pst-solides3d:
The Documentation – The Basics

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1. Basics for the package

1.1. Constitution of the package – Distribution

- **Required files:** pst-solides3d.sty, pst-solides3d.tex, solides.pro and the latest version of the basic PSTricks package.
- **Workflow:** This package is made for dvips and ps2pdf, however pdfTEX won't work.
- **Documentation and examples:** pst-solides3d-doc.tex(pdf), doc-exemples-solides3d.tex(pdf).

This package is available on: http://syracuse.eu.org/syracuse/pstricks/pst-solides3d/ as well as on CTAN.

Numerous examples are available on: http://syracuse.eu.org/lab/bpst/pst-solides3d

Finally, the actual developer's version is available on the SVN of *mélusine*: http://syracuse-dev.org/pst-solides3d

1.2. Installation hints

Here we give some hints on how to install pst-solides3d on your TEX system.

The pst-solides3d package consists of three main files:

- solides.pro: the prolog file for pst-solides3d
- pst-solides3d.sty: the appropriate style file
- pst-solides3d.tex: the appropriate tex file

as well as the actual PSTricks base files:

- pstricks.pro: the prolog file for pstricks
- pstricks.tex: the appropriate tex file

available on CTAN.

Some extension files for pst-rubans:

- pst-rubans.sty: the appropriate style file
- pst-rubans.tex: the appropriate tex file

Save the files pst-solides3d.sty—tex, pst-rubans.sty—tex and pstricks.tex in a directory which is part of your local TEX tree.

However the solides.pro and the pstricks.pro file should go into the folder $TEXMF/dvips/pstricks/

Do not forget to run texhash to update this tree. For MiKTEX users, do not forget to update the file name database (FNDB).

For more detailed information see the documentation of your personal LATEX distribution on installing packages to your local TEX system.

1.3. Preface

The package presented in this documentation arose from teamwork initiated via the mailing list of the syracuse web site (http://melusine.eu.org/syracuse).

The idea was born of a confrontation between the work of Jean-Paul Vignault on the software package *jps2ps*[1] and Manuel Luque's work on PSTricks[2], especially in relation to the subject of representing solids in three-dimensional space.

The two authors decided to unify their efforts and co-author a PSTricks package dedicated to three-dimensional scenes. The work took place on the "machine *mélusine*" within an environment generated and maintained by Jean-Michel Sarlat.

The team was completed with the addition of Arnaud Schmittbuhl, Herbert Voss and Jürgen Gilg, the latter specialising in animation-based beta-testing[3].

1.4. Presentation

The package pst-solides3d, with the help of PSTricks, allows for 3D views of predefined or user-generated solids. You will find most of the usual solids, which can be drawn with or without hidden edges, whose colour can be varied with lighting.

This package can project text or simple graphics (in 2D) onto arbitrarily chosen planes or onto plane faces of solids that are created by the user.

From the user's standpoint, most of its functionalities are accessible by way of three TEX macros: \psSolid, which can manipulate objects in 3 dimensions, \psSurface, related to the first macro and designed to represent surfaces that are defined by an equation of the type $f(x, y) = z$ and \psProjection which allows the user to project two-dimensional graphics/text onto any plane face of a 3D solid.

In using this package, two languages come together: on the one hand PSTricks, with its well-known macros and familiar syntax, and on the other PostScript code, which appears within the optional arguments of the former.

We have made the decision to strictly limit the involvement of PSTricks. Its function is only to transmit parameters from TEX to PostScript. All calculations and displays are done by the latter.

A PostScript library, which was developed for another application (the software package *jps2ps*), is used for all calculations and display routines. The PostScript code used in this library is called *jps code*.

The aim of the present document is to describe PSTricks syntax for each operation provided by the package.

[1] http://melusine.eu.org/syracuse/bbgraf/
[2] http://melusine.eu.org/syracuse/pstricks/pst-v3d/
[3] http://melusine.eu.org/syracuse/pstricks/pst-solides3d/animations/

1.5. Changes by comparison with previous versions

1.5.1. Changes compared to version 3.0

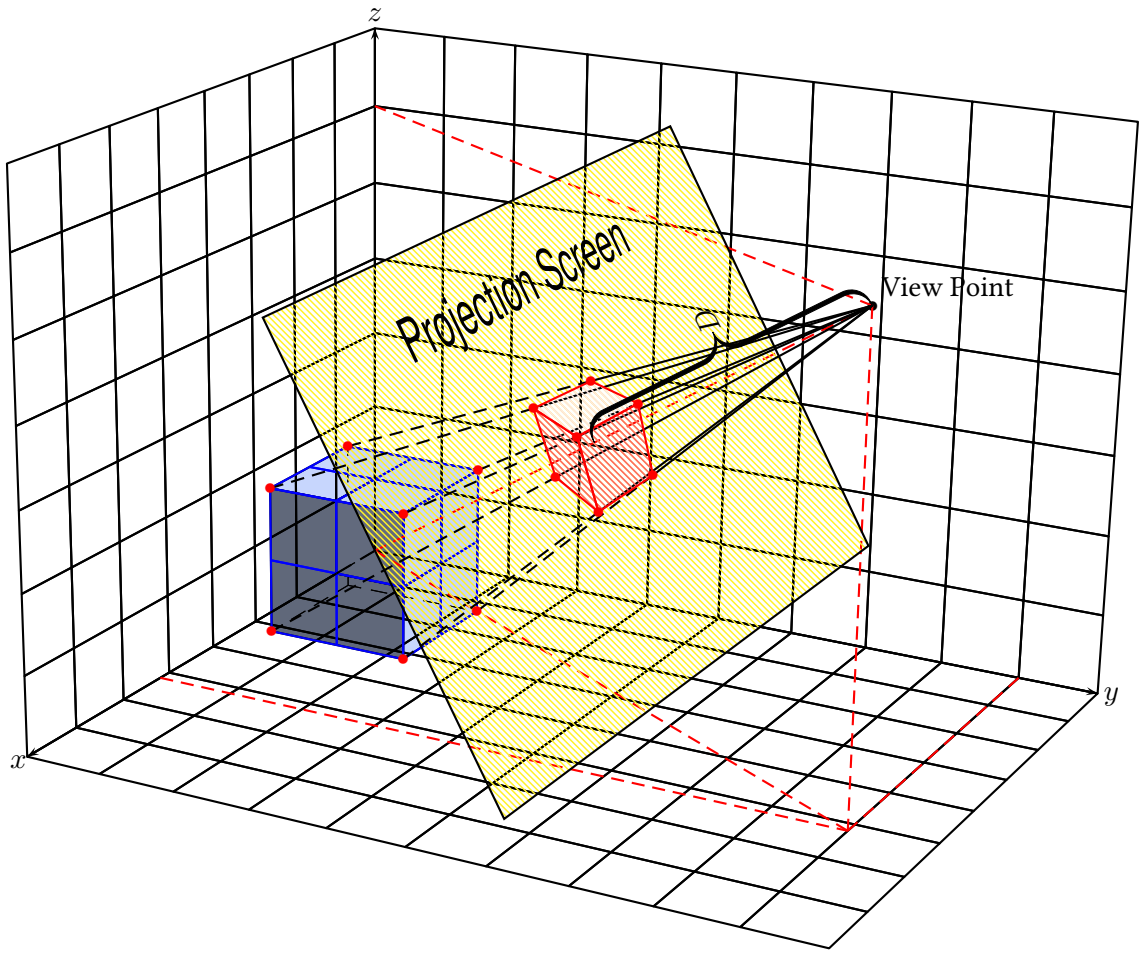
- The macro \psProjection has been completely rewritten. We now need to use an object of type plan to define a projection.
- The object courbe now uses the argument r. To reproduce the previous behaviour we now have to specify $r = 0$.
- The option resolution of the object courbe is replaced with the option ngrid
- Suppression of the argument tracelignedeniveau.

1.5.2. Changes compared to version 2.0

- The option hue is not a Boolean anymore.
- The scaling in PostScript will from now on follow the workings of *jps code*. To be consistent, the commands smoveto, srmoveto, slineto, srlineto now respectively replace the commands moveto, rmoveto, lineto, rlineto.

2. Setting the layout of the scenery

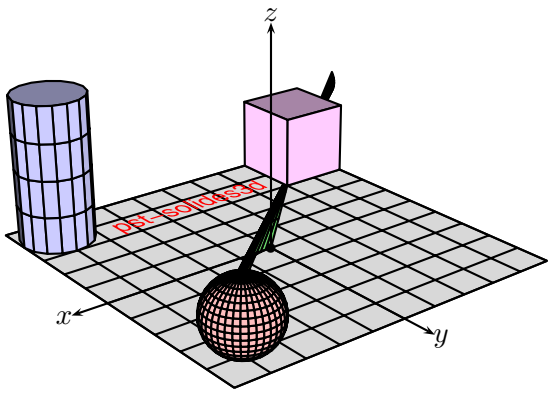
2.1. Choice of the view point



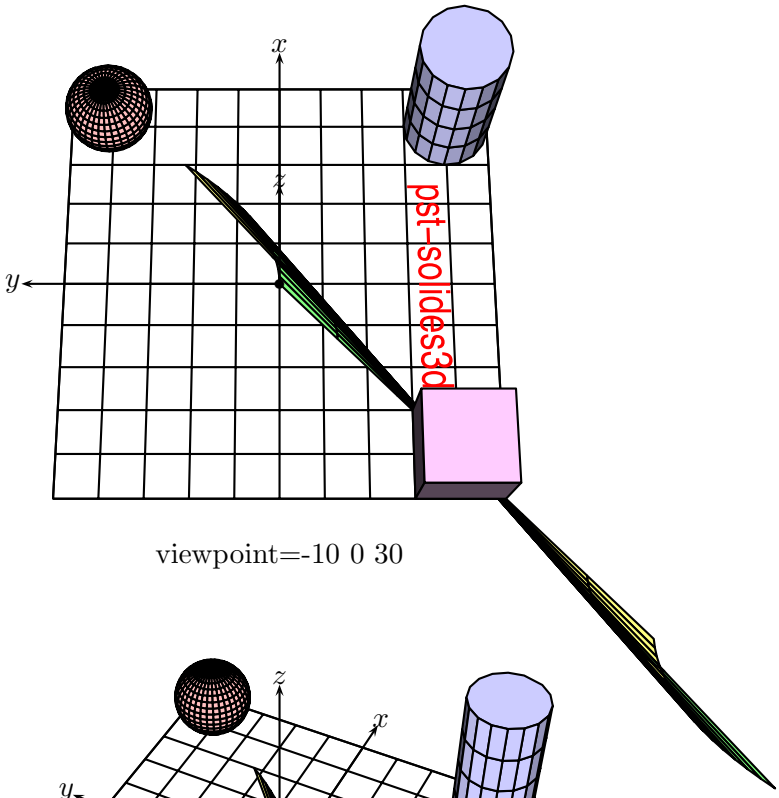
The coordinates of the object, in this case the bluish cube, are setup in the axes of coordinates $Oxyz$. The coordinates of the view point (V), are setup in the same axes of coordinates, either in spherical coordinates—with the adding option [rtp2xyz], or in Cartesian coordinates—which is the default option.

Example: [viewpoint=50 30 20 rtp2xyz] (here the notation with spherical coordinates)

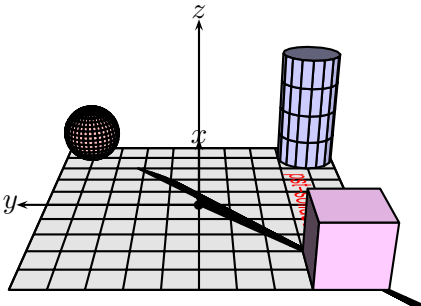
See some examples:



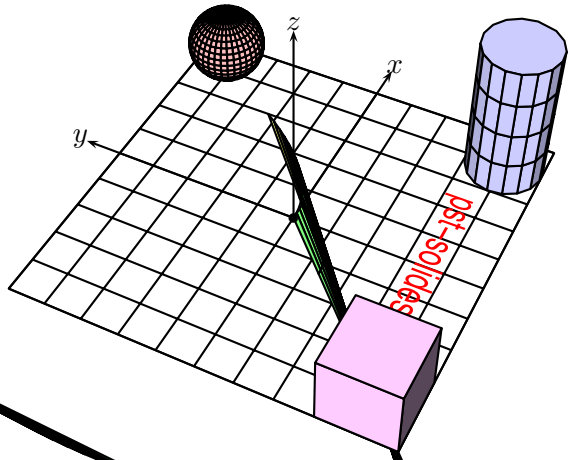
viewpoint=20 25 15



viewpoint=-10 0 30



viewpoint=-20 0 10

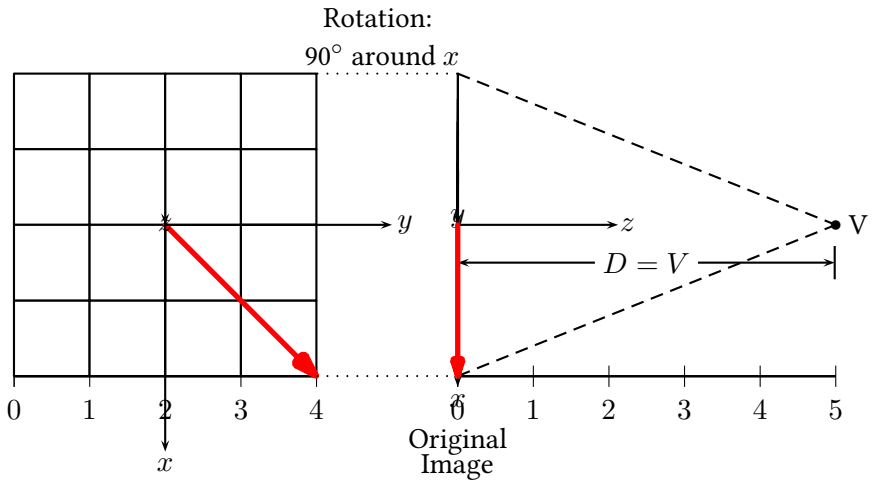


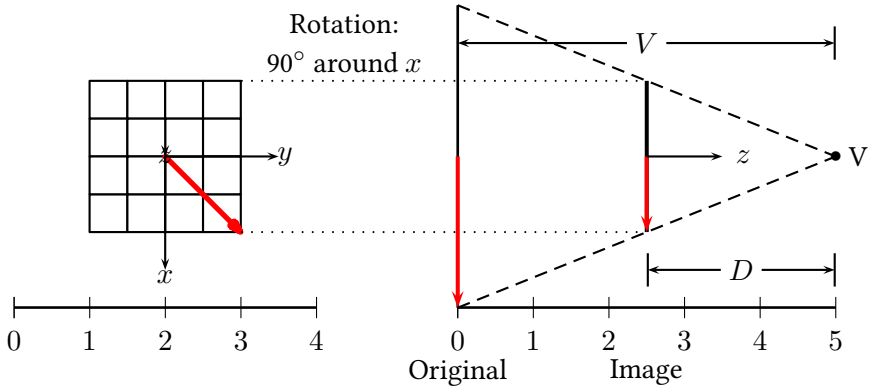
viewpoint=-20 -10 15

2.2. The definition of the option Decran

The projection screen is placed perpendicular to the direction OV—central perspective, at a distance D from the view point V: We call that distance 'Decran', with the default value of Decran=50; this value can either be positive or negative.

The following examples show the behaviour of the parameter Decran.





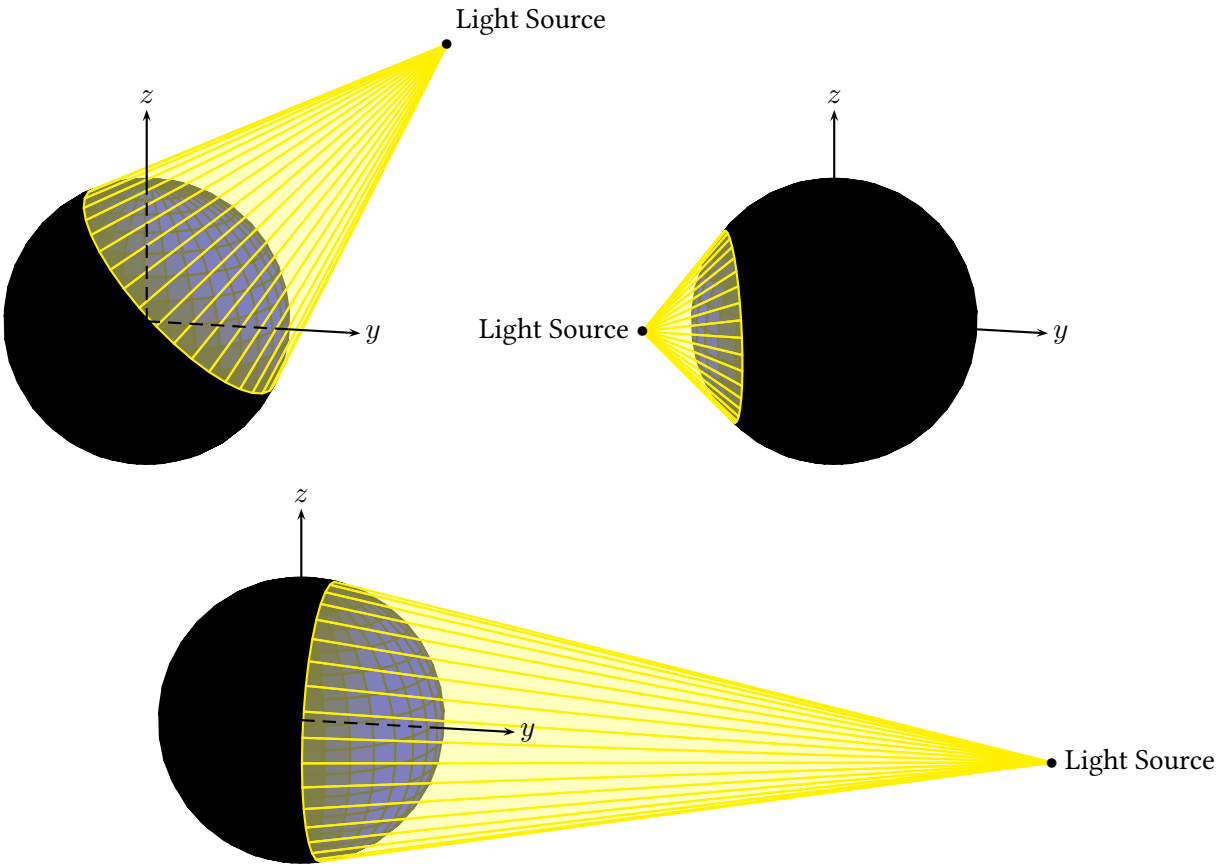
If you keep the view point and make the Decran value smaller, then the image gets smaller. If you make the Decran value larger, then the image gets larger.

Here are some examples, where we keep the same object, the same view point and just vary the Decran value:

2.3. Lighting by a point light source

Two parameters, the first one positions the light source, the second one sets the light intensity:

- lightsrc=20 30 50 in Cartesian coordinates, or lightsrc=viewpoint to put the light source at the view point.
- lightintensity=2 (default value).

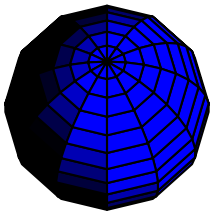


As you can see, the intersecting plane (section of the sphere with the cone of light) divides the object into two half spaces: the first half space (the one on the side of the light source) is illuminated and the other half space is the shadow region referring to this light source position.

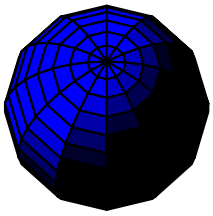
Now it is clear, that if the view point is setup with the same coordiates as the light source, the object is illuminated uniquely.

Note: In order to get some shadow regions to appear in the graphic—which emphasises the 3D character—we would suggest choosing the light source and the view point differently.

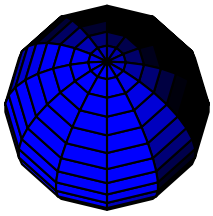
Here follow a few examples:



lightsrc=10 20 30

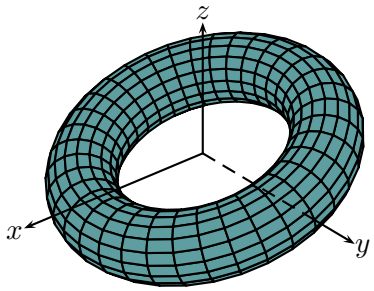


lightsrc=-10 -20 30

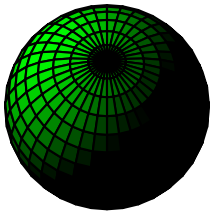


lightsrc=30 -20 30

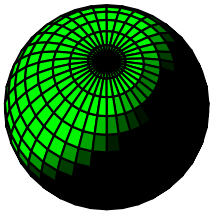
When the option [lightsrc=value1 value2 value3] is not specified, the object is uniformly illuminated.



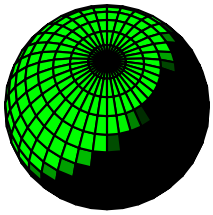
Here are some examples, where we always keep the same object, the same view point, the same light source coordinates and just vary the lightintensity value:



lightintensity=2



lightintensity=3



lightintensity=8

Here we can see, that by increasing the lightintensity value, the shading nuances of the solid are decreasing.

2.4. The axes in 3d

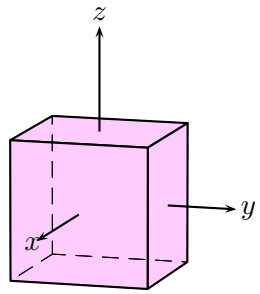
The command "axesIIID[options](x1,y1,z1)(x2,y2,z2) draws the axes Ox, Oy and Oz dashed from the origin O to the coordinates $(x_1, 0, 0)$ for the x-axis, $(0, y_1, 0)$ for the y-axis and $(0, 0, z_1)$ for the z-axis and from there continues drawing the axes as lines to the points $(x_2, 0, 0)$, $(0, y_2, 0)$ and $(0, 0, z_2)$.

The options are the following:

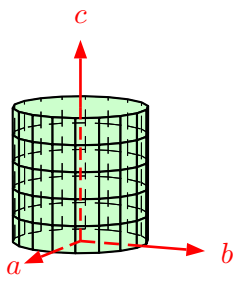
- all colour options, line width as well as all types of arrows.

- labelsep=length which allows you to position the label in a self defined distance away from the extremity of the arrow of the axis, the default value is labelsep=5pt—this is a real distance in three dimensions and not on screen.
- the choice of the labels on each of the axes with the option: axisnames=a,b,c, the default values are axisnames=x,y,z.
- the potential to specify the style of the labels with the option: axisemph=“boldmath“Large“color–red″. By default there is no style predefined, which means, if no style is chosen one will get x,y,z.
- showOrigin is a Boolean, true—by default. If it is set to showOrigin=false the dashed lines aren't drawn to the origin anymore.
- mathLabel is a Boolean, true—by default, in which case the math mode is activated. Set to mathLabel=false the labels are set in text mode.

Note: The labels are placed at the extemities of the axes.




```
“begin–pspicture″(-2,-2) (3,3)
“psset–viewpoint=100 30 20,Decran=100″
“psSolid[object=cube,a=2,
          action=draw*,
           fillcolor =magenta!20]
“axesIIID[showOrigin=false](1,1,1) (3,2,2.5)
“end–pspicture″
```




```
“begin–pspicture″(-2,-1) (3,4)
“psset–viewpoint=100 45 20,Decran=100″
“psSolid[object=cylindre,h=2,r=1,
          action=draw*,mode=4,
           fillcolor =green!20]
“axesIIID[linewidth=1pt,linecolor=red,arrowsize=5pt,
            arrowinset=0,axisnames=–a,b,c″,
            axisemph=–“boldmath“Large“color–red″″,
            labelsep=10pt]
           (1,1,2) (2,2,3)
“end–pspicture″
```

3. Predefined solids and their positioning

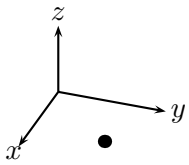
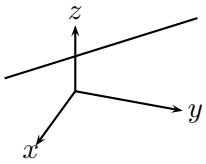
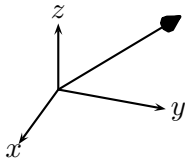
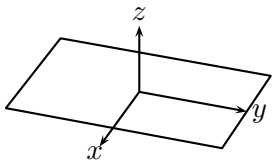
3.1. The predefined solids and their parameters

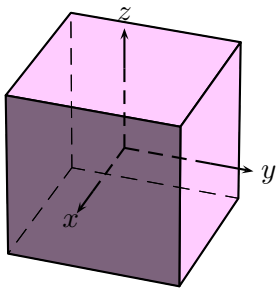
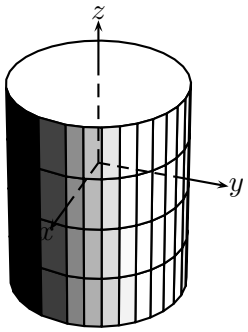
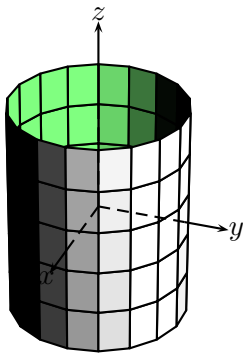
The basic command is: \psSolid[object=name](x, y, z) which allows us to translate the chosen object to the point with the coordinates (x, y, z).

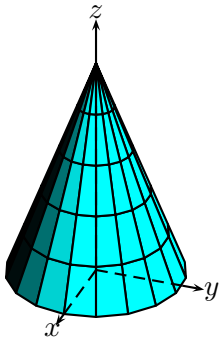
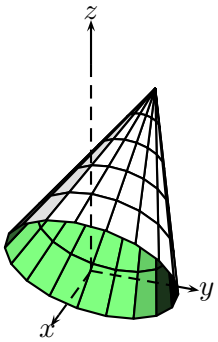
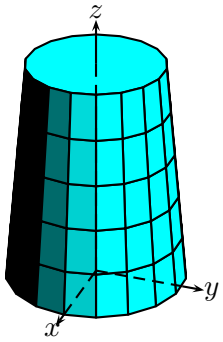
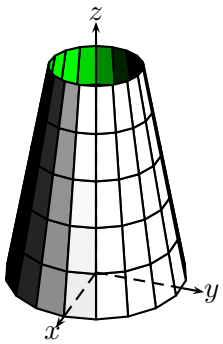
The available predefined names for the objects are:

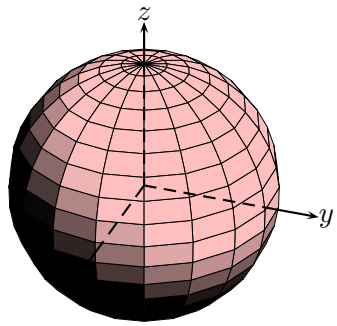
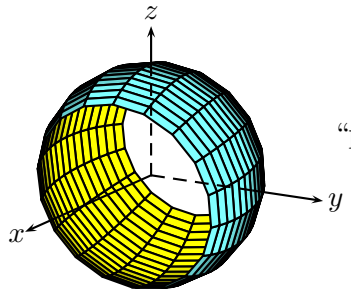
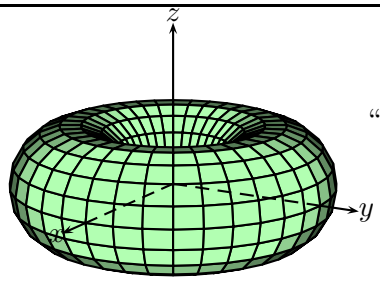
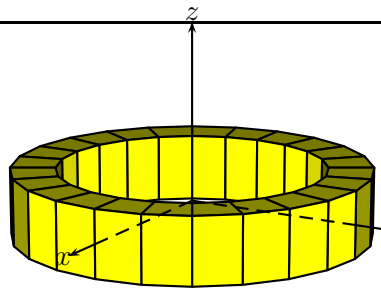
point, line, vector, plan, grille, cube, cylindre, cylindrecreux, cone, conecreux, tronccone, tronc-conecreux, sphere, calottesphere, calottespherecreuse, tore, tetrahedron, octahedron, dodecahedron, isocahedron, anneau, prisme, prismecreux, parallelepiped, face, polygonregulier, ruban, surface, surface*, surfaceparamettree, pie, fusion, geode, load, offfile, objfile, datfile, new.

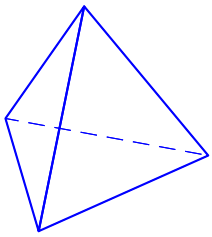
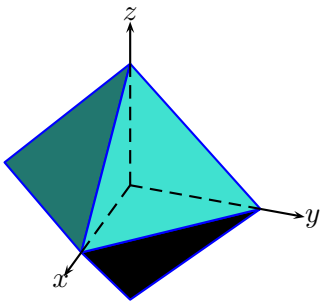
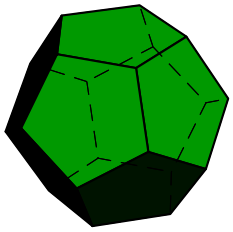
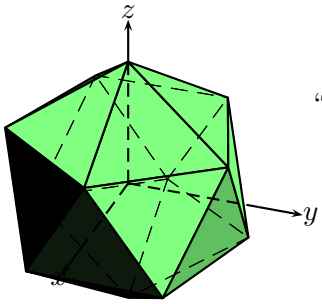
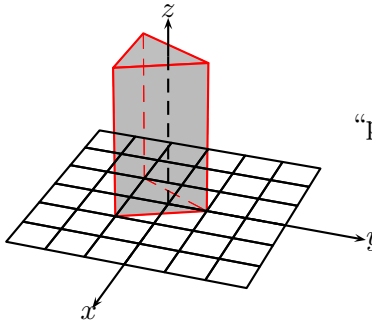
The following table gives an example of every one of the above named solids with their specified parameters:

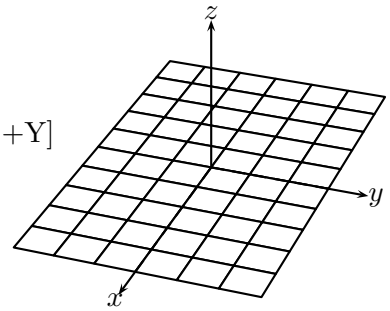
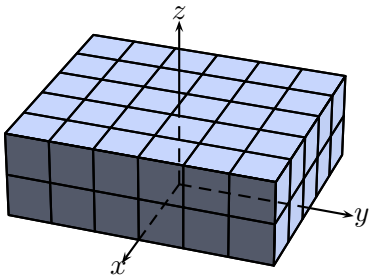
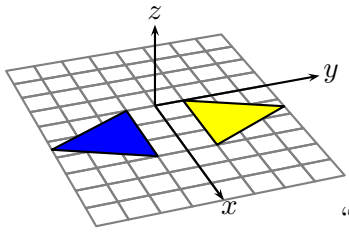
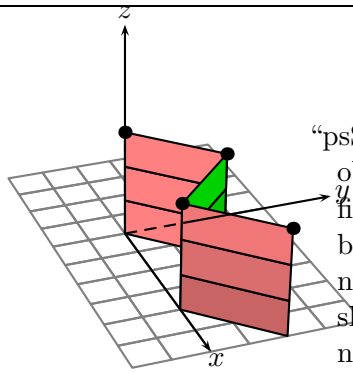
Solid	Default Parameters	View	Code
Point	[args=1 1 0] coordinates		“psSolid[object=point, args=1 1 0]%
Line	[args=0 -1 0 1 2 2] coordinates of the end points		“psSolid[object=line, args=0 -1 0 1 2 2]
Vector	[args=1 2 2] components of the vector		“psSolid[object=vecteur, args=1 2 2]
Plane	[base=-x x -y y] range of plane args=[0 0 1 0] equation of plane		“psSolid[object=plan, definition=equation, args=–[0 0 1 0]″, base=-1 1 -1.5 1.5]

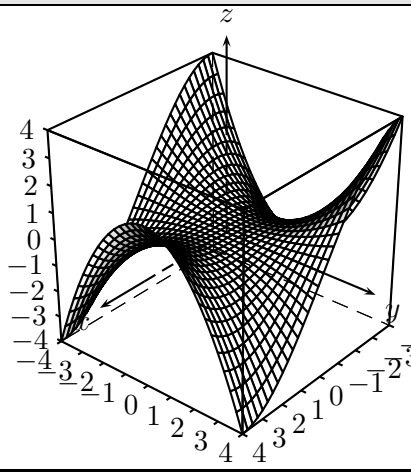
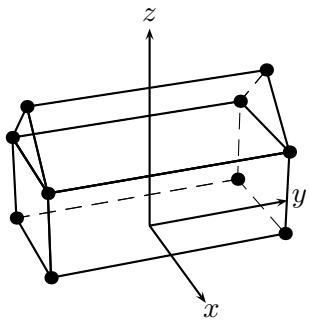
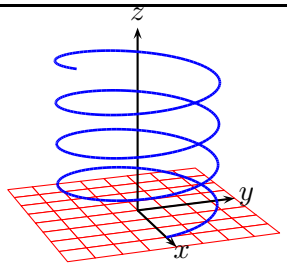
Solid	Default Parameters	View	Code
Cube	[a=4] edge's length		"psSolid[object=cube, a=2, action=draw*, fillcolor=magenta!20]
Cylinder	[h=6,r=2] height and radius grid: [ngrid=n1 n2]		"psSolid[object=cylindre, h=5,r=2, fillcolor=white, ngrid=4 32] (0,0,-3)
Hollow Cylinder	[h=6,r=2] height and radius grid: [ngrid=n1 n2]		"psSolid[object=cylindrecreux, h=5,r=2, fillcolor=white, mode=4, incolor=green!50] (0,0,-3)

Solid	Default Parameters	View	Code
Cone	[h=6,r=2] height and radius grid: [ngrid=n1 n2]		“psSolid[object=cone, h=5,r=2, fillcolor=cyan, mode=4]%
Hollow Cone	[h=6,r=2] height and radius grid: [ngrid=n1 n2]		“psSolid[object=conecreux, h=5,r=2, RotY=-60, fillcolor=white, incolor=green!50, mode=4]%
Truncated Cone	[h=6,r0=4,r1=1.5] height and radii grid: [ngrid=n1 n2]		“psSolid[object=tronccone, r0=2,r1=1.5,h=5, fillcolor=cyan, mode=4]%
Truncated Hollow Cone	[h=6,r0=4,r1=1.5] height and radii grid: [ngrid=n1 n2]		“psSolid[object=troncconecreux, r0=2,r1=1,h=5, fillcolor=white, mode=4]%

Solid	Default Parameters	View	Code
Sphere	[r=2] radius grid: [ngrid=n1 n2]		“psSolid[object=sphere, r=2,fillcolor=red!25, ngrid=18 18]%
Spherical zone	[r=2] radius [phi=0,theta=90] latitude for slicing the zone respectively from the bottom and top		“psSolid[object=calottesphere, r=3,ngrid=16 18, theta=45,phi=-30, hollow,RotY=-80]%
Torus	[r0=4,r1=1.5] inner radius mean radius grid: [ngrid=n1 n2]		“psSolid[r1=2.5,r0=1.5, object=tore, ngrid=18 36, fillcolor=green!30, action=draw*]%
Cylindric Ring	[R=4,r=3 inner and outer radius h=6,section=...] height cross section		“psSolid[object=anneau, yfillcolor=yellow, h=1.5,R=4,r=3]%

Solid	Default Parameters	View	Code
Tetrahedron	[r=2] radius of the circumscribed sphere		“psSolid[object=tetrahedron, r=3, linecolor=blue, action=draw]%
Octahedron	[a=2] radius of the circumscribed sphere		“psSolid[object=octahedron, a=3, linecolor=blue, fillcolor=Turquoise]%
Dodecahedron	[a=2] radius of the circumscribed sphere		“psSolid[object=dodecahedron, a=2.5,RotZ=90, action=draw*, fillcolor=OliveGreen]%
Icosahedron	[a=2] radius of the circumscribed sphere		“psSolid[object=icosahedron, a=3, action=draw*, fillcolor=green!50]%
Prism	[axe=0 0 1] direction of the axis [base= -1 -1 1 -1 0 1] coordinates of the vertices of the base [h=6] height		“psSolid[object=prisme, action=draw*, linecolor=red, h=4]%

Solid	Default Parameters	View	Code
Grid	[base=-X +X -Y +Y]		“psSolid[object=grille, base=-5 5 -3 3]%
Cuboid	[a=4,b=3,c=2] edge lenghts with center in O		“psSolid[object=parallelepiped,% a=5,b=6,c=2, fillcolor=yellow]% (0,0,c 2 div)
Face	[base=x0 y0 x1 y1 x2 y2 etc.] the coordinates of the vertices		“psSolid[object=face, fillcolor=yellow, incolor=blue, base=0 0 3 0 1.5 3](0,1,0) “psSolid[object=face, fillcolor=yellow, incolor=blue, base=0 0 3 0 1.5 3, RotX=180](0,-1,0)
Strip	[base=x0 y0 x1 y1 x2 y2 etc.] [h=height] [ngrid=value] number of gridlines [axe=0 0 1] direction of inclination of the strip		“psSolid[object=ruban,h=3, fillcolor=red!50, base=0 0 2 2 4 0 6 2, num=0 1 2 3, show=0 1 2 3, ngrid=3])

Solid	Default Parameters	View	Code
Surface	see the related paragraph in the documentation		“psSurface[ngrid=.25 .25, incolor=white,axesboxed] (-4,-4)(4,4)–% x dup mul y dup mul 3 mul sub x mul 32 div″
New	solid defined by the coordinates of the vertices and the vertices of each face		“psSolid[object=new, action=draw, sommets= 2 4 3 -2 4 3 -2 -4 3 2 -4 3 2 4 0 -2 4 0 -2 -4 0 2 -4 0 0 4 5 0 -4 5, faces=– [0 1 2 3] [7 6 5 4] [0 3 7 4] [3 9 2] [1 8 0] [8 9 3 0] [9 8 1 2] [6 7 3 2] [2 1 5 6]″]%
Curve	curve of a function $\mathbb{R} \to \mathbb{R}^3$ defined by its paramterised equations		“defFunction[algebraic]% –helice″(t) –3*cos(4*t)″–3*sin(4*t)″–t″ “psSolid[object=courbe,r=0, range=0 6, linecolor=blue, linewidth=0.1, resolution=360, function=helice]%

Some information about rings and parallelepipeds is available in the documents:

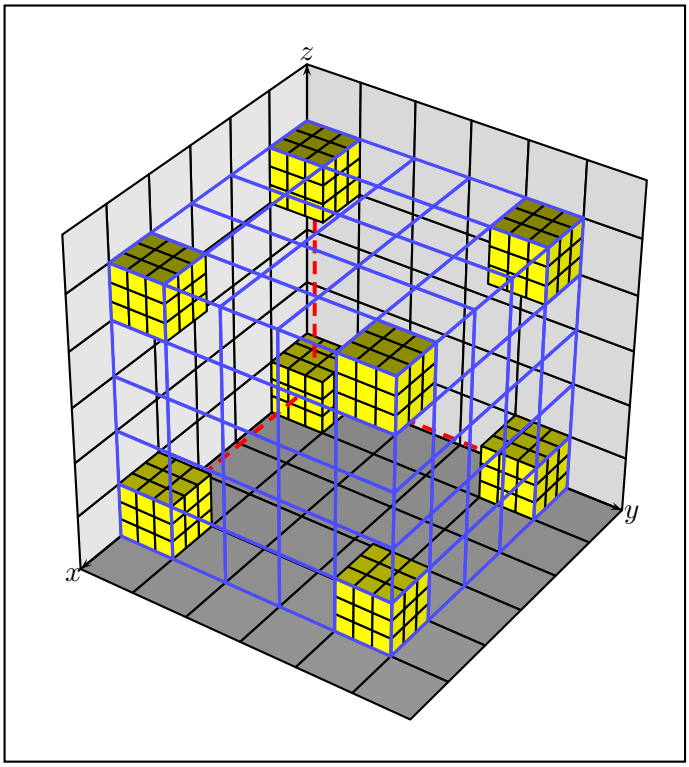
- doc-grille-parallelepiped.tex(.pdf);
- doc-anneau.tex(.pdf).

3.2. Positioning a solid

3.2.1. Translation

The following command \psSolid[object=cube,+options](x,y,z) shifts the centre of the cube to the point with the coordinates (x, y, z).

The next example will copy the cube with edge length of 1  to the points with the coordinates (0.5, 0.5, 0.5), (4.5, 0.5, 0.5) etc. so that the copied cubes setup the vertices of a new cube with the edge length 5.

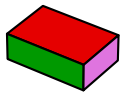


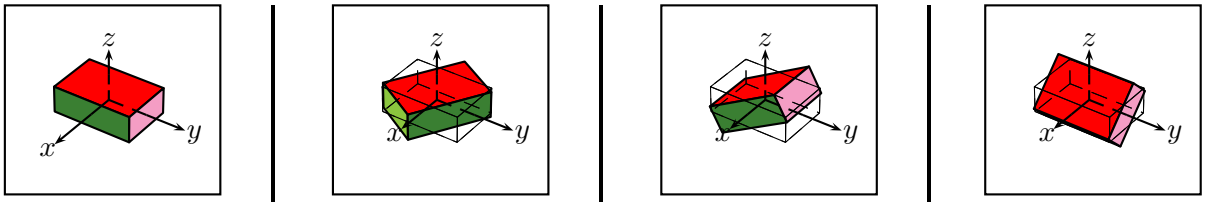
“psset–fillcolor=yellow,mode=3″
“psSolid[object=cube](0.5,0.5,0.5)
“psSolid[object=cube](4.5,0.5,0.5)
“psSolid[object=cube](0.5,4.5,0.5)
“psSolid[object=cube](0.5,0.5,4.5)
“psSolid[object=cube](4.5,4.5,4.5)
“psSolid[object=cube](4.5,0.5,4.5)
“psSolid[object=cube](4.5,4.5,0.5)
“psSolid[object=cube](0.5,4.5,4.5)

3.2.2. Rotation

3.2.3. Default sequence xyz

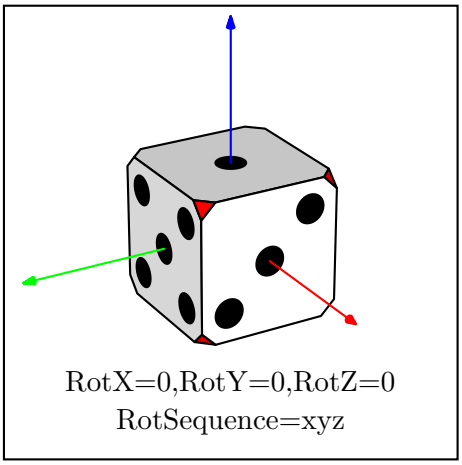
The rotation is effected around the three axes Ox, Oy and Oz. Let's take a cuboid as an example, which will be rotated seperately around the axes Ox, Oy and Oz.



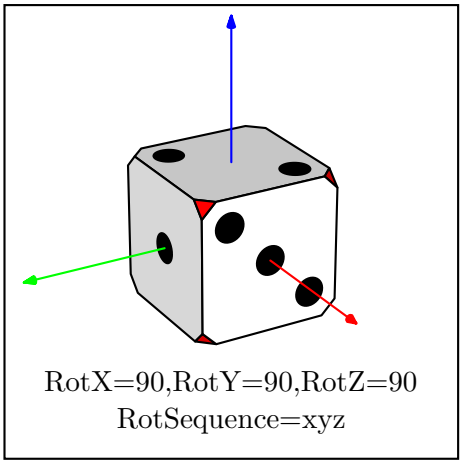


[RotZ=60] [RotX=30] [RotY=-45]

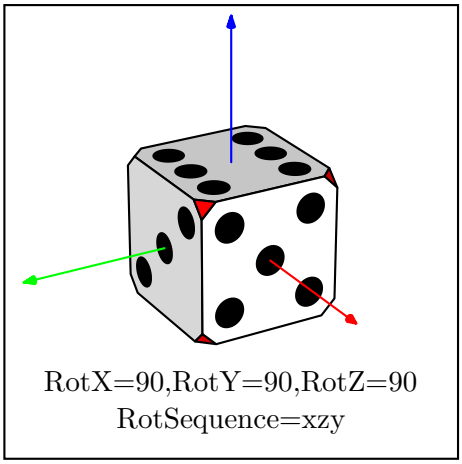
3.2.4. Rotations Sequence



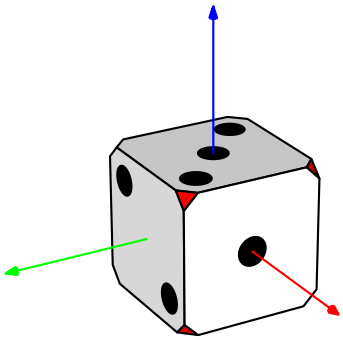
RotX=0,RotY=0,RotZ=0
RotSequence=xyz



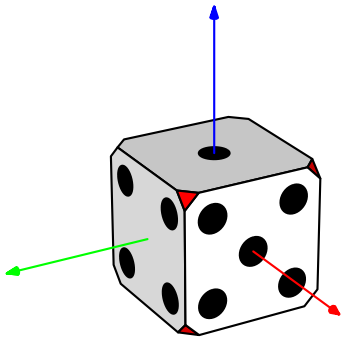
RotX=90,RotY=90,RotZ=90
RotSequence=xyz



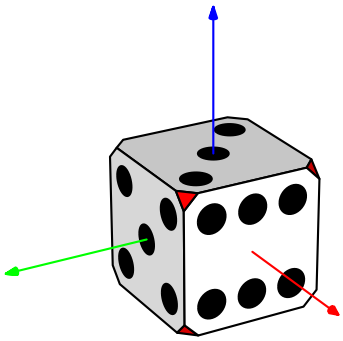
RotX=90,RotY=90,RotZ=90
RotSequence=xzy



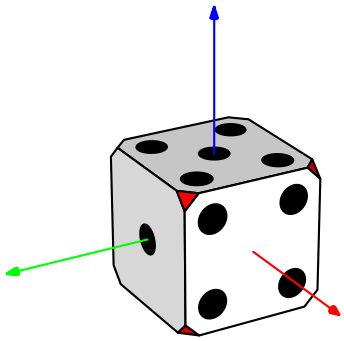
RotX=90,RotY=90,RotZ=90
RotSequence=yxz



RotX=90,RotY=90,RotZ=90
RotSequence=yzx



RotX=90,RotY=90,RotZ=90
RotSequence=zxy



RotX=90,RotY=90,RotZ=90
RotSequence=zyx

4. More options of \psSolid

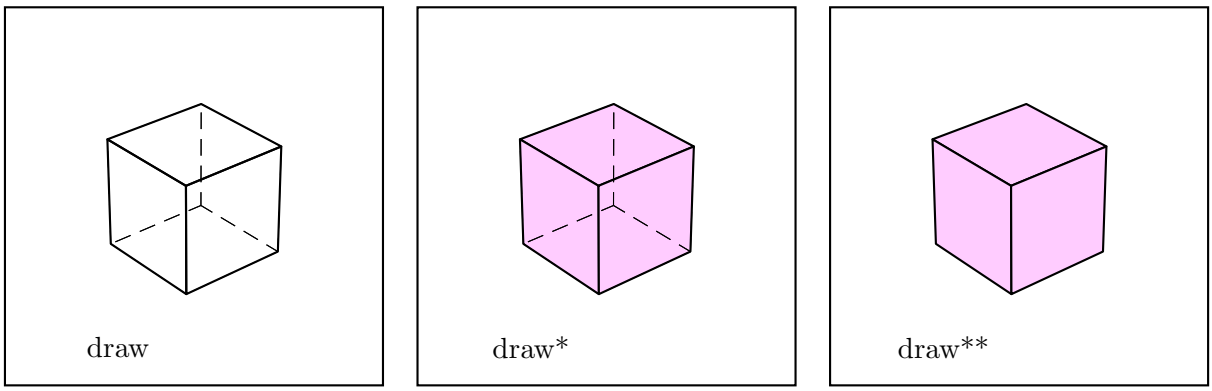
4.1. Commands for drawing

The parameter for drawing comes with the key value action within the command \psSolid.

Four values are possible:

- none: nothing is drawn.
- draw: draws the solid as a framework and sets up dashed lines for the hidden edges.
- draw*: draws the solid with dashed lines for the hidden edges and colours the visible faces.
- draw**: draws the solid with a painting algorithm, without the hidden edges and with colouration of the visible faces.

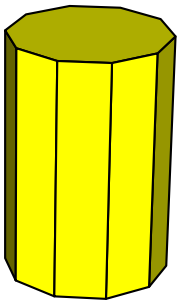
Note: The key values draw and draw* only make sense for convex solids.



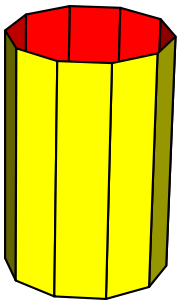
4.2. Emptying a solid

Several of the predefined solids have a "*hollow*" relative which is naturally associated with it (the cone, the truncated cone, the cylinder, the prism and the spherical zone). For all those, the option hollow=true is provided. Set to false, we get the "filled" solid; set to true we get the "hollow" version.

Example 1: a cylinder and a hollow cylinder

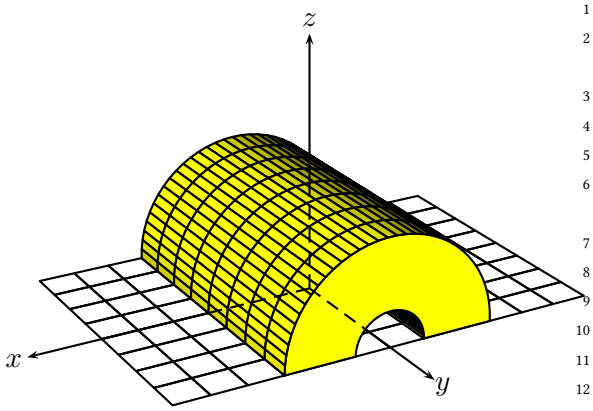


```
“psset–unit=0.5″
“psset– lightsrc =viewpoint,viewpoint=50 60 25 rtp2xyz,Decran=50″
“begin–pspicture″(-2,-3) (6,6)
“psSolid[object=cylindre,h=6,r=2,
    fillcolor =yellow,
      ](0,4,0)
“end–pspicture″
```

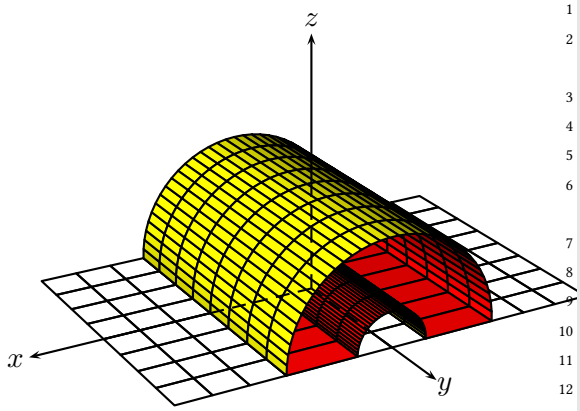


```
“psset–unit=0.5″
“psset– lightsrc =viewpoint,viewpoint=50 60 25 rtp2xyz,Decran=50″
“begin–pspicture″(-2,-3) (6,6)
“psSolid[object=cylindre,h=6,r=2,
    fillcolor =yellow,incolor=red,
   hollow ](0,4,0)
“end–pspicture″
```

Example 2: a prism and a hollow prism

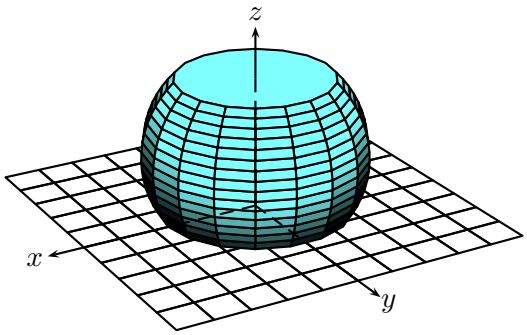



```
"psset-unit=0.5"
"psset-lightsrc=viewpoint,viewpoint=50 60 25 rtp2
    xyz,Decran=50"
"begin-pspicture"(-9,-4) (4,8)
"defFunction-F"(t)-t cos 3 mul"-t sin 3 mul"-"
"defFunction-G"(t)-t cos"-t sin"-"
"psSolid[object=grille,base=-6 6 -4 4,action=draw]
    %
"psSolid[object=prisme,
    h=8, fillcolor=yellow,
    RotX=90,ngrid=8 18,
    base=0 180 -F" CourbeR2+
        180 0 -G" CourbeR2+](0,4,0)
"axesIIID(3,4,3) (8,6,7)
"end-pspicture"
```

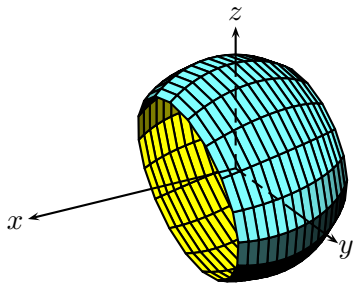



```
"psset-unit=0.5"
"psset-lightsrc=viewpoint,viewpoint=50 60 25 rtp2
    xyz,Decran=50"
"begin-pspicture"(-9,-4) (3,8)
"defFunction-F"(t)-t cos 3 mul"-t sin 3 mul"-"
"defFunction-G"(t)-t cos"-t sin"-"
"psSolid[object=grille,base=-6 6 -4 4,action=draw]
    %
"psSolid[object=prisme,
    h=8, fillcolor=yellow,incolor=red,
    RotX=90,hollow,ngrid=8 18,
    base=0 180 -F" CourbeR2+
        180 0 -G" CourbeR2+](0,4,0)
"axesIIID(3,4,3) (8,6,7)
"end-pspicture"
```

Example 3: a spherical zone and a hollow spherical zone




```
“psset–unit=0.5″
“psset– lightsrc =10 20 30,viewpoint=50 60 25 rtp2xyz,
      Decran=50″
“begin–pspicture″(-7,-4) (5,7)
“psSolid[object= grille ,
    base=-5 5 -5 5,
    action=draw]%
“psSolid[object=calottesphere,
    r=3,ngrid=16 18,
     fillcolor =cyan!50,
    incolor =yellow,
    theta=45,phi=-30](0,0,1.5)%
“axesIIID(3,3,3.6) (6,6,5)
“end–pspicture″
```



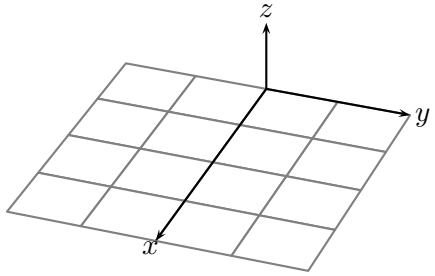

```
“psset–unit=0.5″
“psset– lightsrc =10 20 30,viewpoint=50 60 25 rtp2xyz,
      Decran=50″
“begin–pspicture″(-7,-5) (7,5)
“psSolid[object=calottesphere,
    r=3,ngrid=16 18,
     fillcolor =cyan!50,
    incolor =yellow,
    theta=45,phi=-30,
    hollow,
    RotY=-80]%
“axesIIID(0,3,3) (6,5,4)
“end–pspicture″
```

4.3. Numbering of the faces

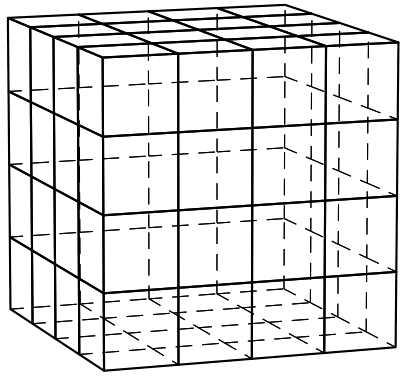
The option numfaces gives permission to number every face with its correspondent index number.

- numfaces=all all faces are numbered;
- numefaces=0 1 2 3 only the faces that have index 0, 1, 2 and 3 are numbered.

The option fontsize allows to fix the measurement of the used character set. Finally, the Boolean visibility the numbering of faces that are not visible. By default, the Boolean is set to visibility=true, so the visibility is set up (e. g. numbers are not set to invisible faces).



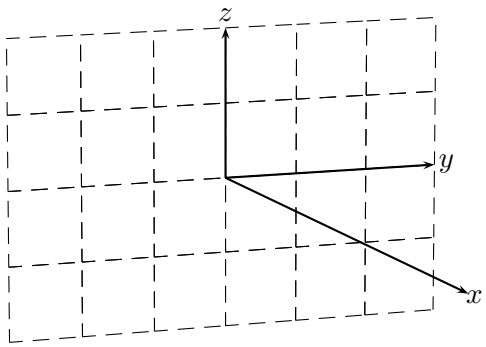

```
“psset–unit=1″
“begin–pspicture″(-4,-3) (3,1.5)
“psSolid[object=grille ,
    base=0 4 -2 2,
    numfaces=2 6 7 10,
     linecolor =gray](0,0,0)
“axesIIID(0,0,0) (4,2,1)
“end–pspicture″
```



```
"begin-pspicture*"(-4,-3) (4,3)
"psSolid[object=cube,
    RotY=90,
    ngrid=4,
     fontsize=15,
    action=draw,
    numfaces=all,](0,0,0)
"end-pspicture*"
```

The options of \psSolid accept PostScript commands, in particular the for loop.

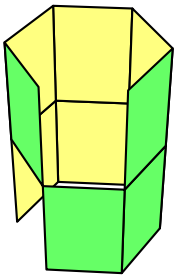
With the instruction numfaces=0 1 5 -" for all faces with the index numbers between 0 and 5 are set up. The instruction numfaces=8 3 23 -" for sets up every third index number between 8 and 23.



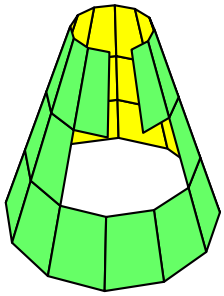

```
"begin-pspicture*"(-4,-3) (4,3)
"axesIIID(0,0,0) (8,3,2)
"psSolid[object=grille,
    RotY=90,
    RotZ=180,
    ngrid=1.,
     fontsize=15,
    numfaces=
        0 1 5 -" for
        8 3 23 -" for,
    base=-2 2 -3 3,
     visibility=false,
    action=draw](0,0,0)
"end-pspicture*"
```

4.4. Removing faces

The key value rm=1 2 8 allows to suppress the drawing of the faces with the index numbers 1, 2 and 8, to be able to have a look inside a hollow solid.



```
"psset-Decran=12,grid=true,viewpoint=15 10 15"
"begin-pspicture "(-2.5,-2.5) (2.5,2.5)
"psSolid[object=cylindrecreux,
      ngrid=2 6,
      h=6,r=2,
       fillcolor=green!60,
      incolor=yellow!50,
      RotZ=-60,
      rm=1 3 6,](0,0,-3)
"end-pspicture"
```

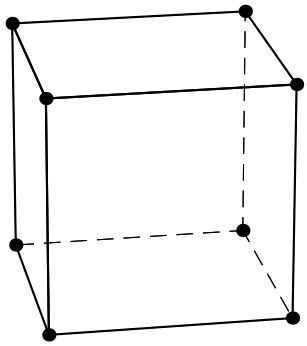


```
“psset–Decran=12,grid=true,viewpoint=15 10 15″
“begin–pspicture ″(-2.5,-2.5) (2.5,2.5)
“psSolid[object=troncconecreux,
    rm=1 12 13 14,
    r0=3,r1=1,h=6,
     fillcolor =green!60,
    incolor=yellow,
    mode=3](0,0,-3)
“end–pspicture″
```

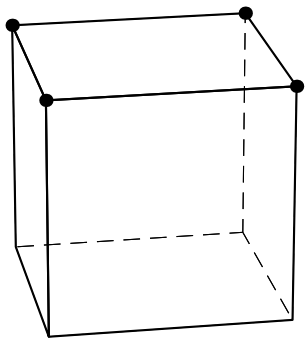
4.5. Numbering of the vertices

There is an option that permits the marking of the vertices (with a black circle) and/or numbers them either globally or individually.

- show=all marks all the vertices;
- num=all numbers all the vertices;
- show=0 1 2 3 marks the vertices with the index number 0, 1, 2 and 3;
- num=0 1 2 3 numbers the vertices with the index number 0, 1, 2 and 3.



```
“begin–pspicture ″(-3,-2.5) (7,2.5)
“psset–viewpoint=50 20 20 rtp2xyz,Decran=40″
“psSolid[
    action=draw,
    object=cube,
    RotZ=30,
    show=all,
    num=all
     ]%
“end–pspicture″
```



```
“begin–pspicture ″(-3,-2.5) (7,2.5)
“psset–viewpoint=50 20 20 rtp2xyz,Decran=40″
“psSolid[action=draw,
    object=cube,
    RotZ=30,
    show=0 1 2 3,
    num=0 1 2 3
     ]%
“end–pspicture″
```

4.6. Colours and the nuances of a colour

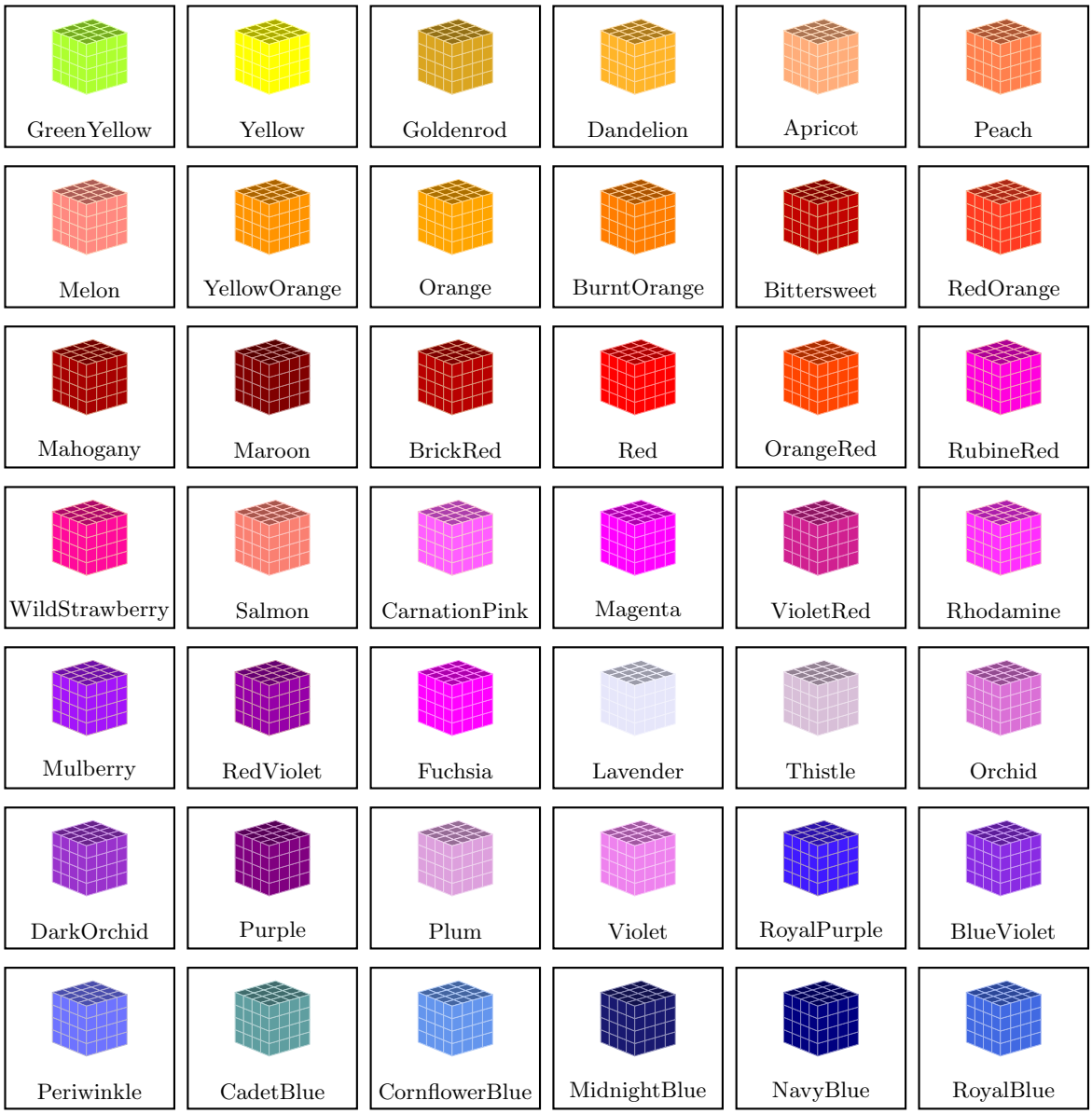
The key word fillcolor=colourname allows us to specify the wanted colour for the outer faces of a solid. The key word incolor=colourname allows us to specify the wanted colour for the inner faces of a solid.

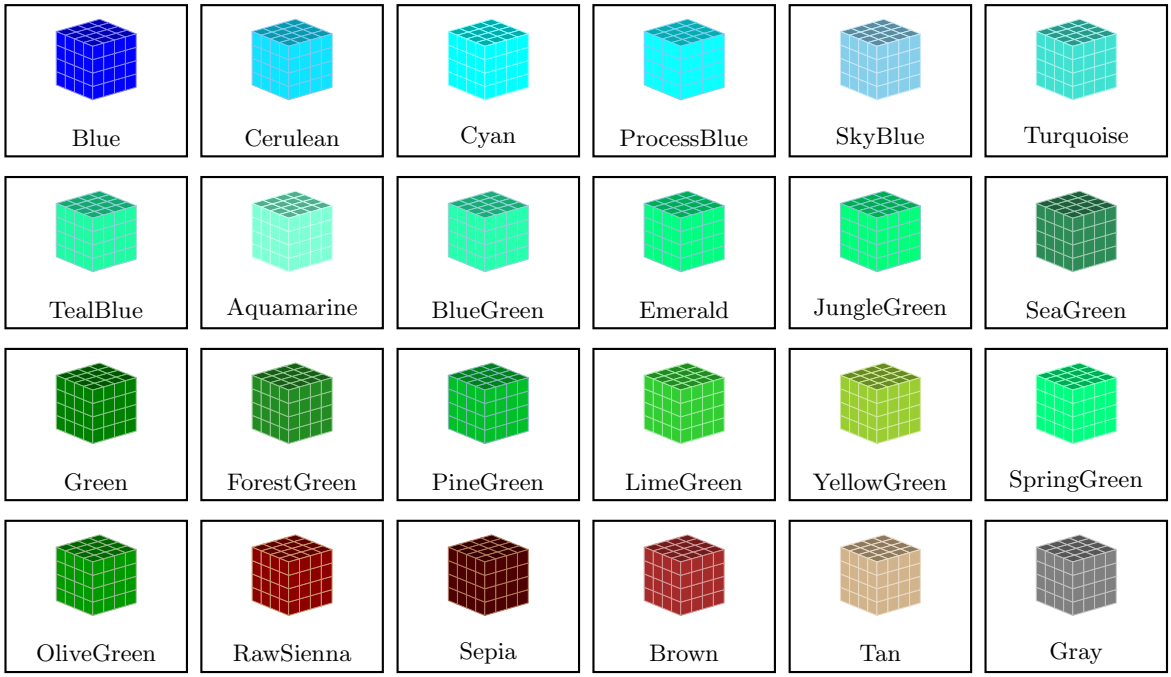
The possible values for *name* are those known to PSTricks (and particularly those of the package xcolor).

We can directly use the colour nuances in the color schemes of HSB, RGB or CMYK. In that case we use the key values hue, inhue or inouthue for the outer faces, the inner faces, or for all the faces. The number of arguments hue determines nuances.

4.6.1. Predefined colours by the option dvipsnames

There are 68 predefined colours, which are identified by solides.pro: Black, White, and the 66 colours below.

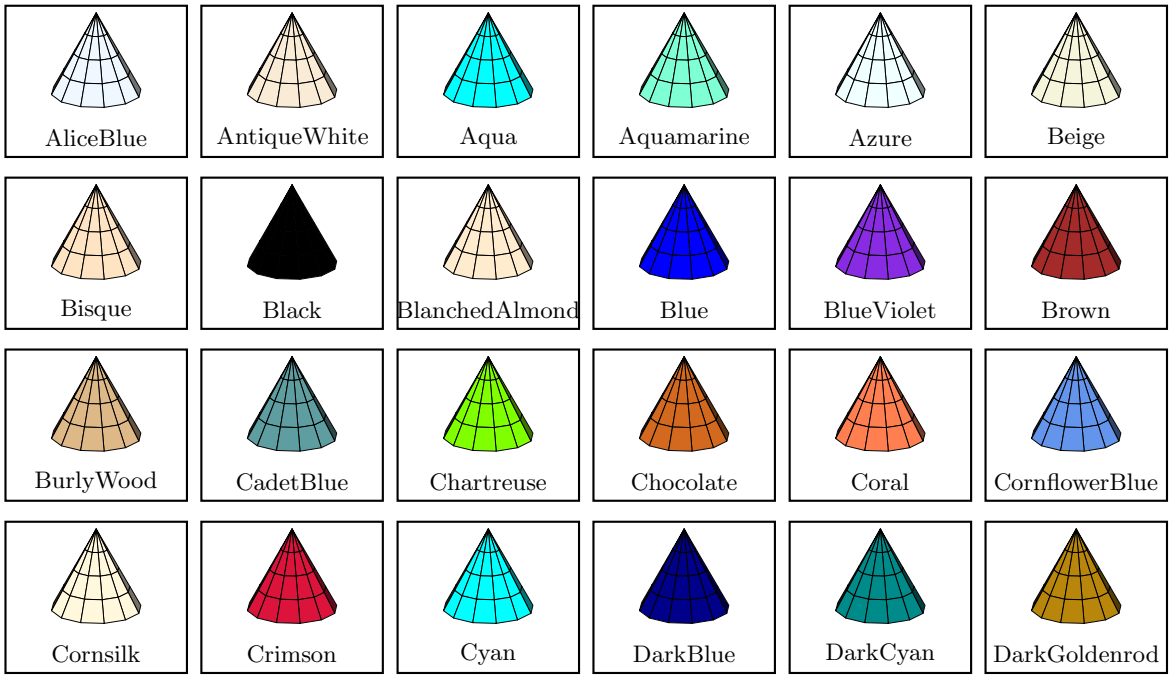


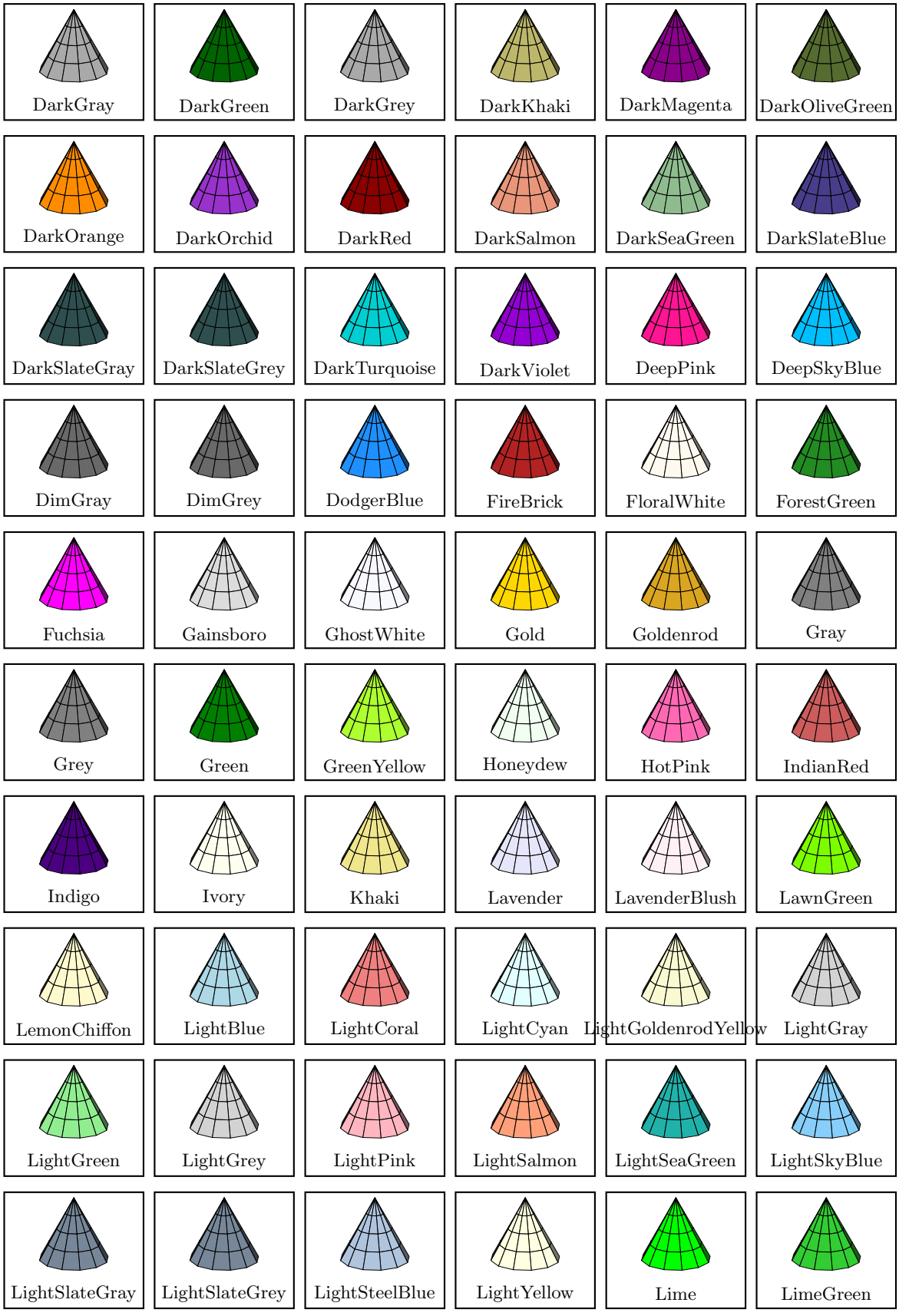


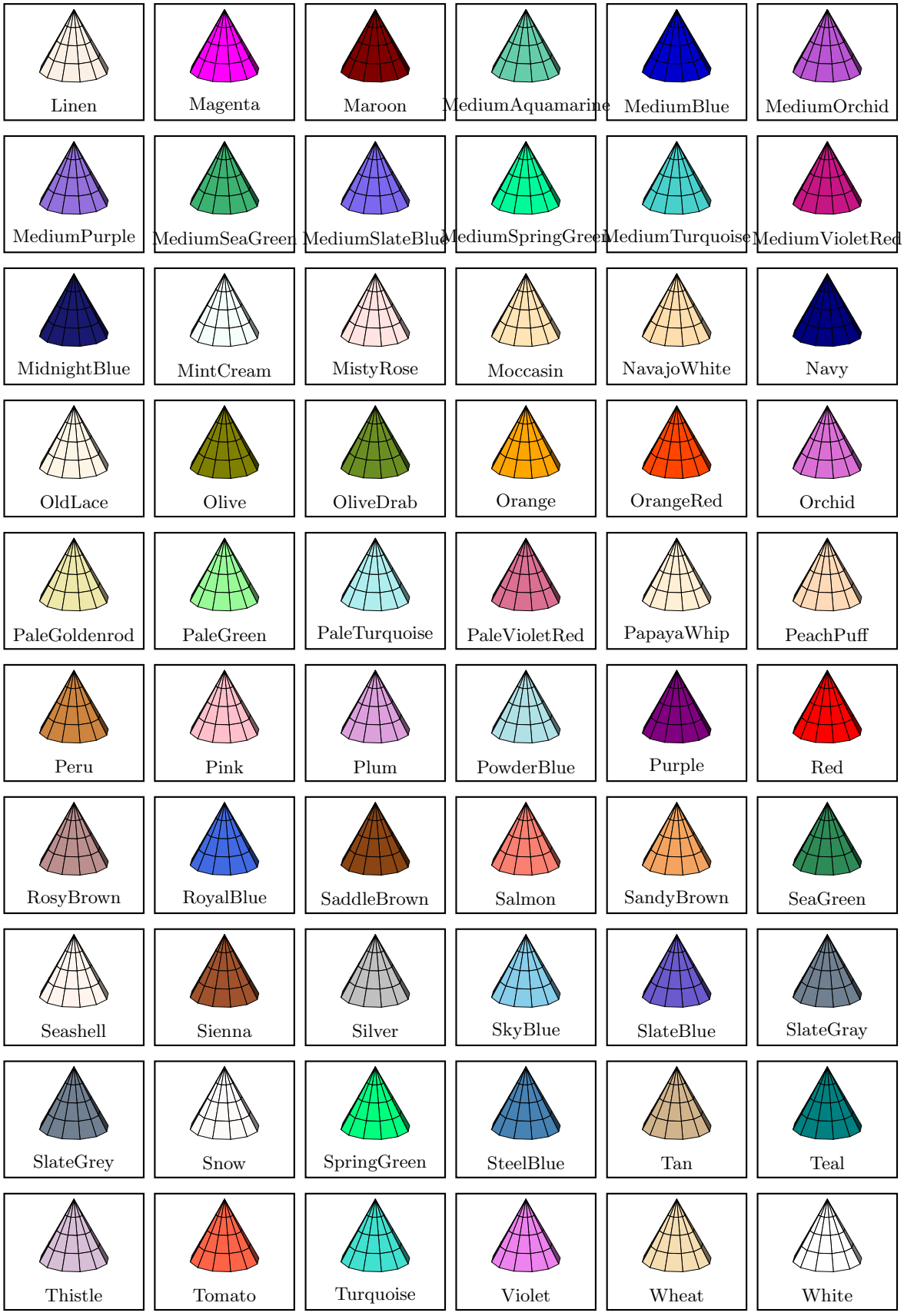
4.6.2. Predefined colours by the option svgnames

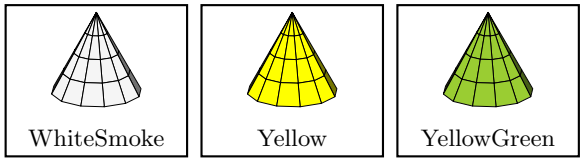
The following colours are known by PSTricks, when the option svgnames is given. These ones are not identified by the file solides.pro: we can use them directly with the option fcol.

These colours are delivered from the package xcolor.



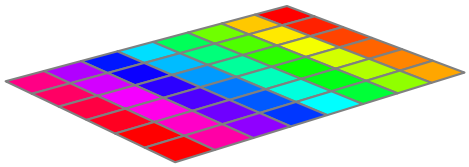

DarkGray
DarkGreen
DarkGrey
DarkKhaki
DarkMagenta
DarkOliveGreen
DarkOrange
DarkOrchid
DarkRed
DarkSalmon
DarkSeaGreen
DarkSlateBlue
DarkSlateGray
DarkSlateGrey
DarkTurquoise
DarkViolet
DeepPink
DeepSkyBlue
DimGray
DimGrey
DodgerBlue
FireBrick
FloralWhite
ForestGreen
Fuchsia
Gainsboro
GhostWhite
Gold
Goldenrod
Gray
Grey
Green
GreenYellow
Honeydew
HotPink
IndianRed
Indigo
Ivory
Khaki
Lavender
LavenderBlush
LawnGreen
LemonChiffon
LightBlue
LightCoral
LightCyan
LightGoldenrodYellow
LightGray
LightGreen
LightGrey
LightPink
LightSalmon
LightSeaGreen
LightSkyBlue
LightSlateGray
LightSlateGrey
LightSteelBlue
LightYellow
Lime
LimeGreen


Linen
Magenta
Maroon
MediumAquamarine
MediumBlue
MediumOrchid
MediumPurple
MediumSeaGreen
MediumSlateBlue
MediumSpringGreen
MediumTurquoise
MediumVioletRed
MidnightBlue
MintCream
MistyRose
Moccasin
NavajoWhite
Navy
OldLace
Olive
OliveDrab
Orange
OrangeRed
Orchid
PaleGoldenrod
PaleGreen
PaleTurquoise
PaleVioletRed
PapayaWhip
PeachPuff
Peru
Pink
Plum
PowderBlue
Purple
Red
RosyBrown
RoyalBlue
SaddleBrown
Salmon
SandyBrown
SeaGreen
Seashell
Sienna
Silver
SkyBlue
SlateBlue
SlateGray
SlateGrey
Snow
SpringGreen
SteelBlue
Tan
Teal
Thistle
Tomato
Turquoise
Violet
Wheat
White

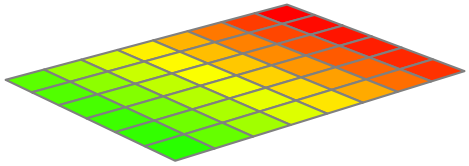


4.6.3. Nuances in the colour scheme of HSB, saturation and maximum brilliance

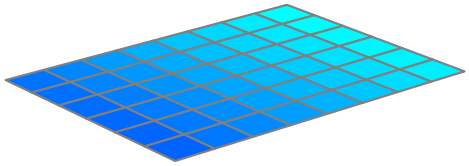
There are 2 key values: hue=h_0 h_1 where the numbers h_0 and h_1 with $0 \leq h_0 < h_1 \leq 1$ respect the limits of the colour scheme of HSB.



```
"psset-unit=1"
"begin-pspicture"(-4,-1.5) (3,1)
"psSolid[object=grille,
    base=-3 5 -3 3,
    linecolor=gray,
    hue=0 1](0,0,0)
"end-pspicture"
```



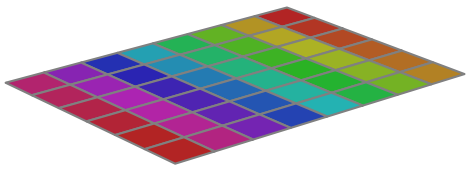
```
"psset-unit=1"
"begin-pspicture"(-4,-1.5) (3,1)
"psSolid[object=grille,
    base=-3 5 -3 3,
    linecolor=gray,
    hue=0 .3](0,0,0)
"end-pspicture"
```



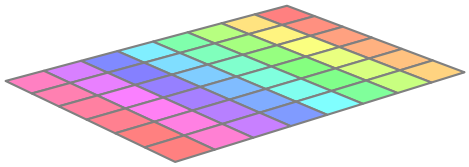
```
"psset-unit=1"
"begin-pspicture"(-4,-1.5) (3,1)
"psSolid[object=grille,
    base=-3 5 -3 3,
    linecolor=gray,
    hue=.5 .6](0,0,0)
"end-pspicture"
```

4.6.4. Nuances in the colour scheme of HSB, saturation and fixed brilliance

There are 4 key values: hue=h_0 h_1 s b or the numbers h_0 and h_1 with $0 \leq h_0 < h_1 \leq 1$ respect the limits of the colour scheme HSB and s and b are the values for saturation and brillance.



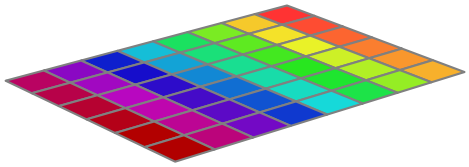
```
"psset-unit=1"
"begin-pspicture"(-4,-1.5) (3,1)
"psSolid[object=grille,
    base=-3 5 -3 3,
    linecolor=gray,
    hue=0 1 .8 .7](0,0,0)
"end-pspicture"
```



```
"psset-unit=1"
"begin-pspicture"(-4,-1.5) (3,1)
"psSolid[object=grille,
    base=-3 5 -3 3,
    linecolor=gray,
    hue=0 1 .5 1](0,0,0)
"end-pspicture"
```

4.6.5. Nuances in the colour scheme of HSB, gneral case

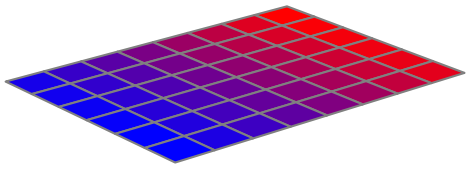
There are 7 key values: hue=h_0 s_0 b_0 h_1 s_1 b_1 (hsb) or the numbers h_i, s_i and b_i respecting the limits of the parameters of HSB.



```
"psset-unit=1"
"begin-pspicture"(-4,-1.5) (3,1)
"psSolid[object=grille,
    base=-3 5 -3 3,
    linecolor=gray,
    hue=0 .8 1 1 1 .7 (hsb)](0,0,0)
"end-pspicture"
```

4.6.6. Nuances in the colour scheme of RGB

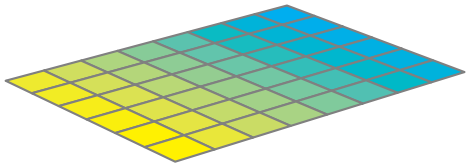
There are 6 key values: hue=r_0 g_0 b_0 r_1 g_1 b_1 or the numbers r_i, g_i and b_i respecting the limits of the 3 parameters of RGB.



```
"psset-unit=1"
"begin-pspicture"(-4,-1.5) (3,1)
"psSolid[object=grille,
    base=-3 5 -3 3,
    linecolor=gray,
    hue=1 0 0 0 0 1](0,0,0)
"end-pspicture"
```

4.6.7. Nuances in the colour scheme of CMYK

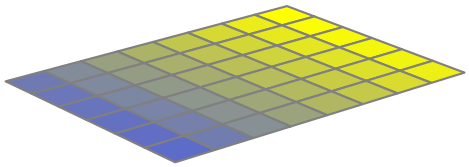
There are 8 key values: hue=c_0 m_0 y_0 k_0 c_1 m_1 y_1 k_1 or the numbers c_i, m_i, y_i and k_i respecting the limits of the 4 parameters of CMYK.



```
"psset-unit=1"
"begin-pspicture"(-4,-1.5) (3,1)
"psSolid[object=grille,
    base=-3 5 -3 3,
    linecolor=gray,
    hue=1 0 0 0 0 0 1 0](0,0,0)
"end-pspicture"
```

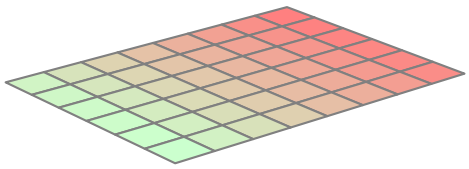
4.6.8. Nuances between 2 named colours

There are 2 key values hue=(color1) (color2) where color1 and color2 are the names of colours known by solides.pro.



```
"psset-unit=1"
"begin-pspicture"(-4,-1.5) (3,1)
"psSolid[object=grille,
    base=-3 5 -3 3,
    linecolor=gray,
    hue=(jaune) (CadetBlue)](0,0,0)
"end-pspicture"
```

If we like to use some defined colours of xcolor, we use the key values color1, color2, etc. from \psSolid.



```
“psset–unit=1”
“begin–pspicture”(-4,-1.5) (3,1)
“psSolid[object=grille,
    base=-3 5 -3 3,
    linecolor=gray,
    color1=red!50,
    color2=green!20,
    hue=(color1) (color2)](0,0,0)
“end–pspicture”
```

4.6.9. Deactivation of the colour application

For specific purposes it is possible to disable the application of colour. This is particularly the case, when an object is already memorized or defined in external files. Within these configurations, if we do not deactivate the colours and if we do not define some new colours, these will be the colours by default that overwrite the colours that were defined.

To deactivate the colour application we use the option deactivatecolor.

4.7. Colouring some single faces

The key value fcol=i_0 (c_0) i_1 (c_1) ... i_n (c_n), where i_k are integers and c_k the names of the colours, permits to specify a colour for special faces. To the face with the index i_k corresponds the colour c_k. The integer n must be lower than the maximum of the number of faces of the chosen solid.

The colour names c_k, there are 68 predefined values, are defined names in the color.pro. These values are: *GreenYellow*, *Yellow*, *Goldenrod*, *Dandelion*, *Apricot*, *Peach*, *Melon*, *YellowOrange*, *Orange*, *BurntOrange*, *Bittersweet*, *RedOrange*, *Mahogany*, *Maroon*, *BrickRed*, *Red*, *OrangeRed*, *RubineRed*, *WildStrawberry*, *Salmon*, *CarnationPink*, *Magenta*, *VioletRed*, *Rhodamine*, *Mulberry*, *RedViolet*, *Fuchsia*, *Lavender*, *Thistle*, *Orchid*, *DarkOrchid*, *Purple*, *Plum*, *Violet*, *RoyalPurple*, *BlueViolet*, *Periwinkle*, *CadetBlue*, *CornflowerBlue*, *MidnightBlue*, *NavyBlue*, *RoyalBlue*, *Blue*, *Cerulean*, *Cyan*, *ProcessBlue*, *SkyBlue*, *Turquoise*, *TealBlue*, *Aquamarine*, *BlueGreen*, *Emerald*, *JungleGreen*, *SeaGreen*, *Green*, *ForestGreen*, *PineGreen*, *LimeGreen*, *YellowGreen*, *SpringGreen*, *OliveGreen*, *RawSienna*, *Sepia*, *Brown*, *Tan*, *Gray*, *Black*, *White*. The list of these 68 colours is available in the command “colorfaces (see an example in the section about the grating of a cube).

Thinking on that case, the number of the faces $\mathtt{n_1} \times \mathtt{n_2} + 2$(outer faces inner faces) must be lower than 68!

However users can define their own colours. There are two methods:

- They can use one of the 4 optional arguments color1, color2, color3, color4 from \psSolid, then transmit to fcol a pair of the type i (color1), where i is the index of the chosen face. The arguments color1, etc. are used in the same way as the arguments from color and incolor.
  A possible command could be the following:
  “psSolid[a=1,object=cube,color1=red!60!yellow!20,fcol=0 (color1)]%

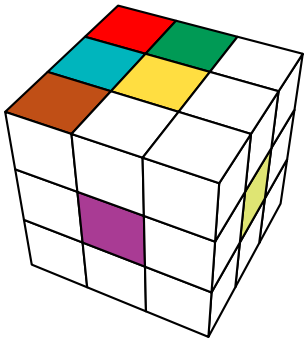
- They define their own colour names with the command “pstVerb, and then use these names with the argument fcol. For example:

```
"pstVerb–/hetre –0.764 0.6 0.204 setrgbcolor" def
      /chene –0.568 0.427 0.086 setrgbcolor" def
      /cheneclair –0.956 0.921 0.65 setrgbcolor" def
      "%
```

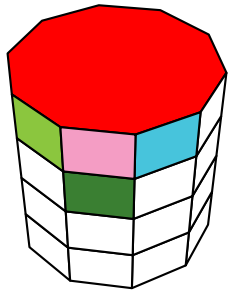
And therefore:
fcol=0 (hetre) 1 (chene) 2 (cheneclair)

The 4 arguments color1, color2, color3, color4 have default values:

- color1=cyan!50
- color2=magenta!60
- color3=blue!30
- color4=red!50



```
"psset–Decran=20,viewpoint=10 5 10,unit=0.5"
"begin–pspicture"(-5,-5) (5,5)
"psSolid[
    fcol=0 (red) 1 (Aquamarine) 2 (Bittersweet)
         3 (ForestGreen) 4 (Goldenrod)
         13 (GreenYellow)
         40 (Mulberry),
    object=cube,mode=3]%
"end–pspicture"
```

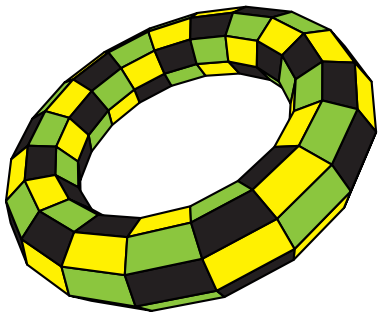


```
"psset–Decran=20,viewpoint=10 5 10,unit=0.5"
"begin–pspicture"(-5,-5) (5,5)
"psSolid[
    fcol=0 (red) 2 (Lavender) 3 (SkyBlue) 11 (LimeGreen) 12 (OliveGreen),
    object=cylindre,
    h=4,
    ngrid=4 10](0,0,-2)
"end–pspicture"
```

The choice of the faces to be coloured can be specified with some PostScript code,

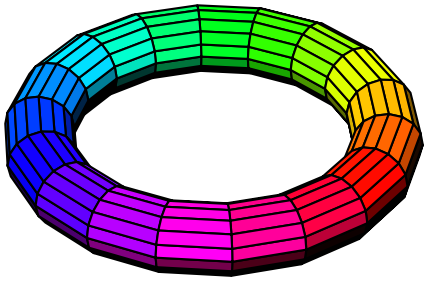
fcol=48 –i (Black) i 1 add (LimeGreen) i 2 add (Yellow) /i i 3 add store" repeat

which will alternately colour the faces in black, green and yellow.



```
“begin–pspicture”(-3,-3) (3.5,2.5)
“psset–Decran=7.5,viewpoint=10 10 5”
“pstVerb–/iface 0 store”%
“psSolid[
fcol=48 –iface (Black)
  iface 1 add (LimeGreen)
  iface 2 add (Yellow) /iface
  iface 3 add store” repeat,
  r1=4,r0=1,
  object=tore,
  ngrid=8 18,
  RotY=30]
“end–pspicture”
```

When the option hue is activated, the faces of the solid are coloured with the nuance of the rainbow colours.



```
“begin–pspicture”(-3,-2.5) (3,2.5)
“psset[pst-solides3d]–viewpoint=50 50 50,Decran=40,lightsrc=50 20 1e
    2”
“psSolid[r1=5,r0=1,object=tore,ngrid=16 18,hue=0 1]%
“end–pspicture”
```

4.8. Nuances of transparency

The key value opacity=k with $k \in \mathbb{R}$ and $0 \leq k \leq 1$, allows you to define the level of opacity.

Within *jps code*, we use an equivalent expression k setfillopacity. The last expression finds its application in the option fcol. For example the instruction, fcol=0 (.5 setfillopacity yellow), which defines the face with the index number 0, sets it to yellow with an opacity of 50%.

4.9. Definition of grating

The user can specify the grating of the solid with the option ngrid within the command \psSolid.

For the objects cube, prisme, prismecreux, the syntax is ngrid=n_1 where n_1 represents the number of vertical gridlines.

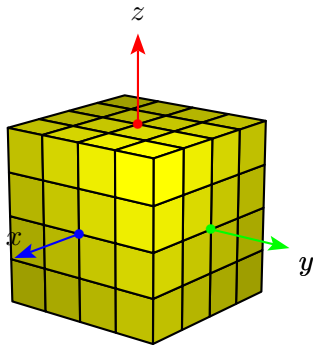
For the objects cylindre, cylindrecreux, cone, conecreux, tronccone, troncconecreux, the syntax is ngrid=n_1 n_2 where n_1 is an integer greater or equal to 1 (2 for tore) representing the number of the vertical gridlines, and n_2 is an integer representing the number of divisions on the circle.

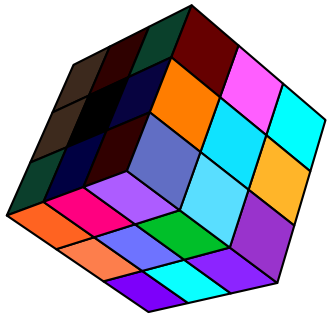
For the object sphere, the syntax is ngrid=n_1 n_2 where n_1 is an integer, representing the number of divisions on the vertical axis, and n_2 is an integer representing the number of divisions on the circle horizontally.

For the object tore, the syntax is ngrid=n_1 n_2 where n_1 and n_2 are integers.

Here are some examples:

4.9.1. The cube





For the first example, the grid is fixed to 4×4 facettes/faces and the command is the following:

“psSolid[a=8,object=cube,ngrid=4,fillcolor=yellow]%

In the second example, the face grid is set to 3×3 and the colours of the faces are different. We use the package arrayjob to easily save the colours:

```
“newarray“colors
“readarray–colors”–%
    Apricot&Aquamarine%
    etc.”
```

The list of the colours is given by the command:

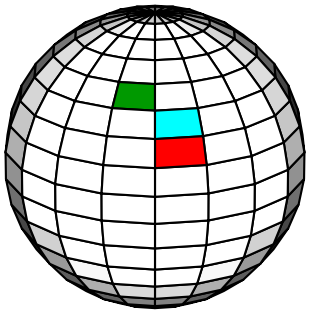
```
“edef“colorfaces–”%
“multido–“i=0+1”–67”–%
    “checkcolors(“i)
    “xdef“colorfaces–%
    “colorfaces“i“space(“cachedata)“space”
     ”
```

One sets up: fcol=“colorfaces. The gridded cube now is called with:

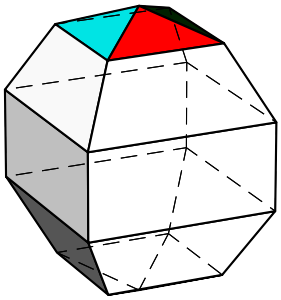
```
“psSolid[a=8,object=cube,ngrid=3,%
        fcol=“colorfaces,
        RotY=45,RotX=30,RotZ=20]%
```

The option grid suppresses the drawing of the gridlines.

4.9.2. Sphere

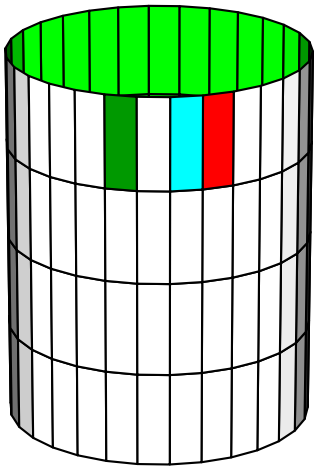


```
“begin–pspicture”(-3,-3) (3,3)
“psset–viewpoint=50 50 20 rtp2xyz,Decran=50,lightsrc=viewpoint”
“psset–color1=cyan,color2=red”
“psSolid[
    fcol=251 (OliveGreen) 232 (color1) 214 (color2),
    object=sphere,
    ngrid=16 18,
    RotX=180,RotZ=30]%
“end–pspicture”
```



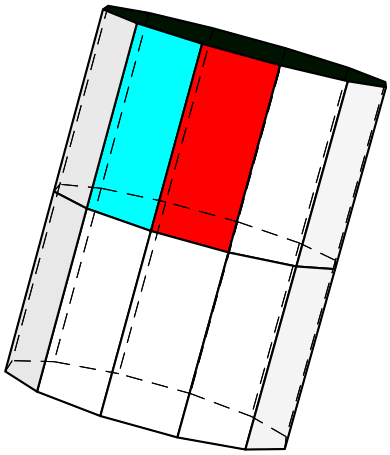
```
“begin–pspicture”(-3,-3) (3,3)
“psset–viewpoint=50 50 20 rtp2xyz,Decran=50,lightsrc=viewpoint”
“psset–color1=cyan,color2=red”
“psSolid[
    action=draw*,
    fcol=0 (OliveGreen) 2 (color1) 3 (color2),
    object=sphere,
    ngrid=4 4,
    RotX=180,RotZ=30]%
“end–pspicture”
```

4.9.3. Cylinders



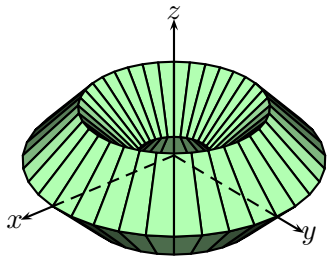
```

“begin–pspicture”(-3,-4) (3,4)
“psset–viewpoint=50 50 20 rtp2xyz,Decran=50,lightsrc=viewpoint”
“psset–color1=cyan,color2=red”
“psSolid[
    fcol=0 (OliveGreen) 2 (color1) 3 (color2),
    h=5,r=2,
    object=cylindrecreux,
    ngrid=4 30,
    RotZ=30
 ](0,0,-2.5)
“end–pspicture”
```

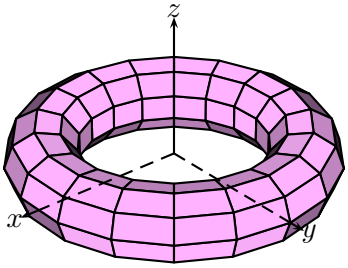


```
“begin–pspicture”(-3,-4) (4,4)
“psset–viewpoint=50 50 20 rtp2xyz,Decran=50,lightsrc=
      viewpoint”
“psset–color1=cyan,color2=red”
“psSolid[
   action=draw*,
   fcol=0 (OliveGreen) 2 (color1) 3 (color2),
   h=5,r=2,
   object=cylindre,
   ngrid=2 12,
   RotY=-20
 ](0,0,-2.5)
“end–pspicture”
```

4.9.4. Torus




```
“begin–pspicture”(-3,-2) (3,2)
“psset–viewpoint=50 50 30 rtp2xyz,Decran=25,lightsrc=viewpoint”
“psSolid[r1=2.5,r0=1.5,
     object=tore,
     ngrid=4 36,
      fillcolor =green!30,
     action=draw**]%
“axesIIID(4,4,0) (5,5,4)
“end–pspicture”
```

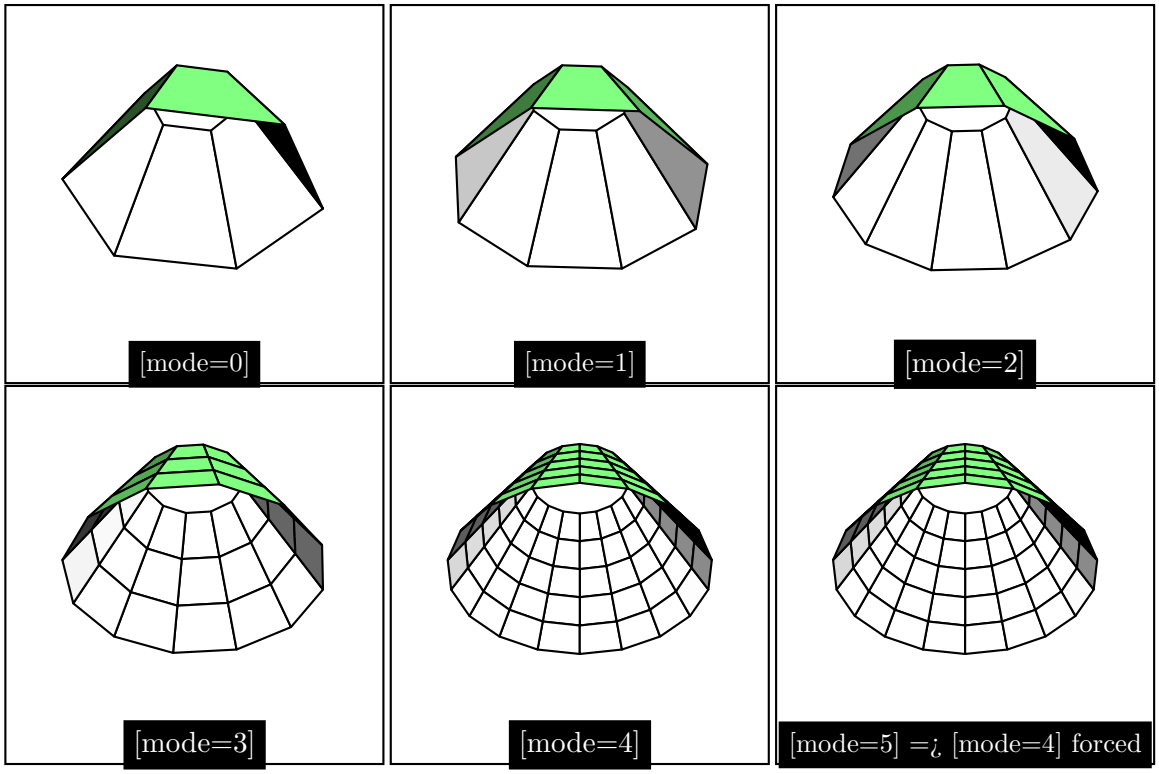



```
“begin–pspicture”(-3,-2) (3,2)
“psset–viewpoint=50 50 30 rtp2xyz,Decran=25,lightsrc=viewpoint”
“psSolid[r1=3.5,r0=1,
     object=tore,
     ngrid=9 18,
      fillcolor =magenta!30,
     action=draw**]%
“axesIIID (4.5,4.5,0) (5,5,4)
“end–pspicture”
```

4.10. The modes

For some solids, there are certain gratings predefined. We can setup the key values to mode=0, 1, 2, 3 or 4 which allows to have some some gratings from very coarse mode=0 up to very fine mode=4.

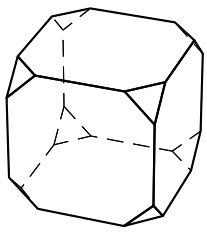
This permits us to have a draft version of a solid with mode=0 (fewer calculations) and then refine it with mode=4 for the final version.



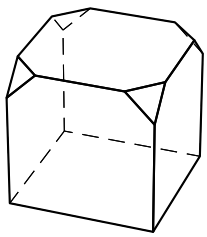
4.11. Truncate a solid's vertices

The option trunc allows us to truncate a solid's vertices either globally or individually. This option uses the key trunccoeff (value 0.25 by default) which indicates the ratio k used for the truncation ($0 < k \leq 0.5$).

- trunc=all truncates all the vertices;
- trunc=0 1 2 3 truncates the vertices 0, 1, 2 and 3.



```
"psset–viewpoint=50 50 30 rtp2xyz,Decran=25,lightsrc=viewpoint"
"begin–pspicture"(-3,-2) (2,2)
"psSolid[
    action=draw,
    object=cube,
    RotZ=30,
     trunccoeff=.2,
    trunc=all]%
"end–pspicture"
```

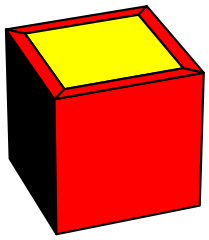


```
"psset–viewpoint=50 50 30 rtp2xyz,Decran=25,lightsrc=viewpoint"
"begin–pspicture"(-3,-2) (2,2)
"psSolid[action=draw,
    object=cube,
    RotZ=30,
     trunccoeff=.2,
    trunc=0 1 2 3]%
"end–pspicture"
```

4.12. Hollowing out a solid's faces

We call *hollowing by the ratio k* an operation, which for a given face with the center G, executes a dilation on that face with the ratio k, then divides the original face with using this new face.

For example, a cube with a hollow of its top face with a ratio of 0.8:

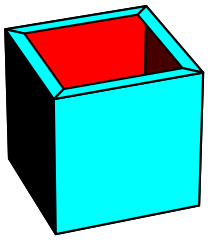


The option affinage allows us to hollow a solid's faces either globally or individually. This option uses the key affinagecoeff (value 0.8 by default) which indicates the ratio k used for the hollow ($0 < k < 1$).

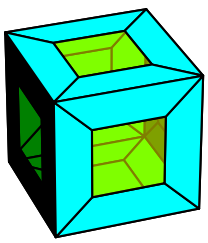
- affinage=all hollows all the faces;
- affinage=0 1 2 3 hollows the faces 0, 1, 2 and 3;

When a face is hollowed out, the default behaviour suppresses the resulting central face. However, the option affinagerm allows us to conserve that central face.

When we conserve the centre face, it is—by default—drawn with the same colour as the original. The option fcolor permits to specify another colour.

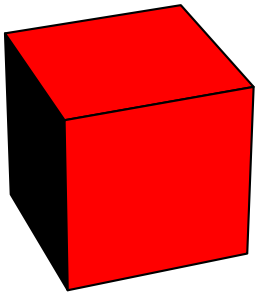


```
"psset-unit=0.5"
"begin-pspicture*"(-5,-4) (6,5)
"psSolid[object=cube,
    fillcolor =cyan,
    incolor=red,
    hollow,
    affinage=0]
"end-pspicture*"
```

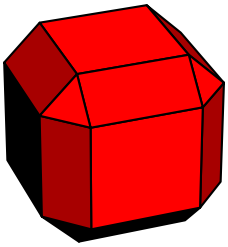


```
"psset-unit=0.5"
"begin-pspicture*"(-5,-4) (6,5)
"psSolid[object=cube,
    fillcolor =cyan,
    affinagecoeff =.5,
    affinagerm,
    fcolor =.5 setfillopacity Yellow,
    hollow,
    affinage=all]
"end-pspicture*"
```

4.13. Chamfering a solid

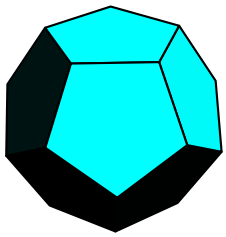


```
"psset-unit=0.5"
"begin-pspicture*"(-4,-4) (4,4)
"psSolid[object=cube,
    a=5,
     fillcolor =red]
"end-pspicture*"
```

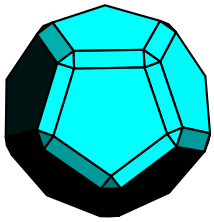


```
"psset-unit=0.5"
"begin-pspicture*"(-4,-4) (4,4)
"psSolid[object=cube,
    a=5,
     fillcolor =red,
    chanfrein,
     chanfreincoeff=.6]
"end-pspicture*"
```

The option chanfrein allows us to chamfer a solid. This option uses the key chanfreincoeff (value 0.8 by default) which indicates the ratio k with $(0 < k < 1)$. This ratio is the one of a centre dilation with the centre in the middle of the chosen face.



```
"psset-unit=0.5"
"begin-pspicture*"(-4,-4) (4,4)
"psSolid[object=dodecahedron,
    a=5,
     fillcolor =cyan]
"end-pspicture*"
```



```
"psset-unit=0.5"
"begin-pspicture*"(-4,-4) (4,4)
"psSolid[object=dodecahedron,
    a=5,
     fillcolor =cyan,
    chanfrein,
     chanfreincoeff=.8]
"end-pspicture*"
```

4.14. The option transform

The option transform, which is nothing else than a formula $\mathbb{R}^3 \to \mathbb{R}^3$, which is applied to every point of the solid. In the first example, the object that accepts the transformation is a cube. The referenced cube is yellow, the transformed cube is green and the cube before the transformation is setup with a reticule.

4.14.1. Identical scaling factor in the three coordinates

The scaling factor is set to 0.5. It is either introduced within the PostScript variable '/Facteur':

```
"pstVerb–/Facteur –.5 mulv3d" def"%
```

and then passed to the option transform:

```
"psSolid[object=cube,a=2,ngrid=3,
        transform=Facteur](2,0,1)%
```

or directly passed to the option:

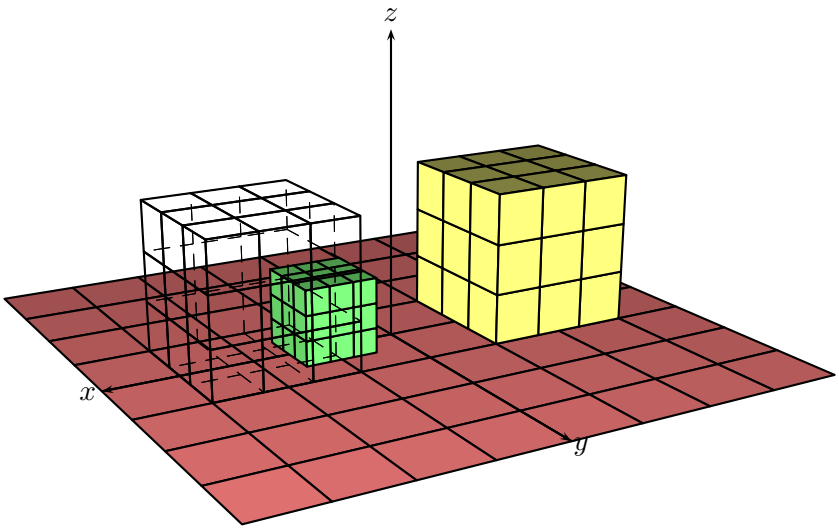
```
"psSolid[object=cube,a=2,ngrid=3,
        transform=–.5 mulv3d"](2,0,1)%
```

Here the *jps* abbreviation transform={.5 mulv3d} for a function $\mathbb{R}^3 \to \mathbb{R}^3$ was used.

Another method would be to use the code

```
"defFunction[algebraic]–matransformation"(x,y,z)
  –.5*x"
  –.5*y"
  –.5*z"
```

and then pass it to the option transform=matransformation.

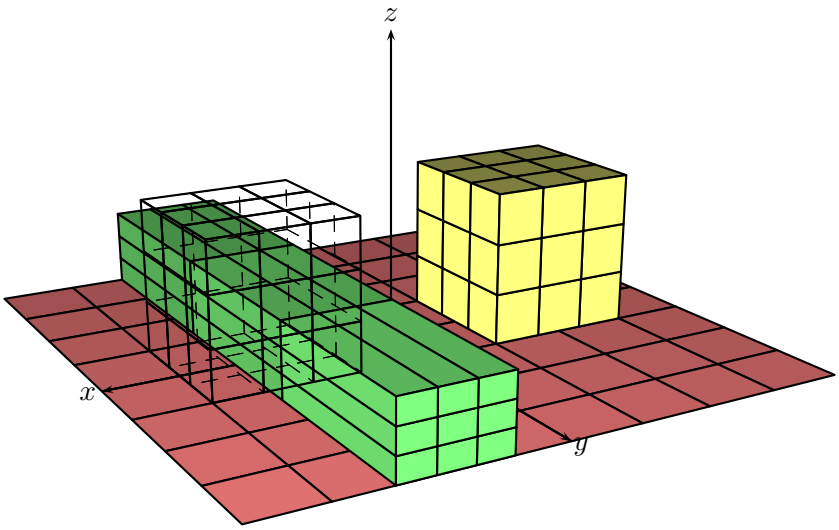



```
“psset–viewpoint=20 60 20 rtp2xyz,lightsrc=viewpoint,Decran=20″
“begin–pspicture″(-5,-3) (6,5)
“psSolid[object=grille ,base=-4 4 -4 4, fillcolor =red!50]%
“axesIIID(0,0,0) (4,4,4) %
“psSolid[object=cube, fillcolor =yellow!50,
        a=2,ngrid=3](-2,0,1)
“psSolid[object=cube, fillcolor =green!50,
        a=2,transform=–.5 mulv3d″,
        ngrid=3](2,0,1)
“psSolid[object=cube,
        action=draw,
        a=2,ngrid=3](2,0,1)
“end–pspicture″
```

Note: The scaling factor also affects the position coordinates of the cube's center.

4.14.2. Different scaling factors for the three coordinates

Let's for example use a factor 0.75 for x, 4 for y and 0.5 for z using the function scaleOpoint3d from the *jps* library—so a cube will be transformed to a cuboid.

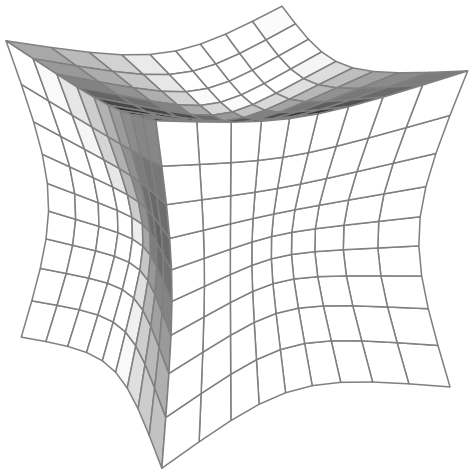



```
“psset–viewpoint=20 60 20 rtp2xyz,lightsrc=viewpoint,Decran=20″
“begin–pspicture″(-5,-3) (6,5)
“psSolid[object=grille ,base=-4 4 -4 4, fillcolor =red!50]%
“axesIIID(0,0,0) (4,4,4) %
“psSolid[object=cube, fillcolor =yellow!50,
        a=2,ngrid=3](-2,0,1)
“psSolid[object=cube, fillcolor =green!50,
        a=2,transform=–.75 4 .5 scaleOpoint3d″,
        ngrid=3](2,0,1)
“psSolid[object=cube,
        action=draw,
        a=2,ngrid=3](2,0,1)
“end–pspicture″
```

4.14.3. Transformation associated with the distance to the origin

Here an example applied to a cube:

$$\begin{cases} x' = \left(0.5\sqrt{x^2+y^2+z^2}+1-0.5\sqrt{3}\right)x \\ y' = \left(0.5\sqrt{x^2+y^2+z^2}+1-0.5\sqrt{3}\right)y \\ z' = \left(0.5\sqrt{x^2+y^2+z^2}+1-0.5\sqrt{3}\right)z \end{cases}$$

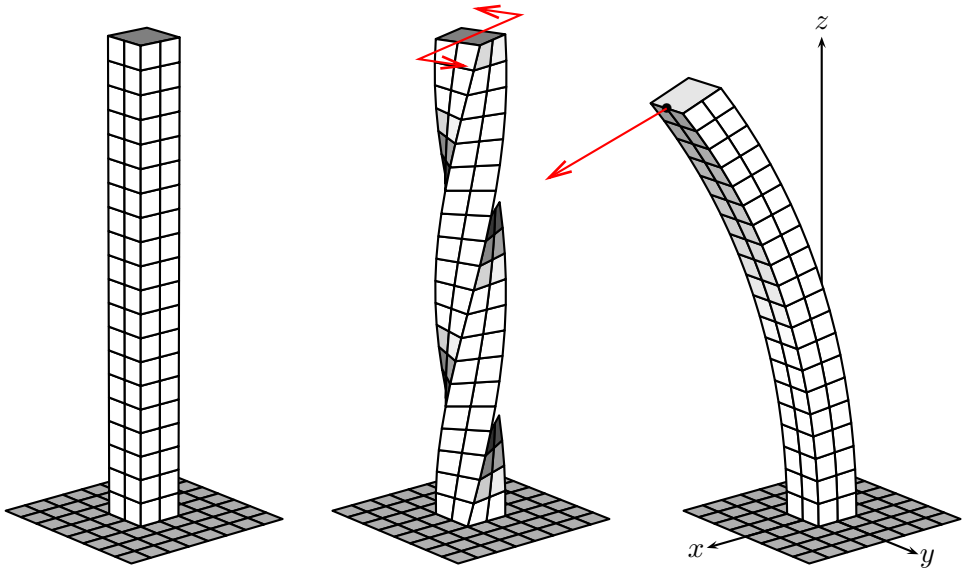


```
“begin–pspicture”(-3,-4) (4,3)
“psset–viewpoint=20 60 20 rtp2xyz,lightsrc=10 15 7,Decran=20”
“pstVerb–
/gro –
4 dict begin
   /M defpoint3d
   /a .5 def
   /b 1 a 3 sqrt mul sub def
   /k M norme3d a mul b add def
   M k mulv3d
end
” def”%
“psset–linewidth=.02, linecolor =gray”
“psSolid [object=cube,a=3,ngrid=9,
       transform=gro]%
“end–pspicture”
```

4.14.4. Bending and torsion of beams

The solid to the left is a prism of the height 10 cm with 20 floors (ngrid=20 2). In every floor, an additional angle of rotation—for example 10° around the Oz axis is—given. Now that the adjacent floors have a distance of 0.5 cm, one multiplies $z \times 20$.

La flexion est envisagée dans le plan xOz sous l'action d'une force perpendiculaire à la poutre appliquée en son extrémité.




```
“psset–viewpoint=100 50 20 rtp2xyz,lightsrc=viewpoint,Decran=100,unit=0.65″
“begin–pspicture″(-3,-1) (3.5,11)
“psSolid[object=grille,base=-2 2 -2 2,ngrid=8]%
“psSolid[object=prisme,h=10,ngrid=20 2,
        base=0.5 0 0.5 0.5 0 0.5 -0.5 0.5 -0.5 0 -0.5 -0.5 0 -0.5 0.5 -0.5] %
“end–pspicture″
“begin–pspicture″(-3,-1) (3.5,11)
“psSolid[object=grille,base=-2 2 -2 2,ngrid=8]%
“pstVerb–
/torsion –% on tourne de 10 degr“’–e″s suivant l’axe Oz “‘–a″ chaque niveau
2 dict begin
  /M defpoint3d % on r“’–e″cup“‘–e″re les coordonn“’–e″es
  M /z exch def pop pop
   M 0 0 z 20 mul rotateOpoint3d
end″ def″%
“psSolid[object=prisme,h=10,ngrid=20 2,
        base=0.5 0 0.5 0.5 0 0.5 -0.5 0.5 -0.5 0 -0.5 -0.5 0 -0.5 0.5 -0.5,
        transform=torsion]%
“psTransformPoint[RotZ=20](2 0 10)(0,0,0)–A″
“psTransformPoint[RotZ=20](2 1 10)(0,0,0)–A’″
“psTransformPoint[RotZ=20](-2 0 10)(0,0,0)–B″
“psTransformPoint[RotZ=20](-2 -1 10)(0,0,0)–B’″
“psline[linecolor=red]–v-v″(A’)(A)(B)(B’)
“end–pspicture″
“begin–pspicture″(-3.5,-1) (3,11)
“psSolid[object=grille,base=-2 2 -2 2,ngrid=8]%
“pstVerb–% id“’–e″e de Christophe Poulain
/flexion –% on tourne de 2 degr“’–e″s suivant l’axe Oy “‘–a″ chaque niveau
2 dict begin
  /M defpoint3d % on r“’–e″cup“‘–e″re les coordonn“’–e″es
  M /z exch def pop pop
   M 0 z 2 mul 0 rotateOpoint3d
end″ def″%
“axesIIID(0,0,0) (3,3,10)
“psSolid[object=prisme,h=10,ngrid=20 2,
        base=0.5 0 0.5 0.5 0 0.5 -0.5 0.5 -0.5 0 -0.5 -0.5 0 -0.5 0.5 -0.5,
        transform=flexion]%
“psTransformPoint[RotY=20](0.5 0 10)(0,0,0)–A″
“psPoint(3 20 cos mul 20 sin 10 mul add 0.5 add,0, 20 cos 10 mul 20 sin 3 mul sub)–A’″
“psdot(A)“psline[linecolor=red]–-v″(A)(A’)
“end–pspicture″
```

4.15. Lines of intersecting planes

For every object of the type \psSolid, it is possible to draw the lines of intersection between a chosen solid and one or more planes.

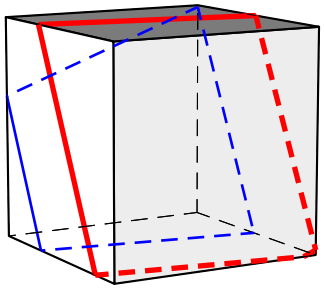
The numeric argument intersectiontype=k (value -1 by default) determines whether or not to draw the intersection lines. Set to 0, the intersection lines are drawn.

There are three keys to be handled:

- intersectionplan=$\{[eq_1]\ \ldots\ [eq_n]\}$ defines a list of the equations eq_i of the intersecting planes. The eq_i could as well be some objects from the type plan (see the related section).

$$ax + by + cz + d = 0 \qquad \text{that would deliver } [a\,b\,c\,d\,] \text{ as one of the } n \text{ equations}$$

- intersectionlinewidth=$w_1\ \ldots\ w_n$ defines a list of the thickness in picas w_i for each of the intersection lines.
- intersectioncolor=color$_1$ ... color$_n$ defines a list for the colors of the intersection lines.



```
"psset-lightsrc=20 -20 10,viewpoint=50 -20 10 rtp2xyz,Decran=50"
"psset-unit=0.5"
"begin-pspicture*"(-5,-4) (5,5)
"psSolid[object=cube,
    intersectiontype=0,
    intersectionplan=-[1 0 .5 2] [1 0 .5 -1]",
    intersectionlinewidth=1 2,
    intersectioncolor=(bleu) (rouge),
    RotX=20,RotY=90,RotZ=30,
    a=6,
    action=draw*]
"end-pspicture*"
```

5. Usage of external files

5.1. Using the data file types .obj and .off

Sometimes it will helpful to use external files, either for reading or writing. When there is a solid which needs a long time to be calculated and which will be tested in different views or different colors, it is very interesting to save them externally and then only reread them by avoiding the time expensive recalculations. In particular, this technique is often used to generate some animations. One can also export a solid by that method to reuse with another software.

For pst-solides3d, all the procedures of reading/writing are delegated to the PostScript interpreter (and not to TEX or LATEX). Consequently it is not the LATEX compilation that will cause the execution of reading/writing, but the visualisation of the PostScript file that is produced.

Generally the reading of external files by a PostScript interpreter doesn't cause any trouble normally. The writing of files however, can cause some security problems and it is often the case that the PostScript viewer forbids the writing by default. So the system must be configured to get authorisation for that writing.

Note: By default, under Windows and Linux, the security of files on the hard drive is activated and doesn't allow to write on the drive. To deactivate that security option, more or less temporarily, here the two corresponding procedures:

Linux: The advice from Jean-Michel Sarlat: the simplest will be to use GhostScript directly, within the console. As there is no image to wait for:

$> gs -dNOSAFER monfichier.ps quit.ps

Windows: Within the menue Options, the option Security of files must be turned to unchecked.

5.1.1. .dat files (specific to pst-solides3d)

In pst-solides3d, the data structure used for a solid has 4 fields. It can be stored in a set of 4 .dat files.

Writing .dat files

One uses the action writesolid within \psSolid, and one uses the option file to specify the name of the file.

For example, let's look at the code below:

```
"psSolid[object=tore,
  filename=montore,
  action=writesolid]
```

The command chain LaTeX-¿dvips-¿GSview (Windows) or gv (Linux) first compiles, then transforms into PostScript to finally get visualised.

That last operation creates 4 files:

- montore-sommets.dat → the list of the vertices;
- montore-faces.dat → the list of the faces;
- montore-couleurs.dat → the colors of the faces;
- montore-io.dat → the limits of the indices of the external and internal faces.

Note: All these four files will automatically be saved within the same folder as the generating file.

Reading .dat files

We use the object datfile of \psSolid, with the argument file to specify the name. Now the code

“psSolid[object=datfile, filename=montore]

will allow us to use the object—now saved in the .dat files generated— as described in the previous paragraph.

5.1.2. .obj files

We use only a simplified form of the .obj format. In particular, the files should not contain a character like # (the character for a comment in that format).

This format just uses a single file and permits within this file to specify the vertices and the faces.

Writing .obj files

One uses the action writeobj in \psSolid, and one uses the option file to specify the name of the file.

For example, the code below:

```
“psSolid[object=tore,
  filename=montore,
  action=writeobj]
```

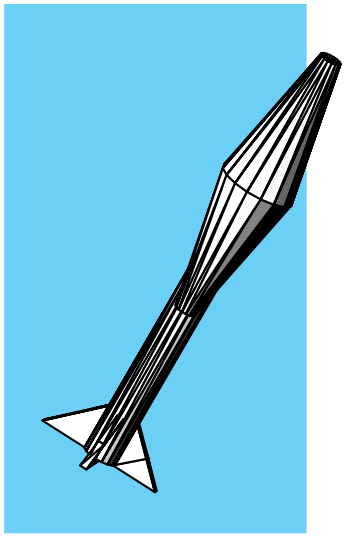
will produce a single file montore.obj (after compilation and visualisation of the .ps that was produced).

Reading .obj files

One uses the option objfile of \psSolid, with the argument file to specify the name of the file. Now the following code

“psSolid[object=objfile, filename=montore]

will allow to use the object—now saved in the .obj file generated—as described in the previous paragraph.



```
“psset–viewpoint=20 15 10 rtp2xyz,Decran=20”
“begin–pspicture”(-3,-4) (3,3)
“psframe*[linecolor=cyan!50](-3,-4) (1,3)
“psSolid[object=objfile,
        unit=20,RotX=60,
        filename=data/rocket]%
“end–pspicture”
```

5.1.3. .off files

We use only a simplified form of the .off format. In particular, these files only comprise v and f entries.

This format just uses a single file and permits within this file to specify the vertices and the faces.

Writing .off files

We use the action writeobj in \psSolid, and we use the option file to specify the name of the file.

For example the code below:

“psSolid[object=tore,
  filename=montore,
  action=writeoff]

will produce the montore.off file (after compilation and visualisation of the .ps that was produced).

Reading.off files

We use the option offfile of \psSolid, with the argument file to specify the name of the file. Now the following code

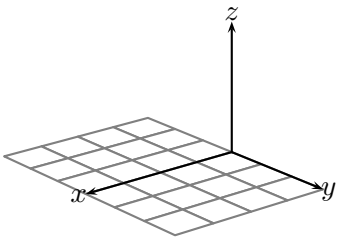
“psSolid[object=offfile, filename=montore]

will allow to use the object—now saved in the .off file generated—like described in the previous paragraph.

6. Some special objects

6.1. The grid

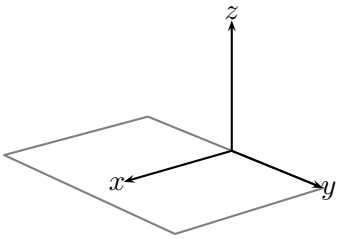
The object grille allows you to obtain a solid plane. The key [base=$xmin$ $xmax$ $ymin$ $ymax$] lets you specify the dimension of the grid.



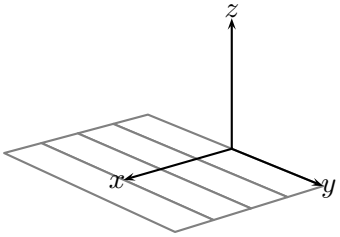

```
“begin–pspicture ”(-3.5,-1.5) (3.5,2.5)
“psSolid[object=grille ,
    base=0 4 -3 3,
    linecolor =gray](0,0,0)
“axesIIID(0,0,0) (4,3,3)
“end–pspicture”
```

The key [ngrid=n_1 n_2] lets you specify fineness of the grid. If n_2 is not set up, it is considered that $n_2 = n_1$.

If n_1 is an integer, it represents the number of grid points along the Ox axis. If it is a real, it represents the step size along the Ox axis. For example, the number 1 is an integer, the number 1. is real (note the decimal point).




```
“begin–pspicture ”(-3.5,-1.5) (3.5,2.5)
“psSolid[object=grille ,
    ngrid=1,
    base=0 4 -3 3,
    linecolor =gray](0,0,0)
“axesIIID(0,0,0) (3,3,3)
“end–pspicture”
```




```
“begin–pspicture ”(-3.5,-1.5) (3.5,2.5)
“psSolid[object=grille ,
    ngrid=1. 1,
    base=0 4 -3 3,
    linecolor =gray](0,0,0)
“axesIIID(0,0,0) (3,3,3)
“end–pspicture”
```

6.2. The object point

6.2.1. Definition via coordinates

The object point defines a point. The simplest method is to use the argument args=$x\ y\ z$ to specify its coordinates. If we have already named a point $M(x, y, z)$ (see chapter "*Advanced usage*"), we can easily use the argument args=M.

6.2.2. Some other definitions

There are some other possibilities for defining a point. Here a list of possible definitions with the appropriate arguments:

- definition=solidgetsommet; args= $solid\ k$.

  The vertex with index k of the solid $solid$.

- definition=solidcentreface; args=$solid\ k$.

  The centre of the face with index k of the solid $solid$.

- definition=isobarycentre3d; args=$\{[\ A_0\ \ldots\ A_n\ ]\}$.

  The isobarycentre of the system $[(A_0, 1); \ldots ; (A_n, 1)]$.

- definition=barycentre3d; args= $A\ a\ B\ b$.

  The barycentre of the system $(A, a); (B, b)$.

- definition=hompoint3d; args=$M\ A\ \alpha$.

  The image of M via a homothety with centre A and ratio α.

- definition=sympoint3d; args= $M\ A$.

  The image of M via the center of symmetry A

- definition=translatepoint3d; args= $M\ u$.

  The image of M under the translation via the vector $\vec{u}$

- definition=scaleOpoint3d; args= $x\ y\ z\ k_1\ k_2\ k_3$.

  This gives a "dilation" of the coordinates of the point $M(x, y, z)$ on the axes Ox, Oy and Oz each multiplied by an appropriate factor k_1, k_2 and k_3

- definition=rotateOpoint3d; args= $M\ \alpha_x\ \alpha_y\ \alpha_z$.

  The image of M through consecutive rotations—centered at O—and with respective angles α_x, α_y and α_z around the axes Ox, Oy and Oz.

- definition=orthoprojplane3d; args= $M\ A\ \vec{v}$.

  The projection of the point M to the plane P which is defined by the point A and the vector $\vec{v}$, perpendicular to P.

- definition=milieu3d; args= $A\ B$.

  The midpoint of $[AB]$

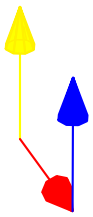
- definition=addv3d; args= A u.

  Gives the point B so that $\overrightarrow{AB} = \vec{u}$

6.3. The object vecteur

6.3.1. Definition with components

The object vecteur allows us to define a vector. The simplest way to do that is to use the argument args=x y z to specify its components.



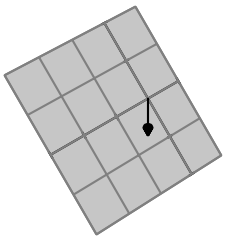
```
“begin–pspicture*”(-1,-1) (1,2)
“psSolid[object=vecteur,
    action=draw*,
   args=0 0 1,
    linecolor =yellow]%
“psSolid[object=vecteur,
   args=1 0 0,
    linecolor =red]
“psSolid[object=vecteur,
   args=0 0 1,
    linecolor =blue](1,0,0)
“end–pspicture*”
```

6.3.2. Definition with 2 points

We can also define a vector with 2 given points A and B of $\mathbb{R}^3$.

We then use the arguments definition=vecteur3d and args=x_A y_A z_A x_B y_B z_B where (x_A, y_A, z_A) and (x_B, y_B, z_B) are the appropriate coordinates of the points A and B

If the points A and B were already defined, we can easily use the named variables: args=A B.



```
“begin–pspicture*”(-3,-3) (4.5,2)
“psSolid[object=plan,
    linecolor =gray,
    definition =equation,
   args=–[0 1 1 0]”,
   base=-1 3 -2 2,
   planmarks,
   plangrid]
“psSolid[object=vecteur,
    definition =vecteur3d,
   args=0 0 1 1 1 1]%
“end–pspicture*”
```

6.3.3. Some other definitions of a vector

There are some other possibilities to define a vector. Here a list of some possible definitions with the appropriate arguments:

- definition=addv3d; args= $\vec{u}$ $\vec{v}$.

  Addition of 2 vectors.

- definition=subv3d; args= $\vec{u}$ $\vec{v}$.

  Difference of 2 vectors.

- definition=mulv3d; args= $\vec{u}$ λ.

  Multiplication of a vector with a real.

- definition=vectprod3d; args= $\vec{u}$ $\vec{v}$.

  Vector product of 2 vectors.

- definition=normalize3d; args= $\vec{u}$.

  Normalized vector $\|\vec{u}\|^{-1}\vec{u}$.

6.4. The object plan

6.4.1. Presentation: type plan and type solid

The object plan is special in pst-solides3d. However, all the objects presented until now have had a common structure: they are of type solid: in other words, they are defined by a list of vertices, faces and colours.

For many applications, it is necessary to have some additional information for a plane: an origin, an orientation, a reference base etc.

To fulfill all these requirements, another data structure of type plan was created, which allows one to save all this necessary information. These manipulations of the plane will be controlled by such an object. Only when rendering takes place will an object of type plan be converted to an object of type solid which conforms to the macro \psSolid.

An object of type plan is used to describe an oriented affine plane. For a complete definition of such an object, an origin I, a basis $(\vec{u}, \vec{v})$ for that plane, a scaling of the axis $(I, \vec{u})$ and a scaling of the axis $(I, \vec{v})$ are needed. In addition, we can specify the fineness of the grid—in other words, the number of faces—used to represent that portion of the affine plane while transforming in an object of the type solid.

This type of object can be used to define planes of section; it is then necessary to define a plane for projection.

Its usage is quite easy to understand for users of PSTricks. The only thing that you need to know is that, if we manipulate a object=plan with the macro \psSolid, we manipulate two objects at the same time: one of type plan and the other of type solid. When we select a backup of that object (see chapter "*Advanced usage*") with the name *monplan* for example with the option name=monplan, there are in fact 2 backups that are effected. The first, with the name monplan, is an object of type plan, and the second, with the name monplan_s, is an object of type solid.

6.4.2. Defining an oriented plane

To generate such an object, one uses object=plan which comes with a few arguments:

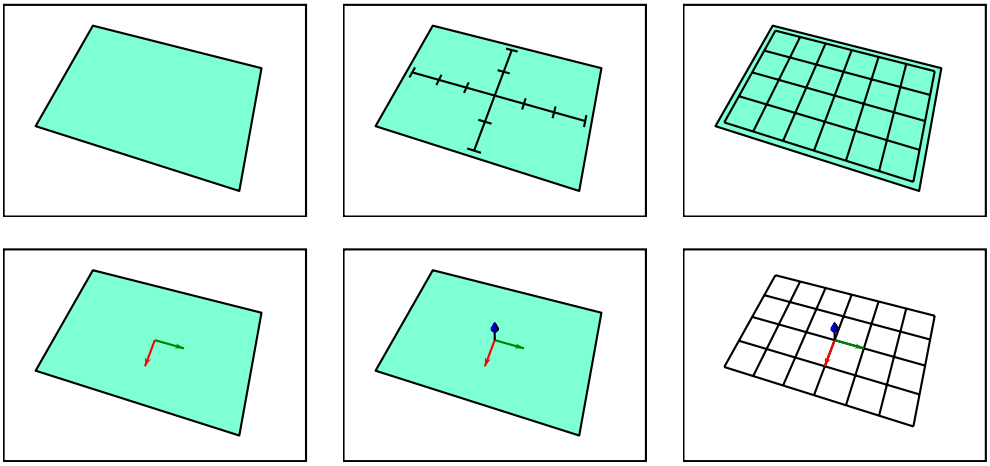
- definition which specifies the method to defining the plane.
- args which specifies the necessary arguments for the method chosen.
- base=$xmin$ $xmax$ $ymin$ $ymax$ which specifies the dimensions of each axis.
- [phi] (value 0 by default) which specifies the angle of rotation (in degrees) of the plane around its normal.

6.4.3. Special options

The object plan comes with some special options for viewing:

- planmarks which shows axes and scaling (with ticks),
- plangrid which shows the grid,
- showbase which shows the basis vectors for the plane, and
- showBase (note the capital letters) which shows the basis vectors of the plane and draws the associated normal vector.

These options apply regardless of the method of definition of the plane.



These options can be used, even if the plane is not drawn.

6.4.4. Defining a plane with a cartesian equation

The *cartesian equation* of a plane is of the form

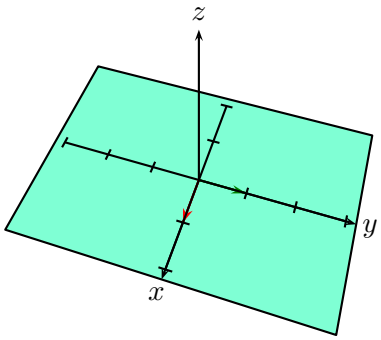
$$ax + by + cz + d = 0$$

The coefficients a, b, c and d determine an affine plane.

Usage with default orientation and origin

To define an affine plane, we can use definition=equation, and args={[a b c d]}. The orientation and origin of the affine plane must be given.

For example, the quadruple $(a, b, c, d) = (0, 0, 1, 0)$ determines the plane with the equation $z = 0$:



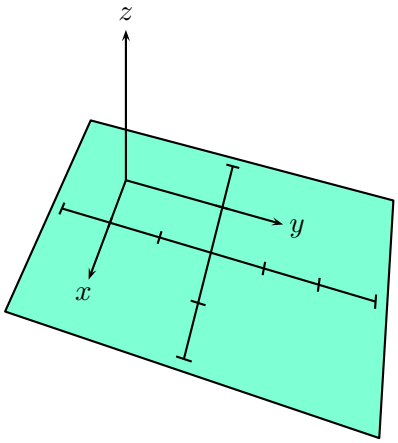

```
"psset=viewpoint=10 18 60 rtp2xyz,Decran=10,
  fontsize=10,unit=0.65"
"begin=pspicture*"(-5,-4) (5,4)
"psSolid[object=plan,
    definition=equation,
    args=-[0 0 1 0]",
    fillcolor=Aquamarine,
    planmarks,
    base=-2.2 2.2 -3.2 3.2,
    showbase]
"axesIIID(0,0,0) (2.2,3.2,4)
"end=pspicture*"
```

The parameter base=$xmin$ $xmax$ $ymin$ $ymax$ specifies the extent along each axis.

Specifying the origin

The parameter origine=x_0 y_0 z_0 specifies the origin of the affine plane. If the chosen point (x_0, y_0, z_0) doesn't fit the equation of the plane, it will be ignored.

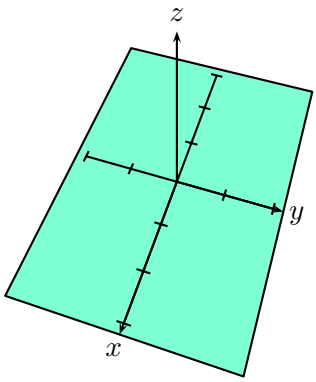
For example, a plane with the equation $z = 0$ for which $(1, 2, 0)$ has been chosen as a possible origin:




```
"psset=viewpoint=10 18 60 rtp2xyz,Decran=10,
  fontsize=10,unit=0.65cm"
"begin=pspicture*"(-4,-5.5) (6,4)
"psSolid[object=plan,
    definition=equation,
    args=-[0 0 1 0]",
    fillcolor=Aquamarine,
    origine=1 2 0,
    base=-2.2 2.2 -3.2 3.2,
    planmarks]
"axesIIID(0,0,0) (2.2,3.2,4)
"end=pspicture*"
```

Specifying the orientation

If the chosen orientation is unsatisfactory, we can specify an angle of rotation α (in degrees) around the normal of the plane with the syntax args={[a b c d] α}.




```
“psset–viewpoint=10 18 60 rtp2xyz,
  Decran=10,fontsize=10,unit=0.65cm”
“begin–pspicture*”(-5,-4) (5,4)
“psSolid[object=plan,
    definition =equation,
    args=–[0 0 1 0] 90”,
     fillcolor =Aquamarine,
    base=-2.2 2.2 -3.2 3.2,
    planmarks]
“axesIIID(0,0,0) (3.2,2.2,4)
“end–pspicture*”
```

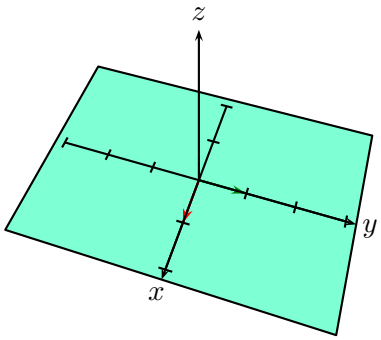
6.4.5. Defining a plane using a normal vector and a point

It is also possible to define a plane by giving a point and a normal vector. In this case one uses the parameter definition=normalpoint.

If wanted, we can specify the orientation, but it can be omitted.

First Method: orientation Unspecified

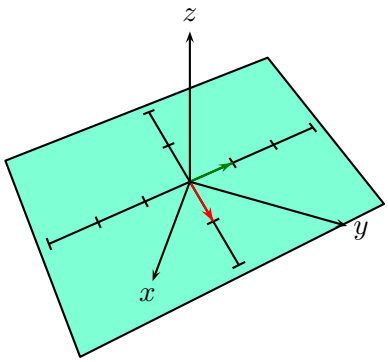
We use args={x_0 y_0 z_0 [a b c]} where (x_0, y_0, z_0) is the origin of the affine plane, and (a, b, c) is a vector normal to that plane.




```
“psset–viewpoint=10 18 60 rtp2xyz,
  Decran=10,fontsize=10,unit=0.65cm”
“begin–pspicture*”(-5,-4) (5,4)
“psSolid[object=plan,
    definition =normalpoint,
    args=–0 0 0 [0 0 1]”,
     fillcolor =Aquamarine,
    planmarks,
    base=-2.2 2.2 -3.2 3.2,
    showbase]
“axesIIID(0,0,0) (2.2,3.2,4)
“end–pspicture*”
```

Second Method: Specifying an angle of rotation

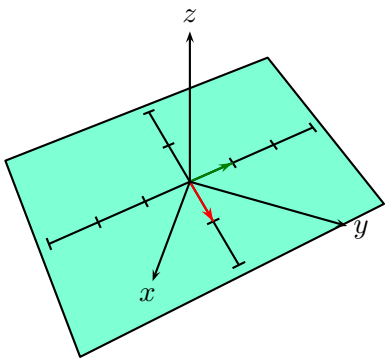
We use args={x_0 y_0 z_0 [a b c α]} where (x_0, y_0, z_0) is the origin of the affine plane, (a, b, c) a normal vector of that plane, and α the angle of rotation (in degrees) around the normal vector of that plane.




```
“psset–viewpoint=10 18 60 rtp2xyz,
  Decran=10,fontsize=10,unit=0.65″
“begin–pspicture*″(-5,-4) (5,4)
“psSolid[object=plan,
    definition =normalpoint,
    args=–0 0 0 [0 0 1  45]″,
     fillcolor  =Aquamarine,
    planmarks,
    base=-2.2 2.2  -3.2   3.2,
    showbase]
“axesIIID(0,0,0) (2.2,3.2,4)
“end–pspicture*″
```

Third Method: Specifying the first basis vector

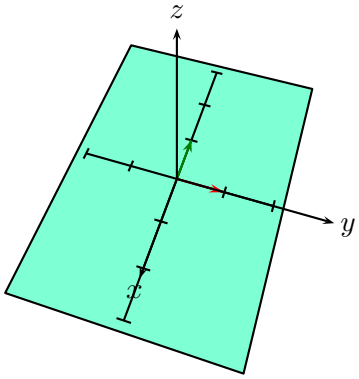
We use args=$\{x_0\ y_0\ z_0\ [u_x\ u_y\ u_z\ a\ b\ c\ ]\}$ where (x_0, y_0, z_0) is the origin of the affine plane, (a, b, c) a normal vector of that plane, and (u_x, u_y, u_z) the first basis vector for that plane.




```
“psset–viewpoint=10 18 60 rtp2xyz,
  Decran=10,fontsize=10,unit=0.65cm″
“begin–pspicture*″(-5,-4) (5,4)
“psSolid[object=plan,
    definition =normalpoint,
    args=–0 0 0 [1 1 0 0 0  1]″,
     fillcolor  =Aquamarine,
    planmarks,
    base=-2.2 2.2  -3.2   3.2,
    showbase,
]
“axesIIID(0,0,0) (2.2,3.2,4)
“end–pspicture*″
```

Fourth Method: Specifying the first basis vector and an angle of rotation

We use args=$\{x_0\ y_0\ z_0\ [u_x\ u_y\ u_z\ a\ b\ c\ \alpha]\}$ where (x_0, y_0, z_0) is the origin of the affine plane, (a, b, c) is a normal vector of that plane, (u_x, u_y, u_z) is the first basis vector for that plane and α (in degrees) is a rotation around the axis of the normal vector.

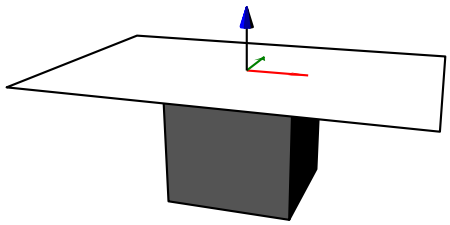



```
“psset–viewpoint=10 18 60 rtp2xyz,
  Decran=10,fontsize=10,unit=0.65cm″
“begin–pspicture*″(-5,-4) (5,4)
“psSolid[object=plan,
    definition =normalpoint,
    args=–0 0 0 [1 1 0 0 0 1  45]″,
     fillcolor  =Aquamarine,
    planmarks,
    base=-2.2 2.2  -3.2   3.2,
    showbase]
“axesIIID(0,0,0) (2.2,3.2,4)
“end–pspicture*″
```

6.4.6. Defining a plane from a face of a solid

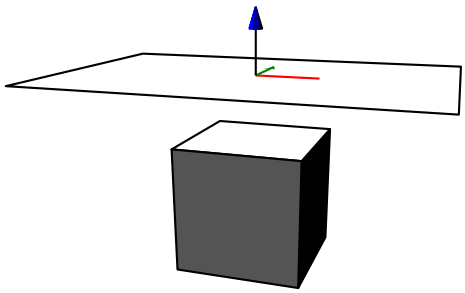
We use definition=solidface with the arguments args=$name\ i$ where $name$ is the name of the designated solid and i is the index of the face. The origin is taken as the centre of the chosen face.

In the example below, the plane is defined through the face with the index 0 from the cube named A.



```
"psset-viewpoint=10 18 20 rtp2xyz,Decran=8"
"begin-pspicture "(-3.5,-2) (3,2.5)
"psset-solidmemory"
"psSolid[object=cube,a=2,fontsize=20,numfaces=all,name=A]
"psSolid[object=plan,
    definition=solidface,
    args=A 0,
    showBase]
"end-pspicture"
```

If the user specifies the coordinates (x, y, z) within the macro "psSolid[...](x, y, z), a plane is generated parallel to the face with index i of the solid $name$, and translated to the point (x, y, z) which now is taken as the origin.



```
"psset-viewpoint=10 18 20 rtp2xyz,Decran=8"
"begin-pspicture "(-3.5,-1.5) (3,3)
"psset-solidmemory"
"psSolid[object=cube,a=2,fontsize=20,numfaces=all,name=A]
"psSolid[object=plan,
    definition=solidface,
    args=A 0,
    showBase](0,0,2)
"end-pspicture"
```

6.5. The object geode

6.5.1. Mathematical presentation

Some excellent tutorials about geodes and their duals are available on the following websites:
http://fr.wikipedia.org/wiki/G%C3%A9ode

The parametrisation of a geode complies with that given on the website:
http://hypo.ge-dip.etat-ge.ch/www/math/html/amch104.html

"*We can define a geode with two parameters: a number N indicating the type of the initial polyhedron ($N = 3$ for the tetrahedron, $N = 4$ for the octahedron and $N = 5$ for the icosahedron) and a number n indicating the number of divisions along the edge's length.*"

The article *Indexing the Sphere with the Hierarchical Triangular Mesh* describes a method that allows us to obtain a representation of geodes:
http://research.microsoft.com/research/pubs/view.aspx?msr_tr_id=MSR-TR-2005-123

6.5.2. Construction with pst-solides3d

Two approaches are possible to generate a geode or its dual: either via “codejps, or via the objects of \psSolid. For a geode, the codes

“codejps–N n newgeode drawsolid**”

and

“psSolid[object=geode,ngrid=N n]

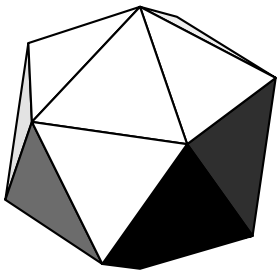
are equivalent. And for its dual, the codes

“codejps–N n newdualgeode drawsolid**”

and

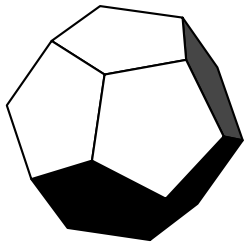
“psSolid[object=geode,dualreg,ngrid=N n]

6.5.3. Some examples of geodes and their duals



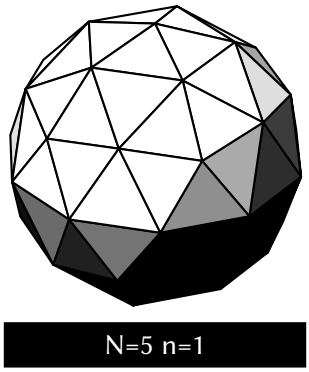
N=5 n=0

```
“begin–pspicture”(-3,-3) (3,3)
“psset–viewpoint=50 -20 30 rtp2xyz,Decran=100”
“psSolid[object=geode,
          ngrid=5 0]
%“codejps–5 0 newgeode drawsolid**”
“psframe*(-2,-2.8) (2,-2.2)
“rput(0,-2.5)–“textcolor–white”–“textsf–N=5 n=0””
“end–pspicture”
```

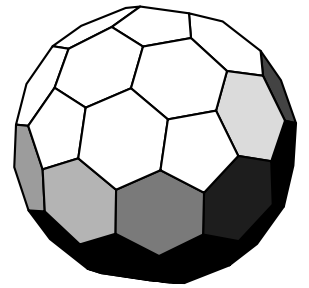


N=5 n=0

```
“begin–pspicture”(-3,-3) (3,3)
“psset–viewpoint=50 -20 30 rtp2xyz,Decran=100”
“psSolid[object=geode,
   dualreg,
   ngrid=5 0]
%“codejps–5 0 newdualgeode drawsolid**”
“psframe*(-2,-2.8) (2,-2.2)
“rput(0,-2.5)–“textcolor–white”–“textsf–N=5 n=0””
“end–pspicture”
```




```
“begin–pspicture”(-3,-3) (3,3)
“psset–viewpoint=50 -20 30 rtp2xyz,Decran=100”
“psSolid[object=geode,
    ngrid=5 1]
%“codejps–5 1 newgeode drawsolid**”
“psframe*(-2,-2.8) (2,-2.2)
“rput(0,-2.5)–“textcolor–white”–“textsf–N=5 n=1”””
“end–pspicture”
```




```
“begin–pspicture”(-3,-3) (3,3)
“psset–viewpoint=50 -20 30 rtp2xyz,Decran=100”
“psSolid[object=geode,
    dualreg,
    ngrid=5 1]
%“codejps–5 1 newdualgeode drawsolid**”
“psframe*(-2,-2.8) (2,-2.2)
“rput(0,-2.5)–“textcolor–white”–“textsf–N=5 n=1”””
“end–pspicture”
```

6.5.4. The parameters of the geodes

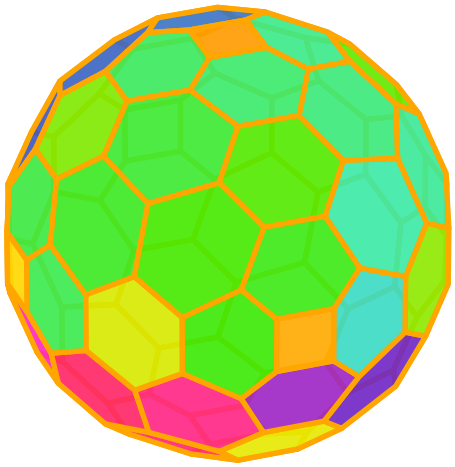
The radius of the sphere is fixed at 1, so to vary the dimensions of the geodes one plays around with one or the other of the two following parameters:

- The unit: “psset–unit=2”
- The position of the screen: viewpoint=50 -20 30,Decran=100, if the distance to the screen is twice as far as the distance to the viewer, one scales the scenery by a factor of two.

Note: Within *jps*, the setup for the geode is \codejps{**N n newgeode**} and for its dual it is \codejps{**N n newdualgeode**}.

Note: With \psSolid, the parameters N and n are transmitted via the argument ngrid

The color and transparency options are available for the geodes as well.



```
“psset–viewpoint=50 -20 30 rtp2xyz,Decran=150″
“begin–pspicture ″(-3.5,-3.5) (3.5,3.5)
“psset–linewidth=2pt″
“codejps–
/geode42–4 2 newdualgeode″ def
.7 setfillopacity
orange
/geodetransparente–
geode42
dup videsolid
dup (orange) inputcolors
dup [.1 .9] solidputhuecolors″ def
geodetransparente
drawsolid**″
“end–pspicture″
```

6.5.5. Advice for a ‘fast’ construction of a geode

The calculation time for the geodes and their duals depends on the number of divisions of an edge (the second parameter n) and will increase rapidly with n which is really uncomfortable, because one has to wait more or less patiently, until the result of the transformation `dvips-¿ps2pdf` is ready.

As happens for all other solids, it is possible to save the calculation in external files, which then saves calculation time when one has to make a test run of colours or view point.

We have to operate in two stages:

Backup the parameters of the geodes in a .dat file

“documentclass–article″
“usepackage–pst-solides3d″
“begin–document″
“codejps–
4 4 newdualgeode
dup –[.5 .6]″ exec solidputhuecolors
(geodedual44) writesolidfile
″
“end–document″

`LaTeX-¿dvips-¿GSview (Windows)ou gv (Linux)`

The last operation will generate 4 files:

- geodedual44-couleurs.dat → the colors of the faces;
- geodedual44-faces.dat → the list of the faces;
- geodedual44-sommets.dat → the list of the vertices;
- geodedual44-io.dat → the number of the faces and vertices.

Note: By default, under Windows and Linux, the security of files on the hard drive is activated and doesn't allow you to write on the drive. To deactivate that security option, more or less temporarily, here the two corresponding procedures:

Linux: Advice from Jean-Michel Sarlat: the simplest will be to use GhostScript directly, within the console. As there is no image to wait for:

$> gs -dNOSAFER monfichier.ps quit.ps

Windows: Within the menu Options, the option Security of files must be unchecked.

Reading the data and drawing the geode

The advantage of this method becomes even more evident when one compares the compilation of two files producing the same result by different methods:

The file geode42_direct.tex calculates the solid and its view. The file geode42_precalcul.tex uses the file .dat including the precalculated data of the file calc_geode42.tex. These three files are included in the distribution.

6.5.6. Some other examples

You will find numerous other examples of geodes on the website:
http://melusine.eu.org/lab/bpst/pst-solides3d/geodes

7. Generating some new solids

7.1. The jps code

jps code contains all the PostScript code that is used by the library developed for the software *jps2ps*.

The solides.pro file of the solides3d package contains all the elements native to that library, which contains about 4 500 functions and procedures.

It allows us to have available some adapted commands in mathematical form, without having to construct them with the primitives moveto, lineto, curveto, etc.

For example, we can define a function F with $F(t) = (3\cos^3 t, 3\sin^3 t)$, and draw its curve with the *jps code* 0 360 –F″ CourbeR2.

If we only want to have the path of that curve, we use the code 0 360 –F″ CourbeR2˙, and if we want to add this to the stack of points of the curve, we use 0 360 –F″ CourbeR2+.

In all of the 3 examples below, the number of points is declared by the global variable resolution.

In other words, with the function F named above and a fixed resolution of 36, the *jps code*

```
0 360 –F″ CourbeR2+
```

is equivalent to the PostScript code

```
0 10 360 –
  /angle exch def
  3 angle cos 3 exp mul
  3 angle sin 3 exp mul
″ for
```

We haven't yet developed documentation for the library hidden in the solides.pro file. For the moment we refer the *Guide de l'utilisateur de jps2ps* for the interested user available at the website melusine.eu.org/syracuse/bbgraf.

7.2. Defining a function

It is possible to define functions usable in a PostScript environment.

The domain can be $\mathbb{R}$, $\mathbb{R}^2$ or $\mathbb{R}^3$, and the codomain can be $\mathbb{R}$, $\mathbb{R}^2$ or $\mathbb{R}^3$.

The definition is made with the macro "defFunction. This macro comes with six arguments, where the first is optional.

"defFunction[¡options¿]–¡name¿″(¡var¿)–¡x(var)¿″–¡y(var)¿″–¡z(var)¿″

Once you have defined a function, this function is always called by its chosen name ¡name¿.

Here some examples:

¡options¿	We insert the options typical to PSTricks, like linewidth etc., and, some of them defined by pst-solides3d. A very nice and helpful option is algebraic, with which one can avoid RPN (Reverse Polish Notation). All the options are key value pairs separated with commas.
¡name¿	This is a unique name of your choice—but be careful: avoid names that contain accents, PostScript doesn't like them at all.
¡var¿	We insert at most three variables, arbitrarily chosen and separated with commas.
¡x(var)¿ ¡y(var)¿ ¡z(var)¿	Here, we place functions defining the three Euclidean components x, y, z. If one of the three components is not wanted, just enter a 0 within parentheses—this will also allow you to define some projections of the lines of functions.

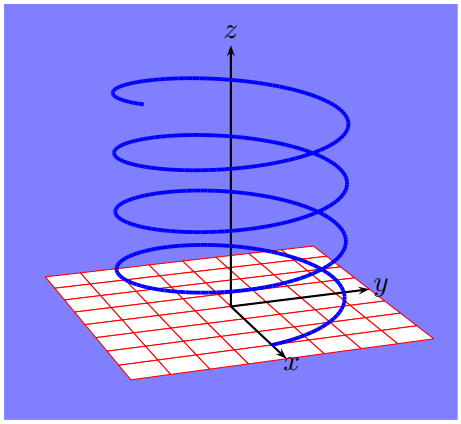
- "defFunction–moncercle"(t)–t cos 3 mul"–0"–t sin 3 mul"
  draws a circle with radis 3 in the xOz plane (notation RPN).
- "defFunction[algebraic]–helice"(t)–cos(t)"–sin(t)"–t"
  draws a helix in algebraic notation.
- "defFunction[algebraic]–F"(t)–t"–"–"
  draws a function from $\mathbb{R}$ in $\mathbb{R}$
- "defFunction[algebraic]–F"(t)–t"–t"–"
  draws a function from $\mathbb{R}$ in $\mathbb{R}^2$
- "defFunction[algebraic]–F"(t)–t"–t"–t"
  draws a function from $\mathbb{R}$ in $\mathbb{R}^3$

There remains work to be done on this macro. For the moment it does not permit an arbitrary choice of names of variables, as this risks conflict with existing names. Please use names analogous to those used in the documentation. A good strategy is to systematically use one or more numerical characters at the end of the names of your variables.

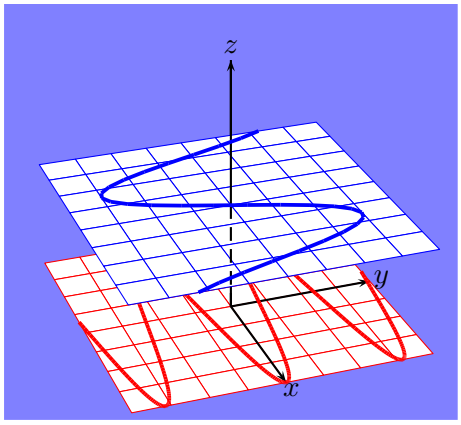
7.3. Curves of functions from $\mathbb{R}$ in $\mathbb{R}^3$

The line of a defined function calls the object courbe and the option function. We can realize a helix in algebraic notation with the function:

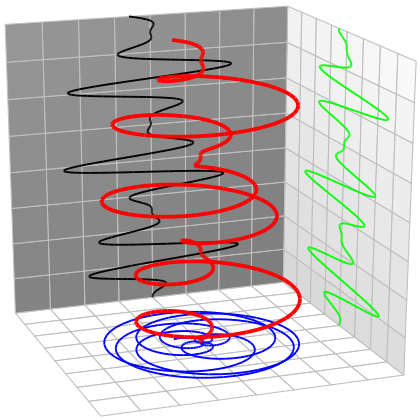
"defFunction[algebraic]–helice"(t)–3*cos(4*t)"–3*sin(4*t)"–t"




```
"psset–unit=0.5"
"begin–pspicture"(-6,-3) (6,8)
"psframe*[linecolor=blue!50](-6,-3) (6,8)
"psSolid[object=grille,base=-4 4 -4 4, linecolor=red,linewidth=0.5"
    pslinewidth]%
"axesIIID(0,0,0) (4,4,7)
"defFunction[algebraic]– helice"(t)–3*cos(4*t)"–3*sin(4*t)"–t"
"psSolid[object=courbe,
        r=0,
        range=0 6,
        linecolor=blue,linewidth=0.1,
        resolution=360,
        function=helice]%
"end–pspicture"
```




```
"psset-unit=0.5"
"begin-pspicture"(-6,-3) (6,8)
"psframe*[linecolor=blue!50](-6,-3) (6,8)
"psset- lightsrc=10 -20 50,viewpoint=50 -20 30 rtp2xyz,Decran=50"
"psSolid[object=grille,base=-4 4 -4 4, linecolor=red,linewidth=0.5"
    pslinewidth]%
"axesIIID(0,0,0) (4,4,7)
"psset-range=-4 4"
"defFunction-cosRad"(t)- t 2 mul Cos 4 mul "- t "- 0 "
"psSolid[object=courbe,linewidth=0.1,
  r=0,linecolor=red,
  resolution=360,
  function=cosRad]
"psSolid[object=grille,base=-4 4 -4 4, linecolor=blue,linewidth
    =0.5"pslinewidth](0,0,3)
"psPoint(0,0,3)-O1""psPoint(0,0,7)-Z1""psline(O1)(Z1)"psline[
    linestyle=dashed](O1)(O)
"pstVerb-/tmin -4 def /tmax 4 def"%
"defFunction-sinRad"(t)- t "- t Sin 3 mul "- 3 "
"psSolid[object=courbe,linewidth=0.1,
  r=0,linecolor=blue,
  resolution=30,
  function=sinRad]
"end-pspicture"
```



```
"psset-unit=0.5"
"begin-pspicture"(-6.5,-3) (7,11)
"psset- lightsrc=10 -20 50,viewpoint=50 -20 20 rtp2xyz,Decran=50"
"psSolid[object=grille,base=-4 4 -4 4,
  linecolor=lightgray,linewidth=0.5"pslinewidth]%
"psSolid[object=grille,base=-4 4 0 8,
  linecolor=lightgray,RotX=90,
  linewidth=0.5"pslinewidth](0,4,0)
"psSolid[object=grille,base=-4 4 -4 4,
  linecolor=lightgray,RotY=90,
  linewidth=0.5"pslinewidth](-4,0,4)
"defFunction[algebraic]-helice"(t)%
  -1.3*(1-cos(2.5*t))*cos(6*t)"
  -1.3*(1-cos(2.5*t))*sin(6*t)"-t"
"defFunction[algebraic]-helice˙xy"(t)%
  -1.3*(1-cos(2.5*t))*cos(6*t)"
  -1.3*(1-cos(2.5*t))*sin(6*t)"-0"
"defFunction[algebraic]-helice˙xz"%
  (t)-1.3*(1-cos(2.5*t))*cos(6*t)"-4"-t"
"defFunction[algebraic]-helice˙yz"%
  (t)--4"-1.3*(1-cos(2.5*t))*sin(6*t)"-t"
"psset-range=0 8"
"psSolid[object=courbe,r=0,linecolor=blue,
  linewidth=0.05,resolution=360,
  normal=0 0 1,function=helice˙xy]
"psSolid[object=courbe,r=0,
  linecolor=green,linewidth=0.05,
  resolution=360,normal=0 0 1,
  function=helice˙xz]
"psSolid[object=courbe,r=0,
  linewidth=0.05,resolution=360,
  normal=0 0 1,function=helice˙yz]
"psSolid[object=courbe,r=0,
  linecolor=red,linewidth=0.1,
  resolution=360,function=helice]
"end-pspicture"
```

These last function lines are found in an animated form on the website:
http://melusine.eu.org/syracuse/pstricks/pst-solides3d/animations/

7.4. Tubes

This section is about to substitute a curve in two or three dimensions (2D or 3D), that are setup parameterised, by a tube, where the initial curve is the axes and we can choose the radius and grid. We find some mathematical elements concerning these objects on the following websites:
http://fr.wikipedia.org/wiki/Tube_(math%C3%A9matiques)
http://www.mathcurve.com/surfaces/tube/tube.shtml

As usual, the pst-solides3d package offers two possibilities to draw the tubes:

- via PSTricks and the argument object of \psSolid
- directly with "codejps

Note: It is often advisable to calculate in advance, by hand or with a preferred software, the first derivatives of the parametric functions which define the coordinates.

However, if this derivative isn't defined explicitly by the user, the package makes some approximate calculations, but the result then is not always sufficient.

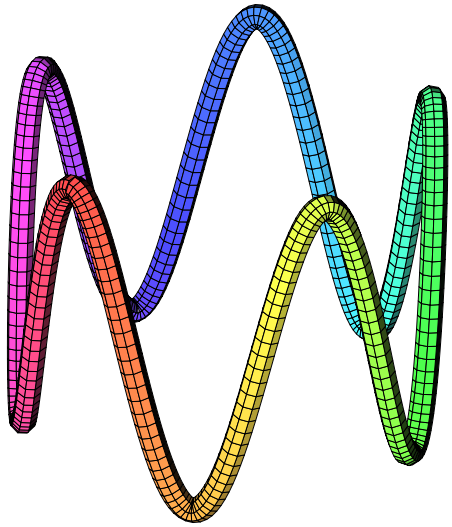
7.4.1. Usage with PSTricks

Give your curves a relief

"*Donnez du relief à vos courbes*", this is the title of the article from Robert Ferréol, available on:

http://mapage.noos.fr/r.ferreol/atelecharger/textes/relief/courbes%20en%20relief.html

from who the following functions were borrowed and which are analogous to a Lissajous figure enrolled around a cylinder.



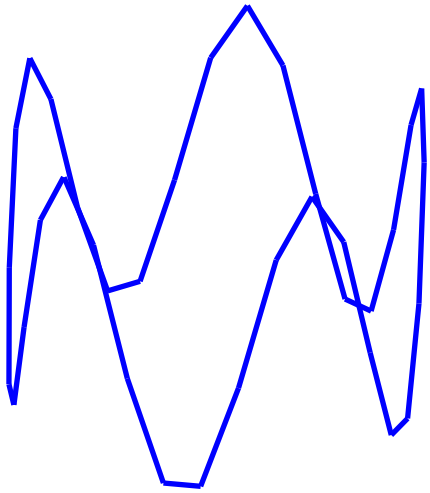
```
"begin-pspicture "(-3.5,-4) (4,4)
"psset-lightsrc =80 30 30,viewpoint=100 45 30 rtp2xyz,Decran=110,linewidth=0.2pt"
"defFunction[algebraic]-Func"(t)-2.5*cos(t)"-2.5*sin(t)"-2*cos(5*t)"
"defFunction[algebraic]-Func'"(t)--2.5*sin(t)"-2.5*cos(t)"--10*sin(5*t)"
"psSolid[object=courbe,range=0 6.28,hue=0 1 0.7 1,
    ngrid=360 8,function=Func,r=0.15]
"end-pspicture"
```

The argument object=courbe with the parameters r, function and range is used to specify the radius of the tube, the name of the function to be used and the range.

We can also refine the grid with the optional argument ngrid=n_1 n_2 where n_1 represents the number of vertices of a section of a tube (if $n_1 = 6$, this gives a tube with a hexagonal section) and n_2 represents the number of divisions along it.

A hairline curve is produced with the radius r=0

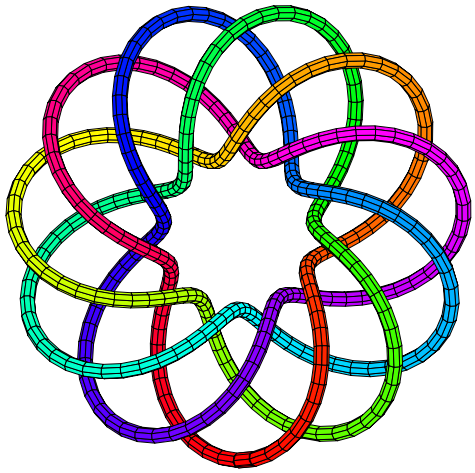
And thus, no fear to specify the derived function.



```
"begin-pspicture "(-3.5,-4) (4,4)
"psset- lightsrc =80 30 30,viewpoint=100 45 30 rtp2xyz,Decran=110"
"defFunction[algebraic]-FI"(t)-2.5*cos(t)"-2.5*sin(t)"-2*cos(5*t)"
"psSolid[object=courbe,range=0 6.28,linewidth=2pt,linecolor=blue,function=FI,r=0]
"end-pspicture"
```

7.4.2. Usage with \codejps

The syntax is \codejps{t_min t_max (name_function) radius_tube [n1 n2] newtube}.



```
“begin–pspicture ″(-3.5,-3.5) (4,3.5)
“psset– lightsrc =80 30 30,viewpoint=100 45 90 rtp2xyz,Decran=100,linewidth=0.2pt″
“codejps–
/rpn –tx@AlgToPs begin AlgToPs end cvx exec″ def
/xc –((2+1*cos(2.75*t))*cos(t)) rpn ″ def
/yc –((2+1*cos(2.75*t))*sin(t)) rpn ″ def
/zc –(1*sin(2.75*t)) rpn ″ def
/xc’ –(-2.75*sin(2.75*t)*cos(t)-(2+cos(2.75*t))*sin(t)) rpn ″ def
/yc’ –(-2.75*sin(2.75*t)*sin(t)+(2+cos(2.75*t))*cos(t)) rpn ″ def
/zc’ –(2.75*cos(2.75*t)) rpn ″ def
/g – 3 dict begin /t exch def xc yc zc end ″ def
/g’ – % first derivative
3 dict begin /t exch def xc’ yc’ zc’ end ″ def
/solenoide–
% t˙min t˙max (name˙function) radius˙tube [resolution]
    0 25.2 (g) 0.1 [360 8] newtube dup [0 1] solidputhuecolors″ def
solenoide
drawsolid**
″%
“end–pspicture″
```

7.4.3. Improving the speed of readout

The curve with the name “*horopter*” is the subject of this website:
http://www.mathcurve.com/courbes3d/horoptere/horoptere.shtml

Obtaining the curve directly

The following lines allow us to calculate the points and draw the curve. The resolution ngrid=72 12 of the curve was increased, so some more calculation time to produce the result, which some will judge as very long.

“begin–pspicture″(-7,-2)(7,4)
“psset–lightsrc=80 30 30″
“psset–viewpoint=1000 60 20 rtp2xyz,Decran=1000″
“psframe(-7,-2)(7,4)
“psset–solidmemory″

```
“codejps–/a 2 def /b 2 def″%
“defFunction[algebraic]–F3″(t)
  –a*(1+cos(t))″
  –b*tan(t/2)″
  –a*sin(t)″
“defFunction[algebraic]–F3’″(t)
  –-a*sin(t)″
  –b*(1+tan(1/2*t)ˆ2)″
  –a*cos(t)″
“psSolid[object=courbe,
  range=-2.7468 2.7468,
  ngrid=72 12,
  function=F3,hue=0 1 0.7 1,
  action=none,name=H1,
  r=1]%
“psSolid[object=cylindrecreux,
        h=20,r=1,RotX=90,
        incolor=green!30,action=none,
        name=C1,
        ngrid=36 36](2,10,0)
“psSolid[object=fusion,
  base=H1 C1]
“composeSolid
“end–pspicture″
```

Saving the parameters of the curve

If this curve is used several times, it is advisable to backup all the characteristics of that curve, like: coordinates of the vertices, list of colours of the faces with placing the last command action=writesolid:

```
“psSolid[object=fusion,
        base=H1 C1,
        filename=horoptere,
        action=writesolid]
```

The following sequence `LaTeX fichier.tex-¿dvips-¿GSview (Windows) or gv (Linux)` will generate 4 files:

- horoptere-couleurs.dat → the colours of the faces;
- horoptere-faces.dat → the list of faces;
- horoptere-sommets.dat → the list of vertices;
- horoptere-io.dat → the number of faces and vertices.

then read and execute the files with the command: \psSolid[object=datfile,filename=horoptere], the time saved can be quite significant

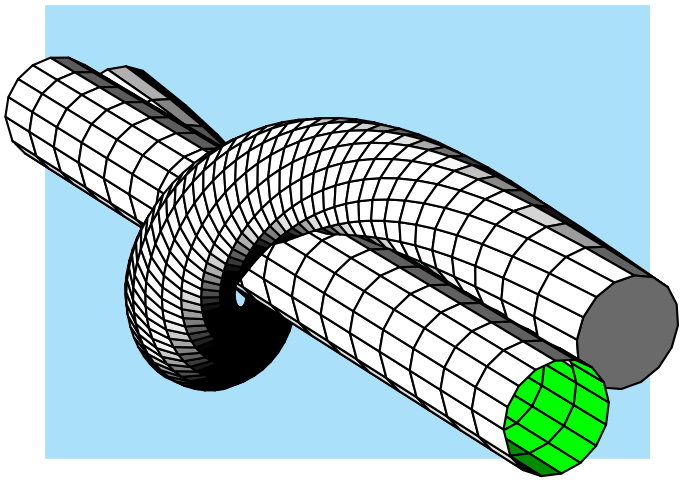
Note: By default, under Windows and Linux, the security of files on the hard drive is activated and doesn't allow to write on the drive. To deactivate that security option, more or less temporarily, here the two corresponding procedures:

Linux: The advice from Jean-Michel Sarlat: the simplest will be to use GhostScript directly, within the console. As there is no image to wait for:

$> gs -dNOSAFER monfichier.ps quit.ps

Windows: Within the menue Options, the option Security of files must be turned to unchecked.

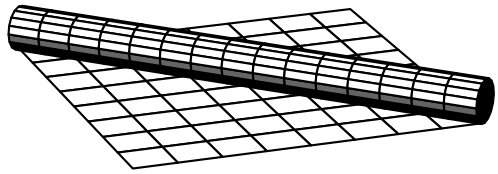
The plot of the curve



```
1 “begin–pspicture ”(-5,-3.5) (4,3)
2 “psset–lightsrc =80 30 30”
3 “psset–viewpoint=100 60 20 rtp2xyz,
4         Decran=75”
5 “psframe*[linecolor=cyan!30](-4.5,-3) (3.5,3)
6 “psSolid[object=datfile,filename=data/horoptere]
7 “end–pspicture”
```

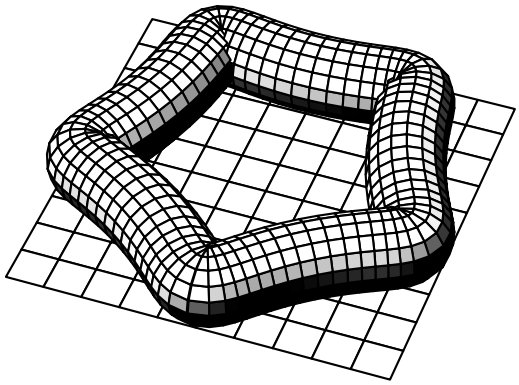
7.4.4. Some other examples

A straight line



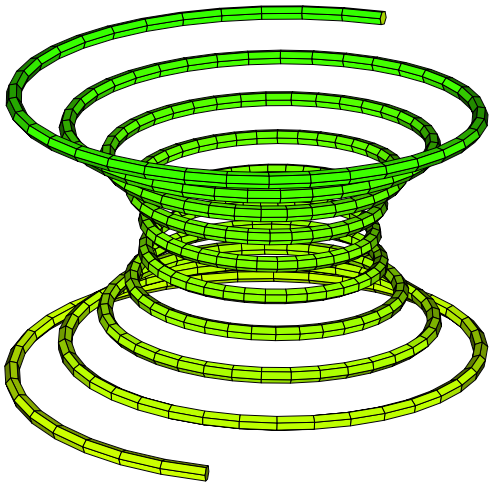
```
“begin–pspicture ″(-3.5,-2) (3.5,2)
“psset–viewpoint=100 -20 20 rtp2xyz,
        Decran=75,unit=0.8″
“psSolid[object=grille ,base=-4 4 -4 4]%
“defFunction[algebraic]–FIV″(t)–t″–t″–0.5″
“defFunction[algebraic]–FIV’″(t)–1″–1″–0″
“psSolid[object=courbe,
   range=-4 4, ngrid=16 16,
   function=FIV, r=0.5]
“end–pspicture″
```

A hypocycloid



```
“begin–pspicture ″(-3.5,-3) (3.5,3)
“psset–viewpoint=100 20 45 rtp2xyz,
        Decran=75,unit=0.7″
“psSolid[object=grille ,base=-5 5 -5 5]%
“defFunction[algebraic]–FII″(t)
   –4*cos(t)+cos(4*t)/2″
   –4*sin(t)-sin(4*t)/2″
   –1″
“defFunction[algebraic]–FII’″(t)
   –-4*sin(t)-2*sin(4*t)″
   –4*cos(t)-2*cos(4*t)″
   –0″
“psSolid[object=courbe,
   range=0 6.28,ngrid=90 16,
   function=FII,r=1]
“end–pspicture″
```

The spring of Gaston



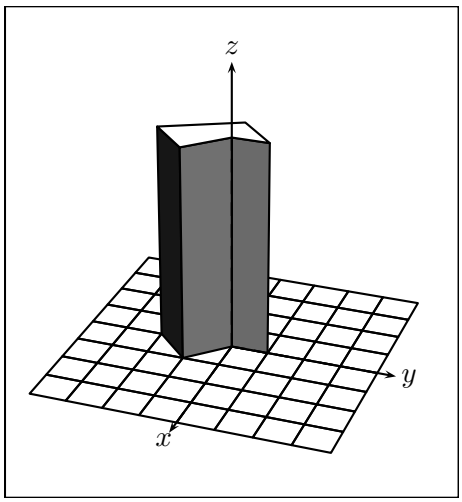
```
“begin–pspicture ”(-3.5,-4) (3.5,4.5)
“psset– lightsrc =80 30 30,
  viewpoint=100 20 20 rtp2xyz,Decran=50”
“defFunction[algebraic]–FIII”(t)
  –(t^2+3)*sin(15*t)”
  –(t^2+3)*cos(15*t)”–2*t”
“defFunction[algebraic]–FIII’”(t)
  –2*t*sin(15*t)+15*(t^2+3)*cos(15*t)”
  –2*t*cos(15*t)-15*(t^2+3)*sin(15*t)”–2”
“psSolid[object=courbe,
  range=-2 2,ngrid=360 6,
  function=FIII,hue=0.2 0.3,
  linewidth=0.1pt,r=0.2]
“end–pspicture”
```

7.5. The prism

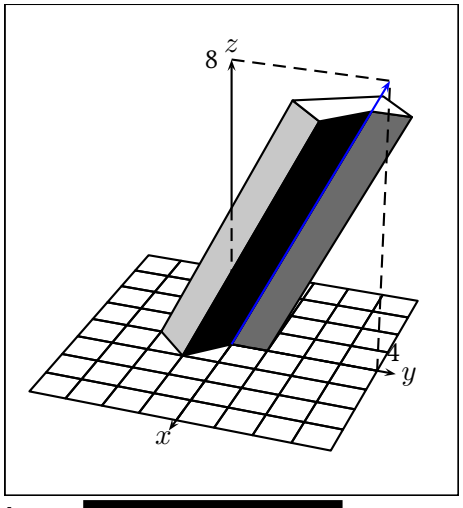
A prism is determined by two parameters:

- The base of the prism can be defined by the coordinates of the vertices in the xy-plane. Note that it is necessary that the four vertices be given in counterclockwise order with respect to the barycentre of the base;
- the direction of the prism axis (the components of the shearing vector).

Example 1: a right and oblique prisms with polygonal section

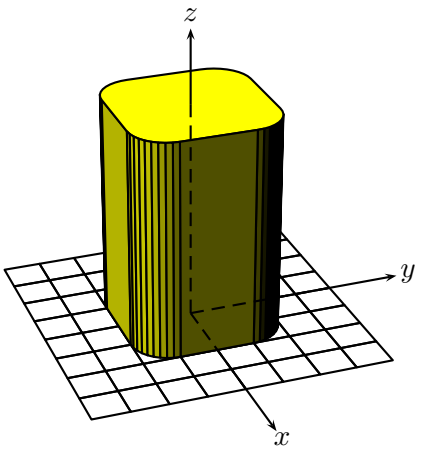


[base= 0 1 -1 0 0 -2 1 -1 0 0 ,h=6]



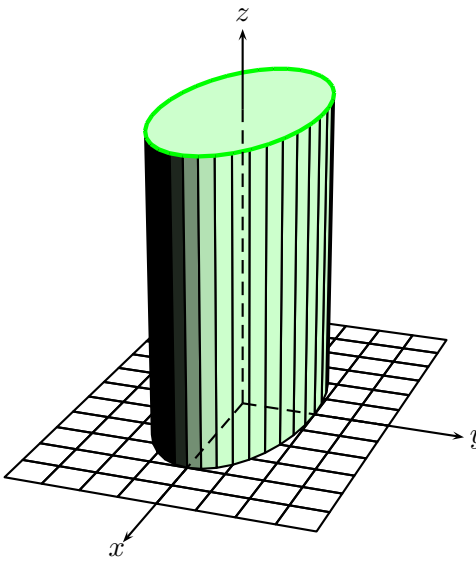
[base= 0 -2 1 -1 0 0 0 1 -1 0 ,
axe= 0 4 8 ,h=8]

Example 2: a right prism with cross-section a rounded square



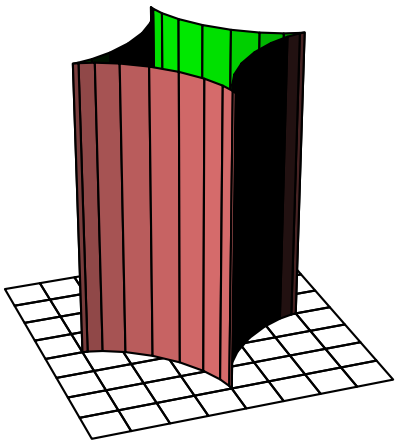

```
"psset–unit=0.5cm"
"psset– lightsrc =10 -20 50,viewpoint=50 -20 30 rtp2xyz,Decran=50"
"begin–pspicture"(-5,-4) (3,9)
"psSolid[object=grille ,base=-4 4 -4 4,action=draw]
"psSolid[object=prisme,h=6,fillcolor=yellow,
 base=
     0 10 90 –/i exch def i cos 1 add i sin 1 add " for
    90 10 180 –/i exch def i cos 1 sub i sin 1 add" for
   180 10 270 –/i exch def i cos 1 sub i sin 1 sub" for
   270 10 360 –/i exch def i cos 1 add i sin 1 sub" for]
"axesIIID(4,4,6) (6,6,8)
"end–pspicture"
```

Example 4: a prism with an elliptic section



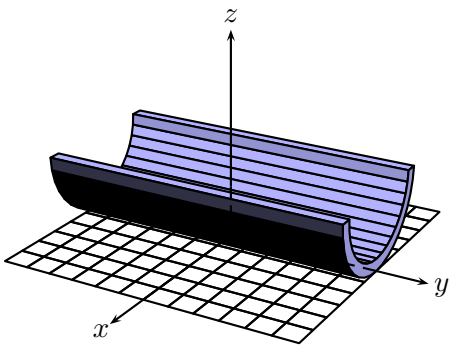

```
"psset–unit=0.5cm"
"begin–pspicture"(-6,-5) (4,12)
"psset– lightsrc =10 20 30,viewpoint=50 20 25 rtp2xyz,Decran=50"
"psSolid[object=grille ,base=-6 6 -4 4,action=draw]
"defFunction–FuncI"(t)–t cos 4 mul"–t sin 2 mul"–"
"psSolid[object=prisme,h=8,fillcolor=green!20,
        base=0 350 –FuncI" CourbeR2+]%
"defFunction–FuncII"(t)–t cos 4 mul"–t sin 2 mul"–8"
"psSolid[object=courbe,r=0,
   function=FuncII,range=0 360,
   linewidth=2"pslinewidth,
    linecolor =green]
"axesIIID(6,4,8) (8,6,10)
"end–pspicture"
```

Example 3: a right prism with a star-shaped section



```
"psset-unit=0.5cm"
"psset- lightsrc =10 -20 50,viewpoint=50 -20 30 rtp2xyz,Decran=50"
"begin-pspicture*"(-5,-4) (6,9)
"defFunction-F"(t)-3 t cos 3 exp mul"-3 t sin 3 exp mul"-"
"psSolid[object=grille ,base=-4 4 -4 4,action=draw]%
"psSolid[object=prismecreux,h=8,fillcolor=red!50,
        resolution =36,
        base=0 350 -F" CourbeR2+
      ]%
"end-pspicture*"
```

Example 5: a roof gutter with a semi-circular section




```
"psset-unit=0.35cm"
"psset-lightsrc=10 20 30,viewpoint=50 30 25 rtp2xyz,Decran
    =50"
"begin-pspicture"(-10,-5)(6,10)
"defFunction[algebraic]-F"(t)
  -3*cos(t)"-3*sin(t)"-"
"defFunction[algebraic]-G"(t)
  -2.5*cos(t)"-2.5*sin(t)"-"
"psSolid[object=grille,
  base=-6 6 -6 6,action=draw]%
"psSolid[object=prisme,h=12,
   fillcolor=blue!30,RotX=-90,
  resolution=19,
  base=0 pi -F" CourbeR2+
  pi 0 -G" CourbeR2+](0,-6,3)
"axesIIID(6,6,2)(8,8,8)
"end-pspicture"
```

We draw the exterior face (semicircle of radius 3 cm) in counterclockwise order: 0 pi –F″ CourbeR2+ Then the interior face (semicircle of radius 2.5 cm), is drawn in clockwise order: pi 0 –G″ CourbeR2+

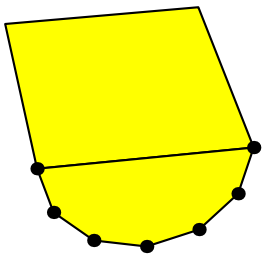
We can turn the solid -90^o and place it at the point $(0, -6, 3)$. If we use the algebraic option to define the functions F and G, the functions sin and cos are in radians.

The parameter decal

We wrote above that the first four vertices must be given in counterclockwise order with respect to the barycentre of the vertices of the base. In fact, this is the default version of the following rule: If the base has $n + 1$ vertices, and if G is their barycentre, then (s_0, s_1) on one hand and (s_{n-1}, s_n) on the other, should be in counterclockwise order with respect to G.

This rule puts constraints on the coding of the base of a prism which sometimes renders the latter unaesthetically. For this reason we have introduced the argument decal (default value= -2) which allows us to consider the list of vertices of the base as a circular file which you will shift round if needed.

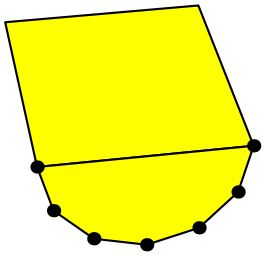
An example: default behavior with decal=-2:



```
"psset-unit=0.5"
"begin-pspicture"(-6,-4)(6,7)
"defFunction-F"(t)-t cos 3 mul"-t sin 3 mul"-"
"psSolid[object=prisme,h=8,
        fillcolor=yellow,RotX=-90,
       num=0 1 2 3 4 5 6,
       show=0 1 2 3 4 5 6,
       resolution=7,
       base=0 180 -F" CourbeR2+
       ](0,-10,0)
"end-pspicture"
```

We see that the vertex with index 0 is not where we expect to find it.

We start again, but this time suppressing the renumbering:

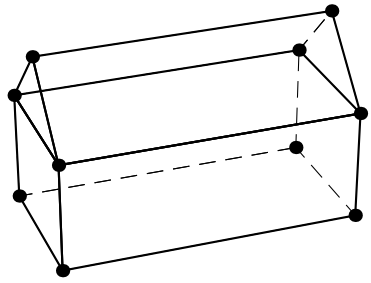


```
"psset-unit=0.5"
"begin-pspicture"(-6,-4) (6,7)
"defFunction-F"(t)-t cos 3 mul"-t sin 3 mul"-"
"psSolid[object=prisme,h=8,
        fillcolor =yellow,RotX=-90,
       decal=0,
       num=0 1 2 3 4 5 6,
       show=0 1 2 3 4 5 6,
       resolution=7,
       base=0 180 -F" CourbeR2+
       ](0,-10,0)
"end-pspicture"
```

7.6. Construction from scratch

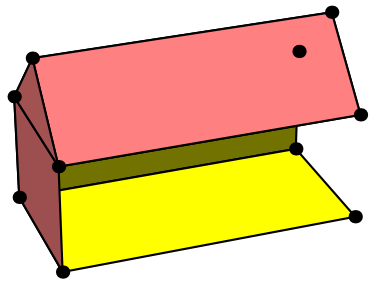
The object new constructs a solid. Two parameters are used: sommets which indicates the list of coordinates of the different vertices, and faces which gives the list of faces of the solid; a face is characterized by a list of the indices of itsvertices, listed in counterclockwise order when the face is viewed from the exterior of the solid.

7.6.1. Example 1: a house



```
"psset-unit=0.5"
"psset- lightsrc =10 -20 50,viewpoint=50 -20 30 rtp2xyz,Decran=50"
"begin-pspicture*"(-7,-4) (7,7)
"psSolid[object=new,
  sommets=
    2  4  3   -2  4  3  -2 -4  3   2 -4  3
    2  4  0   -2  4  0  -2 -4  0   2 -4  0
    0  4  5    0 -4  5,
  faces=-
  [0 1 2 3] [7 6 5 4] [0 3 7 4]
  [3 9 2]   [1 8 0]   [8 9 3 0]
  [9 8 1 2] [6 7 3 2] [2 1 5 6]",
  num=all,show=all,action=draw]
"end-pspicture*"
```

Note that the solid new uses the same options as the other solids. For example, we give the same solid as above below, using the parameters hollow, incolor, fillcolor, and rm.



```
"psset-unit=0.5"
"psset- lightsrc =10 -20 50,viewpoint=50 -20 30 rtp2xyz,Decran=50"
"begin-pspicture*"(-7,-3.5) (7,7.5)
"psSolid[object=new, fillcolor =red!50,incolor=yellow,
  action=draw**,hollow,rm=2,
  sommets=
    2  4  3  -2  4  3  -2 -4  3   2 -4  3
    2  4  0  -2  4  0  -2 -4  0   2 -4  0
    0  4  5   0 -4  5,
  faces=-   [0 1 2 3][7 6 5 4][0 3 7 4]
    [3 9 2]   [1 8 0]   [8 9 3 0][9 8 1 2]
    [6 7 3 2][2 1 5 6]",
  num=all,show=all]
"end-pspicture*"
```

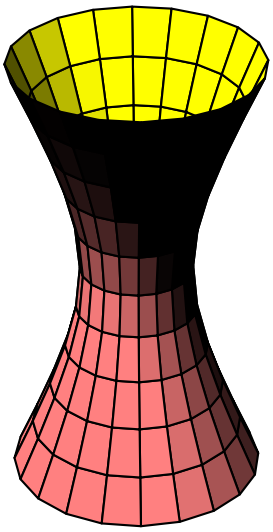
7.6.2. Example 2: a hyperboloid with a fixed radius

As always, the options of the macro \psSolid can handle Postscript code, even *jps code*

Unlike an example in pure PostScript, where we use the parameters a, b and h which are transmitted by the options of PSTricks. In this way one obtains a variable solid constructed from scratch.

Remark: the code being used comes from a *jps* source used in practice, as in:

http://melusine.eu.org/lab/bjps/solide/tour.jps

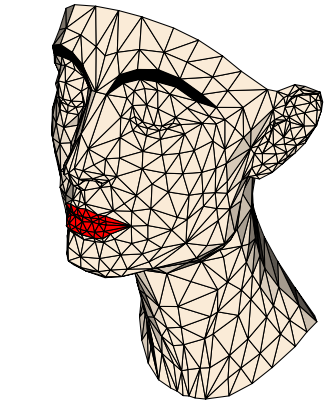


```
"psset-unit=0.75"
"psset-lightsrc=10 -20 50,viewpoint=50 -20 30 rtp2xyz,Decran=50"
"begin-pspicture*"(-5,-5) (3,5)
"psSolid[object=new,fillcolor=red!50,incolor=yellow,
  hollow, a=10, %% nb d'etages
  b=20, %% diviseur de 360, nb de meridiens
  h=8, %% hauteur
  action=draw**,sommets=
   /z0 h neg 2 div def
   a -1 0 -
    /k exch def
    0 1 b 1 sub -
     /i exch def
     /r z0 h a div k mul add dup mul 4 div 1 add sqrt def
     360 b idiv i mul cos r mul 360 b idiv i mul sin r mul
     z0 h a div k mul add
    " for
   " for,
   faces=-
    0 1 a 1 sub -
    /k exch def
    k b mul 1 add 1 k 1 add b mul 1 sub -
    /i exch def
    [i i 1 sub b i add 1 sub b i add]
   " for
   [k b mul k 1 add b mul 1 sub k 2 add b mul 1 sub k 1 add b mul
        ]
  " for
"]
"end-pspicture*"
```

7.6.3. Example 3: importing external files

From a file describing a solid in a particular format (other than .obj or .off), we can create a .dat file containing the coordinates of the vertices, and another .dat file containing the tables of indices of the vertices on each face. These files can then be entered as parameters sommets and faces when using the PostScript instruction run.

In the example below, the files sommets˙nefer.dat and faces˙nefer.dat have been placed in the directory of the compiler.



```
“psset–unit=0.4”
“definecolor–AntiqueWhite”–rgb”–0.98,0.92,0.84”
“begin–pspicture”(-7,-9) (7,7)
“psset– lightsrc =30 -40 10”
“psset–viewpoint=50 -50 20 rtp2xyz,Decran=50”
“psset–RotX=90,sommets= (data/sommets˙nefer.dat) run”
“psSolid[object=new, fillcolor =AntiqueWhite,linewidth=0.5“pslinewidth,
    faces=–(data/faces˙nefer.dat) run”]%
“psSolid[object=new, fillcolor =red,linewidth=0.5“pslinewidth,
    faces=–(data/faces˙nefer˙ levres .dat) run”]%
“psSolid[object=new, fillcolor =black,
    faces=–(data/faces˙nefer˙ sourcils .dat) run”]%
“end–pspicture”
“ hfill
“begin–pspicture”(-7,-9) (7,7)
“psset– lightsrc =-10 -40 -5, lightintensity =.5”
“psset–viewpoint=50 -80 10 rtp2xyz,Decran=50”
“psset–RotX=90,RotZ=30,sommets= (data/sommets˙nefer.dat) run”
“psSolid[object=new, fillcolor =AntiqueWhite,linewidth=0.5“pslinewidth,
  grid , faces=–(data/faces˙nefer.dat) run”]
“psSolid[object=new, fillcolor =red,linewidth=0.5“pslinewidth,grid,
    faces=–(data/faces˙nefer˙ levres .dat) run”]
“psSolid[object=new, fillcolor =black,
    faces=–(data/faces˙nefer˙ sourcils .dat) run”]
“end–pspicture”
```

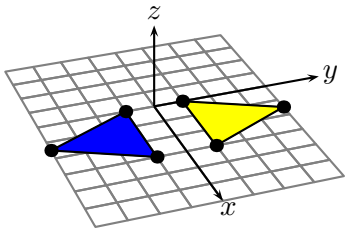
7.7. One- and two-sided solids

The contour of face is defined in the plane Oxy by

“psSolid[object=face,base=x1 y1 x2 y2 x3 y3 ...xn yn](0,0,0)%

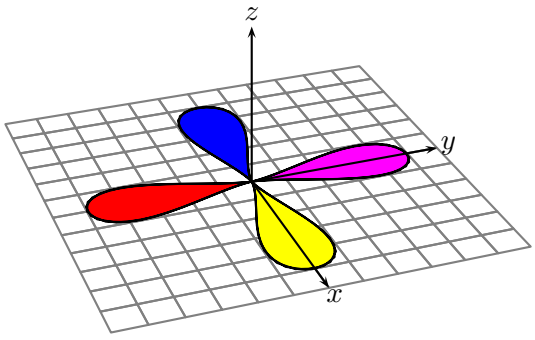
The edge of face is defined in the plane Oxy by the coordinates of its vertices, given in counterclockwise order by the parameter base:

7.7.1. **Triangular** ‘faces’




```
“psset–unit=0.4″
“psset–viewpoint=50 -20 30 rtp2xyz,Decran=50″
“begin–pspicture ″(-5.5,-4.5) (7,3.5)
“psSolid[object=grille,base=-4 6 -4 4,action=draw,linecolor=gray
    ](0,0,0)
“psSolid[object=face, fillcolor =yellow,action=draw*,
  incolor=blue,biface,base=0 0 3 0 1.5 3,
  num=all,show=all](0,1,0)
“psSolid[object=face, fillcolor =yellow,
  action=draw*,incolor=blue,
  base=0 0 3 0 1.5 3,num=all,
  show=all,biface,RotX=180](0,-1,0)
“axesIIID(0,0,0) (6,6,3)
“end–pspicture″
```

7.7.2. ‘face’ **defined by a function**



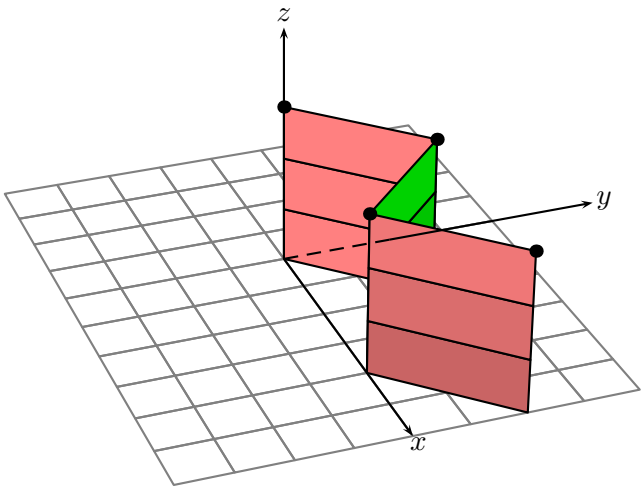

```
“psset–unit=0.45″
“psset–viewpoint=50 -20 30 rtp2xyz,Decran=50″
“def“BASE–0 10 360–/Angle ED 5 Angle cos dup mul mul %
      x
 3 Angle cos 3 exp Angle sin mul mul ″ for″% y
“begin–pspicture ″(-7,-5.5) (9,6)
“defFunction[algebraic]–F″(t)–5*(cos(t))^2″
   –3*(sin(t))*(cos(t))^3″–″
“psSolid[object=grille,base=-6 6 -6 6,action=draw,linecolor
    =gray](0,0,0)
“psSolid[object=face, fillcolor =magenta,action=draw*,
  incolor=blue,biface,RotZ=90,
  base=0 2 pi mul –F″ CourbeR2+](0,0,0)
“psSolid[object=face, fillcolor =yellow,action=draw*,
  incolor=blue,biface,
  base=0 2 pi mul –F″ CourbeR2+](0,0,0)
“psSolid[object=face, fillcolor =yellow,action=draw*,
  incolor=blue,biface,RotY=180,
  base=0 2 pi mul –F″ CourbeR2+](0,0,0)
“psSolid[object=face, fillcolor =yellow,action=draw*,
  incolor=red,biface,RotY=180,RotZ=90,
  base=0 2 pi mul –F″ CourbeR2+](0,0,0)
“axesIIID(0,0,0) (6,6,5)
“end–pspicture″
```

7.8. Solid strip

The strip is a folding screen positioned horizontally on the floor. The base of the folding screen is defined in the plane Oxy by the coordinates of its vertices by the parameter base:

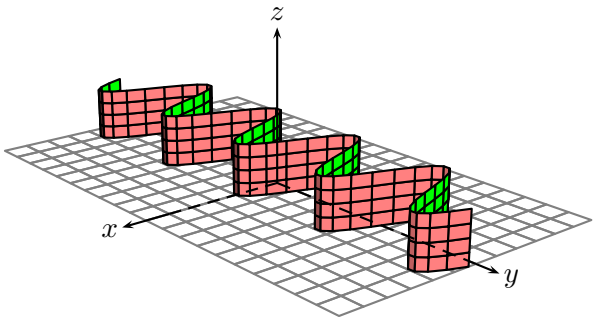
“psSolid[object=ruban,h=3,base=x1 y1 x2 y2 x3 y3 ...xn yn,ngrid=n](0,0,0)%

7.8.1. A simple folding screen




```
"psset-lightsrc=10 0 10,viewpoint=50 -20 30
    rtp2xyz,Decran=50,unit=0.75"
"begin-pspicture"(-5.5,-4.5) (7,5)
"psSolid[object=grille,base=-4 6 -4 4,action=
    draw,linecolor=gray](0,0,0)
"psSolid[object=ruban,h=3,fillcolor=red!50,
      base=0 0 2 2 4 0 6 2,
      num=0 1 2 3,
      show=0 1 2 3,
      ngrid=3
      ](0,0,0)
"axesIIID(0,2,0) (6,6,4.5)
"end-pspicture"
```

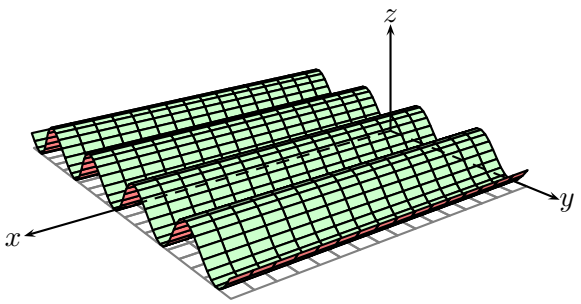
7.8.2. A sinusoidal folding screen




```
"psset-unit=0.35"
"begin-pspicture"(-10,-6) (12,8)
"defFunction-F"(t)-2 t 4 mul cos mul"-t 20 div"-"
"psSolid[object=grille,base=-6 6 -10 10,action=draw,
    linecolor=gray](0,0,0)
"psSolid[object=ruban,h=2,fillcolor=red!50,
      resolution=72,
      base=-200 200 -F" CourbeR2+, %% -200 5 200
          -/Angle ED 2 Angle 4 mul cos mul Angle
          20 div " for,
      ngrid=4](0,0,0)
"axesIIID(5,10,0) (7,11,6)
"end-pspicture"
```

7.8.3. A corrugated surface

This is the same object as before with an additional rotation of 90° around Oy.




```
"psset-unit=0.4"
"begin-pspicture"(-14,-7) (8,5)
"defFunction-F"(t)-t 4 mul cos"-t 20 div"-"
"psSolid[object=grille,base=0 16 -10 10,action=draw,
    linecolor=gray](0,0,0)
"psSolid[object=ruban,h=16,fillcolor=red!50,RotY
    =90,incolor=green!20,
      resolution=72,
      base=-200 200 -F" CourbeR2+,
      ngrid=16](0,0,1)
"axesIIID(16,10,0) (20,12,6)
"end-pspicture"
```

We can then imagine it to be like a corrugated iron roof of a shed.

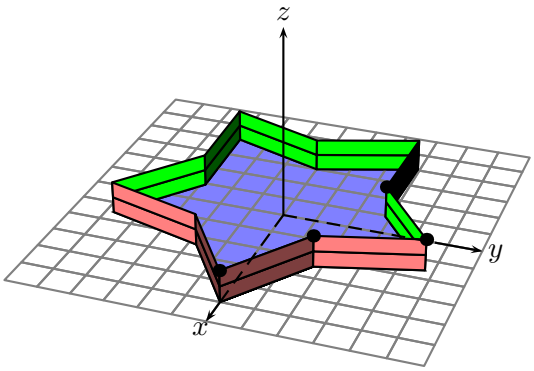
7.8.4. An asteroidal folding screen: version 1

The contour of the folding screen is defined within a loop:

```
base=0 72 360 -/Angle ED 5 Angle cos mul 5 Angle sin mul
    3 Angle 36 add cos mul 3 Angle 36 add sin mul" for
```

the blueish surface on the bottom is defined with the help of a polygon, where the vertices are calculated by the command
"psPoint(x,y,z)-P"

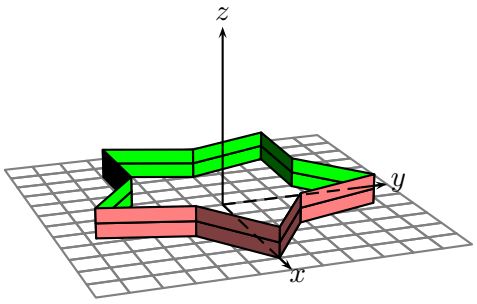
```
"multido-"iA=0+72,"iB=36+72,"i=0+1"-6"-%
   "psPoint("iA"space cos 5 mul,"iA"space sin 5 mul,0)-P"i"
   "psPoint("iB"space cos 3 mul,"iB"space sin 3 mul,0)-p"i"
   "%
"pspolygon[fillstyle=solid,fillcolor=blue!50](P0)(p0)(P1)(p1)(P2)(p2)
                                              (P3)(p3)(P4)(p4)(P5)(p5)
```




```
"psset-unit=0.45"
"begin-pspicture"(-9,-5) (9,7)
"multido-"iA=0+72,"iB=36+72,"i=0+1"-6"-%
    "psPoint("iA"space cos 5 mul,"iA"space sin 5 mul,0)-P"i
        "
    "psPoint("iB"space cos 3 mul,"iB"space sin 3 mul,0)-p"i
        "
    "%
"pspolygon[ fillstyle =solid, fillcolor =blue!50](P0)(p0)(P1)(p
    1)(P2)(p2)(P3)(p3)(P4)(p4)(P5)(p5)
"defFunction-F"(t)-t cos 5 mul"-t sin 5 mul"-"
"defFunction-G"(t)-t 36 add cos 3 mul"-t 36 add sin 3 mul
    "-"
"psSolid[object=grille ,base=-6 6 -6 6,action=draw,linecolor
    =gray](0,0,0)
"psSolid[object=ruban,h=1,fillcolor=red!50,
      base=0 72 360 -/Angle exch def Angle F Angle G" for,
      num=0 1 2 3,show=0 1 2 3,ngrid=2](0,0,0)
"axesIIID(5,5,0) (6,6,6)
"end-pspicture"
```

7.8.5. An asteroidal folding screen: version 2

The bottom of the pot is defined by the object face with the option biface:




```
“psset–unit=0.4″
“begin–pspicture″(-9,-4) (9,7)
“defFunction–F″(t)–t cos 5 mul″–t sin 5 mul″–″
“defFunction–G″(t)–t 36 add cos 3 mul″–t 36 add sin 3 mul
    ″–″
“psSolid[object=face, fillcolor =blue!50,biface,
      base=0 72 360 –/Angle exch def Angle F Angle G″ for
          ,](0,0,0)
“psSolid[object=grille,base=-6 6 -6 6,action=draw,linecolor
    =gray](0,0,0)
“psSolid[object=ruban,h=1,fillcolor=red!50,
      base=0 72 360 –/Angle exch def Angle F Angle G″ for,
      ngrid=2](0,0,0)
“axesIIID(5,5,0) (6,6,6)
“end–pspicture″
```

7.9. Solid rings

This paragraph discusses the cylindric rings. Within the macro \psSolid, this object is passed with the option: object=anneau, that comes with 3 parameters:

- the inner radius r=1.5 (value by default);
- the outer radius R=4 (value by default);
- the height h=6 (value by default).

The argument ngrid defines the number of sections used to make a complete rotation of 360 degrees. Its default value is 24.

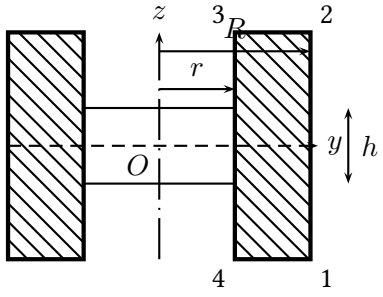
The section of the ring, whose shape is *rectangular* was chosen as default, and can be redesigned by the user. We will discuss different examples of sections for rings.

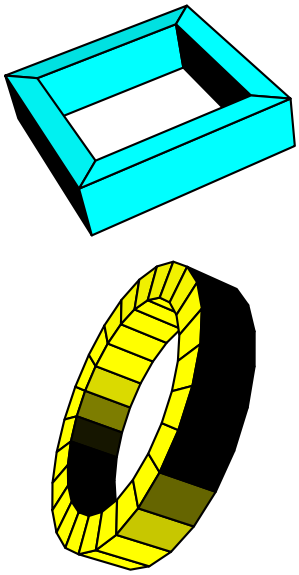
7.9.1. Predefined command: the ring with a rectangular section

This section is defined in the plane Oyz, it is parameterized with the triple (r, R, h). The values of the outer radius R, inner radius r and the height h are passed in the macro \psSolid. By default, one has a ring with a variable rectangular section, and the definition takes place at the time of the transmission of the values (r, R, h) into the options of \psSolid.

If the user redefines the TEX macro “Section with some numeric values instead of the parameters r, R and h, then the ring won't be variable anymore and it is not necessary to transmit the values r, R, and h into the options of \psSolid.

```
“newcommand“Section–%
% y z
  R h 2 div neg % sommet 1
  % S1 (R,-h/2)
  R h 2 div     % sommet 2
  % S2 (r,h/2)
  r h 2 div     % sommet 3
  % S3 (r,h/2)
  r h 2 div neg % sommet 4
  % S4 (r,-h/2)
          ″
```

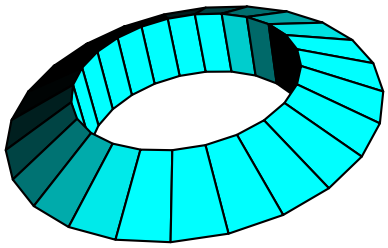




```
“psset–unit=0.5”
“begin–pspicture”(-5,-4) (5,4)
“psset[pst-solides3d]–viewpoint=50 20 40 rtp2xyz,
  Decran=25,lightsrc=10 20 20”
“psSolid[object=anneau,fillcolor=cyan,
  h=3,R=8,r=6,ngrid=4,RotX=10](0,0,0)
“end–pspicture”“
“begin–pspicture”(-5,-4) (5,4)
“psset[pst-solides3d]–viewpoint=50 -20 -40 rtp2xyz,
  Decran=25,lightsrc=-10 -20 -20”
“psSolid[object=anneau,
 fillcolor =yellow,h=3,R=8,r=6,
RotX=90,RotZ=10](0,0,0)
“end–pspicture”
```

7.9.2. Example 1: a simple ring with a triangular section

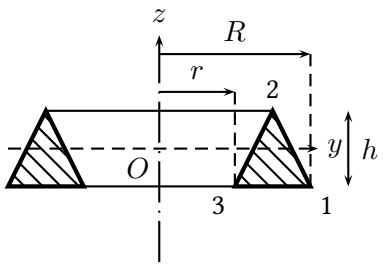
Below is a very simple ring with a fixed triangular section. The section is defined by 3 points $(6,-2)$, $(10,0)$ and $(6,2)$ within the option section of \psSolid.

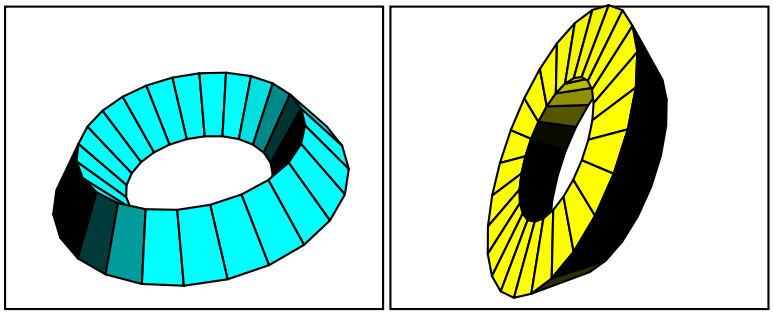


```
“psset–unit=0.5”
“begin–pspicture”(-5,-6) (5,6)
“psset[pst-solides3d]–viewpoint=50 20 40 rtp2xyz,Decran=25,
    lightsrc=10 20 20”
“psSolid[object=anneau,
   section=6 -2 10 0 6 2,
    fillcolor =cyan,RotX=10]%
“end–pspicture”
```

7.9.3. Example 2: a ring with a variable triangular section

```
“newcommand“SectionTriangulaire–
% y ¡----z----¿
  R h 2 div neg
  % S1 (R,-h/2)
  R r add 2 div h 2 div
  % S2 ((R+r)/2,h/2)
  r h 2 div neg
  % S3 (r,-h/2)
”
```

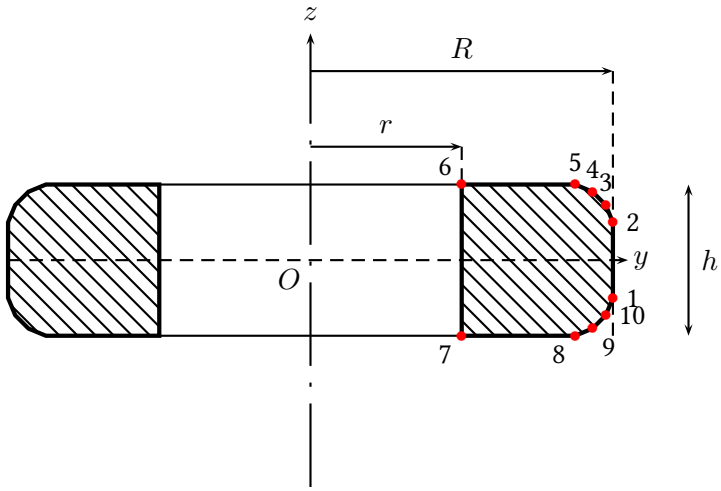


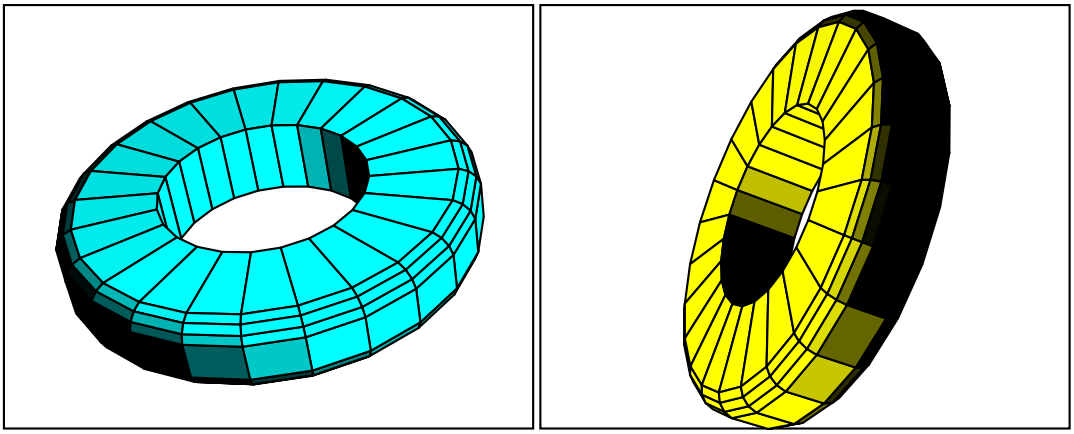


“psSolid[object=anneau,section=“SectionTriangulaire,%
fillcolor=cyan,h=3,R=8,r=4,RotX=10](0,0,0)
“psSolid[object=anneau,section=“SectionTriangulaire,%
fillcolor=yellow,h=3,R=8,r=4,RotX=-90,RotZ=10](0,0,0)

7.9.4. Example 3: a ring with a“tyre”-like section: cylindric ring with chamfered edges

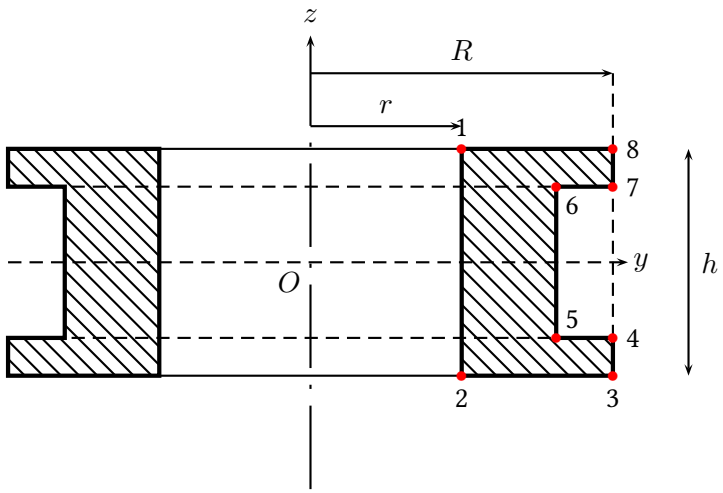
“renewcommand“SectionPneu–
/m –90 4 div″ bind def
/Scos –m cos 2 m mul cos add 3 m mul cos add″ bind def
/Z0 –h 4 div″ bind def
/c –Z0 Scos div″ bind def
/Z1 –Z0 c m cos mul add″ bind def
/Z2 –Z1 c m 2 mul cos mul add″ bind def
/R1 –R c m sin mul sub″ bind def
/R2 –R1 c m 2 mul sin mul sub″ bind def
/R3 –R2 c m 3 mul sin mul sub″ bind def
R h 4 div neg % 1
R h 4 div % 2
R1 Z1 % 3
R2 Z2 % 4
R3 h 2 div % 5
r h 2 div % 6
r h 2 div neg % 7
R3 h 2 div neg % 8
R2 Z2 neg % 9
R1 Z1 neg % 10
″



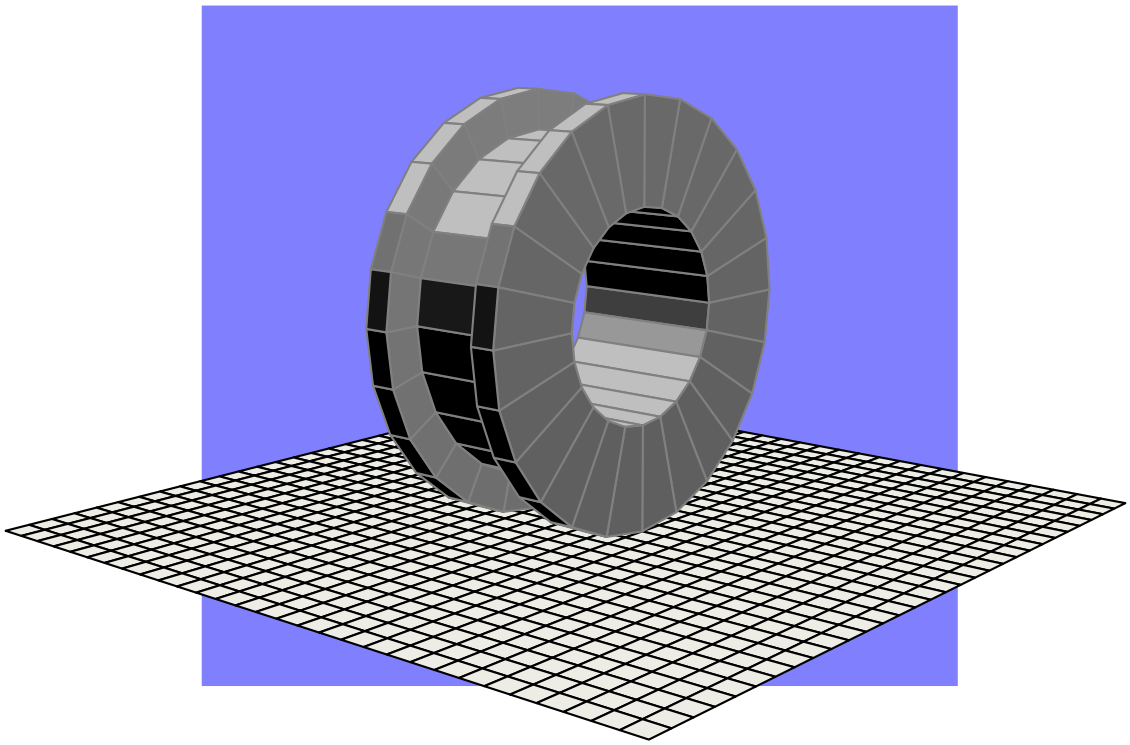


“psSolid[object=anneau,section=“SectionPneu,%
fillcolor=cyan,h=3,R=8,r=4,RotX=10](0,0,0)
“psSolid[object=anneau,section=“SectionPneu,%
fillcolor=yellow,h=3,R=8,r=4,RotX=-90,RotZ=10]%

7.9.5. Example 4: an empty bobbin




```
“newcommand“SectionBobine–
  r h 2 div % 1
  r h 2 div neg % 2
  R h 2 div neg % 3
  R h 3 div neg % 4
  R h 4 div sub h 3 div neg % 5
  R h 4 div sub h 3 div % 6
  R h 3 div % 7
  R h 2 div % 8
  ”
```



```
“psSolid[object=grille,base=-15 15 -15 15,fillcolor=yellow!30](0,0,-8)
“psSolid[object=anneau,section=“SectionBobine,%
        fillcolor=gray!50,h=6,R=8,r=4,RotX=90,linecolor=gray]%
```

7.9.6. Some other rings

Three other examples are available on the website:
http://syracuse.eu.org/lab/bpst/pst-solides3d/anneaux

7.10. Generalization of the notion of a cylinder and a cone

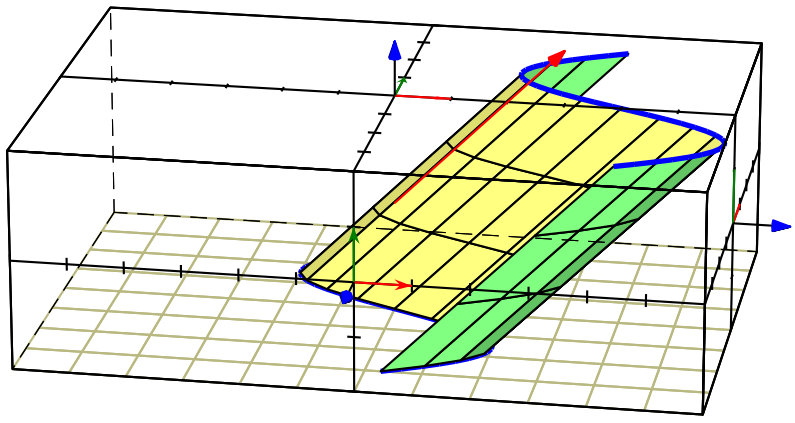
7.10.1. Cylinder or cylindric area

This paragraph generalizes the notion of a cylinder, or a cylindric area[1]. A *routing* curve has to be defined by a function and the direction of the *cylinder* axis needs to be arranged. In the example below the routing curve is sinusoidal, situated in the plane $z = -2$:

```
“defFunction[algebraic]–G1″(t)–t″–2*sin(t)″–-2″
```

The direction of the cylinder is defined by the components of a vector axe=0 1 1. The drawing calls object=cylindre which in addition to the usual parameters—which is the height h=4— is about the **length of the generator** and not of the distance between the two base planes, and needs to define the routing curve function=G1 and the interval of the variable t range=-3 3.

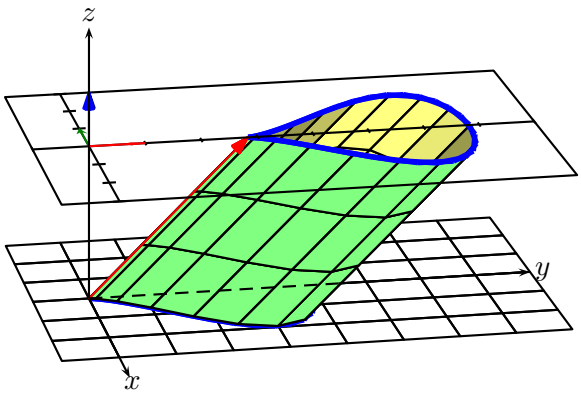
```
“psSolid[object=cylindre,
  h=4,function=G1,
  range=-3 3,
  ngrid=3 16,
  axe=0 1 1,
  incolor=green!50,
  fillcolor=yellow!50]
```



In the following example, before drawing the horizontal planes, we calculate the distance between these two planes.

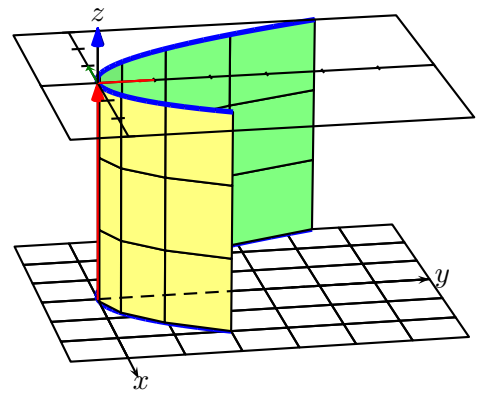
```
“pstVerb–/ladistance 2 sqrt 2 mul def″
```

[1] This was written by Maxime Chupin, as a result of a question on the list http://melusine.eu.org/cgi-bin/mailman/listinfo/syracuse

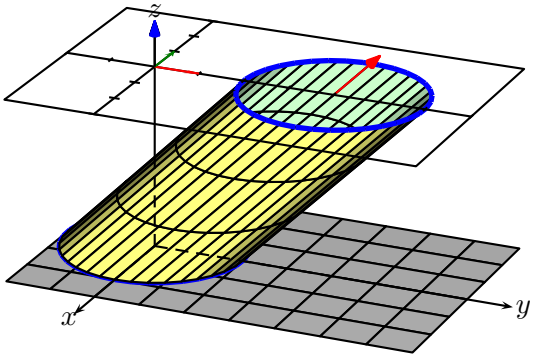


axe=0 1 1

```
“begin–pspicture ”(-1.5,-3) (6.5,6)
“psSolid[object=grille ,base=-3 3 -1 8,action=draw]
“pstVerb–/ladistance 2 sqrt 2 mul def”
“defFunction[algebraic]–G3”(t)–6*(cos(t))^3*sin(t)”–4*(cos(t))^2”–0”
“defFunction[algebraic]–G4”(t)–6*(cos(t))^3*sin(t)”–4*(cos(t))^2+ladistance”–ladistance”
“psSolid[object=courbe,function=G3,range=0 6.28,r=0,linecolor=blue,linewidth=2pt]
“psSolid[object=cylindre,range=0 -6.28,h=4,function=G3,axe=0 1 1,ngrid=3 36,
    fillcolor =green!50,incolor=yellow!50]
“psSolid[object=courbe,function=G4,range=0 6.28,r=0,linecolor=blue,linewidth=2pt]
“psSolid[object=vecteur,linecolor=red,args=0 ladistance dup]
“psSolid[object=plan,action=draw,definition=equation,args=–[0 0 1 ladistance neg] 90”,
  base=-1 8 -3 3,planmarks,showBase]
“axesIIID(0,4.5,0) (4,8,5)
“rput(0,-3)–“texttt–axe=0 1 1””
“end–pspicture”
```

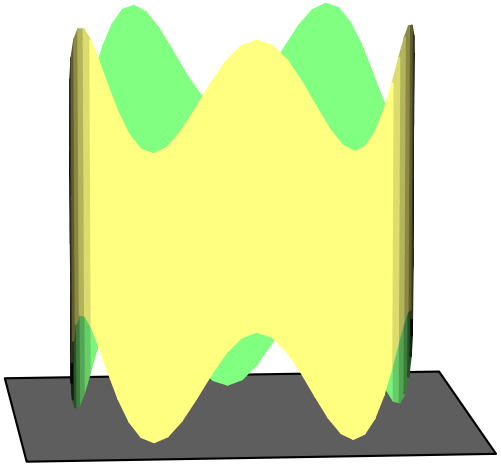



```
“psset–unit=0.75,lightsrc=viewpoint,
  viewpoint=100 -10 20 rtp2xyz,Decran=100″
“begin–pspicture″(-1.5,-3) (6.5,6)
“psSolid[object=grille,base=-3 3 -1 6,action=draw]
“defFunction[algebraic]–G5″(t)
  –t″–0.5*t^2″–0″
“defFunction[algebraic]–G6″(t)
  –t″–0.5*t^2″–4″
“psSolid[object=courbe,function=G5,
  range=-3 2,r=0,linecolor=blue,
  linewidth=2pt]
“psSolid[object=cylindre,
  range=-3 2,h=4,
  function=G5,
  axe=0 0 1, %% valeur par d“’–e″faut
  incolor=green!50,
   fillcolor =yellow!50,
  ngrid=3 8]
“psSolid[object=courbe,function=G6,
  range=-3 2,r=0,linecolor=blue,
  linewidth=2pt]
“axesIIID(0,4.5,0) (4,6,5)
“psSolid[object=vecteur,
   linecolor=red,args=0 0 4]
“psSolid[object=plan,action=draw,
   definition=equation,
  args=–[0 0 1 -4] 90″,
  base=-1 6 -3 3,planmarks,showBase]
“end–pspicture″
```




```
“psset–unit=0.75,lightsrc=viewpoint,
  viewpoint=100 -10 20 rtp2xyz,Decran=100″
“begin–pspicture″(-3.5,-3) (6.5,6)
“psset– lightsrc=viewpoint,viewpoint=100 45 45,Decran
      =100″
“psSolid[object=grille,base=-3 3 -2 7, fillcolor =gray!30]
“defFunction[algebraic]–G7″(t)
   –2*cos(t)″–2*sin(t)″–0″
“defFunction[algebraic]–G8″(t)
     –2*cos(t)″–2*sin(t)+4″–4″
“psSolid[object=courbe,function=G7,
  range=0 6.28,r=0,
   linecolor=blue,linewidth=2pt]
“psSolid[object=cylindre,
  range=0 6.28,h=5.65685,
  function=G7,axe=0 1 1,
  incolor=green!20,
   fillcolor =yellow!50,
  ngrid=3 36]
“psSolid[object=courbe,function=G8,
  range=0 6.28,r=0,linecolor=blue,
  linewidth=2pt]
“axesIIID(2,4.5,2) (4,8,5)
“psSolid[object=vecteur,
   linecolor=red,args=0 1 1](0,4,4)
“psSolid[object=plan,action=draw,
   definition=equation,
  args=–[0 0 1 -4] 90″,
  base=-2 7 -3 3,planmarks,showBase]
“end–pspicture″
```

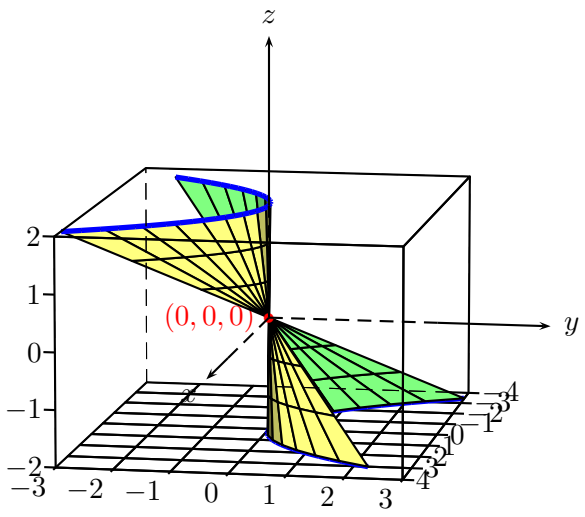
Note: The routing curve can be any curve and need not necessarily be a plane horizontal.



```
"begin-pspicture"(-3.5,-2) (4,5)
"psset-unit=0.75, lightsrc=viewpoint,viewpoint=100 -5 10
      rtp2xyz,Decran=100"
"psSolid[object=grille ,base=-4 4 -4 4,ngrid=8.
      8.](0,0,-1)
"defFunction[algebraic]-G9"(t)
  -3*cos(t)"-3*sin(t)"-1*cos(5*t)"
"psSolid[object=cylindre,
  range=0 6.28,h=5,function=G9,
  axe=0 0 1,incolor=green!50,
   fillcolor =yellow!50,
  ngrid=4 72,grid]
"end-pspicture"
```

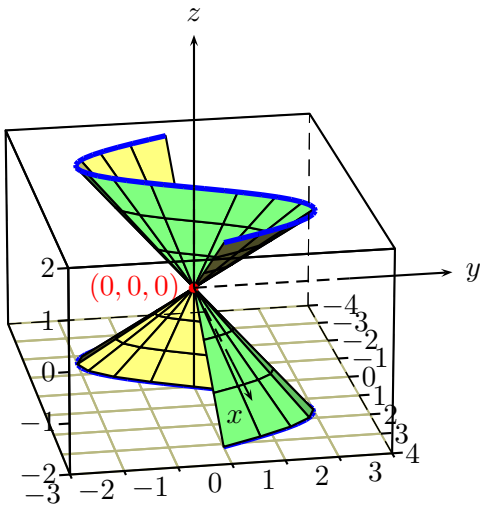
7.10.2. Cone or conic area

This paragraph generalizes the notion of a cone, or a conic area[2]. A *routing* curve needs to be defined by a function which defines the base of the cone, and the vertex of the *cone* which is by default origine=0 0 0. The parts above and below the cone are symmetric concerning the vertice. In the example below, the routing curve is a parabolic arc, situated in the plane $z = -2$.

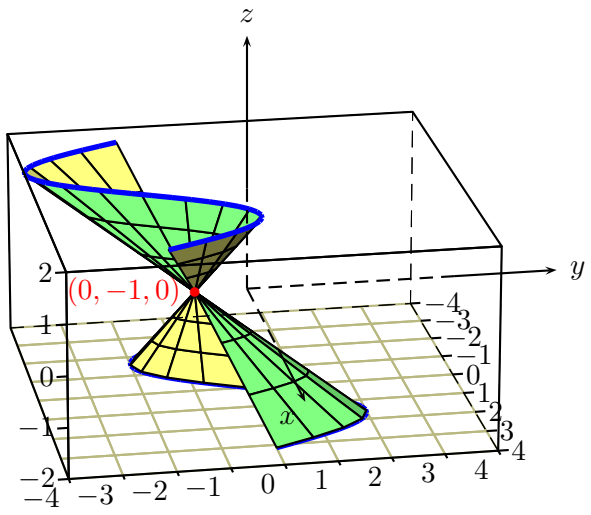



```
"begin-pspicture"(-3,-4) (4.5,6)
"psset-unit=0.75, lightsrc=viewpoint,viewpoint=100 10 10
     rtp2xyz,Decran=100"
"psSolid[object=grille ,base=-4 4 -3 3,action=draw](0,0,-2)
"defFunction[algebraic]-G1"(t)-t"-0.25*t^2"-2"
"defFunction[algebraic]-G2"(t)--t"--0.25*t^2"-2"
"psSolid[object=courbe,function=G1,
  range=-3.46 3,r=0,
   linecolor=blue,linewidth=2pt]
"psSolid[object=cone,function=G1,
  range=-3.46 3,ngrid=3 16,
  incolor=green!50,
   fillcolor =yellow!50,
  origine=0 0 0]
"psSolid[object=courbe,
  function=G2,range=-3.46 3,
   r=0,linecolor=blue,
   linewidth=2pt]
"psPoint(0,0,0)-I"
"uput[l](I)-"red$(0,0,0)$"
"psdot[linecolor=red](I)
"gridIIID[Zmin=-2,Zmax=2,spotX=r](-4,4)(-3,3)
"end-pspicture"
```

[2] This was written by Maxime Chupin, as the result of a question on the list http://melusine.eu.org/cgi-bin/mailman/listinfo/syracuse




```
"begin-pspicture"(-3,-4) (4.5,6)
"psset-unit=0.7, lightsrc =viewpoint,viewpoint=100 -10 20
    rtp2xyz,Decran=100"
"psSolid[object= grille ,base=-4 4 -3 3,
  linecolor =-[rgb]-0.72 0.72 0.5""",action=draw](0,0,-2)
"defFunction[algebraic]-G1"(t)-t"-2*sin(t)"--2"
"defFunction[algebraic]-G2"(t)--t"--2*sin(t)"-2"
"psSolid[object=courbe,function=G1,
   range=-3.14 3.14,r=0,
    linecolor =blue,
   linewidth=2pt]
"psSolid[object=cone,function=G1,
   range=-3.14 3.14,ngrid=3 16,
   incolor=green!50,
    fillcolor =yellow!50,
   origine=0 0 0]
"psSolid[object=courbe,
   function=G2,range=-3.14 3.14,
   r=0,linecolor=blue,
   linewidth=2pt]
"psPoint(0,0,0)-I" "uput[l](I)-"red$(0,0,0)$"
"psdot[linecolor=red](I)
"gridIIID[Zmin=-2,Zmax=2,spotX=r](-4,4)(-3,3)
"end-pspicture"
```




```
"begin-pspicture"(-3,-4) (4.5,6)
"psset-unit=0.7, lightsrc =viewpoint,viewpoint=100 -10 20
    rtp2xyz,Decran=100"
"psSolid[object= grille ,base=-4 4 -4 4, linecolor =-[rgb]-0.72
    0.72 0.5""",action=draw](0,0,-2)
"defFunction[algebraic]-G1"(t)-t"-2*sin(t)"--2"
"defFunction[algebraic]-G2"(t)--t"--2*sin(t)-2"-2"
"psSolid[object=courbe,function=G1,
   range=-3.14 3.14,r=0,
    linecolor =blue,
   linewidth=2pt]
"psSolid[object=cone,
   function=G1,range=-3.14 3.14,
   ngrid=3 16,incolor=green!50,
    fillcolor =yellow!50,
   origine=0 -1 0]
"psSolid[object=courbe,
   function=G2,range=-3.14 3.14,
   r=0,linecolor=blue,
   linewidth=2pt]
"psPoint(0,-1,0)-I""uput[l](I)-"red$(0,-1,0)$"
"psdot[linecolor=red](I)
"gridIIID[Zmin=-2,Zmax=2,spotX=r](-4,4)(-4,4)
"end-pspicture"
```

Note: For the cones as well, the routing curve can be any curve and need not necessarily be a plane horizontal curve, as the following example, written by Maxime Chupin, will show.

http://melusine.eu.org/lab/bpst/pst-solides3d/cone/cone-dir_02.pst

7.11. Parameterised surfaces

7.11.1. The method

The parameterised surfaces are setup as $[x(u,v), y(u,v), z(u,v)]$ and administered thanks to the macro \psSolid by the option object=surfaceparametree and defined either in *Reverse Polish Notation*(*RPN*):

```
"defFunction-shell"(u,v)-1.2 v exp u Sin dup mul v Cos mul mul"% x(u,v)
                        -1.2 v exp u Sin dup mul v Sin mul mul"% y(u,v)
                        -1.2 v exp u Sin u Cos mul mul"         % z(u,v)
```

or in *algebraic notation*:

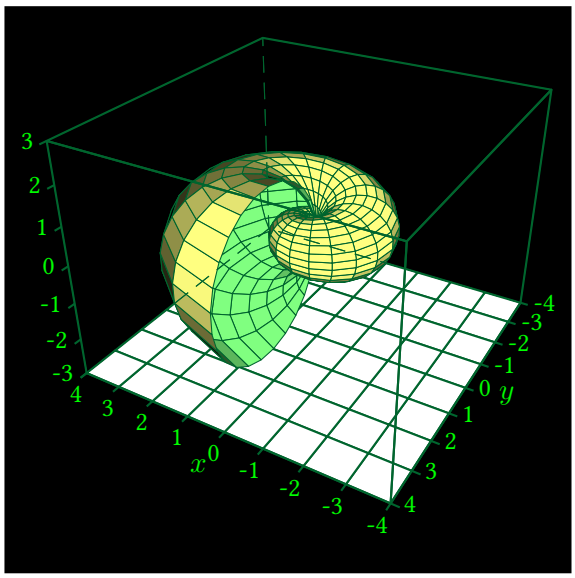
```
"defFunction[algebraic]-shell"(u,v)-1.2^v*(sin(u)^2*cos(v))"% x(u,v)
                                   -1.2^v*(sin(u)^2*sin(v))"% y(u,v)
                                   -1.2^v*(sin(u)*cos(u))"   % z(u,v)
```

The range for the values of u and v are defined within the option range=u_{min} u_{max} v_{min} v_{max}.

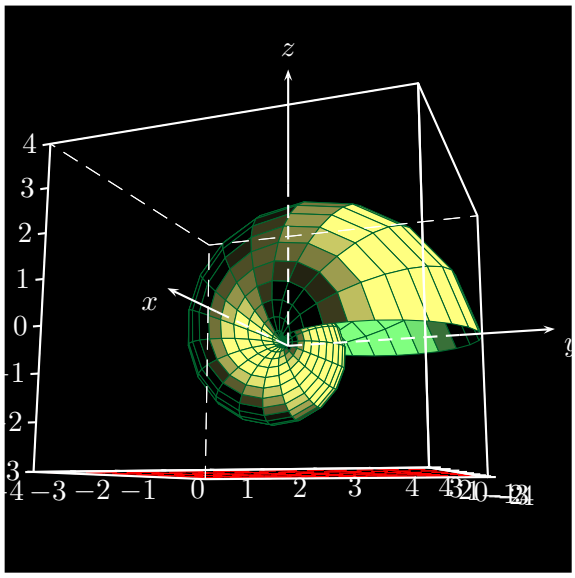
The drawing of the function is activated with function=name, this name is implied when the parametric equations are written: "defFunction-name"...

Any other choice of u and v are accepted. Let's remind that the argument of Sin and Cos must be in radians those of sin and cos in degrees if *RPN* is used. Within the algebraic notation, the argument is in radians.

7.11.2. Example 1: a sea shell

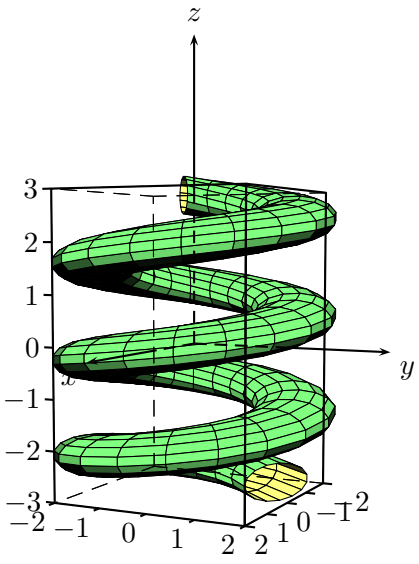



```
"psset-unit=0.75"
"begin-pspicture"(-5.5,-6) (4.5,4)
"psframe*(-5.5,-6) (4.5,4)
"psset[pst-solides3d]-viewpoint=20 120 30 rtp2xyz,
  Decran=15,lightsrc=-10 15 10"
% Parametric Surfaces
"psSolid[object=grille,base=-4 4 -4 4,
  action=draw*,linecolor=-[cmyk]-1,0,1,0.5""]
  (0,0,-3)
"defFunction-shell"(u,v)
  -1.2 v exp u Sin dup mul v Cos mul mul"
  -1.2 v exp u Sin dup mul v Sin mul mul"
  -1.2 v exp u Sin u Cos mul mul"
"psSolid[object=surfaceparametree,
  linecolor=-[cmyk]-1,0,1,0.5"",
  base=0 pi pi 4 div neg 5 pi mul 2 div,
  fillcolor=yellow!50,incolor=green!50,
  function=shell,linewidth=0.5"pslinewidth,ngrid=25]%
"psSolid[object=parallelepiped,a=8,b=8,c=6,
  action=draw,linecolor=-[cmyk]-1,0,1,0.5""]%
"quadrillage
"end-pspicture"
```



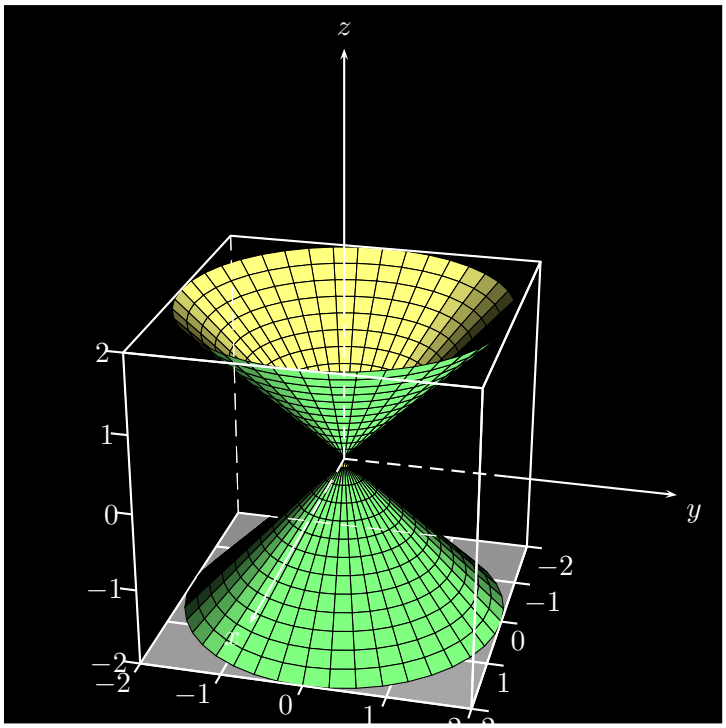

```
“psset–unit=0.75″
“begin–pspicture″(-5,-4) (5,6)
“psframe*(-5,-4) (5,6)
“psset[pst- solides 3d]–viewpoint=20 20 -10 rtp2xyz,
  Decran=15,lightsrc=5 10 2″
% Parametric Surfaces
“psSolid[object=grille,base=-4 4 -4 4,
  action=draw*,linecolor=red](0,0,-3)
“defFunction[algebraic]– shell ″(u,v)
  –1.21^v*(sin(u)*cos(u))″
  –1.21^v*(sin(u)^2*sin(v))″
  –1.21^v*(sin(u)^2*cos(v))″
%% “defFunction–shell″(u,v)
%%   –1.2 v exp u Sin u Cos mul mul″
%%   –1.2 v exp u Sin dup mul v Sin mul mul″
%%   –1.2 v exp u Sin dup mul v Cos mul mul″
“psSolid[object=surfaceparametree,
    linecolor =–[cmyk]–1,0,1,0.5″″,
    base=0 pi pi 4 div neg 5 pi mul 2 div,
     fillcolor =green!50,incolor=yellow!50,
    function=shell,linewidth=0.5“pslinewidth,
    ngrid=25]%
“white%
“gridIIID[Zmin=-3,Zmax=4,linecolor=white,
  QZ=0.5](-4,4)(-4,4)
“end–pspicture″
```

7.11.3. Example 2: a helix




```
“psset–unit=0.75″
“begin–pspicture″(-3,-4) (3,6)
“psset[pst- solides 3d]–viewpoint=20 10 2,Decran=20,
   lightsrc =20 10 10″
% Parametric Surfaces
“defFunction–helix″(u,v)
  –1 .4 v Cos mul sub u Cos mul 2 mul″
  –1 .4 v Cos mul sub u Sin mul 2 mul″
  –.4 v Sin mul u .3 mul add″
“psSolid[object=surfaceparametree,linewidth=0.5“pslinewidth,
  base=-10 10 0 6.28, fillcolor =yellow!50,incolor=green!50,
  function=helix,
  ngrid=60 0.4]%
“gridIIID[Zmin=-3,Zmax=3](-2,2)(-2,2)
“end–pspicture″
```

7.11.4. Example 3: a cone




```
“psset–unit=0.5″
“begin–pspicture″(-9,-7) (10,12)
“psframe*(-9,-7) (10,12)
“psset [pst- solides 3d]–
  viewpoint=20 5 10,
  Decran=50,lightsrc=20 10 5″
“psSolid [
  object= grille , base=-2 2 -2 2,
  linecolor =white](0,0,-2)
% Parametric Surfaces
“defFunction–cone″(u,v)
  –u v Cos mul″–u v Sin mul″–u″
“psSolid [object=surfaceparametree,
    base=-2 2 0 2 pi mul,
     fillcolor =yellow!50,
    incolor =green!50,function=cone,
    linewidth=0.5“pslinewidth,
    ngrid=25 40]%
“psset– linecolor =white″“white
“gridIIID [Zmin=-2,Zmax=2]
   (-2,2) (-2,2)
“end–pspicture″
```

7.11.5. An advised website

You will find on the website:

http://k3dsurf.sourceforge.net/

an excellent software to represent surfaces with numerous examples of parameterised surfaces and others.

8. Surfaces defined by a function of the form $z = f(x, y)$

8.1. Presentation

The command has the following form:

"psSurface[options](xmin,ymin)(xmax,ymax)–equation of the surface z=f(x,y)"
"psSurface*[options,r=...,xytranslate](xmin,ymin)(xmax,ymax)–equation of the surface z=f(x,y)"

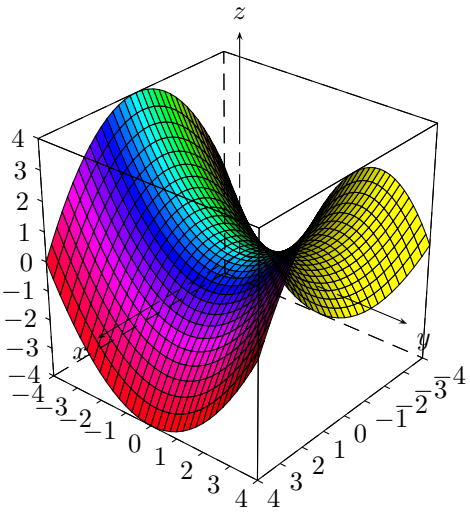
with the same options which apply to solids, and these additional ones:

- The surface grid is defined by the parameter ngrid=n1 n2, which has these specifics:
  - If n1 and/or n2 are integers, the number(s) represent(s) the number of grids following Ox and/or Oy.
  - If n1 and/or n2 are decimals, the number(s) represent(s) the incrementing steps following Ox and/or Oy.
  - If ngrid=n, with only one parameter value, the number of grids, or the incrementing steps, are identical on both axes.
  - r defines the length of an origin vector (radius) which controls the calculated points which must be inside the sphere, defined by the vector $\vec{r}$.
  - xytranslate= x y defines the translation of the vector in the $x - y$-plane.
- algebraic: this option allows you to write the function in algebraic notation; pstricks.pro meanwhile contains the code AlgToPs from Dominique Rodriguez, which allows this notation and which is included in the pstricks-add.pro file. This version of pstricks is provided with pst-solides3d. If necessary, you must load the pstricks-add package in the document preamble.
- grid: by default the grid is activated. If the option grid is used, the grid will be deactivated!
- axesboxed: this option allows you to draw the 3D coordinate axes in a semi-automatic way, but because of the need to specify the limits of z by hand this option is deactivated by default:
  - Zmin: minimum value;
  - Zmax: maximum value;
  - QZ: allows a vertical shift of the coordinate axes with the value QZ=value;
  - spotX: alters the placing of the x-axis tick values at the end of ticks, if the default behaviour is unsatisfactory. The positioning can be altered with the command "uput[angle](x,y)–ticklabel";
  - spotY: is similar;
  - spotZ: likewise.

If the option axesboxed doesn't meet your needs, it is possible to adapt the following command, which is appropriate for the first example:

```
“psSolid[object=parallelepiped,a=8,b=8,c=8,action=draw](0,0,0)
“multido–“ix=-4+1″–9″–%
    “psPoint(“ix“space,4,-4)–X1″
    “psPoint(“ix“space,4.2,-4)–X2″
    “psline(X1)(X2)“uput[dr](X1)–“ix″″
“multido–“iy=-4+1″–9″–%
    “psPoint(4,“iy“space,-4)–Y1″
    “psPoint(4.2,“iy“space,-4)–Y2″
    “psline(Y1)(Y2)“uput[dl](Y1)–“iy″″
“multido–“iz=-4+1″–9″–%
    “psPoint(4,-4,“iz“space)–Z1″
    “psPoint(4,-4.2,“iz“space)–Z2″
    “psline(Z1)(Z2)“uput[l](Z1)–“iz″″
```

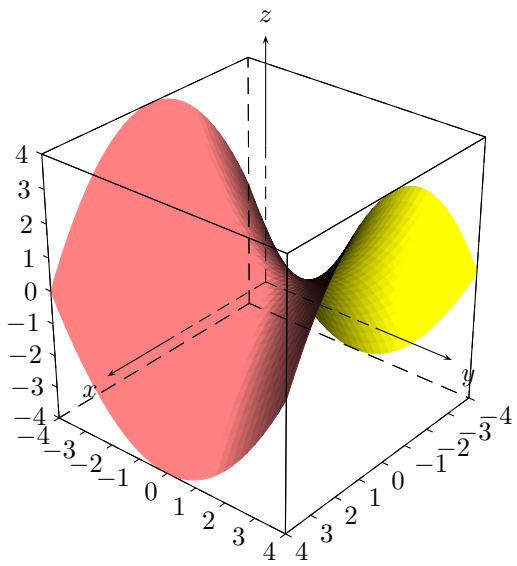
8.2. Example 1: a saddle




```
“psset–unit=0.45″
“psset–viewpoint=50 40 30 rtp2xyz,Decran=50″
“psset– lightsrc =viewpoint″
“begin–pspicture″(-7,-8) (7,8)
“psSurface[ngrid=.25 .25, incolor =yellow,
    linewidth=0.5“pslinewidth,axesboxed,
    algebraic ,hue=0 1](-4,-4) (4,4)–%
    ((y^2)-(x^2))/4 ″
“end–pspicture″
```

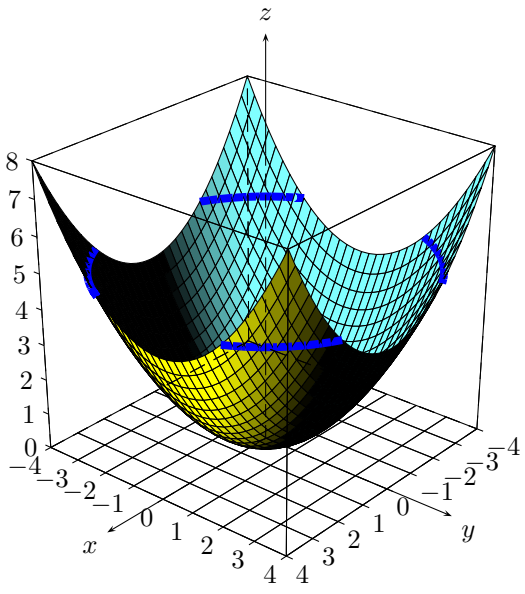
8.3. Example 2: a saddle without a grid

The grid lines are suppressed, when using in the option: grid.




```
"psset-unit=0.5"
"psset- lightsrc =30 30 25"
"psset-viewpoint=50 40 30 rtp2xyz,Decran=50"
"begin-pspicture"(-7,-8) (7,8)
"psSurface[ fillcolor =red!50,ngrid=.25 .25,
    incolor=yellow,linewidth=0.5"pslinewidth,
    grid,axesboxed](-4,-4) (4,4)-%
    y dup mul x dup mul sub 4 div "
"end-pspicture"
```

8.4. Example 3: a paraboloid



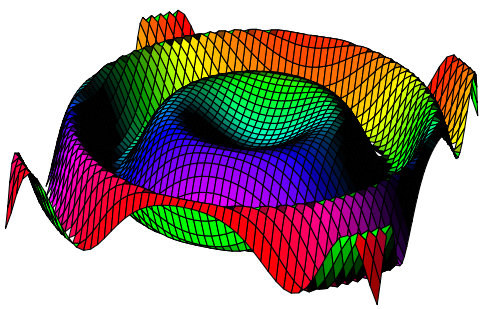

```
"psset-unit=0.5"
"psset- lightsrc =30 -10 10,linewidth=0.5"pslinewidth"
"psset-viewpoint=50 40 30 rtp2xyz,Decran=50"
"begin-pspicture"(-7,-4) (7,12)
"psSolid[object=grille,base=-4 4 -4 4,action=draw]%
"psSurface[
    fillcolor =cyan!50,
    intersectionplan =-[0 0 1 -5]",
    intersectioncolor =(bleu),
    intersectionlinewidth =3,
    intersectiontype=0,
    ngrid=.25 .25,incolor=yellow,
    axesboxed,Zmin=0,Zmax=8,QZ=4](-4,-4)(4,4)-%
    y dup mul x dup mul add 4 div "
"end-pspicture"
```

8.5. Star version of \pstSurface

“psset–viewpoint=50 20 20 rtp2xyz,Decran=100,lightsrc=viewpoint″
“begin–pspicture″(-5,-4)(6,6)
“psSolid[object=grille,base=-2 2 -2 2,action=draw]%
“axesIIID(0,0,0)(2,2,1)
“psSurface*[
fillcolor=cyan,r=1,
ngrid=.25 .25,incolor=yellow,grid,
algebraic](-1,-1)(1,1)– eˆ(x*y) ″
“psSolid[object=cylindre,r=1,h=2,action=draw,ngrid=1 18]
“psPoint(0,0,1)–O″
“psPoint(0,0,3)–Z″
“psline–-¿″(O)(Z)
“uput[r](Z)–z″
“psPoint(0.5,0.5,0)–C″
“psdot[linecolor=red,dotstyle=x,dotscale=2](C)
“end–pspicture″

“begin–pspicture″(-5,-4)(6,10)
“psSolid[object=grille,base=-2 2 -2 2,action=draw]%
“axesIIID(0,0,0)(2,2,1)
“psSurface*[
fillcolor=cyan,r=1,xytranslate=0.5 0.5,
ngrid=.25 .25,incolor=yellow,grid,
algebraic](-1,-1)(1,1)– eˆ(x*y) ″
“psSolid[object=cylindre,r=1,h=4,action=draw,ngrid=1 18](0.5,0.5,0)
“psPoint(0,0,1)–O″
“psPoint(0,0,5)–Z″
“psline–-¿″(O)(Z)
“uput[r](Z)–z″
“psPoint(0.5,0.5,0)–C″
“psdot[linecolor=red,dotstyle=x,dotscale=2](C)
“end–pspicture″

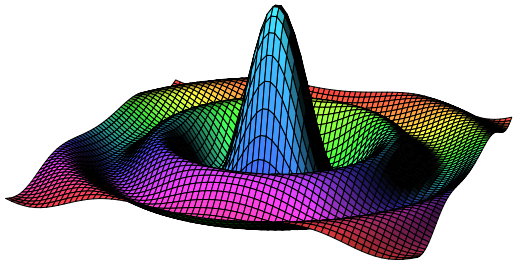
8.6. Example 4: a sinusoidal wave



```
“psset–unit=0.35″
“psset– lightsrc =30 -10 10″
“psset–viewpoint=50 20 30 rtp2xyz,Decran=70″
“begin–pspicture″(-11,-8) (7,8)
“psSurface[ngrid=.2 .2, algebraic ,Zmin=-1,Zmax=1,
                linewidth=0.5“pslinewidth,spotX=r,spotY=d,
                      spotZ=l,
                hue=0 1](-5,-5) (5,5)–%
    sin ((xˆ2+yˆ2)/3) ″
“end–pspicture″
```

8.7. Example 5: another sinusoidal wave

In this example we show how to colour the faces, each with a different coloration, directly using PostScript code.



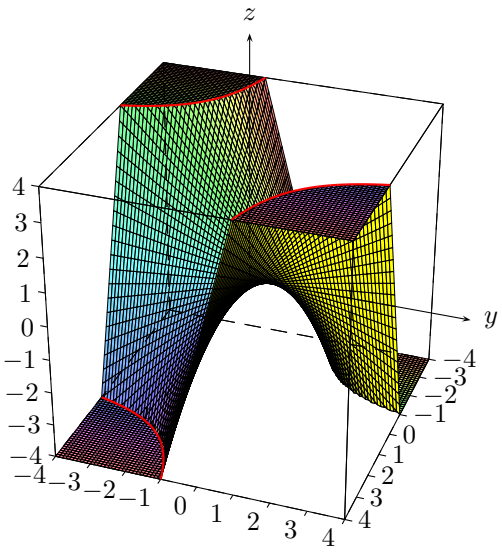
```
“psset–unit=0.25″
“psset– lightsrc =30 -10 10″
“psset–viewpoint=100 20 20 rtp2xyz,Decran=80″
“begin–pspicture″(-15,-10) (7,12)
“psSurface[ngrid=0.4 0.4, algebraic , Zmin=-2,Zmax=10,QZ
    =4,
          linewidth=0.25“pslinewidth,
          fcol=0 1 4225
          –/iF ED iF [iF 4225 div 0.75 1] (sethsbcolor)
              astr2str″ for
        ](-13,-13) (13,13)–%
  10*sin(sqrt((x^2+y^2)))/(sqrt(x^2+y^2)) ″
“end–pspicture″
```

8.8. Example 6: a hyperbolic paraboloid with the equation $z = xy$

In this example we combine the graph of the surface and the curves of intersection of the paraboloid with the planes $z = 4$ and $z = -4$. In this case we use “psSolid[object=courbe].

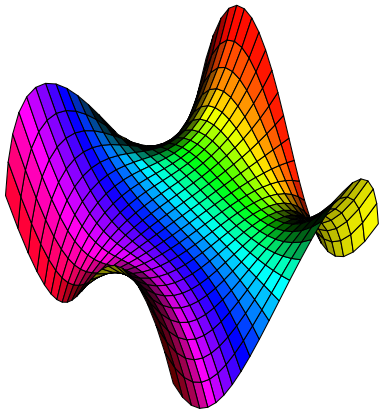
```
“defFunction–F″(t)–t″–4 t div 4 min″–4″
“psSolid[object=courbe,range=1 4,
  linecolor=red,linewidth=2“pslinewidth,
  function=F]
```

You will note the use of the functions min and max, which return the minimum and the maximum, respectively, of two values.



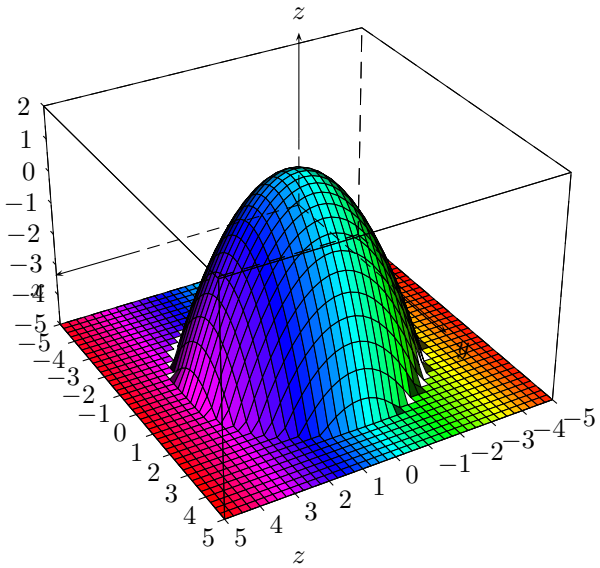

```
“psset–unit=0.5″
“psset–viewpoint=50 20 30 rtp2xyz,Decran=50″
“psset– lightsrc =viewpoint,linewidth=0.5“pslinewidth″
“begin–pspicture″(-7,-8) (7,8)
“psSolid[object=datfile,filename=data/paraboloid,hue=0 1
    0.5 1,incolor=yellow]
“gridIIID[Zmin=-4,Zmax=4,spotX=r](-4,4)(-4,4)
“defFunction–F″(t)–t″–4 t div 4 min″–4″
“psSolid[object=courbe,range=1 4,r=0,
   linecolor =red,linewidth=2“pslinewidth,
   function=F]
“defFunction–G″(t)–t″–4 t div -4 max″–4″
“psSolid[object=courbe,range=-1 -4,r=0,
   linecolor =red,linewidth=2“pslinewidth,
   function=G]
“defFunction–H″(t)–t neg″–4 t div -4 max″–-4″
“psSolid[object=courbe,range=-1 -4,r=0,
   linecolor =red,linewidth=2“pslinewidth,
   function=H]
“end–pspicture″
```

8.9. Example 7: a surface with the equation $z = xy(x^2 + y^2)$

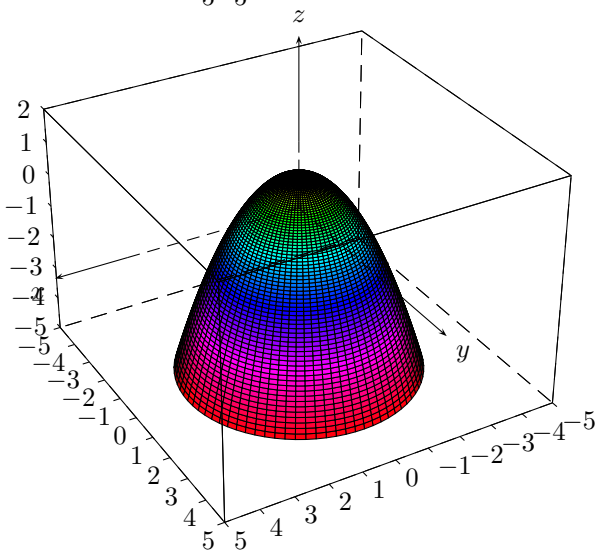


```
"psset-unit=0.35"
"psset-lightsrc=10 12 20,linewidth=0.5"pslinewidth"
"psset-viewpoint=30 50 60 rtp2xyz,Decran=50"
"begin-pspicture"(-10,-10)(12,10)
"psSurface[
    fillcolor=cyan!50,algebraic,
   ngrid=.25 .25,incolor=yellow,hue=0 1,
   Zmin=-3,Zmax=3](-3,-3)(3,3)-%
   x*y*(x^2-y^2)*0.1"
"end-pspicture"
```

8.10. Example 8: a surface with the equation $z = \left(1 - \frac{x^2+y^2}{2}\right)^2$




```
"psset−unit=0.5cm,viewpoint=50 60 30 rtp2xyz,Decran=50"
"psset− lightsrc =viewpoint"
"begin−pspicture"(-4,-5) (6,8)
  "psSurface[ngrid=.25 .25, incolor =yellow,linewidth=0.5"
      pslinewidth,
    base= -2 2 -2 2, axesboxed, Zmin=-5,Zmax=2,hue=0
        1](-5,-5)(5,5)−%
    1 0.5 x dup mul y dup mul add mul sub dup -5 lt − pop
        -5 "if "
"end−pspicture"
```




```
"psset−unit=0.5cm,viewpoint=50 60 30 rtp2xyz,Decran=50,
  lightsrc =viewpoint"
"begin−pspicture"(-4,-5) (6,8)
  "psSurface*[ngrid=.25 .25, incolor =yellow,
    linewidth=0.5"pslinewidth,
    r = 3 sqrt 2 mul, axesboxed, Zmin=-5,Zmax=2,hue=0
        1](-5,-5)(5,5)−%
    1 0.5 x dup mul y dup mul add mul sub dup -5 lt − pop
        -5 "if "
"end−pspicture"
```

8.11. Implicit defined three dimensional function *F(x,y,z)=0*

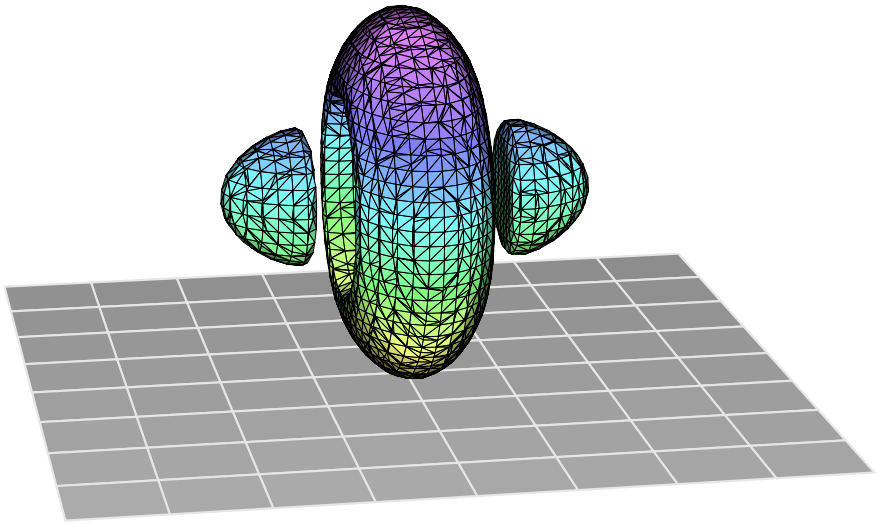
The command has the following syntax:

“psImplicitSurface[options](x0,y0,z0)

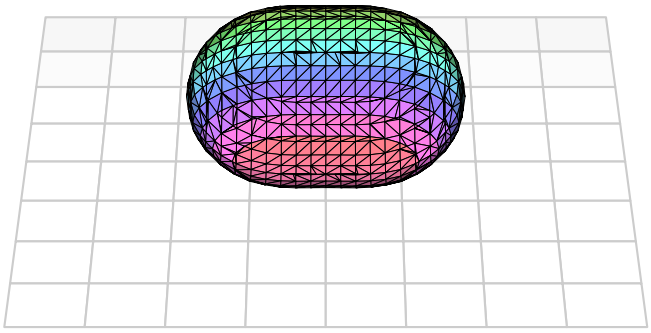
The argument (x0,y0,z0) for the image offset is optional and preset with (0,0,0) The options are the same which apply to solids, and these additional ones:

- algebraic: this option allows you to write the implicit defined function $F(x, y, z)$ in algebraic notation; pst-algparser.pro contains the code AlgToPs.
- XMinMax: three values devided by a space: minimum maximum step;
- YMinMax: three values devided by a space: minimum maximum step;
- ZMinMax: three values devided by a space: minimum maximum step;
- ImplFunction: the function $F(x, y, z) = 0$ where only $F(x, y, z)$ is written in PostScript notation, or with the optional argument algebraic in algebraic notation.

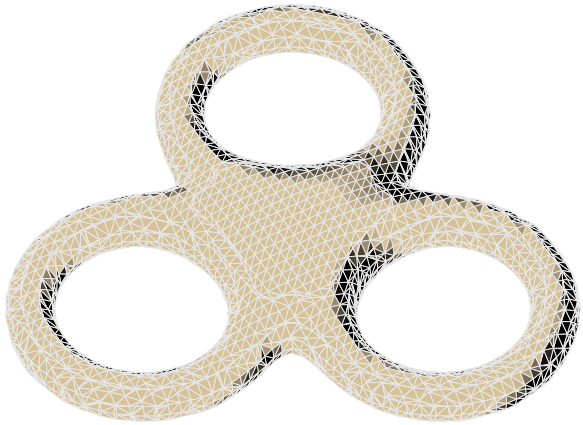
The internal PostScript code of pst-implicitsurface.pro is based on Paul Bourkes ”’Polygonising a scalar field”‘ at http://paulbourke.net/geometry/polygonise/.



```
“begin–pspicture”(-6,-5) (6,4)
“psset– lightsrc =viewpoint,viewpoint=40 80 15 rtp2xyz,Decran=50”
“psSolid[object=grille ,base=-4 4 -4 4,ngrid=8 8,linecolor=black!10](0,0,-2)
“psImplicitSurface[
    XMinMax=-2.0 2.0 0.15,YMinMax=-2.0 2.0 0.15,ZMinMax=-2.0 2.0 0.15,
    algebraic ,
    ImplFunction=4*x^4+4*y^4+8*y^2*z^2+4*z^4+17*x^2*y^2+17*x^2*z^2-20*x^2-20*y^2-20*z^2+17,
     fillcolor =cyan!20,hue=.1 .8 0.5 1,
    linewidth=0.01pt]%
“end–pspicture”
```



```
"begin-pspicture"(-5,-4) (5,4)
"psset- lightsrc =viewpoint,viewpoint=50 90 30 rtp2xyz,Decran=50"
"psSolid[object=grille ,base=-4 4 -4 4,ngrid=8 8,linecolor=black!20](0,0,-1)
"psImplicitSurface[%hollow,
    hue=1 0 0.5 1,
    XMinMax=-4 4 0.2,YMinMax=-4 4 0.2,ZMinMax=-4 4 0.2,
    algebraic ,
    ImplFunction=1/((x+0.75)^2+y^2+z^2)+1/((x-0.75)^2+y^2+z^2)-1,
     fillcolor  =cyan!20,linewidth=0.05pt]
"end-pspicture"
```



```
"begin-pspicture"(-6,-3) (6,4)
"psset-lightsrc=10 20 20 rtp2xyz,viewpoint=100 60 50 rtp2xyz,Decran=150"
"pstVerb-
  /RConst 1 def
  /rConst 0.25 def
  /torusImplicit -
    X dup mul Y dup mul add z dup mul add dup mul
    -2 RConst dup mul rConst dup mul add mul X dup mul Y dup mul add mul
    add
    2 RConst dup mul rConst dup mul sub mul z dup mul mul
    add
    RConst dup mul rConst dup mul sub add
  " def
  /tripleTorus -
    0 120 240 -
      /i exch def
      /X -x 1.5 i cos mul sub" def
      /Y -y 1.5 i sin mul sub" def
      torusImplicit
    " for
    mul mul
    10 sub
  " def
"%
"psImplicitSurface[
  ImplFunction=tripleTorus,linewidth=0.01pt,
   fillcolor=red!60!green!40, linecolor=black!10,
   lightintensity=5,
  XMinMax=-3 3 0.1,YMinMax=-3 3 0.1,ZMinMax=-0.5 0.5 0.1]
"end-pspicture"
```

A lot of examples can be found here: http://www-sop.inria.fr/galaad/surface/. A list of Steiner surfaces at http://www-sop.inria.fr and a list of surfaces with isolated singularities at http://www-sop.inria.fr/galaad/surface/classification/index.html.

9. Advanced usage

9.1. Naming a solid

For certain purposes, it is helpful to save a solid in working storage to allow it to be referenced later on. To do so, we activate the Boolean solidmemory, which allows the transmission of a variable throughout the code.

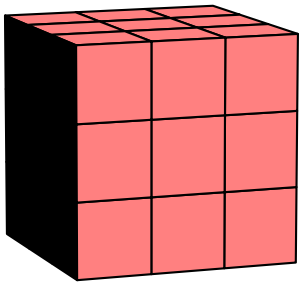
Consequently, activation of this Boolean deactivates drawing by the macros \psSolid, \psSurface and \psProjection immediate. To obtain the drawing, we use the macro at the end of the code.

When "psset–solidmemory" is set up, we can use the option name of the macro \psSolid.

In the example below, a coloured solid is constructed, which is named A. It is drawn using the object object=cube with the parameter load=A.

Note that linecolor=blue, used while constructing our cube, has no effect on the drawing: only the structure of the solid is stored (vertices, faces, colours of faces), not the thickness of any line, nor its colour, nor the position of the light source. The settings of those parameters are taken into account at the time the solid is rendered.

Finally, we demonstrate the use of the option deactivatecolor which allows the cube to keep its original red colour (otherwise the default colours would be used within the object load).



```
"psset–unit=0.75"
"begin–pspicture*"(-4,-4) (5,4)
"psset–solidmemory"
"psSolid[object=cube,
        linecolor =blue,
        a=4, fillcolor =red!50,
        ngrid=3,
        action=none,
        name=A,
        ](0,0,0)
"psSolid[object=load,
    deactivatecolor ,
    load=A]
"composeSolid
"end–pspicture*"
```

With the option solidmemory, the names of variables are relatively well encapsulated, and there will be no conflict with the variables of the dvips driver. There remains however the risk of a collision with the names used in the solides.pro file. You could use only single letter variable names, for example, and it is necessary to avoid names like vecteur, distance, droite, etc. which are already defined in the package.

9.2. Sectioning a solid with a plane

9.2.1. Drawing the intersection between a plane and a solid

The parameters

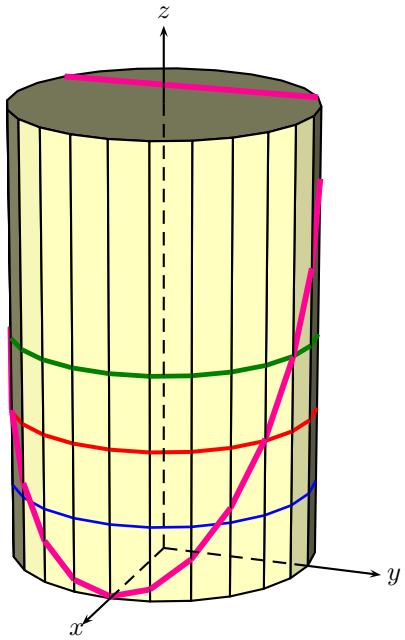
The option intersectionplan={[a b c d]} allows the user to draw the intersection between a plane and a solid. The numbers between the braces are the coefficients of the affine plane with equation: $ax + by + cz + d = 0$. It is possible

to draw the intersection between a solid and more than one plane by placing the appropriate parameters in order, as in the following example.

The drawing is activated with intersectiontype=0 or any value ≥ 0.

The colour of the intersection line is chosen with the option intersectioncolor=(bleu) (rouge) etc.. In the same order, the thickness of the appropriate line intersectionlinewidth=1 2 etc. (dimensions in picas) is set up.

The hidden parts, drawn with dashed lines, will be shown with action=draw.




```
"begin-pspicture"(-3,-2) (3,7.5)
"psset-viewpoint=50 20 20 rtp2xyz,Decran=50"
"psset- lightsrc =viewpoint"
"psSolid [object=cylindre,
    ngrid=1 24,
    r=2,
     fillcolor  =yellow!25,
    intersectiontype =0,
    intersectionplan =-
        [0  0  1  -1]
        [0  0  1  -2]
        [0  0  1  -3]
        [0.894  0  0.447  -1.8]",
    intersectioncolor =(bleu) (rouge) (vert)  (rose),
    intersectionlinewidth =1  1.5  1.8  2.2]
"axesIIID(2,2,6) (3,3,7)
"end-pspicture"
```

9.2.2. Slicing a solid

Slicing a filled solid

The object under consideration is a cylinder. The plane that slices the object is defined by:

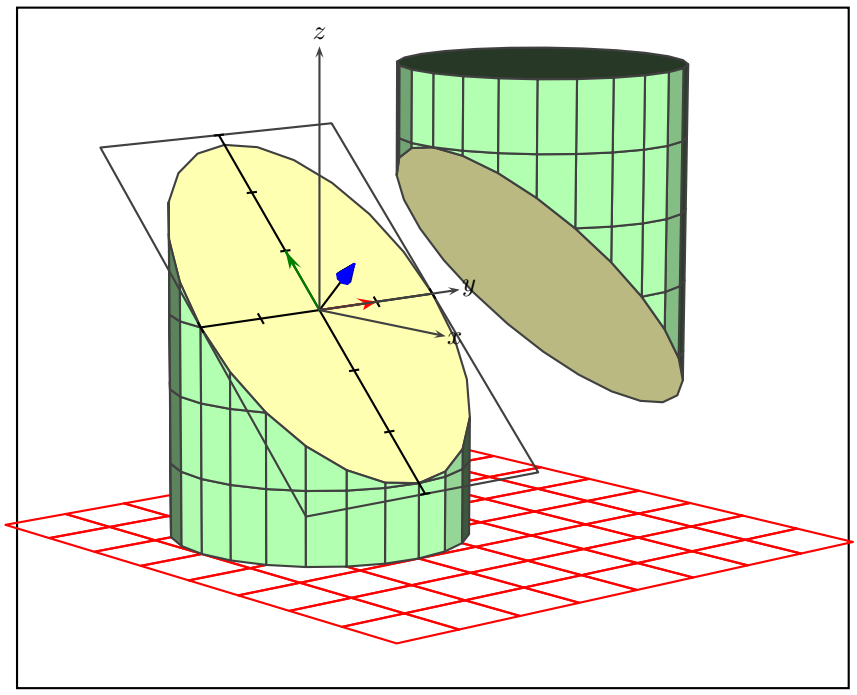
```
plansepare=-[a b c d]"
```

The two parts are not drawn, but memorised with the name name=partiescylindre:

```
"psset-solidmemory"
"psSolid[object=cylindre,
  r=2,h=6
  ngrid=6 24,
  plansepare=-[0.707 0 0.707 0]",
  name=partiescylindre,
  action=none](0,0,-3)
```

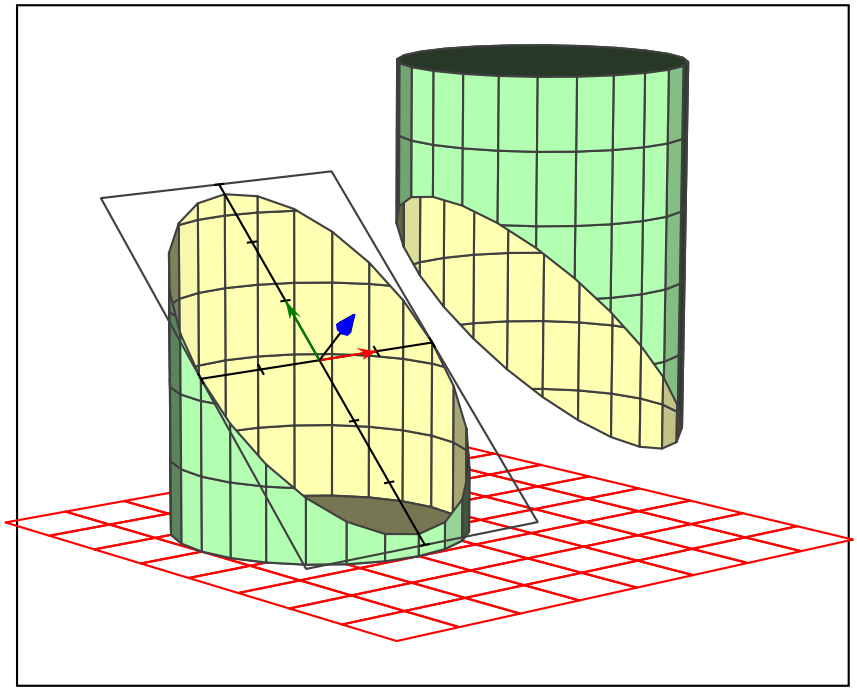
Then they are displayed separately using their respective index numbers. The numbering of the two parts is determined by the direction of the normal to the slicing plane: 0 if above the normal, 1 if below. For both parts, the sliced face carries the number 0. If there are several sliced faces, as may happen in the case of a torus, they are numbered 0, 1 etc.

```
“psSolid[object=load,
  load=partiescylindre1,
  fillcolor=–[rgb]–0.7 1 0.7 ″″,
  fcol=0 (1 1 0.7 setrgbcolor)]
“psSolid[object=load,
  load=partiescylindre0,RotZ=60,
  fillcolor=–[rgb]–0.7 1 0.7 ″″,
  fcol=0 (1 1 0.7 setrgbcolor)](0,4,0)
```



Slicing a hollow solid

The options rm=0,hollow allow us to not only remove a face rm=0 but also to see inside it hollow.



9.2.3. Slice of a pyramid

Highlighting the contour lines and first slice

This pyramid is generated as object=new by giving a list of the coordinates of the vertices, and the vertices of each face.

```
  sommets=
    0 -2 0 %% 0
    -2 0 0 %% 1
    0 4 0  %% 2
    4 0 0  %% 3
    0 0 5, %% 4
  faces=-
   [3 2 1 0]
   [4 0 3]
   [4 3 2]
   [4 2 1]
   [4 1 0]
"
```

In the first diagram, the slicing lines are highlighted.

```
  intersectiontype=0,
  intersectionplan=-[0 0 1 -1] [0 0 1 -2]",
  intersectionlinewidth=1 2,
  intersectioncolor=(bleu) (rouge)
```

Then we cut off the upper part, and draw the slicing plane as well.

```
“psSolid[object=new,
  sommets=
     0 -2 0 %% 0
     -2 0 0 %% 1
     0 4 0  %% 2
     4 0 0  %% 3
     0 0 5, %% 4
  faces=–
     [3 2 1 0]
     [4 0 3]
     [4 3 2]
     [4 2 1]
     [4 1 0]″,
  plansepare=–[0 0 1 -2]″,
  name=firstSlice,
  action=none]
“psSolid[object=load,action=draw*,
       load=firstSlice1]
“psSolid[object=plan,
       definition=equation,
       args=–[0 0 1 -2]″,
       base=-3 5 -3 5,action=draw]
```

To avoid having to repeatedly type the vertices and faces of the pyramid, we save these data to the files:

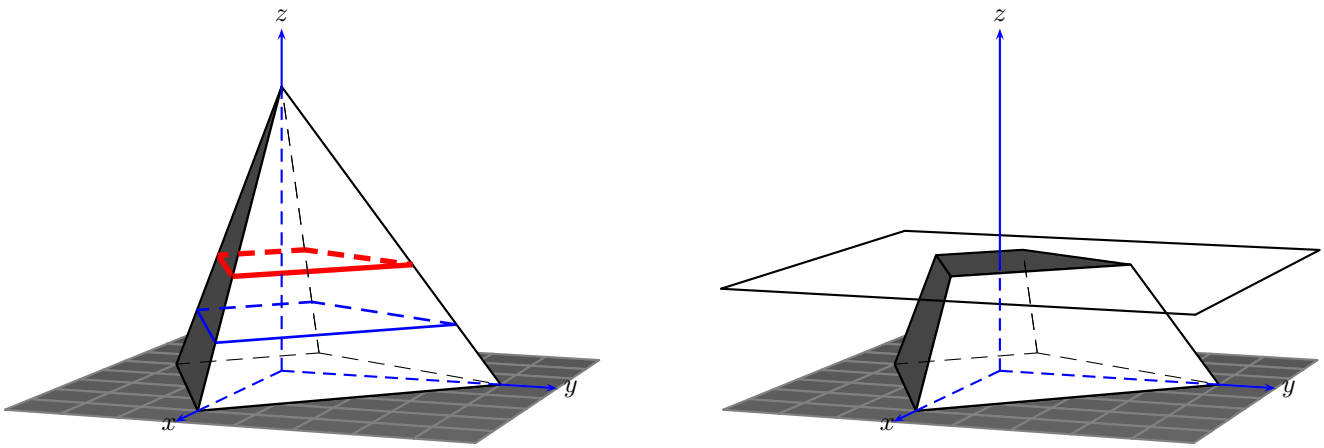
- Pyramid-couleurs.dat
- Pyramid-faces.dat
- Pyramid-sommets.dat
- Pyramid-io.dat

thanks to the command action=writesolid:

```
“psSolid[object=new,
  sommets=
     0 -2 0 %% 0
     -2 0 0 %% 1
     0 4 0  %% 2
     4 0 0  %% 3
     0 0 5, %% 4
  faces=–
     [3 2 1 0]
     [4 0 3]
     [4 3 2]
     [4 2 1]
     [4 1 0]
″,filename=data/Pyramid,fillcolor=yellow!50,
  action=writesolid]
```

All these lines of code could then be removed and, thereafter, we would recall the data with the command:

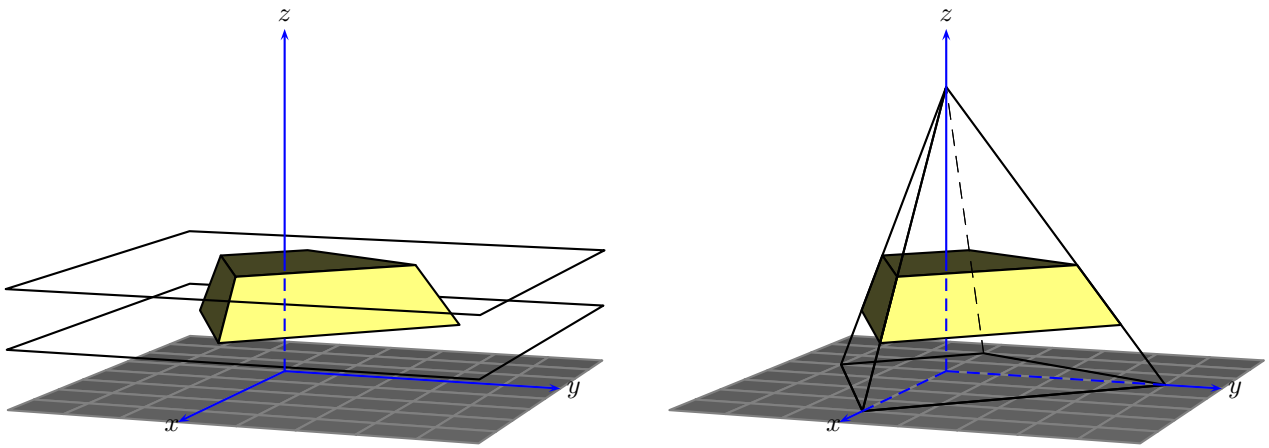
“psSolid[object=datfile,
filename=data/Pyramid]



The second slice and its insertion within the pyramid

Having removed the upper part firstSlice0 (which no longer appears), we slice the frustum of the pyramid firstSlice1, and keep the upper part of this as secondSlice0, then we record it and insert it into a wire frame model of the pyramid:

“psset–solidmemory″
“psSolid[object=datfile,
filename=data/Pyramid,
plansepare=–[0 0 1 -2]″,
name=firstSlice,
action=none]
“psSolid[object=load,
load=firstSlice1,
action=none,
plansepare=–[0 0 1 -1]″,
name=secondSlice]
“psSolid[object=load,action=draw*,
load=secondSlice0]
“psSolid[object=load,
load=secondSlice0,
filename=data/slicePyramid,
action=writesolid]
“psSolid[object=datfile,fillcolor=yellow!50,
filename=data/slicePyramid]



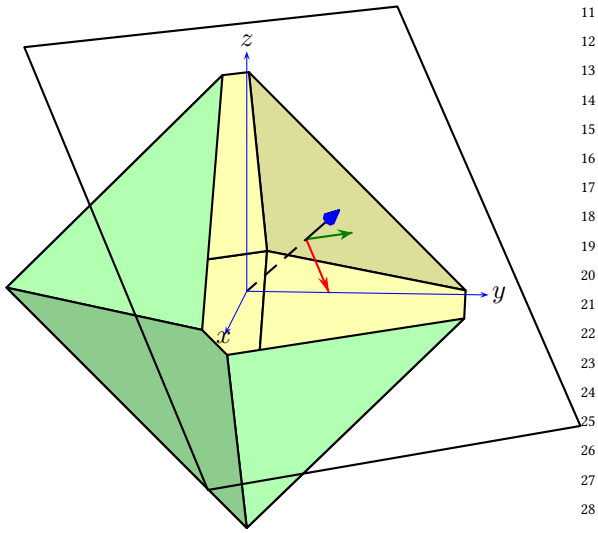
9.2.4. Slicing an octahedron with a plane parallel to one of its faces

The view inside

Recall that there are options rm=0,hollow that allow us, on the one hand, to remove a face rm=0 and, on the other, to look inside hollow.

In the following example, we shall start by generating the required objects without drawing them (action=none).

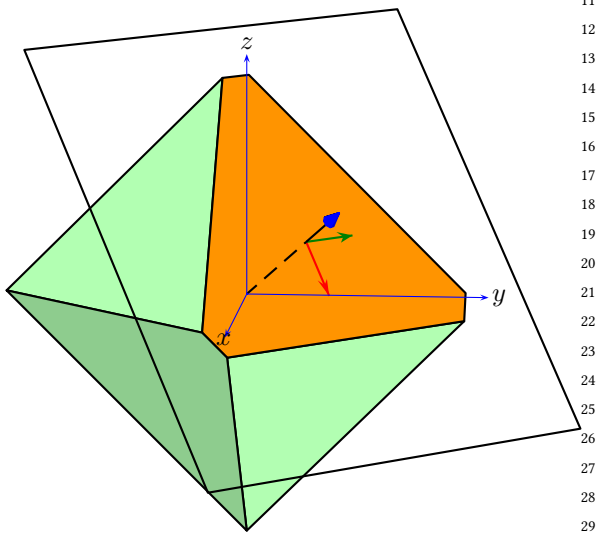
We construct the octahedron, giving the center of the face with index 1 the name G, then define the point H which satisfies $\overrightarrow{OH} = 0.8\,\overrightarrow{OG}$. After that we define P to be the plane through H parallel to the face of the octahedron with index 1. Finally, we slice the octahedron using the plane P.




```
“begin–pspicture ”(-3.5,-3) (4.5,5)
“psset–viewpoint=100 5 10 rtp2xyz,Decran=80,
    lightsrc =viewpoint,solidmemory,action=none”
“psSolid[object=octahedron,
   a=4,name=my˙octahedron,]
“psSolid[object=point,
    definition =solidcentreface,
   args=my˙octahedron 1,
   name=G,]
“psSolid[object=point,
    definition =mulv3d,
   args=G .8,
   name=H,]
“psSolid[object=plan,
    definition =solidface,
   args=my˙octahedron 1,
   base=-4 4 -4 4,
   name=P,](H,,)
“psSolid[object=load,
   load=my˙octahedron,
   plansepare=P,
   name=part]
“psSolid[object=load,load=part1,
            rm=0,hollow,action=draw**,
             fillcolor =–[rgb]–0.7 1 0.7””,
            incolor=–[rgb]–1 1 0.7””,]
“psSolid[object=plan,args=P,
          action=draw,showBase]
“psSolid[object=line,
   args=0 0 0 H,
    linestyle =dashed,]
“psProjection[object=point,plan=P,args=0 0,
     fontsize =20,pos=cl,text=H,phi=90,]
“axesIIID[linecolor =blue,linewidth=0.4pt](0,0,0) (4,4,4)
“end–pspicture”
```

Regarding the solid as filled

The option fcol=0 (YellowOrange) allows us to colour the face with index 0.




```
“begin–pspicture ”(-3.5,-3) (4.5,5)
“psset–viewpoint=100 5 10 rtp2xyz,Decran=80,
    lightsrc =viewpoint,solidmemory,action=none”
“psSolid[object=octahedron,
   a=4,name=my˙octahedron,]
“psSolid[object=point,
    definition =solidcentreface,
   args=my˙octahedron 1,
   name=G,]
“psSolid[object=point,
    definition =mulv3d,
   args=G .8,
   name=H,]
“psSolid[object=plan,
    definition =solidface,
   args=my˙octahedron 1,
   base=-4 4 -4 4,
   name=P,](H,,)
“psSolid[object=load,
   load=my˙octahedron,
   plansepare=P,
   name=part]
“psSolid[object=load,
   load=part1,
    fcol =0 (YellowOrange),
   action=draw**,
     fillcolor =–[rgb]–0.7 1 0.7””,]
“psSolid[object=plan,args=P,
         action=draw,showBase]
“psSolid[object=line,
   args=0 0 0 H,
    linestyle =dashed,]
“psProjection[object=point,plan=P,args=0 0,
     fontsize =20,pos=cl,text=H,phi=90,]
“axesIIID[linecolor =blue,linewidth=0.4pt](0,0,0) (4,4,4)
“end–pspicture”
```

The two parts of a sliced solid

You will recall that the direction of the normal of the slicing plane determines the numbering of the two parts: 0 if above the normal, 1 if below. For both parts, the sliced face carries the number 0. If there are several sliced faces, as in the case of the torus, they are numbered 0, 1 etc.

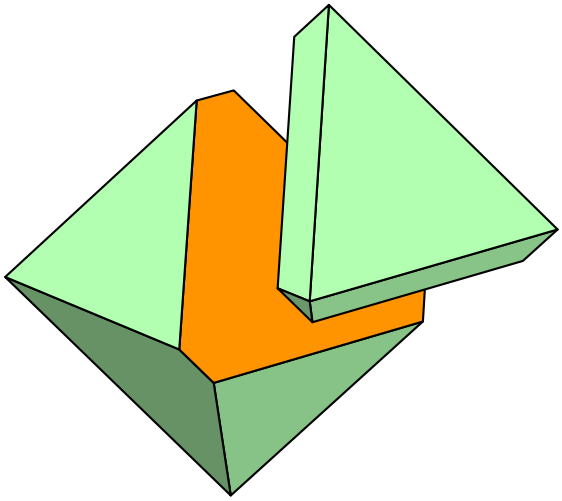
Using two steps, we memorise both parts of the sliced solid:

```
“psSolid[object=load,
  load=my˙octahedron,
  plansepare=P,
  name=part]
```

Then we position and render each part:

```
“psSolid[object=load,
       fcol=0 (YellowOrange),
       fillcolor=–[rgb]–0.7 1 0.7””,
      load=part1]
```

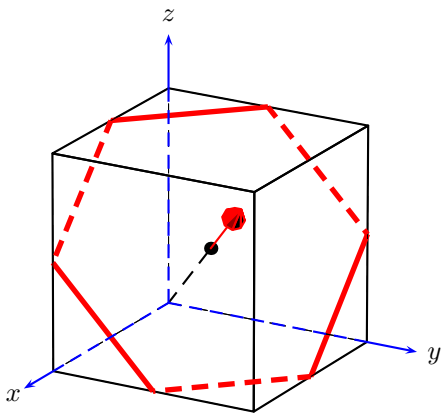
“psSolid[object=load,
fillcolor=–[rgb]–0.7 1 0.7″″,
load=part0](H 2 mulv3d,,)
“composeSolid



```
“begin–pspicture ″(-3.5,-3) (4.5,5)
“psset–viewpoint=100 5 20 rtp2xyz,Decran=150,
    lightsrc =viewpoint,solidmemory,action=none″
“psSolid[object=octahedron,
   a=2,name=my˙octahedron,]
“psSolid[object=point,
    definition =solidcentreface,
   args=my˙octahedron 1,
   name=G,]
“psSolid[object=point,
    definition =mulv3d,
   args=G .7,
   name=H,]
“psSolid[object=plan,
    definition =solidface,
   args=my˙octahedron 1,
   base=-4 4 -4 4,
   name=P,](H,,)
“psSolid[object=load,
   load=my˙octahedron,
   plansepare=P,
   name=part]
“psset–action=draw**″
“psSolid[object=load,
   load=part1,
   fcol=0 (YellowOrange),
    fillcolor =–[rgb]–0.7 1 0.7″″,]
“psSolid[object=load,
            fillcolor =–[rgb]–0.7 1 0.7″″,
         load=part0](H 2 mulv3d,,)
“composeSolid
“end–pspicture″
```

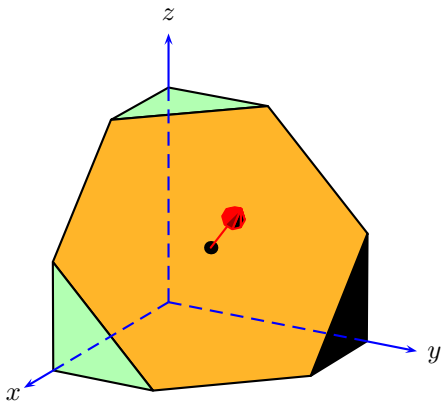
9.2.5. Slices of a cube

Highlighting the edges of the cut




```
"psset-viewpoint=100 30 20 rtp2xyz,Decran=150"
"begin-pspicture"(-4,-3) (4,5)
"psset-solidmemory"
"psSolid[object=plan,definition=normalpoint,
    args=-1 1 1 [1 1 1]",action=none,name=P]
"psSolid[object=cube,a=2,action=draw,
    intersectiontype=0,
    intersectionplan=P,
    intersectionlinewidth=2,
    intersectioncolor=(rouge),
](1,1,1)
"psProjection[object=point,
    args=0 0,fontsize=10,pos=dc,
    text=H,phi=-30,plan=P,
]
"psSolid[object=line,
    linestyle=dashed,
    args=0 0 0 1 1 1]
"psSolid[object=vecteur,
    linecolor=red,
    args=1 1 1 .7 mulv3d](1,1,1)
"axesIIID[linecolor=blue](2,2,2) (2.5,2.5,2.5)
"end-pspicture"
```

Showing the sliced cube with its hexagonal cut face

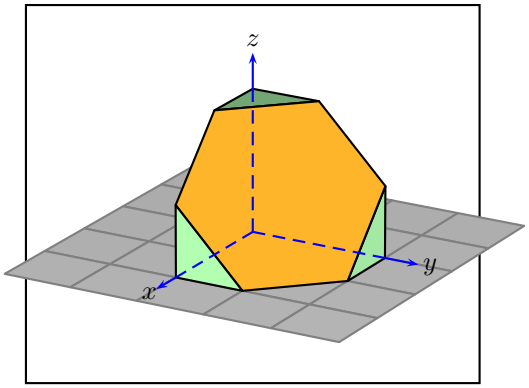


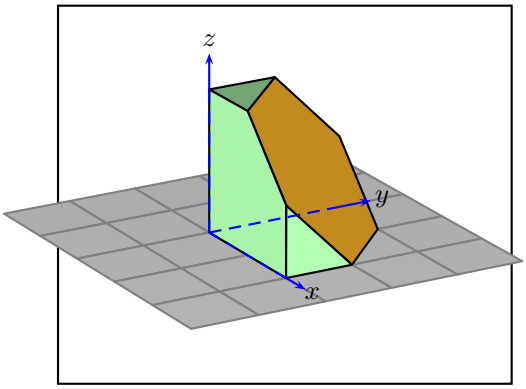

```
"psset-viewpoint=100 30 20 rtp2xyz,Decran=150"
"begin-pspicture"(-4,-3) (4,5)
"psset-solidmemory"
"psSolid[object=plan,action=none,definition=
      normalpoint,
    args=-1 1 1 [1 1 1]",name=P]
"psSolid[object=cube,a=2,
    plansepare=P,
    action=none,
    name=parts'cube,
](1,1,1)
"psSolid[object=load,
            load=parts'cube1,
            fcol=0 (Dandelion),
            fillcolor=-[rgb]-0.7 1 0.7""",
]
"psProjection[object=point,
    args=0 0,fontsize=10,pos=dc,
    text=H,phi=-30,plan=P,
]
"psSolid[object=vecteur,
    linecolor=red,
    args=1 1 1 .7 mulv3d](1,1,1)
"axesIIID[linecolor=blue](2,2,2) (2.5,2.5,2.5)
"end-pspicture"
```

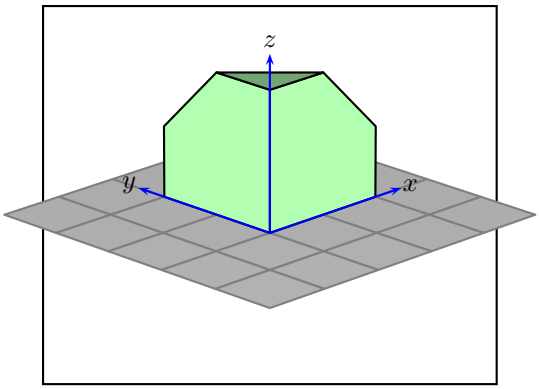
The sliced cube in various positions

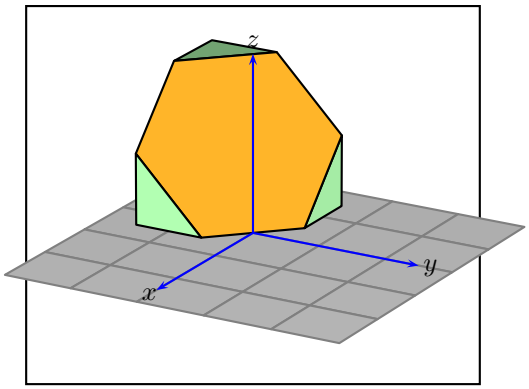
Where we use the option that allows us to memorise a solid, in order to put the truncated cube, after undergoing various transformations, down on its cut face.

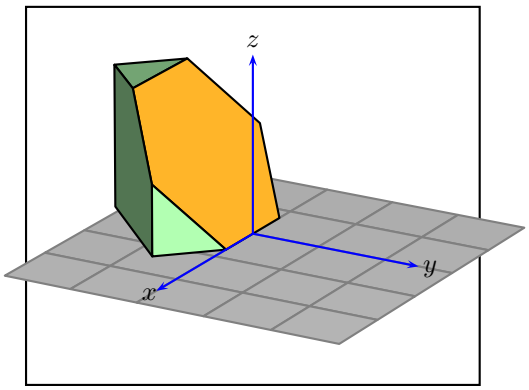
“psset–solidmemory″
“psSolid[object=datfile,
fcol=0 (Dandelion),
fillcolor=–[rgb]–0.7 1 0.7″″,
name=C1,
action=none,
filename=data/cubeHexagone]

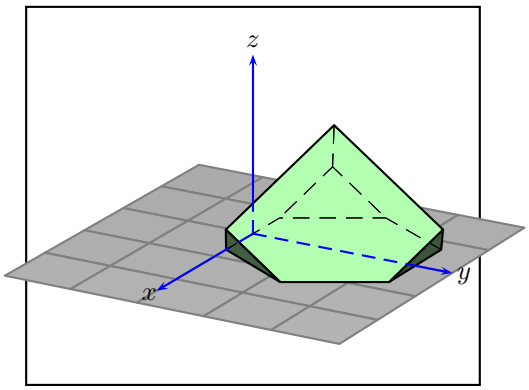






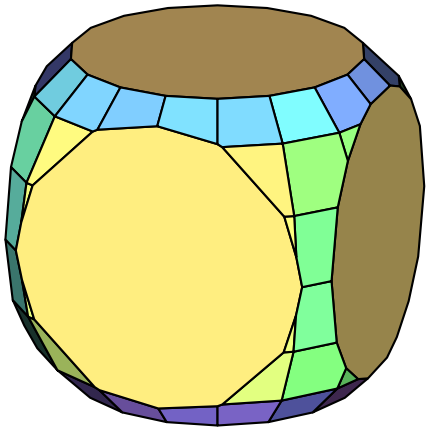






9.2.6. Multiple sections

Slicing a sphere with PStricks

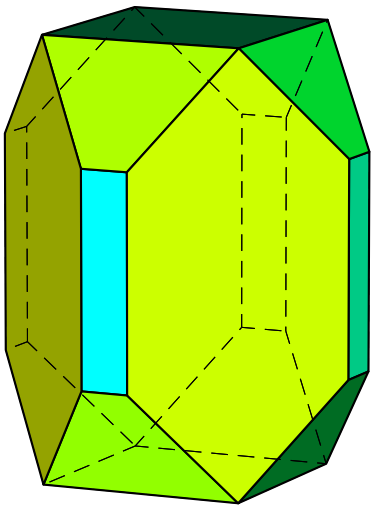


```
“begin–pspicture”(-4,-4) (4,4)
“psset–viewpoint=100 20 20 rtp2xyz,Decran=75”
“psset–solidmemory,lightsrc=viewpoint”
“codejps–
   /coeff 0.75 def /rO 4 def /OH coeff rO mul neg def”
       %
“psSolid[object=sphere,
   r=rO,ngrid=9 18,
   plansepare=–[1 0 0 OH]”,
   name=part,
   action=none]
“psSolid[object=load,
   load=part1,plansepare=–[-1 0 0 OH]”,action=none,
       name=part]
“psSolid[object=load,
   load=part1,plansepare=–[0 1 0 OH]”,action=none,
       name=part]
“psSolid[object=load,
   load=part1,plansepare=–[0 -1 0 OH]”,action=none,
       name=part]
“psSolid[object=load,
   load=part1,plansepare=–[0 0 1 OH]”,action=none,
       name=part]
“psSolid[object=load,
   load=part1,plansepare=–[0 0 -1 OH]”,action=none,
       name=part]
“psSolid[object=load,hue=.1 .8 0.5 1,
   load=part1](0,0,0)
“composeSolid
“end–pspicture”
```

Multiple sections of a parallelepiped

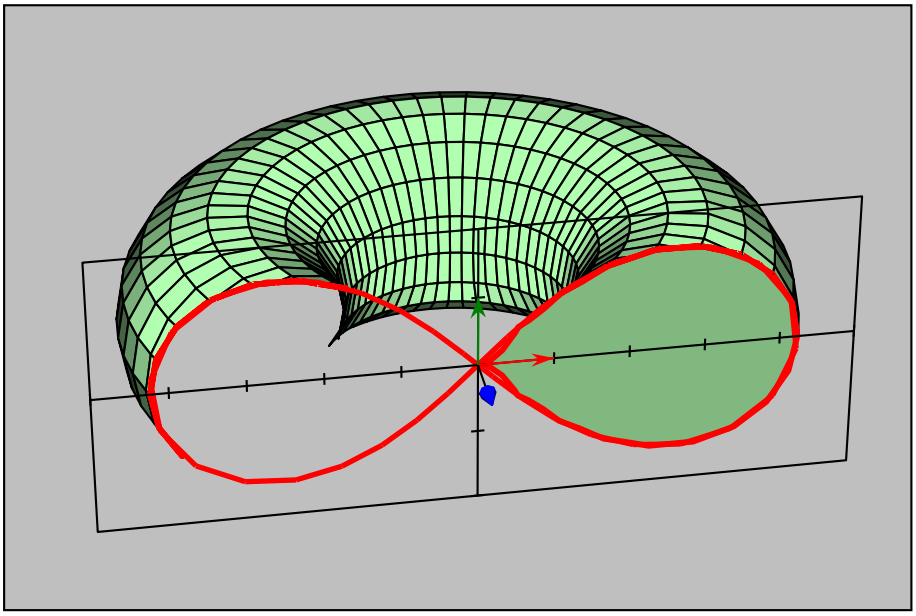
Multiple sections are better carried out inside a PostScript loop, within “codejps; it’s easier and quicker!

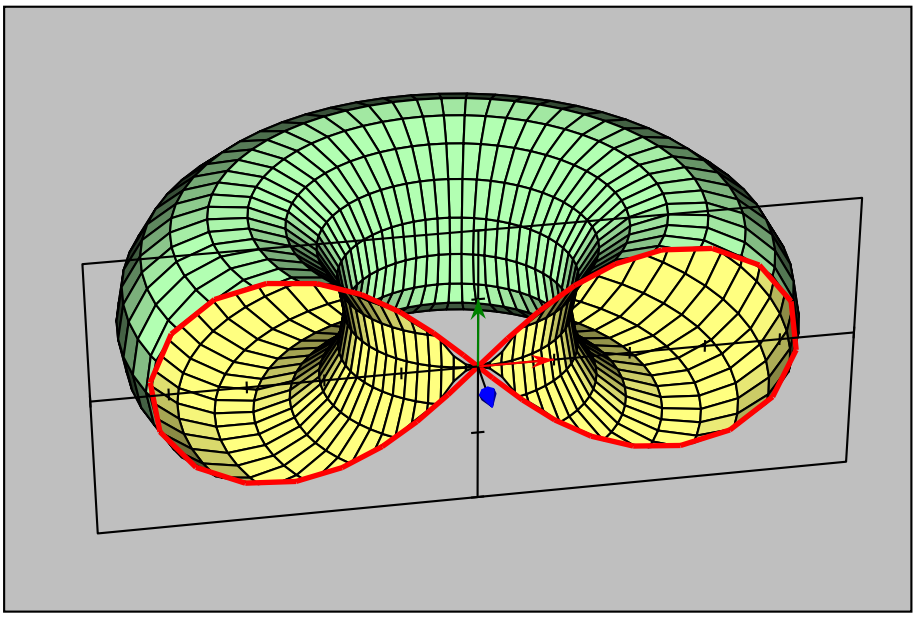
In this example, the original solid is a parallelepiped. Truncations of the vertices and chamfering of the edges are effected by means of slicing planes, starting off with the vertices and finishing with the edges.



```
"begin-pspicture "(-3.5,-4) (3.5,4)
"psset-viewpoint=100 -20 10 rtp2xyz,Decran=100"
%"lightsource
"psset- lightsrc =viewpoint"
"codejps-
4 4 6 newparallelepiped
45 90 360 -
/iAngle exch def
  /n'x iAngle cos 35.2644 cos mul def
  /n'y iAngle sin 35.2644 cos mul def
  /n'z 35.2644 sin def
  /distance 2 3 add 3 sqrt div neg def
[ n'x n'y n'z distance]
solidplansepare
" for
45 90 360 -
/iAngle exch def
  /n'x iAngle cos 35.2644 cos mul def
  /n'y iAngle sin 35.2644 cos mul def
  /n'z 35.2644 sin neg def
  /distance 2 3 add 3 sqrt div neg def
[ n'x n'y n'z distance]
solidplansepare
" for
45 90 360 -
/iAngle exch def
% plan : ax+by+cz-d=0
[ iAngle cos % a
  iAngle sin % b
  0 % c
  -2.5 % -d
] solidplansepare
" for
dup [.5 .2] solidputhuecolors
solidlightOn
drawsolid*"
"end-pspicture"
```

9.2.7. Sections of a torus





9.2.8. Some more examples

1. You will find a *jps* coded version of this document within the "codejps command in the following document:
   http://melusine.eu.org/syracuse/mluque/solides3d2007/sections
2. A lesson about conic sections on:
   http://melusine.eu.org/syracuse/mluque/solides3d2007/sections/sections-cone
3. A lesson about cylindrical sections on:
   http://melusine.eu.org/syracuse/mluque/solides3d2007/sections/section-cylindre
4. A lesson about sections of a torus on:
   http://melusine.eu.org/syracuse/mluque/solides3d2007/sections/section-tore

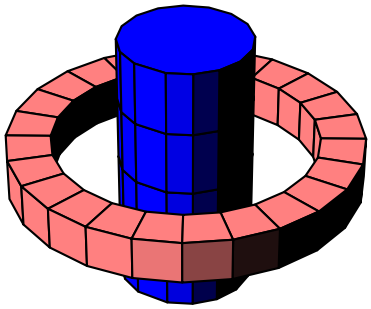
9.3. Fusing solids

It is possible to arrange several solids within the same structure: this is done with the operation fusion of solids. This technique uses the painting algorithm for the whole scene.

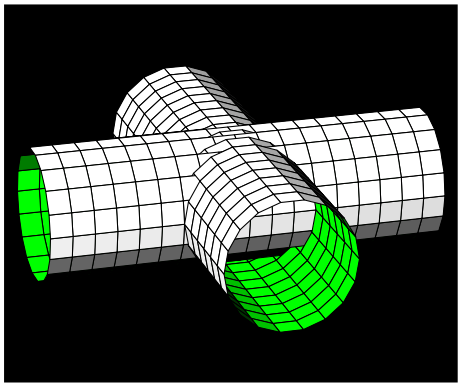
To do so, you must activate the option “psset–solidmemory” to memorize the structures of the different solids within \psSolid, with each of them given a separate name.

You use the object fusion of \psSolid, by indicating in the parameter base the list of names of the solids to be fused.

To draw the scene, don’t forget to conclude the code with “composeSolid.



```
“psset–unit=.6”
“begin–pspicture”(-6,-5) (6,7)
“psset–solidmemory”
“psSolid[object=cylindre,h=6, fillcolor =blue,
        r=1.5,
        ngrid=4 16,
        action=none,
        name=A1,
         ](0,0,-4)
“psSolid[object=anneau,h=6,fillcolor=red!50,
        R=4,r=3,h=1,
        action=none,
        name=B1,
         ](0,0,-1)
“psSolid[object=fusion,
        action=draw**,
        base=A1 B1,
         ](0,0,0)
“composeSolid
“end–pspicture”
```



```
“psset–unit=0.5”
“begin–pspicture”(-6,-5) (6,5)
“psset–solidmemory”
“psset– lightsrc =50 -50 50,viewpoint=100 -30 40,
    Decran=100,linewidth=0.5“pslinewidth,
    ngrid=18 18, fillcolor =white,
    h=12,r=2,RotX=90”
“psframe*[linecolor=black](-6,-5) (6,5)
“psSolid[object=cylindrecreux,
    action=none,
    name=cylindre1](0, 6, 0)
“psSolid[object=cylindrecreux,
    RotZ=90,
    action=none,
    name=cylindre2](-6, 0, 0)
“psSolid[object=fusion,
    base=cylindre1 cylindre2,RotX=0]
“composeSolid
“end–pspicture”
```

9.4. Fusing with *jps code*

We can also fuse solids by passing the code directly using *jps code*. The calculation of the hidden parts is carried out by the PostScript routines of the solides.pro file, but the lines of code are “encapsulated” within a pspicture environment thanks to the command “codejps–ps code”.

9.4.1. Using *jps code*

The choice of object

- [section] n newanneau: choice of a cylindrical ring defined by the coordinates of the vertices of its intersection with the plane Oyz.
- 2 1.5 6 [4 16] newcylindre: choice of a vertical cylinder with the following parameters:
  - z0=2: the position of the base centre on the axis Oz;
  - radius=1.5: radius of the cylinder;
  - z1=6: the position of the top centre on the axis Oz;
  - [4 16]: the cylinder is sliced horizontally into 4 pieces and vertically into 16 sectors.

The transformations

- {-1 2 5 translatepoint3d} solidtransform: the object previously chosen is translated to the point with the coordinates $(x = -1, y = 2, z = 5)$.
- {90 0 45 rotateOpoint3d} solidtransform: the object previously chosen is rotated around the axes (Ox, Oy, Oz), in this order: rotation of 90° about (Ox) followed by a rotation of 45° about (Oz).

The choice of object colour

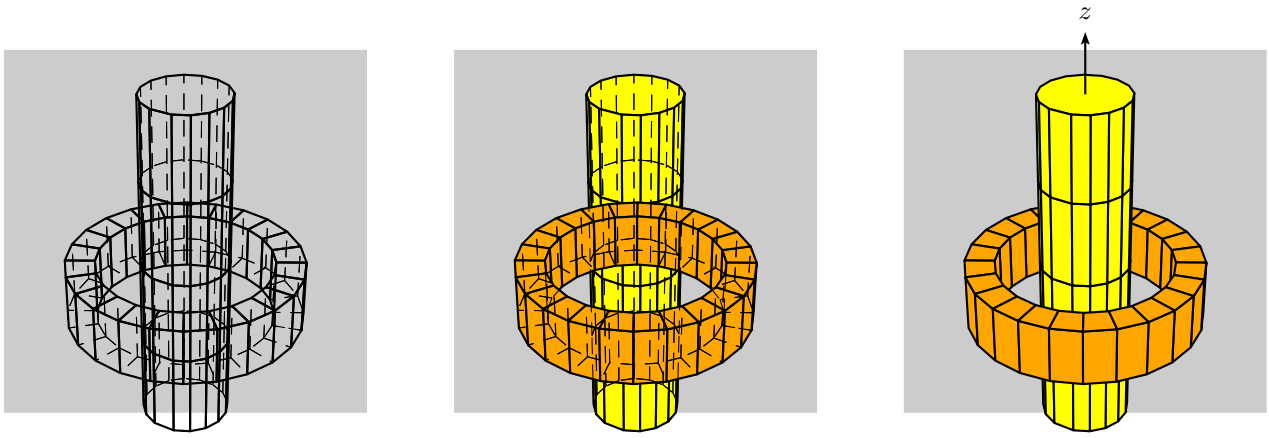
- dup (yellow) outputcolors: a yellow object illuminated in white light.

Fusing objects

- The fusion is finally made with the instruction solidfuz.

Designing objects

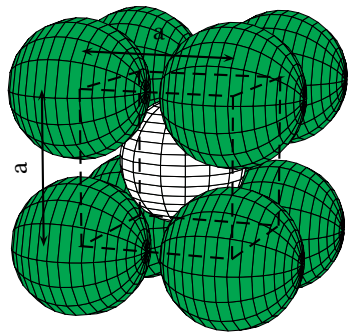
- There are three drawing options:
  - drawsolid: only draw edges; hidden edges are drawn dashed;
  - drawsolid*: draw and fill solids in their coded order (not a very interesting option at first glance); hidden edges are drawn dashed;
  - drawsolid**: draw and fill solids with the painting algorithm; only those parts seen by the observer are drawn.



“psset–lightsrc=50 -50 50,viewpoint=50 20 50 rtp2xyz,Decran=50″
“begin–pspicture″(-6,-2)(6,8)
“psframe(-6,-2)(6,8)
“codejps–
% solide 1

```
    /tour–
      -6 1.5 6 [4 16] newcylindre
      dup (jaune) outputcolors
    ″ def
% solide 2
    /anneau–
      [4 -1 4 1 3 1 3 -1] 24 newanneau
      –0 0 -1 translatepoint3d″ solidtransform
      dup (orange) outputcolors
    ″ def
% fusion
    tour anneau solidfuz
    drawsolid**″
“end–pspicture″
```

9.4.2. A chloride ion




```
"begin–pspicture"(-3,-4) (3,4)
"psset– lightsrc =100 -50 -10, lightintensity =3,viewpoint=200 20 10 rtp
      2xyz,Decran=20"
–"psset–linewidth=0.5"pslinewidth"
"codejps–/Cl –9.02  [18  16]  newsphere
–-90  0  0 rotateOpoint3d" solidtransform
 dup (Green) outputcolors" def
/Cl1 – Cl –10.25  10.25  10.25  translatepoint 3d" solidtransform  " def
/Cl2 – Cl –10.25  -10.25  10.25  translatepoint 3d" solidtransform  " def
/Cl3 – Cl –-10.25  -10.25  10.25  translatepoint 3d" solidtransform  " def
/Cl4 – Cl –-10.25  10.25  10.25  translatepoint 3d" solidtransform  " def
/Cl5 – Cl –10.25  10.25  -10.25  translatepoint 3d" solidtransform  " def
/Cl6 – Cl –10.25  -10.25  -10.25  translatepoint 3d" solidtransform  " def
/Cl7 – Cl –-10.25  -10.25  -10.25  translatepoint 3d" solidtransform  " def
/Cl8 – Cl –-10.25  10.25  -10.25  translatepoint 3d" solidtransform  " def
/Cs –8.38  [18  16]  newsphere
 dup (White) outputcolors" def
/Cl12– Cl1 Cl2 solidfuz" def
/Cl123– Cl12 Cl3 solidfuz" def
/Cl1234– Cl123 Cl4 solidfuz" def
/Cl12345– Cl1234 Cl5 solidfuz" def
/Cl123456– Cl12345 Cl6 solidfuz" def
/Cl1234567– Cl123456 Cl7 solidfuz" def
/Cl12345678– Cl1234567 Cl8 solidfuz" def
/C˙Cs – Cl12345678 Cs solidfuz" def
C˙Cs  drawsolid**""%
"psPoint(0,0,0)–P"
"psPoint(10.25,10.25,10.25) –Cl1"
"psPoint (10.25,-10.25,10.25) –Cl2"
"psPoint (-10.25,-10.25,10.25) –Cl3"
"psPoint (-10.25,10.25,10.25) –Cl4"
"psPoint (10.25,10.25,-10.25) –Cl5"
"psPoint (10.25,-10.25,-10.25) –Cl6"
"psPoint (-10.25,-10.25,-10.25) –Cl7"
"psPoint (-10.25,10.25,-10.25) –Cl8"
"pspolygon[linestyle=dashed](Cl1)(Cl2)(Cl3)(Cl4)
"pspolygon[linestyle=dashed](Cl5)(Cl6)(Cl7)(Cl8)
"psline[ linestyle =dashed](Cl2)(Cl6)
"psline[ linestyle =dashed](Cl3)(Cl7)
"psline[ linestyle =dashed](Cl1)(Cl5)
"psline[ linestyle =dashed](Cl4)(Cl8)
"pcline[ offset =0.5]–¡-¿"(Cl2)(Cl1)
"aput–:U"–a"
"pcline[ offset =0.5]–¡-¿"(Cl6)(Cl2)
"aput–:U"–a"
"end–pspicture"
```

We define the chloride ion Cl^-:

```
/Cl –9.02  [12 8] newsphere
 –-90 0 0 rotateOpoint3d" solidtransform
 dup (Green) outputcolors" def
```

which we shift to each vertex of a cube:

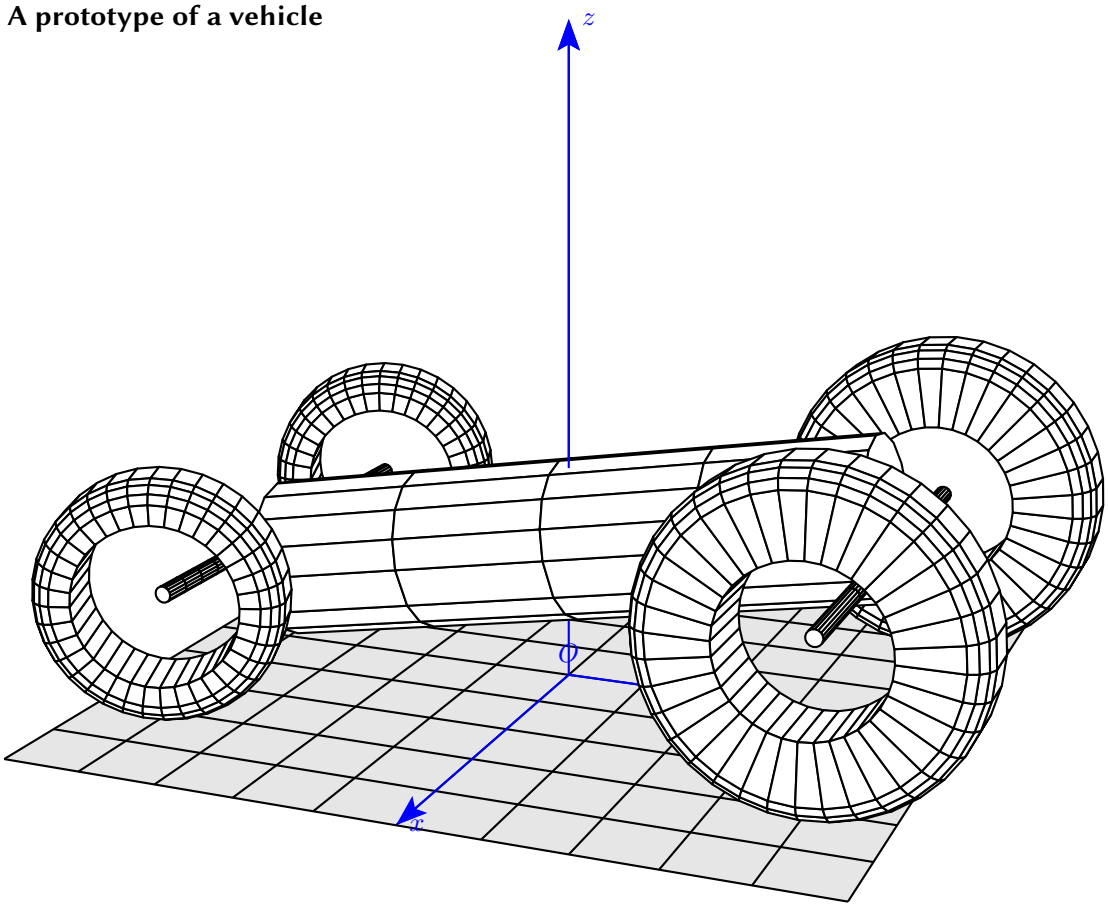
```
/Cl1 – Cl –10.25 10.25 10.25 translatepoint3d″ solidtransform ″ def
/Cl2 – Cl –10.25 -10.25 10.25 translatepoint3d″ solidtransform ″ def
/Cl3 – Cl –-10.25 -10.25 10.25 translatepoint3d″ solidtransform ″ def
/Cl4 – Cl –-10.25 10.25 10.25 translatepoint3d″ solidtransform ″ def
/Cl5 – Cl –10.25 10.25 -10.25 translatepoint3d″ solidtransform ″ def
/Cl6 – Cl –10.25 -10.25 -10.25 translatepoint3d″ solidtransform ″ def
/Cl7 – Cl –-10.25 -10.25 -10.25 translatepoint3d″ solidtransform ″ def
/Cl8 – Cl –-10.25 10.25 -10.25 translatepoint3d″ solidtransform ″ def
```

Then a caesium ion Cs^+ is placed in the center:

```
/Cs –8.38  [12 8] newsphere
 dup (White) outputcolors″ def
```

Finally we fuse the separate spheres in pairs.

9.4.3. A prototype of a vehicle



We have to operate in several steps to fuse the solids in pairs:

- We first fuse the two front wheels roue12:
  /roue12 –
  % solide 1
  /R 2 def /r 1 def /h 1 def
  [Pneu] 36 newanneau
  –90 0 90 rotateOpoint3d″ solidtransform
  –3 4 2 translatepoint3d″ solidtransform
  dup (White) outputcolors
  % solide 2
  [Pneu] 36 newanneau
  –90 0 90 rotateOpoint3d″ solidtransform
  –-3 4 2 translatepoint3d″ solidtransform
  dup (White) outputcolors
  % fusion
  solidfuz ″ def

- Then the two wheels and their axis:
  /axe12–
  0 0.1 6 [4 16] newcylindre
  –90 0 90 rotateOpoint3d″ solidtransform
  –-3 4 2 translatepoint3d″ solidtransform
  dup (White) outputcolors

```
″ def
/roue12axes –
roue12 axe12 solidfuz ″ def
```

- After that the rear wheels and their axis:

```
/roue34 –
% solide 3
   /R 1.5 def /r 1 def /h 1 def
    [Pneu] 36 newanneau
    –90 0 110 rotateOpoint3d″ solidtransform
   –3 -4 1.5 translatepoint3d″ solidtransform
    dup (White) outputcolors
% solide 4
    [Pneu] 36 newanneau
   –90 0 110 rotateOpoint3d″ solidtransform
   –-3 -4 1.5 translatepoint3d″ solidtransform
    dup (White) outputcolors
% fusion
    solidfuz ″ def
/axe34–
0 0.1 6 [16 16] newcylindre
–90 0 90 rotateOpoint3d″ solidtransform
–-3 -4 1.5  translatepoint3d″ solidtransform
dup (White) outputcolors
″ def
/roue34axes34 –
roue34 axe34 solidfuz ″ def
```

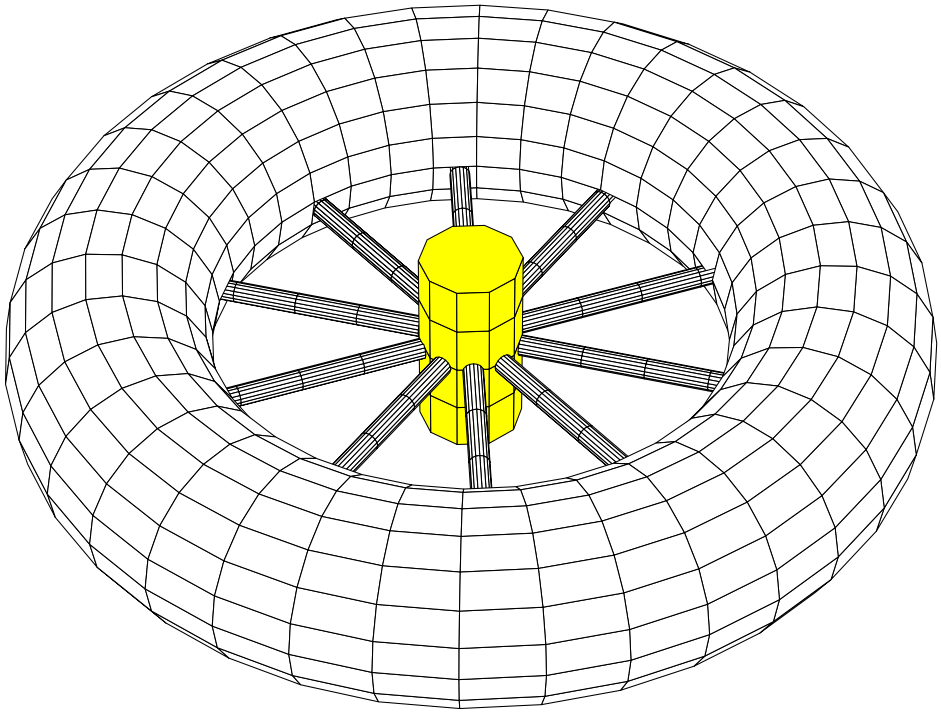
- Then fuse the two wheel assemblies:

```
/roues –roue34axes34 roue12axes solidfuz″ def
```

- The final step is to fuse the previously generated solid with the chassis:

```
/chassis –
0 1 8  [4 16] newcylindre
–100 0 0 rotateOpoint3d″ solidtransform
–0 4 2.5  translatepoint3d″ solidtransform
dup (White) outputcolors
″ def
roues chassis solidfuz
    drawsolid**″
```

9.4.4. A wheel – or a space station



We define the first spoke:

```
/rayon0 –
    1 0.2 6 [4 16] newcylindre
    –90 0 0 rotateOpoint3d″ solidtransform
     dup (White) outputcolors
  ″ def
```

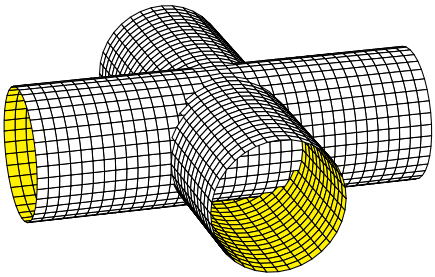
Then, with a loop, we fuse all the spokes of the wheel:

```
36 36 360 –
   /angle exch def
 /rayon1 –
    1 0.2 6  [4 16] newcylindre
    –90 0 angle rotateOpoint3d″ solidtransform
     dup (White) outputcolors
  ″ def
 /rayons –rayon0 rayon1 solidfuz″ def
 /rayon0 rayons def
 ″ for
```

After that, we draw the hub and the tyre of the wheel, and finally fuse all of them:

```
/moyeu – -0.5 1 0.5  [4 10] newcylindre dup (White) outputcolors″ def
/rayonsmoyeu –rayons  moyeu solidfuz″ def
/pneu –2 7 [18 36] newtore dup (jaune) outputcolors″ def
/ROUE –pneu rayonsmoyeu solidfuz″ def
 ROUE  drawsolid**
```

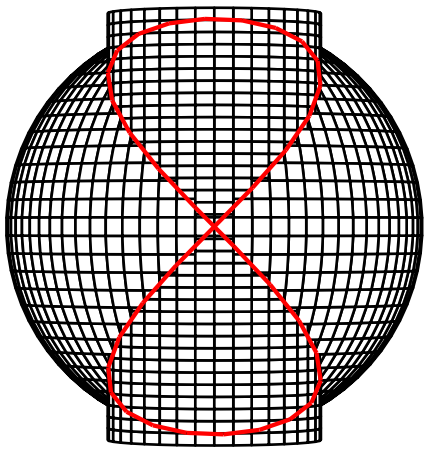
9.4.5. Intersection of two cylinders



```
“begin–pspicture”(-4,-3) (6,3)
“psset– lightsrc =50 -50 50,viewpoint=100 -30
40,Decran=100,linewidth=0.5“pslinewidth, unit=0.5”
“codejps–
 /cylindre1 –
      -6 2 6 [36 36] newcylindrecreux %newcylindre
      –90 0 0 rotateOpoint3d” solidtransform
       dup (Yellow) (White) inoutputcolors
   ” def
 /cylindre2 –
      -6 2 6 [36 36] newcylindrecreux %newcylindre
      –90 0 90 rotateOpoint3d” solidtransform
       dup (Yellow) (White) inoutputcolors
   ” def
 /UnionCylindres –cylindre1 cylindre2 solidfuz” def
  UnionCylindres drawsolid**”
“end–pspicture”
```

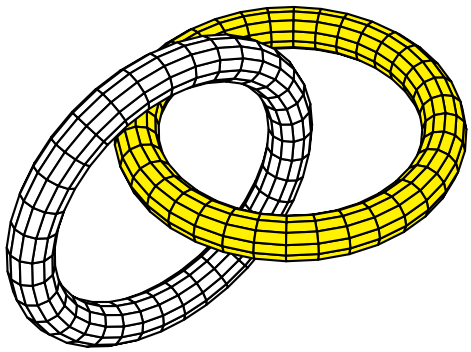
9.4.6. Intersection between a sphere and a cylinder

This time we draw the curve of intersection using “psSolid[object=courbe].



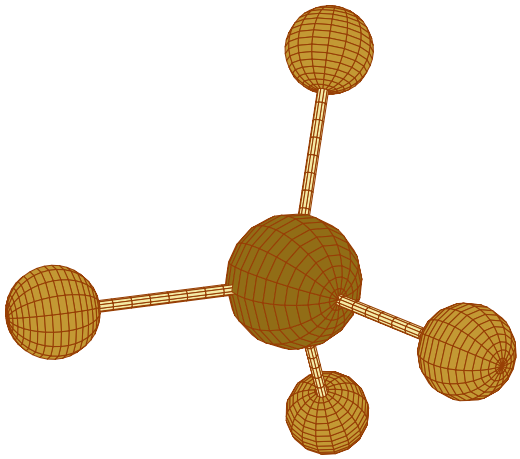
```
“psset–unit=0.5, lightsrc =50 -50 50,viewpoint=100 0 0
      rtp2xyz,Decran=110,linewidth=0.5“pslinewidth”
“begin–pspicture”(-7,-6) (5,6)
“defFunction–F”(t)–t cos dup mul 5 mul”–t cos t sin mul
      5 mul”–t sin 5 mul”
“codejps–%
   /cylindre1 –
        -5 2.5 5 [36 36] newcylindre
        –2.5 0 0 translatepoint3d” solidtransform
         dup (White) outputcolors
   ” def
   /sphere1 –
         5 [36 72] newsphere
         dup (White) outputcolors
   ” def
   /CS –cylindre1 sphere1 solidfuz” def
   CS drawsolid**”
“psPoint(0,0,0)–O”
“psSolid[object=courbe,r=0,
   function=F,
   range=0 360,
    linecolor =red,linewidth=4“pslinewidth]
“end–pspicture”
```

9.4.7. Two linked rings



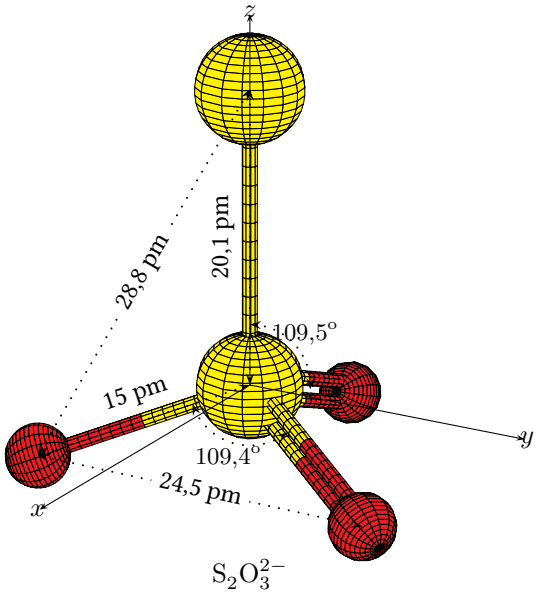
```
"begin–pspicture"(-5,-4) (3,3)
"psset– lightsrc =50 50 50,viewpoint=40 50 60,Decran=30,
      unit=0.85"
"codejps–
 /anneau1 –1 7 [12 36] newtore
 –0 0 0 translatepoint3d" solidtransform
 dup (Yellow) outputcolors" def
 /anneau2 –1 7 [12 36] newtore
 –90 0 0 rotateOpoint3d" solidtransform
 –7 0 0 translatepoint3d" solidtransform
 dup (White) outputcolors" def
 / collier –anneau1 anneau2 solidfuz" def
   collier   drawsolid**"
"end–pspicture"
```

9.4.8. The methane molecule: wooden model



```
“begin–pspicture ″(-4.5,-4) (3.2,5)
“psset– lightsrc =50 50 10, lightintensity =2,viewpoint
      =100 50 20 rtp2xyz,
Decran=30″
“psset– linecolor =–[cmyk]–0,0.72,1,0.45″″,linewidth=0.5“
      pslinewidth,
  unit=1″
%“psframe[ fillstyle =solid, fillcolor =green !20](-4,-4)
      (3.2,5)
“pstVerb–/hetre –0.764 0.6 0.204 setrgbcolor ″ def
          /chene –0.568 0.427 0.086 setrgbcolor ″ def
          /bois –0.956 0.921 0.65 setrgbcolor ″ def
          ″%
“codejps–
 /H1 –
 2 [18 16] newsphere
 –-90 0 0 rotateOpoint3d″ solidtransform
 –0 10.93 0 translatepoint3d″ solidtransform
 dup (hetre) outputcolors″ def
  /L1 –
      0 0.25 10 [12 10] newcylindre
      –-90 0 0 rotateOpoint3d″ solidtransform
       dup (bois) outputcolors
   ″ def
/HL1– H1 L1 solidfuz″ def
/HL2 – HL1 –0 0 -109.5 rotateOpoint3d″ solidtransform ″
      def
/HL3 – HL2 –0 -120 0 rotateOpoint3d″ solidtransform ″
      def
/HL4 – HL2 –0 120 0 rotateOpoint3d″ solidtransform ″
      def
 /C –3 [18 16] newsphere
  –90 0 0 rotateOpoint3d″ solidtransform
   dup (chene) outputcolors″ def
/HL12 – HL1 HL2 solidfuz″ def
/HL123 – HL12 HL3 solidfuz″ def
/HL1234 – HL123 HL4 solidfuz″ def
/methane – HL1234 C solidfuz″ def
  methane drawsolid**″
“end–pspicture″
```

9.4.9. The thiosulphate ion



We first define the two sulphur atoms and place them on the Oz axis. S_1 is placed at the origin O.

```
“codejps–
/Soufre1 –3.56  [20 16] newsphere
 dup (Yellow) outputcolors″ def
/Soufre2 –3.56  [20 16] newsphere
 –0 0.000 20.10 translatepoint3d″ solidtransform
 dup (Yellow) outputcolors″ def
```

Then the single bond S-O using the following convention: half red—the half connected to O, and half yellow—the half connected to S.

```
/LiaisonR –
     7.5 0.5 15  [10 10] newcylindre
      dup (Red) outputcolors
   ″ def
/LiaisonY –
     0 0.5 7.5  [10 10] newcylindre
      dup (Yellow) outputcolors
   ″ def
/Liaison–LiaisonR LiaisonY solidfuz″ def
```

The oxygen atom, its bond, and the setting of the combined unit:

```
/Ox –2.17  [20 16] newsphere
     –0 0 15 translatepoint3d″ solidtransform
     dup (Red) outputcolors″ def
/LO – Liaison Ox solidfuz″ def
/LO1 – LO  –0 -109.5 0 rotateOpoint3d″ solidtransform ″ def
/LOx1 – LO1  –0 0 120 rotateOpoint3d″ solidtransform ″ def
% fin liaison simple S-O
```

For the double bond S=O, we take the single bond above and duplicate it with shifts of 0.75 cm along the Ox axis.

```
% Liaison double S=O
/LiaisonD1 –Liaison –-0.75 0 0 translatepoint3d″ solidtransform″ def
/LiaisonD2 –Liaison –0.75 0 0 translatepoint3d″ solidtransform″ def
/LiaisonDD – LiaisonD1 LiaisonD2 solidfuz″ def
```

Connecting it to the O atom:

```
/LiaisonDOx –LiaisonDD Ox solidfuz″ def
```

and with two successive rotations we position the two bonds =O:

```
/LiaisonDOx1 –LiaisonDOx –0 -109.5 0 rotateOpoint3d″ solidtransform ″ def
/LiaisonDOx2 –LiaisonDOx1 –0  0 -120 rotateOpoint3d″ solidtransform ″ def
```

The following step consists of fusing the two connections:

```
/LO12 – LiaisonDOx1 LiaisonDOx2 solidfuz″ def
/LO123 –LO12 LOx1 solidfuz″ def
```

Then the single bond S-S is created:

```
% liaison simple S-S
/L4 – 0 0.5 20.10  [16 10] newcylindre
     dup (Yellow) outputcolors
   ″ def
```

and fused with the two atoms S-S:

```
/S1L4– Soufre1 L4 solidfuz″ def
/S1S2L4– S1L4 Soufre2 solidfuz″ def
```

The last step will be to fuse the two S-S and the three O already equipped with their bonds:

```
/S2O3 – S1S2L4 LO123 solidfuz″ def
S2O3  drawsolid**″
```

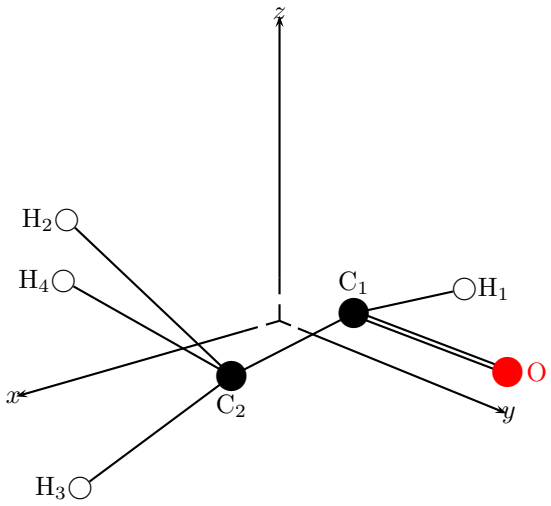
10. Interaction with PSTricks

10.1. Positioning a named point

“psPoint(x,y,z)–name”

This is a command similar to “pnode(! x y)–name”. It places the node (name) at the point with the coordinates (x, y, z), viewed with the chosen point of view viewpoint=vx vy vz. We can now use the point to mark it, draw lines, polygons, etc.

Let’s place the centres of the atoms of the methanol molecule CH_3COH.




```
“begin–pspicture”(-4,-4) (4,5)
“psset–viewpoint=100 50 20 rtp2xyz,Decran=20”
“axesIIID(3,3,3) (20,20,20)
“psPoint (-4.79,2.06,0) –C1”
“psPoint (-4.79,15.76,0) –Ox”
“psPoint (8.43,5.57,0) –C2”
“psPoint (-14.14,3.34,0) –H3”
“psPoint (14.14,-2.94,8.90) –H6”
“psPoint (14.14,-2.94,-8.90) –H7”
“psPoint (6.43,-16.29,0) –H8”
“psline(C1)(H3)“psline(C2)(H7)
“psline(C2)(H8)“psline(C1)(C2)
“psline[doubleline=true](C1)(Ox)
“psline(C2)(H6)
“uput[r](H3)–$“mathrm–H˙1”$”
“uput[l](H6)–$“mathrm–H˙2”$”
“uput[l](H7)–$“mathrm–H˙3”$”
“uput[l](H8)–$“mathrm–H˙4”$”
“uput–0.25”[u](C1)–$“mathrm–C˙1”$”
“uput–0.25”[d](C2)–$“mathrm–C˙2”$”
“uput–0.25”[r](Ox)–$“red“mathrm–O”$”
“psdots[dotstyle=o,dotsize=0.3](H3)(H6)(H7)(H8)
“psdots[dotsize=0.4](C1)(C2)
“psdot[ linecolor =red,dotsize=0.4](Ox)
“end–pspicture”
```

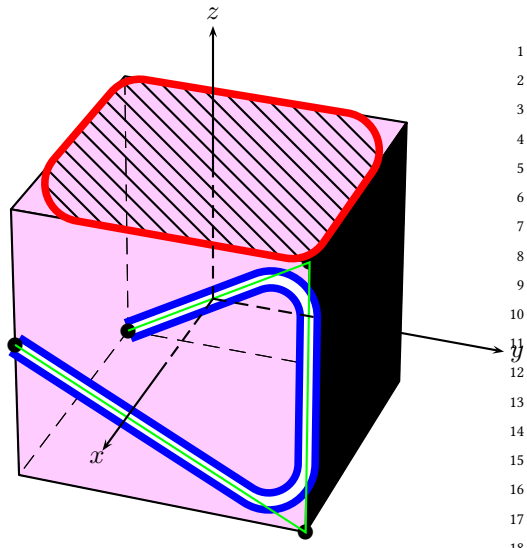
10.2. Drawing a line

This command is adapted from the macro “pstThreeDLine from the package pst-3dplot of Herbert Voss.

We use \psLineIIID[options](x0,y0,z0)(x1,y1,z1)... (xn,yn,zn), with the following possible options:

- linecolor=colour;
- doubleline=true;
- linearc=value.

It is not possible to put arrowheads at the ends of the lines.




```
“psset–viewpoint=50 20 30 rtp2xyz,Decran=50″
“begin–pspicture″(-3,-4) (4,4)
“psSolid[object=cube,a=4,action=draw*,
   fillcolor =magenta!20]%
“psLineIIID[linecolor=blue,
  linewidth=0.1,linearc=0.5,
  doubleline=true ](-2,-2,-2) (2,2,2) (2,2,-2) (2,-2,0)
“psPoint(2,-2,0)–A″“psPoint(-2,-2,-2)–B″
“psPoint(2,2,2)–C″“psPoint(2,2,-2)–D″
“psdot[dotsize=0.2](A)“psdot[dotsize=0.2](B)
“psdot[dotsize=0.2](C)“psdot[dotsize=0.2](D)
“psLineIIID[linecolor=green]%
   (-2,-2,-2) (2,2,2) (2,2,-2) (2,-2,0)
“psPolygonIIID[linecolor=red,
   fillstyle =vlines,linearc=0.5,
  linewidth =0.1](-2,-2,2) (-2,2,2) (2,2,2) (2,-2,2)
“axesIIID(2,2,2) (4,4,4)
“end–pspicture″
```

10.3. Drawing a polygon

We use: \psPolygonIIID[options](x0,y0,z0)(x1,y1,z1)... (xn,yn,zn), with the possible options that follow:

- linecolor=color;
- doubleline=true;
- linearc=value;
- fillstyle=solid;
- fillstyle=vlines or fillstyle=hlines or fillstyle=crosshatch.

10.4. Transformations to a point

Given is an initial point $A(x, y, z)$. Now we make some rotations around the axes Ox, Oy and Oz with the appropriate angles (in degrees): [RotX=valueX,RotY=valueY,RotZ=valueZ], in this order, then translate it with the vector (v_x, v_y, v_z). The problem is to get back the coordinates of the image (final point) $A'(x', y', z')$.

The code \psTransformPoint[RotX=valueX,RotY=valueY, RotZ=valueZ](x y z)(vx,vy,vz){A'}
now allows us to save the node A', the coordinates of the transformed point.

In the following example, $A(2, 2, 2)$ is one of the vertices of the initial cube, where the centre is placed at the origin.

“psSolid[object=cube,a=4,action=draw*,linecolor=red]%

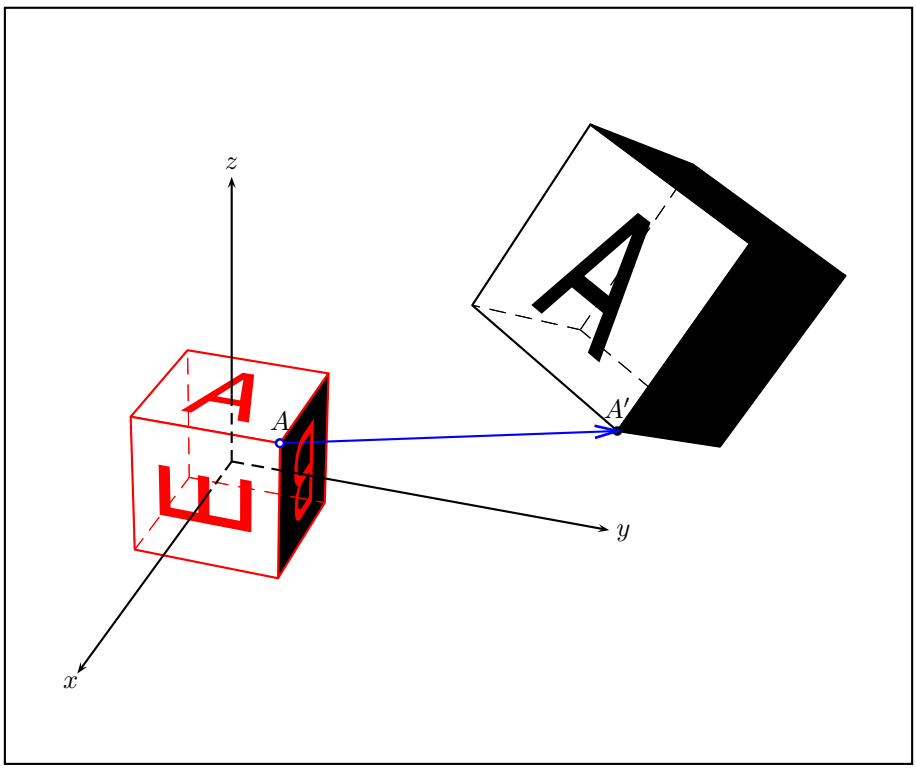
Some transformations are applied to the cube:

“psSolid[object=cube,a=4,action=draw*,RotX=-30,RotY=60,RotZ=-60](7.5,11.25,10)%

To obtain the image of A, we use the following command:

“psTransformPoint[RotX=-30,RotY=60,RotZ=-60](2 2 2)(7.5,11.25,10)–A'″

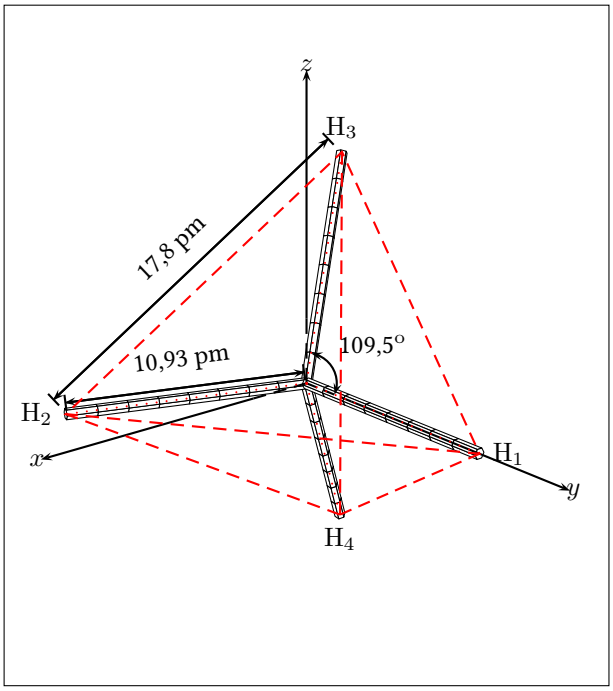
This allows us, for example, to name these points and then draw the vector $\overrightarrow{AA'}$.

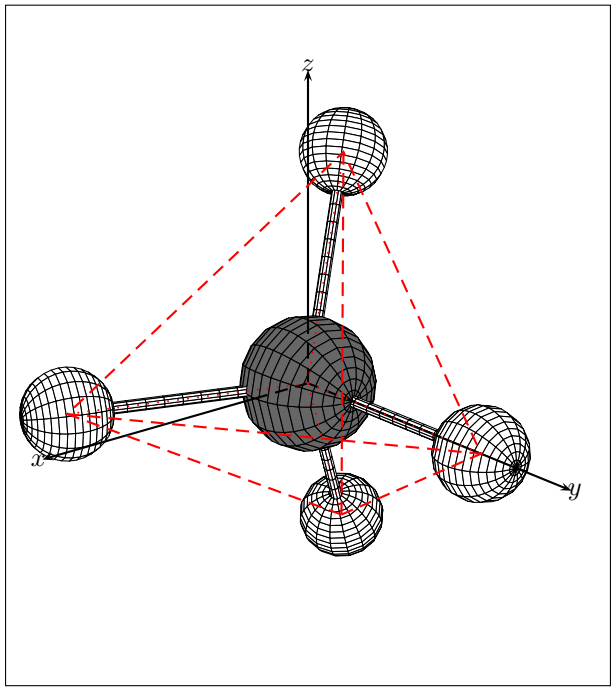


10.5. Adding dimensions to the scenery

It is very interesting to add dimensions to the scenery. We take the example of the methane molecule, where we want to insert the distances and angles.

The first step consists of representing the molecule with its bonds and characteristic dimensions, and then draw it in a good looking way.





The construction of the molecule is detailed in the document molecules.tex. To add a dimensioning you only need to find the vertices of the tetrahedron:

“psPoint(0,10.93,0)–H1″
“psPoint(10.3,-3.64,0)–H2″
“psPoint(-5.15,-3.64,8.924)–H3″
“psPoint(-5.15,-3.64,-8.924)–H4″

and then use the power of the package pst-node. For the distances:

“pcline[offset=0.25]–¡-¿″(H2)(H3)
“aput–:U″–17,8 pm″
“pcline[offset=0.15]–¡-¿″(H2)(O)
“aput–:U″–10,93 pm″
“psPoint(-5.15,-3.64,-8.924)–H4″

Then, for the angles, we take help from the package pst-eucl

“pstMarkAngle[arrows=¡-¿]–H1″–O″–H3″–“small 109,5$ˆ–“mathrm–o″″$″

11. Projections

11.1. Presentation

The package allows the representation and manipulation of some simple objects in two dimensions (2D). The macro \psProjection can project these 2D objects onto a chosen plane.

The syntax is analogous to that of \psSolid, with an obligatory option object, that allows us to specify the type of object to be projected.

The general syntax is \psSolid[object=objectname,plan=plantype,¡options¿](x,y)

11.2. The parameter visibility

For all projections, the Boolean visibility (true by default) specifies whether or not to have the projection made visible.

Set to false, the projection is always carried out. Set to true, the projection is only carried out when the plane of projection is visible from the viewpoint of the observer.

11.3. Defining a projection plane

The plane of projection is defined with the option plan=plantype which expects an argument *type of plane*. The creation of such an argument invariably happens through the command "psSolid[object=plan] (see the relevant paragraph of chapter 4 and the example below in sub-paragraph *Labels* of the paragraph *Points*).

11.4. Points

11.4.1. Direct definition

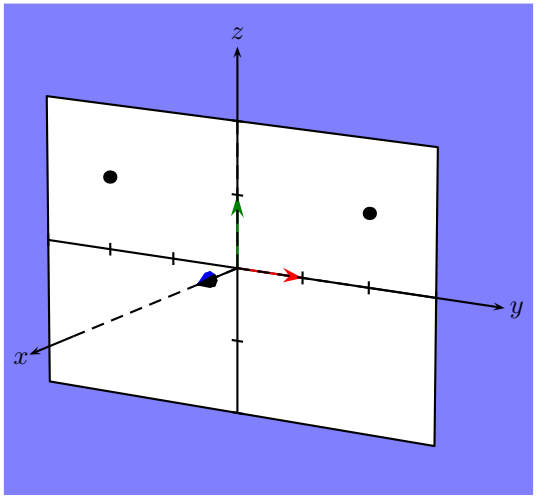
The object point defines a point. The values (x, y) of its coordinates can be passed directly to the macro \psProjection or indirectly via the option args.

Thus the two commands "psProjection[object=point](1,2) and "psProjection[object=point,arg=1 2] are equivalent and lead to the projection of the point with coordinates $(1, 2)$ onto the chosen plane.

11.4.2. Labels

The option text=my text allows us to project a string of characters onto the chosen plane next to a chosen point. The positioning is made with the argument pos=value where value is one of the following {ul, cl, bl, dl, ub, cb, bb, db, uc, cc, bc, dc, ur, cr, br, dr}.

The details of the parameter pos will be discussed in a later paragraph.




```
\begin{pspicture}(-3,-3)(4,3.5)%
\psframe*[linecolor=blue!50](-3,-3)(4,3.5)
\psset{viewpoint=50 30 15,Decran=60}
\psset{solidmemory}
%% definition du plan de projection
\psSolid[object=plan,
    definition=equation,
    args={[1 0 0 0] 90},
    name=monplan,
    planmarks,
    showBase]
\psset{plan=monplan}
%% definition du point A
\psProjection[object=point,
    args=-2 1,
    text=A,
    pos=ur]
\psProjection[object=point,
    text=B,
    pos=ur](2,1)
\composeSolid
\axesIIID(4,2,2)(5,4,3)
\end{pspicture}
```

11.4.3. Naming and memorising a point

If the option name=myName is given, the coordinates (x, y) of the chosen point are saved under the name myName and so can be reused.

11.4.4. Some other definitions

There are other methods to define a point in 2D. The options definition and args support the following methods:

- definition=milieu; args=A B.

  The midpoint of the line segment $[AB]$

- definition=parallelopoint; args=A B C.

  The point D for which $(ABCD)$ is a parallelogram.

- definition=translatepoint; args=M u.

  The image of the point M shifted by the vector $\vec{u}$

- definition=rotatepoint; args=M I r.

  The image of the point M under a rotation about the point I through an angle r (in degrees)

- definition=hompoint; args=M A k.

  The point M' satisfying $\overrightarrow{AM'} = k\overrightarrow{AM}$

- definition=orthoproj; args=+M d.

  The orthogonal projection of the point M onto the line d.

- definition=projx; args=M.

  The projection of the point M onto the Ox axis.

- definition=projy; args=M.

  The projection of the point M onto the Oy axis.

- definition=sympoint; args=$M\ I$.

  The point of symmetry of M with respect to the point I.

- definition=axesympoint; args=$M\ d$.

  The axially symmetrical point of M with respect to the line d.

- definition=cpoint; args=$\alpha\ C$.

  The point corresponding to the angle α on the circle C

- [definition=xdpoint]; args=$x\ d$.

  The Ox intercept x of the line d.

- definition=ydpoint; args=$y\ d$.

  The Oy intercept y of the line d.

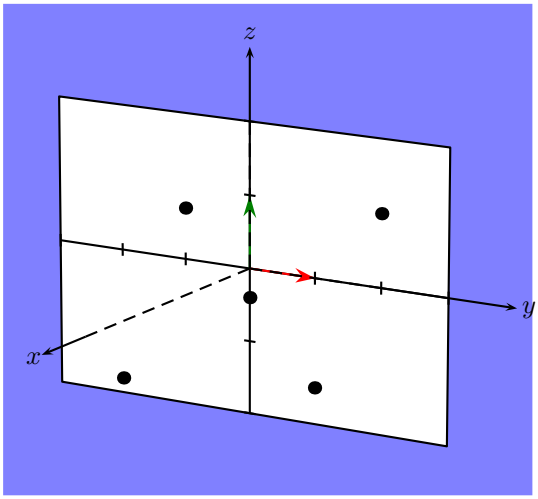
- definition=interdroite; args=$d_1\ d_2$.

  The intersection point of the lines d_1 and d_2.

- definition=interdroitecercle; args=$d\ I\ r$.

  The intersection points of the line d with a circle of centre I and radius r.

In the example below, we define and name three points A, B and C, and then calculate the point D for which $(ABCD)$ is a parallelogram together with the centre of this parallelogram.



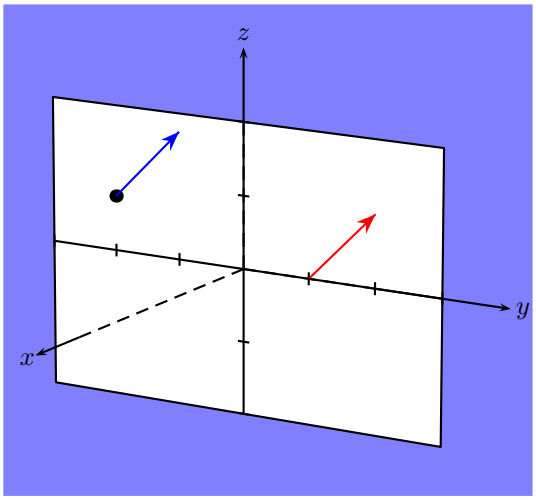

```
“begin–pspicture”(-3,-3) (4,3.5) %
“psframe*[linecolor=blue!50](-3,-3) (4,3.5)
“psset–viewpoint=50 30 15,Decran=60”
“psset–solidmemory”
%% definition du plan de projection
“psSolid[object=plan,
    definition=equation,
    args=–[1 0 0 0] 90”,
    name=monplan,
    planmarks,
    showbase]
“psset–plan=monplan”
%% definition du point A
“psProjection[object=point,
    text=A,pos=ur,name=A](-1,.7)
%% definition du point B
“psProjection[object=point,
    text=B,pos=ur,name=B](2,1)
%% definition du point C
“psProjection[object=point,
    text=C,pos=ur,name=C](1,-1.5)
%% definition du point D
“psProjection[object=point,
    definition=parallelopoint,
    args=A B C,
    text=D,pos=ur,name=D]
%% definition du point G
“psProjection[object=point,
    definition=milieu,
    args=D B]
“composeSolid
“axesIIID(4,2,2) (5,4,3)
“end–pspicture”
```

11.5. Vectors

11.5.1. Direct definition

The object vecteur allows us to define and draw a vector. To do so in a simple way, we use the option args to define its components (x, y) and we specify the point from where the vector starts with the macro \psProjection (or we may use a named point).

As with points, we can save the components of a vector using the option name.




```
“begin–pspicture”(-3,-3) (4,3.5) %
“psframe*[linecolor=blue!50](-3,-3) (4,3.5)
“psset–viewpoint=50 30 15,Decran=60”
“psset–solidmemory”
%% definition du plan de projection
“psSolid[object=plan,
    definition=equation,
    args=–[1 0 0 0] 90”,
    planmarks,
    name=monplan]
“psset–plan=monplan”
%% definition du point A
“psProjection[object=point,
    args=-2 0.75,
    name=A,text=A,
    pos=dl]
“psProjection[object=vecteur,
    linecolor=red,
    args=1 1,
    name=U](1,0)
“psProjection[object=vecteur,
    args=U,
    linecolor=blue](A)
“composeSolid
“axesIIID(4,2,2) (5,4,3)
“end–pspicture”
```

11.5.2. Some more definitions

There are other methods to define a vector in 2D. The options definition and args allow us a variety of supported methods:

- definition=vecteur; args=A B.

  The vector $\overrightarrow{AB}$

- definition=orthovecteur; args=u.

  A vector perpendicular to $\vec{u}$ with the same length.

- definition=normalize; args=u.

  The vector $\|\vec{u}\|^{-1}\vec{u}$ if $\vec{u} \neq \vec{0}$, and $\vec{0}$ otherwise.

- definition=addv; args=u v.

  The vector $\vec{u} + \vec{v}$

- definition=subv; args=u v.

  The vector $\vec{u} - \vec{v}$

- definition=mulv; args=u α.

  The vector $\alpha\vec{u}$

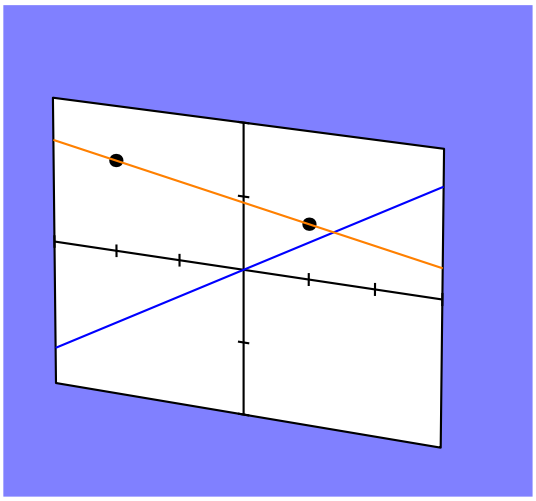
11.6. Lines

11.6.1. Direct definition

The object droite allows us to define and draw a line. In the pst-solides3d package, a line in 2D is defined by its two end-points.

We use the option args to specify the end-points of the chosen line. We can use coordinates or named points.

As with points and vectors, we can save the coordinates of the line with the option name.



```
“begin–pspicture”(-3,-3) (4,3.5) %
“psframe*[linecolor=blue!50](-3,-3) (4,3.5)
“psset–viewpoint=50 30 15,Decran=60”
“psset–solidmemory”
%% definition du plan de projection
“psSolid[object=plan,
    definition=equation,
    args=–[1 0 0 0] 90”,
    planmarks,name=monplan]
“psset–plan=monplan”
%% definition du point A
“psProjection[object=point,
    name=A,text=A,
    pos=ur](-2,1.25)
“psProjection[object=point,
    name=B,text=B,
    pos=ur](1,.75)
“psProjection[object=droite,
    linecolor=blue,
    args=0 0 1 .5]
“psProjection[object=droite,
    linecolor=orange,
    args=A B]
“composeSolid
“end–pspicture”
```

11.6.2. Some other definitions

There are other methods to define a line in 2D. The options definition and args are used in these variants:

- definition=horizontale; args=b.

  The line with equation $y = b$.

- definition=verticale; args=a.

  The line with equation $x = a$.

- definition=paral; args=d A.

  A line parallel to d passing through A.

- definition=perp; args=d A.

  A line perpendicular to d passing through A.

- definition=mediatrice; args=A B.

  The perpendicular bisector of the line segment $[AB]$.

- definition=bissectrice; args=A B C.

  The bisector of the angle $\widehat{ABC}$.

- definition=axesymdroite; args=d D.

  The reflection of the line d in the line D.

- definition=rotatedroite; args=d I r.

  The image of the line d after a rotation with centre I through an angle r (in degrees)

- definition=translatedroite; args=d u.

  The image of the line d shifted by the vector $\vec{u}$.

11.7. Circles

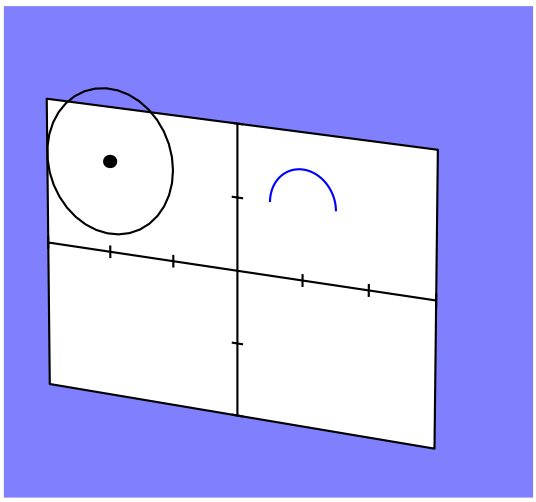
11.7.1. Direct definition

The object cercle allows us to define and draw a circle. In the pst-solides3d package, a circle in 2D is defined by its centre and radius.

We use the option args to specify the centre and radius of the chosen circle. We can use coordinates or named variables.

The argument range=$t_{\min}$ $t_{\max}$ allows us to specify an arc of the chosen circle.

As for all the other object, we can save the circle data using the option name.



```
“begin–pspicture”(-3,-3) (4,3.5) %
“psframe*[linecolor=blue!50](-3,-3) (4,3.5)
“psset–viewpoint=50 30 15,Decran=60”
“psset–solidmemory”
%% definition du plan de projection
“psSolid[object=plan,
    definition=equation,
    args=–[1 0 0 0] 90”,
    planmarks,
    name=monplan]
“psset–plan=monplan”
%% definition du point A
“psProjection[object=point,
    name=A,
    text=A,
    pos=ur](-2,1.25)
“psProjection[object=cercle,
    args=A 1,
    range=0 360]
“psProjection[object=cercle,
    args=1 1 .5, linecolor=blue,
    range=0 180]
“composeSolid
“end–pspicture”
```

11.7.2. Some other definitions

There are additional methods to define a circle in 2D. The options definition and args give the following supported methods:

- definition=ABcercle; args=A B C.

  A circle through the points A, B and C.

- definition=diamcercle; args=A B.

  A circle with diameter $[AB]$.

11.8. Polygons

11.8.1. Direct definition

The object polygone allows us to define a polygon. We use the option args to specify the list of vertices: [object=polygone,args=A_0 A_1 $\ldots$ A_n]

There are other ways to define a polygon in 2D. The options definition and args support these methods:

- definition=translatepol; args=*pol* u.

  Translation of the polygon *pol* by the vector $\vec{u}$

- definition=rotatepol; args=*pol* I α.

  Image of the polygon *pol* after a rotation with centre I and angle α

- definition=hompol; args=*pol* I α.

  Image of the polygon *pol* after a homothety (dilation) with centre I and ratio α.

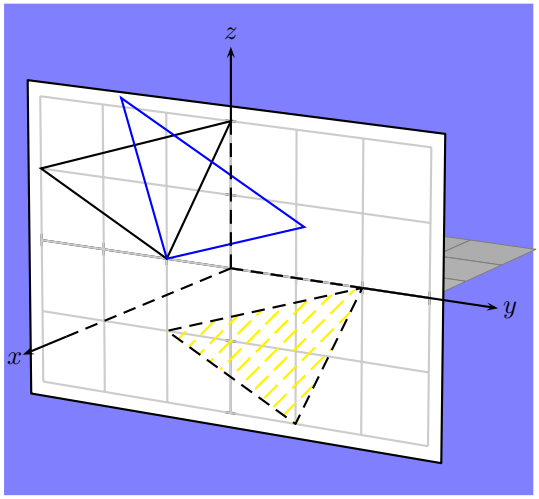
- definition=sympol; args=*pol* I.

  Image of the polygon *pol* after a reflection in the point I.

- definition=axesympol; args=*pol* d.

  Image of the polygon *pol* after a reflection in the line d.

In the following example we define, name and draw the polygon with vertices $(-1, 0)$, $(-3, 1)$, $(0, 2)$, then—in blue—the image after a rotation about the point $(-1, 0)$ through an angle -45. Finally, we translate the polygon with the vector shift $(2, -2)$ by directly incorporating *jps code* within the argument of definition.



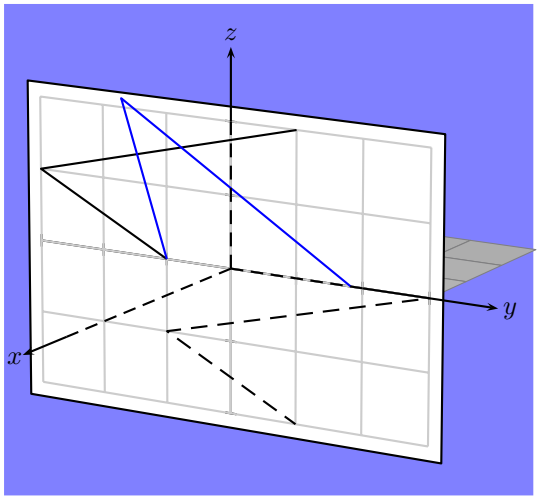

```
“begin–pspicture”(-3,-3) (4,3.5) %
“psframe*[linecolor=blue!50](-3,-3) (4,3.5)
“psset–lightsrc=50 20 20,viewpoint=50 30 15,Decran=60”
“psset–solidmemory”
“psSolid[object=grille,
    base=-3 0 -3 3,
    linewidth=0.5“pslinewidth,linecolor=gray,]
%% definition du plan de projection
“psSolid[object=plan,
    definition=equation,
    args=–[1 0 0 0] 90”,
    base=-3.2 3.2 -2.2 2.2,
    name=monplan,
    planmarks,
]
“psset–plan=monplan”
“psSolid[object=plan,
    args=monplan,
    linecolor=gray!40,
    plangrid,
    action=none,
]
“psProjection[object=polygone,
    args=-1 0 -3 1 0 2,
    name=P,
]
“psProjection[object=polygone,
    definition=rotatepol,
    linecolor=blue,
    args=P -1 0 -45,
]
%% du code jps dans la definition
“psProjection[object=polygone,
    definition=–2 -2 addv” papply,
    fillstyle=hlines,hatchcolor=yellow,
    linestyle=dashed,
    args=P,
]
“composeSolid
“axesIIID(4,2,2) (5,4,3)
“end–pspicture”
```

11.9. Lines

11.9.1. Direct definition

The object line defines a line (or a series of line segments). We use the option args to specify the points: [object=line,args=A_0 A_1 ... A_n]

We can also define a line that has been transformed using a translation, a rotation, a homothety, etc., as though it were a polygon.

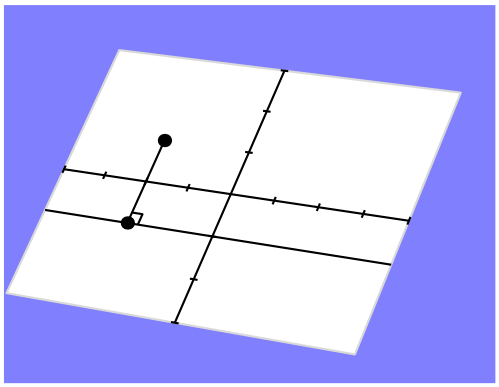



```
“begin–pspicture”(-3,-3) (4,3.5) %
“psframe*[linecolor=blue!50](-3,-3) (4,3.5)
“psset–lightsrc=50 20 20,viewpoint=50 30 15,Decran=60”
“psset–solidmemory”
“psSolid[object=grille,
    base=-3 0 -3 3,
    linewidth=0.5“pslinewidth,linecolor=gray,]
%% definition du plan de projection
“psSolid[object=plan,
    definition=equation,
    args=–[1 0 0 0] 90”,
    base=-3.2 3.2 -2.2 2.2,
    name=monplan,
    planmarks]
“psset–plan=monplan”
“psSolid[object=plan,
    args=monplan,
    linecolor=gray!40,
    plangrid,
    action=none]
“psProjection[object=line,
    args=-1 0 -3 1 1 2,
    name=P]
“psProjection[object=line,
    definition=rotatepol,
    linecolor=blue,
    args=P -1 0 -45]
%% du code jps dans la definition
“psProjection[object=line,
    definition=–2 -2 addv” papply,
    linestyle=dashed,
    args=P]
“composeSolid
“axesIIID(4,2,2) (5,4,3)
“end–pspicture”
```

11.10. Right angle

11.10.1. Direct definition

The object rightangle allows us to specify and draw a right angle. The syntax is: [object=rightangle,args=A B C]



```
“begin–pspicture ″(-3,-2.5) (3.5,2.5) %
“psframe*[linecolor=blue !50](-3,-2.5) (3.5,2.5)
“psset–lightsrc =viewpoint,viewpoint=50 30 15,Decran=40″
“psset–solidmemory″
%% definition du plan de projection
“psSolid[object=plan,
    definition =equation,
    args=–[1 0 1 0] 90″,
    base=-4 4 -3 3,
     fillcolor =white,
    linecolor =gray!30,
%   plangrid,
    planmarks,
    name=monplan]
“psset–plan=monplan,visibility=false″
%% definition droite d
“psProjection[object=droite,
    definition =horizontale,
    args=-1,name=d]
“psset–fontsize=15″
%% definition du point M
“psProjection[object=point,
    args=-2 1,
    name=M,text=M,
    pos=ul]
%% definition du point H
“psProjection[object=point,
    definition =orthoproj,
    args=M d,
    name=H,text=H,
    pos=dr]
%% definition du point H’ pour orienter l’angle droit
%% et mettre la legende
“psProjection[object=point,
    definition =xdpoint,
    args=2 d,name=H’,
    action=none,
    text=d,pos=ur]
%% definition d’une ligne
“psProjection[object=line,
    args=M H]
%% dessin angle droit
“psProjection[object=rightangle,
    args=M H H’]
“composeSolid
%“axesIIID(4,4,2)(5,5,6)
“end–pspicture″
```

11.11. Curves of real-valued and parameterised functions

11.11.1. Curve of a real-valued function

The object courbe allows us to draw a curve, where the name is given with the option function. This function, with values in $\mathbb{R}$, has to be defined by the macro “defFunction (see the appropriate paragraph for more details).

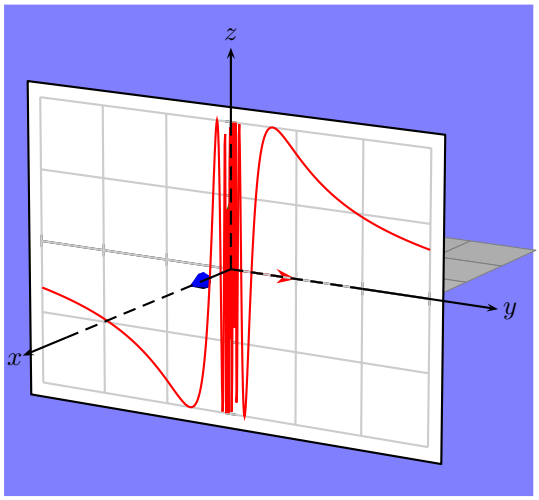
We can define this function either in algebraic notation, with the option algebraic, or in Reverse Polish Notation (RPN), with variables like $(x, u, t \ldots)$, using an expression of the following form:

“defFunction[algebraic]–nom˙fonction″(x)–x*sin(x)″–″–″

“defFunction–nom˙fonction”(x)–x dup sin mul”–”–”

Note: This expression needs to be included within a pspicture environment.

The limits of the variables are defined by the option range=$xmin$ $xmax$, and the option argument=n defines the number of points to be plotted when drawing the curve.




```
“begin–pspicture”(-3,-3) (4,3.5) %
“psframe*[linecolor=blue!50](-3,-3) (4,3.5)
“psset–lightsrc=50 20 20,viewpoint=50 30 15,Decran=60”
“psset–solidmemory”
“defFunction[algebraic]–1˙sin”(x)–2*sin(1/x)”–”–”
“psSolid[object=grille,
    base=-3 0 -3 3,
    linewidth=0.5“pslinewidth,linecolor=gray,]
%% definition du plan de projection
“psSolid[object=plan,
    definition=equation,
    args=–[1 0 0 0] 90”,
    base=-3.2 3.2 -2.2 2.2,
    planmarks,
    showBase,
    name=monplan]
“psset–plan=monplan”
“psSolid[object=plan,
    args=monplan,
    linecolor=gray!40,
    plangrid,
    action=none]
“psProjection[object=courbe,
    linecolor=red,
    range=-3 3,resolution=720,
    function=1˙sin]
“composeSolid
“axesIIID(4,2,2) (5,4,3)
“end–pspicture”
```

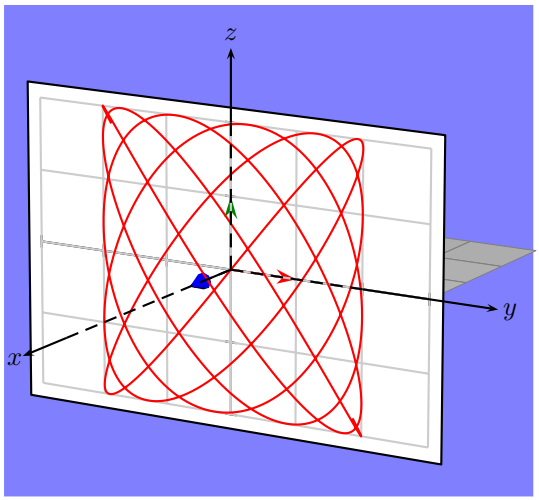
11.11.2. Parameterised curves

The technique used here is analogous to the above, with the difference that the values now come from $\mathbb{R}^2$, and the object for the macro \psProjection is now courbeR2.

For example, to draw a circle of radius 3 and centre O, we type:

“defFunction[algebraic]–cercle”(t)–3*cos(t)”–3*sin(t)”–”

Another example: Lissajous curves.




```
“begin–pspicture”(-3,-3) (4,3.5) %
“psframe*[linecolor=blue!50](-3,-3) (4,3.5)
“psset–lightsrc=50 20 20,viewpoint=50 30 15,Decran=60”
“psset–solidmemory”
“defFunction[algebraic]–F”(t)–2*sin(0.57735*t)”–2*sin
      (0.707*t)”–”
“psSolid[object=grille,
   base=-3 0 -3 3,
   linewidth=0.5“pslinewidth,linecolor=gray,]
%% definition du plan de projection
“psSolid[object=plan,
    definition=equation,
   args=–[1 0 0 0] 90”,
   base=-3.2 3.2 -2.2 2.2,
   name=monplan,
   planmarks,
   showBase]
“psset–plan=monplan”
“psSolid[object=plan,
   args=monplan,
    linecolor=gray!40,
   plangrid,
   action=none]
“psProjection[object=courbeR2,
   range=-25.12 25.12,resolution=720,
   normal=1 1 2,linecolor=red,
   function=F]
“composeSolid
“axesIIID(4,2,2) (5,4,3)
“end–pspicture”
```

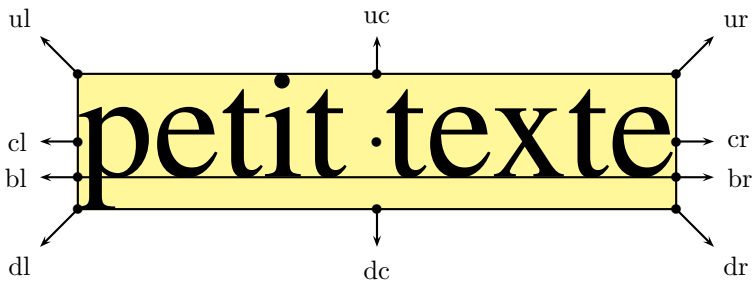
11.12. Text

The object texte of the macro \psProjection allows us to project character strings onto planes.

11.12.1. The parameters and the options

There are three parameters:text which defines the string, fontsize, which gives the dimension of the font in points (remember: 28.45 pts correspond to 1 cm), and finally pos, which defines the position of the text. By default, the text is centred at the origin of the plane.

This last parameter needs some explanation. See the string petit texte represented below.



We have 4 horizontal reference lines: the bottom line (d)own, the base line (b)aseline, the median line, or centre line (c)enter, and the upper line (u)p.

There are as well 4 vertical reference lines: the left line (l)eft, the base line (b)aseline, the centre line (c)enter and the right line (r)ight. In the case of strings, the two vertical lines l and b might be indistinguishable and easily confounded.

The intersection of the 4 horizontal lines with the 4 vertical lines gives us 16 positioning point possibilities dl, bl, cl, ul, db, bb, cb, ub, dc, bc, cc, uc, dr, br, cr, ur.

Of these, 4 are considered as *inner points*: bb, bc, cb and cc.

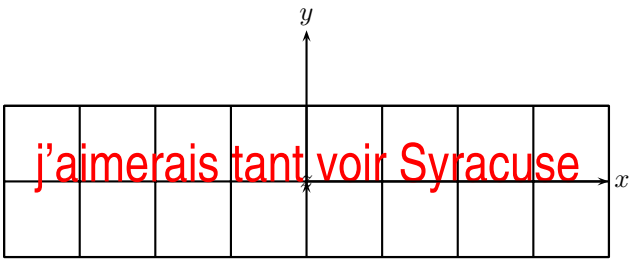
When the parameter pos of \psProjection is assigned one of these four inner points, it means that the latter will be situated at the origin of the plane of projection.

When the parameter pos of \psProjection is assigned one of the twelve remaining points, it indicates the direction in which the text will be positioned relative to the origin of the plane of projection.

For example, "psProjection[...,pos=uc](0,0) indicates that the text will be centred relative to the point $(0, 0)$ and situated above it.

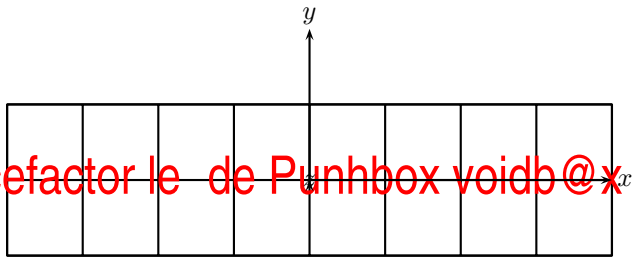
11.12.2. Examples of projecting onto a plane

Example 1: projection onto Oxy, with the option pos=bc



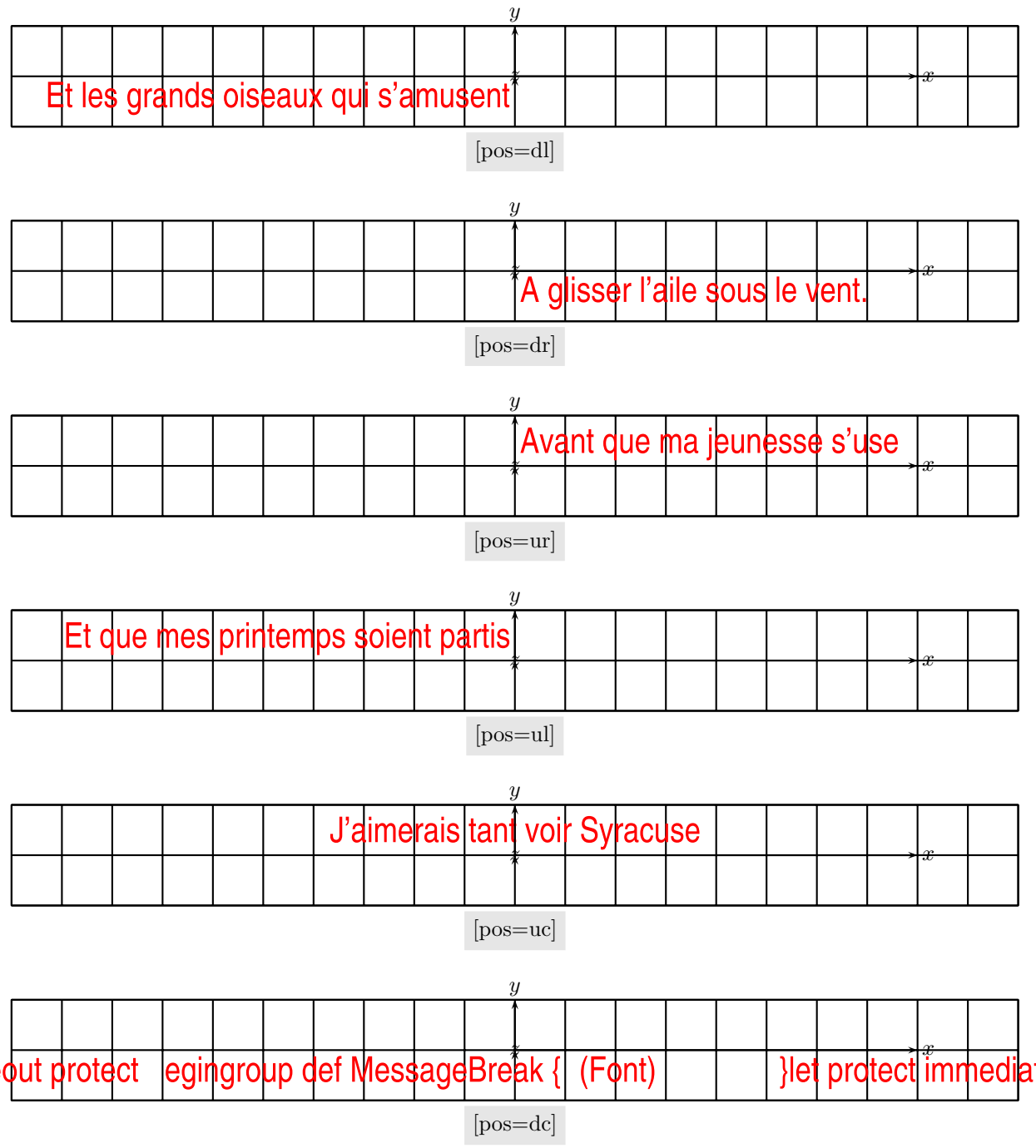

```
"begin-pspicture "(-4,-1.5) (4,1.5)
"psset-solidmemory"
"psset- lightsrc =10 0 10,
    viewpoint=50 -90 89.99 rtp2xyz,Decran=50"
"psSolid[object=plan,definition=normalpoint,plangrid,
    base=-4 4 -1 1,args=-0 0 0 [0 0 1]",name=monplan,]
"psProjection[object=texte,
    fontsize =20,linecolor=red,
    pos=bc,plan=monplan,
    text=j'aimerais tant voir Syracuse,
](0,0) %
"axesIIID(0,0,0) (4,2,1)
"composeSolid
"end-pspicture"
```

Example 2: projection onto Oxy, centred text

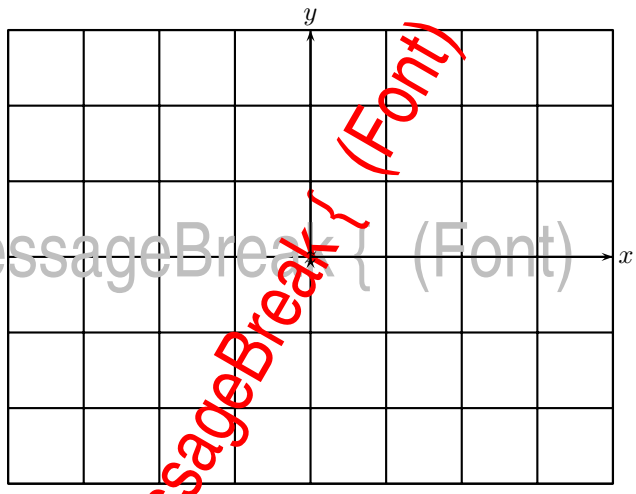



```
"begin-pspicture "(-4,-1.5) (4,1.5)
"psset-solidmemory"
"psset- lightsrc =10 0 10,
    viewpoint=50 -90 89.99 rtp2xyz,,Decran=50"
"psSolid[object=plan,definition=normalpoint,plangrid,
    base=-4 4 -1 1,args=-0 0 0 [0 0 1]",name=monplan,]
"psProjection[object=texte,
    fontsize =20,linecolor=red,
    text= L'"^-"i"le de P"^-a"ques et Kairouan,
    plan=monplan]%
"axesIIID(0,0,0) (4,2,1)
"end-pspicture"
```

Example 3: projection onto Oxy, with different options pos=dl, etc.



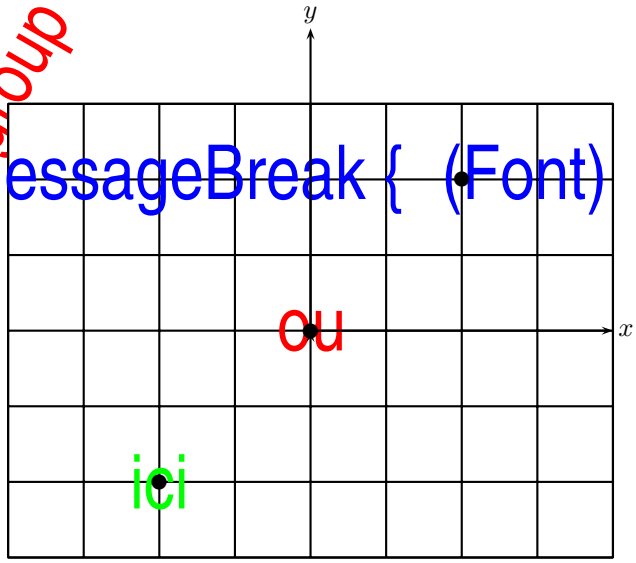
Example 4: projection onto Oxy with text rotation




```
“begin–pspicture”(-4,-3) (4,3)
“psset–solidmemory”
“psset– lightsrc =10 0 10,
    viewpoint=50 -90 89.99 rtp2xyz,Decran=50”
“psSolid[object=plan,definition=normalpoint,plangrid,
    base=-4 4 -3 3,args=–0 0 0 [0 0 1]”,name=monplan,]
“psset–plan=monplan”
“psProjection[object=texte,
    fontsize =28.45,linecolor =gray!50,
    text=Tournez man“‘–e”ges]%
“psProjection[object=texte,
    fontsize =28.45,linecolor =red,
    text=Tournez man“‘–e”ges,
    phi=60]%
“axesIIID(0,0,0) (4,3,1)
“end–pspicture”
```

The text rotation is introduced by the parameter phi=60.

Example 5: positioning text at a point

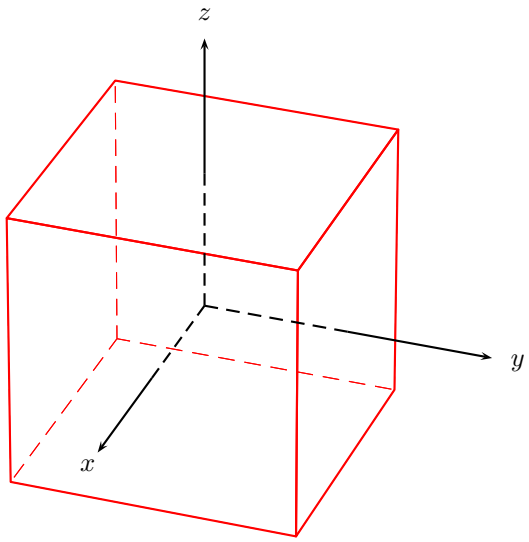



```
“begin–pspicture”(-4,-3) (4,3)
“psset–solidmemory”
“psset–viewpoint=50 -90 89.99 rtp2xyz,Decran=50”
“psSolid[object=plan,definition=normalpoint,plangrid,
    base=-4 4 -3 3,args=–0 0 0 [0 0 1]”,name=monplan,]
“psset– fontsize =28.45,plan=monplan”
“psProjection[object=texte,
    linecolor =green,
    text=ici ](-2,-2)
“psProjection[object=texte,
    linecolor =red,
    text=ou]%
“psProjection[object=texte,
    linecolor =blue,
    text=l“‘–a ”](2,2)
“psPoint(0,0,0)–O”
“psPoint (-2,-2,0)–O1”
“psPoint(2,2,0)–O2”
“psdots[dotsize=0.2](O)(O1)(O2)
“axesIIID(0,0,0) (4,4,1)
“end–pspicture”
```

11.12.3. Examples for projecting onto a face of a solid

Method

The solid must be memorised with the general option \psset{solidmemory}. The first thing to do is to find the numbers of the faces of the solid with the option numfaces=all.

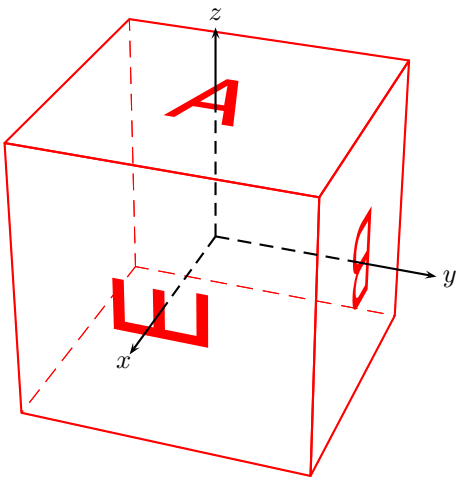



```
“psset–viewpoint=50 20 30 rtp2xyz,Decran=100″
“begin–pspicture″(-4,-4) (4,4)
“psSolid[object=cube,a=2,action=draw,
    linecolor =red,numfaces=all]%
“axesIIID(1,1,1) (2,2,2)
“end–pspicture″
```

Then we define the projection plane as the chosen face, where in this case we put A on the face with the index number 0:

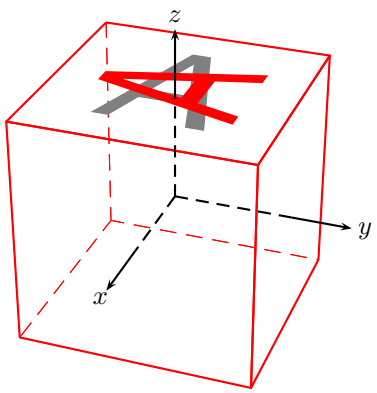
Then we define the projection plane by a chosen face, there we put A on the face with the index number 0:

“psSolid[object=plan,definition=solidface,args=A 0,name=P0]
“psProjection[object=texte,linecolor=red,text=A,plan=P0]%




```
“psset–viewpoint=50 20 30 rtp2xyz,Decran=50″
“begin–pspicture″(-4,-4) (4,5)
“psset–unit=0.5″
“psset–solidmemory″
“psSolid[object=cube,a=8,action=draw,name=A,linecolor
    =red]%
“psset–fontsize=100″
“psSolid[object=plan,action=none,
    definition=solidface,args=A 0,name=P0]
“psProjection[object=texte,linecolor=red,text=A,plan=P
    0]%
“psSolid[object=plan,action=none,
    definition=solidface,args=A 1,name=P1]
“psProjection[object=texte,linecolor=red,text=B,plan=P
    1]%
“psSolid[object=plan,action=none,
    definition=solidface,args=A 4,name=P4]
“psProjection[object=texte,linecolor=red,text=E,plan=P
    4]%
“axesIIID(4,4,4) (6,6,6)
“end–pspicture″
```

Text rotation with the option phi




```
“psset–viewpoint=50 20 30 rtp2xyz,Decran=50″
“psset–unit=0.4″
“begin–pspicture″(-8,-7) (4,9)
“psset–solidmemory″
“psSolid[object=cube,a=8,action=draw,linecolor=red,
    name=A]%
“psset–fontsize=200″
“psSolid[object=plan,action=none,
    definition=solidface,args=A 0,name=P0]
“psProjection[object=texte,linecolor=gray,text=A,plan=
    P0]%
“psset–phi=90″
“psProjection[object=texte,linecolor=red,text=A,plan=P
    0]%
“axesIIID(4,4,4) (6,6,6)
“end–pspicture″
```

11.12.4. Examples of projecting onto different faces of a solid

We project a poem, verse by verse, onto 4 faces of a cube. It is necessary to use the option solidmemory at the beginning

```
“psset–solidmemory″
“psSolid[object=cube,a=8,name=A1](0,0,4.2)%
```

of the code. We then define the cube, which is memorised with the help of the command name=A:

```
“psset–solidmemory″
“psProjection[object=texte,text=po“‘–e″me,fontsize=30,plan=P0](0,3)%
“psSolid[object=cube,a=8,name=A](0,0,4.2)%
```

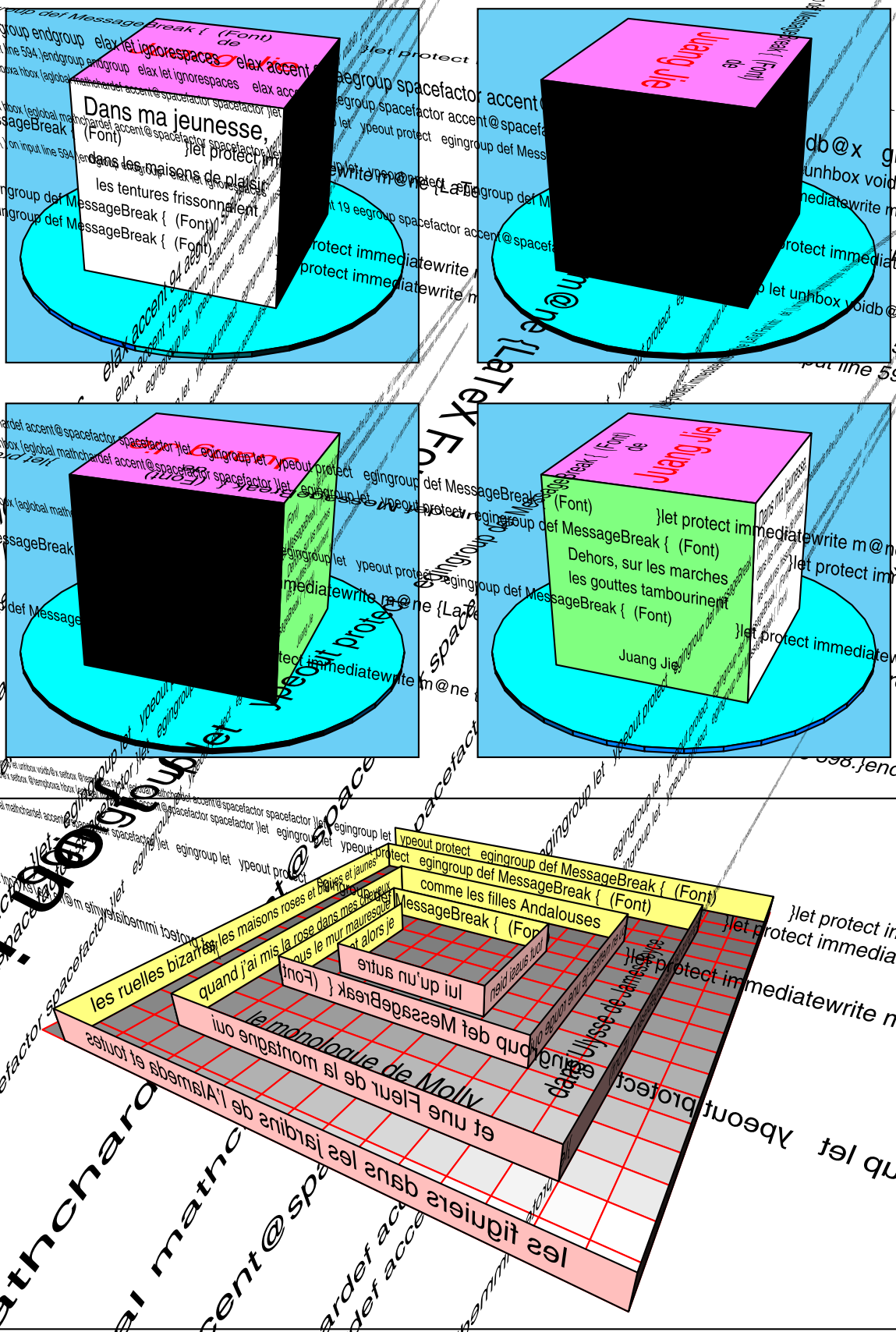
The number of each face needs to be known—from a previous run of the code with the option numfaces=all. The following commands:

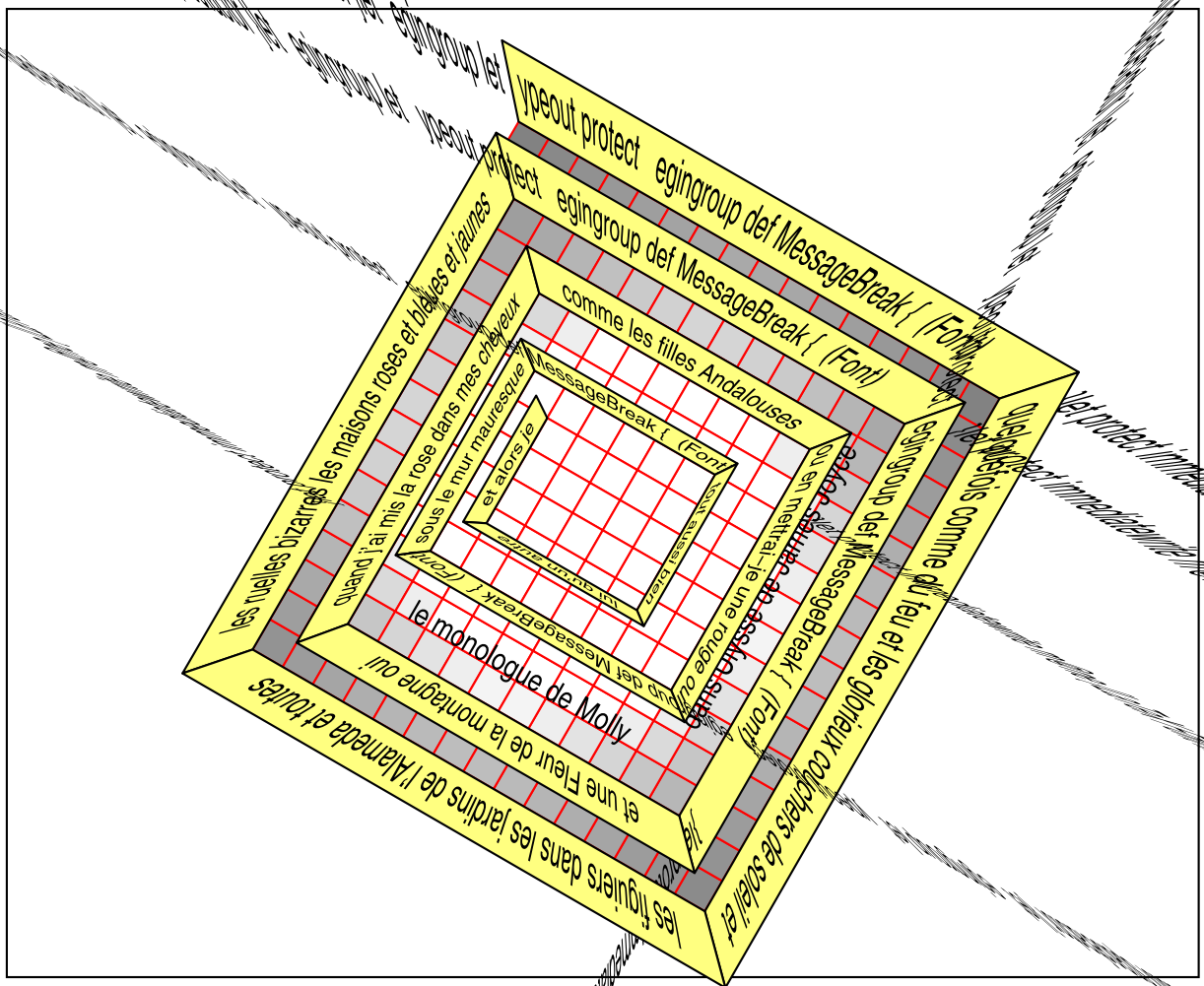
```
“psSolid[object=plan,action=none,definition=solidface,args=A 0,name=P0]%
“psProjection[object=texte,text=po“‘–e″me,fontsize=30,plan=P0](0,3)%
```

define the plane $P0$ as the oriented plane of the face with index number 0 of the solid A, before the word poème is projected onto $P0$, with a font size of 30 pts, to the point with coordinates $(0, 3)$ (within the coordinate system of that plane). We could have changed the orientation of the text to phi=-90 for example, in the one or other of the commands.

By default, if the face is not visible, its text stays hidden. By putting visibility in the options, the text is shown when it would otherwise not be, as in the following example.

You must not forget to write \composeSolid at the end of the text-writing commands for all these lines to be taken into account. Any other PStricks command will have the usual effect and “composeSolid will be unnecessary.


Dans ma jeunesse,
dans les maisons de plaisir
les tentures frissonnaient
Juang Jie
Dehors, sur les marches
les gouttes tambourinent
Juang Jie
les ruelles bizarres
quand j'ai mis la rose dans mes cheveux
et une fleur de la montagne oui
les figuiers dans les jardins de l'Alameda et toutes
le monologue de Molly
de Ulysse de James Joyce



11.13. Projection of images

This command displays an eps image on a plane defined by an origin and a normal, this plan can be the face of a predefined object: a cube for example. The eps image must be prepared according to the method described in the documentation for 'pst-anamorphosis'[1].

The macro includes various options:

"psImage[filename=¡filename with extension¿,
divisions=10,
normale=nx ny nz,
origine=xO yO zO,
phi=angle,
unitPicture=28.45](x,y)

It focuses the image on the plane at the point defined by the origin, it may be moved to another point by setting the *optional* values (x,y). You can omit these values if we do not translate the image into another point than the origin of the plan.

divisions=20 selects the number of sub-segments for lineto in the image file to display. The higher the number, the higher the projected image will be faithful to the original. However, the projection takes place on a plane, the

[1] http://melusine.eu.org/syracuse/G/pst-anamorphosis/doc/

deformation will be small in all cases except one approaches very close to the plane, therefore a small number of subdivisions will generally give a correct result and will perform calculations quickly .

phi can rotate the image of a fixed value in degrees.

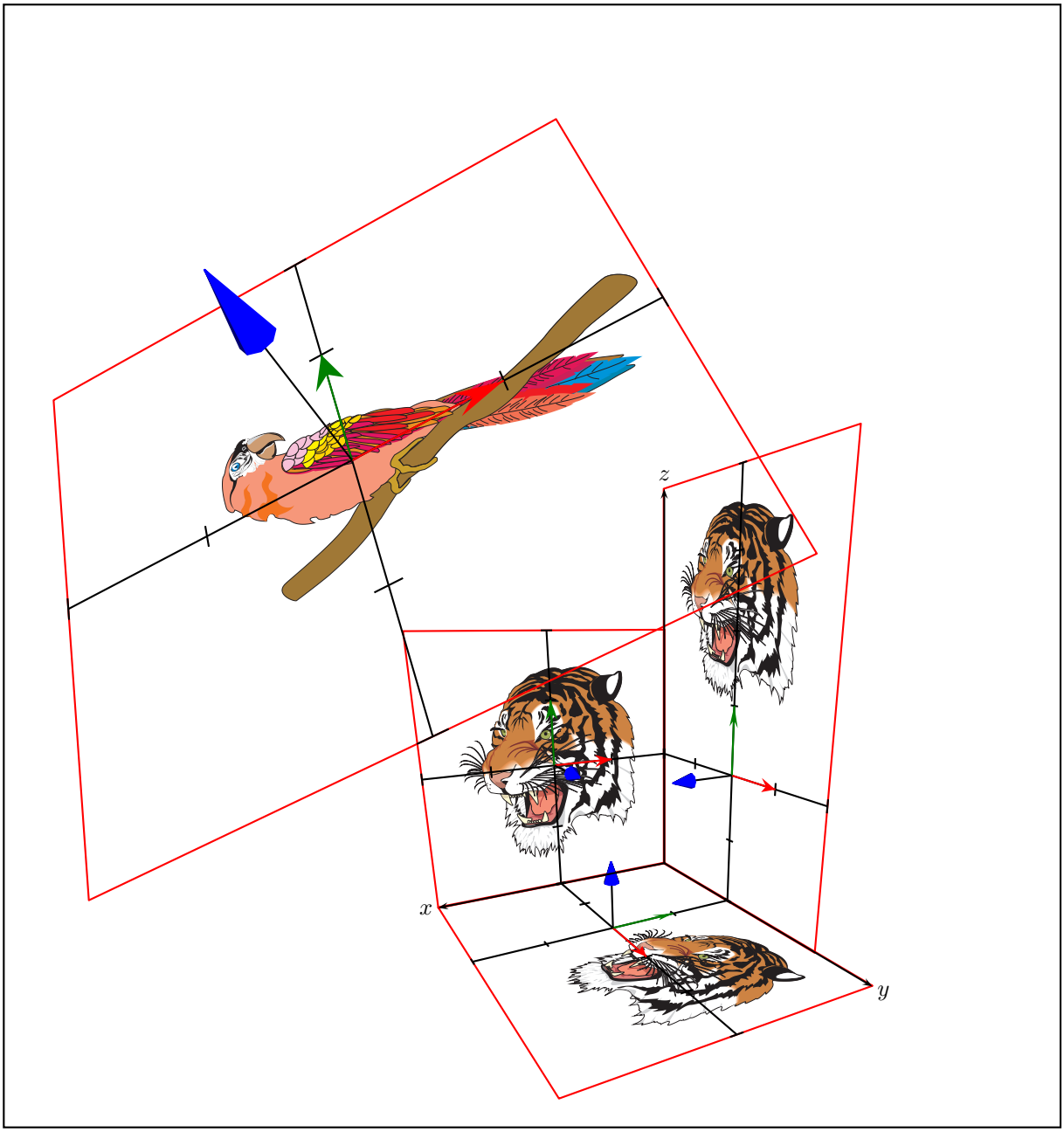
unitImage=28.45 allows to resize the size of the eps image that is generally points per cm, a larger value will give a smaller image.

If you want to place the image on the front of an object, it will follow the following procedure:

- determine the number of faces of the object, see the documentation of 'pst-solides3d ';
- give to the normal of the face in question and origin at the center of that face. We can always shift the image with (x, y).

```
"begin–pspicture"(-5,-5)(5,5)
"psset–solidmemory"
"psSolid[object=cube,a=8,action=draw,name=OBJECT,linecolor=red]%
"psImage[filename=tiger.eps,normal=OBJECT 0 solidnormaleface,
        origine=OBJECT 0 solidcentreface,unitPicture=75]
"psImage[filename=tiger.eps,normal=OBJECT 1 solidnormaleface,
        origine=OBJECT 1 solidcentreface,unitPicture=75]
"psImage[filename=tiger.eps,normal=OBJECT 4 solidnormaleface,
        origine=OBJECT 4 solidcentreface,unitPicture=75]
"psImage[filename=tiger.eps,normal=OBJECT 3 solidnormaleface,
        origine=OBJECT 3 solidcentreface,unitPicture=75]
"psImage[filename=tiger.eps,normal=OBJECT 2 solidnormaleface,
        origine=OBJECT 2 solidcentreface,unitPicture=75]
"end–pspicture"
```

If the selected plan is not visible to the set position, it may, if desired, force the display of the image with the visibility.

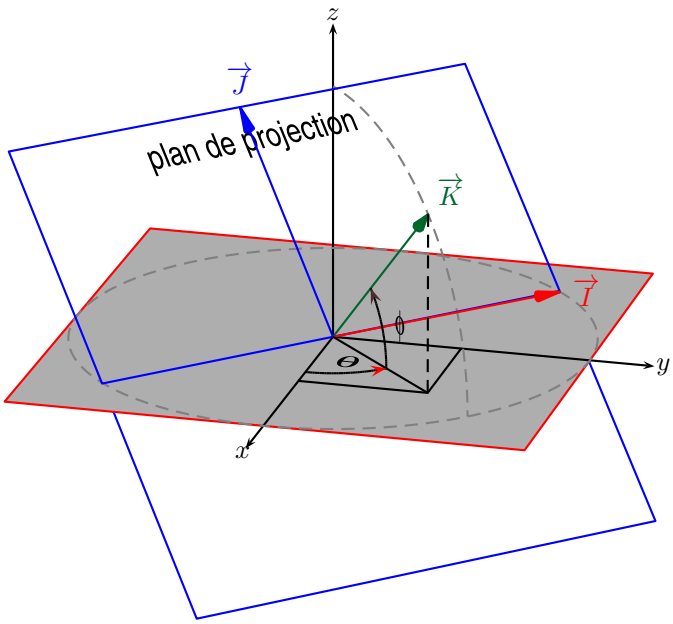

z
x
y

11.14. A bit of theory

The image is projected into a plane defined by a normal $\vec{K}$ and origin $O'(x_O, y_O, z_O)$. The coordinates of points in each image are given in reference to a benchmark plan $(O, \vec{I}, \vec{J})$ whose vectors are determined from $\vec{K}$ as follows: This vector $\vec{K}$ is defined by θ and φ, we calculate these values from the coordinates. With $(O, \vec{i}, \vec{j}, \vec{k})$

$$\vec{K} = \begin{pmatrix} \cos\varphi\cos\theta \\ \cos\varphi\sin\theta \\ \sin\varphi \end{pmatrix}$$

You must then choose the other two basis vectors $(\vec{I}, \vec{J}, \vec{K})$. I choose to keep $\vec{I}$ at the plane Oxy



12. Possible extensions

12.1. Creating your own object

It is possible to create your own object in a separate file and import it into the list of objects recognized by pst-solides3d. Create a text file with the extension of .pro (myObj.pro) and enter the PostScript commands to define your pst-solides3d object.

Reference your .pro file in the preamble with

"pstheader–myObj.pro"

Following this line, add this new object to the list of objects recognized by pst-solides3d with

"addtosolideslistobject–myObj"

For some examples of this technique, see the following web pages:
http://melusine.eu.org/syracuse/mluque/solides3d2007/cristaux/
http://melusine.eu.org/syracuse/mluque/solides3d2007/rhombicuboctaedre/

12.2. Creating a .u3d file

You can manipulate 3D objects created with pst-solides3d; the following three steps are necessary:

1. Save your designed 3D object in the .off or .obj format—see the chapter "*Usage of external files*".
2. Then use, for example, *Meshlab*—an open source software—(http://meshlab.sourceforge.net/) to convert these files into the .u3d format.
3. The LaTeX package movie15 of Alexander Grahn embeds files in the .u3d format into a PDF document, the document can then be viewed using Adobe® Reader® 7 or later.

You will find some examples on the following web pages:
http://melusine.eu.org/syracuse/mluque/solides3d2007/pdf3d/
http://melusine.eu.org/syracuse/mluque/solides3d2007/zeolithes/

A. Appendix

A.1. The parameters of pst-solides3d

Parameter	Default	Description
object		predefined objects for use with \psSolid and \psProjection: object=myName where myName is the type of object
viewpoint	10 10 10	the coordinates of the point of view
a	2	the value of a has several interpretations: the edge length of a cube, the radius of the circumscribed sphere of regular polyhedrons, the length of one of the edges of a parallelepiped
r	2	the radius of a cylinder or sphere
h	6	the height of a cylinder, cone, truncated cone, or prism
r0	1.5	the inner radius of a torus
r1	4	the mean radius of a torus
phi	0	the lower latitude of a spherical zone
theta	90	the upper latitude of a spherical zone
a,b and c	4	the lengths of three incident edges of a parallelepiped
base	-1 -1 1 -1 0 1	the coordinates of vertices in the xy-plane for specified shapes
axe	0 0 1	the direction of the axis of inclination of a prism
action	draw**	uses the painting algorithm to draw the solid without hidden edges and with coloured faces
lightsrc	20 30 50	the Cartesian coordinates of the light source
lightintensity	2	the intensity of the light source
ngrid	n1 n2	sets the grid for a chosen solid
mode	0	sets a predefined grid: values are 0 to 4. mode=0 is a large grid and mode=4 is a fine grid
grid	true	if grid is used then gridlines are suppressed
biface	true	draw the interior face; if you only want the exterior shown write biface=false
algebraic	false	algebraic=true (also written as [algebraic]) allows you to give the equation of a surface in algebraic form (otherwise RPN is enabled); the package pstricks-add must be loaded in the preamble
fillcolor	white	specifies a colour for the outer faces of a solid
incolor	green	specifies a colour for the inner faces of a solid
hue		the colour gradient used for the outer faces of a solid
inhue		the colour gradient used for internal faces
inouthue		the colour gradient used for both internal and external faces as a single continuation
fcol		permits you to specify, in order of face number 0 to $n-1$ (for n faces) the colour of the appropriate face: fcol=0 (Apricot) 1 (Aquamarine) etc.
rm		removes visible faces: rm=1 2 8 removes faces 1, 2 and 8
show		determines which vertices are shown as points: show=0 1 2 3 shows the vertices 0, 1, 2 and 3, show=all shows all the vertices

Continued on next page

Parameter	Default	Description
num		numbers the vertices; for example num=0 1 2 3 numbers the vertices 0,1,2 and 3, and num=all numbers all the vertices
name		the name given to a solid
solidname		the name of the active solid
RotX	0	the angle of rotation of the solid around Ox (in degrees)
RotY	0	the angle of rotation of the solid around Oy (in degrees)
RotZ	0	the angle of rotation of the solid around Oz (in degrees)
hollow	false	draws the inside of hollow solids: cylinder, cone, truncated cone and prism
decal	-2	reassign the index numbers of the vertices within a base
axesboxed	false	this option for surfaces allows semi-automatic drawing of the 3D coordinate axes, since the limits of z must be set by hand; enabled with axesboxed
Zmin	-4	the minimum value of z
Zmax	4	the maximum value of z
QZ	0	shifts the coordinate axes vertically by the chosen value
spotX	dr	the position of the tick labels on the x-axis
spotY	dl	the position of the tick labels on the y-axis
spotZ	l	the position of the tick labels on the z-axis
resolution	36	the number of points used to draw a curve
range	-4 4	the limits for function input
function	f	the name given to a function
path	newpath 0 0 moveto	the projected path
text		the projected text
visibility	false	if false the text applied to a hidden face is not rendered
chanfreincoeff	0.2	the chamfering coefficient
trunccoeff	0.25	the truncation coefficient
dualregcoeff	1	the dual solid coefficient
affinagecoeff	0.8	the hollowing coefficient
affinage		determines which faces are hollowed out: affinage=0 1 2 3 recesses faces 0, 1, 2 and 3, affinage=all recesses all faces
affinagerm		keep the central part of hollowed out faces
intersectiontype	-1	the type of intersection between a plane and a solid; a positive value draws the intersection
plansection		list of equations of intersecting planes, when used only for their intersections
plansepare		the equation of the separating plane for a solid
intersectionlinewidth	1	the thickness of an intersection in pt; if there are several intersections of different thicknesses then list them like so: intersectionlinewidth=1 1.5 1.8 etc.
intersectioncolor	(rouge)	the colour used for intersections; if several intersections in different colours are required, list them as follows: intersectioncolor=(rouge) (vert) etc.
intersectionplan	[0 0 1 0]	the equation of the intersecting plane
definition		defines a point, a vector, a plane, a spherical arc, etc.
args		arguments associated with definition
section	\Section	the coordinates of the vertices of a cross-section of a solid ring
planmarks	false	scales the axes of the plane
plangrid	false	draws the coordinate axes of the plane
showbase	false	draws the unit vectors of the plane
showBase	false	draws the unit vectors of the plane and the normal vector to the plane

Continued on next page

Parameter	Default	Description
deactivatecolor	false	disables the colour management of PSTricks
transform		a formula, applied to the vertices of a solid, to transform it
axisnames	{x,y,z}	the labels of the axes in 3D
axisemph		the style of the axes labels in 3D
showOrigin	true	draws the axes from the origin, or not if set to false
mathLabel	true	draws the axes labels in math mode, or not if set to false
file		the name of the data file having .dat extension written with action=writesolid or read with object=datfile
load		the name of the object to be loaded
fcolor		the colour of the refined parts of the faces of an object
sommets		the list of vertices of a solid for use with object=new
faces		the list of faces of a solid for use with object=new
stepX	1	a positive integer giving the interval between ticks on the x-axis of \gridIIID
stepY	1	a positive integer giving the interval between ticks on the y-axis of \gridIIID
stepZ	1	a positive integer giving the interval between ticks on the z-axis of \gridIIID
ticklength	0.2	the length of tickmarks for \gridIIID
		End of table

A.2. Alphabetical list of keywords

Glossary of symbols	
Symbol	**Use/meaning**
object, sommets, ...	keywords
A, B, C, I, P	names of points
x y	coordinates of a point in a plane
x y z	coordinates of a 3d point
r θ ϕ	spherical coordinates of a 3d point
L, M	names of lines
C, r	circle, centre name C, radius r
a b c	components of a normal
[a b c d]	the plane $ax + by + cz + d = 0$
a, b	intercepts of lines
u, v	names of vectors
α	angle/angle of rotation
k	scaling factor
S	name of a solid
i	index number of a vertex/face
w	linewidth
num	integer
value	real number
length	positive real number
string	text string
a—b—c—...	alternatives

Name	Command/Object	Value	Default
a	\psSolid		

Continued on next page

Name	Command/Object	Value	Default
	object=cube—tetrahedron—octahedron—dodecahedron—icosahedron	*length*	2
a, b and c	\psSolid object=parallelepiped	 *length*	 4
action	\psSolid	none—draw—draw*—draw**—writeobj—writeoff—writesolid	draw**
affinage	\psSolid	all— $i_0\ i_1\ \ldots\ i_n$	
affinagecoeff	\psSolid	*value*	0.8
affinagerm	\psSolid	*boolean*	true
algebraic	\psFunction, \psSurface	*boolean*	false
args	\psSolid object=plan definition =equation =normalpoint =solidface object=point definition =addv3d =barycentre3d =hompoint3d =isobarycentre3d =milieu3d =mulv3d =normalize3d =orthoprojplane3d =rotateOpoint3d =scaleOpoint3d =solidcentreface	 $\{[a\ b\ c\ d\ ]\}$—$\{[a\ b\ c\ d\ ]\ \alpha\}$ $\{x_0\ y_0\ z_0\ [a\ b\ c]\}$— $\{x_0\ y_0\ z_0\ [a\ b\ c\ \alpha]\}$— $\{x_0\ y_0\ z_0\ [u_x\ u_y\ u_z\ a\ b\ c]\}$— $\{x_0\ y_0\ z_0\ [u_x\ u_y\ u_z\ a\ b\ c\ \alpha]\}$ $S\ i$ $x\ y\ z$ — P $x_1\ y_1\ z_1\ x_2\ y_2\ z_2$ — $u\ v$ $A\ i_A\ B\ i_B$ $P\ A\ k$ $\{[A_0\ A_1\ \ldots\ A_n]\}$ $A\ B$ $x\ y\ z\ k$ — $u\ k$ $x\ y\ z$ — u $P\ A\ v$ $P\ \alpha_x\ \alpha_y\ \alpha_z$ $x\ y\ z\ k_x\ k_y\ k_z$ — *name* $k_x\ k_y\ k_z$ $S\ i$	

Continued on next page

Name	Command/Object	Value	Default
	=solidgetsommet	$S\ i$	
	=subv3d	$x_1\ y_1\ z_1\ x_2\ y_2\ z_2$ — $u\ v$	
	=sympoint3d	$P\ A$	
	=translatepoint3d	$P\ v$	
	=vectprod3d	$x_1\ y_1\ z_1\ x_2\ y_2\ z_2$ — $u\ v$	
	object=vecteur	$x\ y\ z$ —	
		$x_1\ y_1\ z_1\ x_2\ y_2\ z_2$ addv3d —	
		$x_1\ y_1\ z_1\ x_2\ y_2\ z_2$ subv3d —	
		$x\ y\ z\ k$ mulv3d —	
		$x\ y\ z$ normalize3d —	
		$x_1\ y_1\ z_1\ x_2\ y_2\ z_2$ vectprod3d	
	object=vecteur3d	$x_A\ y_A\ z_A\ x_B\ y_B\ z_B$ — $A\ B$	
	\psProjection		
args	object=cercle	$x\ y\ r$ — $C\ r$	
	definition		
	=ABcercle	$A\ B\ C$	
	=diamcercle	$A\ B$	
	object=droite	$x_1\ y_1\ x_2\ y_2$ — $A\ B$	
	definition		
	=axesymdroite	$L\ M$	
	=bissectrice	$A\ B\ C$	
	=horizontale	b	
	=mediatrice	$A\ B$	
	=paral	$L\ A$	
	=perp	$L\ A$	
	=rotatedroite	$L\ A\ \alpha$	
	=translatedroite	$L\ u$	
	=verticale	a	
	object=line	$A_0\ A_1$ ... A_n	
	object=point		
	definition		
	=axesympoint	$P\ L$	

Continued on next page

Name	Command/Object	Value	Default
	=cpoint	$\alpha\ C\ r$	
	=hompoint	$P\ A\ k$	
	=interdroite	$L\ M$	
	=interdroitecercle	$L\ C\ r$	
	=milieu	$A\ B$	
	=orthoproj	$P\ L$	
	=parallelopoint	$A\ B\ C$	
	=projx	P	
	=projy	P	
	=rotatepoint	$P\ I\ \alpha$	
	=sympoint	$P\ I$	
	=translatepoint	$P\ u$	
	=xdpoint	$x\ L$	
	=ydpoint	$y\ L$	
	object=polygone	$A_0\ A_1\ ...\ A_n$	
	definition		
	=axesympol	*pol* L	
	=hompol	*pol* $I\ \alpha$	
	=rotatepol	*pol* $I\ \alpha$	
	=sympol	*pol* I	
	=translatepol	*pol* u	
	object=rightangle	$A\ B\ C$	
	object=vecteur		
	definition		
	=addv	$A\ B$	
	=mulv	$u\ k$	
	=normalize	u	
	=orthovecteur	u	
	=subv	$u\ v$	
	=vecteur	$A\ B$	
axe	\psSolid		

Continued on next page

Name	Command/Object	Value	Default
	object=cylindre—prisme—ruban	x y z	0 0 1
axesboxed	\psSolid	*boolean*	false
axisemph	\axesIIID \gridIIID	{*text style*}	
axisnames	\axesIIID	{*a,b,c*}	{x,y,z}
base	\psSolid		
	object=face—prisme—ruban	x_1 y_1 x_2 y_2 x_3 y_3 ... x_n y_n	-1 -1 1 -1 0 1
	object=fusion	S_1 S_2	
	object=grille	$x_{\min}$ $x_{\max}$ $y_{\min}$ $y_{\max}$	
biface	\psSolid		
	object=face	*boolean*	true
chanfrein	\psSolid	*boolean*	false
chanfreincoeff	\psSolid	*value*	0.2
deactivatecolor	\psSolid	*boolean*	false
decal	\psSolid	*num*	-2
definition	\psSolid		
	object=plan	equation—normalpoint—solidface	
	object=point	addv3d—barycentre3d—hompoint3d—isobarycentre3d—milieu3d—orthoprojplane3d—rotateOpoint3d—scaleOpoint3d—solidcentreface—solidgetsommets	
	object=vecteur	vecteur3d—addv3d—subv3d—mulv3d—normalize3d—vectprod3d	
definition	\psProjection		
	object=cercle	ABcercle—diamcercle	
	object=droite	axesymdroite—bissectrice—horizontale—mediatrice—paral—perp—rotatedroite—translatedroite—verticale	
	object=point	axesympoint—cpoint—hompoint—interdroite—interdroitecercle—milieu—orthoproj—parellelopoint—projx—projy—rotatepoint—sympoint—translatepoint—xdpoint—ydpoint	
	object=polygone	axesympol—hompol—rotatepol—sympol—translatepol	
	object=vecteur	addv—normalize—mulv—orthovecteur—subv—vecteur	

Continued on next page

Name	Command/Object	Value	Default
dualreg	\psSolid object=geode	*boolean*	false
faces	\psSolid object=new	{[i_1 i_2 ... i_n][i'_1 i'_2 ... i'_m] ... }	
fcol	\psSolid	i_0 ($color_0$) i_1 ($color_1$) ...	
fcolor	\psSolid affinagerm	*color*	
file	\psSolid action=writesolid object=datfile—objfile—offfile	*filename* *filename*	
fillcolor	\psSolid, \psSurface	*color*	white
function	\psSolid, \defFunction object=cone—courbe—courbeR2—cylindre—surfaceparametree	*name*	
grid	\psSolid	*boolean*	true
h	\psSolid object=cone—cylindre—prisme—tronccone	*length*	6
hollow	\psSolid object=cone—cylindre—prisme—tronccone	*boolean*	false
hue, inhue, inouthue	\psSolid, \psSurface	h_0 h_1 h_0 h_1 s b h_0 s_0 b_0 h_1 s_1 b_1 (hsb) r_0 g_0 b_0 r_1 g_1 b_1 c_0 m_0 y_0 k_0 c_1 m_1 y_1 k_1 (*color*$_1$) (*color*$_2$)	
incolor	\psSolid, \psSurface	*color*	green
intersec-tioncolor	\psSolid	(*color*$_1$) ... (*color*$_n$)	(rouge)
intersec-tionlinewidth	\psSolid	w_1 ... w_n	1
intersec-tionplan	\psSolid, \psSurface	*name* — {eq_1 ... eq_n} where eq$_i$=[a_i b_i c_i d_i]	

Continued on next page

Name	Command/Object	Value	Default
labelsep	\axesIIID	*length[unit]*	
lightintensity	\psSolid, \psSurface	*value*	2
lightsrc	\psSolid, \psSurface	$x\ y\ z$	20 30 50
load	\psSolid object=load	 *name*	
mathLabel	\axesIIID	*boolean*	true
mode	\psSolid	0—1—2—3—4	0
name	\psSolid, \psProjection	*name*	
ngrid	\psSolid object=cube—prisme—prismecreux object=cone—conecreux—cylindre—cylindrecreux—tore—tronccone—troncconecreux object=grille—surface—surface*—surfaceparametree	 n_1 $n_1\ n_2$ n_1— $n_1\ n_2$	
num	\psSolid	all — $i_0\ i_1$ ... i_n	
object	\psSolid \psProjection	new—anneau—calottesphere—cone—conecreux—cube—cylindre—cylindrecreux—datfile—dodecahedron—face—fusion—geode—grille—icosahedron—load—octahedron—objfile—parallelepiped—plan—prisme—ruban—sphere—surfaceparametree—tetrahedron—tore—tronccone—troncconecreux cercle—courbe—courbeR2—droite—line—point—polygone—rightangle—texte—vecteur	
opacity	\psSolid	*value*	1
origine	\psSolid object=plan	 $x_0\ y_0\ z_0$	0 0 0
path	\psProjection	*pscode*	newpath 0 0 moveto
phi	\psSolid, \psProjection	α	0
plangrid	\psSolid object=plan	 *boolean*	false
planmarks	\psSolid object=plan	 *boolean*	false

Continued on next page

Name	Command/Object	Value	Default
plansection	\psSolid	{$plan_1$ ... $plan_n$} where plan$_i$=[a_i b_i c_i d_i]	
plansepare	\psSolid	{[a b c d]}	

Continued on next page

Name	Command/Object	Value	Default
pos	\psProjection object=point	ul—cl—bl—dl—ub—cb—bb—db—uc—cc—bc—dc—ur—cr—br—dr	cc
QZ	\psSolid, \psSurface	*value*	0
RotX, RotY, RotZ	\psSolid	α	0
r	\psSolid object=anneau—courbe	*length*	2
R	\psSolid object=anneau	*length*	4
r0	\psSolid object=tore—troncone—troncconecreux	*length*	1.5
r1	\psSolid object=tore—troncone—troncconecreux	*length*	4
range	\psSolid object=cercle—courbe—courbeR2 object=surfaceparametree	$t_{\min}$ $t_{\max}$ $u_{\min}$ $u_{\max}$ $v_{\min}$ $v_{\max}$	-5 5
resolution	\psSolid object=courbe—courbeR2—ruban	n	36
rm	\psSolid	i_0 i_1 ... i_n	
section	\psSolid object=anneau	*macro{pscode}*	\Section
show	\psSolid	all — i_0 i_1 ... i_n	
showBase	\psSolid object=plan	*boolean*	false
showbase	\psSolid object=plan	*boolean*	false
showOrigin	\axesIIID	*boolean*	true
sommets	\psSolid object=new	x_1 y_1 z_1 x_2 y_2 z_2 ... x_n y_n z_n	

Continued on next page

Name	Command/Object	Value	Default
spotX,spotY, spotZ	\psSurface, \gridIIID	u—ul—l—dl—d—dr—r—ur	
stepX,stepY, stepZ	\gridIIID	n	1
text	\psProjection object=point	*string*	
theta	\psSolid object=calottesphere	α	90
ticklength	\gridIIID	*length*	0.2
transform	\psSolid, \defFunction	{*pscode*}—*function*	
trunc	\psSolid	all — $i_0\ i_1$ ... i_n	
trunccoeff	\psSolid	*value*	0.2
viewpoint	\psset	$x\ y\ z$ — $r\ \theta\ \phi$ rtp2xyz	10 10 10
visibility	\psSolid, \psProjection	*boolean*	true
Zmin	\psSurface, \gridIIID	*value*	-4
Zmax	\psSurface, \gridIIID	*value*	4
			End of table

A.3. Acknowledgments

Spontaneous and diligent proofreading assistance from various members of the PSTricks list made it possible to produce this English version of the pst-solides3d documentation. We hope that this will help and encourage more of you to set about depicting your own 3D solids.

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A.4. The poems

Dans ma jeunesse, j’écoutais le son de la pluie dans les maisons de plaisir ;

les tentures frissonnaient sous la lumière rouge des candélabres.

Dans mon âge mûr, j’ai écouté le son de la pluie en voyage, à bord d’un bateau ;

les nuages pesaient bas sur l’immensité du fleuve ;

une oie sauvage séparée de ses soeurs appelait dans le vent d’ouest.

Aujourd’hui, j’écoute le son de la pluie sous le charme d’un ermitage monastique.

Ma tête est chenue, chagrins et bonheurs, séparations et retrouvailles - tout est vanité.

Dehors, sur les marches, les gouttes tambourinent jusqu'à l'aube.

Juang Jie from *Les idées de autres* by Simon Leys

O cet effrayant torrent tout au fond
O et la mer la mer écarlate quelquefois comme du feu
Et les glorieux couchers de soleil
Et les figuiers dans les jardins de l'Alameda
Et toutes les ruelles bizarres
Et les maisons roses et bleues et jaunes
Et les roseraies et les jasmins et les géraniums
Et les cactus de Gibraltar quand j'étais jeune fille
Et une Fleur de la montagne oui
Quand j'ai mis la rose dans mes cheveux comme les filles Andalouses
Ou en mettrai-je une rouge oui
Et comme il m'a embrassée sous le mur mauresque
Je me suis dit après tout aussi bien lui qu'un autre
Et alors je lui ai demandé avec les yeux de demander encore oui
Et alors il m'a demandé si je voulais oui
Dire oui ma fleur de la montagne
Et d'abord je lui ai mis mes bras autour de lui oui
Et je l'ai attiré sur moi pour qu'il sente mes seins tout parfumés oui
Et son coeur battait comme un fou
Et oui j'ai dit oui
Je veux bien Oui.

Monologue of *Molly Bloom* from *Ulysses* by James Joyce

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