DCpic (5.0) — Manual de Utilização
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Resumo

O *DCpic* é um conjunto de comandos para a escrita de grafos, para tal desenvolveu-se um conjunto de comandos, com uma sintaxe simples, que permite a construção de quase todo o tipo de grafos.

Originalmente o *DCpic* (**D**iagramas **C**omutativos utilizando o **PiC**TeX) foi concebido para a construção de diagramas comutativos tal como são usados em Teoria das Categorias [3, 6], temos então grafos etiquetados e com elementos nos nós. A partir da versão 4.0 o conjunto de comandos foi alterada de forma a considerar-se também a construção de grafos dirigidos, e grafos não dirigidos. A forma de os especificar recorre à colocação dos diferentes objectos (nós e arestas) num dado referencial ortonormado,

O *DCpic* está baseado no PICTEX necessitando deste para poder ser usado.

Coimbra, 2013/04/21
Pedro Quaresma

1 História

11/1990 - versão 1.0

10/1991 - versão 1.1

9/1993 - versão 1.2: argumento "distância entre as extremidades da seta e os objectos" passou a ser opcional; uma nova opção para as "setas" (opção 3).

2/3/1995 - versão 1.3: foi acrescentado o tipo de seta de aplicação (opção 4) a distância da etiqueta à seta respectiva passou a ser fixa (10 unidades de medida).

15/7/1996 - versão 2.1: o comando `mor` passou a ter uma sintaxe distinta. Os parâmetros 5 e 6 passaram a ser a distância entre os objectos e os extremos da seta o parâmetro 7 é o nome do morfismo e os parâmetros 8 e 9, colocação do morfismo e tipo de morfismo passaram a ser opcionais.

5/2001 - versão 3.0: implementação do comando `cmor` baseado no comando de desenho de curvas quadráticas pelo PICTEX.

11/2001 - versão 3.1: modificação das pontas das setas de forma a estas ficarem semelhantes às setas (símbolos) dos TeX.

1/2002 - versão 3.2: modificação dos comandos `obj` e `mor` de forma a introduzir a especificação lógica dos morfismos, isto é, passa-se a dizer qual é 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 relação ao tamanho dos objectos.

5/2002 - versão 4.0: versão incompatível com as anteriores. Modificação dos comandos `begindc` e `obj`. O primeiro passou a ter um argumento (obrigatório) que nos permite especificar o tipo de grafo que estamos a querer especificar:

- `commdiag` (0), para diagramas comutativos;
- `digraph` (1), para grafos orientados;
- `undigraph` (2), para grafos não orientados.

O comando `obj` modificou a sua sintaxe passou a ter um (após a especificação das coordenadas, um argumento opcional, um argumento obrigatório, e um argumento opcional. O primeiro argumento opcional dá-nos a etiqueta que serve como referência para a especificação dos morfismos, na sua ausência usa-se o argumento obrigatório para esse efeito, o argumento obrigatório dá-nos o "conteúdo" do objecto, nos diagramas comutativos é centrado no ponto dado pelas coordenadas sendo o argumento seguinte simplesmente ignorado, nos grafos o "conteúdo" é colocado numa posição a norte, a noroeste, a este, ..., sendo que a posição concreta é especificada pelo último dos argumentos deste comando, o valor por omissão é o `norte`.

3/2003 - versão 4.1: a pedido de Jon Barker `<jeb1@soton.ac.uk>` criei um novo tipo de seta, a seta de sobrejecção. Para já a dupla seta só fica bem nas setas horizontais ou verticais.

12/2004 - versão 4.1.1: nova versão das setas de sobrejecção que corrigue completamente os problemas da solução anterior.

3/2007 - versão 4.2: acrescenta a directiva "providespackage". Acrescenta linhas a ponteado e a tracejado.

5/2008 - versão 4.2.1: apaga alguns contadores para tentar diminuir o excessivo uso dos mesmos por parte do PiCTeX.

8/2008 - versão 4.3: graças a Ruben Debeerst `<debeerst@mathematik.uni-kassel.de>`, acrescentei uma nova "seta" a "equalline". Após isso decidi também acrescentar setas duplas, com o mesmo ou diferentes sentidos. Acrescentou-se também a seta nula, isto é, sem representação gráfica, a qual pode ser usada para acrescentar etiquetas a outras "setas".

12/2008 - version 4.3.1: para evitar conflitos com outros pacotes o comando "id" é internalizado. O comando "dasharrow" é modificado para "dashArrow" para evitar um conflito com o AMSTeX.

12/2009 - version 4.3.2: para evitar um conflito com o pacote "hyperref" mudou-se o contador "d" para "deuc", aproveitei e mudei os contadores "x" e "y" para "xO" e "yO"

4/2013 - version 4.4.0: graças a Xingliang Liang `jkl9543@gmail.com>` acrescentou-se uma nova seta "dotarrow".

4/2013 - version 5.0: uma nova unidade para o sistema de coordenadas, 1/10 da anterior. Esta nova unidade permite corriguir um problema com a construção das setas duplas, além de permitir uma especificação mais fina dos diagramas.

2 Introdução

O conjunto de comandos *DCpic* é um conjunto de comandos TEX [4] dedicado à escrita de diagramas tal como são usados em Teoria das Categorias [3, 6], assim como de grafos dirigidos e não dirigidos [2].

Pretendeu-se com a sua escrita ter uma forma simples de especificar grafos, fazendo-o através da especificação de um conjunto de "objectos" (nós do grafo) colocados num dado referencial ortonormado, e através de um conjuntos de morfismos (arestas) que os são posicionados explicitamente no referido referencial, ou então, a são posição é dada especificando qual é o seu nó de partida e qual é o seu nó de chegada.

O gráfico em si é construído recorrendo aos comandos gráficos do PICTEX.

3 Utilização

Antes de mais é necessário carregar os dois conjuntos de comandos acima referidos, no caso de um documento LATEX [5] isso pode ser feito com o seguinte comando (no preâmbulo).

```
\usepackage{dcpic,pictex}
```

Nos outros formatos ter-se-á de usar um comando equivalente. Após isso os diagramas podem ser escritos através dos comandos disponibilizados pelo *DCpic*. Por exemplo, os comandos:

```
\begindc{\commdiag}[200]
 \obj(1,4){$A^B$}
 \obj(1,1){$C$}
 \obj(3,4){$A$}
 \obj(3,1){$C\times{}B$}
 \obj(6,4){$A^B\times{}B$}
 \mor{$C$}{$A^B$}{$f$}
 \mor{$C\times{}B$}{$A$}{$\bar f$}[\atleft,\dashArrow]
 \mor{$A^B\times{}B$}{$A$}{$ev$}[\atright,\solidarrow]
 \mor{$C\times{}B$}{$A^B\times{}B$}{$f\times{}id$}[\atright,\solidarrow]
\enddc
```

produzem o seguinte diagrama:

$$\begin{tikzcd}
A^B & A & A^B \times B \arrow[l, "ev"'] \\
C \arrow[u, "f"] & C \times B \arrow[u, dashed, "\bar{f}"] \arrow[ur, "f \times id"'] &
\end{tikzcd}$$

O meio ambiente `begindc`, `enddc` permite-nos construir um grafo por colocação dos objectos num referencial ortonormado tendo a origem em (0,0). As arestas (morfismos) vão ligar pares de nós (objectos) entre si.

4 Comandos Disponíveis

De seguida apresenta-se a descrição dos comandos, a sua sintaxe e a sua funcionalidade. Os argumentos entre parêntesis rectos são opcionais.

`\begindc{#1}[#2]` – entrada no ambiente de escrita de grafos:

- `#1` – tipo de grafo
  - 0 ≡ \commdiag, diagrama comutativo;
  - 1 ≡ \digraph, grafo orientado;
  - 2 ≡ \undigraph, grafo não orientado;
  - 3 ≡ \cdigraph, grafo orientado, com objectos circunscritos;
  - 4 ≡ \cundigraph, grafo não orientado, com objectos circunscritos.
- `#2` – factor de escala (opcional)
  - valor por omissão: 300

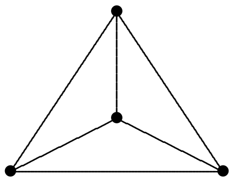
`\enddc` – saída do meio ambiente para a escrita de grafos.

`\obj(#1,#2)[#3]{#4}[#5]:` comando de colocação dos nós (objectos).

`#1` e `#2` – coordenadas do centro da caixa que vai conter o texto
`#3` – etiqueta para identificar o objecto (opcional)
`#4` – texto (conteúdo do nó)
`#5` – colocação relativa do objecto (opcional)
$0 \doteq$ \pcent, centrado
$1 \doteq$ \north, norte
$2 \doteq$ \northeast, nordeste
$3 \doteq$ \east, este
$4 \doteq$ \southeast, sudeste
$5 \doteq$ \south, sul
$6 \doteq$ \southwest, sudoeste
$7 \doteq$ \west, oeste
$8 \doteq$ \northwest, noroeste

A etiqueta explícita-se quando não é possível usar o objecto como forma de identificação do nó, por exemplo num dado grafo não orientado os nós podem não ter conteúdo e como tal serem todos iguais em termos de identificação:

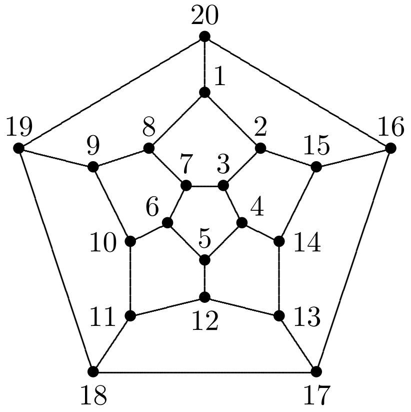
Em alguns casos, por exemplo comandos dos LaTeX complexos, pode ser necessário explicitar o argumento `#3` mesmo que seja através da etiqueta vazia `[]`. Esse especificar da etiqueta vazia torna-se necessário para que o mecanismo interno do DCpic de comunicação entre comandos (pilhas) não se baralhe e entre num ciclo infinito.



foi produzido por:

```
\begindc{\undigraph}[200]
\obj(1,1)[1]{}
\obj(3,2)[2]{}
\obj(5,1)[3]{}
\obj(3,4)[4]{}
\mor{1}{2}{}
\mor{1}{3}{}
\mor{2}{3}{}
\mor{4}{1}{}
\mor{4}{3}{}
\mor{2}{4}{}
\enddc
```

O parâmetro referente à colocação do objecto só é relevante quando se pensa na identificação dos nós num dado grafo orientado (ou não), por exemplo o grafo “Around the Word” [2]:



foi produzido por

```
\begindc{\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}
\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
```

`\mor{#1}{#2}[#5,#6]{#7}[#8,#9]:` Comando de colocação da seta (morfismo) de ligação de dois objectos – Primeira variante.

A numeração errada dos argumentos é aqui feita propositadamente, aquando da explicação da segunda variante deste comando compreender-se-á o porquê desta opção de escrita.

`#1` – referência do nó de partida
`#2` – referência do nó de chegada

`#5` e `#6` – distância do centro dos objectos às extremidades inicial e final respectivamente da seta. Valores por omissão: 10, 10 (para diagramas) 2, 2 (para os grafos)

`#7` – texto, “nome” do morfismo

`#8` – colocação do nome do morfismo em relação à seta. Valor por omissão, \atleft.
1 ≐ \atright, à direita
-1 ≐ \atleft, à esquerda

`#9` – tipo da seta. Valor por omissão, \solidarrow.
0 ≐ \solidarrow, seta sólida
1 ≐ \dashArrow, seta tracejada
2 ≐ \dotArrow, seta ponteada
3 ≐ \solidline, linha sólida
4 ≐ \dashline, linha a tracejado
5 ≐ \dotline, linha a ponteado
6 ≐ \injectionarrow, seta de injecção. Valor anterior 3 (versão < 4.2)
7 ≐ \aplicationarrow, seta de aplicação. Valor anterior 4 (versão < 4.2)
8 ≐ \surjectivearrow, seta de função sobrejectiva. Valor anterior 5 (versão < 4.2)
9 ≐ \equalline, linha dupla
10 ≐ \doublearrow, seta dupla
11 ≐ \doubleopposite, seta dupla em sentidos opostos
12 ≐ \nullarrow, seta nula, serve o propósito de acrescentar etiquetas as outras “setas”.

\`mor(#1,#2)(#3,#4)[#5,#6]{#7}[#8,#9]:` Comando de colocação da seta (morfismo) de ligação de dois objectos – Segunda variante.

`#1` e `#2` – coordenadas do nó de partida
`#3` e `#4` – coordenadas do nó de chegada

Todos os outros argumentos têm o significado já explicado (por isso a numeração errada). É de notar que para a primeira variante é feito o cálculo das coordenadas dos nós de forma automática e depois são passados esses valores para a segunda variante do comando.

\`cmor(#1) #2(#3,#4){#5}[#6]` comando para a especificação de setas curvas. O algoritmo de construção das setas é o do PICTEX o que implica que se está a especificar uma linha quadrática através de um número ímpar de pontos.

`#1`—lista de pontos, em número ímpar
`#2`—direccionamento da seta
  - $0 \doteq$ \pup, apontar para cima
  - $1 \doteq$ \pdown, apontar para baixo
  - $2 \doteq$ \pright, apontar para a direita
  - $3 \doteq$ \pleft, apontar para a esquerda

`#3`—abcissa do morfismo
`#4`—ordenada do morfismo
`#5`—morfismo
`#6`—tipo de "seta", valor por omissão: 0, seta sólida.
Os restantes valores possíveis são os descritos na variante anterior.

O comando `cmor` no caso em que não tem o último parâmetro opcional tem de ser seguido por um espaço. O espaço antes do direccionamento da seta é obrigatório.

No caso de se ter o valor 2 ("\solidline") o valor para o direccionamento da seta não é tipo em conta, no entanto dado se tratar de um do parâmetro obrigatório é necessário dar-lhe um valor

5 Alguns Exemplos

5.1 Setas Duplas, Transformações Naturais, ...

É de notar que alguns casos aparentemente omissos na actual versão podem perfeitamente ser construídos através de uma utilização imaginativa dos actuais comandos. Por exemplo os seguintes diagramas:

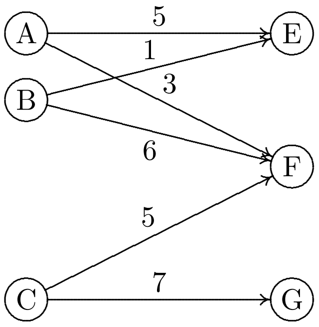
$$\begin{tikzcd} A \arrow[r, shift left, "g"] \arrow[r, shift right, "f"'] & B \end{tikzcd} \qquad \begin{tikzcd} A \arrow[r, shift left=4] \arrow[r, "\downarrow\sigma", "\downarrow\tau"'] \arrow[r, shift right=4] & B \end{tikzcd}$$

Podem ser construídos com a actual versão. Eis como:

```
\begindc{\commdiag}[30]
\obj(5,5){$A$}
\obj(20,5){$B$}
\mor{$A$}{$B$}{$f$}[\atright,\doublearrow]
\mor{$A$}{$B$}{$g$}[\atleft,\nullarrow]

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

5.2 Grafos Orientados com Objectos Circunscritos

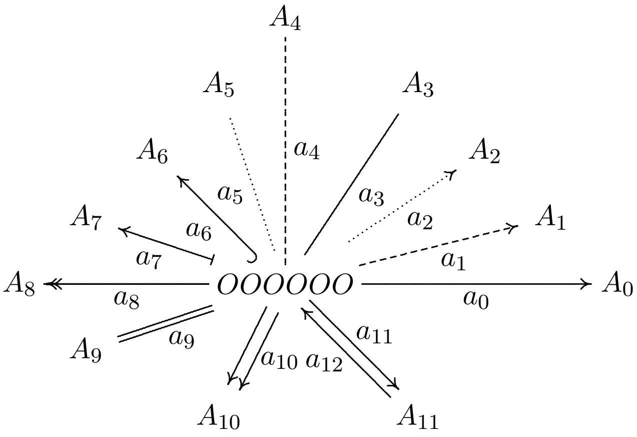


Foi produzido através dos seguintes comandos:

```
\begindc{\commdiag}[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}
\enddc
```

5.3 Diferentes Tipos de Setas/Linhas

```
\begindc{\commdiag}[250]
\obj(10,10)[A]{$OOOOOO$}
\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]
\enddc
```



5.4 Diagramas com Setas Curvas

```
\begindc{\commdiag}[30]
\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}[30]
\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
```

$$\begin{tikzcd}
A \arrow[loop left, "id_A"] \arrow[r, shift left, "f"] & B \arrow[l, shift left, "g"] \arrow[loop right, "id_B"']
\end{tikzcd}
\qquad
\begin{tikzcd}
A \arrow[r, "f"] \arrow[rr, bend right, "id_A"'] & B \arrow[r, "g"] & A
\end{tikzcd}$$

5.5 Um Exemplo Complexo

O diagrama seguinte foi proposto por Feruglio [1] como um caso de teste. Como é possível ver o DCpic produz o diagrama correctamente a partir de uma especificação simples.

```
\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}{\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
```

$$\begin{tikzcd}
& \Sigma^L \arrow[rrrr, "\varphi^r"] \arrow[dddd, "\varphi^m"'] & & & & \Sigma^R \arrow[dddd, "\varphi^{m^*}"] \\
L \arrow[ur, "\lambda^L"] & & L_r \arrow[ll, |->, "i_1"'] \arrow[rr, "r"] & & R \arrow[ur, "\lambda^R"'] & \\
& & & & & \\
L_m \arrow[uu, |->, "i_2"] \arrow[dd, "m"'] & & K_{r,m} \arrow[ll, |->, "i_3"'] \arrow[uu, |->, "i_4"'] \arrow[rr, "r"] \arrow[dd, "m"'] & & R_{m^*} \arrow[uu, |->, "i_6"'] \arrow[dd, "m^*"'] & \\
& \Sigma^G \arrow[rrrr, "\varphi^{r^*}"] & & & & \Sigma^H \\
G \arrow[ur, "\lambda^G"] & & G_{r^*} \arrow[ll, |->, "i_5"] \arrow[rr, "r^*"'] & & H \arrow[ur, dashed, "\lambda^H"'] &
\end{tikzcd}$$

Referências

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A O Código

```
%% 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>
%%
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%
% 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 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)
%%          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 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, 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}
%% \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}
%%-----------------//-------------
%% 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 sintax. The 5th and 6th
%%       parameters are now the distance between the two objects and
%%       the arrow tips. The 7th parameter is the label. The 8th e 9th
%%       parameters (label position and type of arrow) are now optional
%%
%% 5/2001 (version 3.0)
%%       Implementation of the comand "\cmor" based on the quadratic
%%       curver comand of PiCTeX
%%
%% 11/2001 (version 3.1)
%%       Changes on the tips of the arrow to became more LaTeX style
%%       (after a conversation on EuroTeX 2001).
%%
%% 1/2002  (version 3.2)
%%       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 <jkl9543@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\xl%
\newcount\yl%
\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\xaux%
```

```
\newcount\yaux%
\newcount\guardaauxa%
\newcount\alt%
\newcount\larg%
\newcount\prof%
%% for the triming
\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}}

%% 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\yO=\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\xO=\number\xl
     \ifnum\number\yl>\number\yO
```

```
%% 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-xl|<|y-yl| 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
%%
%% quadrado = 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 <- converstion-sp-pt(aux)/2+3
%%  else                                {non-vertical arrow}
%%     if y-yl = 0 then                 {horizontal arrow}
%%        aux <- caixa0 height+depth
%%        dnm <- converstion-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 "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=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%
  \ifdiferentes%
%%
%% error message and ficticious parameters
%%
   Error: Incorrect label specification%
   \xaux=1%
   \yaux=1%
  \fi%
 \fi%
 \let\pilha=\pilhaaux%
 \!ifnextchar({\!morxyl{\number\xaux}{\number\yaux}}{\!morObjB{\number\xaux}{\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 ficticious parameters
%%
   Error: Incorrect label specification
   \xaux=\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}{\
\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-xl)^2+(y-yl)^2)
%%
  \!quadrado{\number\xO}{\number\xl}{\auxa}%
  \!quadrado{\number\yO}{\number\yl}{\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{\xO}{\xl}{\yO}{\yl}{\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\xO}{\number\xl}{\number\xO}{\auxa}{\number\deuc}{\xa}{1}%
  \!ucoord{\number\yO}{\number\yl}{\number\yO}{\auxa}{\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 (xl,yl)
%%
  \auxb=#6
  \!compara{\objNulo}{\objChegada}%
  \ifdiferentes% adjusting only when needed
%  adjustment
   \!ajusta{\xO}{\xl}{\yO}{\yl}{\auxb}{\objChegada}%
   \def\objChegada{}% reset the value of the end object
  \fi
  \advance \auxa by -\auxb%
  \!ucoord{\number\xO}{\number\xl}{\number\xO}{\number\auxa}{\number\deuc}{\xb}{1}%
  \!ucoord{\number\yO}{\number\yl}{\number\yO}{\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\xO}{\number\yO}{\number\xl}{\number\yl}{#7}{\dnm}%
  \!ucoord{\number\yO}{\number\yl}{\number\xmed}{\number\dnm}{\number\deuc}{\xc}{-#8}%
  \!ucoord{\number\xO}{\number\xl}{\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\xl}{\number\x0}{\number\auxa}{\number\deuc}{\xa}{1}%
 \!ucoord{\number\y0}{\number\yl}{\number\y0}{\number\auxa}{\number\deuc}{\ya}{1}%
 \!ucoord{\number\y0}{\number\yl}{\number\xa}{20}{\number\deuc}{\xd}{-1}%
 \!ucoord{\number\x0}{\number\xl}{\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\yl}{\number\xa}{\number\auxa}{\number\deuc}{\xmed}{-1}%
 \!ucoord{\number\x0}{\number\xl}{\number\ya}{\number\auxa}{\number\deuc}{\ymed}{1}%
 \!ucoord{\number\y0}{\number\yl}{\number\xa}{\number\auxa}{\number\deuc}{\xd}{1}%
 \!ucoord{\number\x0}{\number\xl}{\number\ya}{\number\auxa}{\number\deuc}{\yd}{-1}%
%% 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\yl
\auxa=10
\fi
\ifnum\number\x0=\number\xl
\auxa=10
\fi
%% the two parallel lines will be given by (xmed,ymed)(xd,yd), and
%% (xe,ye)(xf,yf)
  \!ucoord{\number\y0}{\number\yl}{\number\xa}{\number\auxa}{\number\deuc}{\xmed}{-1}%
  \!ucoord{\number\x0}{\number\xl}{\number\ya}{\number\auxa}{\number\deuc}{\ymed}{1}%
  \!ucoord{\number\y0}{\number\yl}{\number\xa}{\number\auxa}{\number\deuc}{\xd}{1}%
  \!ucoord{\number\x0}{\number\xl}{\number\ya}{\number\auxa}{\number\deuc}{\yd}{-1}%

  \!ucoord{\number\y0}{\number\yl}{\number\xb}{\number\auxa}{\number\deuc}{\xe}{-1}%
  \!ucoord{\number\x0}{\number\xl}{\number\yb}{\number\auxa}{\number\deuc}{\ye}{1}%
  \!ucoord{\number\y0}{\number\yl}{\number\xb}{\number\auxa}{\number\deuc}{\xf}{1}%
  \!ucoord{\number\x0}{\number\xl}{\number\yb}{\number\auxa}{\number\deuc}{\yf}{-1}%
  \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\yl
\auxa=20
\fi
\ifnum\number\x0=\number\xl
\auxa=20
\fi
%% the two parallel lines will be given by (xmed,ymed)(xd,yd), and
%% (xe,ye)(xf,yf)
  \!ucoord{\number\y0}{\number\yl}{\number\xa}{\number\auxa}{\number\deuc}{\xmed}{-1}%
  \!ucoord{\number\x0}{\number\xl}{\number\ya}{\number\auxa}{\number\deuc}{\ymed}{1}%
  \!ucoord{\number\y0}{\number\yl}{\number\xa}{\number\auxa}{\number\deuc}{\xd}{1}%
  \!ucoord{\number\x0}{\number\xl}{\number\ya}{\number\auxa}{\number\deuc}{\yd}{-1}%

  \!ucoord{\number\y0}{\number\yl}{\number\xb}{\number\auxa}{\number\deuc}{\xe}{-1}%
  \!ucoord{\number\x0}{\number\xl}{\number\yb}{\number\auxa}{\number\deuc}{\ye}{1}%
  \!ucoord{\number\y0}{\number\yl}{\number\xb}{\number\auxa}{\number\deuc}{\xf}{1}%
  \!ucoord{\number\x0}{\number\xl}{\number\yb}{\number\auxa}{\number\deuc}{\yf}{-1}%
  \arrow <4pt> [.2,1.1] from {\xmed} {\ymed} to {\xe} {\ye}
  \arrow <4pt> [.2,1.1] from {\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\yl
\auxa=20
\fi
\ifnum\number\x0=\number\xl
\auxa=20
\fi
%% the two parallel lines will be given by (xmed,ymed)(xd,yd), and
%% (xe,ye)(xf,yf)
  \!ucoord{\number\y0}{\number\yl}{\number\xa}{\number\auxa}{\number\deuc}{\xmed}{-1}%
  \!ucoord{\number\x0}{\number\xl}{\number\ya}{\number\auxa}{\number\deuc}{\ymed}{1}%
  \!ucoord{\number\y0}{\number\yl}{\number\xa}{\number\auxa}{\number\deuc}{\xd}{1}%
  \!ucoord{\number\x0}{\number\xl}{\number\ya}{\number\auxa}{\number\deuc}{\yd}{-1}%

  \!ucoord{\number\y0}{\number\yl}{\number\xb}{\number\auxa}{\number\deuc}{\xe}{-1}%
  \!ucoord{\number\x0}{\number\xl}{\number\yb}{\number\auxa}{\number\deuc}{\ye}{1}%
  \!ucoord{\number\y0}{\number\yl}{\number\xb}{\number\auxa}{\number\deuc}{\xf}{1}%
  \!ucoord{\number\x0}{\number\xl}{\number\yb}{\number\auxa}{\number\deuc}{\yf}{-1}%
  \arrow <4pt> [.2,1.1] from {\xmed} {\ymed} to {\xe} {\ye}
  \arrow <4pt> [.2,1.1] from {\xf} {\yf} to {\xd} {\yd}
\or                   % 11=null arrow (no arrow, only a label)
%%
%% does not draw the arrow, it allows to put two labels in one "arrow"
%%
\fi
%% The label positioning.
%% 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=\xl
\advance \auxa by -\x0%
\ifnum \auxa=0
  \put {#7} at {\xc} {\yc}
\else
  \auxb=\yl
  \advance \auxb by -\y0%
  \ifnum \auxb=0 \put {#7} at {\xc} {\yc}
  \else
    \ifnum \auxa > 0
      \ifnum \auxb > 0
        \ifnum #8=1
          \put {#7} [rb] at {\xc} {\yc}
        \else
          \put {#7} [lt] at {\xc} {\yc}
        \fi
      \else
        \ifnum #8=1
          \put {#7} [lb] at {\xc} {\yc}
        \else
          \put {#7} [rt] at {\xc} {\yc}
        \fi
      \fi
    \else
      \ifnum \auxb > 0
        \ifnum #8=1
          \put {#7} [rt] at {\xc} {\yc}
        \else
          \put {#7} [lb] at {\xc} {\yc}
        \fi
      \else
        \ifnum #8=1
          \put {#7} [lt] at {\xc} {\yc}
        \else
          \put {#7} [rb] at {\xc} {\yc}
        \fi
      \fi
    \fi
  \fi
\fi
}

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

%%
%% 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
  \xl=\x0%
  \yl=\y0%
  \aux=1%
  \multiply \aux by \auxa%
  \advance\xl by \aux%
  \aux=1%
  \multiply \aux by \auxb%
  \advance\yl by \aux%
  \arrow <4pt> [.2,1.1] from {\x0} {\y0} to {\xl} {\yl}}


%%
%% 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 then 1em, the size of the circle is
% adjust in order not to be less then 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)
```