DCpic v4.0

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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.

2 Introduction

DCpic is a package of TEX [3] macros for graph modelling in a (La)TEX [4] or ConTEXt [5] document. Its distinguishing features are: the use of PICTEX [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 PICTEX, 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 by 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 PICTEX" was dedicated to commutative diagrams [6] ("**D**iagramas **C**omutativos" in Portuguese) drawing, that is the reason for the name "obj" (objects) and "mor" (morphism) for the nodes and edges.

Example:

```
\begindc{\commdiag}
  \obj(1,1){$A$}
  \obj(3,1){$B$}
  \obj(3,3){$C$}
  \mor{$A$}{$B$}{$f$}
  \mor{$B$}{$C$}{$g$}
  \mor{$A$}{$C$}{$h$}
\enddc
```
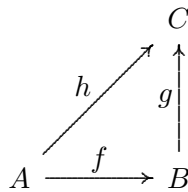

Note: all the numeric values should be integer values.

3 Description

3.1 Available commands

The environment:

```
\begindc{#1}[#2]
    #1 - Graph type
      0 = "commdiag" (commutative diagram)
      1 = "digraph" (direct graph)
      2 = "undigraph" (undirect graph)
    (optional) #2 - magnification factor (default value, 30)
\enddc
```

Objects:

```
\obj(#1,#2)[#3]{#4}[#5]
            #1 and #2 - coordenates
  (optional) #3 - Label, to be used in the morphims 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
```

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```
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) LaTeX command this can cause this command to 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 (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 value
                1 = "\dasharrow"
                2 = "\solidline"
                3 = "\injectionarrow"
                4 = "\aplicationarrow"
```

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   Diagrams with curved edges

```
\begindc{0}[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]
```
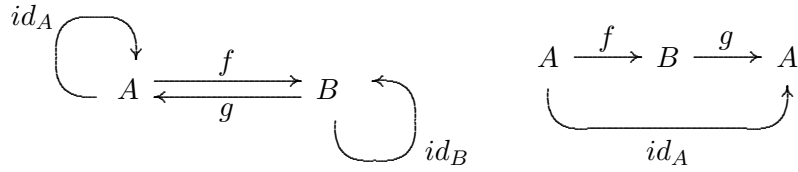
```
\obj(10,15)[A]{$A$}
\obj(40,15)[Aa]{$A$}
\obj(25,15)[B]{$B$}
\mor{A}{B}{$f$}
\mor{B}{Aa}{$g$}
\cmor((10,11)(11,7)(15,6)(25,6)(35,6)(39,7)(40,11))
  \pup(25,3){$id_A$}
\enddc
```


4.2   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.
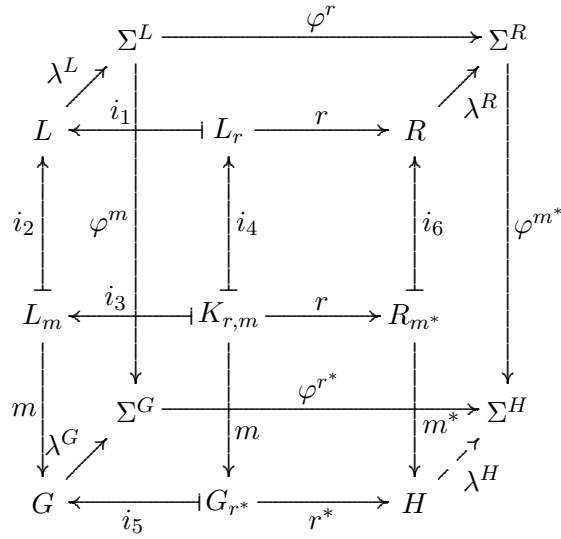
```
\newcommand{\barraA}{\vrule height2em width0em depth0em}
\newcommand{\barraB}{\vrule height1.6em width0em depth0em}
\begindc{\commdiag}[35]
\obj(1,1)[Gr]{$G$}
\obj(3,1)[Grstar]{$G_{r^*}$}
\obj(5,1)[H]{$H$}
\obj(2,2)[SigmaG]{$\Sigma^G$}
\obj(6,2)[SigmaH]{$\Sigma^H$}
\obj(1,3)[Lm]{$L_m$}
\obj(3,3)[Krm]{$K_{r,m}$}
\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}{$i_3\quad$}[\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}{$i_1\quad$}[\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
```
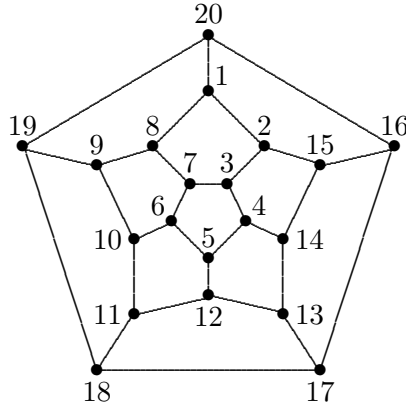

4.3 "Around the Word" [2]

```
\begindc{\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
```


References

[1] Feruglio, Gabriel Valiente. Typesetting commutative diagrams. *TUG-boat*, 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 P_ICTEX Manual.* Personal TeX Inc, 12 Madrona Avenue, Mill Valley, CA 94941 - USA, 3rd edition, March 1992

5   The Code

```
% $Id: dcpic.sty,v 1.25 2003/02/18 12:01:40 pedro Exp $
%% DC-PiCTeX
%% Copyright (c) 1990-2002 Pedro Quaresma de Almeida, Coimbra
%% 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)
\immediate\write10{Package DCpic 2002/05/16 v4.0}


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%%
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%% General Public License for more details.
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%%
%%
%% Coimbra, 16 de Maio de 2002
%% 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 establishe the
%%  coordinate system where the objects will by 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:
%%    \begindc{\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){$g\circ f$}
%%    \enddc
%%
%% NOTES:
%%    all the numeric values should be integer values.
%%
%% Available commands:
%%
%% The environment:
%%    \begindc{#1}[#2]
%%         #1 - Graph type
%%            0 = "commdiag" (commutative diagram)
%%            1 = "digraph" (direct graph)
%%            2 = "undigraph" (undirect graph)
%%         (optional) #2 - magnification factor (default value, 30)
%%
%%    \enddc
%%
%% Objects:
%%    \obj(#1,#2)[#3]{#4}[#5]
%%              #1 and #2 - coordenates
%% (optional) #3 - Label, to be used in the morphims 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
```

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```
%%                      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)
```

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```
%%            #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 = "\injectionarrow"
%%                4 = "\aplicationarrow"
%%
%% 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
%%
%% Exemples:
%%\documentclass[a4paper,11pt]{article}
%%\usepackage{dcpic,pictexwd}
%%
%%\begin{document}
%%\begindc[3]
%%\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
%%
%%\begindc{\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}
%%\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}{$\varphi^{r^*}$}[\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}
%%----------------//-------------
%% Modifica{\c c}{\~o}es (9/1993)
%%        argumento "dist{\^a}ncia entre as extremidades da seta e os
%%        objectos" passou a ser opcional; uma nova op{\c c}{\~a}o para as
%%        "setas" (op{\c c}{\~a}o 3).
%%
%% 2/3/1995 (vers{\~a}o 1.3)
%%        foi acrescentado o tipo de seta de aplica{\c c}{\~a}o
%%        (op{\c c}{\~a}o 4) a dist{\^a}ncia da etiqueta {\`a} seta respectiva
%%        passou a ser fixa  (10 unidades de medida).
%% 15/7/1996 (verso 2.1)
%%        O comando "\mor" passou a ter uma sintaxe distinta. Os
%%        par{\^a}metros 5 e 6 passaram a ser a dist{\^a}ncia entre os
%%        objectos e os extremos da seta o par{\^a}metro 7 {\'e} o nome do
%%        morfismo e os par{\^a}metros 8 e 9, coloca{\c c}{\~a}o do morfismo
%%        e tipo de morfismo passaram a ser opcionais.
%%
%% 5/2001 (vers{\~a}o 3.0)
%%        Implementa{\c c}{\~a}o do comando "\cmor" baseado no comando
%%        de desenho de curvas quadr{\'a}ticas pelo PiCTeX
%%
%% 11/2001 (vers{\~a}o 3.1)
%%        Modifica{\c c}{\~a}o das pontas das setas de forma a estas ficarem
%%        semelhantes {\'a}s setas (s{\'\i}mbolos) dos TeX.
%%
%% 1/2002  (vers{\~a}o 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 (verso 4.0)
%%      Modificao dos comandos "begindc" e "obj"
%% !!! Modificao da sintaxe destes comandos !!!
%%      O comando "begindc" 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" (1), 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
%%      referncia 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".
%%
%%----------------//-------------

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

\newcount\aux%
\newcount\auxa%
\newcount\auxb%
\newcount\m%
\newcount\n%
\newcount\x%
\newcount\y%
\newcount\xl%
\newcount\yl%
\newcount\d%
\newcount\dnm%
\newcount\xa%
\newcount\xb%
\newcount\xmed%
\newcount\xc%
\newcount\xd%
```

```
\newcount\ya%
\newcount\yb%
\newcount\ymed%
\newcount\yc%
\newcount\yd
%% "variveis globais"
\newcount\expansao%
\newcount\tipografo%       verso 4.0
\newcount\distanciaobjmor% verso 4.0
\newcount\tipoarco%        verso 4.0
%\newif\ifarredondada%         verso 4.0 (valor inicial "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%
%% para os ajustes
\newcount\auxqx
\newcount\auxqy
\newif\ifajusta%
\newif\ifajustadist
\def\objPartida{}%
\def\objChegada{}%
\def\objNulo{}%


%%
%% Stack specification
%%

%%
%% Emtpy stack
%%
\def\!vazia{:}
```

```
%%
%% Is Empty? : Stack -> Bool
%%
%% nvazia - True if Not Empy
%% vazia  - True if Empty
\def\!pilhanvazia#1{\let\arg=#1%
\if:\arg\ \nvaziafalse\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}%
\xaux=#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\diferentestrue\fi}
```

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

%%Comando Interno
%% Valor absoluto (absolute value)
%% \absoluto{n}{absn}
%% entrada
%%  n - natural
%% sa{\'\i}da
%%  absn - o valor absoluto de n
\def\!absoluto#1#2{\n=#1%
  \ifnum \n > 0
    #2=\n
  \else
    \multiply \n by -1
    #2=\n
  \fi}


%% Name definitions for edge types and directions
\def\solidarrow{0}
\def\dasharrow{1}
\def\solidline{2}
\def\injectionarrow{3}
\def\aplicationarrow{4}
%% 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}
%% Posicionamento da etiquetas nos grafos
\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 dist{\^a}ncia entre as setas e os objectos em fun{\c c}{\~a}o das
%% dimens{\~o}es destes {\'u}ltimos
%% \ajusta{x}{xl}{y}{yl}{d}{Objecto}
%% entrada
%%  (x,y) e (xl,yl), coordenadas dos pontos de {\'\i}nicio e fim da seta
%%  d, dist{\^a}ncia especificada pelo utilizador ou 10 (valor por
%%  omiss{\~a}o), Objecto d{\'a}-nos a refer{\^e}ncia do objecto ao qual se est{\'a]
%%  efectuar o ajuste.
%% sa{\'\i}da
%%  d, dist{\^a}ncia alterada.
%%
%% A dist{\^a}ncia alterada {\'e} o maior valor entre 10 e as dimens{\~o}es
%% apropriadas da caixa que cont{\^e}m o objecto.
%% Se o utilizador especificar um valor essa especifica{\c c}{\~a}o
%% n{\~a}o {\'e} alterada.
%%
%% Se a seta {\'e} horizontal usa-se o valor da largura
%% Se a seta {\'e} vertical usa-se:
%%  o valor da altura se a seta est{\'a} no 1o ou 2o quadrante
%%  o valor da profundidade se a seta est{\'a} no 3o ou 4o quadrante
%% Se a seta {\'e} {\'o}bliqua 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 omisso ajusta
    \else
      \ajustadistfalse  % caso contrrio 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 omisso ajusta
%    \else
%      \ajustadistfalse % caso contrrio 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=1310720% 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\y=\number\yl
%% 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\x=\number\xl
      \ifnum\number\yl>\number\y
%% 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. O 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 315o a  45o; |x-xl|>|y-yl| e
%% Caso 3.3 de 135o a 225o; |x-xl|>|y-yl|; Largura
      \auxqx=\x
      \advance\auxqx by -\xl
      \!absoluto{\auxqx}{\auxqx}%
      \auxqy=\y
      \advance\auxqy by -\yl
      \!absoluto{\auxqy}{\auxqy}%
      \ifnum\auxqx>\auxqy
       \ifnum\larg<10
        \larg=10
       \fi
       \advance\larg by 3
       #5=\larg
      \else
%% Caso 3.2 de  45o a 135o; |x-xl|<|y-yl| e y>0; Largura
       \ifnum\yl>\y
        \ifnum\larg<10
         \larg=10
        \fi
       \advance\alt by 6
        #5=\alt
```

```
      \else
%% Caso 3.4 de 225o a 315o; |x-xl|<|y-yl| 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{\n=#1%
  \m=1%
  \loop
    \aux=\m%
    \advance \aux by 1%
    \multiply \aux by \aux%
    \ifnum \aux < \n%
      \advance \m by 1%
      \paratrue%
    \else\ifnum \aux=\n%
      \advance \m by 1%
      \paratrue%
       \else\parafalse%
       \fi
    \fi
  \ifpara%
  \repeat
#2=\m}

%%Comando Interno
%% Calcula os pontos de
%%      come{\c c}o da "seta"
%%      fim da "seta"
%%   coloca{\c c}{\~a}o do s{\'\i}mbolo
%%
```

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```
%% ucoord{x1}{x2}{x3}{x4}{x5}{x6}{+|- 1}
%% entrada
%%   x1,x2,x3,x4,x5
%% sa{\'\i}da
%%   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}


%%Comando Interno
%% C{\'a}lculo do Quadrado da Dist{\^a}ncia Euclidiana entre dois pontos
%% quadrado{n}{m}{l}
%% entrada
%%   n - natural
%%   m - natural
%% sa{\'\i}da
%%   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
}


%%
%% O ambiente "begindc...enddc"
%%
\def\begindc#1{\!ifnextchar[{\!begindc{#1}}{\!begindc{#1}[30]}}
\def\!begindc#1[#2]{\beginpicture
  \let\pilha=\!vazia
  \setcoordinatesystem units <1pt,1pt>
  \expansao=#2
  \ifcase #1
    \distanciaobjmor=10
    \tipoarco=0          % seta
```

```
     \tipografo=0        % diagrama comutativo
   \or
     \distanciaobjmor=2
     \tipoarco=0         % seta
     \tipografo=1        % grafo orientado
   \or
     \distanciaobjmor=1
     \tipoarco=2         % linha
     \tipografo=2        % grafo no orientado
   \or
     \distanciaobjmor=8
     \tipoarco=0         % seta
     \tipografo=3        % grafo orientado
%    \arredondadotrue    % objectos com molduras circulares
   \or
     \distanciaobjmor=8
     \tipoarco=2         % linha
     \tipografo=4        % grafo no orientado
%    \arredondadotrue    % objectos com molduras circulares
   \fi}

\def\enddc{\endpicture}


%%
%% Comando para construir a "seta" entre dois objectos
%%
%% Os pontos definidores da seta e da etiqueta respectiva s{\~a}o:
%%
%%                   (xd,yd)
%%                      o
%%                      |
%%   o------o---------o---------o------o
%%%(x,y) (xa,ya)    (xm,ym)   (xb,yb)(xl,yl)
%%
\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\distanciaobjm
\def\!morObjA#1{%
 \let\pilhaaux=\pilha%
 \def\objPartida{#1}%
```

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```
 \loop%
    \!topo\pilha%
    \!retira\pilha%
    \!compara{\id}{\objPartida}%
    \ifcompara \nvaziafalse \else \!pilhanvazia\pilha \fi%
  \ifnvazia%
 \repeat%
 \ifvazia%
  \ifdiferentes%
%%
%% Mensagem de erro e atribui{\c c}{\~a}o de valores fict{\'\i}cios aos
%% argumentos dos comandos que se seguem.
%%
   Error: Incorrect label specification%
   \xaux=1%
   \yaux=1%
  \fi%
 \fi%
 \let\pilha=\pilhaaux%
 \!ifnextchar({\!morxyl{\number\xaux}{\number\yaux}}{\!morObjB{\number\xaux}{\number
\def\!morObjB#1#2#3{%
  \x=#1
  \y=#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%
%%
%% Mensagem de erro e atribui{\c c}{\~a}o de valores fict{\'\i}cios aos
%% argumentos dos comandos que se seguem.
%%
   Error: Incorrect label specification
   \xaux=\x%
   \advance\xaux by \x%
   \yaux=\y%
   \advance\yaux by \y%
  \fi
```

```
 \fi
 \let\pilha=\pilhaaux
 \!ifnextchar[{\!mora{\number\x}{\number\y}{\number\xaux}{\number\yaux}}{\!mora{\nu
\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}{#
\def\!morb#1#2#3#4#5#6#7[#8,#9]{\x=#1%
  \y=#2%
  \xl=#3%
  \yl=#4%
  \multiply \x by \expansao%
  \multiply \y by \expansao%
  \multiply \xl by \expansao%
  \multiply \yl by \expansao%
%%
%% calcular a dist{\^a}ncia Euclidiana entre dois pontos
%% d = \sqrt((x-xl)^2+(y-yl)^2)
%%
  \!quadrado{\number\x}{\number\xl}{\auxa}%
  \!quadrado{\number\y}{\number\yl}{\auxb}%
  \d=\auxa%
  \advance \d by \auxb%
  \!raiz{\d}{\d}%
%%
%% o ponto (xa,ya) est{\'a} {\`a} dist{\^a}ncia #5 (valor por omiss{\~a}o 10) do po
%% (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{\x}{\xl}{\y}{\yl}{\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\x}{\number\xl}{\number\x}{\auxa}{\number\d}{\xa}{1}%
  \!ucoord{\number\y}{\number\yl}{\number\y}{\auxa}{\number\d}{\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=\d%
%%
%% o ponto (xb,yb) est{\'a} {\`a} dist{\^a}ncia #6 (valor por omiss{\~a}o 10) do por
%% (xl,yl)
%%
    \auxb=#6
    \!compara{\objNulo}{\objChegada}%
    \ifdiferentes% S{\'o} vai fazer o ajuste quando {\'e} necess{\'a}rio
%    Vou ajustar
      \!ajusta{\x}{\xl}{\y}{\yl}{\auxb}{\objChegada}%
      \def\objChegada{}% re-inicializar o valor do Objecto de Chegada
    \fi
    \advance \auxa by -\auxb%
    \!ucoord{\number\x}{\number\xl}{\number\x}{\number\auxa}{\number\d}{\xb}{1}%
    \!ucoord{\number\y}{\number\yl}{\number\y}{\number\auxa}{\number\d}{\yb}{1}%
    \xmed=\xa%
    \advance \xmed by \xb%
    \divide \xmed by 2
    \ymed=\ya%
    \advance \ymed by \yb%
    \divide \ymed by 2
%%
%%
    \!distnomemor{\number\x}{\number\y}{\number\xl}{\number\yl}{#7}{\dnm}%
    \!ucoord{\number\y}{\number\yl}{\number\xmed}{\number\dnm}{\number\d}{\xc}{-#8}%
    \!ucoord{\number\x}{\number\xl}{\number\ymed}{\number\dnm}{\number\d}{\yc}{#8}%
\ifcase #9  % seta s{\'o}lida
    \arrow <4pt> [.2,1.1] from {\xa} {\ya} to {\xb} {\yb}
\or  % seta a tracejado
    \setdashes
    \arrow <4pt> [.2,1.1] from {\xa} {\ya} to {\xb} {\yb}
    \setsolid
\or  % linha s{\'o}lida
    \setlinear
    \plot {\xa} {\ya}  {\xb} {\yb} /
\or  % seta de injec{\c c}{\~a}o
%% C{\'a}lculos auxiliares
%%
%% 3 valor para o raio do "rabo" da "seta"
%%
%% repor o valor de auxa
    \auxa=\guardaauxa
%% dar a compensa{\c c}{\~a}o para o "rabo"
    \advance \auxa by 3%
```

```
%%
%% IMPORTANTE os valores de xa e ya v{\~a}o ser alterados
%%
 \!ucoord{\number\x}{\number\xl}{\number\x}{\number\auxa}{\number\d}{\xa}{1}%
 \!ucoord{\number\y}{\number\yl}{\number\y}{\number\auxa}{\number\d}{\ya}{1}%
 \!ucoord{\number\y}{\number\yl}{\number\xa}{3}{\number\d}{\xd}{-1}%
 \!ucoord{\number\x}{\number\xl}{\number\ya}{3}{\number\d}{\yd}{1}%
%% Constru{\c c}{\~a}o da "seta"
   \arrow <4pt> [.2,1.1] from {\xa} {\ya} to {\xb} {\yb}
%% e do seu "rabo"
   \circulararc -180 degrees from {\xa} {\ya} center at {\xd} {\yd}
\or  % seta de aplica{\c c}{\~a}o ("|-->")
   \auxa=3% valor para o meio-segmento do "rabo" da "seta"
%% c{\'a}lculo dos pontos (xmed,ymed) e (xd,yd) para o segmento de recta que
%% define o "rabo" da seta
 \!ucoord{\number\y}{\number\yl}{\number\xa}{\number\auxa}{\number\d}{\xmed}{-1}%
 \!ucoord{\number\x}{\number\xl}{\number\ya}{\number\auxa}{\number\d}{\ymed}{1}%
 \!ucoord{\number\y}{\number\yl}{\number\xa}{\number\auxa}{\number\d}{\xd}{1}%
 \!ucoord{\number\x}{\number\xl}{\number\ya}{\number\auxa}{\number\d}{\yd}{-1}%
%% Constru{\c c}{\~a}o da "seta"
   \arrow <4pt> [.2,1.1] from {\xa} {\ya} to {\xb} {\yb}
%% e do seu "rabo"
   \setlinear
   \plot {\xmed} {\ymed}  {\xd} {\yd} /
\fi
%% Coloca{\c c}{\~a}o do nome do morfismo.
%% Se os morfismos s{\~a}o horizontais ou verticais constro{\'\i} uma caixa
%% centrada no ponto pr{\'e}viamente calculado. Se as setas s{\~a}o
%% obl{\'\i}quas coloca a caixa de forma a n{\~a}o colidir com o morfismo
%% tendo em aten{\c c}{\~a}o o quadrante assim como a posi{\c c}{\~a}o
%% relativa do morfismo e do respectivo nome.
\auxa=\xl
\advance \auxa by -\x%
\ifnum \auxa=0
  \put {#7} at {\xc} {\yc}
\else
  \auxb=\yl
  \advance \auxb by -\y%
  \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
\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){\x=#1%
  \y=#2%
  \multiply \x by \expansao%
  \multiply \y by \expansao%
  \!start (\x,\y)
```

```
    \!modifQjoin}
\def\!modifQjoin(#1,#2)(#3,#4){\x=#1%
  \y=#2%
  \xl=#3%
  \yl=#4%
  \multiply \x by \expansao%
  \multiply \y by \expansao%
  \multiply \xl by \expansao%
  \multiply \yl by \expansao%
  \!qjoin (\x,\y) (\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){\x=#1%
  \y=#2
  \multiply \x by \expansao
  \multiply \y by \expansao
  \xl=\x%
  \yl=\y%
  \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 {\x} {\y} 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
  \x=#3%
  \y=#4%
  \multiply \x by \expansao%
  \multiply \y by \expansao%
  \put {#5} at {\x} {\y}}

%%
%% 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]{%
  \x=#1%
  \y=#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 \x by \expansao%
\multiply \y by \expansao%
\setbox\caixa=\hbox{#4}%
\!coloca{(\!arg)(#1,#2)(\number\ht\caixa,\number\wd\caixa,\number\dp\caixa)}{\pill
\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 {\x} {\y}
\or                   % grafos dirigidos
  \ifcase #5 % c=0
    \put{#4} at {\x} {\y}
  \or        % n=1
    \put{\!pinta} at {\x} {\y}
    \advance \y by \number\auxb  % height+depth+5
    \put{#4} at {\x} {\y}
  \or        % ne=2
    \put{\!pinta} at {\x} {\y}
    \advance \auxa by -2  % para fazer o ajuste (imperfeito)
    \advance \auxb by -2  % ao raio da circunferncia de centro (x,y)
    \advance \x by \number\auxa  % width+5
    \advance \y by \number\auxb  % height+depth+5
    \put{#4} at {\x} {\y}
  \or        % e=3
    \put{\!pinta} at {\x} {\y}
    \advance \x by \number\auxa  % width+5
    \put{#4} at {\x} {\y}
  \or        % se=4
    \put{\!pinta} at {\x} {\y}
    \advance \auxa by -2  % para fazer o ajuste (imperfeito)
```

```
      \advance \auxb by -2  % ao raio da circunferncia de centro (x,y)
      \advance \x by \number\auxa  % width+5
      \advance \y by -\number\auxb  % height+depth+5
      \put{#4} at {\x} {\y}
    \or        % s=5
      \put{\!pinta} at {\x} {\y}
      \advance \y by -\number\auxb  % height+depth+5
      \put{#4} at {\x} {\y}
    \or        % sw=6
      \put{\!pinta} at {\x} {\y}
      \advance \auxa by -2  % para fazer o ajuste (imperfeito)
      \advance \auxb by -2  % ao raio da circunferncia de centro (x,y)
      \advance \x by -\number\auxa  % width+5
      \advance \y by -\number\auxb  % height+depth+5
      \put{#4} at {\x} {\y}
    \or        % w=7
      \put{\!pinta} at {\x} {\y}
      \advance \x by -\number\auxa  % width+5
      \put{#4} at {\x} {\y}
    \or        % nw=8
      \put{\!pinta} at {\x} {\y}
      \advance \auxa by -2  % para fazer o ajuste (imperfeito)
      \advance \auxb by -2  % ao raio da circunferncia de centro (x,y)
      \advance \x by -\number\auxa  % width+5
      \advance \y by \number\auxb  % height+depth+5
      \put{#4} at {\x} {\y}
    \fi
  \or                    % grafos no dirigidos
    \ifcase #5 % c=0
      \put{#4} at {\x} {\y}
    \or        % n=1
      \put{\!pinta} at {\x} {\y}
      \advance \y by \number\auxb  % height+depth+5
      \put{#4} at {\x} {\y}
    \or        % ne=2
      \put{\!pinta} at {\x} {\y}
      \advance \auxa by -2  % para fazer o ajuste (imperfeito)
      \advance \auxb by -2  % ao raio da circunferncia de centro (x,y)
      \advance \x by \number\auxa  % width+5
      \advance \y by \number\auxb  % height+depth+5
      \put{#4} at {\x} {\y}
    \or        % e=3
      \put{\!pinta} at {\x} {\y}
      \advance \x by \number\auxa  % width+5
```

```
      \put{#4} at {\x} {\y}
   \or        % se=4
      \put{\!pinta} at {\x} {\y}
      \advance \auxa by -2  % ver acima
      \advance \auxb by -2
      \advance \x by \number\auxa  % width+5
      \advance \y by -\number\auxb % height+depth+5
      \put{#4} at {\x} {\y}
   \or        % s=5
      \put{\!pinta} at {\x} {\y}
      \advance \y by -\number\auxb % height+depth+5
      \put{#4} at {\x} {\y}
   \or        % sw=6
      \put{\!pinta} at {\x} {\y}
      \advance \auxa by -2  % ver acima
      \advance \auxb by -2
      \advance \x by -\number\auxa % width+5
      \advance \y by -\number\auxb % height+depth+5
      \put{#4} at {\x} {\y}
   \or        % w=7
      \put{\!pinta} at {\x} {\y}
      \advance \x by -\number\auxa % width+5
      \put{#4} at {\x} {\y}
   \or        % nw=8
      \put{\!pinta} at {\x} {\y}
      \advance \auxa by -2  % ver acima
      \advance \auxb by -2
      \advance \x by -\number\auxa % width+5
      \advance \y by \number\auxb  % height+depth+5
      \put{#4} at {\x} {\y}
   \fi
% \or % grafos dirigidos com molduras circulares nos objectos
%    \advance \auxa by 4
%    \put{\circle{\auxa}} [Bl] at {\x} {\y}
%    \put{#4} at {\x} {\y}
% \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}} [Bl] at {\x} {\y}
    \else
      \multiply\auxa by 2
      \multiply\auxb by 2
      \put{\oval(\auxa,\auxb)} [Bl] at {\x} {\y}
    \fi
    \put{#4} at {\x} {\y}
  \fi
}


\catcode'!=12 %  *****  THIS MUST NEVER BE OMITTED (Ver PiCTeX)
```