

DCpic v5.0.0
2013/05/01 (v15)

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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, examples.tex, manDCPiC.tex, manDCPiCpt.tex

Coimbra, 2013/05/01
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 was a conflict between dcpic.sty and hyperref in current texlive-2009 due to the one letter macro “\d” (thanks to Thorsten S <thorsten.schwander@gmail.com>). The “d” changed to “deuc” (Euclidian Distance). The “x” and “y” changed to “xO” “yO”

4/2013 - **version 4.4.0:** thanks to Xingliang Liang <jkl19543@gmail.com>. He added a new arrow “dotarrow”.

5/2013 - **version 5.0: new unit for the coordinate system**, 1/10th of the previous one. This allow a better implementation of the double line arrows and also a more fine specification of the diagrams/graphs (Thanks to Antonio de Nicola <adenicola@mat.uc.pt>).

2 Introduction

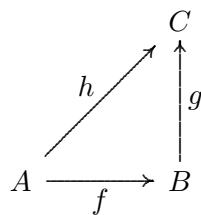
DCpic is a package of T_EX [3] macros for graph modelling in a (La)T_EX [4] or ConT_EXt [5] document. Its distinguishing features are: the use of P_TCT_EX [7] a powerful graphical engine, and a simple specification syntax. A graph is described in terms of its objects and its edges. The objects are textual elements and the edges can have various straight or curved forms.

A graph [2] in DCpic is a “picture” in P_TCT_EX, 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 P_TCT_EX” 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(10,10){$A$}
  \obj(30,10){$B$}
  \obj(30,30){$C$}
  \mor{$A$}{$B$}{$f$}[\atright,\solidarrow]
  \mor{$B$}{$C$}{$g$}[\atright,\solidarrow]
  \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, 300)
\enddc

```

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 = "\dotArrow"
    3 = "\solidline"
    4 = "\dashline"
    5 = "\dotline"
    6 = "\injectionarrow"
    7 = "\aplicationarrow"
    8 = "\surjectivearrow"
    9 = "\equalline"
   10 = "\doublearrow"
   11 = "\doubleopposite"
   12 = "\nullarrow" (to allow adding labels to existing arrows)
```

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 - 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.

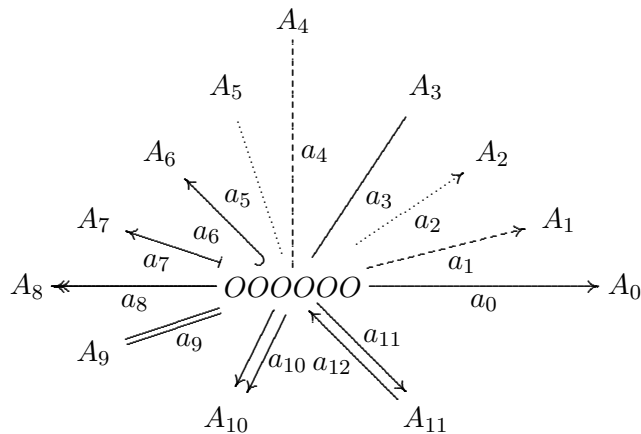
4 Examples

4.1 Different Types of Lines/Arrows

```

\begincd{\commdiag}[250]
\obj(10,10)[A]{\$OOOOO\$}
\obj(15,10)[A0]{\$A_0\$}
\obj(14,11)[A1]{\$A_1\$}
\obj(13,12)[A2]{\$A_2\$}
\obj(12,13)[A3]{\$A_3\$}
\obj(10,14)[A4]{\$A_4\$}
\obj(9,13)[A5]{\$A_5\$}
\obj(8,12)[A6]{\$A_6\$}
\obj(7,11)[A7]{\$A_7\$}
\obj(6,10)[A8]{\$A_8\$}
\obj(7,9)[A9]{\$A_9\$}
\obj(9,8)[A10]{\$A_{10}\$}
\obj(12,8)[A11]{\$A_{11}\$}
\mor{A}{A0}{\$a_0\$}[\ atright , \ solidarrow]
\mor{A}{A1}{\$a_1\$}[\ atright , \ dashArrow]
\mor{A}{A2}{\$a_2\$}[\ atright , \ dotArrow]
\mor{A}{A3}{\$a_3\$}[\ atright , \ solidline]
\mor{A}{A4}{\$a_4\$}[\ atright , \ dashline]
\mor{A}{A5}{\$a_5\$}[\ atleft , \ dotline]
\mor{A}{A6}{\$a_6\$}[\ atleft , \ injectionarrow]
\mor{A}{A7}{\$a_7\$}[\ atleft , \ aplicationarrow]
\mor{A}{A8}{\$a_8\$}[\ atleft , \ surjectivearrow]
\mor{A}{A9}{\$a_9\$}[\ atleft , \ equalline]
\mor{A}{A10}{\$a_{10}\$}[\ atleft , \ doublearrow]
\mor{A}{A11}{\$a_{11}\$}[\ atleft , \ doubleopposite]
\mor{A}{A11}{\$a_{12}\$}[\ atright , \ nullarrow]
\endcd

```



4.2 Diagrams with Curved Edges, Double Arrows, ...

Curved edges

```

\begincd{0}
\obj(14,11){\$A\$}
\obj(39,11){\$B\$}

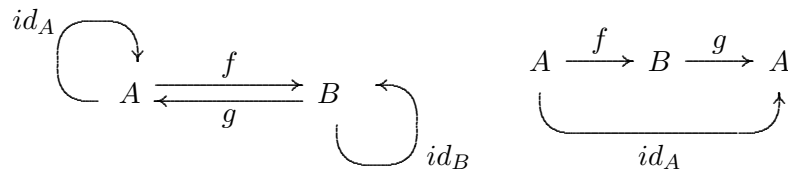
```

```

\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}
\obj(10,15)[A]{$A$}
\obj(40,15)[Aa]{$Aa$}
\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}
\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}
\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.

```

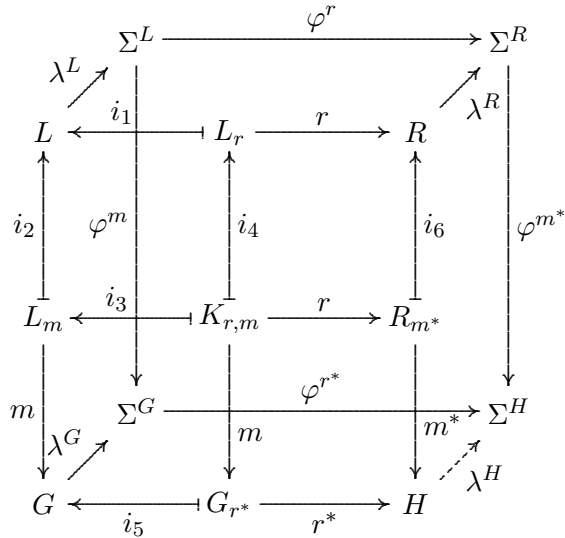
\newcommand{\barraA}{\vrule height2em width0em depth0em}
\newcommand{\barraB}{\vrule height1.6em width0em depth0em}
\begindc{\commdiag}[350]
\obj(1,1)[Gr]{$G$}
\obj(3,1)[Grstar]{$G_{r^*}$}
\obj(5,1)[H]{$H$}
\obj(2,2)[SigmaG]{$\Sigma^G$}
\obj(6,2)[SigmaH]{$\Sigma^H$}
\obj(1,3)[Lm]{$L_m$}
\obj(3,3)[Krm]{$K_{r,m}$}

```

```

\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}{\bar{A}m\$}
\mor{Rmstar}{R}{\$i_{-6}\$}[\atright,\aplicationarrow]
\mor{Rmstar}{H}{\bar{B}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

```



4.4 “Around the Word” [2]

```

\begin{c}
\undigraph[70]
\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}
\end{c}

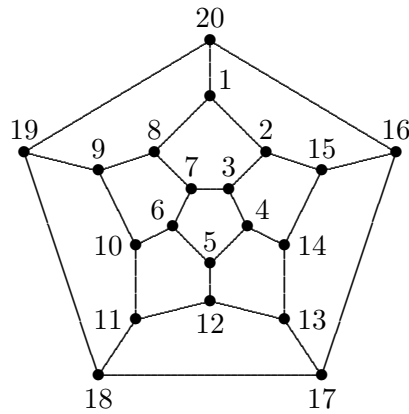
```



```

\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

```

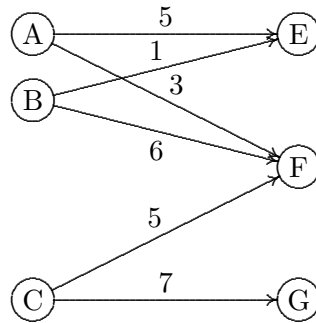


4.5 Incircled Objects

```

\begin{cdigraph}[250]
\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}[80,80]{5}
\mor{A}{F}[80,80]{3}
\mor{B}{F}[80,80]{6}[\atright,\solidarrow]
\mor{B}{E}[80,80]{1}
\mor{C}{F}[80,80]{5}
\mor{C}{G}[80,80]{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. *L^AT_EX: A Document Preparation System*. Addison-Wesley Publishing Company, Reading, Massachusetts, 2nd edition, 1994.
- [5] Otten, Ton and Hagen, Hans . *ConT_EXt 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_ICT_EX Manual*. Personal T_EX Inc, 12 Madrona Avenue, Mill Valley, CA 94941 - USA, 3rd edition, March 1992

5 The Code

```

%% DC-PiCTeX
%% Copyright (c) 1990–2013 Pedro Quaresma, University of 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)
%% 4/2013 (version 4.4.0)
%% 5/2013 (version 5.0)

```

```

\immediate\write10{Package DCpic 2013/05/01 v5.0}

\ProvidesPackage{dcpic}[2013/05/01 v5.0]

%% Version X.Y.Z
%% X - major versions
%% Y - minor versions
%% Z - bug corrections
%%
%% Copyright (c) 1990-2013 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, 1st of May, 2013 (2013/05/01)
%% Pedro Quaresma
%%
%% 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 establishes 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{dcpic}[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{dcpic}
%%
%% NOTES:
%% all the numeric values should be integer values.
%%
%% Available commands:
%%
%% The environment:
%% \begin{dcpic}[#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, 300)
%%
%% \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
%%                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 coordenates, 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 coordenates specification
%% \mor(#1,#2)(#3,#4)[#5,#6]{#7}[#8,#9]
%%
%% Now we can describe all the arguments
%%
%%      #1 and #2 - coordenates (beginning)
%%      #3 and #4 - coordenates (ending)
%% (optional)#5,#6 - correction factors (default values, 100 and 100 (10pt))
%%      #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 = "\dotArrow (thanks to Xingliang Liang <jkl9543@gmail.com>)
%%          3 = "\solidline"
%%          4 = "\dashline"
%%          5 = "\dotline"
%%          6 = "\injectionarrow"
%%          7 = "\aplicationarrow"
%%          8 = "\surjectivearrow"
%%          9 = "\equalline" (thanks to Ruben Debeerst <debeerst@mathematik.uni-kassel.de>)
%%         10 = "\doublearrow"
%%         11 = "\doubleopposite"
%%         12 = "\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 - 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
%%
%% Examples:
%% \documentclass[a4paper,11pt]{article}
%% \usepackage{dcpic,pictexwd}
%%
%% \begin{document}
%% \begin{dcpic}[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$}
%% \cmor((40,7)(41,3)(45,2)(49,3)(50,7)(49,11)(45,12))
%% \pleft(54,3){id_B$}
%% \end{dcpic}
%%
%% \begin{dcpic}{\commdiag}[3]
%% \obj(10,15)[A]{A$}
%% \obj(40,15)[Aa]{Aa$}
%% \obj(25,15)[B]{B$}
%% \mor{A}{B}{f$}%[\atright,\solidarrow]
%% \mor{B}{Aa}{g$}%[\atright,\solidarrow]
%% \cmor((10,11)(11,7)(15,6)(25,6)(35,6)(39,7)(40,11))
%% \pup(25,3){id_A$}
%% \end{dcpic}
%%
%% \newcommand{\barraA}{\vrule height2em width0em depth0em}
%% \newcommand{\barraB}{\vrule height1.6em width0em depth0em}
%% \begin{dcpic}{\commdiag}[35]
%% \obj(1,1)[Gr]{G$}
%% \obj(3,1)[Grstar]{G_{r^*}$}
%% \obj(5,1)[H]{H$}

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%% \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 (100 units).
%% 15/7/1996 (version 2.1)
%%     The comand "\mor" has a new syntax. 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)
%%     Modification of the commands "obj" and "mor" in such a way
%%     that allows the logical specification of the morphisms, that
%%     is, it is now possible to specify the starting object and the
%%     ending object instead of specify the coordinates.
%%
%%     The length of the arrows is automatically trimmed to the
%%     objects' size.
%%
%% 5/2002 (version 4.0)
%%     New syntax for the commands "begindc" e "obj"

```

```

%% !!! New syntax !!!
%% The command "beginDC" now have an obligatory argument, this
%% argument allows the specification of the graph type
%% "commdiag" (0), commutative diagrams
%% "digraph" (1), directed graphs
%% "undigraph" (2), undirected graphs
%% The command "obj" has a new syntax: after the coordinates
%% specification, an optional argument specifying a label, an
%% obligatory argument given the "value" of the object and the
%% final optional argument used in the graphs to set the
%% relative position of the "value" to the "dot" defining the
%% objects position, the default value is "north".
%%
%% 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
%% 4/2013 (version 4.4.0)
%% Thanks to Xingliang Liang <jk19543@gmail.com>. He added a new
%% arrow "dotarrow".
%% 5/2013 (version 5.0)
%% The base scale of the graph has changed from 1pt to .1pt to
%% solve a problem with the implementation of the oblique
%% equalline (Thanks to Antonio de Nicola).
%% The LaTeX circle and oval commands where replaced by the
%% PiCTeX circulararc and ellipticalarc commands to avoid
%% differences in scales.
%%-----//-----

```

```
\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\ifpara%
%% version 3.2
\newbox\caixa%
\newbox\caixaaux%
\newif\ifnvazia%
\newif\ifvazia%
\newif\ifcompara%
\newif\ifdiferentes%
\newcount\iaux%
\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\!pilha#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}%
\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\diferentestru\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\dotArrow{2}
\def\solidline{3}
\def\dashline{4}
\def\dotline{5}
\def\injectionarrow{6}
\def\aplicationarrow{7}
\def\surjectivearrow{8}
\def\equalline{9}
\def\doublearrow{10}
\def\doubleopposite{11}
\def\nullarrow{12}

%% 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}

%%Private Macro
%% Adjust the distance between the arrows and the objects regarding
%% the dimensions of the objects.
%%
%% \ajusta{x}{xl}{y}{yl}{d}{Object} (ajusta = adjust)
%%
%% Input
%% (x,y) e (xl,yl) - start, end coordinates of arrow
%% d - distance specified by the user (default value, 100)
%% Objecto - reference of the object pointed by the arrow
%% Output
%% d - adjusted distance
%%
%% The adjusted distance is the greatest value between 100 and the
%% object's box dimensions. If the user specify a value this is not
%% altered.
%%
%% If the arrow is horizontal the length is used.
%% If the arrow is vertical the height is used for arrows in the 1st
%% or 2nd quadrante, or the depth if the arrow is in the 3rd or 4th
%% quadrante. If the arrow is oblique the value is chosen accordingly:
%% from 315 to 45 degrees length is used
%% from 45 to 135 degrees height is used
%% from 135 to 225 degrees length is used
%% from 225 to 315 degrees depth is used
\def\!ajusta#1#2#3#4#5#6{\aux=#5%
\let\auxobj=#6%
\ifcase \tipografo % commutative diagrams
\ifnum\number\aux=100
\ajustadisttrue % if needed, adjust
\else
\ajustadistfalse % if not, keeps unchanged
\fi
\else % graphs (directed, undirected, with frames)
\ajustadistfalse
\fi
\ifajustadist
\let\pilhaaux=\pilha%
\loop%
\!topo{\pilha}%
\!retira{\pilha}%
\!compara{\!id}{\auxobj}%
\ifcompara\nvaziafalse \else\!pilhanvazia\pilha \fi%

```

```

        \ifnvazia%
    \repeat%
%% push the values into the stack
    \let\pilha=\pilhaaux%
    \ifvazia%
        \ifdiferentes%
%%
%% It is not possible to make de adjustment given the fact that the
%% user did not provide a label for the object in question. We set a
%% value equal to the default value (100)
%%
        \larg=131072% these values are for unit of .1pt
        \prof=65536%
        \alt=65536%
        \fi%
    \fi%
    \divide\larg by 13107% these values are for unit of .1pt
    \divide\prof by 6553%
    \divide\alt by 6553%
    \ifnum\number\y0=\number\yl
%% Case 1 -- horizontal arrow
%%
%% with the division by 13107 we get half the size of the box, for a
%% centered text, the adding of 30 is an empirical adjustment.
        \advance\larg by 30
        \ifnum\number\larg>\aux
            #5=\larg
        \fi
    \else
        \ifnum\number\x0=\number\xl
            \ifnum\number\yl>\number\y0
%% Case 2.1 -- vertical arrow, down direction
%%
                \ifnum\number\alt>\aux
                    #5=\alt
                \fi
            \else
%% Case 2.2 -- vertical arrow, up direction
%%
                with the division by 6553 we get the box height. The adjustment
                %% of 50 is an empirical adjustment.
                \advance\prof by 50
                \ifnum\number\prof>\aux
                    #5=\prof
                \fi
            \fi
        \else
%% Case 3 -- oblique arrow
%% Case 3.1 --- from 315o to 45o; |x-xl|>|y-yl|
%% Case 3.3 --- from 135o to 225o; |x-xl|>|y-yl|; Length
        \auxqx=\x0
        \advance\auxqx by -\xl
        \!absoluto{\auxqx}{\auxqx}%
        \auxqy=\y0
        \advance\auxqy by -\yl
        \!absoluto{\auxqy}{\auxqy}%
        \ifnum\auxqx>\auxqy
            \ifnum\larg<100
                \larg=100
            \fi
            \advance\larg by 30
            #5=\larg
        \else
%% Case 3.2 --- from 45o to 135o; |x-xl|<|y-yl| e y>0; Length
            \ifnum\yl>\y0
                \ifnum\larg<100

```

```

        \larg=100
        \fi
        \advance\alt by 60
        #5=\alt
        \else
%% Case 3.4 -- from 225o to 315o; |x-x1|<|y-y1| e y<0; Depth
        \advance\prof by 110
        #5=\prof
        \fi
        \fi
        \fi
        \fi
\fi} % the branch else is missing

%%Private Macro
%% Square root
%% raiz{n}{m} (raiz = root)
%% ->
%% n - natural number
%% <-
%% n - natural number
%% m - greatest natural number less then the square root of 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
%%
%% cuadrado = square

```

```

%%
%% 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}

%%Private Macro
%% Euclidean distance between arrows and its tags
%%
%% Input
%% (x,y), (x',y') morphism's name (tag)
%% Output
%% dnm - distance between an arrow and its tags
%% (with a trim given by the tag's size
%% Observations
%% The trimming is for horizontal and vertical arrows
%% only. Oblique arrows are dealt in a different way
%%
%% Algorithm
%% caixa0 <- morfism name
%% if x-xl = 0 then {vertical arrow}
%% aux <- caixa0 width
%% dnm <- conversion-sp-pt(aux)/2+3
%% else {non-vertical arrow}
%% if y-yl = 0 then {horizontal arrow}
%% aux <- caixa0 height+depth
%% dnm <- conversion-sp-pt(aux)/2+3
%% else {oblique arrow}
%% dnm <- 3
%% endif
%% endif
%% endalgorithm
\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 13107%2
    \advance \aux by 30
    #6=\aux
  \else
    \aux=#2
    \advance \aux by -#4
    \ifnum \aux=0
      \aux=\ht0 \advance \aux by \dp0 \divide \aux by 13107%2
      \advance \aux by 30
      #6=\aux%
    \else
      #6=30
    \fi
  \fi
}

%%
%% The environment "begin dc...end dc"
%%
\def\begin dc#1{\!ifnextchar[{\!begin dc{#1}}{\!begin dc{#1}[30]}}
\def\!begin dc#1[#2]{\begin picture
  \let\pilha=\!vazia
  \setcoordinatesystem units <.1pt,.1pt>
  \expansao=#2

```

```

\ifcase #1
  \distanciaobjmor=100
  \tipoarco=0      % arrow
  \tipografo=0     % commutative diagram
\or
  \distanciaobjmor=20
  \tipoarco=0      % arrow
  \tipografo=1     % directed graph
\or
  \distanciaobjmor=10
  \tipoarco=3      % line
  \tipografo=2     % undirected graph
\or
  \distanciaobjmor=80
  \tipoarco=0      % arrow
  \tipografo=3     % directed graph
\or
  \distanciaobjmor=80
  \tipoarco=3      % line
  \tipografo=4     % undirected graph
\fi}

\def\enddc{\endpicture}

\def\drawarrowhead <#1> [#2,#3]{%
  \ifnextchar<{\!drawarrowhead{#1}{#2}{#3}}{\!drawarrowhead{#1}{#2}{#3}<\!zpt,\!zpt> }}

% Xingliang Liang <jkl9543@gmail.com>
% ** \!ljoin (XCOORD,YCOORD)
% ** Draws a straight line starting at the last point specified
% ** by the most recent \!start, \!ljoin, or \!qjoin, and
% ** ending at (XCOORD,YCOORD).
\def\!ljoindummy (#1,#2){%
  \advance\!intervalno by 1
  \!xE=\!M{#1}\!xunit \!yE=\!M{#2}\!yunit
  \!rotateaboutpivot\!xE\!yE
  \!xdiff=\!xE \advance \!xdiff by -\!xS%** xdiff = xE - xS
  \!ydiff=\!yE \advance \!ydiff by -\!yS%** ydiff = yE - yS
  \!Pythag\!xdiff\!ydiff\!arclength% ** arclength = sqrt(xdiff**2+ydiff**2)
  \global\advance \totalarclength by \!arclength%
  %\!drawlinearsegment% ** set by dashpat to \!linearsolid or \!lineardashed
  \!xS=\!xE \!yS=\!yE% ** shift ending points to starting points
  \ignorespaces}

%%
%% \!drawarrowhead{4pt}{DimC}{DimD} <xshift,yshift> from {\xa} {\ya} to {\xb} {\yb}
%%
\def\!drawarrowhead#1#2#3<#4,#5> from #6 #7 to #8 #9 {%
%
% ** convert to dimensions
  \!xloc=\!M{#8}\!xunit
  \!yloc=\!M{#9}\!yunit
  \!dxpos=\!xloc \!dimenA=\!M{#6}\!xunit \advance \!dxpos -\!dimenA
  \!dypos=\!yloc \!dimenA=\!M{#7}\!yunit \advance \!dypos -\!dimenA
  \let\!MAH=\!M% ** save current c/d mode
  \!setdimenmode% ** go into dimension mode
%
  \!xshift=#4\relax \!yshift=#5\relax% ** pick up shift
  \!reverserotateonly\!xshift\!yshift% ** back rotate shift
  \advance\!xshift\!xloc \advance\!yshift\!yloc
%
% ** draw shaft of arrow
  \!xS=-\!dxpos \advance\!xS\!xshift
  \!yS=-\!dypos \advance\!yS\!yshift
  \!start (\!xS,\!yS)
  \!ljoindummy (\!xshift,\!yshift)
}

```

```

%
% ** find 32*cosine and 32*sine of angle of rotation
\!Pythag\!dxpos\!dypos\!arclength
\!divide\!dxpos\!arclength\!dxpos
\!dxpos=32\!dxpos \!removept\!dxpos\!cos
\!divide\!dypos\!arclength\!dypos
\!dypos=32\!dypos \!removept\!dypos\!sin
%
% ** construct arrowhead
\!halfhead{#1}{#2}{#3}%          ** draw half of arrow head
\!halfhead{#1}{-#2}{-#3}%       ** draw other half
%
\let\!M=\!MAH%                  ** restore old c/d mode
\ignorespaces}

%% 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,\number\distanciaobjmor]}})}
\def\!morObjA#1{%
  \let\pilhaaux=\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 ficticious parameters
%%
  Error: Incorrect label specification%
  \aux=1%
  \yaux=1%
  \fi%
  \fi%
  \let\pilha=\pilhaaux%
  \!ifnextchar({\!morxyl{\number\aux}{\number\yaux}}{\!morObjB{\number\aux}{\number\yaux}})}
\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
    \aux=\x0%
    \advance\xaux by \x0%
    \yaux=\y0%
    \advance\yaux by \y0%
  \fi
\fi
\let\pilha=\pilhaaux
\!ifnextchar[{\!mora{\number\x0}{\number\y0}{\number\xaux}{\number\yaux}}{\!mora{\number\x0}{\number\y0}{\number\xaux}{\number\y0}}{\!mora{\number\x0}{\number\y0}{\number\xaux}{\number\y0}}]{}
\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,\number\tipoarco] ]{}
\def\!morb#1#2#3#4#5#6#7[#8,#9]{\x0=#1%
  \y0=#2%
  \x1=#3%
  \y1=#4%
  \multiply \x0 by \expansao%
  \multiply \y0 by \expansao%
  \multiply \x1 by \expansao%
  \multiply \y1 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 100) from the
%% point (x,y)
%%
%% given the fact that we have two points (start,end) we need to
%% recover their value searching the stack
  \auxa=#5
  \!compara{\objNulo}{\objPartida}%
  \ifdiferentes% adjusting only when needed
  \!ajusta{\x0}{\x1}{\y0}{\y1}{\auxa}{\objPartida}%
  \ajustatrue
  \def\objPartida{}% reset the value of the starting object
\fi
%% save the value of aux (after adjustment) to be used in the case of
%% an injective morphism
  \guardaauxa=\auxa
%%
  \!ucoord{\number\x0}{\number\x1}{\number\y0}{\number\y1}{\number\deuc}{\xa}{1}%
  \!ucoord{\number\y0}{\number\y1}{\number\y0}{\number\y1}{\number\deuc}{\ya}{1}%
%% auxa has the value of the distance between the objects minus the
%% distance between the arrow and the objects (100 default value)
  \auxa=\deuc%
%%
%% the point (xb,yb) is at a distance #6 (default value 100) from the
%% point (x1,y1)
%%
  \auxb=#6
  \!compara{\objNulo}{\objChegada}%

```



```

\ifdiferentes% adjusting only when needed
% adjustment
\!ajusta{\x0}{\x1}{\y0}{\y1}{\auxb}{\objChegada}%
\def\objChegada{}% reset the value of the end object
\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 <2pt>
\plot {\xa} {\ya} {\xb} {\yb} /
\setsolid%
\drawarrowhead <4pt> [.2,1.1] from {\xa} {\ya} to {\xb} {\yb}
\or % 2=dotted arrow (Xingliang Liang <jkl9543@gmail.com> - 4.4.0)
\setdots <2pt>
\plot {\xa} {\ya} {\xb} {\yb} /
\setsolid%
\drawarrowhead <4pt> [.2,1.1] from {\xa} {\ya} to {\xb} {\yb}
\or % 3=solid line
\setlinear
\plot {\xa} {\ya} {\xb} {\yb} /
\or % 4=dashed line
\setdashes <2pt>
\setlinear
\plot {\xa} {\ya} {\xb} {\yb} /
\setsolid
\or % 5=dotted line
\setdots <2pt>
\setlinear
\plot {\xa} {\ya} {\xb} {\yb} /
\setsolid
\or % 6=injective arrow
%%
%% 30 units, the radius for the tail of the arrow
%%
%% recover the value of auxa
\auxa=\guardaauxa
%% makes an adjustment to cope with the tail of the arrow, giving
%% space to the semi-circle
\advance \auxa by 30%
%%
%% 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 2pt (20*0.1) 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\ya}{20}{\number\deuc}{\xd}{-1}%
\!ucoord{\number\x0}{\number\x1}{\number\ya}{20}{\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 % 7=maps "arrow" ("|-->")
\auxa=20 %
%%
%% 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\ya}{\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\ya}{\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 % 8=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 % 9=equalline
%% by Ruben Debeerst: equal-line
%%
%% sets the separation (distance) between the two parallel lines, if
%% horizontal or vertical 1pt (10*0.1) is enough, if not 1.1pt (11*0.1)
\auxa=11
\ifnum\number\y0=\number\y1
\auxa=10
\fi
\ifnum\number\x0=\number\x1
\auxa=10
\fi
%% the two parallel lines will be given by (xmed,ymed)(xd,yd), and
%% (xe,ye)(xf,yf)
\!ucoord{\number\y0}{\number\y1}{\number\ya}{\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\ya}{\number\auxa}{\number\deuc}{\xd}{1}%
\!ucoord{\number\x0}{\number\x1}{\number\ya}{\number\auxa}{\number\deuc}{\yd}{-1}%

\!ucoord{\number\y0}{\number\y1}{\number\yb}{\number\auxa}{\number\deuc}{\xe}{-1}%
\!ucoord{\number\x0}{\number\x1}{\number\yb}{\number\auxa}{\number\deuc}{\ye}{1}%
\!ucoord{\number\y0}{\number\y1}{\number\yb}{\number\auxa}{\number\deuc}{\xf}{1}%
\!ucoord{\number\x0}{\number\x1}{\number\yb}{\number\auxa}{\number\deuc}{\yf}{-1}%
\setlinear
\plot {\xmed} {\ymed} {\xe} {\ye} /
\plot {\xd} {\yd} {\xf} {\yf} /
\or % 10=double arrow
%%
%% sets the separation (distance) between the two parallel lines, if
%% horizontal or vertical 2pt is enough, if not 2.5pt. The extra space
%% is needed because of the arrow tip.
\auxa=25
\ifnum\number\y0=\number\y1
\auxa=20
\fi
\ifnum\number\x0=\number\x1

```

```

\auxa=20
\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\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}%

\!ucoord{\number\y0}{\number\y1}{\number\xb}{\number\auxa}{\number\deuc}{\xe}{-1}%
\!ucoord{\number\x0}{\number\x1}{\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\x1}{\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 2.5pt. The extra space
%% is needed because of the arrow tip.
\auxa=22
\ifnum\number\y0=\number\y1
\auxa=20
\fi
\ifnum\number\x0=\number\x1
\auxa=20
\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\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}%

\!ucoord{\number\y0}{\number\y1}{\number\xb}{\number\auxa}{\number\deuc}{\xe}{-1}%
\!ucoord{\number\x0}{\number\x1}{\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\x1}{\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.
%% If the arrows are horizontal or verticals the box is built centered
%% in the object center. If the arrows are oblique the box is built in
%% such a way to avoid the arrow label, having in account the
%% quadrante and the relative position of the arrow and the
%% corresponding label
\auxa=\x1
\advance \auxa by -\x0%
\ifnum \auxa=0
    \put {#7} at {\xc} {\yc}
\else
    \auxb=\y1
    \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
            \fi
        \fi
    \fi

```

```

\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
}

%%
%% Curved arrow command
%%
%% \cmor(<list of points (n. odd)>){<label>}
%%
%% The plot must be changed in such a way that its syntax is coherent
%% with the other commands
%%
\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%
\x1=#3%
\y1=#4%
\multiply \x0 by \expansao%
\multiply \y0 by \expansao%
\multiply \x1 by \expansao%
\multiply \y1 by \expansao%
\!qjoin (\x0,\y0) (\x1,\y1) % \!qjoin is defined in QUADRATIC
\!ifnextchar{\!fim}{\!modifQjoin}}
\def\!fim){\ignorespaces}

%%
%% The command to draw the arrow tip receives the list of points, get
%% from it the last pair of points and depending of the user choice
%% the arrow tip is drawn.
%%
\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
\x1=\x0%
\y1=\y0%
\aux=1%
\multiply \aux by \auxa%
\advance\x1 by \aux%
\aux=1%
\multiply \aux by \auxb%
\advance\y1 by \aux%
\arrow <4pt> [.2,1.1] from {\x0} {\y0} to {\x1} {\y1}}

%%
%% The definition of the command "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% "\pup" (pointing up)
    \auxa=0% x do not change
    \auxb=1% y "up"
  \or% \pdown" (pointing down)
    \auxa=0% x do not change
    \auxb=-1% y "down"
  \or% "\pright" (pointing right)
    \auxa=1% x "right"
    \auxb=0% y do not change
  \or% "\pleft" (pointing left)
    \auxa=-1% x "left"
    \auxb=0% y do not change
  \fi % the line
\ifcase #6 % arrow solid
  \modifplot#1% draw the line
  % and the arrow tip
  \setaxy#1
\or % arrow (with tip) dashed
  \setdashes
  \modifplot#1% draw the line
  \setaxy#1
  \setsolid
\or % arrow (without tip)
  \modifplot#1% draw the line
\fi % injection morphism
%% label
\x0=#3%
\y0=#4%
\multiply \x0 by \expansao%
\multiply \y0 by \expansao%
\put {#5} at {\x0} {\y0}}

%%
%% Command to build the objects
%% \obj(x,y){<text>}[<label>]
%%
\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$\bullet$}% sets the normal size of the bullet
  \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 13107%2
\advance \auxa by 50
\auxb=\ht\caixa
\advance \auxb by \number\dp\caixa
\divide \auxb by 13107%2
\advance \auxb by 50
\ifcase \tipografo % commutative diagrams
  \put{#4} at {\x0} {\y0}
\or % directed graphs
  \ifcase #5 % c=0, placement of the object (c=center)
    \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 -20 % adjusting to the radius of the circle
    \advance \auxb by -20 % with center in (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 -20 % adjusting to the radius of the circle
    \advance \auxb by -20 % with center in (x,y)
    \advance \x0 by -\number\auxa % width+5
    \advance \y0 by \number\auxb % height+depth+5
    \put{#4} at {\x0} {\y0}
  \fi
\or % undirect graphs
  \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 -20 % adjusting to the radius of the circle
\advance \auxb by -20 % with center in (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 -20 % see above
\advance \auxb by -20
\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 -20 % see above
\advance \auxb by -20
\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 -20 % see above
\advance \auxb by -20
\advance \x0 by -\number\auxa % width+5
\advance \y0 by \number\auxb % height+depth+5
\put{#4} at {\x0} {\y0}
\fi
\else % graphs with circular frames
\ifnum\auxa<\auxb % set aux to be the greatest dimension
\aux=\auxb
\else
\aux=\auxa
\fi
% if the length of the box is less than 1em, the size of the circle is
% adjust in order not to be less than 10pt
\ifdim\wd\caixa<1em
\dimen99 = 10pt
\aux=\dimen99
\divide \aux by 13107
\advance \aux by 50
\fi
\advance\aux by -20
\x1=\x0
\advance\x1 by \aux
\ifnum\aux<120 % gives (more or less) three digits
\circulararc 360 degrees from {\x1} {\y0} center at {\x0} {\y0}
\else
\ellipticalarc axes ratio {\auxa}:\{\auxb} 360 degrees from {\x1} {\y0} center at {\x0} {\y0}
\fi
\put{#4} at {\x0} {\y0}

```

```
\fi  
}
```

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