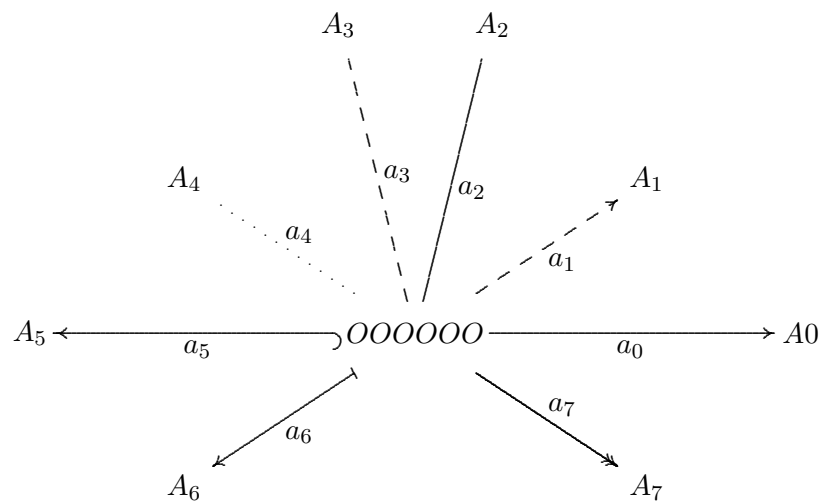
\begin{dc}{\commdiag}[29]
\obj(10,10)[A]{$000000$}
\obj(15,10)[A0]{$A0$}
\obj(13,12)[A1]{$A_1$}

```

```

\obj(11,14)[A2]{$A_2$}
\obj(9,14)[A3]{$A_3$}
\obj(7,12)[A4]{$A_4$}
\obj(5,10)[A5]{$A_5$}
\obj(7,8)[A6]{$A_6$}
\obj(13,8)[A7]{$A_7$}
\mor{A}{A0}{a_0$}[\atright,\solidarrow]
\mor{A}{A1}{a_1$}[\atright,\dashArrow]
\mor{A}{A2}{a_2$}[\atright,\solidline]
\mor{A}{A3}{a_3$}[\atright,\dashline]
\mor{A}{A4}{a_4$}[\atright,\dotline]
\mor{A}{A5}{a_5$}[\atleft,\injectionarrow]
\mor{A}{A6}{a_6$}[\atleft,\aplicationarrow]
\mor{A}{A7}{a_7$}[\atleft,\surjectivearrow]
\enddc

```



4.2 Diagrams with curved edges, double arrows, ...

Curved edges

```

\begin{dc}{3}
\obj(14,11){A$}
\obj(39,11){B$}
\mor(14,12)(39,12){f$}
\mor(39,10)(14,10){g$}
\cmor((10,10)(6,11)(5,15)(6,19)(10,20)(14,19)(15,15))
\pdown(2,20){id_A$}

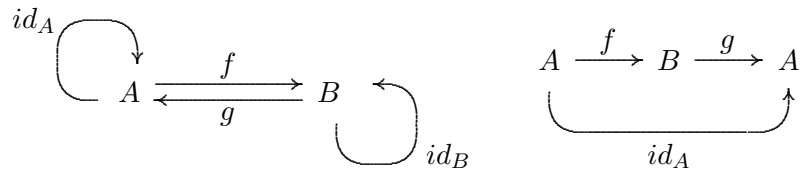
```

```

\cmor((40,7)(41,3)(45,2)(49,3)(50,7)(49,11)(45,12))
  \pleft(54,3){$id_B$}
\enddc

\begindc{\commdiag}[3]
\obj(10,15)[A]{$A$}
\obj(40,15)[Aa]{$A$}
\obj(25,15)[B]{$B$}
\mor{A}{B}{$f$}
\mor{B}{Aa}{$g$}
\cmor((10,11)(11,7)(15,6)(25,6)(35,6)(39,7)(40,11))
  \pup(25,3){$id_A$}
\enddc

```



Double arrows and Natural Transformations

```

\begindc{\commdiag}[1]
\obj(5,5){$A$}
\obj(20,5){$B$}
\mor(5,4)(20,4){$f$}[\atright,\solidarrow]
\mor(5,6)(20,6){$g$}
\enddc

\begindc{\commdiag}[14]
\obj(5,5){$A$}
\obj(9,5){$B$}
\mor(5,6)(9,6){$\downarrow\sigma$}[\atright,\solidarrow]
\mor{$A$}{$B$}{}
\mor(5,4)(9,4){$\downarrow\tau$}
\enddc

```



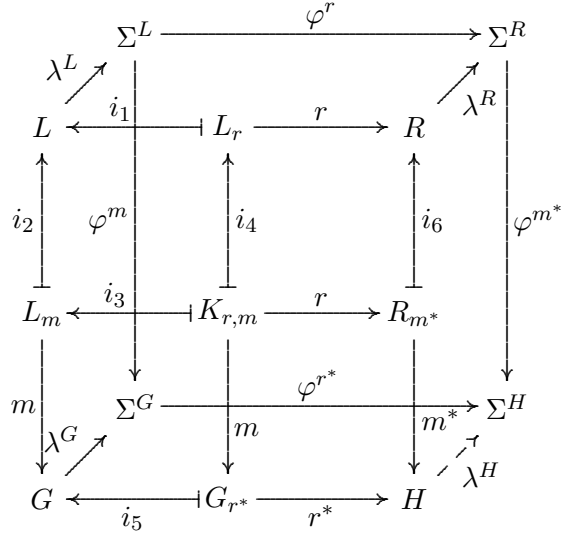
4.3 A complex diagram

The following diagram is one of the test-diagrams used by Feruglio [1], as we can see DCPic performs very well, drawing the complete diagram based on a very simple specification.

```

\newcommand{\barraA}{\vrule height2em width0em depth0em}
\newcommand{\barraB}{\vrule height1.6em width0em depth0em}
\begindc{\commdiag}[35]
\obj(1,1)[Gr]{$G$}
\obj(3,1)[Grstar]{$G_{r^*}$}
\obj(5,1)[H]{$H$}
\obj(2,2)[SigmaG]{$\Sigma^G$}
\obj(6,2)[SigmaH]{$\Sigma^H$}
\obj(1,3)[Lm]{$L_m$}
\obj(3,3)[Krm]{$K_{r,m}$}
\obj(5,3)[Rmstar]{$R_{m^*}$}
\obj(1,5)[L]{$L$}
\obj(3,5)[Lr]{$L_r$}
\obj(5,5)[R]{$R$}
\obj(2,6)[SigmaL]{$\Sigma^L$}
\obj(6,6)[SigmaR]{$\Sigma^R$}
\mor{Gr}{SigmaG}{$\lambda^G$}
\mor{Grstar}{Gr}{$i_5$}[\atleft,\aplicationarrow]
\mor{Grstar}{H}{$r^*$}[\atright,\solidarrow]
\mor{H}{SigmaH}{$\lambda^H$}[\atright,\dashArrow]
\mor{SigmaG}{SigmaH}{$\varphi^{r^*}$}[\atleft,\solidarrow]
\mor{Lm}{Gr}{$m$}[\atright,\solidarrow]
\mor{Lm}{L}{$i_2$}[\atleft,\aplicationarrow]
\mor{Krm}{Lm}{$i_3\text{quad}$}[\atright,\aplicationarrow]
\mor{Krm}{Rmstar}{$r$}
\mor{Krm}{Lr}{$i_4$}[\atright,\aplicationarrow]
\mor{Krm}{Grstar}{\barraA$m$}
\mor{Rmstar}{R}{$i_6$}[\atright,\aplicationarrow]
\mor{Rmstar}{H}{\barraB$m^*$}
\mor{L}{SigmaL}{$\lambda^L$}
\mor{Lr}{L}{$i_1\text{quad}$}[\atright,\aplicationarrow]
\mor{Lr}{R}{$r$}
\mor{R}{SigmaR}{$\lambda^R$}[\atright,\solidarrow]
\mor{SigmaL}{SigmaG}{$\varphi^m$}[\atright,\solidarrow]
\mor{SigmaL}{SigmaR}{$\varphi^r$}
\mor{SigmaR}{SigmaH}{$\varphi^{m^*}$}
\enddc

```



4.4 “Around the Word” [2]

```

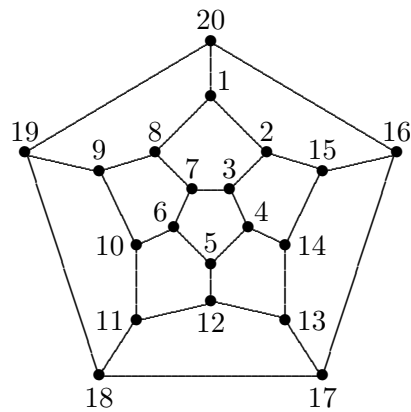
\begin{cd}{\undigraph}[7]
\obj(6,4){18}[\south]
\obj(18,4){17}[\south]
\obj(8,7){11}[\west]
\obj(12,8){12}[\south]
\obj(16,7){13}[\east]
\obj(8,11){10}[\west]
\obj(10,12){6}[\northwest]
\obj(12,10){5}
\obj(14,12){4}[\northeast]
\obj(16,11){14}[\east]
\obj(2,16){19}
\obj(6,15){9}
\obj(9,16){8}
\obj(11,14){7}
\obj(13,14){3}
\obj(15,16){2}
\obj(18,15){15}
\obj(22,16){16}
\obj(12,19){1}[\northeast]
\obj(12,22){20}
\mor{18}{17}{}\mor{18}{11}{}\mor{18}{19}{}
\mor{11}{12}{}\mor{11}{10}{}\mor{12}{13}{}
\mor{12}{5}{}\mor{10}{6}{}\mor{10}{9}{}

```

```

\mor{5}{6}{-}\mor{5}{4}{-}\mor{13}{17}{-}
\mor{13}{14}{-}\mor{9}{19}{-}\mor{9}{8}{-}
\mor{6}{7}{-}\mor{4}{3}{-}\mor{4}{14}{-}
\mor{19}{20}{-}\mor{8}{1}{-}\mor{8}{7}{-}
\mor{7}{3}{-}\mor{3}{2}{-}\mor{2}{1}{-}
\mor{2}{15}{-}\mor{14}{15}{-}\mor{17}{16}{-}
\mor{16}{20}{-}\mor{1}{20}{-}\mor{15}{16}{-}
\enddc

```

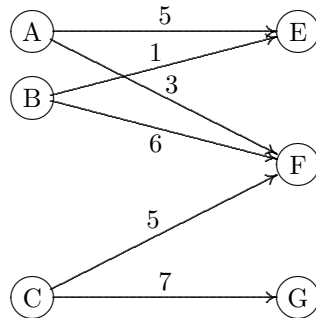


4.5 Incircled diagram

```

\begin{cdigraph}[25]
\obj(1,5){A}
\obj(1,4){B}
\obj(1,1){C}
\obj(5,5){E}
\obj(5,3){F}
\obj(5,1){G}
\mor{A}{E}[8,8]{5}
\mor{A}{F}[8,8]{3}
\mor{B}{F}[8,8]{6}[\atright,\solidarrow]
\mor{B}{E}[8,8]{1}
\mor{C}{F}[8,8]{5}
\mor{C}{G}[8,8]{7}
\end{cdigraph}

```



References

- [1] Feruglio, Gabriel Valiente. Typesetting commutative diagrams. *TUGboat*, 15(4):466–484, 1994.
- [2] Harary, Frank. 1972. *Graph Theory*. Reading, Massachusetts: Addison-Wesley.
- [3] Knuth, Donald E. *The TeXbook*. Addison-Wesley Publishing Company, Reading, Massachusetts, 1986.
- [4] Lamport, Leslie. *LaTeX: A Document Preparation System*. Addison-Wesley Publishing Company, Reading, Massachusetts, 2nd edition, 1994.
- [5] Otten, Ton and Hagen, Hans . *ConTeXt an excursion*. Pragma ADE, Hasselt, 1999.
- [6] Pierce, Benjamin. *Basic Category Theory for Computer Scientists*. Foundations of Computing. The MIT Press, London, England, 1998.
- [7] Wichura, Michael. *The PICTEX Manual*. Personal TeX Inc, 12 Madrona Avenue, Mill Valley, CA 94941 - USA, 3rd edition, March 1992

5 The Code

```

%% DC-PiCTeX
%% Copyright (c) 1990–2009 Pedro Quaresma, Coimbra, Portugal
%% 11/1990 (version 1.0);
%% 10/1991 (version 1.1);
%% 9/1993 (version 1.2);
%% 3/1995 (version 1.3);
%% 7/1996 (version 2.1);
%% 5/2001 (version 3.0);
%% 11/2001 (version 3.1);
%% 1/2002 (version 3.2)
%% 5/2002 (version 4.0);

```

```

%%      3/2003 (version 4.1);
%%      12/2004 (version 4.1.1)
%%      3/2007 (version 4.2)
%%      5/2008 (version 4.2.1)
%%      8/2008 (version 4.3)
%%      12/2008 (version 4.3.1)
%%      12/2009 (version 4.3.2)

\immediate\write10{Package DCpic 2009/12/22 v4.3.2}

\ProvidesPackage{dcpic}[2009/12/22 v4.3.2]

%% Version X.Y.Z
%% X - major versions
%% Y - minor versions
%% Z - bug corrections
%%
%% Copyright (c) 1990–2009 Pedro Quaresma <pedro@mat.uc.pt>
%%
% This work may be distributed and/or modified under the
% conditions of the LaTeX Project Public License, either version 1.3
% of this license or (at your option) any later version.
% The latest version of this license is in
% http://www.latex-project.org/lppl.txt
% and version 1.3 or later is part of all distributions of LaTeX
% version 2005/12/01 or later.
%
% This work has the LPPL maintenance status ‘maintained’.
%
% The Current Maintainer of this work is Pedro Quaresma (pedro@mat.uc.pt).
%
% This work consists of the files dcpic.sty.
%%
%% Coimbra, 22 de Dezembro de 2009 (2009/12/22)
%% Pedro Quaresma de Almeida
%%
%% DCpic is a package of \TeX\ macros for graph modelling in a
%% (La)\TeX\ or Con\TeX t document. Its distinguishing features are:
%% the use of \PiCTeX\ a powerful graphical engine, and a simple
%% specification syntax. A graph is described in terms of its objects
%% and its edges. The objects are textual elements and the edges can
%% have various straight or curved forms.
%%
%%
%% A graph in DCpic is a "picture" in \PiCTeX, in which we place our

```

```

%% {\em objects} and {\em morphisms} (edges). The user's commands in
%% DCpic are: {\tt begindc} and {\tt enddc} which establish the
%% coordinate system where the objects will be placed; {\tt obj}, the
%% command which defines the place and the contents of each object;
%% {\tt mor}, and {\tt cmor}, the commands which define the
%% morphisms, linear and curved edges, and its labels.
%%
%% Example:
%% \begin{dc}{\commdiag}[3]
%% \obj(10,15){A}
%% \obj(25,15){B}
%% \obj(40,15){C}
%% \mor{A}{B}{f}
%% \mor{B}{C}{g}
%% \cmor((10,11)(11,7)(15,6)(25,6)(35,6)(39,7)(40,11))
%% \pup(25,3){g\circ f}
%% \end{dc}
%%
%% NOTES:
%% all the numeric values should be integer values.
%%
%% Available commands:
%%
%% The environment:
%% \begin{dc}{#1}[#2]
%% #1 - Graph type
%% 0 = "commdiag" (commutative diagram)
%% 1 = "digraph" (direct graph)
%% 2 = "undigraph" (undirect graph)
%% 3 = "cdigraph" with incircled objects
%% 4 = "cundigraph" with incircled objects
%% (optional) #2 - magnification factor (default value, 30)
%%
%% \end{dc}
%%
%% Objects:
%% \obj(#1,#2)[#3]{#4}[#5]
%% #1 and #2 - coordinates
%% (optional) #3 - Label, to be used in the morphisms command, if not
%% present the #4 will be used to that purpose
%% #4 - Object contents
%% (optional) #5 - placement of the object (default value \north)
%% 0 = "\pcent", center
%% 1 = "\north", north
%% 2 = "\northeast", northeast

```

```

%%          3="\east", east
%%          4="\southeast", southeast
%%          5="\south", south
%%          6="\southwest", southwest
%%          7="\west", west
%%          8="\northwest", northwest
%%  !!! Note !!!
%%  if you omit the #3 argument (label) and the #4 argument is a
%%  complex LaTeX command this can cause this command to crash. In
%%  this case you must specify a label (the empty label [], if you do
%%  needed it it for nothing).
%%
%% Morphims (linear edges). This commando has to two major variants
%% i) Starting and Ending objects specification
%%   \mor{#1}{#2}[#5,#6]{#7}[#8,#9]
%%
%% As you can see this first form is (intencionaly) badly formed, the
%% arguments #3 and #4 are missing (the actual command is correctly
%% formed).
%%
%%      #1 - The starting object reference
%%      #2 - The ending object reference
%%
%% from this two we will obtain the objects coordinates, and also the
%% dimensions of the enclosing box.
%%
%% The objects box dimensions are used to do an automatic adjustment of
%% the edge width.
%%
%% from #1 we obtain (x,y), (#1,#2) in the second form
%% from #2 we obtain (x',y'), (#3,#4) in the second form
%%
%% this values will be passed to the command second form
%%
%%ii) Two points coordinates specification
%%   \mor(#1,#2)(#3,#4)[#5,#6]{#7}[#8,#9]
%%
%% Now we can describe all the arguments
%%
%%      #1 and #2 - coordinates (beginning)
%%      #3 and #4 - coordinates (ending)
%%(optional)#5,#6 - correction factors (defaul values, 10 and 10)
%%      #5 - actual beginning of the edge
%%      #6 - actual ending of the edge
%%      #7 - text (morphism label)

```

```

%%(optional)#8,#9
%%      #8 - label placement
%%      1 = "\atright", at right, default value
%%      -1 = "\atleft", at left
%%      #9 - edge type
%%      0 = "\solidarrow", default edge
%%      1 = "\dashArrow"
%%      2 = "\solidline"
%%      3 = "\dashline"
%%      4 = "\dotline"
%%      5 = "\injectionarrow" --- old value 3
%%      6 = "\applicationarrow" --- old value 4
%%      7 = "\surjectivearrow" --- old value 5
%%      8 = "\equalline" (thanks to Ruben Debeerst),
%%      9 = "\doublearrow"
%%      10 = "\doubleopposite"
%%      11 = "\nullarrow" (to allow adding labels to existing arrows)
%%
%% Notes: the equalline "arrow" does not provide a second label.
%%
%% Curved Morphisms (quadratic edges):
%%   \cmor(#1) #2(#3,#4){#5}[#6]
%%   #1 - list of points (odd number)
%%   #2 - tip direction
%%   0 = "\pup", pointing up
%%   1 = "\pdown", pointing down
%%   2 = "\pright", pointing right
%%   3 = "\pleft", pointing left
%%   #3 and #4 - coordinates of the label
%%   #5 - morphism label
%%(optional)#6 - edge type
%%   0 = "\solidarrow", default value
%%   1 = "\dashArrow"
%%   2 = "\solidline"
%%
%% Notes: insert a space after the command.
%%       the space after the list of points is mandatory
%%
%% Exemples:
%%\documentclass[a4paper,11pt]{article}
%%\usepackage{dcpic,pictexwd}
%%
%%\begin{document}
%%\begin{dcpic}
%%\obj(14,11){$A$}

```



```

%%\obj(39,11){B$}
%%\mor(14,12)(39,12){f$}%[\atright,\solidarrow]
%%\mor(39,10)(14,10){g$}%[\atright,\solidarrow]
%%\cmor((10,10)(6,11)(5,15)(6,19)(10,20)(14,19)(15,15))
%% \pdown(2,20){$id_A$}
%%\cmor((40,7)(41,3)(45,2)(49,3)(50,7)(49,11)(45,12))
%% \pleft(54,3){$id_B$}
%%\enddc
%%
%%\begin{dc}\commdiag}[3]
%%\obj(10,15)[A]{A$}
%%\obj(40,15)[Aa]{A$}
%%\obj(25,15)[B]{B$}
%%\mor{A}{B}{f$}%[\atright,\solidarrow]
%%\mor{B}{Aa}{g$}%[\atright,\solidarrow]
%%\cmor((10,11)(11,7)(15,6)(25,6)(35,6)(39,7)(40,11))
%% \pup(25,3){$id_A$}
%%\enddc
%%
%%\newcommand{\barraA}{\vrule height2em width0em depth0em}
%%\newcommand{\barraB}{\vrule height1.6em width0em depth0em}
%%\begin{dc}\commdiag}[35]
%%\obj(1,1)[Gr]{G$}
%%\obj(3,1)[Grstar]{G_{r^*}$}
%%\obj(5,1)[H]{H$}
%%\obj(2,2)[SigmaG]{\Sigma^G$}
%%\obj(6,2)[SigmaH]{\Sigma^H$}
%%\obj(1,3)[Lm]{L_m$}
%%\obj(3,3)[Krm]{K_{r,m}$}
%%\obj(5,3)[Rmstar]{R_{m^*}$}
%%\obj(1,5)[L]{L$}
%%\obj(3,5)[Lr]{L_r$}
%%\obj(5,5)[R]{R$}
%%\obj(2,6)[SigmaL]{\Sigma^L$}
%%\obj(6,6)[SigmaR]{\Sigma^R$}
%%\mor{Gr}{SigmaG}{\lambda^G$}
%%\mor{Grstar}{Gr}{i_5$}[\atleft,\aplicationarrow]
%%\mor{Grstar}{H}{r^*}$[\atright,\solidarrow]
%%\mor{H}{SigmaH}{\lambda^H$}[\atright,\dashArrow]
%%\mor{SigmaG}{SigmaH}{\varphi^r^*}$[\atright,\solidarrow]
%%\mor{Lm}{Gr}{m$}[\atright,\solidarrow]
%%\mor{Lm}{L}{i_2$}[\atleft,\aplicationarrow]
%%\mor{Krm}{Lm}{i_3\quad}$[\atright,\aplicationarrow]
%%\mor{Krm}{Rmstar}{r$}
%%\mor{Krm}{Lr}{i_4$}[\atright,\aplicationarrow]

```

```

%%\mor{Krm}{Grstar}{m}
%%\mor{Rmstar}{R}{i_6}[\atright,\aplicationarrow]
%%\mor{Rmstar}{H}{m^*}
%%\mor{L}{SigmaL}{\lambda^L}
%%\mor{Lr}{L}{i_1\quad}[\atright,\aplicationarrow]
%%\mor{Lr}{R}{r}
%%\mor{R}{SigmaR}{\lambda^R}[\atright,\solidarrow]
%%\mor{SigmaL}{SigmaG}{\varphi^m}[\atright,\solidarrow]
%%\mor{SigmaL}{SigmaR}{\varphi^r}
%%\mor{SigmaR}{SigmaH}{\varphi^{m^*}}
%%\enddc
%%
%%\end{document}
%%-----//-----
%% Modifications (9/1993)
%%     argument "distance" between de tip of the arrow and the objects
%%     became optional; a new option for the "arrows" (option 3)
%%
%% 2/3/1995 (version 1.3)
%%     adds "the aplication arrow" (option 4); the distance between
%%     the label and the "arrow" is now a fixed value (10 units).
%% 15/7/1996 (version 2.1)
%%     The comand "\mor" has a new sintax. The 5th and 6th
%%     parameters are now the distance between the two objects and
%%     the arrow tips. The 7th parameter is the label. The 8th e 9th
%%     parameters (label position and type of arrow) are now optional
%%
%% 5/2001 (version 3.0)
%%     Implementation of the comand "\cmor" based on the quadratic
%%     curver comand of PiCTeX
%%
%% 11/2001 (version 3.1)
%%     Changes on the tips of the arrow to became more LaTeX style
%%     (after a conversation on EuroTeX 2001).
%%
%% 1/2002 (version 3.2)
%%     Modifica{\c c}{\~a}o dos comandos "obj" e "mor" de forma a introduzir
%%     a especifica{\c c}{\~a}o l{\'o}gica dos morfismos, isto {\'e}, passa-se a
%%     dizer qual {\'e} o objecto de partida e/ou o objecto de chegada
%%     em vez de ter de especificar o morfismo em termos de
%%     coordenadas.
%%     Por outro lado o tamanho das setas passa a ser ajustado
%%     automaticamente em rela{\c c}{\~a}o ao tamanho dos objectos.
%%
%% 5/2002 (version 4.0)

```

```

%%      Modificao dos comandos "begin dc" e "obj"
%% !!! Modificao da sintaxe destes comandos !!!
%%      O comando "begin dc" passou a ter um argumento (obrigatrio)
%%      que nos permite especificar o tipo de grafo que estamos a
%%      querer especificar:
%%      "commdiag" (0), para diagramas comutativos
%%      "digraph" (1), para grafos orientados
%%      "undigraph" (2), para grafos no orientados
%%      O comando "obj" modificou a sua sintaxe passou a ter um (aps
%%      a especificao das coordenadas, um argumento opcional, um
%%      argumento obrigatrio, e um argumento opcional. O primeiro
%%      argumento opcional d-nos a etiqueta que serve como
%%      referencia para a especificao dos morfismos, na sua
%%      ausncia usa-se o argumento obrigatrio para esse efeito, o
%%      argumento obrigatrio d-nos o "contedo" do objecto, nos
%%      diagramas comutativos centrado no ponto dado pelas
%%      coordenadas sendo o argumento seguinte simplesmente ignorado,
%%      nos grafos o "contedo" colocado numa posio a norte, a
%%      noroeste, a este, ..., sendo que a posio concreta
%%      especificada pelo ltimo dos argumentos deste comando, o
%%      valor por omisso o "norte".
%%
%% 3/2003 (version 4.1)
%%      Responding to a request of Jon Barker <jeb1@soton.ac.uk> I
%%      create a new type of arrow, the surjective arrow.
%%      For now only horizontal and vertical versions, other angles
%%      are poorly rendered.
%% 12/2004 (version 4.1.1)
%%      New version for the surjective arrows, solve the problems
%%      with the first implementation of this option.
%% 3/2007 (version 4.2)
%%      Adds the "providespackage" directive that was missing.
%%      Adds dashed lines, and dotted lines.
%% 5/2008 (version 4.2.1)
%%      Deleting some counters, trying to avoid the problem "running
%%      out of counters", that occurs because of the use of PiCTeX
%%      and DCpic (only two...)
%% 8/2008 (version 4.3)
%%      Thanks to Ruben Debeerst (debeerst@mathematik.uni-kassel.de),
%%      he added a new arrow "equalline". After that I
%%      decided to add: the doublearrow; the doublearrow with
%%      opposite directions; the null arrow. This last can be used as
%%      a simple form of adding new labels.
%% 12/2008 (version 4.3.1)
%%      The comand \id is internalised (\!id), it should be that way

```

```

%%      from the begining because it is not to be used from the
%%      outside.
%%      The comand \dasharrow was changed to \dashArrow to avoid a
%%      clash with the AMS command with the same name.
%%12/2009 (version 4.3.2)
%%      There is a conflict between dcpic.sty and hyperref in current
%%      texlive-2009 due to the one letter macro \d (thanks Thorsten
%%      S <thorsten.schwander@gmail.com>).
%%      The \d changed to \deuc (Euclidian Distance). The \x and \y
%%      changed to \x0 \y0
%%-----//-----

```

```

\catcode'\!=11 % ***** THIS MUST NEVER BE OMITTED (See PiCTeX)

```

```

\newcount\aux%
\newcount\auxa%
\newcount\auxb%
\newcount\x0%
\newcount\y0%
\newcount\x1%
\newcount\y1%
\newcount\deuc%
\newcount\dnm%
\newcount\xa%
\newcount\xb%
\newcount\xmed%
\newcount\xc%
\newcount\xd%
\newcount\xe
\newcount\xf
\newcount\ya%
\newcount\yb%
\newcount\ymed%
\newcount\yc%
\newcount\yd
\newcount\ye
\newcount\yf
%% "global variables"
\newcount\expansao%
\newcount\tipografo%          version 4.0
\newcount\distanciaobjmor%   version 4.0
\newcount\tipoarco%          version 4.0
%\newif\ifarredondada%       version 4.0 (initial value "false")
\newif\ifpara%
%% version 3.2

```

```

\newbox\caixa%
\newbox\caixaaux%
\newif\ifnvazia%
\newif\ifvazia%
\newif\ifcompara%
\newif\ifdiferentes%
\newcount\xaux%
\newcount\yaux%
\newcount\guardaauxa%
\newcount\alt%
\newcount\larg%
\newcount\prof%
%% for the trimming
\newcount\auxqx
\newcount\auxqy
\newif\ifajusta%
\newif\ifajustadist
\def\objPartida{}%
\def\objChegada{}%
\def\objNulo{}%

%%
%% Stack specification
%%

%%
%% Empty stack
%%
\def\!vazia{:}

%%
%% Is Empty? : Stack -> Bool
%%
%% nvazia - True if Not Empty
%% vazia - True if Empty
\def\!pilhanvazia#1{\let\arg=#1%
\if:\arg\ \nvaziaafalse\vaziatrue \else \nvaziatrue\vaziafalse\fi}

%%
%% Push : Elems x Stack -> Stack
%%
\def\!coloca#1#2{\edef\pilha{#1.#2}}

%%

```

```

%% Top : Stack -> Elems
%%
%% the empty stack is not taken care
%% the element is "kept" ("guardado")
\def\!guarda(#1)(#2,#3)(#4,#5,#6){\def\!id{#1}%
\aux=#2%
\yaux=#3%
\alt=#4%
\larg=#5%
\prof=#6%
}

\def\!topaux#1.#2:{\!guarda#1}
\def\!topo#1{\expandafter\!topaux#1}

%%
%% Pop : Stack -> Stack
%%
%% the empty stack is not taken care
\def\!popaux#1.#2:{\def\pilha{#2:}}
\def\!retira#1{\expandafter\!popaux#1}

%%
%% Compares words : Word x Word -> Bool
%%
%% compara - True if equal
%% diferentes - True if not equal
\def\!comparaaux#1#2{\let\argA=#1\let\argB=#2%
\ifx\argA\argB\comparatrue\diferentesfalse\else\comparafalse\diferentestruer\fi}

\def\!compara#1#2{\!comparaaux{#1}{#2}}

%% Private Macro
%% Absolute Value)
%% \absoluto{n}{absn}
%% input
%% n - integer
%% output
%% absn - |n|
\def\!absoluto#1#2{\aux=#1%
\ifnum \aux > 0
#2=\aux
\else
\multiply \aux by -1
#2=\aux
}

```

```

\fi}

%% Name definitions for edge types and directions
\def\solidarrow{0}
\def\dashArrow{1}
\def\solidline{2}
\def\dashline{3}
\def\dotline{4}
\def\injectionarrow{5}
\def\applicationarrow{6}
\def\surjectivearrow{7}
\def\equalline{8}
\def\doublearrow{9}
\def\doubleopposite{10}
\def\nullarrow{11}

%% Name definitions for edge label placement
\def\atright{-1}
\def\atleft{1}
%% Tip direction for curved edges
\def\pup{0}
\def\pdown{1}
\def\pright{2}
\def\pleft{3}
%% Type of graph
\def\commdiag{0}
\def\digraph{1}
\def\undigraph{2}
\def\cdigraph{3}
\def\cundigraph{4}
%% Positioning of labels in graphs
\def\pcent{0}
\def\north{1}
\def\northeast{2}
\def\east{3}
\def\southeast{4}
\def\south{5}
\def\southwest{6}
\def\west{7}
\def\northwest{8}

%%Comando Interno

```

```

%% Ajusta a distância entre as setas e os objectos em função das
%% dimensões destes últimos
%% \ajusta{x}{xl}{y}{yl}{d}{Objecto}
%% entrada
%% (x,y) e (xl,yl), coordenadas dos pontos de início e fim da seta
%% d, distância especificada pelo utilizador ou 10 (valor por
%% omissão), Objecto d-nos a referência do objecto ao qual se está a
%% efectuar o ajuste.
%% saída
%% d, distância alterada.
%%
%% A distância alterada é o maior valor entre 10 e as dimensões
%% apropriadas da caixa que contém o objecto.
%% Se o utilizador especificar um valor essa especificação
%% não é alterada.
%%
%% Se a seta horizontal usa-se o valor da largura
%% Se a seta vertical usa-se:
%% o valor da altura se a seta está no 1o ou 2o quadrante
%% o valor da profundidade se a seta está no 3o ou 4o quadrante
%% Se a seta oblíqua vai-se escolher o valor conforme:
%% de 315 a 45 graus usa-se a largura
%% de 45 a 135 graus usa-se a altura
%% de 135 a 225 graus usa-se a largura
%% de 225 a 315 graus usa-se a profundidade
\def!ajusta#1#2#3#4#5#6{\aux=#5%
  \let\auxobj=#6%
  \ifcase \tipografo % diagramas comutativos
    \ifnum\number\aux=10
      \ajustadisttrue % se o valor o valor por omissão ajusta
    \else
      \ajustadistfalse % caso contrário no ajusta
    \fi
  \else % grafos (dirigidos, no dirigidos, com molduras)
    \ajustadistfalse
  \or % grafos no dirigidos
    \ajustadistfalse
  \else % grafos dirigidos com molduras circulares nos objectos
    \ifnum\number\aux=8
      \ajustadisttrue % se o valor o valor por omissão ajusta
    \else
      \ajustadistfalse % caso contrário no ajusta
    \fi
  \fi
\ifajustadist

```



```

% \tiny Vou ajustar %%
% \ifnum\number\aux=10% verificar se s{\~a}o os valores por omiss{\~a}o
\let\pilhaaux=\pilha%
\loop%
  \!topo{\pilha}%
  \!retira{\pilha}%
  \!compara{\!id}{\auxobj}%
  \ifcompara\nvaziafalse \else\!pilhanvazia\pilha \fi%
  \ifnvazia%
\repeat%
%% rep{\~o}e os valores na pilha
\let\pilha=\pilhaaux%
\ifvazia%
  \ifdiferentes%
%%
%% N{\~a}o {\'e} poss{\'i}vel efectuar o ajuste dado o utilizador n{\~a}o ter
%% especificado uma etiqueta para o objecto em quest{\~a}o. {\'E} dado o
%% valor de 10, igual ao valor por omiss{\~a}o.
%%
  \larg=131072% n{\~a}o faz o ajuste
  \prof=655360%
  \alt=655360%
  \fi%
\fi%
\divide\larg by 131072
\divide\prof by 65536
\divide\alt by 65536
\ifnum\number\y0=\number\y1
%% Caso 1 -- seta horizontal
%%
%% divide-se por 131072 para se obter metade da largura da caixa em
%% pontos (pt), isto dado que o texto est{\'a} centrado na caixa. Soma-se
%% mais tr{\^e}s, que constitue um ajuste imp{\'i}rico.
  \advance\larg by 3
  \ifnum\number\larg>\aux
    #5=\larg
  \fi
\else
  \ifnum\number\x0=\number\x1
    \ifnum\number\y1>\number\y0
%% Caso 2.1 -- seta vertical de cima para baixa
%%
  \ifnum\number\alt>\aux
    #5=\alt
  \fi

```

```

\else
%% Caso 2.2 -- seta vertical de baixo para cima
%%
%% divide-se por 65536 para se obter a altura da caixa em pt. 0 ajuste
%% de 5 foi obtido imp{\'\i}ricamente
\advance\prof by 5
\ifnum\number\prof>\aux
#5=\prof
\fi
\fi
\else
%% Caso 3 -- seta obl{\'\i}qua
%% Caso 3.1 de 3150 a 450;  $|x-x_1|>|y-y_1|$  e
%% Caso 3.3 de 1350 a 2250;  $|x-x_1|>|y-y_1|$ ; Largura
\auxqx=\x0
\advance\auxqx by -\x1
\!absoluto{\auxqx}{\auxqx}%
\auxqy=\y0
\advance\auxqy by -\y1
\!absoluto{\auxqy}{\auxqy}%
\ifnum\auxqx>\auxqy
\ifnum\larg<10
\larg=10
\fi
\advance\larg by 3
#5=\larg
\else
%% Caso 3.2 de 450 a 1350;  $|x-x_1|<|y-y_1|$  e  $y>0$ ; Largura
\ifnum\y1>\y0
\ifnum\larg<10
\larg=10
\fi
\advance\alt by 6
#5=\alt
\else
%% Caso 3.4 de 2250 a 3150;  $|x-x_1|<|y-y_1|$  e  $y<0$ ; Profundidade
\advance\prof by 11
#5=\prof
\fi
\fi
\fi
\fi
\fi} % o ramo "else" {\'e} omisso

```

```

%%Comando Interno
%% C{\a}lculo da Raiz Quadrada
%% raiz{n}{m}
%% entrada
%% n - natural
%% sa{\i}da
%% n - natural
%% m - maior natural contido na raiz quadrada de n
\def\!raiz#1#2{\auxa=#1%
  \auxb=1%
  \loop
  \aux=\auxb%
  \advance \aux by 1%
  \multiply \aux by \aux%
  \ifnum \aux < \auxa%
  \advance \auxb by 1%
  \paratrue%
  \else\ifnum \aux=\auxa%
  \advance \auxb by 1%
  \paratrue%
  \else\parafalse%
  \fi
  \fi
  \ifpara%
  \repeat
#2=\auxb}

%%Private Macro
%% Find the starting and ending points of the "arrow" and also the
%% label position (one coordinate at a time)
%%
%% ucoord{x1}{x2}{x3}{x4}{x5}{x6}{+|- 1}
%% Input
%% x1,x2,x3,x4,x5
%% Output
%% x6
%%
%%          x2 - x1
%% x6 = x3 +|- ----- x4
%%          x5
\def\!ucoord#1#2#3#4#5#6#7{\aux=#2%
  \advance \aux by -#1%
  \multiply \aux by #4%
  \divide \aux by #5%
  \ifnum #7 = -1 \multiply \aux by -1 \fi%

```

```

\advance \aux by #3%
#6=\aux}

%%Private Macro
%% Euclidean distance between two points
%%
%% quadrado{n}{m}{l}
%% Input
%% n - natural number
%% m - natural number
%% Output
%% l = (n-m)*(n-m)
\def!quadrado#1#2#3{\aux=#1%
\advance \aux by -#2%
\multiply \aux by \aux%
#3=\aux}

%%Comando Interno
%% C{\a}lculo auxiliar para determinar a dist{\^a}ncia entre o nome do
%% morfismo e a seta.
%% entrada
%% (x,y), (x',y') e o nome do morfismo
%% sa{\'\i}da
%% dnm - dist{\^a}ncia do nome ao morfismo respectivo devidamente
%% compensada pelo tamanho do objecto
%% Observa{\c c}{\~o}es
%% A compensa{\c c}{\~a}o s{\'\o} est{\'a} a ser feita para setas
%% horizontais e verticais. As obl{\'\i}quas s{\~a}o tratadas de
%% outra forma.
%% algoritmo
%% caixa0 <- nome do morfismo
%% se x-xl = 0 entao {recta vertical}
%% aux <- largura da caixa0
%% dnm <- convers{\^a}o-sp-pt(aux)/2+3
%% sen{\~a}o {recta n{\~a}o vertical}
%% se y-yl = 0 entao {recta horizontal}
%% aux <- altura+profundidade da caixa0
%% dnm <- convers{\~a}o-sp-pt(aux)/2+3
%% sen{\~a}o {recta obl{\'\i}qua}
%% dnm <- 3
%% fimse
%% fimse
%% fimalgoritmo
\def!distnomemor#1#2#3#4#5#6{\setbox0=\hbox{#5}%
\aux=#1

```

```

\advance \aux by -#3
\ifnum \aux=0
  \aux=\wd0 \divide \aux by 131072
  \advance \aux by 3
  #6=\aux
\else
  \aux=#2
  \advance \aux by -#4
  \ifnum \aux=0
    \aux=\ht0 \advance \aux by \dp0 \divide \aux by 131072
    \advance \aux by 3
    #6=\aux%
  \else
    #6=3
  \fi
\fi
}

%%
%% 0 ambiente "beginnc...endnc"
%%
\def\beginnc#1{\!ifnextchar[{\!beginnc{#1}}{\!beginnc{#1}[30]}}
\def\!beginnc#1[#2]{\beginpicture
  \let\pilha=\!vazia
  \setcoordinatesystem units <1pt,1pt>
  \expansao=#2
  \ifcase #1
    \distanciaobjmor=10
    \tipoarco=0          % arrow
    \tipografo=0        % commutative diagram
  \or
    \distanciaobjmor=2
    \tipoarco=0          % arrow
    \tipografo=1        % directed graph
  \or
    \distanciaobjmor=1
    \tipoarco=2          % line
    \tipografo=2        % undirected graph
  \or
    \distanciaobjmor=8
    \tipoarco=0          % arrow
    \tipografo=3        % directed graph
% \arredondadotrua    % objetos com molduras circulares
  \or

```

```

        \distanciaobjmor=8
        \tipoarco=2          % line
        \tipografo=4        % undirected graph
%       \arredondadotrue    % objetos com molduras circulares
    \fi}

\def\enddc{\endpicture}

%% Public macro: "mor"
%%
%%
%% Funtion to built the "arrow" between two points
%%
%% The points that are uses to built all the elements of the "arrows"
%% are:
%%
%%                (xc,yc)
%%                o
%%                |
%% o-----o-----o-----o-----o
%%(x,y) (xa,ya)  (xm,ym)  (xb,yb)(xl,yl)
%%
%% auxa - distance between (x,y) and (xa,ya), 10pt by default
%% auxb - distance between (xl,yl) and (xb,yb), 10pt by default
%%
\def\mor{%
  \!ifnextchar({\!morxy}{\!morObjA})}
\def\!morxy(#1,#2){%
  \!ifnextchar({\!morxyl{#1}{#2}}{\!morObjB{#1}{#2}})}
\def\!morxyl#1#2(#3,#4){%
  \!ifnextchar[{\!mora{#1}{#2}{#3}{#4}}{\!mora{#1}{#2}{#3}{#4}[\number\distanciaobjmor,\nu]}]}
\def\!morObjA#1{%
  \let\pilhaux=\pilha%
  \def\objPartida{#1}%
  \loop%
    \!topo\pilha%
    \!retira\pilha%
    \!compara{\!id}{\objPartida}%
    \ifcompara \nvaziafalse \else \!pilhanvazia\pilha \fi%
    \ifnvazia%
  \repeat%
  \ifvazia%
  \endifdiferentes%
%%
}

```

```

%% error message and fictitious parameters
%%
    Error: Incorrect label specification%
    \iaux=1%
    \yiaux=1%
    \fi%
\fi%
\let\pilha=\pilhaaux%
\!ifnextchar({\!morxyl{\number\iaux}{\number\yiaux}}{\!morObjB{\number\iaux}{\number\yiaux}}
\def\!morObjB#1#2#3{%
    \x0=#1
    \y0=#2
\def\objChegada{#3}%
\let\pilhaaux=\pilha%
\loop
    \!topo\pilha %
    \!retira\pilha%
    \!compara{\!id}{\objChegada}%
    \ifcompara \nvaziafalse \else \!pilhanvazia\pilha \fi
    \ifnvazia
\repeat
\ifvazia
    \ifdiferentes%
%%
%% error message and fictitious parameters
%%
    Error: Incorrect label specification
    \iaux=\x0%
    \advance\iaux by \x0%
    \yiaux=\y0%
    \advance\yiaux by \y0%
    \fi
\fi
\let\pilha=\pilhaaux
\!ifnextchar[{\!mora{\number\x0}{\number\y0}{\number\iaux}{\number\yiaux}}{\!mora{\number\x0}{\number\y0}{\number\iaux}{\number\yiaux}}
\def\!mora#1#2#3#4[#5,#6]#7{%
    \!ifnextchar[{\!morb{#1}{#2}{#3}{#4}{#5}{#6}{#7}}{\!morb{#1}{#2}{#3}{#4}{#5}{#6}{#7}[1,]}
\def\!morb#1#2#3#4#5#6#7[#8,#9]{\x0=#1%
    \y0=#2%
    \xl=#3%
    \yl=#4%
    \multiply \x0 by \expansao%
    \multiply \y0 by \expansao%
    \multiply \xl by \expansao%
    \multiply \yl by \expansao%

```

```

%%
%% Euclidean distance between two points
%%  $d = \sqrt{(x-x_1)^2+(y-y_1)^2}$ 
%%
\!quadrado{\number\x0}{\number\x1}{\auxa}%
\!quadrado{\number\y0}{\number\y1}{\auxb}%
\deuc=\auxa%
\advance \deuc by \auxb%
\!raiz{\deuc}{\deuc}%
%%
%% the point (xa,ya) is at a distance #5 (default value 10) from the
%% point (x,y)
%%
%% como existem dois pontos em considera{\c c}{\~a}o, o ponto de partida e o
%% ponto de chegada, vai sei necess{\'a}rio recuperar de novo os seus
%% valores por pesquisa na pilha
\auxa=#5
\!compara{\objNulo}{\objPartida}%
\ifdiferentes% S{\'o} vai fazer o ajuste quando {\'e} necess{\'a}rio
\!ajusta{x0}{x1}{y0}{y1}{\auxa}{\objPartida}%
\ajustatrue
\def\objPartida{ }% re-inicializar o valor do Objecto de Partida
\fi
%% vai guardar o valor de auxa (ap{\'o}s ajuste) para ser usado no caso
%% dos morfismos de injec{\c c}{\~a}o.
\guardaauxa=\auxa
%%
\!ucoord{\number\x0}{\number\x1}{\number\x0}{\auxa}{\number\deuc}{\xa}{1}%
\!ucoord{\number\y0}{\number\y1}{\number\y0}{\auxa}{\number\deuc}{\ya}{1}%
%% auxa vai ter o valor da dist{\^a}ncia entre os objectos menos a
%% dist{\^a}ncia da seta ao objecto (10 por omiss{\~a}o)
\auxa=\deuc%
%%
%% the point (xb,yb) is at a distance #6 (default value 10) from the
%% point (x1,y1)
%%
\auxb=#6
\!compara{\objNulo}{\objChegada}%
\ifdiferentes% S{\'o} vai fazer o ajuste quando {\'e} necess{\'a}rio
% Vou ajustar
\!ajusta{x0}{x1}{y0}{y1}{\auxb}{\objChegada}%
\def\objChegada{ }% re-inicializar o valor do Objecto de Chegada
\fi
\advance \auxa by -\auxb%
\!ucoord{\number\x0}{\number\x1}{\number\x0}{\number\auxa}{\number\deuc}{\xb}{1}%

```



```

\!ucoord{\number\y0}{\number\y1}{\number\y0}{\number\auxa}{\number\deuc}{\yb}{1}%
\xmed=\xa%
\advance \xmed by \xb%
\divide \xmed by 2
\ymed=\ya%
\advance \ymed by \yb%
\divide \ymed by 2
%%
%% find the coordinates of the label position: (xc,yc)
%%
%% after this the values of xmed and ymed are no longer important
%%
\!distnomemor{\number\x0}{\number\y0}{\number\x1}{\number\y1}{#7}{\dnm}%
\!ucoord{\number\y0}{\number\y1}{\number\xmed}{\number\dnm}{\number\deuc}{\xc}{-#8}%
\!ucoord{\number\x0}{\number\x1}{\number\ymed}{\number\dnm}{\number\deuc}{\yc}{#8}%
%%
%% draw the "arrow"
%%
\ifcase #9          % 0=solid arrow
  \arrow <4pt> [.2,1.1] from {\xa} {\ya} to {\xb} {\yb}
\or                 % 1=dashed arrow
  \setdashes
  \arrow <4pt> [.2,1.1] from {\xa} {\ya} to {\xb} {\yb}
  \setsolid
\or                 % 2=solid line
  \setlinear
  \plot {\xa} {\ya} {\xb} {\yb} /
\or                 % 3=dashed line
  \setdashes
  \setlinear
  \plot {\xa} {\ya} {\xb} {\yb} /
  \setsolid
\or                 % 4=dotted line
  \setdots
  \setlinear
  \plot {\xa} {\ya} {\xb} {\yb} /
  \setsolid
\or                 % 5=injective arrow
%% C{\a}lculos auxiliares
%%
%% 3 units, the radius for the tail of the arrow
%%
%% repor o valor de auxa
  \auxa=\guardaauxa
%% dar a compensa{\c c}{\~a}o para o "rabo"

```

```

\advance \auxa by 3%
%%
%% Note: the values of (xa,ya) will be modified, they will be
%% "pushed" further away from (x,y) in order to acomodate the tail
%% of the "arrow"
%%
%% find the point (xd,yd), the center of a 3pt circle
%%
\!ucoord{\number\x0}{\number\x1}{\number\x0}{\number\auxa}{\number\deuc}{\xa}{1}%
\!ucoord{\number\y0}{\number\y1}{\number\y0}{\number\auxa}{\number\deuc}{\ya}{1}%
\!ucoord{\number\y0}{\number\y1}{\number\xa}{3}{\number\deuc}{\xd}{-1}%
\!ucoord{\number\x0}{\number\x1}{\number\ya}{3}{\number\deuc}{\yd}{1}%
%% building the "arrow"
\arrow <4pt> [.2,1.1] from {\xa} {\ya} to {\xb} {\yb}
%% and its "tail"
\circulararc -180 degrees from {\xa} {\ya} center at {\xd} {\yd}
\or % 6=maps "arrow" ("|-->")
\auxa=3
%%
%% Note: the values of xmed and ymed will be modified
%%
%% find the two points that defines the tail of the arrow (segment
%% (xmed,ymed)(xd,yd))
\!ucoord{\number\y0}{\number\y1}{\number\xa}{\number\auxa}{\number\deuc}{\xmed}{-1}%
\!ucoord{\number\x0}{\number\x1}{\number\ya}{\number\auxa}{\number\deuc}{\ymed}{1}%
\!ucoord{\number\y0}{\number\y1}{\number\xa}{\number\auxa}{\number\deuc}{\xd}{1}%
\!ucoord{\number\x0}{\number\x1}{\number\ya}{\number\auxa}{\number\deuc}{\yd}{-1}%
%% building the "arrow"
\arrow <4pt> [.2,1.1] from {\xa} {\ya} to {\xb} {\yb}
%% and its "tail"
\setlinear
\plot {\xmed} {\ymed} {\xd} {\yd} /
\or % 7=surjective arrow ("-->>")
%% building arrow with the first tip
\arrow <4pt> [.2,1.1] from {\xa} {\ya} to {\xb} {\yb}
%% and the second tip
\setlinear
\arrow <6pt> [0,.72] from {\xa} {\ya} to {\xb} {\yb}
\or % 8=equalline
%% by Ruben Debeerst: equal-line
%%
%% sets the separation (distance) between the two parallel lines, if
%% horizontal or vertical 1pt is enough, if not 2pt
\auxa=2
\ifnum\number\y0=\number\y1

```

```

\auxa=1
\fi
\ifnum\number\x0=\number\xl
\auxa=1
\fi
%% the two parallel lines will be given by (xmed,ymed)(xd,yd), and
%% (xe,ye)(xf,yf)
\!ucoord{\number\y0}{\number\y1}{\number\xa}{\number\auxa}{\number\deuc}{\xmed}{-1}%
\!ucoord{\number\x0}{\number\xl}{\number\ya}{\number\auxa}{\number\deuc}{\ymed}{1}%
\!ucoord{\number\y0}{\number\y1}{\number\xa}{\number\auxa}{\number\deuc}{\xd}{1}%
\!ucoord{\number\x0}{\number\xl}{\number\ya}{\number\auxa}{\number\deuc}{\yd}{-1}%

\!ucoord{\number\y0}{\number\y1}{\number\xb}{\number\auxa}{\number\deuc}{\xe}{-1}%
\!ucoord{\number\x0}{\number\xl}{\number\yb}{\number\auxa}{\number\deuc}{\ye}{1}%
\!ucoord{\number\y0}{\number\y1}{\number\xb}{\number\auxa}{\number\deuc}{\xf}{1}%
\!ucoord{\number\x0}{\number\xl}{\number\yb}{\number\auxa}{\number\deuc}{\yf}{-1}%
\setlinear
\plot {\xmed} {\ymed} {\xe} {\ye} /
\plot {\xd} {\yd} {\xf} {\yf} /
\or % 9=double arrow
%%
%% sets the separation (distance) between the two parallel lines, if
%% horizontal or vertical 2pt is enough, if not 3pt. The extra space
%% is needed because of the arrow tip.
\auxa=3
\ifnum\number\y0=\number\y1
\auxa=2
\fi
\ifnum\number\x0=\number\xl
\auxa=2
\fi
%% the two parallel lines will be given by (xmed,ymed)(xd,yd), and
%% (xe,ye)(xf,yf)
\!ucoord{\number\y0}{\number\y1}{\number\xa}{\number\auxa}{\number\deuc}{\xmed}{-1}%
\!ucoord{\number\x0}{\number\xl}{\number\ya}{\number\auxa}{\number\deuc}{\ymed}{1}%
\!ucoord{\number\y0}{\number\y1}{\number\xa}{\number\auxa}{\number\deuc}{\xd}{1}%
\!ucoord{\number\x0}{\number\xl}{\number\ya}{\number\auxa}{\number\deuc}{\yd}{-1}%

\!ucoord{\number\y0}{\number\y1}{\number\xb}{\number\auxa}{\number\deuc}{\xe}{-1}%
\!ucoord{\number\x0}{\number\xl}{\number\yb}{\number\auxa}{\number\deuc}{\ye}{1}%
\!ucoord{\number\y0}{\number\y1}{\number\xb}{\number\auxa}{\number\deuc}{\xf}{1}%
\!ucoord{\number\x0}{\number\xl}{\number\yb}{\number\auxa}{\number\deuc}{\yf}{-1}%
\arrow <4pt> [.2,1.1] from {\xmed} {\ymed} to {\xe} {\ye}
\arrow <4pt> [.2,1.1] from {\xd} {\yd} to {\xf} {\yf}
\or % 10=double arrow, opposite directions

```

```

%%
%% sets the separation (distance) between the two parallel lines, if
%% horizontal or vertical 2pt is enough, if not 3pt. The extra space
%% is needed because of the arrow tip.
\auxa=3
\ifnum\number\y0=\number\yl
\auxa=2
\fi
\ifnum\number\x0=\number\xl
\auxa=2
\fi
%% the two parallel lines will be given by (xmed,ymed)(xd,yd), and
%% (xe,ye)(xf,yf)
\!ucoord{\number\y0}{\number\yl}{\number\xa}{\number\auxa}{\number\deuc}{\xmed}{-1}%
\!ucoord{\number\x0}{\number\xl}{\number\ya}{\number\auxa}{\number\deuc}{\ymed}{1}%
\!ucoord{\number\y0}{\number\yl}{\number\xa}{\number\auxa}{\number\deuc}{\xd}{1}%
\!ucoord{\number\x0}{\number\xl}{\number\ya}{\number\auxa}{\number\deuc}{\yd}{-1}%

\!ucoord{\number\y0}{\number\yl}{\number\xb}{\number\auxa}{\number\deuc}{\xe}{-1}%
\!ucoord{\number\x0}{\number\xl}{\number\yb}{\number\auxa}{\number\deuc}{\ye}{1}%
\!ucoord{\number\y0}{\number\yl}{\number\xb}{\number\auxa}{\number\deuc}{\xf}{1}%
\!ucoord{\number\x0}{\number\xl}{\number\yb}{\number\auxa}{\number\deuc}{\yf}{-1}%
\arrow <4pt> [.2,1.1] from {\xmed} {\ymed} to {\xe} {\ye}
\arrow <4pt> [.2,1.1] from {\xf} {\yf} to {\xd} {\yd}
\or
% 11=null arrow (no arrow, only a label)
%%
%% does not draw the arrow, it allows to put two labels in one "arrow"
%%
\fi
%% The label positioning.
%% Se os morfismos  $s^{\sim a}$  horizontais ou verticais constro  $\{ \sim i \}$  uma caixa
%% centrada no ponto  $pr$   $\{ \sim e \}$  viamente calculado. Se as setas  $s^{\sim a}$ 
%%  $obl$   $\{ \sim i \}$  quas coloca a caixa de forma a  $n^{\sim a}$  colidir com o morfismo
%% tendo em aten  $\{ c \}$   $\{ \sim a \}$  o quadrante assim como a posi  $\{ c \}$   $\{ \sim a \}$ 
%% relativa do morfismo e do respectivo nome.
\auxa=\xl
\advance \auxa by  $-\x0$ %
\ifnum \auxa=0
\put {#7} at {\xc} {\yc}
\else
\auxb=\yl
\advance \auxb by  $-\y0$ %
\ifnum \auxb=0 \put {#7} at {\xc} {\yc}
\else
\ifnum \auxa > 0

```

```

\ifnum \auxb > 0
  \ifnum #8=1
    \put {#7} [rb] at {\xc} {\yc}
  \else
    \put {#7} [lt] at {\xc} {\yc}
  \fi
\else
  \ifnum #8=1
    \put {#7} [lb] at {\xc} {\yc}
  \else
    \put {#7} [rt] at {\xc} {\yc}
  \fi
\fi
\else
  \ifnum \auxb > 0
    \ifnum #8=1
      \put {#7} [rt] at {\xc} {\yc}
    \else
      \put {#7} [lb] at {\xc} {\yc}
    \fi
  \else
    \ifnum #8=1
      \put {#7} [lt] at {\xc} {\yc}
    \else
      \put {#7} [rb] at {\xc} {\yc}
    \fi
  \fi
\fi
\fi
\fi
}

%%
%% Comando para construir a "seta" curvilinea entre dois objectos
%%
%% \cmor(<lista de pontos (n. impar)>){<etiqueta>}
%%
%% Em primeiro lugar {\e} necess{\a}rio modificar o comando plot de forma a
%% que a sintaxe de utiliza{\c c}{\~a}o do novo comando seja coerente com a
%% sintaxe dos restantes comandos
%%
\def\modifplot(#1{\!modifqcurve #1}
\def\!modifqcurve(#1,#2){\x0=#1%
  \y0=#2%
  \multiply \x0 by \expansao%

```

```

\multiply \y0 by \expansao%
\!start (\x0,\y0)
\!modifQjoin}
\def\!modifQjoin(#1,#2)(#3,#4){\x0=#1%
\y0=#2%
\xl=#3%
\yl=#4%
\multiply \x0 by \expansao%
\multiply \y0 by \expansao%
\multiply \xl by \expansao%
\multiply \yl by \expansao%
\!qjoin (\x0,\y0) (\xl,\yl) % \!qjoin is defined in QUADRATIC
\!ifnextchar){\!fim}{\!modifQjoin}}
\def\!fim){\ignorespaces}

%%
%% O comando para desenhar a seta vai receber a lista de pontos da qual
%% retira o {\u}ltimo par de pontos, dependente da escolha dada pelo
%% utilizador a seta vai ser desenhada para cima, para baixo, para a
%% direita ou para a esquerda
%%
\def\setaxy(#1{\!pontosxy #1}
\def\!pontosxy(#1,#2){%
\!maispontosxy}
\def\!maispontosxy(#1,#2)(#3,#4){%
\!ifnextchar){\!fimxy#3,#4}{\!maispontosxy}}
\def\!fimxy#1,#2){\x0=#1%
\y0=#2
\multiply \x0 by \expansao
\multiply \y0 by \expansao
\xl=\x0%
\yl=\y0%
\aux=1%
\multiply \aux by \auxa%
\advance\xl by \aux%
\aux=1%
\multiply \aux by \auxb%
\advance\yl by \aux%
\arrow <4pt> [.2,1.1] from {\x0} {\y0} to {\xl} {\yl}}

%%
%% Temos agora a defini{\c c}{\~a}o do comando "cmor"
%%
\def\cmor#1 #2(#3,#4)#5{%

```

```

\!ifnextchar[{\!cmora{#1}{#2}{#3}{#4}{#5}}{\!cmora{#1}{#2}{#3}{#4}{#5}[0] ]}
\def\!cmora#1#2#3#4#5[#6]{%
\ifcase #2% para cima "\pup" (pointing up)
\auxa=0% x mant{\^e}m-se
\auxb=1% o y "sobe"
\or% para baixo "\pdown" (pointing down)
\auxa=0% x mant{\^e}m-se
\auxb=-1% o y "desce"
\or% para a direita "\pright" (pointing right)
\auxa=1% o x move-se para a direita
\auxb=0% o y mant{\^e}m-se
\or% para a esquerda "\pleft" (pointing left)
\auxa=-1% o x move-se para a esquerda
\auxb=0% o y mant{\^e}m-se
\fi % constru{\c c}{\^a}o do arco
\ifcase #6 % arco (com seta) s{\^o}lido
\modifplot#1% Desenhar o arco
% constru{\c c}{\^a}o da seta
\setaxy#1
\or % arco (com seta) a tracejado
\setdashes
\modifplot#1% Desenhar o arco
\setaxy#1
\setsolid
\or % arco sem seta
\modifplot#1% Desenhar o arco
\fi % seta de injec{\c c}{\^a}o
%% coloca{\c c}{\^a}o da etiqueta do morfismo
\x0=#3%
\y0=#4%
\multiply \x0 by \expansao%
\multiply \y0 by \expansao%
\put {#5} at {\x0} {\y0}}

%%
%% Comando para construir os Objectos
%% \obj(x,y){<texto>}[<etiqueta>]
%%
\def\obj(#1,#2){%
\!ifnextchar[{\!obja{#1}{#2}}{\!obja{#1}{#2}[Nulo]}}
\def\!obja#1#2[#3]#4{%
\!ifnextchar[{\!objb{#1}{#2}{#3}{#4}}{\!objb{#1}{#2}{#3}{#4}[1]}}
\def\!objb#1#2#3#4[#5]{%
\x0=#1%
\y0=#2%

```

```

\def\!pinta{\normalsize$\bullet$}% para definir o tamanho normal das pintas
\def\!nulo{Nulo}%
\def\!arg{#3}%
\!compara{\!arg}{\!nulo}%
\ifcompara\def\!arg{#4}\fi%
\multiply \x0 by \expansao%
\multiply \y0 by \expansao%
\setbox\caixa=\hbox{#4}%
\!coloca{(\!arg)(#1,#2)(\number\ht\caixa,\number\wd\caixa,\number\dp\caixa)}{\!pilha}%
\auxa=\wd\caixa \divide \auxa by 131072
\advance \auxa by 5
\auxb=\ht\caixa
\advance \auxb by \number\dp\caixa
\divide \auxb by 131072
\advance \auxb by 5
%(\number\auxa,
%\number\auxb)
% \aux=\ht\caixa \divide \auxa by 131072
% \advance \auxa by 5
% \auxb=\dp\caixa \divide \auxb by 131072
% \advance \auxb by 8
\ifcase \tipografo % diagramas comutativos
  \put{#4} at {\x0} {\y0}
\or % grafos dirigidos
  \ifcase #5 % c=0
    \put{#4} at {\x0} {\y0}
  \or % n=1
    \put{\!pinta} at {\x0} {\y0}
    \advance \y0 by \number\auxb % height+depth+5
    \put{#4} at {\x0} {\y0}
  \or % ne=2
    \put{\!pinta} at {\x0} {\y0}
    \advance \auxa by -2 % para fazer o ajuste (imperfeito)
    \advance \auxb by -2 % ao raio da circunferencia de centro (x,y)
    \advance \x0 by \number\auxa % width+5
    \advance \y0 by \number\auxb % height+depth+5
    \put{#4} at {\x0} {\y0}
  \or % e=3
    \put{\!pinta} at {\x0} {\y0}
    \advance \x0 by \number\auxa % width+5
    \put{#4} at {\x0} {\y0}
  \or % se=4
    \put{\!pinta} at {\x0} {\y0}
    \advance \auxa by -2 % para fazer o ajuste (imperfeito)
    \advance \auxb by -2 % ao raio da circunferencia de centro (x,y)

```



```

\advance \x0 by \number\auxa % width+5
\advance \y0 by -\number\auxb % height+depth+5
\put{#4} at {\x0} {\y0}
\or % s=5
\put{\!pinta} at {\x0} {\y0}
\advance \y0 by -\number\auxb % height+depth+5
\put{#4} at {\x0} {\y0}
\or % sw=6
\put{\!pinta} at {\x0} {\y0}
\advance \auxa by -2 % para fazer o ajuste (imperfeito)
\advance \auxb by -2 % ao raio da circunferencia de centro (x,y)
\advance \x0 by -\number\auxa % width+5
\advance \y0 by -\number\auxb % height+depth+5
\put{#4} at {\x0} {\y0}
\or % w=7
\put{\!pinta} at {\x0} {\y0}
\advance \x0 by -\number\auxa % width+5
\put{#4} at {\x0} {\y0}
\or % nw=8
\put{\!pinta} at {\x0} {\y0}
\advance \auxa by -2 % para fazer o ajuste (imperfeito)
\advance \auxb by -2 % ao raio da circunferencia de centro (x,y)
\advance \x0 by -\number\auxa % width+5
\advance \y0 by \number\auxb % height+depth+5
\put{#4} at {\x0} {\y0}
\fi
\or % grafos nao dirigidos
\ifcase #5 % c=0
\put{#4} at {\x0} {\y0}
\or % n=1
\put{\!pinta} at {\x0} {\y0}
\advance \y0 by \number\auxb % height+depth+5
\put{#4} at {\x0} {\y0}
\or % ne=2
\put{\!pinta} at {\x0} {\y0}
\advance \auxa by -2 % para fazer o ajuste (imperfeito)
\advance \auxb by -2 % ao raio da circunferencia de centro (x,y)
\advance \x0 by \number\auxa % width+5
\advance \y0 by \number\auxb % height+depth+5
\put{#4} at {\x0} {\y0}
\or % e=3
\put{\!pinta} at {\x0} {\y0}
\advance \x0 by \number\auxa % width+5
\put{#4} at {\x0} {\y0}
\or % se=4

```

```

\put{\!pinta} at {\x0} {\y0}
\advance \auxa by -2 % ver acima
\advance \auxb by -2
\advance \x0 by \number\auxa % width+5
\advance \y0 by -\number\auxb % height+depth+5
\put{#4} at {\x0} {\y0}
\or % s=5
\put{\!pinta} at {\x0} {\y0}
\advance \y0 by -\number\auxb % height+depth+5
\put{#4} at {\x0} {\y0}
\or % sw=6
\put{\!pinta} at {\x0} {\y0}
\advance \auxa by -2 % ver acima
\advance \auxb by -2
\advance \x0 by -\number\auxa % width+5
\advance \y0 by -\number\auxb % height+depth+5
\put{#4} at {\x0} {\y0}
\or % w=7
\put{\!pinta} at {\x0} {\y0}
\advance \x0 by -\number\auxa % width+5
\put{#4} at {\x0} {\y0}
\or % nw=8
\put{\!pinta} at {\x0} {\y0}
\advance \auxa by -2 % ver acima
\advance \auxb by -2
\advance \x0 by -\number\auxa % width+5
\advance \y0 by \number\auxb % height+depth+5
\put{#4} at {\x0} {\y0}
\fi
% \or % grafos dirigidos com molduras circulares nos objectos
% \advance \auxa by 4
% \put{\circle{\auxa}} [Bl] at {\x0} {\y0}
% \put{#4} at {\x0} {\y0}
% \or % grafos no dirigidos com molduras circulares nos objectos
\else % grafos com molduras circulares nos objectos
\ifnum\auxa<\auxb % determina a maior das dimenses
\aux=\auxb
\else
\aux=\auxa
\fi
% se a largura da caixa menor do que 1em ento o tamanho
% tamanho ajustado para esse valor mnimo
\ifdim\wd\caixa<1em
\dimen99 = 1em
\aux=\dimen99 \divide \aux by 131072

```

```

    \advance \aux by 5
  \fi
  \advance\aux by -2 %folga entre o objecto e a moldura
  \multiply\aux by 2 %
  \ifnum\aux<30
    \put{\circle{\aux}} [B1] at {\x0} {\y0}
  \else
    \multiply\auxa by 2
    \multiply\auxb by 2
    \put{\oval(\auxa,\auxb)} [B1] at {\x0} {\y0}
  \fi
  \put{#4} at {\x0} {\y0}
\fi
}

```

```

\catcode'\!=12 % ***** THIS MUST NEVER BE OMITTED (see PiTeX)

```