Introdução ao pgfplots

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UFPR

TUG 2021

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Breve histórico

TUG2021

- criado e registrado em 2008-04-08 por Christian Feuersänger.
- várias versões relatadas:
  - home page e repositório: `http://pgfplots.sourceforge.net/`.
  - disponibilizada: `https://www.ctan.org/pkg/pgfplots`
  - versão atual: 1.18.1 (2021-05-15)

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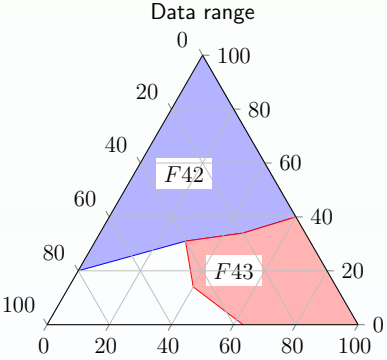
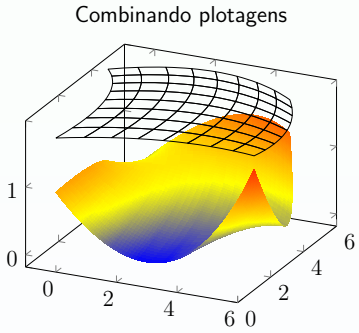
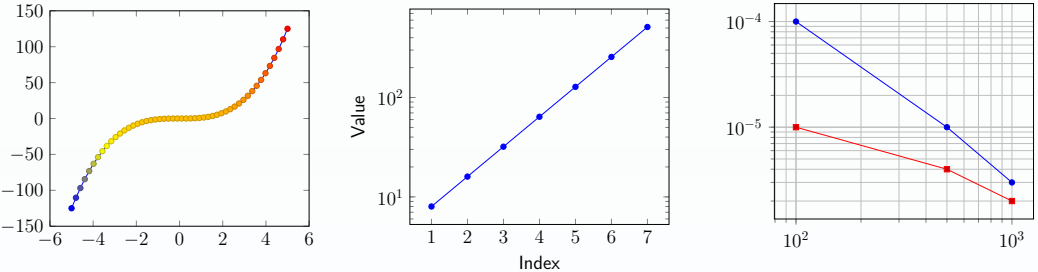
É um pacote de ferramentas que permite gerar gráficos 2D & 3D.





Fonte: Feuersänger (2021b)

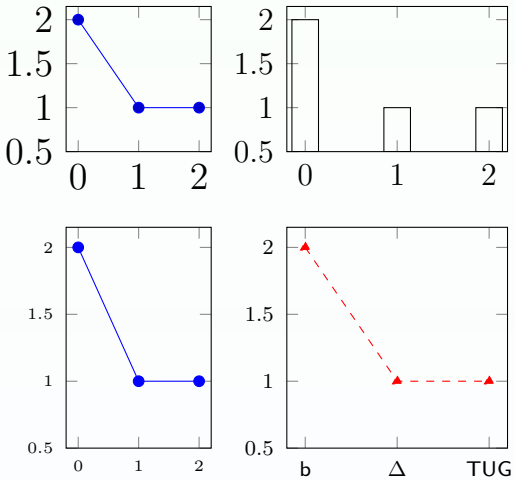
Gráficos lineares, semilog, logaritmicos



Fonte: Adaptado de Feuersänger (2021b)

O que é pgfplots?

Controle sobre todos os elementos que compõem o gráfico:



Fonte: Adaptado de Feuersänger (2021b)

O que é pgfplots?

- é um software free sob licença GNU 3.0;
- é uma ferramenta de apresentação de gráficos de alta qualidade a partir de dados ou de funções matemáticas;
- gera figuras consistentes com os requisitos de tipo e tamanho de fonte;
- trabalha diretamente com o modo matemático do TEX;
- não há necessidade de softwares externos;
- mantém a consistência do documento através de ajustes, configurações e estilos no preambulo;
- produz arquivos gráficos (.pdf ou .eps) através de bibliotecas do Tikz.

- PGPLOTS requer o PGF;
  Verifique se está instalado em seu computador (*offline*), e está disponível nos ambientes *online*;

UFPR

- No preambulo:
  Primeiro pacote: [a]

```
\usepackage{etex}
```

- no corpo do documento:

[a] Maiores detalhes sobre registradores em Feuersänger (2021a, p. 14)

Preliminares:

- No preambulo:
  Primeiro pacote: [a]

```
\usepackage{etex}
```

[a] Maiores detalhes sobre registradores em Feuersänger (2021a, p. 14)

De Feuersänger (2021a, p. 14) documentação do PGFPlots, possíveis causas de problemas nos registros para PGF e PGFPLOTS:

> *Some of these cases are:*
>
> 1. *The axis range (for example, for x) becomes relatively small. It's no matter if you have absolutely small ranges like [$10^{-18}, 10^{-17}$]. But if you have an axis range like [1.99999999, 2], where* **a lot of significant digits are necessary**, *this may be problematic. [...]*
> 2. *This may happen as well if you only* **view a very small portion of the data range**. *[...]*
>   **Consider using the restrict x to domain*=hmini:hmaxi key** *in such a case, where the hmini and hmaxi should be (say) four times of your axis limits (see page 397 for details).*
> 3. *The* **axis equal key** *will be confused if x and y have a very different scale.*
> 4. *You may have found a bug – please contact the developers.*

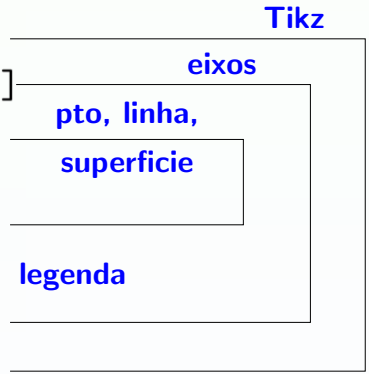
- No preambulo:

```
\usepackage{etex}

...
\usepackage{pgfplots}
\pgfplotsset{compat=1.18}
```

- no corpo do documento:

- No preambulo:
- no corpo do documento:

```
\begin{tikzpicture}
    \begin{env}[keys]
        \addplot..
        \addplot3..
          ...
        \legend..
    \end{env}
\end{tikzpicture}
```



- Possui todas as opções gráficas do Tikz[1]:
  - opções e chaves;
  - conjuntos - *tikzset*;
  - estilos - *styles*;

  Podem ser ativadas local e globalmente no documento;
- Possui vários eixos (*axis*).

Detalhar um pouco
axis

- Possui as opções e estilos para os eixos (local e globalmente);
- Possui várias plotagens (*addplot*s).

- Possui as opções e estilos para os eixos (local e globalmente);
- Possui várias plotagens (*addplot*s).

Opções para eixos:

Ambiente	Tipo de escala	
	eixo x	eixo y
axis	linear	linear
semilogxaxis	log	linear
semilogyaxis	linear	log
loglogaxis	log	log

Detalhar um pouco
addplot

- Possui as opções e estilos para as plotagens;
  Podem ser definidas local e globalmente.

- Possui as opções e estilos para as plotagens;
  Podem ser definidas local e globalmente.

Comandos para plotagens:

addplot insere uma plotagem 2D;

addplot3 insere uma plotagem 3D;

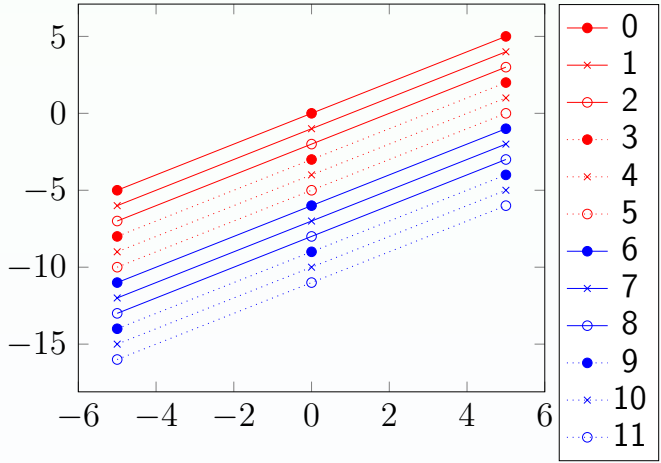
addplot+ explicado mais adiante. ▸▸ detalhar

Estrutura mais elaborada

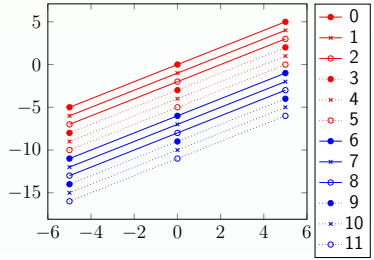

```
\begin{figure}[!ht]
    \caption{Exemplo}\label{fig:Exemplo}
    \begin{tikzpicture}[opt1]
        \begin{env}[keys1]
            \addplot[opt2a]
            \addplot[opt2b]
              ...
            \legend..
        \end{env}

        \begin{env}[keys2]
            \addplot[opt3a]
            \addplot[opt3b]
              ...
            \legend..
        \end{env}
    \end{tikzpicture}
\end{figure}
```

- o ambiente tikzpicture (com as opt1) estrutura os vários eixos.
- cada ambiente eixo (com as keys1 e keys2) definem a área gráfica para as plotagens.
- cada plotagem possui suas opções

O PGFPlots tem ajustes padrão(default).



Fonte: Feuersänger (2021a)



- addplot segue a seq. da lista;
- addplot[*options*] insere as *options* pausando a seq. da lista;
- addplot+[*options*] insere as *options* na seq. da lista;

Entenda-se lista como sendo a padrão ou a definida pelo usuário.

voltar ao addplot

O PGF tem basicamente três formas de entrada de dados, através de:

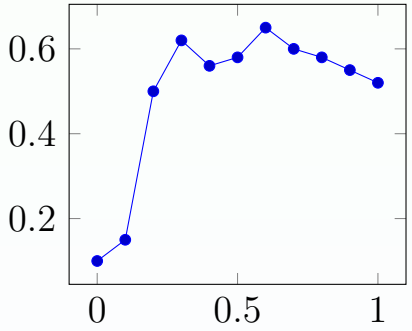
1. dados estão no arquivo .tex;
2. dados estão em arquivo externo (.csv, por exemplo);
3. uma função.

vejamos como funciona...

Entrada de dados

Coordenadas no .tex

```
\begin{tikzpicture}
    \begin{axis}
    \addplot coordinates {
        (0,0.1)(0.1,0.15)
        (0.2,0.5)(0.3,0.62)
        (0.4,0.56) (0.5,0.58)
        (0.6,0.65) (0.7,0.6)
        (0.8,0.58) (0.9,0.55)
        (1,0.52)};%
    \end{axis}
\end{tikzpicture}
```

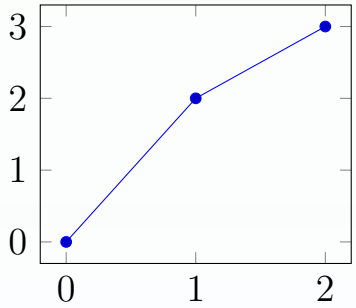


Fonte: Adaptado de Feuersänger (2021a, p. 41)

Entrada de dados

Tabelados no .tex

```
\begin{tikzpicture}
    \begin{axis}
    \pgfplotstableread{A B
                       0 0
                       1 2
                       2 3}\dat
    \addplot table from \dat;
    \end{axis}
\end{tikzpicture}
```



Fonte: Adaptado de Feuersänger (2021a, p. 45)

Entrada de dados

Arquivo externo

```
\begin{tikzpicture}
    \begin{loglogaxis}
        \addplot table
            [x=a,y=B]
            {datafile.dat};
    \end{loglogaxis}
\end{tikzpicture}
```

Fonte: Adaptado de Feuersänger (2021a, p. 402)

a	B
1	1
2	4
3	9
4	16
5	25
6	36

Entrada de dados
Arquivo externo

```
\begin{tikzpicture}
    \begin{loglogaxis}
        \addplot table
            [x=a,y=B]
            {datafile.dat};
    \end{loglogaxis}
\end{tikzpicture}
```

Fonte: Adaptado de Feuersänger (2021a, p. 402)

a	B
1	1
2	4
3	9
4	16
5	25
6	36

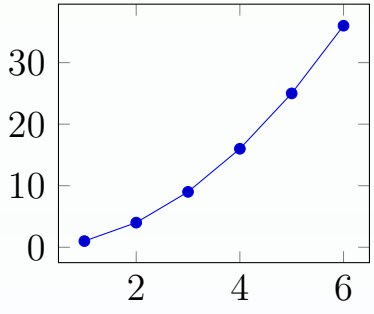
Há inúmeras opções para se carregar dados de um arquivo externo,

Entrada de dados

Arquivo externo

```
\begin{tikzpicture}
    \begin{loglogaxis}
        \addplot table
            [x=a,y=B]
            {datafile.dat};
    \end{loglogaxis}
\end{tikzpicture}
```

Fonte: Adaptado de Feuersänger (2021a, p. 402)

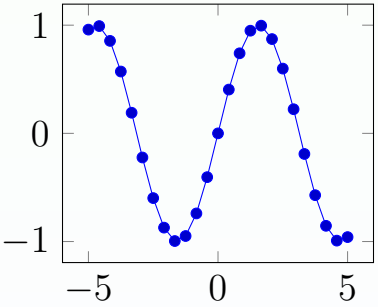


Entrada de dados

Função matemática

```
\begin{tikzpicture}
    \begin{axis}
      \addplot {sin(deg(x))};
    \end{axis}
\end{tikzpicture}
```

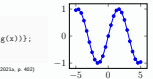
Fonte: Adaptado de Feuersänger (2021a, p. 402)



Entrada de dados
Função matemática

```
\begin{tikzpicture}
    \begin{axis}
        \addplot {sin(deg(x))};
    \end{axis}
\end{tikzpicture}
```

Fonte: Adaptado de Feuersänger (2021a, p. 402)



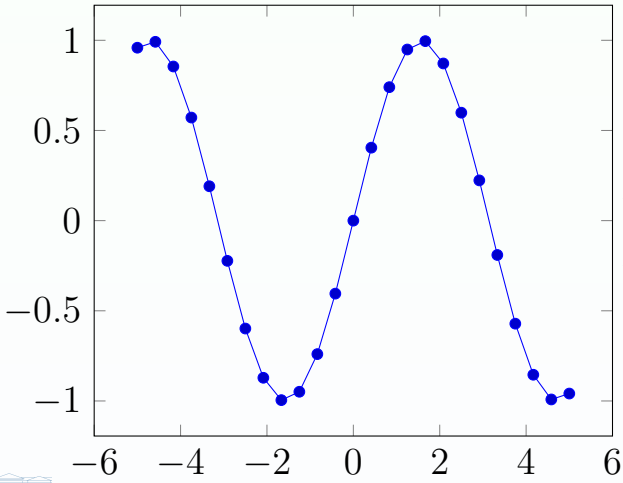
Pode-se

- usar expressões matemáticas mas isso tem um custo.
  "exp, sin, cos, sqrt, [...] can use exponents using the a^b syntax[...]"
  (FEUERSÄNGER, 2021a, p. 20);
- usar expressões matemáticas para dados em tabela.
  (FEUERSÄNGER, 2021a, subsecção 4.3.4 - p. 57);
- usar o processamento com GNUPlot para expressões mais elaboradas:
  \addplot gnuplot

  Feuersänger (2021a, subsecção 4.3.5 - p. 59)

Ajuste de aparências

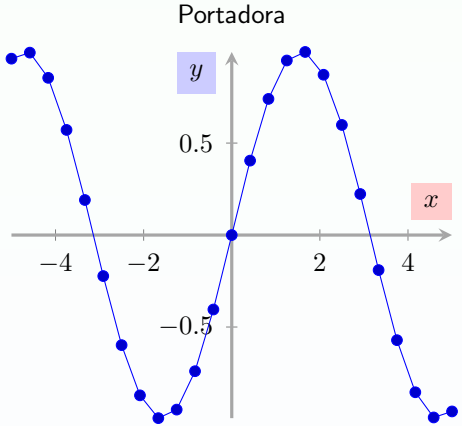
Valores padrões



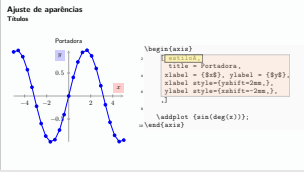

```
\begin{tikzpicture}
    \begin{axis}
        \addplot
            {sin(deg(x))};
    \end{axis}
\end{tikzpicture}
```

Ajuste de aparências

Títulos




```
\begin{axis}
    [ estiloA,
      title = Portadora,
     xlabel = {$x$}, ylabel = {$y$},
     xlabel style={yshift=2mm,},
     ylabel style={xshift=-2mm,},
    ,]

   \addplot {sin(deg(x))};
\end{axis}
```

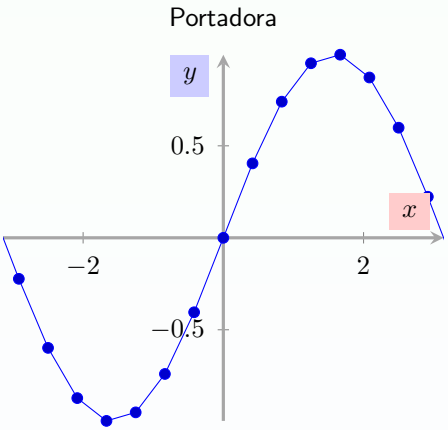


Preambulo: Coloque no preambulo um estilo pré definido:

```
\pgfplotsset{
estiloA/.style={
    axis lines=middle,
    font=\footnotesize\sffamily,
    axis lines=center,
    inner axis line style={very thick,gray!70},
    xlabel style={    at=(current axis.right of origin),
                  anchor=south east,
                    fill=red!20,},
  %
    ylabel style={   at=(current axis.above origin),
                  anchor=north east,
                    fill=blue!20,
     % rotate=-90,
     },}}
```

Ajuste de aparências

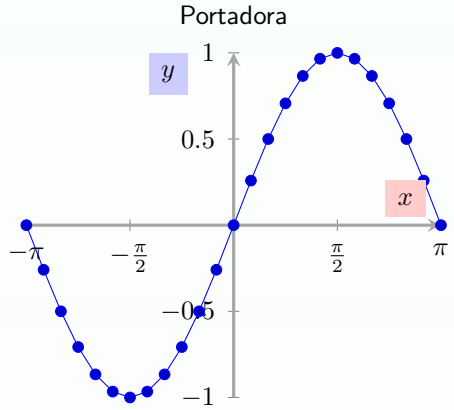
Intervalos




```
\begin{axis}
    [estiloA,
      title = Portadora,
     xlabel = {$x$},
     ylabel = {$y$},
       xmin = -pi, xmax = +pi,
    xlabel style={yshift=1mm,
                  xshift=-19mm,},
    ylabel style={xshift=-19mm,},]

   \addplot {sin(deg(x))};
\end{axis}
```

Ajuste de aparências

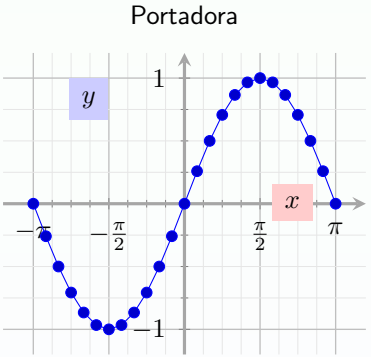
Marcações nos eixos




```
\begin{axis}[estiloA,
    scale=.80,
    title = Portadora,
    xlabel= {$x$}, ylabel= {$y$},
    xlabel style={yshift=1mm,
                  xshift= -2mm,},
    ylabel style={xshift=-6mm,},
    xmin=-pi, xmax=+pi,
    xtick={-pi,-.5*pi,...,pi},
    domain=-pi:pi,
    xticklabels={$-\pi$,
        $-\frac{\pi}{2}$,
        0,$\frac{\pi}{2}$,
        $\pi$},]

    \addplot {sin(deg(x))};
\end{axis}
```

Ajuste de aparências

Grade

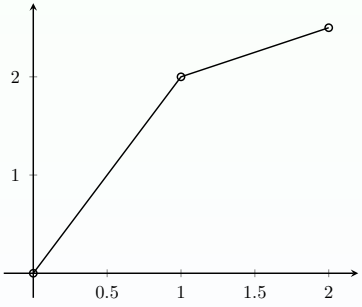



```
\begin{axis}[estiloA, title = Portadora,
    xlabel= {$x$}, ylabel= {$y$},
    xlabel style={yshift=1mm, xshift= -2mm,},
    ylabel style={xshift=-6mm,},
    xmin=-pi, xmax=+pi,
    xtick={-pi,-.5*pi,...,pi},
    domain=-pi:pi,
    xticklabels={$-\pi$, $-\frac{\pi}{2}$,
        0,$\frac{\pi}{2}$, $\pi$},
    minor tick num=3, grid=both,
    grid style=
        {line width=.2pt, draw=gray!20},
    major grid style=
        {line width=.5pt,draw=gray!50},
    enlargelimits=true,
    \addplot {sin(deg(x))};
\end{axis}
```

Secção 4.5

1. sharp
2. smooth
3. constant
4. bars
5. box
6. comb

Linear



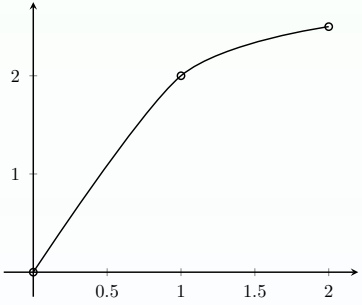
Fonte: Adaptado de Feuersänger (2021, p. 78)

```
\begin{axis}[enlargelimits=true]
    \addplot [sharp plot,]
        coordinates
        {(0,0) (1,2) (2,2.5)};
\end{axis}
```

Secção 4.5

1. sharp
2. smooth
3. constant
4. bars
5. box
6. comb

Smooth

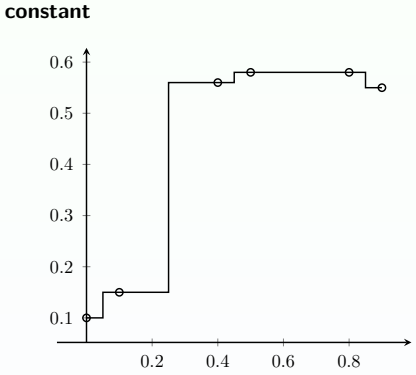


Fonte: Adaptado de Feuersänger (2021, p. 78)

```
\begin{axis}[enlargelimits=true]
 \addplot [smooth,]
coordinates{
    (0,0)(1,2)(2,2.5)};
\end{axis}
```

Secção 4.5

1. sharp
2. smooth
3. constant
4. bars
5. box
6. comb



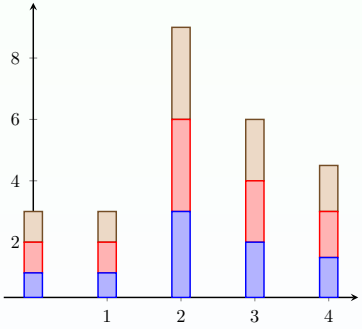
Fonte: Adaptado de Feuersänger (2021, p. 79)

```
\begin{axis}[enlargelimits=auto]
  \addplot [const plot mark mid,]
      coordinates {
        (0,0.1) (0.1,0.15)
        (0.4,0.56) (0.5,0.58)
        (0.8,0.58) (0.9,0.55)};
\end{axis}
```

Secção 4.5

1. sharp
2. smooth
3. constant
4. bars
5. box
6. comb

bars



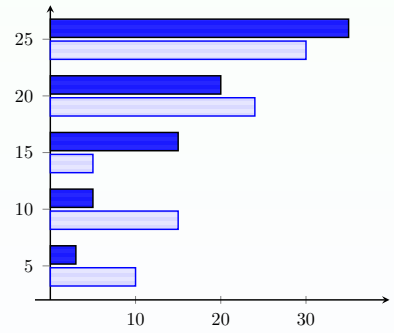
Fonte: Adaptado de Feuersänger (2021, p. 80)

```
\begin{axis}
    \addplot [const plot,]
    coordinates {
    (0,0.1) (0.1,0.15)
    (0.4,0.56) (0.5,0.58)
    (0.8,0.58) (0.9,0.55)};
\end{axis}
```

Secção 4.5

1. sharp
2. smooth
3. constant
4. bars
5. box
6. comb

box

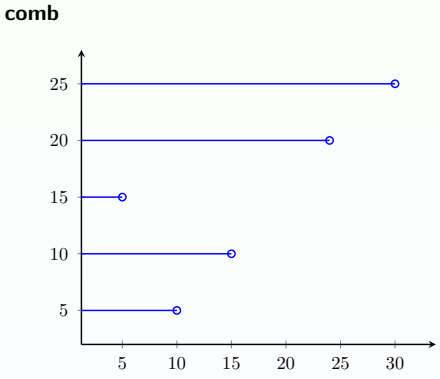



```
\begin{axis}
  [xbar,enlargelimits=0.15,]

  \addplot [draw=blue,mark= none,
    pattern=
    horizontal lines light blue,]
        coordinates {
        (10,5) (15,10) (5,15)
        (24,20) (30,25)};
  \addplot [draw=black,mark= none,
    pattern=
    horizontal lines dark blue,]
        coordinates {
        (3,5) (5,10) (15,15)
        (20,20) (35,25)};
\end{axis}
```

Fonte: Adaptado de Feuersänger (2021, p. 81)

Secção 4.5

1. sharp
2. smooth
3. constant
4. bars
5. box
6. comb

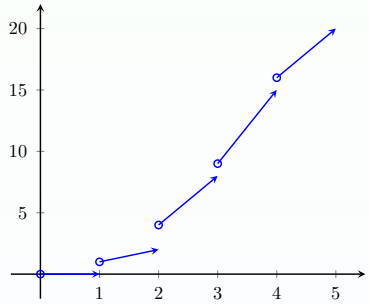



```
\begin{axis}[xcomb,
  enlargelimits=0.15]

  \addplot [draw=blue,]
     coordinates {
       (10,5) (15,10)
       (5,15) (24,20) (30,25)};
\end{axis}
```

Fonte: Adaptado de Feuersänger (2021, p. 89)

Secção 4.5

quiver

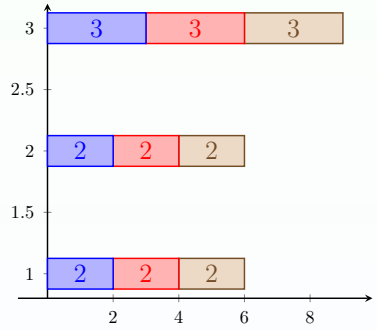



```
\begin{axis}[enlargelimits=true]
    \addplot[blue,
        quiver={u=\thisrow{u},
                v=\thisrow{v}},
                -stealth]
        table
        {x y u v
         0 0 1 0
         1 1 1 1
         2 4 1 4
         3 9 1 6
         4 16 1 4
         };
\end{axis}
```

Fonte: Adaptado de Feuersänger (2021, p. 92)

Secção 4.5

stacked



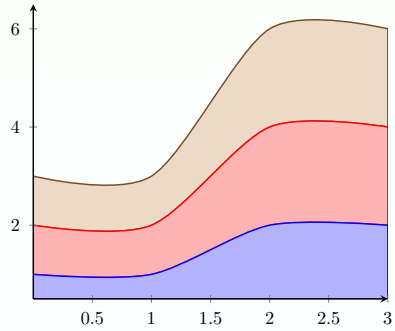

```
\begin{axis}[xbar stacked,
             nodes near coords,
             bar width=0.25,
             enlargelimits=auto]
\addplot coordinates
    {(0,1) (2,1) (2,2) (3,3)};
\addplot coordinates
    {(0,1) (2,1) (2,2) (3,3)};
\addplot coordinates
    {(0,1) (2,1) (2,2) (3,3)};
\end{axis}
```

Fonte: Adaptado de Feuersänger (2021, p. 94)

Secção 4.5

7. quiver
8. stacked
9. area
10. closedcycle
11. scatter
12. colored

area



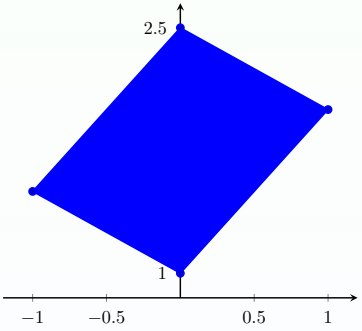

```
\begin{axis}[smooth,
    stack plots=y,
    area style,
    enlarge x limits=false,]

\addplot coordinates
    {(0,1) (1,1) (2,2) (3,2)}
    \closedcycle;
\addplot coordinates
    {(0,1) (1,1) (2,2) (3,2)}
    \closedcycle;
\addplot coordinates
    {(0,1) (1,1) (2,2) (3,2)}
    \closedcycle;
\end{axis}
```

Fonte: Adaptado de Feuersänger (2021, p. 101)

Secção 4.5

7. quiver
8. stacked
9. area
10. closedcycle
11. scatter
12. colored

closedcyle



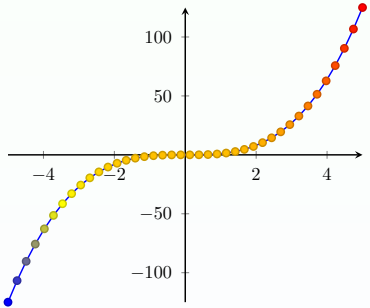

```
\begin{axis}
\addplot+ [fill] coordinates
    {(0,1) (1,2)
    (0,3) (-1,1.5)}--cycle;
\end{axis}
```

Fonte: Adaptado de Feuersänger (2021, p. 107)

Secção 4.5

7. quiver
8. stacked
9. area
10. closedcycle
11. scatter
12. colored

scatter



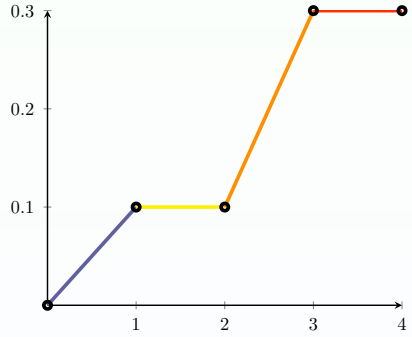

```
\begin{axis}[enlargelimits=true]
\addplot+ [scatter, samples=40,
            scatter src=y,] {x^3};
\end{axis}
```

Fonte: Adaptado de Feuersänger (2021, p. 109)

Secção 4.5

7. quiver
8. stacked
9. area
10. closedcycle
11. scatter
12. colored

1D colored

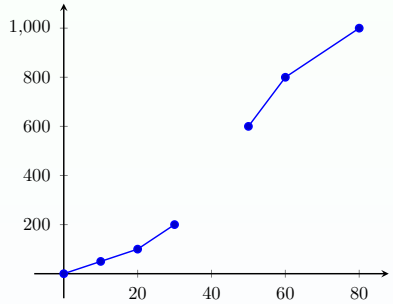



```
\begin{axis}
\addplot [mesh,
        point meta=explicit,]
        coordinates {
        (0,0)   [0]
        (1,0.1) [1]
        (2,0.1) [2]
        (3,0.3) [3]
        (4,0.3) [4]};
\end{axis}
```

Fonte: Adaptado de Feuersänger (2021, p. 120)

Secção 4.5

Interrupted

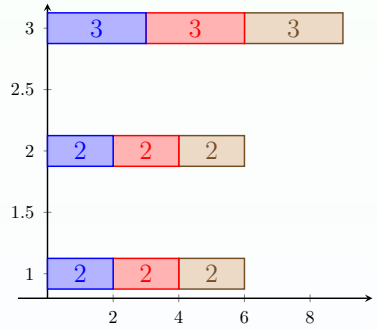



```
\begin{axis}
    [elargelimits = true]
    \addplot coordinates {
        (0,0) (10,50)
        (20,100) (30,200)

        (50,600) (60,800)
        (80,1000)};
\end{axis}
```

Fonte: Adaptado de Feuersänger (2021, p. 120)

Secção 4.5

patch



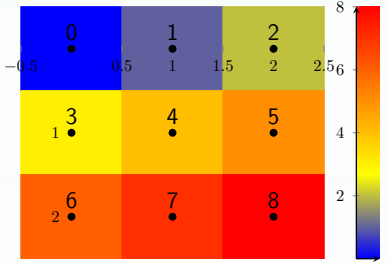

```
\begin{axis}[xbar stacked,
             nodes near coords,
             bar width=0.25,
             enlargelimits=auto]
\addplot coordinates
    {(0,1) (2,1) (2,2) (3,3)};
\addplot coordinates
    {(0,1) (2,1) (2,2) (3,3)};
\addplot coordinates
    {(0,1) (2,1) (2,2) (3,3)};
\end{axis}
```

Fonte: Adaptado de Feuersänger (2021, p. 94)

Secção 4.5

Image

13. interrupted
14. patch
15. image
16. polar
17. tieline
18. Smith



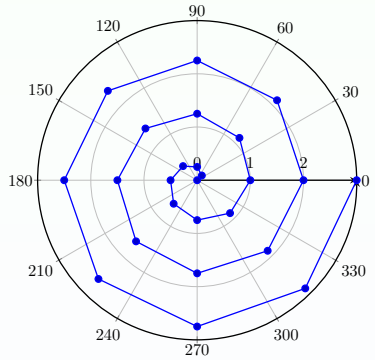

```
\begin{axis}[enlargelimits=false,
        colorbar]
    \addplot [matrix plot,
    nodes near coords=\coordindex,
    mark=*, point meta=explicit,]
    coordinates {
    (0,0) [0] (1,0) [1] (2,0) [2]

    (0,1) [3] (1,1) [4] (2,1) [5]

    (0,2) [6] (1,2) [7] (2,2) [8]};
\end{axis}
```

Fonte: Adaptado de Feuersänger (2021, p. 174)

Secção 4.5

13. interrupted
14. patch
15. image
16. polar coordenadas
17. tieline
18. Smith

Polar axes



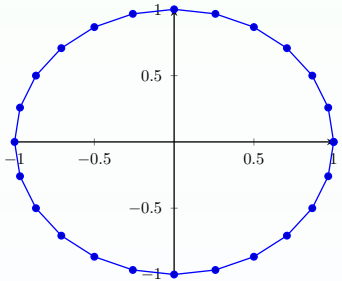
Fonte: Adaptado de Feuersänger (2021, p. 486)

```
\begin{polaraxis}[axis x line= top
    \addplot+ [domain=0:3]
        (360*x,x);
\end{polaraxis}
```

Secção 4.5

13. interrupted
14. patch
15. image
16. polar
    eixos
17. tieline
18. Smith

Polar coordinates



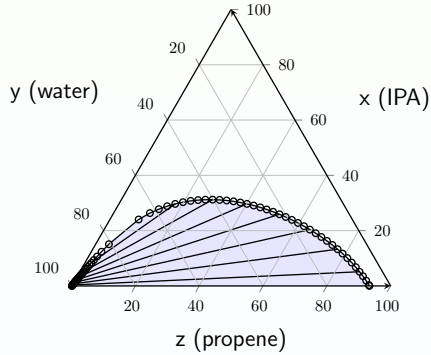
Fonte: Adaptado de Feuersänger (2021, p. 480)

```
\begin{axis}
    \addplot+[data cs=polar,
        domain=0:360] (\x,1);
\end{axis}
```

Secção 4.5

13. interrupted
14. patch
15. image
16. polar
17. tieline
18. Smith

Tieline



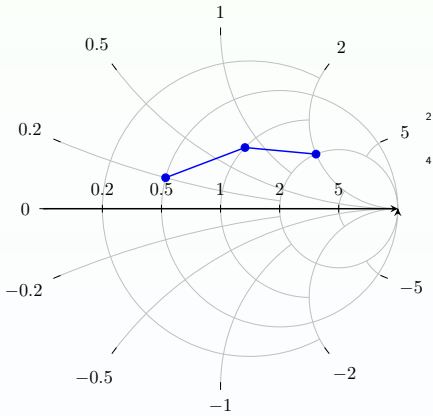

```
\begin{ternaryaxis}[
    xlabel=x (IPA),
    ylabel=y (water),
    zlabel=z (propene),
    axis on top,]

\addplot3 [
    tieline={each nth tie=5},
    fill=blue!10,]
    table [x=A_IPA,
           y=A_water,
           z=A_propene]
{plotdata/ternary_data.txt};
\end{ternaryaxis}
```

Fonte: Adaptado de Feuersänger (2021, p. 94)

Secção 4.5

13. interrupted
14. patch
15. image
16. polar
17. tieline
18. Smith

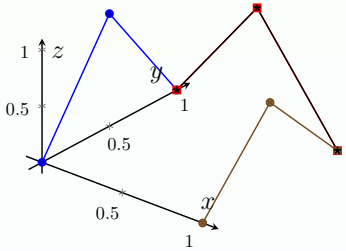
Smith




```
\begin{smithchart}
\addplot coordinates {
(0.5,0.2) (1,0.8) (2,2)
};
\end{smithchart}
```

1. line
2. scatter
3. mesh
4. surface

Linear

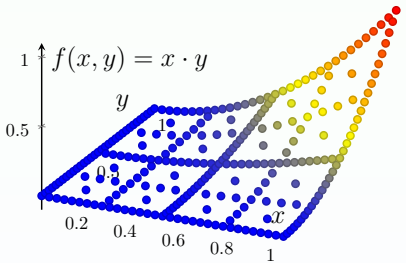


Fonte: Adaptado de Feuersänger (2021, p. 134)

```
\begin{axis}[xlabel=$x$,
        ylabel=$y$,
        zlabel=$z$,
        enlargelimits= true,
        view={40}{40},]

  \addplot3 coordinates{(0,0,0)
  (0,0.5,1)(0,1,0)};
  \addplot3 coordinates{(0,1,0)
  (0.5,1,1)(1,1,0)};
  \addplot3 coordinates{(1,1,0)
  (1,0.5,.75)(1,0,0)};
  \addplot3 coordinates{(0,1,0)
  (0.5,1,1)(1,1,0)};
\end{axis}
```

Scatter

1. line
2. scatter
3. mesh
4. surface

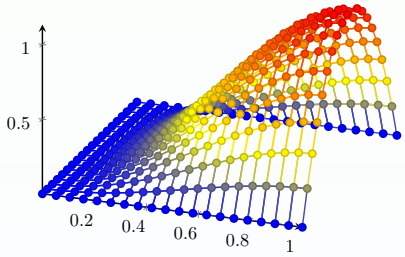


Fonte: Adaptado de Feuersänger (2021, p. 132)

```
\begin{axis}[ xlabel=$x$,
              ylabel=$y$,
  zlabel={$f(x,y)=x\cdot y$},]
\addplot3+ [only marks, scatter]
  table
  {plotdata/
    pgfplotsexample4_grid.dat};
\end{axis}
```

mesh

1. line
2. scatter
3. mesh
4. surface

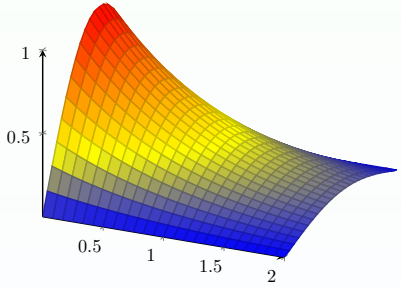


Fonte: Adaptado de Feuersänger (2021, p. 135)

```
\begin{axis}[grid=major,
view={40}{30},]
\addplot3+ [mesh,scatter,
        samples=20,domain=0:1,]
        {5*x*sin(2*deg(x)) * y*(
\end{axis}
```

1. line
2. scatter
3. mesh
4. surface

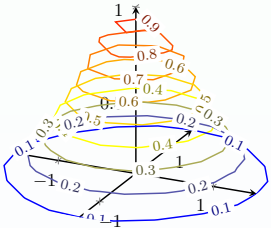
surface



Fonte: Adaptado de Feuersänger (2021, p. 139)

```
\begin{axis}[grid=major,
             mark=none]

\addplot3 [surf,
    shader=faceted,
    samples=25,
    domain=0:2,
    y domain=0:1,]
    {exp(-x)*sin(pi*deg(y))};
\end{axis}
```

contour

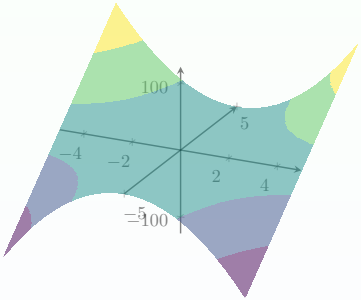



```
\begin{axis}[mark=none]
2
    \addplot3 [contour gnuplot
4       ={number=14},
        label=false]
6   {exp(0-x^2-y^2)};
\end{axis}
```

Fonte: Adaptado de Feuersänger (2021, p. 154)

filled contour

5. countour
6. filled contour
7. parametrized
8. 3D quiver

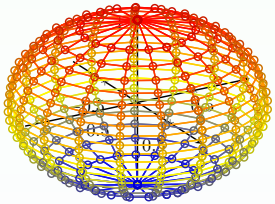


Fonte: Adaptado de Feuersänger (2021, p. 165)

```
\begin{axis}[
        colormap name=viridis,
        mark = none,
        opacity=.5]

    \addplot3 [contour filled]
        {x^2*y};
\end{axis}
```

parametrized

5. countour
6. filled contour
7. parametrized
8. 3D quiver

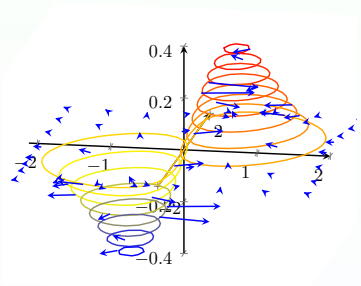


```
\begin{axis}[view={60}{20}]
\addplot3[only marks,
        mesh,z buffer=sort,
        scatter,scatter src=z,
        samples=20,
        domain=-1:1,
        y domain=0:2*pi,]
    ({sqrt(1-x^2)*cos(deg(y))},
    {sqrt( 1-x^2 )*sin(deg(y))},
    x);
\end{axis}
```

Fonte: Adaptado de Feuersänger (2021, p. 172)

5. countour
6. filled contour
7. parametrized
8. 3D quiver

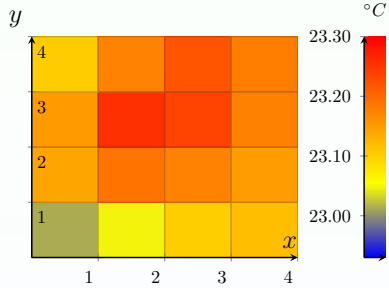
3D quiver




```
\begin{axis}[domain=-2:2,
             view={45}{45},
  axis background/.style=
  {fill=white},]

\addplot3 [
  contour gnuplot={number=20,
                   labels=false,},
    thick,] {exp(0-x^2-y^2)*x};

\addplot3 [blue,-stealth,
    samples=10, quiver={
    u={exp(0-x^2-y^2)*(1-2*x^2)},
    v={exp(0-x^2-y^2)*(-2*x*y)},
    scale arrows=0.3,},]
    {exp(0-x^2-y^2)*x};
\end{axis}
```

Fonte: Adaptado de Feuersänger (2021, p. 160)

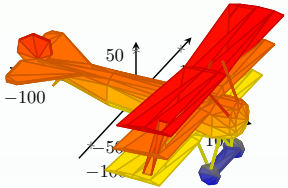
image




```
\begin{axis}[view={0}{90},
  xlabel=$x$,ylabel=$y$,
  colorbar, mark=none,
  colorbar style={
  title={\footnotesize $^\circ C$},
  yticklabel style={
        /pgf/number format/.cd,
        fixed, fixed zerofill}},
 scale=.75,
 colorbar style={
   width=.03\linewidth,
   at={(1.25,0)},
   anchor=south west},]

 \addplot3[surf] file
   {plotdata/tempdata.dat};
 \end{axis}
```

Fonte: Adaptado de sergej (2015)

patch

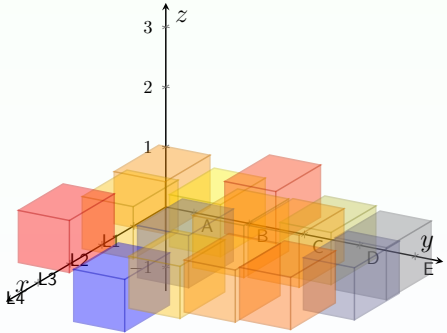


Fonte: Adaptado de Feuersänger (2021, p. 182)

```
\begin{axis}[mark=none,]
 \addplot+ [fill] coordinates
    {(0,1) (1,2)
    (0,3) (-1,1.5)}--cycle;
\end{axis}
```

9. image
10. patch
11. 3D bars, constant

3D bar/constant



Fonte: Adaptado de owen (2020)

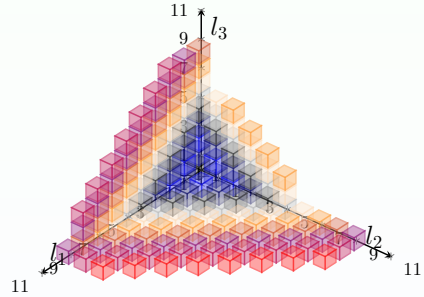
Nota:There are currently no equivalents of const plot and its variants or the bar plot types like ybar for three dimensional axes, sorry. (FEUERSÄNGER, 2021, p. 185)

9. image
10. patch
11. 3D bars, constant

```
\begin{axis}[view={120}{20},
    width=10cm,height=10cm, grid=major,xmin=1,xmax=4,
    ymin=1,ymax=5,zmin=-1,zmax=3,
    xtick={1,2,3,4},   xticklabels={L1, L2, L3, L4},
    ytick={1,2,3,4,5}, yticklabels={A, B, C, D, E},
    ylabel={$y$}, xlabel={$x$}, zlabel={$z$},
    axis equal,]

\addplot3[only marks,scatter,mark=cube*,mark size=1cm,
fill=blue,opacity=0.5] coordinates
{(1,1,0.7)(1,2,0.5)(1,3,0.9)(1,4,0.4)(1,5,0.33)};

\addplot3[only marks,scatter,mark=cube*,mark size=1cm,
fill=orange,opacity=0.5]coordinates
{(2,1,0.6)(2,2,0.3)(2,3,0.65)(2,4,0.67)(2,5,0.31)};

\addplot3[only marks,scatter,mark=cube*,mark size=1cm,
fill=red,opacity=0.5]coordinates
{(4,1,1)(4,2,0.2)(4,3,0.6)(4,4,0.72)(4,5,0.78)};
\end{axis}
```

9. image
10. patch
11. 3D bars, constant

scatter 3D



Fonte: Adaptado de Feuersänger (2021, p. 133)

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